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DOCKET
08-AFC-5
DATE MAY 17 2010
RECD. MAY 17 2010

May 17, 2010

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 08-AFC-5
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512

Re: Imperial Valley Solar, LLC; Docket 08-AFC-5

Dear Docket Clerk:

Enclosed are an original and one copy of CURE's Partial Rebuttal Testimony. Please process the document and return a conformed copy in the envelope enclosed.

Thank you for your assistance.

Yours truly,

/s/

Loulena A. Miles

LAM:bh
Enclosures

2218-119a

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May 17, 2010

Raoul Renaud, Hearing Officer
California Energy Commission
1516 Ninth Street, MS-15
Sacramento, CA 95814

Re: CURE Partial Rebuttal Testimony Regarding Imperial Valley Solar Project (08-AFC-5)

Dear Hearing Officer Renaud:

This filing includes our partial rebuttal testimony regarding the Imperial Valley Solar Project. CURE will be filing additional testimony after the Staff files its Staff Assessment pursuant to 20 CCR § 1742.5. Based on the Staff's filing today entitled *Staff Comments on Schedule Impacts of AFC Supplement*, we do not anticipate sponsoring any testimony at the hearings on May 24th and May 25th.

Sincerely,

/s/

Loulena A. Miles

LAM:bh
cc: Service List Docket No. 08-AFC-5

2218-120a

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STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

CALIFORNIA UNIONS FOR RELIABLE ENERGY
REVISED SEQUENTIAL EXHIBIT LIST

EXHIBIT NO.	DATE	TITLE	SUBJECT	SPONSOR
400	5/10/10	Opening Testimony of Dr. Vernon C. Bleich on Behalf of the California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project	Biology	Vernon C. Bleich
401	5/10/10	Bleich Declaration	Biology	Vernon C. Bleich
402		Bleich C.V.	Biology	Vernon C. Bleich
403	1993	DeForge, J. R., S. D. Ostermann, D. E. Toweill, P. E. Cyrog, and E. M. Barrett. 1993. Helicopter survey of peninsular bighorn sheep in northern Baja California. Desert Bighorn Council Transactions 37:24-28	Biology	Vernon C. Bleich
404	2000	U.S. Fish and Wildlife Service. 2000. Recovery plan for bighorn sheep in the peninsular ranges, California	Biology	Vernon C. Bleich
405	6/17/09	Memo from Guy Wagner to Toni Parr dated 17 June 2009, with a subject line of Solar Two Map PBHS Map.ppt	Biology	Vernon C. Bleich
406	1990	Bleich, V. C., J. D. Wehausen, and S. A. Holl. 1990. Desert-dwelling mountain sheep: conservation implications of a naturally fragmented distribution. Conservation Biology 4:383-390.	Biology	Vernon C. Bleich
407	2007	Epps, C. W., J. D. Wehausen, V. C. Bleich, S. G. Torres, and J. S. Brashares. 2007. Optimizing dispersal and corridor models using landscape genetics. Journal of Applied Ecology 44:714-724.	Biology	Vernon C. Bleich
408	1986	Schwartz, O. A., V. C. Bleich, and S. A. Holl. 1986. Genetics and the conservation of mountain sheep *Ovis canadensis nelsoni*. Biological Conservation 37:179-190.	Biology	Vernon C. Bleich
409	1996	Bleich, V. C., J. D. Wehausen, R. R. Ramey II, and J. L. Rechel. 1996. Metapopulation theory and mountain sheep: implications for conservation. Pages 353-373 in D. R. McCullough (editor). Metapopulations and wildlife conservation. Island Press, Covelo, California.	Biology	Vernon C. Bleich
410	2005	Bleich, V. C. 2005. Politics, promises, and illogical legislation confound wildlife conservation. Wildlife Society Bulletin 33:66-73.	Biology	Vernon C. Bleich
411	2010	Flesch, A. D., C. W. Epps, J. W. Cain III, M. Clark, P. R. Krausman, and J. R. Morgart.	Biology	Vernon C. Bleich

		2010. Potential effects of the United States-Mexico border fence on wildlife. Conservation Biology 24:171-181.		
412	1999	Andrew, N. G., V. C. Bleich, and P. V. August. 1999. Habitat selection by mountain sheep in the Sonoran Desert: implications for conservation in the United States and Mexico. California Wildlife Conservation Bulletin 12:1-30.	Biology	Vernon C. Bleich
413	2004	Pierce, B. M., R. T. Bowyer, and V. C. Bleich. 2004. Habitat selection by mule deer: forage benefits or risk of predation? Journal of Wildlife Management 68:533-541.	Biology	Vernon C. Bleich
414	1997	Bleich, V. C., R. T. Bowyer, and J. D. Wehausen. 1997. Sexual segregation in mountain sheep: resources or predation? Wildlife Monographs 134:1-50.	Biology	Vernon C. Bleich
415	1994	Andrew, N. G. 1994. Demography and habitat use of desert-dwelling mountain sheep in the East Chocolate Mountains, Imperial County, California. MS Thesis, University of Rhode Island, Kingston, Rhode Island, USA.	Biology	Vernon C. Bleich
416	2005	Marshal, J. P., P. R. Krausman, and V. C. Bleich. 2005. Dynamics of mule deer forage in the Sonoran Desert. Journal of Arid Environments 60:593-609.	Biology	Vernon C. Bleich
417		SES Solar Two LLC, Response to CURE Data Requests, Set One, 08-AFC-5.	Biology	Vernon C. Bleich
418	2000	Rubin, E. S., W. M. Boyce, and V. C. Bleich. 2000. Reproductive strategies of desert bighorn sheep. Journal of Mammalogy 81:769-786.	Biology	Vernon C. Bleich
419	2005	Marshal, J. P., P. R. Krausman, and V. C. Bleich. 2005. Rainfall, temperature, and forage dynamics affect nutritional quality of desert mule deer forage. Rangeland Ecology and Management 58:360-365.	Biology	Vernon C. Bleich
420	1992	Bleich, V. C., R. T. Bowyer, D. J. Clark, and T. O. Clark. 1992. Quality of forages eaten by mountain sheep in the eastern Mojave Desert, California. Desert Bighorn Council Transactions 36:41-47.	Biology	Vernon C. Bleich
421	2003	Oehler, M. W., Sr., R. T. Bowyer, and V. C. Bleich. 2003. Home ranges of mountain sheep: effects of precipitation in a desert ecosystem. Mammalia 67:385-402.	Biology	Vernon C. Bleich
422	2005	Oehler, M. W., V. C. Bleich, R. T. Bowyer, and M. C. Nicholson. 2005. Mountain sheep	Biology	Vernon C. Bleich

		and mining: implications for conservation and management. California Fish and Game 91:149-178.		
423	2005	Wehausen, J. D. 2005. Nutrient predictability, birthing seasons, and lamb recruitment for desert bighorn sheep. Pages 37-50 in J. Goerrissen and J. M. Andre, editors. Sweeney Granite Mountains Desert Research Center 1978-2003. A Quarter Century of Research and Teaching. University of California Natural Reserve System, Riverside, California, USA.	Biology	Vernon C. Bleich
424		SES Solar Two, Appendix Y. Biological Resources Technical Report, Attachment B. Plant species observed on the Solar Two project site. Pages B-1 – B-4.	Biology	Vernon C. Bleich
425	1968	Weaver, R. A., J. L. Mensch, and W. V. Fait. 1968. A survey of the California desert bighorn (*Ovis canadensis*) in San Diego County. California Department of Fish and Game, Federal Aid in Wildlife Restoration Project W-51-R-14. Final Report.	Biology	Vernon C. Bleich
426	1978	Hicks, L. L. 1978. The status and distribution of peninsular bighorn sheep in the In-Ko-Pah Mountains, California. USDI Bureau of Land Management, Riverside District, El Centro, California, USA.	Biology	Vernon C. Bleich
427	1989	Dodd, N. 1989. Dietary considerations. Pages 109-134 in R. M. Lee (editor). The desert bighorn sheep in Arizona. Arizona Game and Fish Department, Phoenix, Arizona, USA.	Biology	Vernon C. Bleich
428	1986	Scott, J. E. 1986. Food habits and nutrition of desert bighorn sheep (*Ovis canadensis cremnobates*) in the Santa Rosa Mountains, California. MS Thesis, California State Polytechnic University, Pomona, California, USA.	Biology	Vernon C. Bleich
429	5/10/10	Opening Testimony of Scott Cashen on Behalf of the California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project - Figure 1 – Map #1 of MA blockage - Figure 2 – Map #2 of MA blockage - Figure 3 – GOEA nesting habitat - Figure 4 – CDFTL map - Figure 5 – Pictures of sensitive communities	Biology	Scott Cashen

		- Figure 6 – SS plants near Seeley - Figure 7 – Yuha and W. Mesa MAS		
430	5/10/10	Cashen Declaration	Biology	Scott Cashen
431		Cashen C.V.	Biology	Scott Cashen
432		Calico Solar Project SA/DEIS	Biology	Scott Cashen
433		Calico Solar Project. Applicant's response to CURE data request 162	Biology	Scott Cashen
434		Energy Commission Staff's Rebuttal Testimony, Ivanpah Solar Electric Generating System	Biology	Scott Cashen
435		Final Staff Assessment, Ivanpah Solar Electric Generating System	Biology	Scott Cashen
436	3/12/10	Applicant's Comments on the SA/DEIS. Imperial Valley Solar (formerly solar Two) (08-AFC-5)	Biology	Scott Cashen
437	2010	California Native Plant Society (CNPS). 2010. Inventory of Rare and Endangered Plants (online edition, v7-10a). California Native Plant Society. Sacramento, CA	Biology	Scott Cashen
438	4/29/10	California Natural Diversity Database Info [internet]. Sacramento: California Department of Fish and Game; [cited 2010 Apr 29].	Biology	Scott Cashen
439	2009	Bureau of Land Management. 2009. Survey Protocols Required for NEPA/ESA Compliance for BLM Special Status Plant Species	Biology	Scott Cashen
440	2003	Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices	Biology	Scott Cashen
441	1991	Dodd CK Jr., RA Seigel. 1991. Relocation, repatriation, and translocation of amphibians and reptiles: Are they conservation strategies that work? Herpetologica 47(3): 336-350	Biology	Scott Cashen
442	3/2009	Flat-tailed Horned Lizard Interagency Coordinating Committee. 2009 Mar. Annual Progress Report: Implementation of the Flat-tailed Horned Lizard Rangewide Management Strategy, January 1, 2008 – December 31, 2008.	Biology	Cashen
443	4/21/09	Ecosphere Environmental Services. 2009 Apr 21. SES Solar Two AFC Supplemental Cumulative Analysis	Biology	Scott Cashen
444	2005	Young KV and AT Young. 2005. Indirect effects of development on the flat-tailed horned lizard. Final Report submitted to Arizona Game and Fish Department, Yuma. 11 pp.	Biology	Scott Cashen
445	2007	Painter ML, MF Ingraldi. 2007. Use of Simulated Highway Underpass Crossing Structures by Flat-Tailed Horned Lizards (*Phrynosoma mcallii*), Final Report 594.	Biology	Scott Cashen

		Arizona Department of Transportation, Phoenix, Arizona		
446	11/29/93	58 Fed. Reg. 62624 (November 29, 1993), Proposed Rule to List Flat-tailed Horned Lizard as Threatened.	Biology	Scott Cashen
447	2000	Okin GS, B Murray, WH Schlesinger. 2000. Degradation of sandy arid shrubland environments: observations, process modelling, and management implications. Journal of Arid Environments Vol. 47, No. 2	Biology	Scott Cashen
448	2006	Bates C. 2006. Burrowing Owl (*Athene cunicularia*). In The Draft Desert Bird Conservation Plan: a strategy for reversing the decline of desert-associated birds in California. California Partners in Flight.	Biology	Scott Cashen
449	2004	DeSante DF, ED Ruhlen, DK Rosenberg. 2004. Density and abundance of burrowing owls in the agricultural matrix of the Imperial Valley, California. Studies in Avian Biology No. 27: 116-119	Biology	Scott Cashen
450	2004	Rosenburg, DK and KL Haley. 2004. The ecology of burrowing owls in the agroecosystem of the Imperial Valley, California. Studies in Avian Biology No. 27: 120-135	Biology	Scott Cashen
451	1993	The California Burrowing Owl Consortium. 1993. Burrowing Owl Survey Protocol and Mitigation Guidelines	Biology	Scott Cashen
452	1995	California Department of Fish and Game. 1995. Staff Report on Burrowing Owl Mitigation	Biology	Scott Cashen
453		AFC, Biological Resources, Figure 6	Biology	Scott Cashen
454	2009	US Fish and Wildlife Service, Division of Migratory Bird Management. 2009. Final Environmental Assessment, Proposal to Permit Take. Provided Under the Bald and Golden Eagle Protection Act. Washington: Dept. of Interior	Biology	Scott Cashen
455		AFC, p. 5.6-9	Biology	Scott Cashen
456	1993	Martin TE, GR Geupel. 1993. Nest-Monitoring Plots: Methods for Locating Nests and Monitoring Success. J. Field Ornithol. 64(4):507-519	Biology	Scott Cashen
457	2009	North American Bird Conservation Initiative, U.S. Committee, 2009. The State of the Birds, United States of America, 2009. U.S. Department of Interior: Washington, DC.	Biology	Scott Cashen
458	1986	DeSante DF, GR Geupel. 1987. Landbird productivity in central coastal California: the relationship to annual rainfall and a reproductive failure in 1986. Condor. 89:636-653	Biology	Scott Cashen
459	1996	Martin TE, C Paine, CJ Conway, WM Hochacka. 1996. BBIRD field protocol. Montana Cooperative Wildlife Research Unit, Missoula (MT)	Biology	Scott Cashen
460		AFC p. 5.6-4	Biology	Scott Cashen

461	12/28/09	California Department of Fish and Game. 2009 Dec 28. List of California Vegetation Alliances. Sacramento: Biogeographic Data Branch	Biology	Scott Cashen
462	2003	BRG Consulting, Inc. 2003. Final Mitigated Negative Declaration and Environmental Assessment: Proposed Seeley Water / Wastewater Master Plans	Biology	Scott Cashen
463	2010	US Fish and Wildlife Service. 2010. Species Profile: Yuma clapper rail [internet]. Environmental Online Conservation System.	Biology	Scott Cashen
464	2009	Dudek. 2009. Draft Mitigated Negative Declaration for the Seeley Wastewater Reclamation Facility Improvements, Imperial County, California	Biology	Scott Cashen
465	1975	Gould GI Jr. 1975. Yuma Clapper Rail Study – Census and Habitat Distribution. Wildlife Management Branch Administrative Report No. 75-2. Supported by Federal Aid in Wildlife Restoration Project W-54-R-7, Nongame Wildlife Investigations	Biology	Scott Cashen
466	2006	US Fish and Wildlife Service. 2006. Yuma Clapper Rail 5-Year Review.	Biology	Scott Cashen
467	2006	California Department of Water Resources and California Department of Fish and Game. 2006. Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report.	Biology	Scott Cashen
468	9/23/09	URS Corporation. 2009 Sep 23. Letter from Matt Moore, Project Engineer, to David Dale, Seeley County Water District	Biology	Scott Cashen
469	1/7/10	Imperial Irrigation District. 2010 Jan 7. Comment letter on the Seeley County Water District's Wastewater Reclamation Facility Improvements Project	Biology	Scott Cashen
470	6/09	URS. 2009 Jun. Supplement to SES Solar Two Application for Certification. p. 2.6-1	Biology	Scott Cashen
471	2002	Evans Ogden LJ. 2002. Summary Report on the Bird Friendly Building Program: Effect of Light Reduction on Collision of Migratory Birds. Special Report for the Fatal Light Awareness Program (FLAP). Available at: http://www.flap.org/	Biology	Scott Cashen
472	1994	National Park Service. 1994. Report to Congress: Report on effects of aircraft overflights on the National Park System	Biology	Scott Cashen
473		A. Letter from Sierra Club San Diego Chapter to David Dale, Seeley County Water District, February 2, 2010. B. Salton Sea Authority Website Information, Environmental Issues Around the Sea, accessed online at http://www.saltonsea.ca.gov/environ.htm on 2/2/2010. C. Letter from U.S. Fish and Wildlife Service to Seeley County Water District, February 2, 2010, re: Draft Mitigated Negative Declaration for the Seeley Wastewater Treatment	Biology	Scott Cashen

		Plant Improvements, Imperial County, California. D. California Environmental Protection Agency, Regional Water Quality Control Board, Staff Report: Water Quality Issues in the Salton Sea Transboundary Watershed, February 2003. E. State Water Resources Control Board – Colorado River Basin Region, website, www.waterboards.ca.gov/coloradoriver/water_issues/programs/salton_sea/index.shtml, accessed on 2/2/2010. F. Letter from Imperial County Public Works Department, January 25, 2010 re: Notice of Intent to adopt a Mitigated Negative Declaration for Seeley County Water District. G. Letter from Department of Toxic Substances Control to Seeley County Water District, January 25, 2010 re: Notice of Intent to adopt a Proposed Mitigated Negative Declaration for Seeley County Water District Wastewater Reclamation Facility.		
474	6/2/01	CNPS Botanical Survey Guidelines, December 9, 1983, Revised June 2, 2001	Biology	Scott Cashen
475	11/24/09	Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities, State of California, Natural Resources Agency, Department of Fish and Game, November 24, 2009	Biology	Scott Cashen
476		Yuma Clapper Rail, Species Profile, US Fish and Wildlife Service	Biology	Scott Cashen
477	2000	Klem, Preventing Bird-Window Collisions (2000) Wilson Ornithological Society	Biology	Scott Cashen
478	5/10/10	Opening Testimony of Dr. Chris Bowles and Chris Campbell on Behalf of California Unions for Reliable Energy on Soil and Water Resources for the Imperial Valley Solar Project - Figure 1 – 100-year discharge comparison - Figure 2 – 6-hour temporal rainfall distributions	Soil Water	Chris Bowles Chris Campbell ("Bowles/Campbell")
479	5/7/10	Bowles Declaration	Soil Water	Chris Bowles
480	5/17/10	Campbell Declaration	Soil Water	Chris Campbell
481		Christopher Bowles, Ph.D., C.V.	Soil	Chris Bowles

			Water	
482		Christopher Campbell, M.S., C.V.	Soil Water	Chris Campbell
483	10/2006	California Department of Water Resources, California Department of Fish and Game (October 2006), Salton Sea Ecosystem Restoration Program, Draft Programmatic Environmental Impact Report, Volume I: PEIR, Hydrology chapter	Soil Water	Bowles/Campbell
484	2005	Y.A. Wood, R.C. Graham, S.G. Wells. 2005. Surface control of desert pavement pedologic process and landscape function, Cima Volcanic field, Mojave Desert, California	Soil Water	Bowles/Campbell
485	2008	Julianne J. Miller, Todd G. Caldwell, Michael H. Young, and Graham K. Dalldorf (2008) Verifying Curve Numbers in Arid Environments by Combining Detailed Geomorphic Mapping and Pedotransfer Functions	Soil Water	Bowles/Campbell
486	2009	Young & Chen. (2009) "Soil Heterogeneity and Moisture Distribution Due to Rainfall Events in Vegetated Desert Areas: Potential Impact on Soil Recharge and Ecosystems Annual Report 2009"	Soil Water	Bowles/Campbell
487	2007	Jon D. Pelletier, Michael Cline, Stephen B. DeLong (2007) Desert pavement dynamics: numerical modeling and field-based calibration	Soil Water	Bowles/Campbell
488		An Introduction to Biological Soil Crusts, accessed 5/10/10 at www.soilcrust.org	Soil Water	Bowles/Campbell
489	2005	James R. Angel, Michael A. Palecki, Steven E. Hollinger. (2005) Storm Precipitation in the United States. Part II: Soil Erosion Characteristics	Soil Water	Bowles/Campbell
490	2004	F. Gonzalez-Bonrino, W.R. Osterkamp (2004) Applying RUSLE 2.0 on burned-forest lands: An appraisal	Soil Water	Bowles/Campbell
491	2009	Li Chen, Jun Yin, Julianne Miller, Michael Young (2009) The Role of the Clast Layer of Desert pavement in Rainfall-Runoff Processes	Soil Water	Bowles/Campbell
492	2006	Peter R. Griffiths, Richard Hereford, Robert H. Webb (2006) Sediment yield and runoff frequency of small drainage basins in the Mojave Desert, U.S.A.	Soil Water	Bowles/Campbell
493	3/26/10	Draft Programmatic Agreement – Imperial Valley Solar Project	Cultural	Janet M. Laurain
494	5/7/09	CURE Comments on the Draft Programmatic Agreement	Cultural	Janet M. Laurain
495		National Register Bulletin, Guidelines for Evaluating and Documenting Historic Aids to Navigation to the National Register of Historic Places	Cultural	Janet M. Laurain
496		Letter from the National Park Service to the Energy Commission and BLM commenting	Cultural	Janet M. Laurain

		on The Staff Assessment/Draft Environmental Impact Statement		
497	5/4/10	Letter from Quechan Indian Tribe, Ft. Yuma Indian Reservation, to Carrie Simmons, Bureau of Land Management commenting on the Draft Programmatic Agreement	Cultural	Janet M. Laurain
498-A	5/17/10	Rebuttal Testimony of Scott Cashen on Behalf of California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project	Biology	Scott Cashen
498-B		Cashen Declaration	Biology	Scott Cashen
498-C		Cashen comment letter to Army Corps	Biology	Scott Cashen
498-D		Manci KM, DN Gladwin, R Villella, MG Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. National Ecology Research Center Report # NERC-88/29	Biology	Scott Cashen
498-E		ICC Meeting Minutes	Biology	Scott Cashen
498-F	2010	Western Regional Climate Center [internet]. 2010. Period of Record Monthly Climate Summary, El Centro 2 SSW, California. Available at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2713	Biology	Scott Cashen
498-G	2003	Department of Fish and Game. List of California Terrestrial Natural Communities Recognized by The California Natural Diversity Database. September 2003 edition.	Biology	Scott Cashen
498-H	2001	Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144	Biology	Scott Cashen
498-I		US Gypsum Final EIR/EIS, p. 3.3-42	Biology	Scott Cashen
498-J	5/12/10	USEPA letter to USACE (5/12/10) re Public Notice (PN) SPL-2008-01244-MLM for the proposed Imperial Valley Solar Project, Tessera Solar North America, Imperial County, California	Biology	Scott Cashen
498-K		Travis Huxman, UA Biosphere 2 and B2 Earthscience, Associate Professor, Ecology and Evolutionary Biology, University of Arizon, Tucson, Arizona: Climate Change and the Sonoran Desert	Biology	Scott Cashen
498-L	5/28/09	CURE letter addressed to Christopher Meyer and Jim Stobaugh (5/28/09) re Biological Resource Survey Techniques for the Solar Two Project	Biology	Scott Cashen
498-M		Monthly Precipitation, El Centro 2 SSW, California	Biology	Scott Cashen
498-N		EPA: Sole Source Aquifer Designations in EPA, Region 9	Biology	Scott Cashen
498-O		Ground-Water Resources, Ocotillo-coyote Wells Basin, Calif.	Biology	Scott Cashen
498-P		U.S. Geological Survey Water-Resources Investigations 77-30: Digital-Model Evaluation of the Ground-Water Resources in the Ocotillo-Coyote Wells Basin, Imperial	Biology	Scott Cashen

		County, California		
498-Q	5/17/20	Rebuttal Testimony of Dr. Vernon C. Bleich on Behalf of California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project	Biology	Vernon C. Bleich
498-R		Bleich Declaration	Biology	Vernon C. Bleich
498-S	5/13/10	S. Torres email	Biology	Vernon C. Bleich
498-T	5/14/10	R. Botta email	Biology	Vernon C. Bleich
498-U	5/11/10	Felicia Sirchia email	Biology	Vernon C. Bleich
498-V	5/17/10	Testimony of Bridget Nash-Chrabascz on Cultural Resources for the Imperial Valley Solar Project	Cultural	B. Nash-Chrabascz
498-W	5/17/10	Nash-Chrabascz Declaration	Cultural	B. Nash-Chrabascz
498-X		Nash-Chrabascz C.V.	Cultural	B. Nash-Chrabascz
498-Y	5/17/10	Quechan Indian Tribe Comments on Staff Assessment/Draft Environmental Impact Statement, May 17, 2010	Cultural	B. Nash-Chrabascz
498-Z		Comment letters on Draft Programmatic Agreement for Imperial Valley Solar Project from consulting parties	Cultural	B. Nash-Chrabascz
499-A	5/17/10	Rebuttal Testimony of Dr. Christopher Bowles and Christopher Campbell on Behalf of California Unions for Reliable Energy on Soil and Water Resources for the Imperial Valley Solar Project	Soil/Water	Bowles/Campbell
499-B		Bowles/Campbell Declaration	Soil/Water	Bowles/Campbell
499-C	5/15/10	Grismer, M.E., M. Orang, R. Snyder, and R. Matyac. 2002. Pan evaporation to reference evapotranspiration conversion methods. *Journal of Irrigation and Drainage Engineering* 128(3):180-184	Soil/Water	Bowles/Campbell
499-D	4/05	Coleman, MacRae and Stein, Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams, April 2005	Soil/Water	Bowles/Campbell
499-E	5/17/10	Janet Laurain Declaration with comment letter from Center for Biological Diversity of the USACE dated 5/11/10	Soil/Water	Janet M. Laurain

STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

CALIFORNIA UNIONS FOR RELIABLE ENERGY
REVISED TOPIC EXHIBIT LIST

BIOLOGY				
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400	5/10/10	Opening Testimony of Dr. Vernon C. Bleich on Behalf of the California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project	Biology	Vernon C. Bleich
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402		Bleich C.V.	Biology	Vernon C. Bleich
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404	2000	U.S. Fish and Wildlife Service. 2000. Recovery plan for bighorn sheep in the peninsular ranges, California	Biology	Vernon C. Bleich
405	6/17/09	Memo from Guy Wagner to Toni Parr dated 17 June 2009, with a subject line of Solar Two Map PBHS Map.ppt	Biology	Vernon C. Bleich
406	1990	Bleich, V. C., J. D. Wehausen, and S. A. Holl. 1990. Desert-dwelling mountain sheep: conservation implications of a naturally fragmented distribution. Conservation Biology 4:383-390.	Biology	Vernon C. Bleich
407	2007	Epps, C. W., J. D. Wehausen, V. C. Bleich, S. G. Torres, and J. S. Brashares. 2007. Optimizing dispersal and corridor models using landscape genetics. Journal of Applied Ecology 44:714-724.	Biology	Vernon C. Bleich
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409	1996	Bleich, V. C., J. D. Wehausen, R. R. Ramey II, and J. L. Rechel. 1996. Metapopulation theory and mountain sheep: implications for conservation. Pages 353-373 in D. R. McCullough (editor). Metapopulations and wildlife conservation. Island Press, Covelo, California.	Biology	Vernon C. Bleich
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413	2004	Pierce, B. M., R. T. Bowyer, and V. C. Bleich. 2004. Habitat selection by mule deer: forage benefits or risk of predation? Journal of Wildlife Management 68:533-541.	Biology	Vernon C. Bleich
414	1997	Bleich, V. C., R. T. Bowyer, and J. D. Wehausen. 1997. Sexual segregation in mountain sheep: resources or predation? Wildlife Monographs 134:1-50.	Biology	Vernon C. Bleich
415	1994	Andrew, N. G. 1994. Demography and habitat use of desert-dwelling mountain sheep in the East Chocolate Mountains, Imperial County, California. MS Thesis, University of Rhode Island, Kingston, Rhode Island, USA.	Biology	Vernon C. Bleich
416	2005	Marshal, J. P., P. R. Krausman, and V. C. Bleich. 2005. Dynamics of mule deer forage in the Sonoran Desert. Journal of Arid Environments 60:593-609.	Biology	Vernon C. Bleich
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425	1968	Weaver, R. A., J. L. Mensch, and W. V. Fait. 1968. A survey of the California desert bighorn (*Ovis canadensis*) in San Diego County. California Department of Fish and Game, Federal Aid in Wildlife Restoration Project W-51-R-14. Final Report.	Biology	Vernon C. Bleich
426	1978	Hicks, L. L. 1978. The status and distribution of peninsular bighorn sheep in the In-Ko-Pah Mountains, California. USDI Bureau of Land Management, Riverside District, El Centro, California, USA.	Biology	Vernon C. Bleich
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429	5/10/10	Opening Testimony of Scott Cashen on Behalf of the California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project - Figure 1 – Map #1 of MA blockage - Figure 2 – Map #2 of MA blockage - Figure 3 – GOEA nesting habitat - Figure 4 – CDFTL map	Biology	Scott Cashen

		- Figure 5 – Pictures of sensitive communities - Figure 6 – SS plants near Seeley - Figure 7 – Yuha and W. Mesa MAS		
430	5/10/10	Cashen Declaration	Biology	Scott Cashen
431		Cashen C.V.	Biology	Scott Cashen
432		Calico Solar Project SA/DEIS	Biology	Scott Cashen
433		Calico Solar Project. Applicant's response to CURE data request 162	Biology	Scott Cashen
434		Energy Commission Staff's Rebuttal Testimony, Ivanpah Solar Electric Generating System	Biology	Scott Cashen
435		Final Staff Assessment, Ivanpah Solar Electric Generating System	Biology	Scott Cashen
436	3/12/10	Applicant's Comments on the SA/DEIS. Imperial Valley Solar (formerly solar Two) (08-AFC-5)	Biology	Scott Cashen
437	2010	California Native Plant Society (CNPS). 2010. Inventory of Rare and Endangered Plants (online edition, v7-10a). California Native Plant Society. Sacramento, CA	Biology	Scott Cashen
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		Structures by Flat-Tailed Horned Lizards (*Phrynosoma mcallii*), Final Report 594. Arizona Department of Transportation, Phoenix, Arizona		
446	11/29/93	58 Fed. Reg. 62624 (November 29, 1993), Proposed Rule to List Flat-tailed Horned Lizard as Threatened.	Biology	Scott Cashen
447	2000	Okin GS, B Murray, WH Schlesinger. 2000. Degradation of sandy arid shrubland environments: observations, process modelling, and management implications. Journal of Arid Environments Vol. 47, No. 2	Biology	Scott Cashen
448	2006	Bates C. 2006. Burrowing Owl (*Athene cunicularia*). In The Draft Desert Bird Conservation Plan: a strategy for reversing the decline of desert-associated birds in California. California Partners in Flight.	Biology	Scott Cashen
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452	1995	California Department of Fish and Game. 1995. Staff Report on Burrowing Owl Mitigation	Biology	Scott Cashen
453		AFC, Biological Resources, Figure 6	Biology	Scott Cashen
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455		AFC, p. 5.6-9	Biology	Scott Cashen
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462	2003	BRG Consulting, Inc. 2003. Final Mitigated Negative Declaration and Environmental Assessment: Proposed Seeley Water / Wastewater Master Plans	Biology	Scott Cashen
463	2010	US Fish and Wildlife Service. 2010. Species Profile: Yuma clapper rail [internet]. Environmental Online Conservation System.	Biology	Scott Cashen
464	2009	Dudek. 2009. Draft Mitigated Negative Declaration for the Seeley Wastewater Reclamation Facility Improvements, Imperial County, California	Biology	Scott Cashen
465	1975	Gould GI Jr. 1975. Yuma Clapper Rail Study – Census and Habitat Distribution. Wildlife Management Branch Administrative Report No. 75-2. Supported by Federal Aid in Wildlife Restoration Project W-54-R-7, Nongame Wildlife Investigations	Biology	Scott Cashen
466	2006	US Fish and Wildlife Service. 2006. Yuma Clapper Rail 5-Year Review.	Biology	Scott Cashen
467	2006	California Department of Water Resources and California Department of Fish and Game. 2006. Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report.	Biology	Scott Cashen
468	9/23/09	URS Corporation. 2009 Sep 23. Letter from Matt Moore, Project Engineer, to David Dale, Seeley County Water District	Biology	Scott Cashen
469	1/7/10	Imperial Irrigation District. 2010 Jan 7. Comment letter on the Seeley County Water District's Wastewater Reclamation Facility Improvements Project	Biology	Scott Cashen
470	6/09	URS. 2009 Jun. Supplement to SES Solar Two Application for Certification. p. 2.6-1	Biology	Scott Cashen
471	2002	Evans Ogden LJ. 2002. Summary Report on the Bird Friendly Building Program: Effect of Light Reduction on Collision of Migratory Birds. Special Report for the Fatal Light Awareness Program (FLAP). Available at: http://www.flap.org/	Biology	Scott Cashen
472	1994	National Park Service. 1994. Report to Congress: Report on effects of aircraft overflights on the National Park System	Biology	Scott Cashen
473		A. Letter from Sierra Club San Diego Chapter to David Dale, Seeley County Water District, February 2, 2010. B. Salton Sea Authority Website Information, Environmental Issues Around the Sea, accessed online at http://www.saltonsea.ca.gov/environ.htm on 2/2/2010. C. Letter from U.S. Fish and Wildlife Service to Seeley County Water District, February	Biology	Scott Cashen

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475	11/24/09	Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities, State of California, Natural Resources Agency, Department of Fish and Game, November 24, 2009	Biology	Scott Cashen
476		Yuma Clapper Rail, Species Profile, US Fish and Wildlife Service	Biology	Scott Cashen
477	2000	Klem, Preventing Bird-Window Collisions (2000) Wilson Ornithological Society	Biology	Scott Cashen
498-A	5/17/10	Rebuttal Testimony of Scott Cashen on Behalf of California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project	Biology	
498-B		Cashen Declaration	Biology	
498-C		Cashen comment letter to Army Corps	Biology	
498-D		Manci KM, DN Gladwin, R Villella, MG Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. National Ecology Research Center Report # NERC-88/29	Biology	
498-E		ICC Meeting Minutes	Biology	
498-F	2010	Western Regional Climate Center [internet]. 2010. Period of Record Monthly Climate	Biology	

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498-G	2003	Department of Fish and Game. List of California Terrestrial Natural Communities Recognized by The California Natural Diversity Database. September 2003 edition.	Biology	
498-H	2001	Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144	Biology	
498-I		US Gypsum Final EIR/EIS, p. 3.3-42	Biology	
498-J	5/12/10	USEPA letter to USACE (5/12/10) re Public Notice (PN) SPL-2008-01244-MLM for the proposed Imperial Valley Solar Project, Tessera Solar North America, Imperial County, California	Biology	
498-K		Travis Huxman, UA Biosphere 2 and B2 Earthscience, Associate Professor, Ecology and Evolutionary Biology, University of Arizon, Tucson, Arizona: Climate Change and the Sonoran Desert	Biology	
498-L	5/28/09	CURE letter addressed to Christopher Meyer and Jim Stobaugh (5/28/09) re Biological Resource Survey Techniques for the Solar Two Project	Biology	
498-M		Monthly Precipitation, El Centro 2 SSW, California	Biology	
498-N		EPA: Sole Source Aquifer Designations in EPA, Region 9	Biology	
498-O		Ground-Water Resources, Ocotillo-coyote Wells Basin, Calif.	Biology	
498-P		U.S. Geological Survey Water-Resources Investigations 77-30: Digital-Model Evaluation of the Ground-Water Resources in the Ocotillo-Coyote Wells Basin, Imperial County, California	Biology	
498-Q	5/17/20	Rebuttal Testimony of Dr. Vernon C. Bleich on Behalf of California Unions for Reliable Energy on Biological Resources for the Imperial Valley Solar Project	Biology	
498-R		Bleich Declaration	Biology	
498-S	5/13/10	S. Torres email	Biology	
498-T	5/14/10	R. Botta email	Biology	
498-U	5/11/10	Felicia Sirchia email	Biology	

	SOIL/WATER			
478	5/10/10	Opening Testimony of Dr. Chris Bowles and Chris Campbell on Behalf of California Unions for Reliable Energy on Soil and Water Resources for the Imperial Valley Solar Project - Figure 1 – 100-year discharge comparison - Figure 2 – 6-hour temporal rainfall distributions	Soil Water	Chris Bowles Chris Campbell ("Bowles/Campbell")
479	5/7/10	Bowles Declaration	Soil Water	Chris Bowles
480	5/17/10	Campbell Declaration	Soil Water	Chris Campbell
481		Christopher Bowles, Ph.D., C.V.	Soil Water	Chris Bowles
482		Christopher Campbell, M.S., C.V.	Soil Water	Chris Campbell
483	10/2006	California Department of Water Resources, California Department of Fish and Game (October 2006), Salton Sea Ecosystem Restoration Program, Draft Programmatic Environmental Impact Report, Volume I: PEIR, Hydrology chapter	Soil Water	Bowles/Campbell
484	2005	Y.A. Wood, R.C. Graham, S.G. Wells. 2005. Surface control of desert pavement pedologic process and landscape function, Cima Volcanic field, Mojave Desert, California	Soil Water	Bowles/Campbell
485	2008	Julianne J. Miller, Todd G. Caldwell, Michael H. Young, and Graham K. Dalldorf (2008) Verifying Curve Numbers in Arid Environments by Combining Detailed Geomorphic Mapping and Pedotransfer Functions	Soil Water	Bowles/Campbell
486	2009	Young & Chen. (2009) "Soil Heterogeneity and Moisture Distribution Due to Rainfall Events in Vegetated Desert Areas: Potential Impact on Soil Recharge and Ecosystems Annual Report 2009"	Soil Water	Bowles/Campbell
487	2007	Jon D. Pelletier, Michael Cline, Stephen B. DeLong (2007) Desert pavement dynamics: numerical modeling and field-based calibration	Soil Water	Bowles/Campbell
488		An Introduction to Biological Soil Crusts, accessed 5/10/10 at www.soilcrust.org	Soil Water	Bowles/Campbell
489	2005	James R. Angel, Michael A. Palecki, Steven E. Hollinger. (2005) Storm Precipitation in	Soil	Bowles/Campbell

		the United States. Part II: Soil Erosion Characteristics	Water	
490	2004	F. Gonzalez-Bonrino, W.R. Osterkamp (2004) Applying RUSLE 2.0 on burned-forest lands: An appraisal	Soil Water	Bowles/Campbell
491	2009	Li Chen, Jun Yin, Julianne Miller, Michael Young (2009) The Role of the Clast Layer of Desert pavement in Rainfall-Runoff Processes	Soil Water	Bowles/Campbell
492	2006	Peter R. Griffiths, Richard Hereford, Robert H. Webb (2006) Sediment yield and runoff frequency of small drainage basins in the Mojave Desert, U.S.A.	Soil Water	Bowles/Campbell
499-A	5/17/10	Rebuttal Testimony of Dr. Christopher Bowles and Christopher Campbell on Behalf of California Unions for Reliable Energy on Soil and Water Resources for the Imperial Valley Solar Project	Soil/Water	Bowles/Campbell
499-B		Bowles/Campbell Declaration	Soil/Water	Bowles/Campbell
499-C	5/15/10	Grismer, M.E., M. Orang, R. Snyder, and R. Matyac. 2002. Pan evaporation to reference evapotranspiration conversion methods. *Journal of Irrigation and Drainage Engineering* 128(3):180-184	Soil/Water	Bowles/Campbell
499-D	4/05	Coleman, MacRae and Stein, Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams, April 2005	Soil/Water	Bowles/Campbell
499-E	5/17/10	Janet Laurain Declaration with comment letter from Center for Biological Diversity of the USACE dated 5/11/10	Soil/Water	Janet M. Laurain

CULTRURAL				
493	3/26/10	Draft Programmatic Agreement – Imperial Valley Solar Project	Cultural	Janet M. Laurain
494	5/7/09	CURE Comments on the Draft Programmatic Agreement	Cultural	Janet M. Laurain
495		National Register Bulletin, Guidelines for Evaluating and Documenting Historic Aids to Navigation to the National Register of Historic Places	Cultural	Janet M. Laurain
496		Letter from the National Park Service to the Energy Commission and BLM commenting on The Staff Assessment/Draft Environmental Impact Statement	Cultural	Janet M. Laurain
497	5/4/10	Letter from Quechan Indian Tribe, Ft. Yuma Indian Reservation, to Carrie Simmons, Bureau of Land Management commenting on the Draft Programmatic Agreement	Cultural	Janet M. Laurain
498-V	5/17/10	Testimony of Bridget Nash-Chrabascz on Cultural Resources for the Imperial Valley Solar Project	Cultural	B. Nash-Chrabascz
498-W	5/17/10	Nash-Chrabascz Declaration	Cultural	B. Nash-Chrabascz
498-X		Nash-Chrabascz C.V.	Cultural	B. Nash-Chrabascz
498-Y	5/17/10	Quechan Indian Tribe Comments on Staff Assessment/Draft Environmental Impact Statement, May 17, 2010	Cultural	B. Nash-Chrabascz
498-Z		Comment letters on Draft Programmatic Agreement for Imperial Valley Solar Project from consulting parties	Cultural	B. Nash-Chrabascz

498-A

STATE OF CALIFORNIA
California Energy Commission

In the Matter of:	
The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

REBUTTAL TESTIMONY OF SCOTT CASHEN ON BEHALF OF CALIFORNIA UNIONS FOR RELIABLE ENERGY ON BIOLOGICAL RESOURCES FOR THE IMPERIAL VALLEY SOLAR PROJECT

May 17, 2010

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IMPACTS FROM UPGRADES TO THE SEELEY WASTEWATER TREATMENT FACILITY

The applicant has not provided any new testimony from which to evaluate impacts associated with upgrades to the Seeley Wastewater Treatment Facility (SWWTF). It is my professional opinion that the various components of the Imperial Valley Solar Project (including the SWWTF, power generation facilities, and linear features), and the synergistic interactions among the components, would have adverse effects on the health of the Salton Sea watershed. In addition to my opening testimony, I provide a discussion of these adverse effects in my comment letter to the Army Corps that is attached as an exhibit with this rebuttal testimony. I anticipate submitting additional comments once the applicant has submitted its hydrology study and the results of protocol-level plant and animal surveys.

IMPACTS TO THE FLAT-TAILED HORNED LIZARD

Culvert Use

The applicant has testified that movement of flat-tailed horned lizards (FTHL) between the Yuha Desert Management Area (south of I-8) and the Project site is "unlikely as there is only a single culvert that offers potential access, the extended distance through the culvert between these areas, and the lack of access to all the remaining culverts."[1] The applicant's testimony lacks support and contravenes the scientific method:

1. The applicant has not provided any scientific basis to support its conclusion that only a single culvert offers potential access between the Yuha Desert Management Area (MA) and the Project site. Specifically,
    a. The applicant has not provided <u>any</u> data (quantitative or qualitative) to explain what prevents or enables FTHL access to the various culverts that were examined.
    b. The applicant has not referenced a single source of information that provides research on, or otherwise describes, what prevents or enables FTHL access to culverts (or any other feature).
2. The applicant has not provided any scientific basis to support its conclusion that the distance of the culverts makes FTHL movement unlikely. Culvert length is believed to be one of the variables that influences wildlife use. However, the effect of culvert length on FTHL has not been examined. Painter and Ingraldi (2007) studied FTHL use of 40-foot long culverts. Their observations were that: "[d]ark culverts were used more frequently (9 crossings) than culverts with skylights (3 crossings)."[2] Some of the FTHL used for the study were even found lingering inside the dark culvert for several hours before passing all the way

[1] Testimony of Pat Mock, response to question #9.
[2] Painter ML, MF Ingraldi. 2007. Use of Simulated Highway Underpass Crossing Structures by Flat-Tailed Horned Lizards (*Phrynosoma mcallii*), Final Report 594. Arizona Department of Transportation, Phoenix, Arizona. Exhibit 445.

through. This led the researchers to conclude that lizards may use culverts as thermoregulatory microhabitat or hiding cover because they provide vertical structure.[3]

I have reviewed the photographs of the culverts provided by the applicant. Based on those photographs, I have concluded that several of the culverts under I-8 may be accessible to FTHL. Regardless of whether FTHL use the culverts, the applicant's testimony ignores the fact that FTHLs will cross roads, and they currently may do so to access the Project site and move between MAs.

As a result of these issues, it is my professional opinion that the Project continues to pose an unmitigated, significant impact to FTHL movement.

Impacts of Project Noise

The applicant has testified that "[c]onstruction noise will not be an issue for the FTHL as all lizards detected during construction will be translocated off site and they are not considered to be noise sensitive. Mitigation measures BIO 9, BIO 10 and BIO 11 will ensure that impacts to the FTHL are mitigated to a less than significant level."[4]

Once again, the applicant's testimony is misleading and completely lacks any scientific basis. First, it fails to acknowledge the undisputed fact that FTHL are notoriously hard to detect. As a result, some FTHL will remain on the site despite the translocation effort. The lizards that remain on the site will be subject to noise and many other threats (e.g., ground disturbance).

Second, the statement that FTHL are "not considered to be noise sensitive" is nothing more than a vague (e.g., *who* considers them insensitive to noise?) and untested claim. Notably, the applicant did not submit any evidence to support the claim that FTHL are not considered to be noise sensitive. Studies have shown that certain desert reptiles **are sensitive** to low-intensity sound.[5] Bondello et al. (1979) tested the effects of dune buggy sounds on the hearing of Mojave fringe-toed lizards.[6] All noise-exposed lizards suffered actual hearing loss after exposure to 510 seconds of 95-dB dune buggy sounds. Surprisingly, the lizards appeared to be vulnerable to noise-induced hearing loss even when buried beneath shallow layers of sand.

According to the Flat-tailed Horned Lizard Rangewide Management Strategy (RMS), it is not known whether noise at levels and durations anticipated in the desert negatively impact FTHLs.[7] However, the RMS concluded effects are more likely where prolonged,

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[3] *Id.*

[4] Testimony of Pat Mock, response to question #9.

[5] Manci KM, DN Gladwin, R Villella, MG Cavendish. 1988. Effects of aircraft noise and sonic booms on domestic animals and wildlife: a literature synthesis. National Ecology Research Center Report # NERC-88/29.

[6] Bondello MC, AC Huntley, HB Cohen, BH Brattstrom. 1979. *In Id.*

[7] Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices. p. 14. Exhibit 440.

loud noise occurs (such as the noise generated by the 30,000 SunCatchers).

Third, the applicant's testimony ignores the adverse effects Project noise may have on FTHL outside of the Project boundaries. Adverse effects of noise on FTHL in areas directly surrounding the Project site should be analyzed and mitigated.

Lastly, the applicant's testimony ignores the noise generated by Project operation and maintenance activities. For example, in the Calico Solar Project proceeding, Energy Commission staff concluded noise from the SunCatchers would limit, and in some cases preclude, the use of habitat (for wildlife in general) adjacent to the project site.[8] The same conclusion should be reached here. The applicant has proffered no evidence to suggest otherwise.

Mitigation

The applicant has testified that FTHL mitigation consists of 1:1 for onsite habitat acreage impacts and 5:1 for impacts within the Yuha Desert MA. The applicant further testifies that the mitigation for impacts to FTHL is consistent with the agency approved management strategy.[9] The applicant's testimony is potentially misleading for the following reasons:

1. The applicant's compensatory mitigation consists of a fee payment to the Bureau of Land Management. Provision of the fee does not guarantee Project impacts to FTHL habitat will be offset (I discussed this issue in my opening testimony). Members of the Interagency Coordinating Committee, which oversees implementation of the FTHL Rangewide Management Strategy, have expressed concerns over the limited availability of private land for habitat acquisition, and the purchasing power of compensation funds over time (i.e., the lag time between when money is received and spent).[10]
2. The agency approved management strategy requires the applicant to mitigate or compensate for indirect impacts, impacts the applicant's proposed mitigation generally ignores. The "agency approved management strategy" is the FTHL Rangewide Management Strategy (RMS). The RMS provides "[i]f these and other adverse indirect effects (e.g., habitat fragmentation, decreased FTHL density near roads) cannot be mitigated (with FTHL barriers or corridors, for e.g.), <u>compensation for indirect effects will be required</u>."[11] As discussed in my opening testimony, the applicant has not properly mitigated the indirect impacts of the Project. Indirect impacts, such as those that would result from the Project, are known to have a significant adverse effect on FTHL. Because the applicant has made few attempts to mitigate the Project's indirect impacts, the proposed mitigation should not be considered consistent with the RMS.

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[8] Calico Solar SA/DEIS, p. C.2-84, 85.
[9] Supplemental testimony of Patrick Mock, response to question #10.
[10] ICC Meeting Minutes.
[11] [emphasis added] Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices. p. 64. Exhibit 440.

SPECIAL-STATUS PLANT SPECIES

Need for Fall Surveys

I concur with the Energy Commission and Bureau of Land Management's conclusion that fall surveys are necessary to assess the presence of special-status plant species within the Project area. My conclusion is based on:

1. Consultations with several botanical experts with particular knowledge of the Desert Floristic Province (e.g., Dr. Jim Andre,[12] Dr. Bruce Pavlik,[13] and Greg Suba[14]).
2. Review of natural history information associated with various plant species known to occur in the Project region.
3. Review of historic rainfall data from rain gauges located both east (El Centro) and west (Ocotillo 2 and Coyote Wells) of the Project site.

In rebuttal and supplemental testimony, the applicant states it does not believe fall surveys are necessary.[15] This conclusion is based on a number of unsupported statements and inaccurate data. The applicant provides almost no scientific evidence to support this position. Furthermore, the applicant's rationale supports the need for additional plant surveys. In the subsequent sections I provide a review of the assertions that the applicant used to support the conclusion that fall surveys are unnecessary.

RAINFALL DATA

The applicant testified that "[f]all rains were 70% of normal in 2007 and 1% of normal in 2008."[16] This testimony by the applicant is not accurate. Rainfall data provided by the applicant were collected at the "El Centro 2 SSW" station, and were obtained from the Western Regional Climate Center.[17] The data (Table 1) do not support the applicant's statement.[18] For the El Centro station, they indicate: (a) above average rainfall in September and November 2007, and July and August 2008; (b) above average fall rainfall in 2007; and (c) missing data from which to assess October, November, and total fall rainfall in 2008.

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[12] Director of the Sweeney Granite Mountains Desert Research Center for the University of California.
[13] Professor of Biology and Gibbons-Young Chair for the Advancement of Science, Mills College.
[14] Conservation Director for the California Native Plant Society.
[15] Testimony of Pat Mock, response to question #3.
[16] *Id.*
[17] Applicant's response to CURE data request 34. Applicant's exhibit #13.
[18] Western Regional Climate Center [internet]. 2010. Period of Record Monthly Climate Summary, El Centro 2 SSW, California. Available at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2713.

Table 1. Inches and mean percent of precipitation recorded at the El Centro 2 SSW station. Months with above average precipitation are shaded gray.						
	Jul	Aug	Sep	Oct	Nov	Total
2007	0.00 (0.0)	0.14 (0.42)	0.37 (1.37)	0.00 (0.0)	1.03 (5.72)	1.54 (1.36)
2008	0.12 (1.5)	0.47 (1.42)	0.06 (0.22)	N/A	N/A	N/A
Mean[a]	*0.08*	*0.33*	*0.27*	*0.27*	*0.18*	*1.13*

[a] From years 1932-2009.

POSSIBLE FALL SPECIES

The applicant testified: "[a]s suggested by Joy Nishida of the CEC, only 2 summer/fall flowering special-status species are known from Imperial County."[19] The applicant provides nothing to substantiate this claim. In the SA, Joy Nishida testified "many ephemerals bloom after the summer monsoonal rains in the desert so the documentation of the occurrence of *many* additional plant species may be lacking."[20] Moreover, the lack of data about a species in the region "should not be used as verification that the species does not exist in a given location."[21] This is explicitly stated in the Bureau of Land Management (BLM) plant survey protocol, which applies to the Project.

DETECTABILITY DURING THE SPRING

The applicant testified that desert unicorn-plant...as a perennial... would have been recognizable during the prior surveys.[22] The applicant's testimony is refuted by its own survey results. Desert unicorn-plant is a perennial herb. Of the five special-status plant species that have been newly detected during the applicant's 2010 surveys, two are perennial herbs and one is a perennial shrub.[23] Yet, these species were apparently not "recognizable" during the applicant's prior (i.e., 2007 and 2008) surveys.

When asked if he had an opinion as to why special-status plant species were identified in 2010 but not during the two previous surveys, Michael Wood testified that it was because the 2009-2010 winter rainy season ended a severe three-year drought.[24] However, Mr. Wood's testimony conflicts with the applicant's previous statement that "[l]arge scrub/tree species like crucifixion thorn would likely have been detected regardless of

[19] Testimony of Michael Wood, response to question #7.
[20] SA/DEIS, p. C.2-20. [emphasis added].
[21] Bureau of Land Management. 2009. Survey Protocols Required for NEPA/ESA Compliance for BLM Special Status Plant Species. Exhibit 439.
[22] Testimony of Michael Wood, response to question #7.
[23] Testimony of Michael Wood, response to question #3.
[24] Testimony of Michael Wood, response to question #4.

rainfall conditions."[25] Crucifixion thorn is morphologically similar to Wiggin's croton, which was detected in 2010 but not 2007 or 2008.

RECENT ADDITIONS TO THE CNDDB

The applicant testified that four species were added to the California Natural Diversity Database (CNDDB) vicinity list after the 2008 surveys: chaparral sand verbena, pink fairy duster, Thurber's pilostyles and dwarf germander. This testimony only supports the position that the applicant should not rely on a preconceived list of target species to define the parameters of the survey (e.g., determine what species to look for and when to survey). Instead, the survey parameters should be defined by the environmental conditions (e.g., rainfall) that affect plant detection.

THRESHOLD FOR NEED

Project botanist Michael Wood testified: "[i]n my experience, it seems like an extraordinary requirement to complete fall surveys for a single species whose likelihood of being present onsite is moderate."[26]

First, I believe the applicant has sufficiently demonstrated that it does not have a lot of skill in predicting likelihood of plant occurrence. The applicant's comments on the SA/DEIS said the following about Wiggin's croton:

> The reported nearby sighting of *Croton wigginsii* has been withdrawn by BLM staff. *Croton wigginsii* is not known within 10 miles of the site. Croton shrubs if present would have been detectable and probably identifiable at the time of the surveys. In addition, this particular plant is found in sand dune habitat, a habitat type that is relatively rare within the site. Just stating "suitable habitat occurs on the project site" implies that all or most of the site contains suitable habitat. This is important because a question that can potentially arise is the feasibility of Mitigation Measure BIO-19, which heavily relies on new surveys and subsequent avoidance if sensitive plants are found.[27]

The applicant then went on to recommend Wiggin's croton be **completely deleted** from the SA/DEIS's list of potentially occurring special-status species.[28] Seven Wiggin's croton plants were recently detected during the applicant's 2010 surveys.

Second, fall surveys would still be required even *if* only one species had the potential to occur. According to the BLM plant survey protocol:

> Inventories must be timed so that contractors can both locate and positively identify target plant species in the field. Inventories must be scheduled so that they will detect all special status species present. A single inventory on a single

[25] Applicant's comments on the SA/DEIS, p. 17. Applicant's exhibit #28.
[26] Testimony of Michael Wood, response to question #7.
[27] Applicant's comments on the SA/DEIS, p. 17. Applicant's exhibit #28.
[28] Applicant's comments on the SA/DEIS, p. 18. Applicant's exhibit #28.

date will seldom suffice. For example, when one special status plant species suspected to be in the inventory can only be found and identified in April and another species can only be located and identified in August, at least two inventories are necessary. The first inventory can facilitate the second and/or third inventory, however, if potential sites for the late-flowering species are flagged during the first inventory.

Therefore, the protocol has made it very clear that inventories are required even if only one special-status plant species is suspected.

Quality of Prior Plant Surveys

The applicant continues to argue that its botanical surveys were consistent with agency guidelines in force at the time of the survey effort.[29] The applicant's argument has absolutely no validity. Table 2 provides a comparison of the applicant's plant surveys with the 2000 California Department of Fish and Game (CDFG) plant survey guidelines.

Table 2. Comparison of applicant's surveys with CDFG protocol guidelines.

CDFG survey guidelines (2000)	Applicant's plant surveys
Surveyors should possess experience conducting floristic field surveys, knowledge of plant taxonomy, and familiarity with special-status species that occur in the region being surveyed.	Based on their resumes, many of the surveyors did not meet this requirement. It appears several surveyors had no prior botanical survey experience.[30]
Surveys should be conducted when rare plants are evident and identifiable. Sufficient number of visits spaced throughout the growing season.	Debatable and unknown (due to lack of reference sites). Limited spring survey window during below average rainfall years. No fall surveys.
Surveyors should visit reference sites.	Not done.[31]
Surveys should be conducted using systematic field techniques.	Not done. Meandering transects do not constitute a systematic technique.[32]
Every plant observed should be identified to the extent necessary to determine its rarity and listing status.	Not done. Applicant reported *Lepidium* sp., *Mentzelia* sp., *Camissonia* sp., and *Astragalus* sp.[33] All of these genera have species that are listed as special-status.

[29] Testimony of Pat Mock, response to question #3.
[30] *See* Supplemental Information in Response to CEC Data Adequacy Requests and BLM Minimum Requirement Comments dated September 2008. Applicant's exhibit #6.
[31] Applicant's response to CURE data request #144. Applicant's exhibit #17.
[32] Applicant's response to CURE data request #31. Applicant's exhibit #13.
[33] *See* Application for Certification, Vol. II, Attachment B of Biology Technical Report. Applicant's exhibit #1.

EIRs and EIS should provide a detailed description of survey methodology.	Not provided. Survey methods were reported as: "[s]pecial-status plant surveys were conducted in 2007 and 2008 during the months of March and May to maximize the probability of detection of blooming annuals. Special-status plant surveys were conducted either concurrently with vegetation habitat surveys, or as focused species surveys during appropriate blooming periods, throughout the Project Site and along the off-site transmission line and waterline."[34]
Report total person-hours spent on field surveys.	Hours for 2007 surveys were never provided. Hours for 2008 were provided after two rounds of data requests by CURE.[35]
Report persons contacted, herbaria visited.	None reported.

Energy Commission staff has agreed that the applicant's surveys were not done properly, and thus were inadequate to document occurrence of special-status plant species. It was on that basis that fall surveys were requested by staff. Fall surveys are needed and should be conducted. I reserve the right to provide additional testimony once these surveys are completed and the results have been provided in a report that meets the minimum standards established by the protocols.

Mitigation for Impacts to Special-Status Plant Species

In supplemental testimony, the applicant states "**[m]aintaining sustainable populations [of plants] on the project is not practicable** given the sensitivity status of the species, the small numbers present, and their distribution within the project boundaries. Offsite habitat mitigation for FTHL will also benefit rare plant resources in the project vicinity."[36] The applicant's supplemental testimony is extremely important: it demonstrates that the applicant is unable or unwilling to comply both with the mitigation *strategy* and *conditions* set forth in the SA/DEIS. Condition of Certification BIO-19 requires the applicant to protect "any populations of listed plant species identified during the surveys."[37] Wiggin's croton, which was recently detected on the site, is listed as Rare by the State of California.[38]

The applicant has no scientific basis to conclude mitigation for FTHL will also benefit rare plant resources in the project vicinity. First, the SA/DEIS enables compensation lands to be "poor quality habitat";[39] and/or compensation funds to be applied to other purposes besides land acquisition (e.g., educational purposes or management actions).[40]

[34] Application for Certification, Vol. I, p. 5.6-6. Applicant's exhibit #1.
[35] *See* Applicant's response to CURE data request #151. Applicant's exhibit #17.
[36] Supplemental testimony of Patrick Mock, response to question #11.
[37] SA/DEIS, p. C.2-98.
[38] Testimony of Michael Wood, response to question #3.
[39] *Id.*
[40] SA/DEIS, p. C.2-42.

Second, lands targeted for acquisition are supposed to be within the nearest FTHL MA.[41] This would be either the Yuha Desert or West Mesa MA. However, based on database records from the CNDDB and Consortium of California Herbaria, the special-status plant species that occur on the Project site do not occur in either the Yuha Desert or West Mesa MA (Figures 1-3).[42] [43]

When asked how the recent detection of five different special-status plant species affected his conclusion on the Project's potential impacts and mitigation, Patrick Mock testified that "given the level of habitat conservation in the project vicinity (Anza Borego [*sic*] State Park, BLM Management Areas), it is *likely* that these sensitive species are adequately conserved offsite."[44]

In my opinion, Dr. Mock's testimony demonstrates that the applicant has not made any real attempt to assess Project impacts and mitigation for special status plants species. Besides failing to provide anything to substantiate that the species *are* adequately conserved offsite, Dr. Mock's testimony failed to convey the local or regional significance his findings.[45] In that regard, occurrence records from the CNDDB and Consortium of California Herbaria reveal the following:

- The Project site represents the westernmost range of Wiggin's croton. The next nearest occurrence is approximately 42 miles to the east (Figure 2). In addition, development in the Imperial Valley isolates the population on the Project site from all other known occurrences (Figure 4).
- The population of brown turbans on the Project site represents the southernmost and easternmost known population of the species in California (Figure 2).
- The population of Utah vine milkweed on the Project site represents the southernmost known population of the species in California (Figure 3).

Peripheral populations, such as these, are important for the long-term conservation of genetic diversity and evolutionary potential, especially when considering the need to adapt to future climate change. Dr. Mock cannot simply presume the responsibility to mitigate Project impacts will be borne by some other entity.

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[41] SA/DEIS, p. C.2-85.
[42] Data provided by the participants of the Consortium of California Herbaria (ucjeps.berkeley.edu/consortium/).
[43] California Natural Diversity Database. 2009. Rarefind [computer program]. Version 3.1.0. Mar 2, 2010. Sacramento (CA): Wildlife & Habitat Data Analysis Branch. California Department of Fish and Game.
[44] Supplemental testimony of Patrick Mock, response to question #6. [emphasis added].
[45] CEQA §15125 (c).

Map 1. Management areas of the Flat-tailed Horned Lizard (*Phrynosoma mcallii*) in relation to the Solar Two project site.

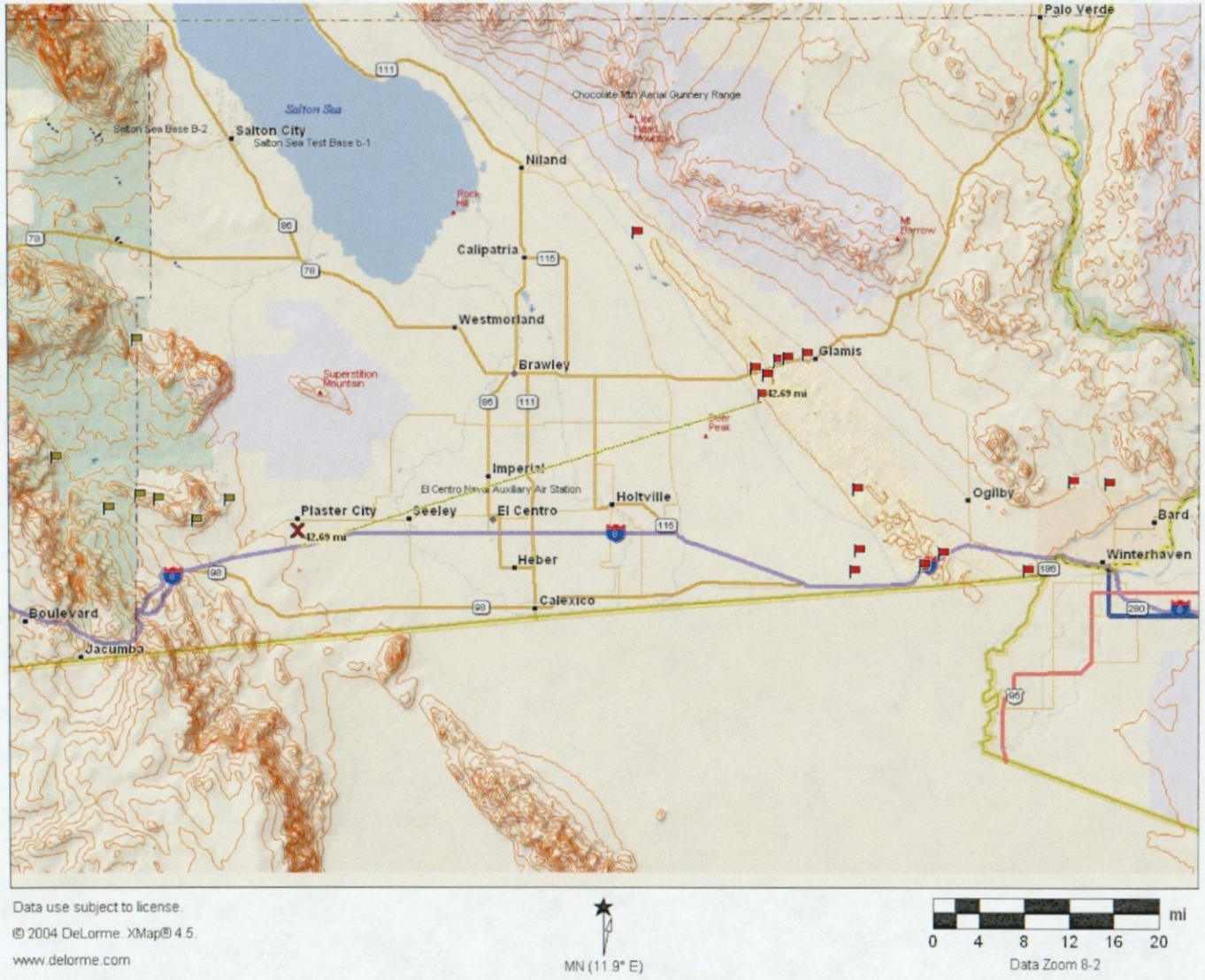

Figure 2. Known occurrences of brown turbans (copper flags) and Wiggin's croton (red flags) in the Project vicinity.

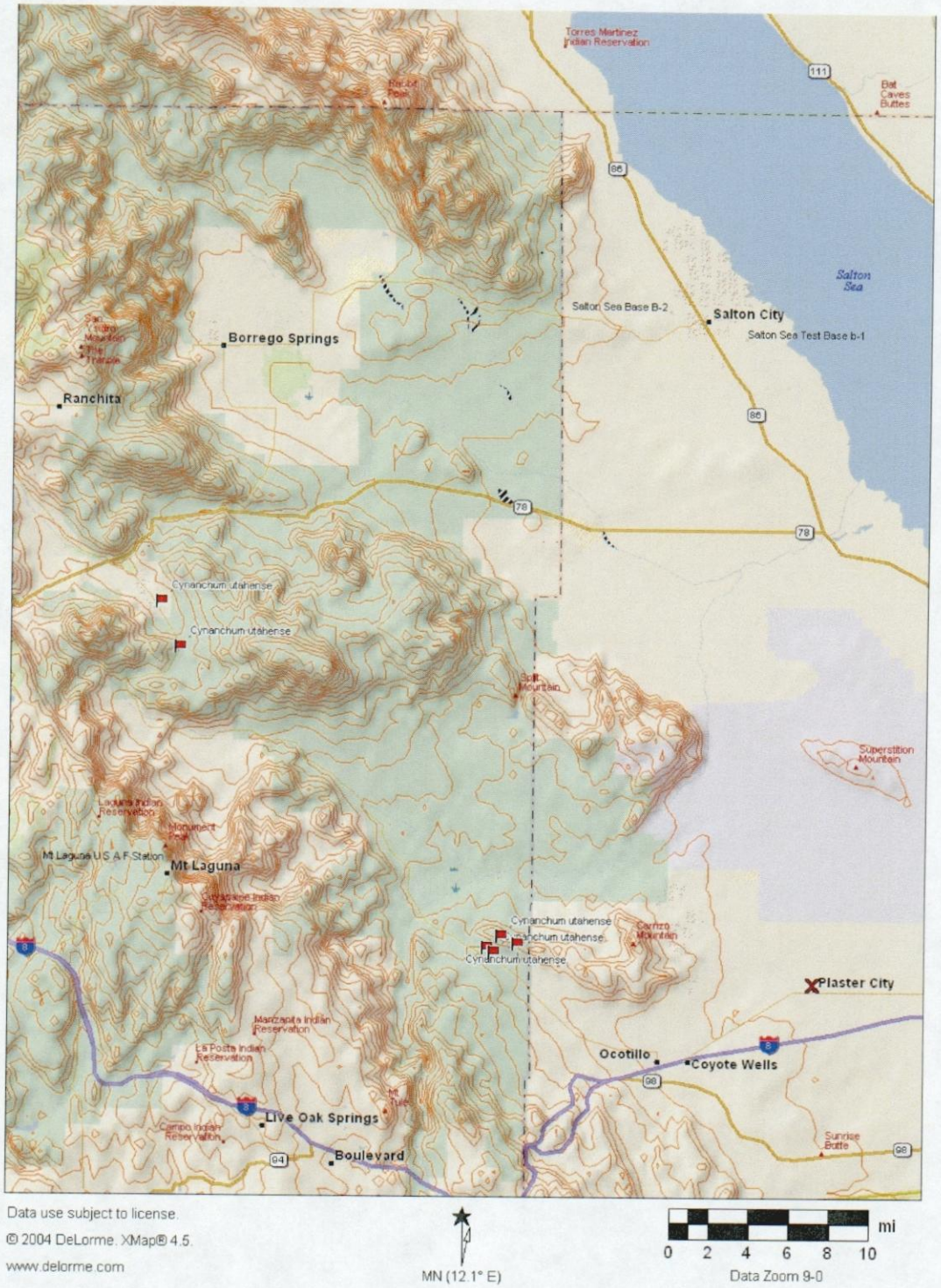

Figure 3. Known occurrences of Utah vine milkweed in the Project vicinity.

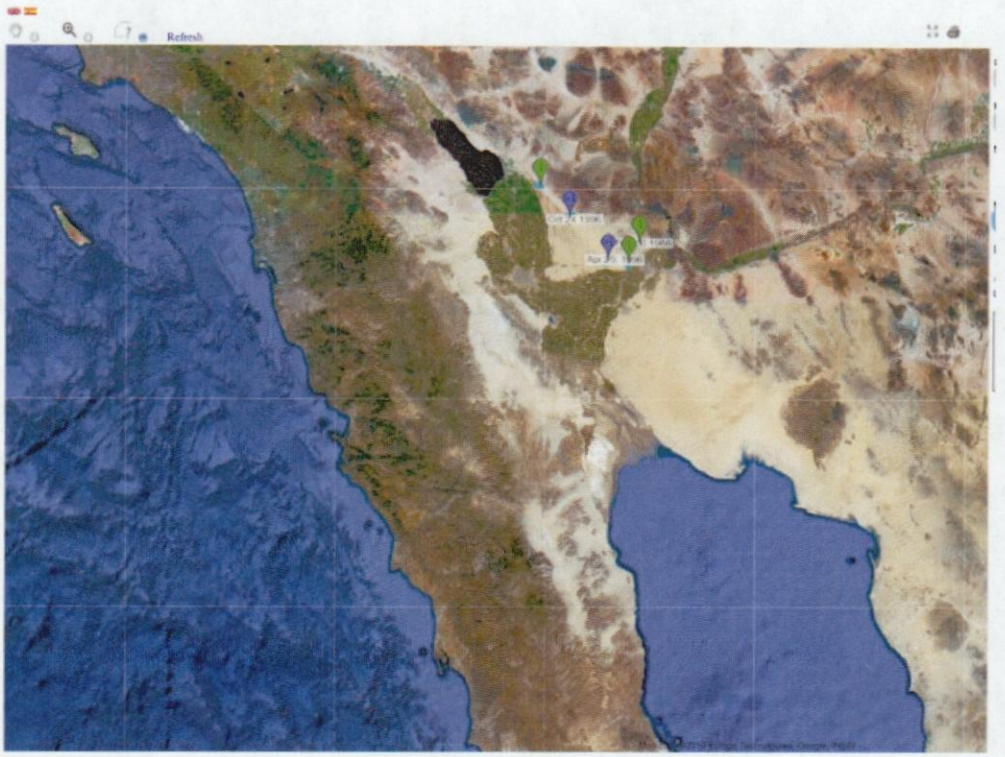

Figure 4. Occurrences of Wiggin's croton documented since 1985 (excluding recent occurrence on the Project site).[46]

[46] Data provided by the participants of the Consortium of California Herbaria (ucjeps.berkeley.edu/consortium/).

QUALITY OF BIOLOGICAL RESOURCE SURVEYS

a. Agency Approval of Applicant's Surveys

The applicant's supplemental testimony concluded that the surveys performed for the Project adhered to either approved protocols or modified protocols that were approved in advance by the agencies.[47] The applicant's testimony is misleading. First, the applicant **only** attempted protocol (or focused) surveys for rare plants and FTHL.[48] The applicant relied on **incidental observations** to document all other sensitive wildlife species.[49] With respect to the burrowing owl, failure to implement the recommended survey guidelines is a violation of CEC Siting Guidelines. Second, the applicant's surveys did not follow protocol as suggested by the applicant (see prior discussion of applicant's plant surveys, and information provided in a letter that I submitted to the California Energy Commission and Bureau of Land Management. This letter is attached as an exhibit with this rebuttal testimony).

b. Surveyor Experience

The applicant has testified that "[i]n all cases the individuals performing the surveys either had or were under the direct oversight of [an] individual that had appropriate training and levels of experience to perform the surveys."[50] This statement lacks credibility. Based on the resumes provided by the applicant: (a) none of the FTHL surveyors had any prior experience conducting surveys for the species; and (b) many of the individuals used for plant surveys had a very limited amount of prior training and experience.[51] [52]

IMPACTS TO GOLDEN EAGLE

The applicant has testified that "[t]here are no known golden eagle nesting areas within 10 miles of the site, so the site is consider [*sic*] potential foraging habitat for raptor species such as eagles, but no effects to nesting eagles is expected."[53] The applicant's testimony is misleading. The lack of data should not be used as verification that a species does not exist in a given location, especially because the applicant made no attempt to document golden eagle nest sites. Identifying golden eagle nests generally entails helicopter surveys. The applicant did not conduct these surveys, or any other activities directed at identifying Project impacts to golden eagles. In addition, the applicant has provided no indication that it attempted to obtain data that may be available from helicopter surveys conducted by SDGE (in support of the Sunrise Powerlink).

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[47] Supplemental testimony of Patrick Mock, response to question #4.
[48] Applicant's response to CURE data request 83. Applicant's exhibit #13.
[49] AFC, p. 5.6-6. Applicant's exhibit #1.
[50] Supplemental testimony of Patrick Mock, response to question #4.
[51] Data adequacy supplement. Applicant's exhibit #6.
[52] *See* Applicant's response to CURE data requests # 150, 149, 151. Applicant's exhibit #17.
[53] Supplemental testimony of Patrick Mock, response to question #12.

The applicant identifies the Project site as potential foraging habitat for golden eagles. The SA/DEIS concluded the potential loss of foraging habitat for golden eagles may require a permit for take under the Bald and Golden Eagle Protection Act.[54] However, neither the applicant nor the SA/DEIS have provided any mitigation for loss of golden eagle foraging habitat. As a result, it remains a potentially significant, unmitigated Project impact.

DESERT KIT FOX AND AMERICAN BADGER

The applicant has testified that the desert kit fox is not listed as a protected species, and that the State definition of "take" is not applicable.[55] I recognize the protection afforded desert kit fox is a confusing issue for many project proponents. However, Title 14, Section 460 of California Code states: "[f]isher, marten, river otter, *desert kit fox* and red fox may not be *taken* at any time."[56] At a recent Staff Assessment workshop held for the Genesis Solar Project, Magdalena Rodriguez, Environmental Scientist for the California Department of Fish and Game, confirmed that the regulation applies to <u>any</u> activities that may cause take of desert kit fox.

For the American badger, the applicant states the badger's designation as a California Species of Special Concern carries no formal legal status.[57] CEQA guidelines direct lead agencies to consider whether a project would "[h]ave a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or *special status species* in local or regional plans, policies, or regulations, or *by the California Department of Fish and Game* or U.S. Fish and Wildlife Service."[58]

Regarding impact avoidance and mitigation, the applicant has testified that Condition of Certification BIO-15 reduces the potential for mortality to desert kit fox, and that passive removal will be sufficient to protect badgers.[59] I do not believe this issue has been fully addressed, particularly with respect to fencing and the roadways. The entire Project site would be surrounded by a fence that would prevent ingress and egress of most wildlife. The key segments of the perimeter fence are likely to be installed during early phases of construction to establish site control and security.[60] In testifying that badgers are not likely to remain on the site during construction due to increased human activity, the applicant suggests badgers (and presumably kit fox) will be present onsite when construction begins, at which time they will be forced to flee. However, it appears once construction begins, the perimeter fence will be in place and badgers and kit fox will be trapped within the construction zone.

Irrespective of Project fencing, roads surround the Project site. These include I-8, which is a heavily traveled. Badgers, kit fox, and other wildlife that are forced (or encouraged)

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[54] SA/DEIS, p. C.2-57.
[55] Testimony of Pat Mock, response to question #10.
[56] [emphasis added].
[57] Testimony of Pat Mock, response to question #10.
[58] CEQA Appendix G: Environmental Checklist Form. [emphasis added].
[59] Testimony of Pat Mock, response to question #10 and #11.
[60] Applicant's response to CURE data request #91. Applicant's exhibit #13.

to leave the site will have to cross at least one roadway, where they will be subject to collisions with vehicles. Animal-vehicle collisions are known to be a serious hazard to wildlife, and people.

Neither the applicant nor the SA/DEIS has analyzed or mitigated these potentially significant impacts to desert kit fox, badger, and public safety.

SENSITIVE NATURAL COMMUNITIES

The California Department of Fish and Game has identified vegetation series or associations that are considered rare and worthy of consideration by CNDDB.[61] CEQA guidelines direct lead agencies to consider whether a project would "[h]ave a substantial adverse effect on any riparian habitat *or other sensitive natural community identified* in local or regional plans, policies, regulations or *by the California Department of Fish and Game* or US Fish and Wildlife Service."[62]

The applicant has indicated that no sensitive natural communities are present within the Project study area.[63] This contradicts anecdotal reports issued by members of the public who have visited the site. As a result, I had a six-person field crew investigate the site to document whether any sensitive natural communities were present. The field crew spent the entire day of 9 May 2009 on the Project site, during which time they documented the following sensitive natural communities or associations (Table 3):

Table 3. Sensitive natural communities/associations present on the Project site.

Community/Association	Location (UTM zone 11S)
Smoketree Wash Woodland	Approximately 50m long centered at 602791 3624582
Smoketree Wash Woodland	Extending 250 m from 602861 3624208
Creosote Bush- Big Galleta	602303 3626641
Creosote Bush-White Bursage-Indigo Bush	603050 3625071
Creosote Bush-White Ratteny-Big Galleta	603008 3625809
Creosote Bush-White Ratteny-Big Galleta	601182 3625697
Creosote Bush-White Ratteny-Big Galleta	601219 3625673 to 601355 3625534
White Bursage-Big Galleta	601592 3625452 to 601639 3625395
White Bursage-Big Galleta	601623 3625355
White Bursage-Big Galleta	606439 3626475
Creosote Bush-White Ratteny-Big Galleta *and* White-Bursage-Big Galleta	601337 3625165
Creosote Bush-Big Galleta *and* White Bursage-Big Galleta	606173 3626408
Mesquite Woodland	606581 3626385

[61] Department of Fish and Game. List of California Terrestrial Natural Communities Recognized by The California Natural Diversity Database. September 2003 edition.
[62] CEQA Appendix G: Environmental Checklist Form. [emphasis added].
[63] Application for Certification, Vol. I, p. 5.6-9. Applicant's exhibit #1.

Creosote Bush-White Bursage - Cryptogrammic crust	Various locations throughout.

The field crew did not have time to examine the entire Project site. Therefore, additional sensitive natural communities may be present, and the information I have presented should not be used to evaluate the abundance of sensitive communities/associations. However, it provides evidence that the applicant and SA/DEIS have not provided full disclosure of relevant environmental information, including the impacts of the Project on sensitive natural communities. Without this information, neither the Commission nor the public has any understanding of the impacts of the Project on sensitive natural communities. In my opinion, these impacts are potentially significant and unmitigated.

Cryptobiotic Soil Crusts

Cryptobiotic (or cryptogrammic) soil crusts are communities of cyanobacteria, lichens, and mosses. These crusts bind fine soil particles by linked cyanobacterial fibres, which protect the soil from wind erosion. Several studies have suggested that the presence of cryptobiotic crusts dramatically decreases wind and water erosion.[64] When disturbed, cryptobiotic crusts lose most of their protective qualities allowing mobilization of the underlying mineral soils.[65]

Once the desert crust or pavement is removed (or damaged), sand may be blown several kilometers downwind, resulting in an area of indirect disturbance that can exceed the directly disturbed area by several-fold. For example, Okin et al. (2001) reported that 3,000 ha of land directly disturbed would be expected to indirectly disturb an additional 3,000 to 9,000 ha of land. The encroachment of blowing sand into adjacent shrublands has dramatic consequences for the landscape. Field observations indicate that blowing sand abrades plants, resulting in leaf stripping and damage to the cambium and therefore to the plant's ability to distribute and use water. Young plants are especially vulnerable to the effect of blowing sand as they lack woody tissue. This results in the suppression of revegetation in bare areas and the loss of vegetation on adjacent lands. Nitrogen-fixing microbial communities and cryptobiotic crusts are buried by sand, reducing inputs of nitrogen to the soil (Belnap *et al.*, 1993; Evans & Belnap, 1999).

The Project would involve site grading for roadways and foundations, the removal of topographic undulations, and within channels to "improve" hydraulics. Site grading will destroy vegetation. In addition, the Project would involve brush trimming between every other row of SunCatchers (i.e., the power generation units) and trenching for underground piping and infrastructure. Schlesinger and Pilmanis (1998) have reviewed field experiments in which shrubs have been removed by cutting, herbicides, or fire. These studies show variable rates of soil degradation, but in each case, "a loss of the local biogeochemical cycle associated with shrubs has allowed physical processes to disperse

[64] Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144. Exhibit #447.
[65] *Id.*

soil nutrients across the landscape." Thus, the progressive reduction in fertility acts in tandem with the mechanical action of sand to further decrease shrub cover, which, in turn, increases the susceptibility of the land to wind and water erosion. The permanent removal of suspension-sized particles from the soil by erosion results in a change of the soil texture, which may also reduce soil-binding properties, resulting in increased erodibility. Whether by wind or water, the fine particles and soil organic matter that are removed by erosion are key to the healthy functioning of soils because they increase soil nutrient content, soil porosity, water-holding capacity, and cation-exchange capacity. Because new vegetation growth is inhibited by blowing sand, the ability of vegetation to stem erosion is limited. This results in a negative feedback loop that ultimately results in severe land degradation.

PROJECT WATER SUPPLY

On 6 May 2010 the applicant docketed a supplement to the AFC. The supplement contains hundreds of pages of analysis of environmental impacts pertaining to the use of water from the Dan Boyer Water Company. Because the material was only recently submitted, and because its submittal coincided with preparation of rebuttal testimony, we have not yet had the opportunity to fully assess it. However, I have made the following preliminary observations of the applicant's analyses:

1. The Project would require approximately 50 acre-feet per year (afy) during construction.[66] [67] Construction is expected to last 39 to 40 months.[68] However, the Dan Boyer Water Company operates a well that is restricted to 40 afy.[69] The applicant has not explained how it will meet the demand of 50 afy with a supply of 40 afy.
2. The Dan Boyer Water Company draws water from a "sole source aquifer." Designation as a sole source aquifer provides the EPA with the authority to review federal financially assisted projects planned for the area to determine their potential for contaminating the aquifer.[70] However, neither the applicant, nor the SA/DEIS, has discussed if and when the EPA review would occur.
3. According to the applicant, "[t]he Project would not introduce any contaminants into the aquifer, and an aquifer test performed for this well indicates that pumping of the well at the prescribed rates will have no significant impact on water levels and water quality in the area, as the zone of influence (ZOI) is considerably less than the distance to the closest well, approximately 500 feet away."[71] These conclusions appear to conflict with those provided in the Draft Environmental Impact Report (DEIR) conducted for the US Gypsum (USG) expansion project. Specifically, the DEIR concluded:

[66] Rebuttal testimony of Matt Moore.
[67] SA/DEIS, p. C.7-15.
[68] *Id.* and Rebuttal Testimony of Matt Moore.
[69] Supplement to the AFC, p. 1-2. Applicant's exhibit #32.
[70] Supplement to AFC, p. 2-3. Applicant's exhibit #32.
[71] *Id.*

a. Increased pumping from USG wells could degrade water quality in individual wells due to lateral migration of higher TDS water located to the east of Coyote Wells, lateral migration of higher TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin. This impact was considered significant.

b. Increased pumping of USG wells could reduce water levels throughout broad areas of the Ocotillo/Coyote Wells Basin, reducing the total amount of water available in the basin. This was considered a significant, unavoidable, and unmitigable impact on the Basin-wide groundwater.

c. Increased pumping of USG wells and the additional commercial pumping from the *Westwind well* (i.e., the Dan Boyer well) could reduce water levels, increasing the cost of pumping groundwater, causing some wells to go dry, and reducing the amount of available water in the Groundwater Basin. The combined effects of the Proposed Action and the proposed additional pumping from the *Westwind well* have the potential to cause cumulative impacts on water levels and water quality in the Groundwater Basin. The impact was considered significant, and the conclusion was made even though the modeling conducted for the DEIR assumed the Dan Boyer well would pump less water than has been proposed by the applicant (i.e., 40 afy).[72]

d. Increased pumping of USG wells and the additional commercial pumping from the *Westwind well* could degrade water quality due to lateral migration of higher TDS water located to the east of Coyote Wells, lateral migration of higher TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the Groundwater Basin. The Proposed Action could result in a significant impact on water quality in the Groundwater Basin. The cumulative impact of the additional commercial pumping (i.e., pumping of the Dan Boyer well) has the potential to further exacerbate this impact.

4. The applicant has testified that "[i]t was determined that it [Dan Boyer water] is a reliable water source and would not result in significant impacts if used for the life of the Project, if needed."[73] However, the applicant did not analyze the impacts associated with using the water for the life of the Project, but instead assumed that the Project would require water from the Dan Boyer Water Company for approximately six months to three years.[74] Further, the applicant does not have a contractual agreement to purchase water; the "will serve letter" provided in the AFC supplement only provides an option to purchase water

[72] US Gypsum DEIR, p. 3.3-106, provided in Supplement to AFC, Section 2. Applicant's exhibit #32.
[73] Rebuttal testimony of Matt Moore.
[74] Letter from Robert Scott, URS Corporation, to Richard Know, Tessera Solar. Provided in Supplement to AFC, Section 3. Applicant's exhibit #32.

temporarily. None of this information was included in the SA/DEIS and it has not yet been evaluated by Staff.

5. The applicant concluded that "[c]omparison of the water quality data collected following our aquifer test is identical to that observed in well 16S/9E-36G4 [i.e., the Dan Boyer well] in 1974 and 1975."[75] The applicant's conclusion appears to be misleading. According to dataset that was used to support the conclusion, data on many water quality parameters were not collected in 1974 or 1975.[76]

6. The applicant concluded that "[a]ccording to the USG DEIR/EIS, groundwater extraction from the basin since 1975 has ranged from approximately 500 to 850 afy, and there has been no change in water quality in the proposed water supply well. Because the well will provide water for the Project for approximately 10 months at a rate of approximately 40 afy, pumping at this rate is not expected to result in a change in water quality."[77]

   There appear to be several flaws with these particular conclusions:

   a. Whereas groundwater extraction in the 1970's appears to have been in the range indicated by the applicant, it appears to have been considerably less in recent years.[78] As a result, the USG DEIR considered the baseline to be the period from 1994 to 1998. Extraction during that time was < 500 afy.

   b. The USG DEIR indicates water quality data were unavailable from the proposed water supply well.[79] Therefore, the applicant does not appear to have the basis to suggest the USG DEIR reported no change in water quality.

   c. The Project may use water from the well for more than 10 months.

7. The applicant concluded that "[t]he aquifer penetrated by the well can support water demands for the Imperial Valley Solar Project during construction and the lifespan of its operations (as needed)."[80] It is unclear whether Mr. Boyer would be willing (or able) to provide the applicant with water for that length of time. The "Will Serve" letter signed by Dan Boyer commits to providing the applicant with a *temporary* water supply, which Mr. Boyer indicates is expected to last for 6 to 11 months.[81]

8. The applicant concluded that "[c]ontinuous pumping of the well at the rate specified in the CUP for a period of one, two or three years will have no significant impact on water levels in the area, as the ZOI is considerably less than the distance to the closest well, which is approximately 500 feet away."[82]

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[75] Supplement to AFC, Section 3, p. 6-1. Applicant's exhibit #32.
[76] *See* Table 1 in Supplement to AFC, Section 3. Applicant's exhibit #32.
[77] Supplement to AFC, Section 3, p. 6-1. Applicant's exhibit #32.
[78] US Gypsum DEIR, Table 3.3-4, provided in Supplement to AFC, Section 2. Applicant's exhibit #32.
[79] US Gypsum DEIR, Tables 3.3-3A, 3.3-3B, and 3.3-5, provided in Supplement to AFC, Section 2. Applicant's exhibit #32.
[80] Supplement to AFC, Section 3, p. 6-1. Applicant's exhibit #32.
[81] Supplement to AFC, Section 3, Appendix A. Applicant's exhibit #32.
[82] Supplement to AFC, Section 3, p. 6-1. Applicant's exhibit #32.

The applicant's conclusion appears to have several flaws:

a. The analysis used a porosity value of 0.2, which the applicant indicates is the default value. I do not have the expertise to evaluate whether a value of 0.2 is appropriate or not. However, the Final EIR for the US Gypsum expansion project reported the following: "[t]he effective porosity in the alluvium is uncertain. Estimates range from 8.3 percent to 30 percent... It should be noted that the estimate of velocity is inversely proportional to the estimate effective porosity. Based on the range of possible porosity values, velocity could range from 100 to 375 ft/yr, or 50 years per mile and 14 years per mile respectively."[83]

b. The analysis assumed a construction use of 36,000 gallons per day. However, the SA/DEIS indicates the Project would use an average of 45,000 gallons per day (during construction).

c. The analysis does not explain how aquifer thickness was derived.

I am sponsoring the following exhibits:

Exhibit 498-J	USEPA letter to USACE (5/12/10) re Public Notice (PN) SPL-2008-01244-MLM for the proposed Imperial Valley Solar Project, Tessera Solar North America, Imperial County, California
Exhibit 498-K	Travis Huxman, UA Biosphere 2 and B2 Earthscience, Associate Professor, Ecology and Evolutionary Biology, University of Arizon, Tucson, Arizona: Climate Change and the Sonoran Desert
Exhibit 498-L	CURE letter addressed to Christopher Meyer and Jim Stobaugh (5/28/09) re Biological Resource Survey Techniques for the Solar Two Project
Exhibit 498-M	Monthly Precipitation, EL Centro 2 SSW, California
Exhibit 498-N	EPA: Sole Source Aquifer Designations in EPA, Region 9
Exhibit 498-O	Ground-Water Resources, Ocotillo-Coyote Wells Basin, Calif.
Exhibit 498-P	U.S. Geological Survey Water-Resources Investigations 77-30: Digital-Model Evaluation of the Ground-Water Resources in the Ocotillo-Coyote Wells Basin, Imperial County, California

[83] US Gypsum Final EIR/EIS, p. 3.3-42.

498-B

Declaration of Scott Cashen
Imperial Valley Solar Project

Docket 08-AFC-5

I, Scott Cashen, declare as follows:

1) I am an independent biological resources consultant. I have been operating my own consulting business for the past three years. Prior to starting my own business I was the Senior Biologist for TSS Consultants.

2) I hold a Master's degree in Wildlife and Fisheries Science. My relevant professional qualifications and experience are set forth in the attached testimony and are incorporated herein by reference.

3) I prepared the rebuttal testimony attached hereto and incorporated herein by reference, relating to the biological resource impacts of the Imperial Valley Solar Project.

4) I prepared the rebuttal testimony and maps attached hereto and incorporated herein by reference relating to the distribution of solar energy generation infrastructure in Imperial County.

5) It is my professional opinion that the attached rebuttal testimony and maps are true and accurate with respect to the issues that they address.

6) I am personally familiar with the facts and conclusions described within the attached rebuttal testimony and maps, and if called as a witness, I could testify competently thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Dated: 5-17-10 Signed: _____

At: Walnut Creek, CA

498-C

Scott Cashen, M.S.—Independent Biological Resources Consultant

Comment Letter of Scott Cashen
Regarding Biological Impacts of Imperial Valley Solar Project
Prepared as a Comment Letter to US Army Corps of Engineers
May 12, 2010

This letter provides my assessment of the impacts the Imperial Valley Solar Project (Project) will have on the biological resources within the Project site and Salton Sea watershed. My comments were derived after a thorough review of the Staff Assessment and Draft Environmental Impact Statement (SA/DEIS); other environmental documents associated with the Project (including those submitted by the applicant, resource agencies, and intervenors); and relevant scientific literature (e.g., journal articles). I addressed many of my concerns in the testimony I recently submitted to the California Energy Commission. These include the adverse effects the Project will have on: (1) the flat-tailed horned lizard (which is proposed for listing under the Endangered Species Act); (2) sensitive botanical resources; (3) the federally protected golden eagle; (4) the western burrowing owl (a California Species of Special Concern); (5) migratory birds protected under the Migratory Bird Treaty Act; and (6) other special-status wildlife species. Because my testimony is relevant to the Army Corps of Engineer's analysis, I have included it as an attachment to this letter.

Since submitting my testimony, I have conducted additional analysis of the impacts the Project will have on the ecological integrity of the Salton Sea watershed. Whereas the focus of this letter is on those impacts, I encourage the reader to review the issues discussed in my attached testimony to obtain a complete picture of the many biological resources that would be affected by the Project.

For the purposes of this assessment, I have broken down Project impacts into those caused by: (a) the power production facility (including laydown area and transmission lines); (b) the upgrades to the Seeley Wastewater Reclamation Facility (WWRF) necessary to provide the Project with the preferred water supply; and (c) the synergistic (or interactive) effect of these two Project components. Each of these components will (or may) have direct, indirect, and cumulative impacts. As a result, the Project may cause up to nine different types of impacts to biological resources (Table 1).

Table 1. Types, sources, and examples of impacts associated with the Imperial Valley Solar Project.

	Source		
	Power Facility	Seeley WWRF	Power Facility * Seeley WWRF (Interaction)
Type			
Direct	Soil disturbance	Owl burrow loss	None identified
Indirect	Vegetation loss	Wetland loss	Salton Sea water quality
Cumulative	Land degradation	Increased salinity	Ecosystem integrity

POWER FACILITY

The applicant proposes a project that would cause extensive ground disturbance across approximately 6,100 acres of a relatively undisturbed portion of the Colorado Desert.[1] Initial ground disturbance would occur as a result of site grading, vegetation removal, road construction, trenching, and installation of power generation equipment and infrastructure. Once construction begins, continual ground disturbance would occur as a result of ongoing maintenance, vegetation trimming, and general activities associated with operation of the facility.

The scientific literature is very clear in demonstrating the consequences of soil disturbance in fragile desert environments. These include:

1. sand blasting of vegetation and equipment;
2. burial of vegetation and equipment;
3. dust emissions leading to decreased nutrient availability, cation-exchange capacity, water-holding capacity, and atmospheric pollution.[2]

WIND EROSION

The Project site is susceptible to severe winds. For example, recent (April 2009) wind data for El Centro indicated average wind gusts of 30 mph and a maximum gust of 55 mph (Attachment A).[3] Wind erosion is the principle mechanism of land degradation. Agriculture, urban development, military maneuvers, pipeline, road and powerline construction, and recreational vehicles all destroy vegetation cover and expose the soil to wind erosion.[4] These activities can result in increased dust emission, blowing sand, and

[1] Ecosphere Environmental Services. 2009 Apr 21. SES Solar Two AFC Supplemental Cumulative Analysis. p . 15.
[2] Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144.
[3] Weather Underground. History for El Centro, CA, April 2009 [internet]. Attachment A.
[4] Sharifi et al. 1999. *In* Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144.

damage of native vegetation; which can then cause severe financial and societal consequences including property damage, increased health and safety hazards, and decreased agricultural productivity.[5] Some of these consequences are irremediable on human timescales at reasonable cost.[6]

Impacts to Cryptobiotic Soil Crusts and Desert Pavement

Cryptobiotic soil crusts—communities of cyanobacteria, lichens, and mosses—are found throughout the world's deserts, and are present on the Project site (John Donovan, American Conservation Experience, personal communication, 2010 May 11). These crusts bind fine soil particles by linked cyanobacterial fibres, which protect the soil from wind erosion. Several studies have suggested that the presence of cryptobiotic crusts dramatically decreases wind and water erosion.[7] When disturbed, cryptobiotic crusts lose most of their protective qualities allowing mobilization of the underlying mineral soils.[8]

Extensive desert pavement is present on the Project site. Desert pavement is very stable and it protects the soil from wind and water erosion. However, underneath the desert pavement is a layer of extremely wind-erodable, wind-derived material, sometimes meters thick. As a result, anthropogenic disturbance to desert pavement—such as the grading and other activities proposed by the Project applicant—is likely to have profound consequences.

Vegetation Loss

Once the desert crust or pavement is removed (or damaged), sand may be blown several kilometers downwind, resulting in an area of indirect disturbance that can exceed the directly disturbed area by several-fold. For example, Okin et al. (2001) reported that 3,000 ha of land directly disturbed would be expected to indirectly disturb an additional 3,000 to 9,000 ha of land. The encroachment of blowing sand into adjacent shrublands has dramatic consequences for the landscape. Field observations indicate that blowing sand abrades plants, resulting in leaf stripping and damage to the cambium and therefore to the plant's ability to distribute and use water. Young plants are especially vulnerable to the effect of blowing sand as they lack woody tissue. This results in the suppression of revegetation in bare areas and the loss of vegetation on adjacent lands. Nitrogen-fixing microbial communities and cryptobiotic crusts are buried by sand, reducing inputs of nitrogen to the soil (Belnap *et al.*, 1993; Evans & Belnap, 1999).

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[5] Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144.
[6] Dregne HE. 1995. *In* Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144.
[7] Okin GS, B Murray, WH Schlesinger. 2001. Degradation of sandy arid shrubland environments: observations, process modeling, and management implications. Journal of Arid Environments Vol. 47, No. 2, pp. 123–144.
[8] *Id.*

The Project would involve site grading for roadways and foundations, the removal of topographic undulations, and within channels to "improve" hydraulics. Site grading will destroy vegetation. In addition, the Project would involve brush trimming between every other row of SunCatchers (i.e., the power generation units). Schlesinger & Pilmanis (1998) have reviewed field experiments in which shrubs have been removed by cutting, herbicides, or fire. These studies show variable rates of soil degradation, but in each case, 'a loss of the local biogeochemical cycle associated with shrubs has allowed physical processes to disperse soil nutrients across the landscape.' Thus, the progressive reduction in fertility acts in tandem with the mechanical action of sand to further decrease shrub cover, which, in turn, increases the susceptibility of the land to wind and water erosion. The permanent removal of suspension-sized particles from the soil by erosion results in a change of the soil texture, which may also reduce soil-binding properties, resulting in increased erodibility. Whether by wind or water, the fine particles and soil organic matter that are removed by erosion are key to the healthy functioning of soils because they increase soil nutrient content, soil porosity, water-holding capacity, and cation-exchange capacity. Because new vegetation growth is inhibited by blowing sand, the ability of vegetation to stem erosion is limited. This results in a negative feedback loop that ultimately results in severe land degradation.

DESERT WASHES

The applicant plans to locate SunCatchers in the numerous desert washes that occur on the Project site. Desert wash habitats support more bird species at higher densities than other desert habitats with the exception of riparian. They also provide food and cover, and serve as a travel corridor for many wildlife species. Placing SunCatchers in the washes would undoubtedly have numerous adverse consequences to wildlife. First, they are likely to eliminate any residual value of the washes in serving as a travel corridor (which in turn promotes connectivity) as a result of either their appearance, or the loud noise they generate (reported to be 84 dBA Leq at approximately 50 feet). Second, they would serve as a mortality hazard, particularly to birds that strike the reflective surface of the units while exploiting the resources provided by the wash (regular maintenance of the units may exacerbate this issue). Finally, the regular maintenance (e.g., washing) associated with the SunCatchers would result in sustained disturbance of vegetation, soils, and special habitat elements provided by the washes.

There appears to be some disagreement among the applicant, BLM and Energy Commission staff, and intervenors regarding the effects of placing SunCatchers in the washes (e.g., the amount of scour that will occur). However, I believe it is indisputable that placing SunCatchers (and the associated maintenance roads, hydrogen distribution, and electrical collection system) in washes would degrade the inherent physical (e.g., hydrological and sediment transport), chemical, and biological functions and values both on- and off-site. Because these functions and values are important to ecological health, it is my professional opinion that the proposed Project will cause further degradation to the Salton Sea and associated watershed.

The 30,000 SunCatchers proposed for the Project will contain ethylene-glycol and oil, both of which are toxic to wildlife. Placing SunCatchers in the washes increases the risk of introducing these hazardous substances (and perhaps others) into surface and groundwater. It is my understanding that SunCatcher engines may leak (similar to automobiles), and that their ability to withstand storm flows has not been tested. Hazardous substances that escape SunCatchers will be introduced into the watershed and may ultimately end up in the Salton Sea.

Conclusion

The applicant's consultant recently submitted a "Revised Project Wash Avoidance Site Plan." The Plan consists of a figure that shows a modified project design that would exclude SunCatchers from a few of the washes. The Applicant believes this represents the Least Environmentally Damaging Practicable Alternative (LEDPA). The U.S. Army Corps of Engineers has proposed two on-site alternatives: (1) Drainage Avoidance #1, which prohibits permanent impacts within the ten "primary" ephemeral washes; and (2) Drainage Avoidance #2, which eliminates development in the large ephemeral wash complexes located in the eastern and westernmost portions of the Applicant's proposed project site. Although I cannot comment on the economic feasibility of various alternatives, in my professional opinion, a combined hybrid of the two drainage avoidance alternatives should be studied as a new LEDPA because such an alternative would avoid the major washes and would provide for wildlife movement through the area.

SEELEY WASTEWATER RECLAMATION FACILITY

The applicant's proposed water supply is treated effluent from the Seeley Wastewater Reclamation Facility (SWWRF). Currently, the effluent is being released into a channel that flows into the New River. Planned upgrades to the SWWRF would enable all effluent to be directed to the Project site.

In 2003, a Mitigated Negative Declaration (MND) was completed for planned upgrades to the facility. The MND concluded "[r]elocation of the existing point of discharge, as proposed, would potentially result in the rapid demise of an approximately 2-acre wetland area, since the SWWRF effluent is the major water contributor to this drainage."[9] The wetland has been identified as potential habitat for several biological resources, including several State and/or federally-listed bird species. It also has been identified as having wetland resources under the jurisdiction of the California Department of Fish and Game, and likely the Army Corps of Engineers and Regional Water Quality Control Board.[10]

[9] BRG Consulting, Inc. 2003. Final Mitigated Negative Declaration and Environmental Assessment: Proposed Seeley Water / Wastewater Master Plans. p. 31. [emphasis added].
[10] Dudek. 2009. *Draft Mitigated Negative Declaration for the Seeley Wastewater Reclamation Facility* Improvements, Imperial County, California. p. 4-22.

The Salton Sea ecosystem is an extremely valuable resource for resident and migratory birds, including a large number of threatened, endangered, and other special-status species. The Salton Sea is also one of the nation's most imperiled ecosystems. Increasing salinity and declining water quality are the primary threats to the beneficial functions and values provided by the Salton Sea.[11] Reduced inflows are the primary cause of these threats. In its testimony, the applicant states diversion of water to the Project site will result in only a 0.15% decrease in freshwater flows to the New River, and a decrease of approximately 0.05% at the Salton Sea. The applicant concludes these small percentage reductions in flows (of higher quality water) are not anticipated to result in a significant reduction in water quality to the New River or Salton Sea.[12]

As a result of increased water demands on the Colorado River from many Southwest communities, the reduction of inflows will have reasonably foreseeable significant impacts on the Salton Sea. These not only include impacts to fish and wildlife resources, but also the dust problems expected to occur when lakebed sediments are exposed.[13] Given these considerations, it seems impossible to deny that the Project would have an effect on the future health of the Salton Sea ecosystem.

Conclusion

A thorough or complete analysis has yet to be completed on <u>any</u> of the potentially significant impacts that may result from the SWWRF upgrade project. As a result, it is my professional opinion that the project may contribute, both individually and collectively, to significant degradation of aquatic life and other wildlife dependent on aquatic ecosystems; ecosystem diversity, productivity, and stability (including loss of habitat); and recreational and aesthetic values associated with the New River and Salton Sea.

SYNERGISTIC INTERACTIONS

The mechanisms that cause impacts to biological resources tend to be examined in isolation from one another. This is likely because we know very little about the dynamic relationships between discrete mechanisms. Yet, synergistic interactions are especially significant.[14] For instance, a biota's tolerance of one stress tends to be lower when other stresses are present. When one considers the likely outcome of several mechanisms operating at once, one can reasonably surmise that many of their effects will serve to amplify one another.[15] Scientists have postulated that synergistic interactions could well

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[11] California Department of Water Resources and California Department of Fish and Game. 2006. Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report. Chapter 1: Introduction. P.1.
[12] Testimony of Matthew Moore.
[13] California Department of Water Resources and California Department of Fish and Game. 2006. Salton Sea Ecosystem Restoration Program Draft Programmatic Environmental Impact Report. Chapter 1: Introduction. P.2.
[14] Meffe GK, CR Carroll. 1997. Principles of Conservation Biology, 2nd edition. Sinauer Associates, Inc., Sunderland, MA.
[15] *Id.*

prove to be the major, if not predominant, phenomenon at work during the impending extinction spasm.[16]

Especially damaging in its synergized impact will be global climate change.[17] For many species (and I would argue especially those occupying desert environments), a few degrees of temperature change, or slight changes in rainfall pattern, make a difference between survival and extinction.[18] Climate change will be unusually harmful for species already stressed by other human activities.[19] Huxman (2008) provided an excellent summary of the synergistic effect of climate change and various issues associated with the Project:

> Semi-arid and arid ecosystems should be rather responsive to different aspects of climate change, since plant function in these systems is primarily limited by water availability, and many global change factors (CO2 rise, alteration in precipitation, temperature rise, nitrogen deposition) impact surface water budgets on landscapes. The prediction of an increase in 'global warming type' droughts such as those early in 21st Century will increase rates of perennial plant mortality, especially in the Sonoran Desert, which has the highest relative productivity of the North American deserts and contains functional types at risk to such mortality. This should accelerate rates of erosion, and create opportunities for exotic plant invasions. The proliferation of non-native annual and perennial grass will predispose sites to fire resulting in a loss of native woody plants and charismatic mega flora and primarily impacting low elevation sites that will now experience climate-fire synchronization where none previously existed. The climate-driven dynamics of the fire cycle is likely to become the single most important feature controlling future plant distributions in U.S. arid lands. Arid land soils are deficient in nitrogen, so erosional losses of soil nitrogen will further restrict regional productivity; and vegetation, especially exotic grasses, will be very responsive to N-deposition associated with increasing anthropogenic activities. Land use change, increased nutrient availability, increasing human water demand, and the continued pressure from non-native species will act synergistically with climate warming to restructure the rivers and riparian of the southwestern US. Increases precipitation intensity and the proportion of precipitation that comes in high-intensity storms will increase water erosion from uplands and delivery of nutrient-rich sediment to riparian areas. Combined these issues are likely to produce emergent features at the regional scale that may impact our systems in yet to be determined manners.[20]

Given information available in scientific literature, there is little doubt that the landscape-level disturbance caused by the Project will result in synergistic interactions that will have a dramatic effect on the ecology of the region.

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[16] *Id.*
[17] *Id.*
[18] *Id.*
[19] *Id.*
[20] Huxman T. 2008. Climate change and the Sonoran Desert [abstract]. The Climates and Desert Workshop: Adaptive Management of Desert Ecosystems in a Changing Climate; 2008 Apr 9-11; Laughlin (NV). Available at: www.dmg.gov/climate/abstracts/huxman_clmtchng.pdf.

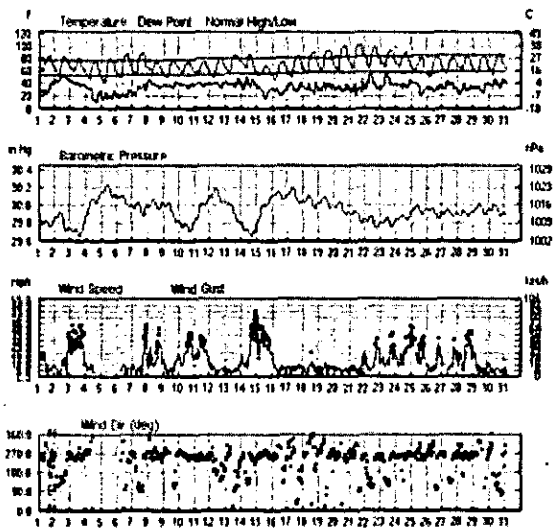
Attachment A. April 2009 wind speed data for El Centro, CA.

History for El Centro, CA

Month of April, 2009

Monthly Summary

	Max:	Avg:	Min:	Sum:
Temperature:				
Max Temperature	102 °F	85 °F	70 °F	
Mean Temperature	82 °F	70 °F	60 °F	
Min Temperature	64 °F	55 °F	43 °F	
Degree Days:				
Heating Degree Days (base 65)	0	1	0	22
Cooling Degree Days (base 65)	18	6	0	165
Growing Degree Days (base 50)	32	20	10	590
Dew Point:				
Dew Point	58 °F	35 °F	9 °F	
Precipitation:				
Precipitation	0.00 in	0.00 in	0.00 in	0.00 in
Snowdepth	-	-	-	-
Wind:				
Wind	41 mph	12 mph	0 mph	
Gust Wind	53 mph	30 mph	16 mph	
Sea Level Pressure:				
Sea Level Pressure	30.24 in	29.94 in	29.63 in	



Monthly Calendar Overview

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498-D

NERC 88/29
AFESC TR 88.14
JUNE 1988

EFFECTS OF AIRCRAFT NOISE

AND SONIC BOOMS ON

DOMESTIC ANIMALS AND WILDLIFE:

A LITERATURE SYNTHESIS

Engineering and Services Center
U.S. Air Force

Fish and Wildlife Service

U.S. Department of the Interior

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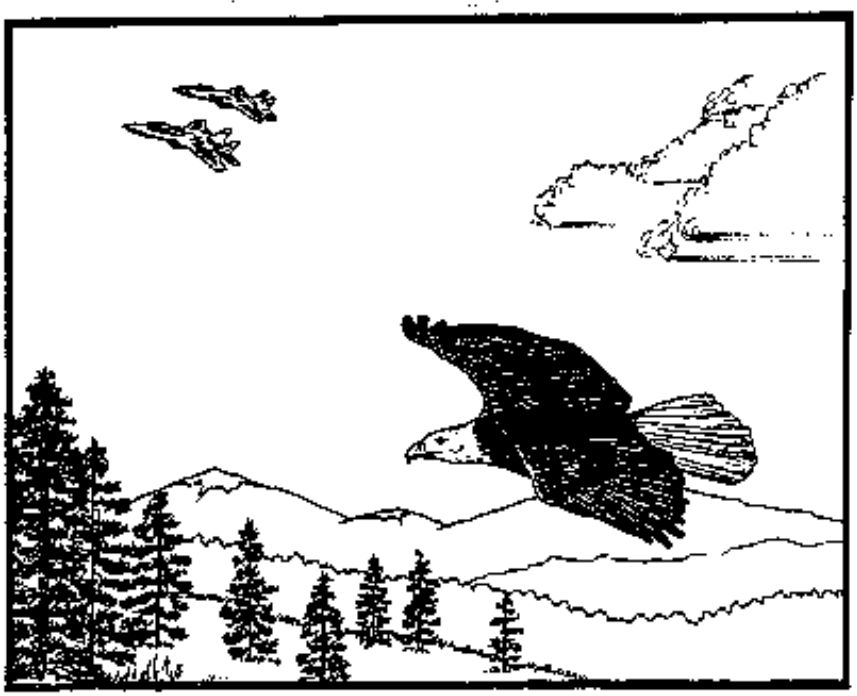
NERC 88/29
JUNE 1988

AFESC TR 88-14

EFFECTS OF AIRCRAFT NOISE AND SONIC BOOMS ON DOMESTIC ANIMALS AND WILDLIFE: A LITERATURE SYNTHESIS



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AFESC TR 88-14
NERC-88/29
June 1988

EFFECTS OF AIRCRAFT NOISE AND SONIC BOOMS ON DOMESTIC ANIMALS AND WILDLIFE: A LITERATURE SYNTHESIS

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PREFACE

This report was produced as the result of a cooperative research project between the National Ecology Research Center, Ft. Collins,

Colorado and the Air Force Engineering and Services Center, Tyndall Air Force Base, Florida, on the effects of aircraft noise and sonic booms on animals. The effort was funded by the Air Force's Noise and Sonic Boom Impact Technology Program, Wright-Patterson Air Force Base, Ohio.

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1.0 INTRODUCTION

The U.S. Air Force must be able to conduct flight operations in assigned airspace over public and private lands to train personnel and test new technologies to fulfill its national defense mission. The Air Force can only fulfill its mission by maximizing use of current aircraft operating areas and varying military training routes to give pilots added experience. Acquiring and maintaining new airspace is vital in light of increasing mission requirements and international agreements. These actions will impose aircraft noise on the environment which may affect wildlife; thus, these actions fall under the auspices of the National Environmental Policy Act (NEPA) of 1969. NEPA requires all Federal government agencies to analyze the environmental impact of proposed Federal actions "significantly affecting the quality of the human environment" (42 USC 4341).

A great deal of research was conducted during the 1960's and 1970's to determine the likely effect of commercial supersonic jet aircraft on the environment, focusing on the effects on humans, due to public fear of adverse ecological impacts. However, the knowledge gained from this research does not apply directly to wildlife on areas overflown by aircraft at supersonic speeds and at low altitudes.

Although scientists have researched some effects of noise on animals, many data gaps still exist on the overall effects of aircraft noise on wildlife. In addition, perceived inadequate or inaccurate analysis of the effects of aircraft noise on wildlife by the general public has resulted in delays of flight operation expansions.

An information base on the effects of aircraft noise and sonic booms on various animal species is necessary to assess potential impacts to wildlife populations from proposed military flight operations. Thus, in a joint U.S. Air Force/U.S. Fish and Wildlife Service effort, the National Ecology Research Center conducted a literature search of information pertaining to animal hearing and the effects of aircraft noise and sonic booms on domestic animals and wildlife. Information concerning other types of noise was also gathered to supplement the lack of knowledge on the effects of aircraft noise. The literature is summarized in this report to provide an overview of current knowledge. No attempt was made to evaluate the appropriateness or adequacy or the scientific approach of each study. A brief overview of the physics of sound and aircraft noise and sonic boom characteristics also is included to familiarize the reader with the terminology and concepts of aircraft noise and sonic boom impact analysis.

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2.0 AIRCRAFT NOISE AND SONIC BOOM CHARACTERISTICS

2.1 PHYSICS OF SOUND

Sound is a pressure fluctuation in the otherwise undisturbed atmosphere or other medium (e.g., ground or water). Although these fluctuations may be relatively small in magnitude, large pressure differences exist between the faintest audible sounds (e.g., leaves rustling in the wind) and the loudest audible sounds (e.g., a rocket launch or bomb explosion). This difference in magnitude is measured in terms of the amplitude of the pressure fluctuation.

Acoustical research has shown that the ear responds to sound pressure level in a logarithmic manner (Hurturbise et al. 1978). Consequently, sound pressure levels are measured with the logarithmic decibel (dB), which corresponds reasonably well to the biological properties of the human ear that determine loudness perception. The zero-end of the scale approximates the lowest level sound that an average human can hear [about 20 micro-Newtons per square meter (mN/m^2)]. A value of about 120 on the scale corresponds roughly to the point at which sound becomes painful (Table 1).

Table 1. Comparison of sound pressures and sound levels from typical sources (Ewbank 1977).

Sound Pressure (N/m^2)	Sound Level (dB)	Typical source
2,000	160	Peak leavel at ear of 0.303 caliber rifle
200	140	Jet aircraft taking off at 25 m
20	120	Human pain threshold
2	100	Very noisy factory
0.2	80	Ringing alarm clock at 1m
0.02	60	Ordinary conversation at 1m
0.002	40	Quiet office
0.0002	20	
0.00002	0	Threshold of human hearing

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Due to the sound pressure compression of the decibel scale, the combined noise produced by two identical jets is, in general, only about 3 dB higher than that produced by either aircraft operating alone (Gladwin 1978). Also, when one noise is much greater than another, the addition of the lesser noise typically adds an almost undetectable amount to the overall decibel level. For example, the addition of one F-15 taking off with a B-52 would not likely increase the detectable sound pressure level generated by the one operating alone.

In addition to sound pressure level, any noise event also has a characteristic pitch, a distribution of sound pressure as a function of frequency. Pitch is a measure of how often these fluctuations repeat during a given period, usually 1 second. Although human response to noise is strongly dependent on frequency, the frequency/response correlation is not known for the majority of wildlife species. The audible frequency range for the average human varies from about 20 Hz (Hertz, i.e., cycles per second) to about 16,000 Hz (16 kHz). In general, people are less sensitive to low-frequency noise (e.g., 100 Hz), than they are to high-frequency noise (e.g., 2 kHz). Domestic sheep are most sensitive to frequencies around 7 kHz (Figure 1).

Pure tone sound (e.g., sound produced by a tuning fork) consists of a single frequency. Aircraft-generated sound is much more complex in frequency structure; each specific aircraft type produces noise extending over a wide frequency range. The narrow-band pure tone whine of a jet engine compressor is readily recognizable above the broad-frequency noise of the jet engine exhaust stream. Each type of aircraft engine and aircraft operating environment produces a characteristic frequency spectrum, which is usually measured in octave bands, either frequency-weighted or one-third octave. The overall noise level, known as the overall sound pressure level, is calculated by summing the sound levels in each octave band, or partial octave band, according to the rules of decibel addition.

Not only is the human ear (and the ears of some other animals) more sensitive to high frequencies than to low frequencies, but also the sensitivity of the human ear to sound of varying frequencies changes with the magnitude of the sound (Figure 2). A technique for relating physical noise properties and measurements to the subjective response of various species is desirable, but rarely attainable. The introduction of noise frequency weighting on sound-level meters is one attempt to solve this problem for human noise impact assessment. However, no such device has been developed for a species of wildlife or domestic animal.

One widely used frequency weighting system is known as the A-weighting network and has been standardized in current sound-level meter specifications (Peterson and Gross 1972). The A-weighting system assigns low weights to the low-frequency tones, to which the human ear (and the ears of some other animals) is less sensitive, and high weights to the typically more audible high-frequency tones. The A-weighting noise analysis technique correlates well with human response to noise. A drawback to its use, however, is that a simple sound level measure usually does not adequately account for this tonal

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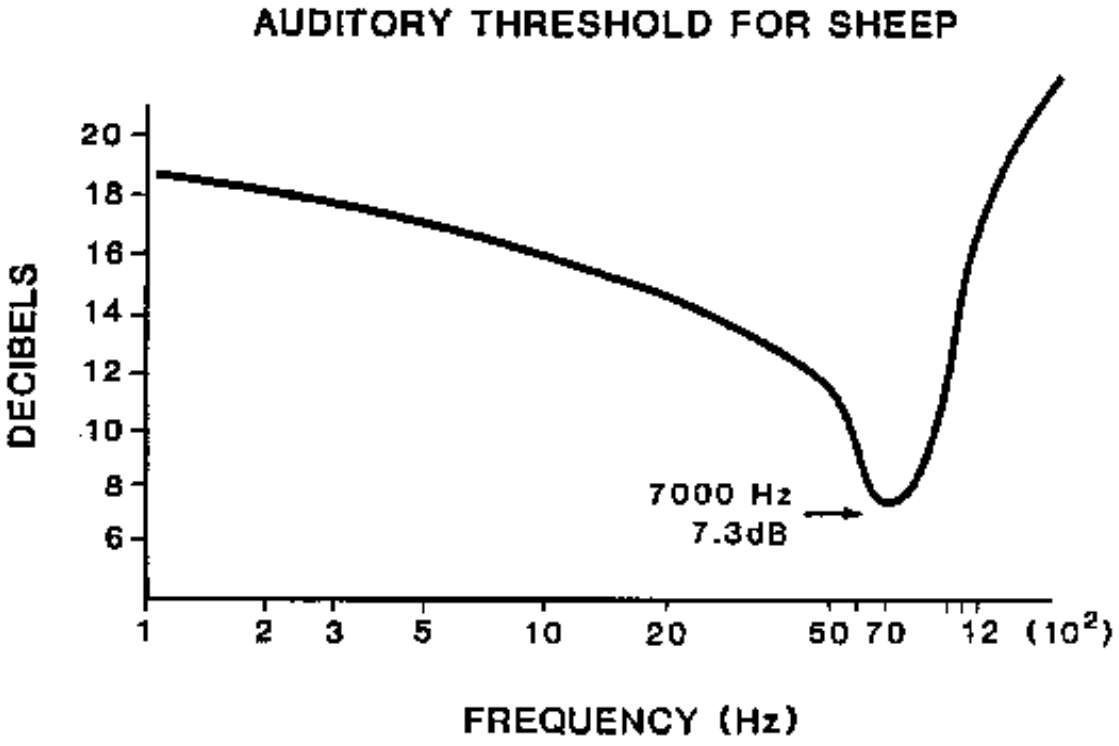

Figure 1. Plot of minimum audible field with decibels shown as sound pressure level above background (26 dB) (Ames 1978).

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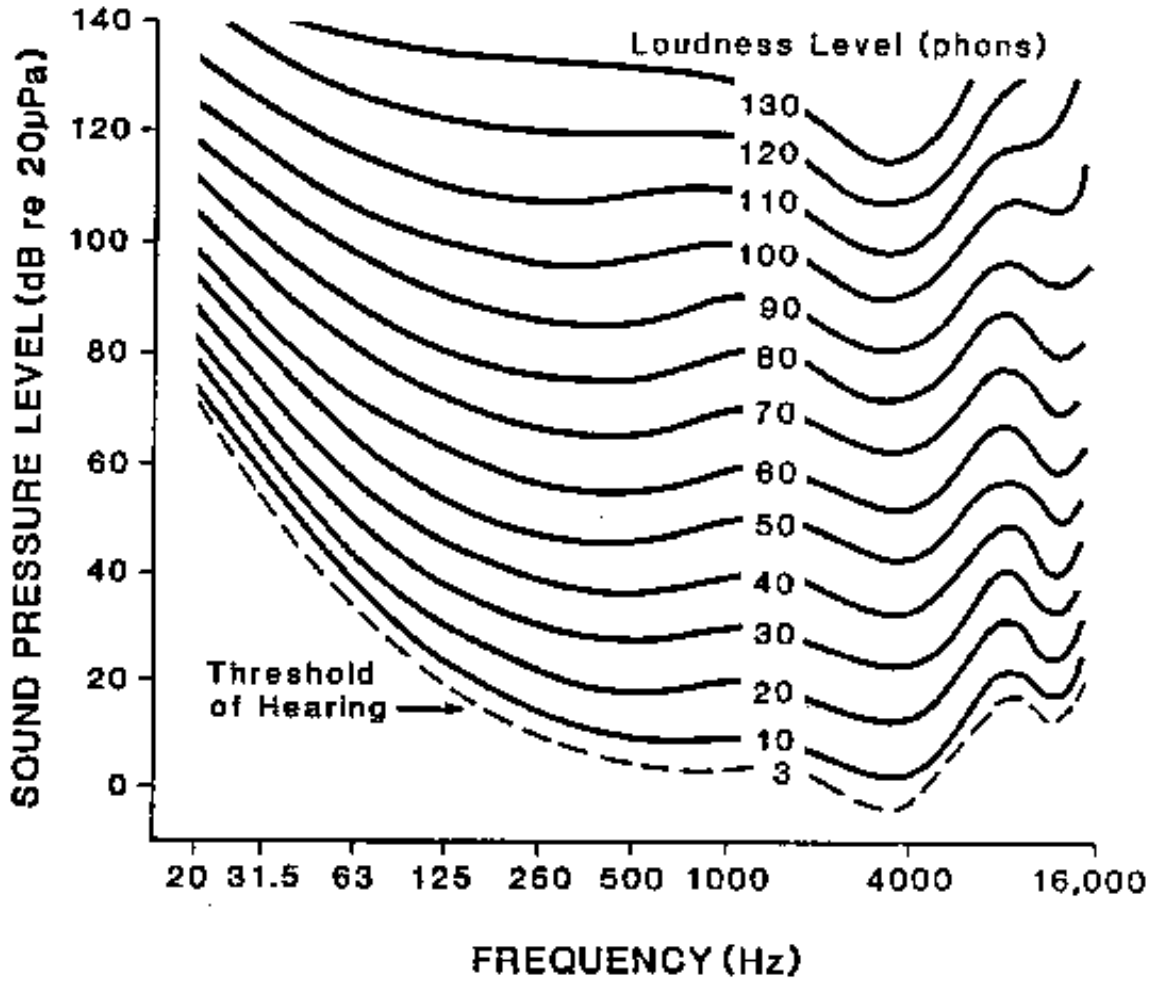

Figure 2. Pure-tone frequency response of the human ear (Peterson and Gross, 1972)

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component effect. In the A-weighting system, a noise subjectively judged to be twice as loud as another sound would have an A-weighted value approximately 10 dBA greater than the first sound, even though this change corresponds to a factor of 10 in actual sound level.

2.2 SOURCES OF AIRCRAFT NOISE

2.2.1 Subsonic Noise

Turbofan and turbojet engines are major sources of intense aircraft noise. Although turboprop-powered aircraft also are used by the U.S. Air Force, their contribution to the overall noise environment is of relatively minor importance compared to jet-powered aircraft. Jet engines are generally more powerful and produce noise of higher magnitude than turboprop or piston aircraft engines. Also, jet engines produce a greater amount of noise in the high-frequency range, thus increasing their relative annoyance factor.

In jet-powered aircraft, the primary sources of engine noise are the roar of the jet exhaust stream and the high pitched noise generated by the engine's turbo-machinery, compressor, and blades. The exhaust roar is created by the rapid expansion of high-velocity exhaust gases.

In general, the amount of noise generated by a jet aircraft engine is proportional to its exhaust stream velocity raised to the eighth power. By forcing atmospheric air into the jet engine intakes, the average velocity of the exhaust stream is reduced, decreasing the resultant noise intensity. For this reason, turbofan aircraft engines produce less noise at the same power setting than turbojet engines. The fan ducts of turbofan aircraft engines create a secondary air flow around the exhaust stream, thereby decreasing noise levels by reducing the magnitude of the shearing gradients between exhaust core and the ambient atmosphere. The higher a turbofan engine's bypass ratio, the less noisy its operation. The use of after-burners in military aircraft creates the opposite effect; the velocity of the exhaust stream is increased, thereby increasing the noise level.

Other jet engine noise sources are readily apparent, and may even be dominant during stationary or low-speed ground operations. The high-frequency whine of the engine's fans and compressors tend to be particularly annoying to most human listeners, and possibly to most animals. High bypass-ratio fan jets are quieter because their engines have slower fan speed, nacelle duct lines with acoustically absorbent material, and no inlet guide vanes.

The loudest noise generated by piston- or turbine-powered propeller aircraft generally occurs during takeoff, when the engine is operated on a high power setting. This noise is composed of a wide range of frequencies, but the major portion is at the lower end of the frequency spectrum. The turboprop engine is typically quieter than the piston engine during takeoff, but the compressor has the high-frequency whine, similar to jet engines.

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2.2.2 Sonic Booms

During supersonic flight, the shock waves generated from forward-facing portions of an aircraft are usually regions of positive overpressure. The waves originating from rear surfaces of the aircraft are typically regions of negative overpressure, or underpressure. The pressure signature is the variation in overpressure generated by the forward- and rearward-facing surfaces of an aircraft flying at supersonic speed, creating the sonic boom (Figure 3). As an aircraft reaches supersonic flight, the pressure signature is propagated along a path commonly referred to as the sonic boom ray (ray AC, Figure 4); the presssure signature is generated at the point on the flight line from which the sonic boom ray emanates (point P, Figure 4).

The sonic boom rays emanating from an aircraft operating at supersonic speed initially form a cone (Figure 4). However, due to atmospheric variations (e.g., wind and temperature gradients) the rays conform to the laws of atmospheric refraction and become horn-shaped, forming a boom conoid (Figure 5). Because all relevant refraction properties of the atmosphere are usually not known, developing an accurate boom conoid for a given supersonic flight event is difficult.

In the absence of winds, the increase in the speed of a sonic boom along a descending ray creates a decrease in the ray angle (Peterson and Gross 1972). For this reason, a boom ray tends to be refracted upward, away from the ground. Due to this phenomenon, angles from the vertical of two boom rays from each point on a supersonic flight path are sufficiently great that the boom rays only graze, or do not reach, the ground. The sonic boom "carpet" (the area on the ground that experiences the sonic boom) is defined by the locus of points of the boom rays that just graze the ground (Figure 6). Surface areas outside these points experience no sonic boom.

A tail wind behind an aircraft enhances the effect of the increase in sound speed. A head wind creates the opposite effect and tends to refract the boom rays toward the ground. Also, the paths of propagation of the atmospheric pressure disturbances depend on the manner the aircraft is flown, as well as on the prevailing atmospheric conditions.

Under certain aircraft operating conditions (e.g., acceleration, dives, turns, and climbs), the sonic boom conoids generated by the aircraft may intersect one another. This effect is known as sonic boom focusing. Such focusing may also result from refraction effects caused by variations in atmospheric sound and wind speed. Focused sonic booms may be of much greater intensity than unfocused booms and are typically generated by fighter aircraft in "dogfight" maneuvers.

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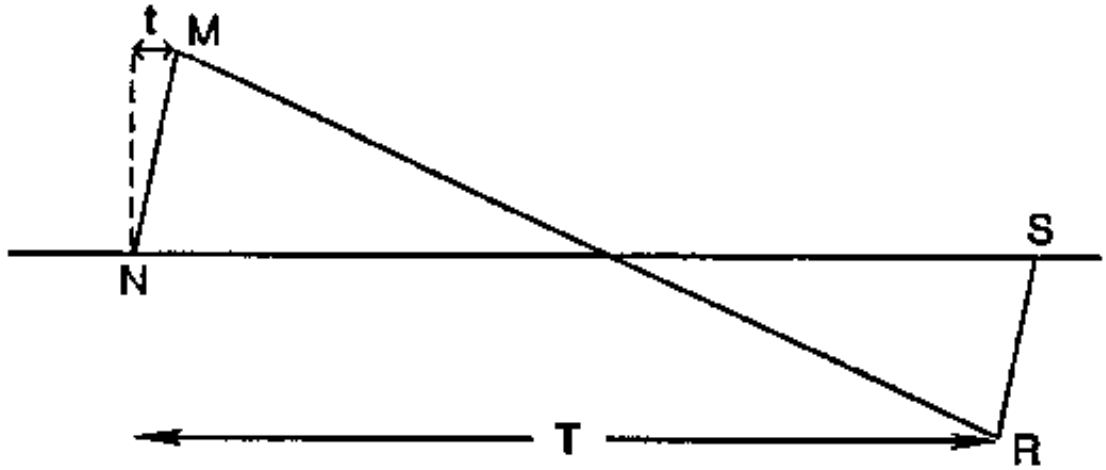

Figure 3. Characteristics of a sonic boom; pressure (vertical axis) plotted against time (horizontal axis) (Cottereau 1978).

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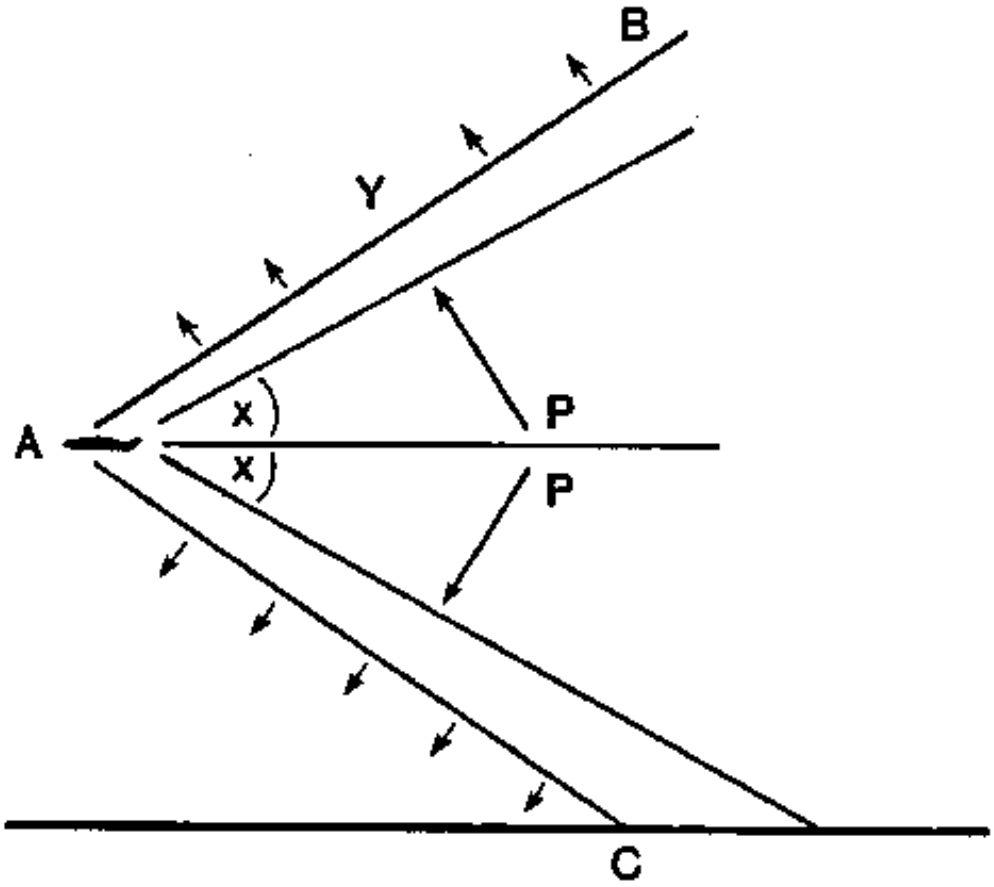

Figure 4. Vertical section of sonic boom cone (Peterson and Gross 1972).

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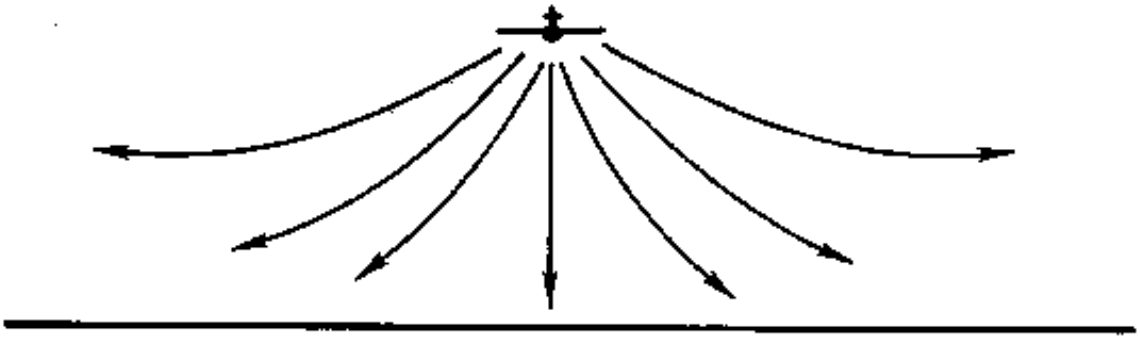

Figure 5. Refraction of boom rays as they pass down from an aircraft to the ground (Peterson and Gross 1972).

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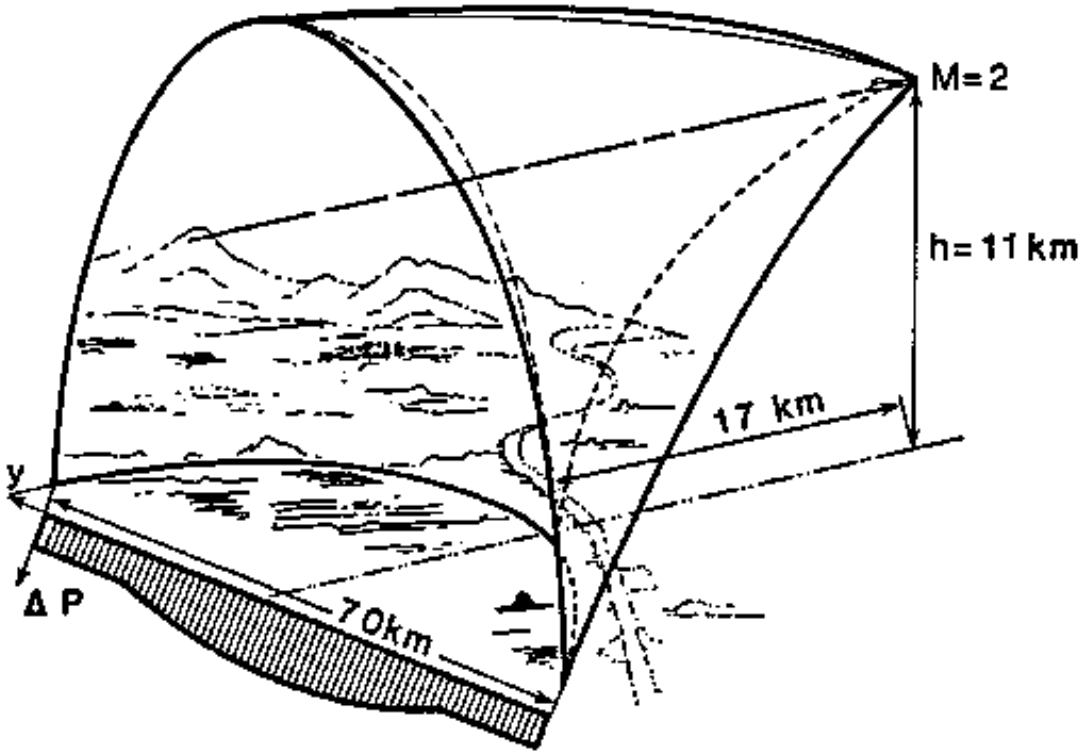

Figure 6. Sonic boom carpet from supersonic flight (Peterson and Gross 1972).

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2.2.3 Aircraft Noise Propagation

The propagation of aircraft noise and sonic boom from source to receiver is a function of several factors, including relative distance; atmospheric attenuation due to wind, humidity, and temperature; and intervening noise barriers (e.g., large stands of trees and buildings). The distance relationship is relatively straightforward; as acoustic energy spreads out over an increasingly larger area, the amount of sound energy per unit volume of atmosphere steadily decreases. For subsonic noise, this decrease is inversely proportional to the square of the distance between the aircraft and the receiver (i.e., a decrease in acoustic intensity of approximately 6 dB for each doubling in relative distance).

Atmospheric conditions affect noise propagation. Water vapor in the atmosphere is relatively effective at absorbing noise. Also, the higher noise frequencies are more readily absorbed. For this reason, high-frequency noise typically decreases with distance more rapidly than does either midrange or low-frequency noise. For aircraft in flight, air absorption has the greatest influence on noise propagation.

Atmospheric temperature gradients also affect aircraft noise propagation. During periods of normal temperature gradients, where air temperature steadily decreases with increasing altitude, aircraft noise is, for the most part, deflected upward, thereby producing areas of little or no noise on the ground at certain distances from the aircraft. During periods of atmospheric temperature inversion, the reverse situation is true and aircraft noise tends to be deflected downward, thus increasing ground noise level (Gladwin 1978).

During low-level aircraft operations, surface absorption and deflection may decrease the observed noise levels at low angles of observation. Intervening objects (e.g., hills, buildings) will also affect noise propagation.

2.2.4 Aircraft Noise Reduction

Aircraft noise reduction measures may include modification of the: (1) noise source, (2) noise pathway between the source and the receiver, or (3) receiver. Although reducing aircraft noise at its source may seem the most expedient method of noise reduction, it generally cannot be done with military aircraft because of their high performance demands. This is especially true of combat aircraft. Use of acoustically modified jet aircraft engines has resulted in some reduction in aircraft-generated noise; however, development of economically feasible, quieter aircraft engines has proven to be a relatively slow process.

Modification of the noise pathway through the use of natural or artificial acoustic barriers has been used to interrupt the acoustical line-of-sight between the aircraft and receiver. Such interruption usually is restricted to locations close to air bases exposed to noise from numerous ground operations. Hills or woodlands can sometimes effectively shield nearby areas from aircraft ground operations, especially when such noise barriers are located close to the noise source. A relatively large area of dense, tall woodland is required before such vegetation has a significant noise reduction effect.

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3.0 EFFECTS OF NOISE AND SONIC BOOMS ON DOMESTIC ANIMALS AND WILDLIFE

The effects of noise and sonic booms on animals vary due to the animal's hearing ability, which varies considerably among animal species. Each species has adapted, physically and behaviorally, to fill an ecological role within a community; an animal's hearing ability often reflects this role. Animals rely on hearing to avoid predators, to obtain food, and to communicate with members of their own species and other members of the community.

If sound has been a determinant in the evolution of behavior and morphology, its production and use have also depended on other aspects of the external environment (Bogert 1960). While specializations such as echolocation entail an integrated evolution of mechanisms of sound production and sound reception, the evolution of one is not always dependent on the evolution of the other. Sound production is not confined to animals with well-developed sound receptors, nor do all animals in which sound perception is well-developed produce sound themselves.

Sound production by animals also varies considerably. For example, mammalian vocalizations range in frequency from 50 to 100 Hz in the horse up to 150 kHz in some bats (Gould 1983). High-frequency sounds are extremely directional and attenuate quickly with distance. Low-frequency sounds attenuate slowly with distance and are relatively omnidirectional. The transmission properties of a vocalization depend on environmental factors, such as temperature, humidity, landscape, and vegetation. Range of vocal signal is influenced by intensity of the source, background noise levels, rates of signal degradation, and the perceptual abilities of the receiver (Gould 1983). Vocal communication in social animals helps maintain group cohesiveness by giving cues to individual identification and the next possible action of group members (Kiley-Worthington 1984). Noise impacts could potentially disrupt a species' ability to communicate, either vocally or by disturbing its behavioral patterns.

The literature concerning hearing ability of animals includes studies of hearing mechanisms and determination of hearing thresholds (audiograms), through primarily behavioral responses to various noise levels in laboratory experiments. Knowledge of specific audiograms for even domestic species is scant; however, a number of studies have been conducted since the mid-1970's on the hearing ability of various wildlife species. Comparisons between groups of species within the same habitat have revealed a wide variety of tolerance to noise levels.

Noise affects wildlife and other animals, including humans, in many ways. Janssen (1980) categorized these effects as primary, secondary, or tertiary. Primary effects are direct physical auditory changes, such as eardrum rupture,

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temporary and permanent hearing threshold shifts, and the masking of auditory signals. Basking is the inability of an animal to hear important environmental signals. These signals include noises made by potential mates, predators, or prey. Aircraft noise could conceivably cause masking of the signals in some species and populations of wildlife. Secondary effects of aircraft noise and sonic booms on wildlife include such nonauditory effects as stress, behavioral changes, interference with mating, and detrimental changes in the ability to obtain sufficient food, water, and cover. Tertiary effects are the direct result of both primary and secondary effects, and include population declines, destruction of important habitat (Klein 1973), and, in extreme cases, potential species extinction (Bender 1977).

Animal species differ greatly in their response to noise of various characteristics and duration. Individual animal response to a given noise event or series of events also can vary widely, due to a variety of factors, including time of day and year, physical condition of the animal, physical environment (such as whether the animal is restrained or unrestrained), the experience of the individual animal, and whether or not other physical stressors (e.g., drought) are present.

The effects of noise on the physiology of laboratory animals have been studied more thoroughly than effects on farm animals or wildlife. Although laboratory studies cannot be directly applied to effects of noise on wildlife in their natural habitats, they do describe a range of potential effects that may possibly occur. Hearing sensitivity, susceptibility to noise-induced hearing loss, and physiological effects of noise vary among animal species. Animals appear to be more sensitive to noise disturbance than humans (Borg,1981). Possible harmful effects of sound may be more related to information content of the sound--information pertaining to risky actions or masking significant information--rather than to sound itself.

A sudden or unfamiliar sound is believed to act as an alarm, activating the sympathetic nervous system. The short-term physiological stress reactions, referred to as "fight-or-flight," are similar for many vertebrate species (Holler 1978). Various stimuli can produce similar physiological effects. Different stressors have their own unique effects, however, and reactions to stress can vary between species and also among individuals of the same species. 0nly laboratory studies have been able to eliminate these variables and show that noise produces certain physiological effects.

The general pattern of response to stress includes activation of the neural and endocrine systems, causing changes such as increased blood pressure, available glucose, and blood levels of corticosteroids. The effect of sympathetic activation on circulation also is believed to have an effect on hearing (Holler 1978). A correlation has been shown to exist between the reaction on the peripheral circulation and the temporary threshold shift caused by noise exposure. Prolonged exposure to severe stress may exhaust an animal's resources and result in death.

The introduction of commercial and military supersonic aircraft has raised the question of whether sonic booms should be considered as severe environmental pollution, with adverse effects on humans, animals, and

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structures (Cottereau 1978). Reviewers of Air Force proposals for new low-altitude training routes and military operating areas frequently express concern regarding the effect of jet noise on wildlife and farm animals (Shotton 1982). Differences in noise from low-altitude subsonic overflight and high-altitude supersonic overflight include the increased duration of noise from a low-altitude overflight, the greater probability that noise from low-altitude overflights will be accompanied by visual perception of the aircraft, and the broad-band frequency distribution of jet engine noise (about 200-20,000 Hz) versus the low-frequency noise of sonic booms (with most of the sound energy between 15-50 Hz).

Much of the knowledge in the past concerning effects of sonic booms was based on occasional booms, many of which had resulted in complaints and claims (Boutelier1968; Bond 1971; Milligan et al. 1983). Although probably not always legitimate, these complaints indicate that concern has developed about the effects of sonic booms, and this concern should stimulate intensified research. However, only a few investigations, under field or simulated conditions, have been undertaken to determine the possible effects of sonic booms. The few documented behavioral observations of animals appear to indicate that sonic booms and subsonic low-altitude-flight noise evoke startle reactions; however, specific reactions differ according to the species involved, whether the animal is alone, and perhaps whether the animal has been previously exposed to sonic booms (Bell 1972). Some animals appear to adapt to the disturbances. Avian species seem to be more affected than mammals.

Trampling, moving, raising the head, stampeding, jumping, and running are among the common reactions reported for mammals exposed to sonic booms (Bell 1972). Birds occasionally run, fly, or crowd. Reactions vary from boom to boom and do not appear to be predictable. Animal reactions to sonic booms are similar to their reactions to low-altitude subsonic airplane flights, helicopters, and sudden noises.

Aircraft noise and sonic booms have been implicated as a cause of lowered reproduction in a variety of animals. The majority of

research on the reproductive effects of noise on animals has been conducted in the laboratory with domestic species, particularly poultry. However, field studies indicate that the reproduction of wild populations may be more affected by noise disturbance than domestic populations. The reproductive effects have primarily been the result of disturbance of the animal's behavior during the reproductive cycle.

In the following sections, literature concerning animal hearing and the effects of aircraft noise and sonic booms on various groups of animals is presented. Some information concerning other types of noise is also included, to supplement the lack of knowledge on the effects of aircraft noise. These sections serve to summarize the literature, not to evaluate the appropriateness or adequacy of the scientific approach of each study.

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3.1 MAMMALS

The sense of hearing has become highly developed and specialized in the mammals relative to other tetrapods (Stebbins 1978; Harrison 1984). Increases in absolute sensitivity to acoustic stimuli in the audible frequency range and enhanced differential acuity to auditory stimuli, such as frequency and intensity, have contributed to the success of the mammals as a group. Evolutionary changes in the structure of the middle ear conducting system, in the cochlea, and, to a lesser extent, in the central nervous system are presumed responsible for the highly developed sense of hearing. The considerable variation in auditory capabilities in the various Orders and Families of mammals reflects the different selective pressures that have played a major role in hearing development. In some mammals, orientation and navigation have emphasized extended high-frequency sensitivity, while in others the obvious adaptive value of tightly knit social organization has placed a premium on the fine discrimination of the small, but significant, changes in the acoustic patterning of intraspecific communication sounds.

The basic characteristics of hearing, communication, and orientation signals were investigated in 30 species of insectivores (e.g., moles, shrews), bats, and marine mammals. The sensitivity of hearing, range of reception, and time parameters were found to be distinctly dependent on ecological factors and the acoustics of the environments of the animals under study (Konstantinov 1978). Animals with exclusively underground life habits (e.g., moles) show hearing of the lowest frequency and relatively high thresholds. A considerable extension of the reception range into the ultrasound frequency zone, with a lowering of the thresholds and more rapid response to the subsequent acoustic signals, was ascertained in species of largely nocturnal life habits. The acoustic system is most refined in animals using ultrasound echolocation for orientation and searching for prey in a tridimensional space, under optically unfavorable conditions (e.g., bats, porpoises).

Sound levels above about 90 dB are likely to be adversive to mammals and are associated with a number of behaviors such as retreat from the sound source, freezing, or a strong startle response. Sound level below about 90 dB usually cause much less adversive behavior. Laboratory studies of domestic mammals have indicated that behavioral responses vary with noise types and levels, and that domestic animals appear to acclimate to some sound disturbances (e.g., Anthony et al. 1959; Bond et al. 1963; Ames and Arehart1972; Espmark et al. 1974; Ames 1978).

Host studies on the effects of noise and sonic booms on mammals have been conducted on laboratory animals (Table 2). However, field studies, primarily investigating behavioral effects, have been conducted on several species of wild mammals.

3.1.1 Domestic Livestock

Surprisingly, the hearing of livestock has not been investigated, with the exception of a few studies that determined auditory thresholds of Suffolk ewe lambs (Ames and Arehart 1972; Ames 1978) and cattle (Ames 1974). The threshold curve of the lambs

declined gradually from 100 to 500Hz, then

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Table 2. Some possible negative effects of noise and sonic booms on animals.

Species	Type of noise	Effect
Domestic livestock:		
Various species	Sonic boom (80-370 mN/m2); low-level subsonic flights (50-200 m) (Nixon et al. 1968; Bond et al. 1974; Espmark et al. 1974).	Startle reaction
Dairy cow	Exploding paper bags (Ely and Petersen 1941)	Cessation of milk ejection
	General noise (105 dB) (Kovalcik and Sottnik 1971)	Reduces feed consumption, milk yield, and rate of milk release
	Tractor engine sound (97 dB) (Broucek et al. 1983)	Increased glucose concentration and leukocyte counts in the blood; reduced level of hemoglobin
	General noise (1 kHz, 110 dB) (Broucek et al. 1983)	Increase in glycemia, nonesterified fatty acids, creatin; decrease in hemoglobin and, thyroxin concentration
Goat	Jet noise (Sugawara et al, 1979)	Reduced milk yield
Swine	General noise (108-120 dB) (Borg 1981)	Influence on hormonal system: increase of plasma 11-OH-corticosterone and catecholamines; decreased corticosteroid level
	General noise (93 dB) (Dufour 1980)	Aldosteronism (excess secretion of aldosterone from the adrenals)
	Recorded aircraft noise (120-135 dB) (Bond et al. 1963)	Increased heart rate
Sheep	White noise (100 dB) (Ames and Arehart 1972)	Higher heart rate and respiration rate; lower feeding efficiency
	White noise (90 dB) (Ames 1978)	Decreased thyroid activity
	General noise (4 kHz, 100 dB) (Ames 1978)	Increased number of corpora lutea; more lambs/ewe
Wild ungulates:		

Reindeer	Sonic booms (35-702 Pa) (Espmark 1972)	Slight startle responses: raising of head, pricking the ears, scenting the air
Caribou	Low-altitude aircraft (<200 ft): fixed-wing, helicopter (Klein 1973)	Running and panic behavior
	Low-altitude aircraft (<500 ft): fixed-wing, helicopter (Calef et al. 1976)	Escape or strong panic reactions
	General noise (Calef 1974)	Increased incidence of miscarriages; lower birth rates
Pronghorn	Low-altitude helicopters (150 ft, slant range of 500 ft; 77 dBA) (Luz and Smith 1976)	Running
Laboratory rodents and rabbits:		
Various species	General noise (150 Hz-40 kHz, 132-140 dB) (Anthony and Ackerman 1957)	"Anxiety-like" behavior
Guinea pig	General noise (128 dB SPL) (Beagley 1965); simulated sonic booms (130 dB) (Hajeau-Chargois et al. 1970)	Anatomical hearing damage; hearing loss
Mouse	Simulated sonic booms (Reinis 1976)	Auditory damage; inner ear bleeding
	Intermittent noise (l10 dB) (Anthony and Ackerman 1955)	Decrease in circulating eosinophils; adrenal activation
	Recorded subway noise (105 dB SPL) (Busnel and Holin 1978)	Longer time interval between litters; lower weight gain of young; increased incidence of miscarriage, resorption and malformations
	Continuous, high-intensity jet engine noise (127 dB); random onset noise (103-ll0 dB); high-frequency noise (l13 dB) (Nawrot et al. 1980)	Decreased pregnancy rate (all groups); decrease in number of implantation sites per litter and fetolethal effects (high-intensity jet noise)
	General noise (106 dB) (Ishii and Yokobori 1960)	Teratogenic effects
Rat	General noise (105 dB SPL) (Moller 1978; Borg 1979, 1981)	Hearing loss; damage to inner ear structure
	General noise (80 dB SPL) (Borg 1978a, b,c)	Vasoconstriction
	General intermittent sound (Buckley and Smookler 1970)	Rise in blood pressure; hypertension
	Recorded thunderclaps (98-100 dB SPL, 50-200 Hz) (Ogle and Lockett 1966)	Increased urinary excretion of sodium and potassium; excretion of oxytocin and vasopressin
	Electric buzzer (110 dB) (Sackler et al. 1959)	Decreased adrenal , body, thymus, spleen, liver, pituitary, ovary, and uterine weights; slight gain in thyroid weight; increased production of ACTH; inhibition of gonadotrphin, ovarian hormones, and possible inhibition of the thyrotrophic and thyroid hormones

	General noise (1 kHz, 95 dB) (Fell et al. 1976)	Suppressed thyroid activity
	General noise (120 Hz, 95-105 dB) (Jurtshuk et al. 1959)	Reduced glutathione levels in blood, increased adrenal weights and ascorbic acid; decrease in total adrenal cholesterol
	Intermittent noise(95 dB)(Hrubes and Benes 1965)	Increased secretion of catecholamines in the urine; increased free fatty acids in the blood plasma; increased weight of the adrenals; inhibition of growth
	General noise (92 dB) (Gamble 1982)	Persistent vaginal estrus prolonged vaginal cornification; higher preweaning mortality of young
	White noise (102-l14 dB) (Friedman et al. 1967)	Change in the hypothalymus
	Electric bell (95-100 dB) (Zondek and Isacher 1964)	Enlarged ovaries; persistent estrus; follicular hematomas
	General noise (Zondek 1964)	Decreased fertility
Domestic rabbit	White noise (107-112 dB) (Nayfield and Besch 1981)	Increased adrenal weights; decreased spleen and thymus weights
	White noise (102-114 dB) (Friedman et al. 1967)	Change in the hypothalymus; higher plasma cholesterol and plasma triglycerides; fat deposits in the irises of the eyes; more aortic atherosclerosis and higher cholesterol content in the aortas
	Electric bell (95-100 dB) (Zondek and Isacher 1964)	Enlarged ovaries; persistent estrus; follicular hematomas
Chinchilla	Simulated sonic booms; general noise (65-105 dB) (Carder and Miller 1971, 1972; Reinis 1976)	Hearing loss; outer cell damage of the cochlea
Wild rodents:		
Desert kangaroo rat	ORV noise (78-110 dB SPL) (Brattstrom and Bondello 1983)	Temporary threshold shift in hearing
House mouse (feral)	Aircraft (110-120 dB) (Chesser et al. 1975)	Increased adrenal weights
Cotton rat	Recorded aircraft noise (110 dB SPL) (Pritchett et al. 1978)	Increased body weights; increased secretion of ACTH
	High-pitched whistles (Hepworth 1966)	Enlarged ovaries; persistent estrus; follicular hematomas
Carnivores:		
Domestic cat	Noisy laboratory (Liberman and Beil 1979)	Hearing threshold shifts; loss or damage to hair cells of inner ear
	General noise (100-1,000 Hz) (Miller et al. 1963)	Hearing threshold shifts
Domestic dog	Sudden loud noises (Stephens 1980)	Increase in plasma corticosteroid concentrations
Farm-raised mink	Simulated sonic booms (167-294 mN/m2) (Travis et al. 1974)	Brief startle reaction

Wolf/grizzly bear	Low-altitude fixed-wing aircraft and helicopters (Klein 1973)	Startle reaction; running
Aquatic mammals:		
Beluga whale	Boat traffic (Acoustical Society of America 1980)	Easily displaced
Pinnepeds	Sonic booms (80-89 dBA SPL) (Jehl and Cooper 1980)	Startle reactions
Elephant seal	Impulse noise created by a carbide pest control cannon (115.6-145.5 dBA) (Stewart 1982)	Alert behavior
Sea lion	Simulated boom (Stewart 1982)	Left beach during non-breeding season and went into surf
other mammal groups:		
Rhesus monkey	General noise (Leq (24): 85 dB) (Peterson et al. 1981)	Increased blood pressure

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decreased rapidly and reached its lowest point at 7,000 Hz. The audiogram for sheep was similar in shape to that for humans, but at a higher frequency (most sensitive at 7,000 Hz). Significant differences were observed among individual sensitivities at different frequencies, with the lower frequencies exhibiting large variations. Therefore, response to sound stimuli can be expected to vary among individuals within a species.

Behavior reactions observed in livestock exposed to sonic booms (80-370 Pa) or low-altitude subsonic flights (50-200 m) have generally consisted of startle reactions that were considered minimal (Nixon et al, 1968; Bond et al. 1974; Espmark et al. 1974). Espmark et al. (1974) suggested that observed reactions (e.g., backward jumping) may be more dangerous for tied-up animals, and that the effects of these disturbances might be more severe for animals under certain physiological conditions, such as gestation.

The use of military aircraft at supersonic speeds has already resulted in damage claims being made (and in some cases, being paid) for alleged injury or losses in domestic livestock (Ewbank 1977). This has prompted a number of investigations of the effects of noise on domestic farm animals, including the physiological effects of aircraft and nonaircraft noise on dairy cows, goats, pigs, and sheep.

0ne of the earliest studies of noise effects on cows was an attempt to determine the relationship between the nervous system and the ejection of milk of three Jersey cows at the Kentucky Agricultural Experiment Station (Ely and Peterson 1941). The left half of the udder of each cow was denervated. After recovering from surgery, all three cows began ejecting milk normally. The denervated half of the udder was able to eject milk just as well as the intact half. 0ne cow was then subjected to various experiments to determine the effect of the nerve supply to the glands under various conditions, such as fright caused by loud noises. Fright was induced by exploding paper bags every 10 seconds for 2 minutes just prior to attaching the mechanical milker. This resulted in an immediate cessation of milk production. Thirty minutes following exposure to exploding paper bags, 70% normal milk production occurred. No difference in response between the two halves of the udder was observed. Injections of adrenalin gave similar results. The amount of adrenalin injected appeared to determine the length of time needed before natural milk ejection resumed. Presumably,

this length of time would be proportional to degree of fright. Fright, such as that caused by a loud sound, could stimulate the natural production of adrenalin.

Parker and Bayley (1960) studied the effects of jet aircraft noise and flyovers on milk production of dairy herds located near existing air bases. Data for 12 months were compiled on the daily milk deliveries of 182 herds located within 3 miles of eight Air Force bases. Although data were lacking at some bases, results of this survey showed no evidence of effects on milk production resulting from jet overflights or proximity to an air base. Milk yield of dairy cows in an area of frequent sonic booms, Edwards Air Force Base, California, was also similar to the yield of control dairy cows; however, the animals had been previously exposed to at least four to eight sonic booms per day prior to data collection (Casady and Lehmann 1967).

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Bond et al. (1974) found no evidence that simulated sonic booms had any effect on eating patterns, total feed intake, or rate of feed intake in dairy cows. However, Kovalcik and Sottnik (1971) found that a noise level of 80 dB (unspecified scale) increased feed intake and the rate of milk-releasing indices, but did not affect the milk yield of dairy cows. (The everyday noise level of the animals' surroundings was 50-60 dB.) Kovalcik and Sottnik (1971) presumed that the noise level of 80 dB was within the limits of the normal tolerance of the animal. When these same animals were exposed to a sudden high-intensity noise (105 dB), feed consumption was reduced as well as milk yield and rate of milk release. The authors found, however, that if the noise is increased gradually, instead of suddenly exposing the animals to the high-intensity noise, the response is not as negative.

Tractor engine sound at 97 dB significantly increased the glucose concentration and leucocyte counts in the blood of dairy cows and markedly reduced the level of hemoglobin (Broucek et al. 1983). An experiment using a tone of 1,000 Hz (l10 dB) resulted in a significant increase in circulating glucosea, nonesterified fatty acids, and creatin; a significant decrease in hemoglobin; and a slight decrease in thyroxin in plasma. High glucose level is a recognized response to stress, in this case, probably sound. The accompanying responses were also the result of stress, and part of the neuroendocrine stress reaction. For example, release of thyroid stimulating hormone (TSH), known to affect growth rates, can be inhibited by negative feedback from adrenocortical hormones after a stress response.

Cottereau (1978) stated that simulated sonic booms had no effect on semen quality or quantity of bulls at an artificial insemination center. Pregnant Charollais cows exposed to 20 simulated sonic booms during the first month of pregnancy gave birth to normal calves. The intensity and frequency of the booms was not described.

Noise (including jet noise) reduced the milk yield in all five goats used in an experiment (Sugawara et al. 1979). The noise had a greater effect on milk yield within the first 3 months after parturition. Sugawara et al. (1979) suggested that intermittent exposure to noise had a greater effect than continuous exposure.

Pigs exposed to120-dB sound for 6 hours showed an increase of plasma 11-OH-corticosterone and catecholamines (Borg 1981). Exposure to 108-dB engine sound for 72 hours resulted in a decreased corticosteroid level, followed by an increase immediately after the stimulation ceased. This biphasic response may indicate a negative feedback effect on the anterior pituitary, which is responsible for releasing ACTH that activates the adrenals during stress. Sound exposure, at least short-term, influences several hormonal systems of pigs.

Excess secretion of hormones from the adrenals, water retention, and sodium retention were observed in castrated male pigs exposed to 93-dB (unspecified frequency) continuous noise over several days (Dufour 1980). Excess aldosterone may be induced by stress, resulting in the upset of the electrolyte balance, which can be manifested by hypertension (possibly due to sodium and water retention), excessive urination, and thirst (Dufour 1980).

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Bond et al. (1963) studied noise effects on feeding efficiency and weight gain of pigs by exposing three to five groups of four to six pigs to recorded aircraft noise at 120-135 dB for 12 hours daily, from weaning to slaughter at 200 pounds body weight. No significant differences between the noise-exposed pigs and controls were observed for rate of feed utilization; rate of weight gain, or food intake, nor was there injury or anatomical change to the organ of Corti of the inner ear.

Heart rate of a large number of weaned pigs was measured before, during, and after sound exposure (Bond et al. 1963). A telemetering electrocardiograph that records heart rate was used to eliminate possible effects of human presence. After a constant heart rate was observed, the experiment was begun. Test recordings of heart rate were made during 15 seconds of prestress, 15 seconds of noise exposure, and 30 seconds of quiet recovery period. Heart rate increased significantly during sound exposure, but decelerated rapidly after the sound was discontinued, although not to baseline rate. No evidence of cochlea injury was found in any of the animals. Histological examination of the thyroid and adrenal glands indicated no evidence of impaired function. Under the conditions of the study, no evidence was found that the pigs were significantly affected by noise. The temporary increase in heart rate was the only indication that noise caused stress.

Pigs, boars, and sows were exposed to reproduced aircraft noise and other loud sounds to determine possible harmful effects on reproduction (Bond et al. 1963). The tape recording consisted of propeller-driven aircraft, jet aircraft in flight, and airfield background noises. The animals were exposed to sound frequencies varying from 100-120 dB. The conception rate of sows exposed to the recorded sounds was similar to that of unexposed sows. The number of pigs farrowed and the number of survivors were not influenced by exposure of the parents to loud sound during mating, or by exposure of sows to reproduced sounds at120 dB for 12 hours daily, beginning 3 days before farrowing and continuing until their piglets were weaned.

The initial physiological responses to sound measured in sheep were heart rate and respiratory rate (Ames and Arehart 1972). Early-weaned lambs were exposed to three sound types: (1) United States of America Standard Institute white noise, (2) instrumental music, and (3) intermittent miscellaneous sound (IMS). Each sound type was studied at two sound pressure levels, 75 and 100dB. The IMS consisted of the following sounds: electrical and diesel engines, jet and propeller aircraft, roller coasters, stadium noise, fog horns, firecrackers, machine guns, cannons, rain, and band marches. White noise and music exposures were continuous. The control period was 21 days with a background noise level of 45 dB. Initial exposure to 75- and 100-dB white noise did not cause a change in heart late in acclimated lambs. In nonacclimated lambs, initial exposure to 100-dB white noise significantly increased heart rate. During the entire test period, nonacclimated lambs exposed to 100-dB white noise had significantly higher heart rate than lambs acclimated at either 75 or 100 dB.

Respiration rate for acclimated lambs was constant when initially exposed to 75 d8, increased rapidly during the first hour, and peaked during the eighth hour. Nonacclimated lambs showed little change in respiration rate

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until the fourth hour, when a rapid increase occurred. After 8 hours of exposure to 100 dB, both acclimated and nonacclimated lambs had significantly higher respiration rates than controls and lambs exposed to 75 dB. This trend continued for the 12-day test

period. Initial exposure to music at 75 dB increased the heart rate. Acclimated lambs exposed to 100 dB music had significantly higher heart rate over the 12-day period compared to lambs exposed to 75 dB. Nonacclimated lambs had significantly higher heart rate than acclimated lambs subjected to both 75 and100 dB. Nonacclimated lambs exposed to 100 dB IMS had significantly higher heart rates than acclimated lambs; however, respiration rates were highest at 75 dB.

Data presented in Ames and Arehart's (1972) study indicated that some physiological responses to sound were characteristic of those of the stress response (e.g., adrenally oriented responses and acclimation to the sound environment). A sudden change that startled an animal usually resulted in tachycardia through action of catecholamines, or bradycardia caused by vagal stimulation. Sound exposures also usually resulted in vagal stimulation, except for nonacclimated lambs exposed to 100-dB white noise. Heart rate response varied less when exposed to music, which suggests that music is less stressful than other sound types. Responses apparently varied by sound pressure level and duration. Respiratory rate appeared to be dependent on sound type (continuous rise in rate during IMS exposure) rather than sound level, with a possible effect of intermittent play versus continuous exposure.

Arehart and Ames (1972) also determined the effect of sound types and intensities on growth and feeding efficiency on early-weaned lambs. Sixty lambs were exposed to the same three sound types and intensities (75 and 100 dB) of the above experiment. White noise at 75 dB significantly increased the average daily weight gain and feeding efficiency. Acclimated and non-acclimated lambs subjected to 100-dB white noise had significantly lower feeding efficiency, which was still higher than the feeding efficiency during the control period. Music at either intensity had no significant effect on performance. Lambs subjected to IMS noise consumed less feed per day than lambs exposed to 75 dB white noise or music. Average daily gain in weight was significantly higher at 75 dB compared to controls and 100 dB IMS exposure.

The pooled data from Arehart and Ames's (1972) experiments indicated that intensity of sound significantly affected growth rate in early-weaned lambs. Again, music was less stressful than other sound types. The data also suggested that acclimation to sound occurred, with respect to daily growth rate. All nonacclimated lambs exposed to 100 dB noise gained significantly less weight than lambs previously exposed to 75 dB noise, suggesting that long-term study is needed to determine whether detrimental effects would actually occur during long-term feeding trials.

Harbers et al. (1975) studied the digestive response of yearling wethers to the same sound types and intensities used in the two studies above: white noise and music presented continuously and IMS. In control metabolism trials, sheep were placed in metabolism crates and exposed to 45 dB background noise for 14 days. Dry matter feed intake was less when sheep were exposed to 75 or 100 dB of each sound type compared to controls. Type of sound had no effect on feed intake. Water intake and urinary output appeared to depend on sound

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type and not intensity. Sheep exposed to IMS consistently drank more water and excreted more urine than sheep exposed to continuous sounds, white noise, or music. If intermittent sounds are more annoying than continuous noise, this might explain why these lambs drank more water. Sound level, type, and the interaction of these influenced fecal moisture. Lambs exposed to 100-dB music or IMS had less fecal water. Music at 75 dB resulted in more fecal water excreted in those lambs, and less when exposed to 75 dB white noise and IMS. However, fecal water was not related to water intake.

Exposure to IMS at 75 and 100 dB not only increased water intake, but also increased metabolizable energy of the ration and improved the apparent nutrient digestibilities. Sound intensity did not affect apparent digestibility coefficients. The high digestibility coefficients for lambs exposed to intermittent sounds suggests that those types of auditory stimuli influenced the digestive system. This increased digestibility of feed, along with water retention, may partly explain the improved growth gain in lambs exposed to IMS. IMS increased metabolizable energy by 100 Kcal/day; no effect of intensity was observed.

Sheep probably acclimated to continuous and intermittent sound of 100 dB or less. None of the sound stimuli seemed to adversely affect digestibility, with intermittent sound actually stimulating digestion. All of the above mentioned effects were short-term only. The effect of intermittent sound on long-term feed intake and digestibility should be investigated. The increased metabolic rate, had it continued, may have proved detrimental to the animal by shortening its life span or causing other physiological changes. Noise exposure above background level may play an important role in digestive efficiency, metabolic balance, and growth rate.

Ames (1978) studied the effects of sound on the endocrine function of sheep. Thyroid activity of 100 lambs exposed to 75-dB and 90-dB white noise was measured and compared to controls. After 14 days of noise exposure, serum samples were collected and analyzed. An index (T4) was calculated and presumed to indicate the level of thyroxin. Lambs exposed to 90 dB showed a significant decrease in this T4 index, indicating that sound was a stressor; decreased thyroid activity is one indicator of stress.

Ames (1978) also examined the effect of sound stress on meat color of sheep. Forty-two lambs were subjected to various sound types and intensities. Color was examined 48 hours after slaughter by visual scores and reflectance spectrophotometry. White noise caused more blue and less red reflectance. Music at 100 dB resulted in brighter visual color. Color change was apparent in the meat of lambs exposed to IMS and white noise, indicating these sound types were more stressful.

As stated by Rylander et al. (1974) and Stephens (1980), sheep are keenly aware of novel stimuli, such as noise or sudden movements. Sonic booms are considered stressors on sheep because they induce a marked startle response that results in physiological changes, however brief (Espmark et al. 1974). Deviations from normal resting levels of various plasma hormones and other elements were detectable in sheep exposed to sudden stimuli, such as noise (Stephens 1980).

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Seventy-nine ewes were evaluated for the effect of sound type (at 100 dB), continuous versus intermittent exposure, and time of exposure (days 12-14 vs. days 14-17) on reproduction (Ames 1978). Exposure to 4,000-Hz pure tone on days 14-17 proestrus appeared to increase the number of corpora lutea produced in the ovary. Ames (1978) presumed that hypothalmic integration of sound stimuli affected the gonadotropin releasing factor, which altered ovarian function. Sound exposed ewes had significantly more lambs born than control ewes. At least over a short-term experiment, white noise or pure tone at 100 dB appeared to have no detrimental effect on reproduction. Several reviewers of noise research on animals also stated that data presently available indicate no impaired reproduction in sheep due to exposure to sonic booms (Ewbank 1977; Cottereau 1978).

3.1.2 Wild Ungulates

Wild ungulates appear to be much more sensitive to noise disturbances than domestic livestock. Behavioral reactions appear to be related to the past history of disturbance (human and aircraft) on the population. Buffalo (Bison bison) on the Wichita Mountains National Wildlife Refuge near Fort Sill Oklahoma, "appeared oblivious" to F-105 overflights (Frazier 1972). The range has been operational since 1957 and is used to fire a variety of weapons, including Honest John missiles. The maximum noise level measured at these sites was below 90 dBA.

The degree of reaction of Arctic ungulates to noise disturbance due to aircraft appears to vary with group size, sex, season, activity engaged in prior to disturbance, previous exposure to noise source, and distance from noise source (Ruth 1976). Reindeer (Rangifer tarandus) kept in an enclosure were exposed to 36 sonic booms (varying from 35 Pa-702 Pa) for 3 days (Espmark 1972). The animals had experienced occasional exposure to sonic booms. No clear differences in reaction were seen between low and high boom strengths. Moderate reactions were found irrespective of boom level. Common reactions were slight startle responses, raising of head, pricking the ears, and scenting the air. Panic reactions or extensive changes in behavior of individual animals were not observed. Reindeer appeared to be more sensitive to disturbances during gestation and the calving season; thus, sonic booms could potentially have some negative influences on reproduction.

Increased use of low-altitude aircraft in remote areas occupied by ungulate populations has focused attention on possible effects of aircraft disturbance on wildlife (Klein 1973). Such disturbance is most detrimental in treeless terrain where escape cover is lacking. 0bservations of flight distances and other behavior of caribou (Rangifer tarandus) in Alaska were recorded in relation to altitude and angle of fixed-wing aircraft and helicopter approach, intensity and frequency of sound, and external factors such as weather and terrain. Running and panic occurred when the aircraft was at altitudes of 200ft or less, and such reactions decreased as flight altitudes increased. Above 500 ft, no panic response was observed. Groups of fewer than 10 animals responded less strongly to the aircraft than larger groups. Groups consisting primarily of cows, calves, and yearlings tended to show a stronger response to the aircraft than groups of bulls. Insufficient

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observations from the helicopter limited comparison of the two types of aircraft, but general observations indicated that animals showed a stronger reaction to the helicopter than to the fixed-wing aircraft. Incidental observations of other wildlife indicated that wolves were least disturbed by aircraft, moose (Alces alces) were less disturbed than caribou, and grizzly bear (Ursos arctos) were the most disturbed of all species observed.

The responses of barren-ground caribou (Rangifer arcticus) to fixed-wing aircraft and to helicopter were observed in the northern Yukon and Alaska (Calef et al. 1976). Escape or strong panic reactions were noted in 65%-75% of all groups observed from the fixed-wing aircraft at altitudes of up to 500 ft, but in only 10%-25% of the caribou observed from the helicopter. Caribou at river crossings reacted more to aircraft than traveling or feeding animals, and resting animals reacted least. Size of group, terrain, or vegetation type did not appear to affect the caribou's response to aircraft. Reactions during the calving season were stronger than during spring and fall migrations. Calef et al. (1976) recommended that aircraft fly at a minimum altitude of 500 ft during summer and fall migrations, and 1,000 ft at other times. Following the herd with a helicopter elicited extreme panic reactions, potentially dangerous to individuals in the herd. Calef (1974) also demonstrated that unfamiliar noise stimuli increased the incidence of miscarriages and lowered the birth rates of caribou.

0n a mesa in New Mexico, reactions of pronghorns (Antilocarpa americana)to helicopters were assessed by aerial photography (Luz and Smith 1976). At an altitude of 400 ft and a slant range from the herd of 3,000 ft, no reactions to the aircraft were observed. Mild reactions (muscle tensing and interruption of grazing) were observed as the craft moved toward the herd at a descent rate of 200 ft/min and a forward air speed of 40-50 knots. Strong reactions (running) began when the craft was at 150-ft altitude and a slant range of 500 ft. Calculated noise levels of no reaction and strong reaction were approximately 60 and 77 dBA, respectively.

Little is known of the long-term effects of noise on the physiology of wild ungulates. However, behavioral changes in wildlife resulting from exposure to sudden or loud noise, such as sustained running or avoidance behavior, cause increased expenditures of energy, which reduces the rate of survival and reproduction. This is particularly harmful during periods of stress, such as late winter. Klein (1973) stated that when aircraft fly at certain altitudes, caribou will run. For a 90-kg animal, the calculated energy expenditure due to aircraft harassment was 64 kilocalories per minute when running and 20 kilocalories per minute when walking. This compares closely to energy expenditure values obtained for other large ungulates when using Gold's (1973) "step rule" that energy cost of locomotion is approximately 3 x 0.0001 calories per gram per step. Under good conditions, increased energy expenditures can be compensated for by increasing food intake. Under adverse conditions, however, such as winter or drought, when increased forage intake is not possible, body reserves are drawn on, resulting in deterioration in the condition of the animals.

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3.1.3 Laboratory Rodents and Rabbits

Host of the research on physiological effects of noise on animals has been conducted with laboratory rodents. The guinea pig has been the laboratory animal most used for studying the mechanics of hearing damage to the ear. Beagley (1965) exposed guinea pigs to 128 dB SPL at 500 Hz for 20 minutes. This intense sound produced irreversible damage to the external hair cells and supporting cells of the third turn of the cochlea. There was no evidence of damage to the nerve tissue. Poche et al. (1968), Pye (1971, 1973), and Bobbin and Gondra (1975) confirmed the occurrence of localized damage and demonstrated that the severity of the damage was dependent on the duration of the exposure as well as sound intensity, and that the location of damage was more variable and widespread at low frequencies than at high frequencies. Conti and Borgs (1964) demonstrated a reduction in cytochrome oxidase activity in the cochlea of guinea pigs exposed to100 dB sound for 3 hours. Hajeau-Chargois et al. (1970) exposed guinea pigs to simulated sonic booms at a rate of one per second. The intensity of each boom was about 130 dB, with no reference level stated. Microscopic examination of the cochleas revealed damage to approximately 10% of the hair cells in the first turn of the cochlea. Covell (1953) reported marked histological changes in the organ of Corti of guinea pigs following exposure to intense sound of 50-100 kHz.

Anthony and Ackerman (1957) studied the stress effects of noise on bodily functions other than hearing in laboratory rodents. Physiological, biochemical, and behavioral effects of intense noise at low and high frequencies were examined using: (1) flame spectrophotometric analysis of serum electrolytes; (2) serum ascorbic acid and blood sugar changes; (3) changes in adrenal and. plasma cholesterol; (4) behavioral changes in noise-exposed rats, mice, and guinea pigs; and (5) relationship of seizure-susceptibility to noise stimulation. A corona speaker was designed and constructed for use in acoustic studies. Short daily exposures to intense noise of about 132- to 140-dB pressure levels induced physiological stress in guinea pigs, mice, and rats by increasing adrenocortical activity (manifested in "anxiety-like" behavior) under stimulation at low frequencies (150-4,800 Hz), and increasing audiogenic seizures at high frequencies (2-40 kHz). Animals appeared to adapt somewhat to noise stress; however, the fact that noise elicits a defense response makes it reasonable to assume that high levels of acoustic noise will overtax the homeostatic adaptive mechanisms.

Auditory damage has also been found in mice exposed to simulated sonic booms (Reinis 1976). Four groups of mice were subjected to a single sonic boom with a 5-msec rise time and duration of 100 msec. Peak overpressure was varied, with values of 1.3, 3.0, 4.0, and 10.0 psf. Mice were sacrificed 72 hours after exposure to the single sonic boom. Another group of mice was exposed to one to five sonic booms at a rate of one every 10 seconds. Although blood clots were never found in inner ears of control mice, they were found regularly in mice exposed to sonic booms of varying rise times and intensities. The blood clots were always found in the scala tympani at the basal turn of the cochlea. Only the superboom (10.0 psf) caused bleeding in more than 60% of the inner ears. The proportion of mice ears experiencing bleeding increased with more rapid rise time and a greater number of booms. Even a single boom having a short rise time of 0.1 msec and a peak overpressure of 3.3 psf caused

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inner ear bleeding. The effects of a short series of sonic booms were cumulative; two or more booms at 10-second intervals caused bleeding, whereas one did not. As few as five successive booms at a rate of only one every 24 hours produced a cumulative effect. The traces of bleeding usually disappeared within 8 weeks after exposure.

Anthony and Ackerman (1955) studied the effects of noise on blood eosinophil levels and adrenals of mice. One group of mice was exposed to intermittent sound of approximately l10 dB (unspecified reference). A timer switch turned the sound on for 100 minutes

and off for 100 minutes alternately throughout the 4-week study. A second group of mice was exposed to a single morning sound exposure of 110 dB for 15 or 45 minutes daily for 1 to 3 months. Anthony and Ackerman (1955) found a slight decrease in circulating eosinophils approximately 3 hours after initiation of the sound stimulus. They also found indications of adrenal activation based on an increase in adrenal weight and by measurement of cellular changes in the adrenal cortex. However, the above stated changes were generally slight and transient. The results indicated that the noise level used was not sufficiently stressful to result in deleterious changes in the adrenals or other organs of the mice.

Busnel and Holin (1978) studied the effect of noise alone and noise plus two other stressors (vibration and crowding) on reproduction of mice. Direct effects of noise and indirect effects of stress reactions of the females were examined. Noise exposure consisted of 1-hr recorded subway noise (approximately 105 dB SPL) played four times daily. No significant differences were found in mothers' weights, number of young born, number of young surviving weaning, or sex ratios of young of the noise-exposed groups compared to the control group. However, noise-exposed mice experienced a longer time-interval between litters and lower weight gain of young. The incidence of miscarriage, resorption, and malformations increased in the stressed groups. Noise alone had less of an effect than when in combinations with the other two stressors.

Teratogenic potential of mice exposed to high intensity continuous noise, high intensity random noise, and high frequency noise was studied in a series of experiments (Nawrot et al, 1980). Groups of mice were exposed to noise during days 1-6 of gestation or days 6-15 (postimplantation). Noise consisted of continuous, extremely high-intensity jet engine noise at levels around 127 dB, random onset noise (i,e., alarm bells, warning devices, jet engine) at 103-110 dB, or high-frequency noise at 113 dB. A significantly decreased pregnancy rate was noted in all groups exposed to noise compared to control groups, except the group exposed to the high-frequency sound from days 6-15 gestation. Significant embryotoxic or lethal effects (decrease in the number of implantation sites per litter) occurred in mice exposed to the extremely high-intensity jet noise from days 1-6 gestation. Significant fetolethal effects occurred in mice exposed to the high-frequency noise from days 6-15 gestation. The fetolethal effects may have resulted from decreased uterine blood flow (possibly caused by catecholamines), resulting in diminished oxygen and nutrient supply to the fetus and retarded removal of waste products. Overall, teratogenic effects did not increase in the noise-exposed mice (all groups combined) compared to the control mice. Ishii and Yokobori (1960) reported teratogenic effects in offspring of female mice exposed to noise at sound pressure levels equivalent to 106 dB.

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Hoffman and Searle (1968) demonstrated that a weak sound signal could inhibit the intensity of the startle reaction in rats in response to an intense sound. Hoffman and Searle (1968) believed that weak signals could activate the neural mechanisms responsible for the startle reaction. They also found that after 675 stimulus exposures the rats had not habituated to the sound.

Holler (1978) and Borg (1979, 1981) studied long-term noise exposure in rats. The goal of these studies was to measure several body functions during the lifetime of the animals and compare their responses under three different noise conditions: (1) no noise except that generated by the animal's own movements, (2) moderate noise level of 85 dB SPL for 10 hours per day, and (3) relatively high noise level of 105 dB SBL for 10 hours per day. Both normotensive rats and spontaneous hypertensive strains of rats were tested. Results showed that the noise exposure levels used in this study did not affect blood pressure in either the normal or hypertensive rats. After 12-15 months of sound exposure, all animals were tested for hearing thresholds. The control animals and the animals exposed to 85 dB SPL did not differ with respect to threshold. The animals exposed to 105 dB SPL suffered significant hearing loss. The normotensive rats had a 30- to 40-dB loss compared to the control rats. The hypertensive rats had a profound hearing loss of at least 60 dB. These rats also showed a corresponding massive damage to the inner ear structures. The results suggested that noise did not cause hypertension, but hypertensive animals were more susceptible to noise-induced hearing loss. Rats housed in an environment where they were exposed to 85 or 105 dB SPL sound for 10 hours a day, for most of their lives, did not show any significant changes in blood pressure, body weight, water consumption, life span, or diseases.

Borg (1978a) studied the vascular response in rats as a function of the duration of a broad-band noise signal of 80 dB SPL. Sound stimuli were presented through a loudspeaker 10 cm in front of the rat and consisted of bursts of varying duration. The rise time of each burst was 1 msec. Sound bursts were presented at 15-minute intervals, with each session lasting between 8 and 12 hours. Noise bursts of durations less than 0.1 second were relatively inefficient for production of vasoconstrictions, and the vasoconstriction habituated slowly when the animal was exposed to continuous 80-dB noise.

Borg (1978b) also studied the sensitivity of vasoconstriction to rate of change of the sound level, using 1.0-sec or 4.0-sec stimulus (same noise signal as the previous study) and rise times of 1, 10, 100, or 1,000 msec. Each session lasted 4 to 12 hours, with the sound presented at 15-min intervals. A 4-sec sound burst produced a smaller vasoconstriction when the rise time was long than when it was short. However, sound bursts with faster rise times were equally efficient. Noise bursts with 1-sec and 4-sec duration gave almost identical vasoconstrictions as long as they had equal rise times, indicating that the vasoconstriction was more sensitive to rapid changes in sound level than slow changes.

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The offset of a continuous noise may elicit a vasoconstriction, but in most cases the vasoconstriction is caused by the onset of noise after the end of a pause (Borg 1978c). A pause as short as 10 msec produced vasoconstrictions the same length as pauses of many seconds' duration. Only for pauses shorter than 10 msec did vasoconstrictions decline . Vasoconstriction reflex was differentially sensitive to onset and offset of noise; onset was a more efficient stimulus. No clear evidence for habituation was apparent. Habituation seemed to depend on the individual animal; some rats showed no response to noise pause, others showed a consistent habituation. Buckley and Smookler (1970) provided evidence that extremely intermittent sounds presented over a few months leads to a rise in blood pressure. Either sound alone or sound in conjunction with other sensory stimuli produced hypertension.

Ogle and Lockett (1966) examined the effects on rats of recorded thunderclaps of 3- to 4-sec duration, frequency range of 50 to 200 Hz at 98 to 100 dB SPL, presented for 2 minutes out of every 15 minutes for 45 minutes. This was compared with effects from a pure tone of 150 Hz at 100 dB presented in the same sequence of time. Urine was collected for analysis of sodium and potassium. Responses were compared among animals that were intact, that had denervated kidneys, and that had neurohypophyseal lesions. Thunderclaps increased the urinary excretion of sodium and potassium by intact rats but not by neurohypophysectomized rats. Ogle and Lockett (1966) concluded that the thunderclaps produced emotional responses, and the pure tone did not. Thunderclaps affected the hypothalamus, resulting in excretion of oxytocin and vasopressin, which produced increases in sodium and potassium excretion with no increase in urine flow.

Sackler etal. (1959) studied the effects of auditory stress on body weight and various body organ changes. One group of rats was subjected individually to 1 minute of intense stimulus, while the control rats spent a corresponding minute in quiet. The stimulus was an electric buzzer with a mean intensity of 110 dB (unspecified reference). The rats received 11 consecutive daily treatments over a 2-week period. Another group of rats was subjected to 15 5-min treatments extending over a 3-week period. Animals exposed to 1-min treatments experienced significant adrenal weight loss and slight loss in body weight, thymus, spleen, pituitary, ovary, and uterine weights: they had a slight gain in thyroid weight. Animals receiving repeated 5-min exposures showed a significant increase in adrenal weights and a significant decrease in liver weights. The stimulus also produced a lowered rate of body weight gains. Similar to the 1-min treatment, weight gain was noted in the thyroid, and weight loss was noted in the thymus, ovary, uterus, and spleen. The 5-min stress stimulus apparently produced the same type of change as the 1-min stimulus, except that the 5-min stimulus changes were more profound. Intense sound, even for brief periods, resulted in serious alterations in weight gain, ovarian (fewer mature ova) and uterine structure, adrenal mass, and pituitary mass in the laboratory rat. The decreased liver weights of the 5-min group, coupled with the loss in body weight and reduced food consumption, may indicate a reduction in the food storage capacity of the liver. Overall, the data provided evidence of increased production of adrenocorticosteroids, inhibition of gonadotropin and ovarian hormones, and possible inhibition of the thyrotrophic and thyroid hormones.

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Increased secretions of adrenocortical hormones due to stress have been related to decreased thyroid function, due to suppressed TSH release from the pituitary. For this reason, Fell et al. (1976) studied the thyroid response of laboratory rats to moderate noise stress. Rats were subjected to a single 1,000-Hz tone at 95d B in 15-min intervals 8 hours per day for 12 weeks. Thyroid activity as measured by radioactive iodine uptake was suppressed in rats exposed to noise. Suppression in female rats began during the first 2 weeks of noise exposure, and between 2 and 12 weeks in the males. Similar sex differences were noted with regard to weight gains. Female rats had significant weight loss during the first 2 weeks, whereas male rats began to lose weight significantly during the sixth week of noise stress. Suppression of cumulative growth rates in females occurred more rapidly than in male rats and appeared to be more severe.

Jurtshuk et al. (1959) subjected female rats to daily intense auditory stimulation (120 Hz, 95-105 dB). Although the animals were visibly disturbed when exposed to intense sound, a seizure pattern was not induced. Intense sound stimulus produced a marked reduction in glutathione (a respiratory carrier of oxygen) levels in the blood. The test animals also showed increased adrenal weights and increased ascorbic acid. Jurtshuk et al. (1959) stated that this finding was similar to reactions associated with chronically stressed animals. Adrenal ascorbic acid content would be greater in animals recovering or adapting to prolonged or repeated stress. The animals also showed a decrease in total adrenal cholesterol, suggesting that the adaptation response of adrenal cholesterol lags behind ascorbic acid response during auditory stress.

Hrubes and Benes (1965) subjected rats to an intermittent noise at 95 dB during 6 hours per day for 5 days with a 3-day pause. After 2 to 4 weeks, they observed increased secretion of catecholamines in the urine, increased free fatty acids in the blood plasma, increased weight of the adrenals, and inhibition of growth.

Studies with rats have shown that loud sound can cause persistent vaginal estrus (Gamble 1982). Prolonged vaginal cornification was produced in rats exposed to daily sound stimulus at levels up to 92 dB. Reducing the ambient sound level from 61 dB to 49 dB, 2 minutes prior to exposing animals to a 92-dB bell, significantly increased duration of the estrus cycle. The estrus cycle of mice stressed by exposure to a pure tone at 92 dB for 6 minutes per hour for 6 days, then left in quiet surroundings, returned to normal; however, despite apparent normal pregnancies, the noise-exposed mice had significantly higher preweaning mortality of young, due mainly to a significant reduction in the number of females able to wean their young.

Nayfield and Besch (1981) exposed laboratory rats and white rabbits to 1.5 hours of white noise per day at intensities of 107-112 dB. The white noise generator was mounted on top of the acoustic chamber. The control animals were exposed to 1.5 hours of white noise per day at a sound pressure level of 60 dB. Compared to the control groups, noise-exposed rabbits and rats had increased adrenal weights. Rabbits also had decreased spleen and thymus weights. Experimental rats had increased total leukocyte counts and a relative eosinopenia. Noise-exposed rats also showed a decrease in food

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intake by the third day of noise exposure. Nayfield and Besch (1981) concluded that organ weight data provided evidence that elevated noise was stressful to both rabbits and rats. The significantly larger adrenals in the experimental animals were indicative of

adrenal hyperfunction.

Friedman et al. (1967) demonstrated findings similar to those of Hrubes and Benes (1965), that auditory stimulation can affect lipid metabolism. Laboratory rats and rabbits were exposed to an auditory stimulus before, during, and after oral intake of fats and cholesterol to test their abilities to handle excess fat while exposed to noise stress. Continuous white noise at 102 dB SPL was presented 24 hours a day, and an additional sound at a level of 114 dB was programmed to occur at random intervals of approximately minutes. Rats were exposed to the sound for 3 weeks, whereas the rabbits were exposed for 10 weeks. Plasma triglycerides were higher in noise-exposed rats; however, no differences between the noise-exposed and control animals were apparent at the end of 3 weeks. In the rabbits, plasma cholesterol and plasma triglycerides were higher than the controls after 4 weeks of sound stimulation. The noise-stressed rabbits also showed fat deposits in the irises of the eyes, more aortic atherosclerosis, and higher cholesterol content in the aortas. Friedman et al. (1967) concluded that the auditory stimulus initiated change in the hypothalamus, affecting the lipid and cholesterol metabolism of the rat and rabbit.

Zondek and Isacher (1964) studied the effect of noise stimulation on the genital function of mature rabbits and both young and mature rats. An electric bell near the animal housing rang 1 minute out of every 10 minutes for 24 hours per day for 9 days prior to mating; peak sound pressure level was 95-100 dB. Auditory stress resulted in enlarged ovaries, persistent estrus, and follicular hematomas in female rats and rabbits; effects were more pronounced in the rabbits. No effects of noise were noted in the male rabbits or rats. Auditory stress induced increased fertility, but pregnancies were often interrupted by auditory stress during the gestation period. Possibly, estrogens and gonadotropins may block or interrupt pregnancy. In another study, Zondek (1964) showed that fertility of both male and female rats decreased with noise exposure.

Chinchillas have been used in several experiments concerning the effect of noise on hearing. Blood clots appeared in the basal turn of the cochlea in ears of chinchillas exposed to single sonic booms of varying rise times and intensities (Reinis 1976). Hearing loss and outer hair cell damage in the cochlea of chinchillas resulted from exposure to sound of 65 to 105 dB from 2 to 21 days (Carder and Miller 1971, 1972). For some intensities and durations, hearing recovery was never complete.

3.1.4 Wild Rodents

Several studies have been conducted on the hearing ability of wild rodents. Heffner and Masterton (1980) compared behavioral audiograms of three feral rodents [cotton rat (Sigmodon hispidus), house mouse (Mus musculus), and kangaroo rat (Dipodomys merriami) and one lagomorph (domestic rabbit). Considerable variation in hearing ability was found among the four

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species, with low-frequency hearing limits varying over 5.5 octaves, from 50 Hz (kangaroo rat) to 2,300 Hz (feral mouse), and high-frequency hearing limits varying from 49 kHz (rabbit) to 90 kHz (feral mouse). Comparison of the characteristics of each audiogram with the audiograms of other animals in the same order, cohort, and class provided further evidence for the validity of two relationships: (1) interaural distance is strongly and inversely correlated with high-frequency hearing ability, and (2) good high-frequency hearing is apparently incompatible with good low-frequency hearing in most, if not all, land mammals. Furthermore, cotton rats and feral mice possess the ability to perform frequency discriminations even at high-frequency levels, and kangaroo rats are not unusual in their ability to localize brief sounds, indicating that these animals have not compromised this ability in the acquisition of their unusual low-frequency sensitivity.

Brattstrom and Bondello (1983) found that off-road vehicle (ORV) noise affected hearing physiology of the desert kangaroo rat (Dipodomys deserti). Peak SPL's measured for ORV's varied from 78 to 110 dB. Dune buggy sounds were played to the animals through an amplifier to produce a sound pressure level reaching 95 dB. The kangaroo rats suffered a temporary threshold shift in their hearing sensitivity. At least 3 weeks were required for their hearing thresholds to recover. Because the ears of kangaroo rats

possess anatomical adaptations to promote amplification of low-frequency sounds, the rats have little means of preventing full amplification in their ears of high-intensity, low-frequency sounds of dune buggies. This could seriously affect their ability to avoid approaching predators.

Only a few studies of the physiological effects of noise on rodents have involved wild animals. A field study by Chesser et al. (1975) involved two populations of house mice near the end of a runway at Memphis International Airport. Adult mice also were collected from a rural field 2.0 km from the airport field. Background noise levels at both fields were 80-85 dB. Noise levels of incoming and outgoing aircraft at the airport field averaged 110 dB, with the highest reading reaching 120 dB. Total body weights and adrenal gland weights of mice from the fields were measured. Additional mice were captured from the rural field, placed in the laboratory, and exposed to 1 minute of 105-dB recorded jet aircraft noise every 6 minutes to determine if noise was the causative factor. Control mice were not subjected to noise. After 2 weeks, the adrenals were removed and weighed. Adrenal gland weights of male and female mice from the airport field were significantly greater than those of mice from the rural field. The noise-exposed mice in the laboratory study had significantly greater adrenal gland weights than the control mice. After ruling out stress factors, such as population density, Chesser et al. (1975) concluded that noise was the dominant stressful factor causing the adrenal weight differences between the two feral populations.

Pritchett et al. (1978) conducted a study to determine if jet aircraft noise alters cortical responsiveness to ACTH in cotton rats. Wild cotton rats were captured and placed in a sound room in a laboratory. Experimental animals were exposed to 30 seconds of recorded jet aircraft noise at 110 dB SPL every 6 minutes for 28 consecutive days. This simulation closely approximated the sound patterns present in the airport habitats of animals in Chesser et al.'s (1975) study with field mice. Total body weights and adrenal weights of rats

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were measured. The adrenals were then quartered and either (1) incubated in the presence or absence of ACTH and analyzed for content of cyclic adenosine monophosphate (cAMP; a molecule believed to moderate some harmful responses) and secretion of corticosterone, or (2) subjected to an initial incubation in the presence or absence of ACTH, followed by a second incubation with ACTH, after which corticosterone content of the incubation media was analyzed. Noise-exposed animals showed significantly greater body weights than the controls. Noise exposure did not significantly alter adrenal weight. During initial incubations, the adrenals from noise-exposed rats in both seasonal groups (spring and fall) showed slight elevations in basal corticosterone secretion rates compared to controls. However, ACTH elicited a significantly smaller secretion of corticosterone in the noise-exposed rats compared to the control groups in either season, and in the autumn as compared to the spring control group. ACTH also produced significantly smaller cAMP accumulations in noise-exposed animals compared to controls. Analysis of ACTH-stimulated corticosterone secretion after incubation with or without ACTH indicated similar significant increases in the relative secretion rate in control and noise-exposed groups not subjected to pretreatment with ACTH. ACTH also elicited significant increases in secretion rate in noise-exposed groups compared to control groups pretreated with ACTH. The data indicated that the intensity and type of noise exposure used in this study may have interacted with the organism to decrease the functional reserve capacity of the adrenal cortex (ability to increase secretory activity in response to physiological stress). Pritchett et al. (1978) suggested that the lack of responsiveness to ACTH in the noise-exposed group may involve a disordering function at some point in the adrenal activating system prior to actual formation of cAMP; cAMP is the intracellular mediator of ACTH in the production of corticosterone in adrenal cortical tissue. The authors also suggested that noise stress plus seasonal factors may restrict the animals' ability to respond to physiologically stressful stimuli.

Hepworth (1966) developed blood values for the cotton rat under average conditions and under conditions of induced stress. Stressors included exposure to cold weather, crowding, insufficient food, lack of cover, continuous light, plus lack of cover, and a continuous, high-pitched loud whistle for periods of 4, 8, and 24 hours. Females survived under stressful conditions better than males. The sound-stressed animals had higher leucocyte counts and exhibited eosinopenia, which is indicative of stress. Eosinopenia

was greater in males than females. Females had a tendency for lymphopenia. The rats reflected all stressful conditions with changes in the hemogram. An inverted neutrophil-lymphocyte ratio appeared to be diagnostic of stress. Of the stressors used in this study, both high density and lack of cover may prove to be major population hazards.

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3.1.5 Carnivores

Predatory mammals can track moving prey at a distance by vision or audition (Langley 1979). In tests where various combinations of vision and audition were deprived and latencies of attack measured, striped skunks (Mephitis mephitis) and opossums (Didelphis virginiana) preferred auditory to visual stimuli of the prey. The coyote's (Canis latrans) preference for use of three senses in hunting was: vision, audition, and olfaction, in order of decreasing importance (Wells and Lehner 1978).

Vocalizations of prey species are sometimes pure-toned calls, which are more difficult to locate than multifrequency calls. Vertebrates do not locate all pure-toned sounds with the same accuracy. In a controlled test, Isley and Gysel (1975) determined how well nine red foxes (Vulpes vulpes) located 13 different frequencies of pure sound, varying from 300 Hz to 34 kHz. Using food as a reward, the foxes were trained to choose the correct location of a 74-dB sound signal emitted from one of two possible loudspeaker positions. The foxes located the sound source best from 0.9 to 14 kHz (<90% accuracy) with a slight decrease in accuracy at 8.5 kHz (84% accuracy). They had the most difficulty locating the source at 0.3, 0.6, 18, and 34 kHz (<78% accuracy). Foxes appear to readily locate a wide range of sound frequencies and may have maximized their chances for locating certain calls, which are presumably difficult to locate.

Audiograms were obtained for two least weasels (Mustela nivalis), using behavioral methods. The hearing range of the least weasel for intensities of 60 dB SPL extends from 51 Hz to 60.5 kHz, with a region of best hearing extending from 1 to 16 kHz (Heffner and Heffner 1985). Hearing in the least weasel appears to be similar to other members of the order Carnivora for which data are available. The high-frequency hearing ability of the least weasel lends additional support to the relationship between functional interaural distance and high-frequency hearing, whereas its sensitivity to low frequencies in the absence of obvious morphological specialization of the middle ear makes the least weasel unusual among the small mammals.

Two wolf (Canis lupus) pups, unexposed to previous wolf calls, were presented a variety of sound stimuli, including standardized recordings of natural and synthetic adult howls (approximately 200-500 Hz) (Shalter et al. 1977). The greatest and most consistent vocal response was elicited by the "real" howls. The nature of the response depended in part upon the: (1) type Of stimulus, (2) number of stimulus presentations, (3) associated manipulations of context, and (4) individual differences in vocal responsiveness. Frequency of pup vocal response varied from approximately 400 to 2,000 Hz. Both extrinsic (environment) and intrinsic (species) factors can determine an animal's response to communication signals.

Liberman and Beil (1979) compared histological data from domestic cats born and raised in a low-noise environment and cats raised in a noisy laboratory environment. Noise-induced hearing threshold shifts were correlated with loss or damage to the hair cells in cochleas of noise-exposed cats. Cats

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from the low-noise environment experienced little cochlea hair cell loss. In each of the noise-exposed animals, hair cells in at least one cochlear region appeared significantly more disordered than in the cochleas of the nonexposed cats.

Miller et al. (1963) confirmed that the sound frequency determined the location of maximal damage to the hair cells in cats. They exposed cats to 115 dB of 100-1,000 Hz for 15 minutes to 8 hours. Permanent threshold shifts were severest for frequencies of 1,000 to 8,000 Hz. Miller et al. (1963) noted that the longer the sound exposure, the greater the threshold shift, and the greater the degree of damage.

Domestic dogs exposed to sudden loud noises produced a large increase in plasma corticosteroid concentrations (Stephens 1980). Techniques for determining plasma corticosteroids in the dog make it possible to evaluate adrenal function. The canine adrenal cortex produces cortisol, the main glucocorticoid.

A study was conducted on Mitkof Island, Alaska, in 1970 to determine the effects of real and simulated sonic booms on late pregnancy, parturition, early kit mortality, and subsequent growth to weaning of farm-raised mink (Travis et al. 1974). The study involved 350 yearling and 148 2-year-old females and their progeny (1,845 kits). Treatment animals received either three real sonic booms (averaging 294 mN/m^2 overpressure) or three simulated sonic booms (averaging 167 mN/m^2) on the day approximately 40% of the females in each group had whelped. Booms occurred over a 60-minute period; the second boom was 45 minutes after the first, and the third was 15 minutes later. The booms caused transient structural vibrations of $10m/sec^2$ or less on the wooden nest boxes. Mean length of gestation, mean number of kits born alive per female whelping, mean number of kits born alive per female, and mean weights of kits at 49 days of age were similar among treatment groups and the control group. The observable behavioral reaction of female mink exposed to real or simulated sonic booms was brief and had no apparent long-term effect on the health and well-being of the females and their newborn kits. Most mink returned to preboom activities within 2 minutes after each boom and appeared to habituate to the acoustic stimuli and vibration of sonic booms after exposure to only three booms in the span of 1 hour. No panic behavior, packing of kits, or killing of kits was observed during the boom tests.

Incidental observations of wildlife disturbed by fixed-wing aircraft and helicopters in northern regions indicated that wolves were less disturbed by aircraft than ungulates; grizzly bears (Ursos arctos) were the most disturbed of all species observed (Klein 1973).

3.1.6 Aquatic Mammals

The auricle and middle ear have undergone significant changes as mammals have adapted to the aquatic mode of life (Solntseva 1975). Conduction of sound signals in water is realized through the closed acoustic duct; efficiency of transmission of acoustic pressure varies with the morphology of the middle ear provided by anatomical changes of auditory ossicles and a character of their arrangement in the tympanic cavity. The definite resemblance of macro-

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and micromorphology of the cochlea has been found in all examined species of aquatic mammals except dolphins. Resemblance of morphology of peripheric parts of the hearing analyzer, in the course of evolution, developed in forms belonging to different phylogenetic stocks but with a similar mode of life. These features define the effective functioning of the ear in different environments.

Mammals that use echolocation or biological sonar to perceive the locations of objects in their environments have unusual acute capacities for localizing sound (echo) sources and for perceiving reverberation, because they rely on echolocation for spatial perception (Simmons 1983). Porpoises determine the distance to targets in water from the arrival time of echoes. The sonar signals

that they emit are directional; porpoises may transmit different waveforms as well as different signal amplitudes in different directions.

The Atlantic bottlenose dolphin (Tursiops truncatus) has exceptionally low-frequency discrimination thresholds, about 6-8 times below those reported for the seal (Phoca spp.) (Herman and Arbeit 1971). Peak hearing sensitivity determined for manatees (Trichechus manatus) (about 3 kHz) is in the range of vocalizations recorded for this species (2-10 kHz) (Bullock et al, 1980). Acoustical communication is an integral component of social interactions among marine mammals and has been studied in walruses (Odobenus rosmarus) (Miller 1985), harbor seals (Phoca vitulina) (Renouf1985), and southern right whales (Eubalaena australis) (Clark 1976).

Myrberg (1978) reviewed the available literature on ocean noise and the hearing ability of marine mammals, primarily the olontocete cetaceans and pinnipeds, because little or nothing is presently known about the subject in other groups of marine mammals. Individual fitness in all species of pinnipeds depends to a great extent on the transmission and reception of acoustical information in the water as well as in the air (Schusterman and Moore 1981). Major features of sound detection, pitch perception, and sound localization are available for otariids [e.g., northern fur seal (Callorhinus ursinus), the sea lion (Zalophus californianus)] and phocids [e.g., ringed seal (Phoca hispida), harbor seal (Phoca vitulina)]. The thresholds for the fur seals, although inferior in air compared to in water, showed good accommodation for hearing airborne sounds (Schusterman 1980). Octariid pinnipeds appear to be more sensitive to airborne sounds than the phocid pinnipeds. One of the major differences between the underwater hearing of otariids and phocids is the high-frequency cutoff (Schusterman and Moore 1978). Although the sample of species and individual s involved in behavioral comparisons is small, comparative anatomical evidence supports the idea that, in water, phocids obtain more spectral information from high frequencies than do otariids. Field observations have indicated that startle or flight reactions to airborne noise habituate at different rates for different species, populations, and groups within a population as a function of age, sex, and time of day (Myrberg 1978). Observations of captive northern fur seals suggest that orientation toward airborne sounds may partly be a function of their hearing sensitivity (Myrberg 1978).

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Harp seal (Phoca groenlandica) cows use visual, auditory, and olfactory clues to locate or identify their pups while on ice flows (Terhune et al. 1979). Identification is made at a close range and the pups are approached from a distance in a random manner. The topography of the ice supporting the pups changes frequently. These changes probably preclude or reduce the use of spatial memory by the adults. Because pups cannot be identified at a distance, and because of the absence of stable landmarks, the cow must probably remain relatively close to her pup at all times. The ability of various mammalian species to use spatial memory may well influence their modes of locating and identifying their young.

Several studies have been conducted on the effects of noise on marine mammals; however, more studies are needed to fully assess the potential impact of aircraft, sonic booms, and other types of noise on this acoustically oriented group of animals (Acoustical Society of America 1980). In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts. Noise sources identified as most likely to produce effects on wildlife were: seismic pulse generators; helicopters and other aircraft; surface vessels, such as tugs and work boats; and vehicles on land and ice, such as trucks, tractors, and snowmobiles. Other possible sources were oil well drilling, island and causeway building, and petroleum and gas production and processing. The known effects of noise on Arctic mammals are limited. Beluga whales (Delphinapterus leucas) are more easily displaced by boat traffic when feeding, and bowhead whales (Balaena mysticetus) appear more wary of noise during spring compared to autumn.

A number of field, laboratory, and library investigations were undertaken between 1978-1980 to assess the potential for adverse effects on biological and physical resources of the Channel Islands resulting from intense sonic booms from launches of the space

shuttle (proposed for southern California) (Jehl and Cooper 1980). Low-flying helicopters, humans on foot, sonic booms, and loud boat noises were the most disturbing influences to pinnipeds. "Loud" sonic booms (80-89 dBA) elicited more startle reactions in animals than "soft" booms (72-79 dBA). Duration of startle responses to loud booms was shorter than to other disturbances. Among the pinnipeds, harbor seals (Phoca vitulina) were most likely to startle; no serious disturbance was recorded among northern elephant seals (Mirounga angustirostris). Historical data indicated that the current level of disturbance on San Miguel Island does not measurably affect pinniped populations. Sonic booms from the space shuttle launches may increase the disturbance level by 10%-20%. Avoiding launches during the pupping season (March-July) was recommended to minimize disturbances. During this season, launches and returns during the noon hours should be avoided to prevent exposure of pups to heat. Temporary decreases in hearing sensitivity of marine mammals could occur following the few intense booms directly over the islands caused by launches of the space shuttle, but these are not expected to have negligible population consequences. Jehl and Cooper (1980) recommended careful observation of behavioral effects of space shuttle booms on Channel Island marine mammals, coupled with long-term population monitoring.

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On San Nicolas and San Miguel Islands in California, breeding elephant seals and sea lions were exposed to loud impulse noise created by a carbide pest control cannon to simulate actual sonic booms (Stewart 1982). Distances of seals from the sound source varied from 5-100 m. Sound pressure level was 145.5 dB(A), 146.9 dB(flat), 20 uPa at 5 m from the cannon and 115.6 dB(A), 125.7 dB(flat), at 50 m from the cannon. The intensity and duration of behavioral responses of each species varied by sex, age, and season. More male elephant seals (74%) reacted with alert behavior than females (65%1); only 26% of the nursing pups reacted. Animals returned to normal activity within a few minutes and no habituation to the sound, movement, trampling of pups, or increase in threat displays were observed. Alert reaction from human intrusion lasted longer than reactions from simulated booms. During the nonbreeding season over 70% of the sea lions left the haul-out areas and went down to the surfline after a simulated boom. During the breeding season, 60%-95% of the females were alert for about a minute after a boom; few males reacted to the noise. No trampling of pups was observed and females moved less than 1 m from their pups.

3.1.7 Other Mammal Groups

Big brown bats (Eptesicus fuscus) use sound at frequencies from 10 to 100 kHz for sonar or for acoustic social communication, and they also hear these ultrasonic frequencies (Poussin 1982). They have a lower frequency region of auditory sensitivity, from 200 Hz to 5 kHz, and may use these lower frequencies to detect insect prey by passive hearing of the insect's own sounds. The hearing is tuned to 0.7 to 1.3 kHz, indicating that some specialization of the auditory system, perhaps in the external or middle ear, may underlie the capacity to hear these lower frequencies.

The resistance of long-eared bats (Plecotus townsendii) to jamming was analyzed by obstacle-avoidance tests in noise of various frequency bands (Griffin et al, 1963). Jamming was significantly more effective in 10-90 kHz noise than in 10-50 kHz noise, but raising the upper limit of the noise spectrum to 120 kHz (with considerable but unmeasured energy above 120 kHz) had no discernible effects. The fundamental frequencies of the bat's orientation sounds sweep from 45 to 25 kHz. Directional discrimination results partly from acoustic properties of the external ears, and partly from a type of binaural interaction between nerve impulses from the two cochleas.

A 7-year-old female Indian elephant was sensitive to low-frequency tones and could hear as low as 16 Hz at 65 dB (Heffner et al. 1979). The frequency of best hearing was 1 kHz, at which the animal's threshold was 8 dB. However, the elephant was insensitive to high-frequency tones and was unable to hear above l2 kHz, at which frequency its threshold was 72 dB. The high-frequency hearing ability of the elephant is the poorest of any mammal yet tested, and the failure of the elephant to hear much above 10 kHz demonstrates that the inverse correlation between head size (i.e., interaural distance) and high-frequency hearing ability is valid even for the largest of terrestrial mammals.

Minimum audible angles were behaviorally determined in macaque (Macaca spp.) monkeys (Brown 1980). Testing was conducted in an anechoic chamber with

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synthetic stimuli that spectraly mimicked representative macaque vocalizations. Localization was tested in quiet and in the presence of a broad-band masker that simulated habitat noise. The results showed that the optimal signal structure for localization was dependent on the ambient noise condition; narrow-band signals were most accurately localized. The data also suggested that, in noisy habitats, narrow bands (heightening the signal-to-noise ratio) may be strategic for the design of signals favoring localization, as well as detection of sound. The acoustic structure of the position marking and rallying calls of some primates may reflect these factors.

Peterson et al. (1981) conducted a study using four rhesus monkeys to explore the possible long-term effects of noise on blood pressure and to determine if a decrease in auditory function accompanies the cardiovascular changes. The monkeys were kept in the experimental environment for 6 to 9 months before the study began. Two monkeys were exposed to 9 months of a daily "round-the-clock" tape recording of miscellaneous sounds to simulate the noise exposure of an industrial worker. The tape included an 8-hour period of intermittent and continuous industrial noise, transportation noise before and after the work day noise period, household noise in the morning and evening, and low-level sounds, such as aircraft overflight noise, during the night. The overall equivalent noise level (Leg (24)) was 85 dB. The two control animals were kept in a low-level noise environment. After 9 months of exposure to the above sounds, both experimental monkeys had elevated blood pressure. Compared with the control monkeys, the net increase in blood pressure for the experimental animals was 18.7 mm Hg, or 22.9%. Blood pressure was highest in the experimental animals during the most intense noise episodes. No permanent noise-induced changes in auditory sensitivity were found. once noise exposure was terminated, blood pressure remained elevated and showed no indication of returning to normal.

3.2 BIRDS

Psychophysical investigations of hearing in a number of avian species over the last two decades have added significantly to the knowledge of hearing capabilities of this vertebrate group. Behavioral measures of absolute auditory sensitivity in a wide variety of bird species show a region of maximum sensitivity between 1 and 5 kHz, with a rapid decrease in sensitivity at higher frequencies. On the basis of this general measure, birds fall between two other major vertebrate groups: reptiles and mammals. Discrimination and masking data from birds include measures of frequency, intensity, and duration difference thresholds (critical ratios, critical bands, and psychophysical tuning curves). Data are also available on temporal summation, temporal resolving power, and temporary threshold shift from noise exposure. Taken together, these data suggest that, in the region of 1-5 kHz, birds show a level of hearing sensitivity similar in most respects to that found for the most sensitive members of the Class Mammalia, with avian performance clearly inferior above and below this range of frequencies (Dooling 1978). Possible exceptions to this general picture include the echolocating oilbird (Steatornis caripensis) and growing evidence that pigeons (Columba livia) are sensitive to infrasound at moderate intensity levels. The relation among critical ratio, critical band, and intensity difference threshold measured in the parakeet is

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similar to that described for the human, but the pattern of masking as a function of frequency is dramatically different from that observed in mammals (Dooling and Searcy 1981). Examples of a correspondence between hearing sensitivity and vocalizations can be demonstrated in a number of species.

Adaptations for directional hearing among nonmammalian vertebrates are quite diverse and include morphological and physiological mechanisms at both peripheral and central levels, as well as behavioral strategies (Fay and Feng 1983). The terrestrial nonmammals are all faced with similar problems in sound localization, including a relatively small interaural distance and generally poor high-frequency hearing. However, birds localize sounds well. In some species, the ear shows a complex, frequency-dependent directionality; the wide coupling of the two middle cavities via the mouth lead to acoustic interactions that enhance interaural time and intensity differences, particularly at low frequencies. Some owls may use more "mammalian" mechanisms for azimuthal localization in addition to a vertical asymmetry in ear position, which gives rise to interaural cues for elevation.

The songs of birds are produced by the modulation of air streams in the syrinx of the singing bird. The notes produced may be modulated in amplitude or frequency and serve to carry information. The range of frequency over which birds produce song spans at least seven octaves from 80 Hz for the spruce grouse (Dendragapus canadensis) to 11 kHz for the cowbird (Molothrus ater) (Knight 1974). Noises in display may also be produced by other means. The use of a given sound structure depends on the physical characteristics of the habitat in which it is commonly used. Compared to mammals, the avian ear falls off more rapidly in sensitivity with increasing and decreasing frequency. Environmental noise, such as wind and falling rain, are predominantly of low frequency, and the avian ear acts as a high-pass filter to filter out incoming sounds at lower frequencies.

The ability of an animal to localize sound is correlated with its behavioral niche. Birds face a particularly difficult task in sound localization because they must localize well in both azimuth and elevation; the azimuth of a target is of no use to an airborne predator unless it can also determine the target's elevation (Knudsen 1978). Furthermore, birds must perform sound localization with access to only a limited range of low sound frequencies (<12 kHz), with heads that provide little sound shadow and ears that have no pinnae and are close together. However, behavioral, physiological, and anatomical data suggest that the auditory systems of birds are capable of extremely fine time resolution. Also, birds have a large, elaborate patent air canal connecting their two middle ears, which might improve the ears' directional properties. Finally, some birds have developed asymmetrical ears that cause interaural time and interaural intensity cues to assume different axes of symmetry. These adaptations permit birds to achieve a high level of sound localization ability, the best of which rivals and may exceed that of man.

Hearing may play an important role in bird migration. Griffin and Hopkins (1974) measured sound levels of frog choruses at altitudes of up to several hundred meters. Bullfrog (Rana catesbeina) choruses from small ponds often were recorded by a radio microphone up to 500 m, and on an especially favorable

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night with light winds, they were clearly audible even at 965 m at about 20 dB SPL in the 1.5 to 2.5 kHz frequency band. Sound travels upward much farther and more predictably than along the surface. Many natural sounds, including those from frogs, insects, whitecaps, and perhaps wind-blown vegetation, arise from large areas and therefore act as extended sources. The intensities of such sounds decrease with altitude more slowly than expected from the inverse square law. Natural sound fields provide migrating birds with a potential source of information about the kind of land or water below them, and their progress over acoustic landmarks could inform the birds about wind velocity. Because atmospheric absorption increases with frequency, several hundred meters of air act as a low-pass filter; thus, altitude could be estimated from the relative reduction of higher frequencies in a familiar sound. Early balloonists studied ground echoes of shouts and other loud sounds generated in the balloon, and they sometimes noted much louder and clearer echoes from lakes or streams than fields or woods (D'Arms and Griffin 1972). This suggests the possibility that nocturnal migrants could employ a crude form of echolocation, provided that their flight calls are loud enough to generate audible

echoes from the surface. No data are available on the degree to which sounds originating at the surface (or echoes from the surface) differ in acoustic spectrum depending upon the direction from which they are heard. If breaking waves or other sounds generated by the wind sound different according to their direction, this could theoretically provide directional information to a migrating bird.

A concern associated with aircraft, and peculiar to this group of animals, has been the potential for bird strike hazards in areas located near airports (e.g., U.S. Department of the Interior 1969). Birds are attracted to airports because of the absence of predators and the presence of roosting, bathing, drinking, and feeding areas (Burger 1983). About 75%-90% of all civil aircraft strikes occur near airports, mostly while planes are taking off and landing. Birds are struck because they do not perceive the threat, or cannot avoid the plane once they perceive it. The number of bird strikes has increased with the faster speeds of aircraft. Burger (1983) examined noise levels of departing and landing aircraft at J.F. Kennedy International Airport in New York, as a function of type of aircraft, and related the types of aircraft to incidence of bird strikes. In general, the wide-bodied aircraft (Boeing 747, L1011, DC10) were significantly quieter than the narrow-bodied aircraft (Boeing 707, 727). Noise levels varied when approaching planes were different distances from the test site. Noise levels did not rise significantly higher than predeparture levels until the planes were between 600 and 800 m from the test site; the planes traversed this distance in an average of 9-14 seconds. For landing planes, the narrow-bodied planes were significantly louder than the wide-bodied planes at touchdown, only 600 m from the test site. Wide-bodied planes had significantly more bird strikes than the narrow-bodied aircraft. These results indicate that birds have less warning of an approaching wide-bodied aircraft than they have for narrow-bodied aircraft. The bird's behavior of facing and flying into the wind (in the same direction that the airplane is moving) decreases the flight speed of the bird and increases the risk of a bird strike, particularly for the wide-bodied aircraft.

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The majority of studies on the effects of noise on birds have dealt with reproductive affects of poultry or behavioral response (i.e., the noise is detected and a startle response may occur) of wild birds; little work has been done on the effects of noise on the physiology of wild birds (Table 3). Birds appear to be more affected behaviorally by a sonic boom than domestic mammals (Casady and Lehmann 1967; Bell 1972; Ewbank 1977; Cottereau 1978). Investigators have been particularly concerned about the potential adverse effects of aircraft noise and sonic booms on the behavior of wild breeding birds, which ultimately could disrupt their reproductive cycle. In addition, a bird startled during incubation could inadvertently knock an egg out of the nest.

3.2.1 Poultry

Intense noise may affect growth of chickens. White leghorn chicks subjected to simulated sonic booms (156.3 dB peak flat) weighed significantly less at 19 days than the control chicks (Jehl and Cooper 1980). However, Stadelman (1958a) found no effect on growth when young chickens up to 10 weeks of age were exposed to various sound intensities produced by recorded flyovers of propeller driven and jet aircraft and background airfield noises (80-118 dB). Stadelman (1958a) did report violent behavioral response (crowding, which resulted in one chick being smothered) to intermittent sound exposure at 100-118 dB and stated that loss in a pen of broilers was more likely to occur from an isolated low-altitude flyover than from continuous noise resulting from close proximity to an airfield. He also speculated that actual flyovers may have different effects, but that sound alone had no effect.

An increase in 11-hydrocorticosteroid in blood plasma was noted in hens exposed to 100 dB noise (unknown reference) 30 minutes daily for 7 days. A slow increase in baseline steroid level was observed in leghorns only (Borg 1981).

In laboratory studies on avian production using white leghorn hens, simulated sonic booms (156.3 dB peak flat) had no effect on oviposition, hatchability, viability, or hatching time (Jehl and Cooper 1980). Recordings of aircraft flyovers were played for 5 minutes out of every 20 minutes for 12 hours daily during incubation of chicken eggs (Stadelman 1958b). Sound intensities of 96 dB in the incubators also had no measurable effect on hatchability or quality of chicks produced. However, sound intensities of 115 dB were effective in interrupting brooding of 11 of 12 hens exposed to recorded flyovers.

Hamm (1967) showed that a single short stress due to aircraft noise did not affect poultry egg production, but longer periods of stress (3 or more days) reduced egg production. Hamm (1967) attributed the loss of egg production to a change in behavior (hens kept from feed and water due to noise stress), not to a physiological change.

Chicken eggs (3,415) were exposed to over 600 sonic booms during the incubation period (Heinemann 1969). Sonic booms were produced by aircraft approaching from eight different directions, creating free-field overpressures from 3-19 psf. When compared with control eggs, no significant differences in

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Table 3. Some possible negative effects of noise and sonic booms on birds.

Species	Type of noise	Effect
Poultry:		
Domestic chicken	Simulated sonic booms (156.3 dB) (Jehl and Cooper 1980)	Decrease in weight of 19-day-old chicks
	General noise (100 dB) (Borg 1981)	Increase in 11-hydrocorticosteroid in blood plasma
	Recordings of aircraft flyovers (115 dB) (Stadelman 1958b)	Interruption of brooding
	Aircraft noise (3 or more days) (Hamm 1967)	Reduced egg production by keeping hens from feed and water due to noise stress
Japanese quail	General noise (100-8,000 Hz, 80 dB) (Woolf et al. 1976)	Accelerated hatching
Laboratory birds:		
Canary	White noise (95-100 dB SPL) (Marler et al. 1973)	Hearing loss (20-60 dB)
Waterbirds:		
Brant/geese	Low-altitude aircraft (helicopter, jet, propeller) and other human disturbances (Ward et al. 1986)	Flight response
Snow goose	Cessna 185 (300-10,000 ft AGL) (Gunn and Livingston 1974)	Flight response; reductions of flock size
Waterfowl/seabirds	Low-altitude aircraft (float-plane, fixed-wing, helicopter; 100-750 ft AGL) (Gunn and Livingston 1974)	Flight response
Seabirds	sonic booms (72-89 dBA SPL) (Jehl and Cooper 1980)	Startle responses; flushed off nest

	Simulated sonic booms (155.6-145.5 dBA) (Stewart 1982)	Flushed and circled; returned to roost within 2-10 minutes
Sooty tern	Frequent sonic booms (Austin et al. 1970)	98% reduction in reproduction of the colony
Herring gull	Low-altitude supersonic transports (Burger 1981)	More fighting; lower clutch size due to broken eggs during fighting bouts
Herons	Helicopter flyovers; fixed-wing (60-120 m) (Kushlan 1979)	Alert reaction
Lapland longspur	Low-altitude helicopters (Gunn and Livingston 1974)	Lower hatching and fledging success; higher nest abandonment; premature disappearance of nestlings
Raptors:		
Bald eagle	Aircraft (jet, propeller) (Fleischner and Weisberg 1986).	"Turning of the head to at the jet" (5% of the observations), flying from a perch site (5%)
Eagles/hawks/ falcons	Low-altitude jets and sonic booms (82-114 dBA) (Ellis 1981)	"Noticeably alarmed" responses
	Helicopter (White and Sherrod 1973)	Panic, frantic escape behavior when helicopter appeared from over the top of a cliff
California condor	Blasting, drilling, sonic boom, low-altitude aircraft (Shaw 1970; Wilbur 1978)	Adults flush from nest; some nests abandoned
Songbirds:		
Unspecified	Sonic boom (1.15 mean psf) created by F-ill jets (Higgins 1974)	Continuous songs of birds were completely silenced 4-8 sec prior to the arrival of the audible sonic boom; "raucous discordant cries" for a few seconds when boom was audible, returned to "normal songs" within 10 seconds after the audible boom
Raven	Sonic boom (Davis 1967)	Raucous calling, flapping, soaring, and chasing by groups of ravens

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hatchability or teratogenic effects were observed, of the chickens raised to sexual maturity, onset of egg laying and egg production were similar between birds exposed to sonic booms and the control group.

The daily egg production of a pheasantry located within 0.75 km of the source of simulated sonic booms (50 mN/m^2-860 mN/m^2) appeared to fall on days subsequent to boom activity; however, when compared with production trends over two other seasons during which no boom activity occurred, the similarities implied that the day-to-day variations were due to some other, unknown

influence (Ruddlesden 1971). Also, the pheasantry was located in an area previously exposed to frequent impulse noises from a testing range prior to this study; thus, results of the sonic boom tests probably provide little useful data for determining the effects of sonic booms. The rate of fertility in the pheasantry was highest for the season when sonic booms occurred.

One 2-hour exposure to auditory stimulation (80 dB, 0.1-8 kHz) during the last 3 days of incubation accelerated the hatching of Japanese quail (Coturnix japonica) (Woolf et al. 1976). The data provided evidence that short-term prenatal sensory stimulation can affect the development of an avian embryo.

In a survey of farm animals in the vicinity of Edwards Air Force Base, sonic booms had no significant effect on turkey egg production (Casady and Lehmann 1967). These turkeys had been exposed regularly to sonic booms prior to the survey, and data were not compared to egg production of turkeys in years prior to sonic booms.

3.2.2 Upland Game Birds

The behavior of four wild turkey (Meleagris gallapavo) hens on their nests was observed during real and simulated sonic booms (Lynch and Speake 1978). Simulated sonic booms were produced by firing 5-cm mortar shells, 300-500 ft from the nest of each hen. Recordings of pressure for both types of booms measured 0.4-1.0 psi at the observer's location. Hens exhibited only a few seconds of head alert behavior at the sound of the sonic boom. No hens were flushed off the nests, and productivity estimates revealed no effect from the booms. Twenty brood groups were also subjected to simulated sonic booms. In no instance did the hens desert any poults, nor did the poults scatter or desert the rest of the brood group. In every observation, the brood group returned to normal activity within 30 seconds after a simulated sonic boom. Teer and Truett (1973) observed no difference in hatching success of bobwhite quail (Colinus virginianus) exposed to simulated sonic booms of 100-250 uN/m^2.

3.2.3 Laboratory Birds

Homing pigeons can detect sounds up 200 Hz and extremely low-frequency sounds (infrasounds) as low as 0.05Hz (Kreithen and Quine 1979). Below 10 Hz, the pigeons were at least 50 dB more sensitive to sound than humans. Natural infrasounds come from many sources, including weather patterns, topographic features, and ocean wave activity. Infrasounds propagate long distances and can be detected hundreds or even thousands of km away from their sources. Because homing pigeons fly at about 6% the speed of sound, they can produce Doppler shifts in flight of plus or minus 6%. The Doppler effect

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refers to the change in the frequency with which waves from a source reach a receiver when the two are in rapid motion with respect to each other so that the frequency increases or decreases according to the speed at which the distance is increasing or decreasing. Pigeons have been shown to detect such frequency shifts in the laboratory (Quine 1979). A Doppler shift mechanism may provide cues for localization of outdoor infrasonic sources. The interaural differences of intensity and phase probably are too small to use at infrasonic frequencies (wavelengths are tens or thousands of meters).

The pigeon has a well-developed ability to detect weak vibrations (Shen 1983). The threshold-frequency relationships indicated that the greatest sensitivity to vibrational stimuli was in the frequency range from 300-1,000 Hz, with thresholds of about 0.1 mm at 500 Hz. Pigeons can respond not only to the frequency of a stimulus, but also to its intensity. Vibration detection may be crucial for sensing approaching predators, for instance, when birds are sleeping perched on a branch.

Marler et al. (1973) investigated the effects of loud noise on vocal development of canaries. Canaries were subjected to white noise at 95-100 dB SPL located 20 cm away. This level corresponded to about 90-95 dB above their auditory threshold at their most

sensitive frequencies. About 70 young canaries were raised by their parents to independence (40 days) under these sound conditions. After 40 days exposure, canaries experienced a 20-dB hearing loss. The males were then separated into three groups: (1) five were surgically deafened, (2) five were housed in a quiet acoustical chamber until sexually mature, and (3) 11 were left in noise until 200 days of age or sexually mature. All birds exposed to the 95- to 100-dB noise became partially deaf. After 200 days exposure, hearing loss was 50-60 dB, with the sensitivity peak shifting towards lower frequencies. From comparison of birds raised in a noise environment to those placed in noise as adults, no systematic differences relating to age of exposure were detected.

The deafened birds showed little to no ability to sing. Birds raised in noise for the first 40 days then placed in acoustical isolation had a slight reduction in the repertoire size of their song, about 13.9 syllable types, compared to a mean of 5.0 syllable types in deafened birds. Birds left in the noise environment up to 200 days of age behaved similar to the surgically deafened birds; these birds had a mean syllable repertoire size of 3.5. This finding indicated that noise at 90-100 dB was effective in masking the canaries' hearing of their own vocalizations. A few months after noise was terminated, their syllable repertoire improved, presumably as a result of restoration of the birds' ability to hear their own songs.

3.2.4 Waterbirds

On the day prior to hatching, wood duck (Aix sponsa) embryos were tested for their response to a taped maternal call of a wood duck or a mallard (Anas platyrhynchos) at acoustic levels of 80-82 dB (Heaton 1972). Sixty-five percent of the embryos receiving the species-specific call increased bill- clapping during stimulus presentation, and 75% of the embryos receiving the mallard call decreased bill-clapping. During each call, the heart rates of embryos increased significantly. Because the wood duck's postnatal behavior

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with respect to the species-specific call was inconsistent, the demonstrated prenatal specificity may require some sort of supportive auditory input, perhaps similar to that occurring in the natural situation, to maintain and carry over for functional significance into postnatal life.

On Izembek Lagoon, near the western end of the Alaska Peninsula, observations during fall 1984 indicated that Pacific black brant (Branta bernicla nigricans), emperor geese (Chen canagica), and Canada geese (Branta canadensis) were disturbed by helicopter traffic across the lagoon (Ward et al. 1986). Air traffic was associated with an existing 3,050 m runway at Cold Bay (<15 km from the east side of the lagoon), used in conjunction with outer Continental Shelf petroleum exploration in the St. George Basin. U.S. Fish and Wildlife Service personnel were concerned that disturbance-induced flight might reduce brant foraging efficiency and feeding time. In a preliminary study undertaken from 23 September to 21 October 1985, the responses of geese to aircraft and other disturbances were observed from six sites along the shoreline of Izembek Lagoon, during a total of 260 hours. A total of 623 possible disturbance events for all geese was recorded, with 65% of these events caused by jets and propeller aircraft, 14% by helicopters, 14% by gunshots, 2% by people, 2% by boats, 2% by eagles, 1% by falcons, and less than 1% each by land vehicles and foxes. All but 22 events were human-induced disturbances. The level of behavioral response differed greatly among the various disturbance stimuli. Eagles, boats, and humans on foot caused a greater percent of flight in brant flocks than any category of aircraft; however, the lateral distances to these stimuli were much less than that typical for aircraft overflights. The Bell-206-B helicopter seemed to cause a greater degree of behavioral flight response compared with similar controlled overflights by single-engine, fixed-wing aircraft.

Disturbance to waterfowl and seabirds during breeding and nonbreeding seasons was studied in the Mackenzie Valley and North Slope of Alaska and Canada (Gunn and Livingston 1974). Float-plane disturbance over 3 days decreased the waterfowl population on a small (0.08 mi^2) experimental lake by 60%; numbers remained stable on a small control lake until a low passing bald eagle (Haliaeetus leucocephalus) caused 45-50 birds to leave the lake. Numbers of waterfowl on larger lakes (0.10-0.62 mi^2) declined

slightly during the disturbance, but population data were inconclusive because of problems obtaining consistent counts. Nonbreeding birds appeared to be more disturbed by people and by aircraft (fixed-wing and helicopter) than were nesting birds. Bolting waterfowl were driven from land by helicopter disturbance 100 yards from shore at altitudes of 100-750 ft AGL. Surf scoters (Melanitta perspicillata) appeared to be more sensitive to the disturbances than oldsquaws (Clangula hyemalis). Resting snow geese (Chen caerulescens) were disturbed by a Cessna 185 at altitudes varying from 300-10,000 ft above ground level. Geese tended to flush at greater distances when the aircraft was under 1,000 ft above ground level. After severe disturbance, snow goose flock sizes were reduced, with a consequent increase in the number of flocks. Geese were driven from a 50-m^2 area by "hazing" with a Cessna 185. Curtailing aircraft flights over the premigratory staging areas between 15 August and 30 September was recommended.

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0ther studies also have indicated that waterfowl, particularly geese, are easily disturbed by aircraft. In the Alaska Arctic, recent experiments have shown that snow geese are sensitive to aircraft disturbance, and low-level (150 m above ground level) aircraft overflights elicited a stronger response from molting, flightless sea ducks (particularly, oldsquaw) than higher level overflights (Acoustical Society of America 1980). In a questionnaire survey on the impact of helicopters in areas of heavy wildlife use, respondents noted that Canada geese and snow geese appeared to be more disturbed by helicopter noise than turkey vultures (Cathartes aura), pronghorns, coyotes, and raptors (Edwards et al. 1979).

Behavioral responses of seabirds to several types of disturbances (including human and noise) were studied on the Channel Islands of California (Jehl and Cooper 1980). In decreasing order of impact, humans at roost sites, helicopter overflights, and sonic booms disturbed birds. "Loud" sonic booms (80-89 dBA SEL) elicited more startle reactions in birds than "soft" booms (72-79 dBA). Duration of startle responses to loud booms was shorter than to other disturbances. Historical data indicated that the current level of disturbance on the islands does not measurably affect seabird populations. However, sonic booms from proposed space shuttle launches over the islands may increase the disturbance level by 10%-20%. Jehl and Cooper (1980) suggested that launches and returns of the space shuttle during the noon hours should be avoided over the nesting season to prevent exposure of seabird nestlings to excessive heat. In noise disturbance tests (shotgun blasts, explosives) at seabird colonies, startled birds that flew from their nests did not knock their eggs from the nests, and the birds returned within 30 seconds. Birds were more susceptible to disturbance while they were roosting or courting than during nest-building, incubation, or rearing young, when their tendency to remain at their nest site was strong.

Also on the Channel Islands, incidental observations of seabirds during behavioral response tests of marine mammals exposed to loud impulse noise created by a carbide pest control cannon (simulating actual sonic booms--115.6 to 145.5 dBA at the source) indicated that most birds within 100 m of the cannon flushed and circled the site (Stewart 1982). Within 2-10 minutes after the simulated boom, birds returned to roost or continued their previous activities.

The greatly increased use of helicopters and fixed-wing aircraft to support the exploration and exploitation of oilfields in the North Sea gives rise to concern about possible disturbance to seabirds breeding in the flight paths (Dunnet 1977). Behavior observations were made at a mixed colony of fulmars (Fulmarus glacialis), shags (Phalocrocorax aristotelis), herring gulls (Larus argentatus), kittiwakes (Rissa tridactyla), guillemots (Uria aalga), razorbills (Alca torda), and puffins (Fratertula arctica) breeding on the Buchan Cliffs about 40 km north of Aberdeen, on 2 days during egg-laying and early nestling stages of the breeding season. The number of birds in attendance at nests or nesting ledges were counted before and after the passage of aircraft, and general observations were made when the planes were overhead. The number of identifiable nests with 0, 1, or 2 adults was noted because disturbance might be most sensitively detected by the departure of nonincubating, brooding adults. No evidence was found to suggest that aircraft

flying at heights of about 100 m above the cliff top affected the attendance of incubating and brooding birds, and there was only a slight indication that a few of the "second adults" at kittiwake nests may have flown off. Groups of kittiwakes resting on nearby cliffs or on the sea did take to the air in response to the planes, but they also did so frequently in the course of the day with no obvious cause. Dunnet (1977) stressed that these findings cannot be extrapolated to other species of seabirds or to different conditions.

Disturbance to waterfowl, seabirds, and terrestrial breeding birds was studied in the Mackenzie Valley and North Slope of Alaska and Canada (Gunn and Livingston 1974). Low-flying helicopter disturbance and human activity did not affect the population density of lapland longspurs (Calcarius lapponicus); however, lower hatching and fledging success, and higher nest abandonment and premature disappearance of nestlings occurred on the disturbed site compared to the control site. In colonies of Pacific black brant (Branta bernicla) common eiders (Somateria mollissima), glaucaus gulls (Larus hyerboreus), and Arctic terns (Sterna paradisaeae), human presence appeared to affect incubating behavior of birds more than fixed-wing aircraft or helicopters. Helicopters were more disturbing to birds than fixed-wing aircraft. Indications were that disturbance as a whole may be detrimental to the nesting success of black brant and Arctic terns. In the Alaska Arctic, nesting common eiders have also been disturbed by low-flying, small, fixed-wing aircraft and by helicopters (Acoustical Society of America 1980).

In 1969, approximately 50,000 pairs of sooty terns (Sterna fuscatus) returned to nest in the Dry Tortugas colony in southern Florida, laid their eggs, and started incubating normally (Austin et al. 1970). When the authors arrived in mid-June to band young, they found 242 sooty chicks instead of the normal 20,000-25,000 chicks; 98% of the tern population had failed to reproduce successfully. About half the normal number of adults were still present and were markedly wild and restless. Apparently, only a few of the earliest-laid eggs had hatched, a few eggs were still being incubated; the rest were deserted and contained dead, partly grown embryos. The colony also contained approximately 2,500 brown noddies (Anous stolidus) whose young hatched successfully. Most possible causes of the sooty terns' nesting failure were ruled out, with the exceptions of an overgrowth of island vegetation (which made it difficult for sooties to reach their nests in the more populous sectors) and frequent sonic booms by jet planes. The booms were almost a daily occurrence and some were strong enough to shatter windows on adjoining Garden Key. Birds reacted to the occasional sonic booms of previous seasons by rising immediately in a "panic flight," circling over the island momentarily, and then usually settling down on their eggs again. The authors had no evidence that sonic booms caused physical damage to the sooty tern eggs, but felt that the strong booms occurred often enough to disturb the sooties' incubating rhythm and cause nest desertion. Actions were taken to curb planes breaking the sound barrier within range of the Tortugas, and much of the excess vegetation was cleared. In mid-May 1970, the birds appeared to be having a normal nesting season.

In a study of herring gulls (Larus argentatus) near J.F. Kennedy International Airport, no effects of subsonic aircraft on nesting gulls were

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noted (Burger 1981). However, when supersonic transports flew over, significantly more nesting gulls flew from their nests, and they engaged in more fights when they landed compared with the other conditions. Many eggs were broken during these fights, and eggs were subsequently eaten by intruders. At the end of the incubation period, mean clutch sizes were lower in dense sections (more potential for fights) of the colony compared with solitary nesting pairs of gulls.

Black et al. (1984) studied the effect of low-altitude military training flights on the establishment, size, and reproductive success of wading bird colonies in Florida. Based on indirect evidence of distribution and turnover rates in relation to jet training routes (<500 ft above ground level) and military operations areas, military activity had no demonstrated effect on colony establishment or size on a Statewide basis. Reproductive activity (including nest success, nestling survival, nestling mortality, and nesting chronology) was

independent of F-16 overflights, but was related to ecological factors including location and physical characteristics of the colony, and climatology.

Behavioral responses of wading birds to helicopter flyovers at a nesting colony in southern Florida were compared to responses during fixed-wing aircraft flyovers at altitudes of 60 and 120 m (Kushlan 1979). In all tests with aircraft, no bird that left its nest failed to return within 5 minutes. In 90% of the observations, birds either showed no reaction or merely looked up. In tests conducted with great egrets (Casmerodius albus), snowy egrets (Egretta thula), and Louisiana herons (Hydranassa tricolor), the helicopter caused the same or less disturbance with the exception of one test with snowy egrets when the helicopter flew at an altitude of 60m. Kushlan (1979) recommended individual tests at specific sites before use of a helicopter for censusing wading birds at other locations.

Ruddlesden (1971) noted the effects of simulated sonic booms (50 mN/m^2 860 mN/m^2) on two lapwings (Vanellus vanellus) nesting 95-220 m from the boom source. The birds appeared unperturbed by the booms, and the process of laying, incubation, hatching, and chick rearing was accomplished in a "natural manner."

3.2.5 Raptors

Owls have extremely sensitive hearing with audible frequency ranges ranking among the best high-frequency (0.4-9 kHz) hearing presently known in birds (Van Dijk 1973; Nieboaer and van der Paardt 1977; Knudsen 1981). Important components in the sonar environment of the long-eared owl (Asio otus) include the sounds of prey (e.g., squeaks and rustle of rodents); calls [nestlings, fledglings, and other adult owls; and nuptial alarm calls (Ilichev et al. 1971). To perceive and locate these sounds (which vary from 0.5 to 11.0 kHz), the owl's hearing has to be selective to distinguish them from natural background noise.

The barn owl (Tyto alba) is a nocturnal hunter that relies solely on its hearing to locate field mice by the rustling and squeaking sounds they make as they traverse runways in snow or grass. The most striking anatomical feature

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of the barn owl, which plays the most important role in its location of prey, is the face. The facial ruff forms a surface that is an efficient reflector of high-frequency sounds (Knudsen 1981). The owl's ears are asymmetrical, which allows the bird to discern elevation. The subtle differences in timing and loudness detected by the owl's unique hearing structure provide enough information for the bird to accurately locate sounds both horizontally and vertically. Although the owl's hearing is sensitive to a broad range of frequencies (from 100 to 12,000 Hz), it can locate accurately only sounds with frequencies between 3,000 and 9,000 Hz. The barn owl maintains maximum spatial acuity when a target sound includes frequencies of only 5-9 kHz, and is quite accurate at localizing even a 7-kHz pure tone (Knudsen et al. 1977). Neither binaural phase nor time differences seem to be used for location. The owl can locate wide-band noises containing frequencies optimal for location more accurately than narrow-band and pure-tone signals (Konishi 1973). Barn owls can learn and remember complex noise spectra and distinguish them from slightly different spectral patterns (Konishi and Kenuk 1975).

The acoustic location capacity of the northern harrier (Circus cyaneus) was measured in both the laboratory and the field (Rice 1982). Laboratory experiments indicated that the directional hearing of the harrier was substantially better than that of a sample of typical diurnal raptors and similar to that of owls capable of capturing prey in total darkness. Angular resolution along the horizontal axis was 2 degrees for the harriers, 1-2 degrees for the owls, and 8-12 degrees for the sample of typical diurnal raptors. For the harriers, angular resolution along the vertical axis was at least 2 degrees. The maximum range of sonic prey detection was estimated at 3-4 m for the harrier and 7 m for the barn owl. Field experiments indicated that free-ranging harriers could locate vole vocalizations (squeaks) accurately and attack prey successfully without the aid of visual or olfactory cues. Additional field experiments were conducted to determine how the harrier integrates auditory and visual cues while capturing concealed prey. These experiments show that the harrier does not require motion cues or auditory depth perception to determine the elevation of a sound source.

In 1985, Pacific Southwest Airlines (PSA) began jet aircraft flights into Bellingham International Airport, Whatcom County, Washington. A biological assessment was undertaken to: (1) determine the status of the bald eagle within the area near the airport,

(2) evaluate eagle habitat in the area, (3) evaluate any effects of jet flights on eagle behavior and population dynamics, and (4) suggest recommendations for mitigation of impact, if appropriate (Fleischner and Weisburg 1986). The project area contained critical bald eagle habitat and bald eagles were resident throughout the year. During field observations, bald eagles reacted to the presence of aircraft in the study area during 12% of the eagle-aircraft observations. A differential eagle response to aircraft types was observed; helicopters and small jets had the greatest effect on bald eagles. Eagles reacted to PSA jets 11% of the time, to propeller airplanes 2% of the time, to helicopters 40% of the time, and to small jet aircraft 55% of the time. Observed reactions of eagles to PSA jets included turning of the head to look at the jet (5% of the observations) and flying from a perch site (5%). Eagle reactions to PSA jets were twice as frequent when the eagle-jet distance was one-half mile or less. Present level of jet flights appeared to have a minor effect on bald eagles

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within the project area. Repeated flight from perches and interrupted eagle interactions due to aircraft disturbances could have a negative effect on bald eagles if overflights occurred more frequently. The authors made several recommendations to minimize the impact of jet aircraft, including location of flight paths to avoid eagle habitat and minimizing the number of jet flights per day.

Jackson et al. (1977) noted an observation of a female northern harrier hunting within the target range, near the target site, on a U.S. Navy bombing range in Noxubee County, Mississippi. During each bombing run, approximately one jet per minute bombed the target with a 25-lb practice bomb from about 1,800 ft above ground level. The practice bombs exploded with a noise (which seemed to the authors about as loud as a 12-gauge shotgun), gave a brief flash, and released a trail of smoke that allowed observers to measure the accuracy of the pilots. The greatest noise associated with the activity was from the jets; approximately 1,500 ft to the side of the target, noise levels varied between 80 and 87 dB. Throughout the bombing, the harrier continued hunting from a height of 15-20 ft--even when a bomb exploded within 200 ft of the bird. Between the bombing runs, the bird hunted over a larger area of the range, but during the bombing, its activities seemed to be focused more on the target area. Jackson et al. (1977) stated that the harrier probably was taking small mammals and birds flushed from cover by the bombing.

In a study of low-level flights and sonic booms and their effects on raptors, Ellis (1981) used a telemetering egg to monitor the heart rate of two prairie falcons (Falco mexicanus) exposed to low-altitude flights and sonic booms. No increase or other significant effect on heart rate due to the disturbances was noted; however, the data could be interpreted as merely reflecting those individuals' heart rates and may not be applicable to the species as a whole. Also, the heart rate sensor in the egg only recorded data when the egg was in close mechanical contact with the nesting adult; usable heart rate data was received only 5% of the time. Finally, not only had the experimental birds probably been exposed to aircraft overflight prior to this study, results were not compared to control birds. Ellis (1981) stressed that the results should be interpreted with caution and not applied to all raptor species.

Data on the likely effects of low-level jets and sonic booms on nesting peregrine falcons (Falco peregrinus) and other raptors were gathered at aeries in Arizona (Ellis 1981). Responses to extremely frequent and nearby jet aircraft were often minimal and never associated with reproductive failure. Nesting success and site reoccupancy rates were high for all aeries. The birds observed were noticeably alarmed by the noise stimuli (82-114 dBA), but the negative responses were brief and apparently not productivity limiting.

Jet engine and piston engine helicopters were used to survey bald eagles, golden eagles (Aquila chrysaetos), peregrine falcons, gyrfalcons (Falco rusticolus), and rough-legged hawks (Buteo lagopus) nesting on cliffs or hillsides in open terrain in Alaska (White and Sherrod 1973). General observations of raptor behavior in response to the rotary-winged aircraft were noted. The high frequency whine made by some of the jet engine helicopters seemed to be much less disturbing to nesting raptors than the low-frequency noise of the

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piston-powered craft. Birds were least disturbed when the helicopter flew parallel to a cliff at an initial distance of about a half mile out, with gradual approach toward the nest. Birds often continued to feed their young or loaf on a cliff when approached in this manner. Birds surprised suddenly by the presence of a helicopter appearing from over the top of a cliff usually panicked and exhibited frantic escape behavior. Approach from above was not nearly as alarming to the bird, especially when they could see the approach from a considerable distance. Disturbance just before egg laying, during egg laying, and during incubation were more deleterious than disturbance during the nestling stage. White and Sherrod (1973) recommended helicopter surveys of nesting raptors after the young had hatched, but before the young were ready to fledge. The presence of a helicopter too close to a nest late in the nesting season may force young birds into premature fledging. Fair-weather days were recommended over inclement weather for clearer observation and to avoid chilled eggs or young if the adults are flushed off the nest in cold, wet weather. Experienced pilots, familiar with maneuvering the aircraft in wind drafts, were also recommended. Approach from upwind is preferred, to avoid inadvertently flushing birds into the helicopter. Raptor attacks on fixed-wing aircraft appear to be more frequent than attacks on helicopters. Productivity estimates of raptors from areas not surveyed by helicopters were similar to productivity estimates of raptors surveyed by helicopters.

Snyder et al. (1978) summarized two studies on the potential impact of the proposed Dade County Training Jetport near Miami, Florida, on the Federally endangered Florida snail kite (Rostrhamus sociabilis plumbeus). An experiment concerning the effects of low overflights of jet aircraft was conducted on a large island colony of kites (15-20 pairs) approximately 2.6 miles west of the proposed jetport runway, during 5 days in early April 1978. Noise levels during overflight varied from 78-89 dBA at the colony. Behavioral response of the kites was limited to "watching the aircraft fly by" (28% of the cases observed). From late April to early May 1978, an assessment was made of the apparent impact of the Barranquilla Airport in Colombia, on snail kite populations in the vicinity. The distribution, breeding success, and behavior of the kites provided no clear evidence that the species was being adversely affected by the Barranquilla Airport. Snyder et al. (1978) suggested that impacts to the habitat by land development associated with the Dade County Jetport could be more detrimental to the kites than the impact of jet noise.

Shaw (1970) discussed the general characteristics, distribution, and population status of the California condor (Gymongyps californicus). Noise from blasting, drilling, and construction are included among several factors contributing to the declining condor population. When disturbed by noise from blasting, drilling, traffic, or sonic booms, the adults frequently abandon their nests. They seem to be particularly sensitive to noise disturbance. Wilbur (1978) documented several references to disturbance from sonic booms and low-altitude aircraft. While sonic booms are not expected to cause breakage of eggs, disturbance has caused the incubating adult to flush from the nest; no known breakage of eggs has been noted, but there is that possibility when such a large bird is startled and flushed from the nest.

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3.2.6 Songbirds

The dominant frequencies in the spectra of a species' calls and song often lie above the frequency range of lowest auditory thresholds (Klump and Curio 1983). Small birds, such as the great tits (Parus major), have difficulties producing low-frequency sounds due to their size. Below a certain frequency threshold, a small bird inevitably has to allocate its sound energy into harmonics rather than into the fundamental frequency. In a bird the size of the great tit, this frequency threshold lies at about 2 kHz. Pure-tone

whistles can only be produced above this frequency. The main effects on sound propagation are attenuation and environmental noise, both parameters strongly depend on the species' habitat. The "excess attenuation" generally increases with increasing frequency above 2 kHz. The increase is 6 dB/100 m and 15 dB/100 m in the range of 2 to 4 kHz and 4 to 8 kHz, respectively. Measurement of spectra of wind-generated noise in the great tit habitat showed an approximately uniform sound pressure level up to 4 kHz that decreases above this frequency with about 5 dB/octave. Hence, noise affects frequencies above 4 kHz less severely. Critical ratios of the great tit vary over a range of 22.4 dB to 26.3 dB for frequencies between 0.25 and 8 kHz. Calls designed for long distance communication (e.g., some contact calls) are not optimally tuned to the hearing of the tits. However, environmental noise has a strong effect on the best frequency for communication, thus resolving the above discrepancy. In a noisy habitat, most of the great tit's vocalizations, even high frequency calls, are well adapted to long transmission distances.

In a series of winter experiments, Sasvari (1973) appraised the locomotory responses of the great tit to alarm, anxiety, attracting, and territorial vocalization forms, reproduced through a loudspeaker. The perceived acoustic signal influence on the locomotory activity of great tits depended on two fundamental factors: (1) the features of the acoustic signal (including the form of signaling as a process and pitch), and (2) the instantaneous physio-psycho state (mood) of individuals (on the basis of inborn and learned experience of the birds connected with the environmental factors). Percent response to alarm and churring calls was greater during cloudy, precipitous weather versus sunny weather. Percent response to the attracting and territorial calls was greater when the tits were "exploring" versus feeding.

Twenty-one male chiffchaffs (Phylloscopus collybita), wild caught and hand-reared, were played back songs of their own and alien species to test the influence of the songs' sound pressure on heart rate (Bastian 1984). Hand-reared birds reacted more often to played back songs than wild caught birds. Neither group showed a preference for song of its own or alien species. Songs with a sound pressure of 70 dB constantly elicited an alteration of heart rate and a conditioning for time after the end of the song's sequence. Songs with a sound pressure of 50 dB neither effected any conditioning nor a constant alteration of heart rate.

Cliff swallow (Hirundo pyrrhonata) chicks, 9 and 18 days old, were played calls (2.1-4.2 kHz) of parents and unrelated (control) adults (Beecher et al. 1985). Younger chicks showed no difference in the frequency of their antiphonal begging calls to parental versus control calls. The older, near

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fledging chicks, however, responded significantly more to parental calls than to control calls; 78% of their total antiphonal calls were in response to parental playback calls. In these older chicks, the degree of preference calls correlated with the measured acoustic differences between the parent and control calls. Results indicated that cliff swallow chicks were able to recognize their parents by voice before they left the nest.

European starlings (Sturnus vulgaris) were trained to discriminate a class of rule-based, four-tone, ascending pitch patterns from a comparable class of descending pitch patterns (Huse 1983). A series of tests examined the birds' ability to maintain the discrimination under various transformations of the original pitch stimuli. The birds performed well when new shifts in tone height occurred within the original pitch training range, but not when shifts in tone height occurred outside that range. When information about the direction of pitch change was reduced by shortening the patterns, the birds could solve the discrimination on the basis of the first two tones in a pattern, although performance improved as pattern length and, therefore, amount of information increased. The same series of transfers showed that in producing accurate discrimination, the birds were using pitch cues based on both an absolute and relative perception of pitch.

During 1973-1974, the Federal Aviation Administration (FAA) studied the effects of sonic booms on the environment during routine U.S. Air Force super-sonic acceptance test flights of F-111 jets southwest of Fort Worth, Texas (Higgins 1974). The behavioral response of songbirds in an oak (Quercus pp.) woodlot to F-111 flyovers were noted in one instance. The jets flew over

the observation area at 20,000-41,000 ft at Mach 1.0-1.55; peak overpressure values at the site were measured at 0.55-3.25 psf (mean = 1.15). The continuous songs of birds were completely silenced 4-8 seconds before the arrival of the audible sonic boom. Further study disclosed that this response of songbirds coincided with the arrival of the seismic signal propagated through the ground and preceding the sonic boom shock wave by 4-8 seconds. This difference in the arrival times of the audible sonic boom and the seismic signal was caused by the greater velocity of the seismic compression wave signal transmitted through the dense earth medium ahead of the audible atmospheric sonic boom shock wave advancing over the Earth's surface at a speed equal to the ground speed of the supersonic aircraft generating the sonic boom. The observation that songbirds were alerted to the seismic compression waves preceding sonic booms helps explain phenomena described in historical tales and literature regarding a "hush or stillness falling over" an area preceding some remarkable event, such as a volcanic eruption, explosion, or earthquake at sea generating a tidal wave. When the sonic booms were audible, the songbirds uttered "raucous discordant cries" for a few seconds. Within 10 seconds after the audible boom, the songbirds were singing their "normal songs."

Davis (1967) noted the response of a population of ravens (Corvus corax) to a sonic boom in central Wales. Three or four ravens were idling in the upcurrents over a high rock spur between two streams. When the silence was shattered by a "very loud sonic bang as a jet aircraft passed overhead," Davis (1967) heard ravens calling agitatedly and saw small groups flying from all directions and converging over the crest of the spur. In about 5 minutes,

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62-70 ravens were present. They were flapping, soaring, and chasing each other, and often settled briefly on the rocks, with a great deal of noise. Ravens from at least 2 or 3 miles around may have been involved. Within 10 minutes, they started to disperse again, and calling died down considerably. About 30 ravens were still soaring over the hill when Davis (1967) left the area, an hour after the boom.

3.3 FISH

Although the hearing of several species of fish has been studied, the effects of aircraft or nonaircraft noise on fish have not been well investigated (Table 4).

Table 4. Some possible negative effects of noise and sonic booms on fish.

Species	Type of noise	Effect
Rainbow trout	Sonic boom (max. 4,16 psf) (Rucker 1973)	Slight behavioral reaction
Herring	Taped sounds from a fishing fleet (Schwarz and Greer 1984)	Avoidance, alarm, and startle responses
	Sound pressures (2-18 Pa) on wall of tank (Blaxter and Hoss 1981)	Startle responses
Sheepshead minnow/ longnose killifish	Tanks exposed to high noise levels (up to +30 dB/ub) (Banner and Hyatt 1973)	Reduced growth rates; reduced viability of minnow eggs
Guppy	Simulated sonic booms (Dancer et al, 1973)	Short duration reactions
Asian aya	Underwater sound (200-600 Hz, 72-80 dB) (Kona9aya 1980a)	Jumping response

Unspecified	Underwater dredging sound (38-75 dB) (Konagaya 1980b)	Negative responses; avoidance of the acoustical field of the worksite

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Some fishes produce a variety of sounds; for example, herring (Clupea harrengus) produce chirps (pulses in the range of 1,800-3,200 Hz) and whistles (narrow-band continuous sounds of 1,600-2,000 Hz) in addition to feeding and hydrodynamic noises (Schwarz and Greer 1984). The importance of acoustic signals in the social behavior of most fishes has not been studied, but available data indicate that more fishes can hear well than can (or do) deliberately produce sounds (Schwarz 1985). This, and the complexity of the teleost auditory system, suggests that a fish's surroundings contain acoustic stimuli that may affect the animal's survival.

Frequency regionalization is similar to the place mechanisms in the cochlea in that different frequencies stimulate different areas of the saccular and lagenar maculae; however, the exact mechanism for frequency discrimination by bony fishes is unknown (Cox et al. 1986). Fishes show great variation in the frequency range that they can hear and in their sensitivity over these frequencies, although related species may exhibit similar auditory capabilities if they inhabit similar acoustic environments (Schwarz 1985). Certain marine fishes can detect quite high frequencies (e.g., herrings--5 to 10 kHz); however, the majority are sensitive only to frequencies below 2,000 Hz (Myrberg 1978).

Results of intense pure-tone stimulation on auditory thresholds of the goldfish (Carassius auratus) indicated that stimulation at 300 and 500 Hz produce lower threshold shifts than at 800-1,000 Hz (Popper and Clarke 1976). Sensitive frequencies in this species varies from 70 Hz to about 4,600 Hz (Sawa 1976). The teleost inner ear responds in relatively complex fashion to different stimulating frequencies, which may indicate some degree of spatial signal analysis in the inner ear.

Investigations conducted on the hearing capabilities and structure of the inner ear in the marine catfish (Arius felis) showed that the catfish was able to detect sounds from 50-1,000 Hz, with best hearing sensitivity from 100-200 Hz (Popper and Tavolga 1981). This was in contrast to the hearing abilities of other 0stariophysi, which can detect sounds to over 3,000 Hz, with best hearing sensitivity at about 500-1,000 Hz. The utricle of the marine catfish is larger and has a different pattern of sensory epithelium than that of other 0stariophysi, probably an adaptation for hearing low-frequency sounds used in the detection of objects in their environment through echolocation.

Popper and Clarke (1976) studied the hearing of salmon (Salmo salar) in the sea and in the laboratory. The fish responded only to low-frequency tones (below 380 Hz); particle motion, rather than sound pressure, proved to be the relevant stimulus. The sensitivity of the fish to sound was not affected by the level of sea noise under natural conditions, but hearing is likely to be masked by ambient noise in a turbulent river. Sound measurements made in the River Dee, near Aberdeen, Scotland, led to the conclusion that salmon are unlikely to detect sounds originating in the air unless the source is nearly directly overhead, but they are sensitive to substrate-borne sounds. Compared with carp and cod, the hearing of the salmon is poor and more like that of the European perch (Perca fluviatilis) and the plaice (Pleuronectes platessa).

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During a study of masking effects on the hearing of the lane snapper (Lutjanus synagris), fish held in certain aquaria had consistently higher than normal thresholds to pure tones when tested later in a low-noise apparatus (Ha 1985). Comparison of laboratory aquaria showed that the only difference in aquaria was the presence of conventional air stones (in the aquaria holding the less sensitive fish) used to release compressed air to oxygenate and mix the water. Hearing tests on two groups of fish, held with and without airstone air release, showed significant differences in hearing sensitivity.

Beulig (1982) demonstrated that sharks are attracted most readily by broad-band, low-frequency, irregularly pulsed sounds of 20-100 Hz. To investigate the possibility that sharks are attracted to biologically significant sounds (such as accelerating schools of fish, injured and struggling fish, and feeding animals) that exist in the frequency range below 20 Hz, Beulig (1982) measured the responses of juvenile lemon sharks (Negaprion brevironstris) to low-frequency (12.5 Hz), irregularly pulsed sounds. The sharks were born in captivity and deprived of normal prey-capturing experience and social interaction with wild sharks. Initially, the juvenile sharks, tested individually, were not attracted to the low-frequency sounds, even after opportunities to capture living prey and to experience auditory stimulation associated with wounded, struggling fish were provided. When the sharks were tested in groups of three, their approach-response level indicated attraction to the low-frequency sound and results compared favorably with juvenile sharks that had species-typical feeding and rearing experience. Thus, the existence of a social factor in response to sounds was verified.

Behavior observations of yearling rainbow trout (Salmo gairdneri) exposed to sonic booms (maximum of 4.16 psf) indicated "no" to "very slight" reactions to the disturbance (Rucker 1973). Blood glucose levels, blood cortisol levels, and plasma osmolality levels of yearling trout exposed to simulated sonic booms (maximum of 4.16 psf) were similar to those of controls.

The effect of sonic booms on fish eggs during critical stages of development was studied at several National fish hatcheries in Nevada, Oregon, and Washington (Rucker 1973). During development, fish eggs reach a critical period when they become sensitive to vibration or disturbance (usually from after the first 24 hours until the "eyed stage" of development). Fish eggs from cutthroat trout (Salmo clarkii), steelhead/rainbow trout, and chinook salmon (Oncorhynchus tshawytscha) were exposed to sonic booms produced by military jets (F-111 or F-101) or simulated sonic booms of varying pressure (maximum of 4.16 psf). Exposure varied from a single sonic boom to repeated exposures over several days. Comparisons with control groups of eggs spawned at the same time indicated that sonic boom exposure caused no increase in egg mortality.

Schwarz and Greer (1984) described the behavioral responses of net-penned Pacific herring (Clupea harengus pallasi) to a variety of tape-recorded sounds. Sounds recorded in the field from a herring fishing fleet included moving and stationary (idling) vessels, sonar, echo sounder, and deck gear. Herring did not respond visibly to any of the taped sounds of sonar or echo sounders. Avoidance responses were elicited by sounds of large vessels approaching at constant speed, by smaller vessels but only when on accelerated approach, and

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by 11 different triads of electronically synthesized sounds. Alarm and, less frequently, startle were both elicited by those electronic sounds with an essentially instantaneous rise time in amplitude. Herring also showed a characteristic "startle" response when subjected to vibrational stimuli elicited by sound pressures between 2 and 18 Pa from a diaphragm in the wall of their tank (Blaxter and Hoss 1981).

Growth rates of sheepshead minnows (Cyprinodon variegatus) and longnose killifish (Fundulus similis) were significantly reduced when tanks were exposed to high noise levels (up to +20 dB/ub) (Banner and Hyatt 1973). Viability of sheepshead minnow eggs was also significantly reduced lethal effects of noise were apparently restricted to embryonic sheepshead minnows; fry exposed subsequent to hatch experienced no losses.

A comparison of the effect of sonic booms on guppies revealed that fish subjected to sonic booms produced by a generator exhibited only observed reactions of short duration (0.5 second), which appeared for intensities higher than 1 mbar (Dancer et al. 1973). Notion pictures of fish in a small tank at the time a bullet traveling 1,200 m/sec passed a few centimeters above the tank indicated that the fish sensed the passage of the shock wave, but suffered "no ill effects" (Wilkins 1972). The pressure rise at the bow shock wave was 0.26 atm or 275 times that associated with a strong sonic boom from a supersonic transport.

While ascending streams from the sea to the upper river, the fry of Asian aya (Plecoglossus altivelis) have a strong anadromous character and show jumping response, not only in waterfalls, but also to underwater sound (Konagaya 1980a). The jumping response of this fish to underwater sound was studied, and the most sensitive frequency was about 200 Hz; however, the sensitivity of the fish was not determinable above 600Hz. The lowest threshold level of underwater sound for jumping response was 72 dB at 200 Hz. The numbers of fish responding to the sound pressure were distributed as described by a normal curve in the range of 70 to 80 dB.

To clarify the effects of construction sounds on fish populations, the change in acoustic environment of Lake Biwa (Japan) caused by dredging was observed (Konagaya 1980b). The response of fish to dredging sounds and the swimming direction of fish near the worksite were studied using acoustic biotelemetry. The spectrum level of the background noise of Lake Biwa was within the limits of prevailing noise of the sea. The sound pressure level of the underwater sound of a dredging boat at a distance of 150 m was about 38 dB, and that of a submerged pipe at a distance of 2 m was 75 dB. The fish showed negative responses and avoided the acoustic field of the worksite.

3.4 OTHER ANIMAL GROUPS

The literature concerning effects of noise on animal groups, other than mammals, birds, and fish, is mainly limited to a few laboratory studies on amphibians, reptiles, and insects (Table 5). Few incidental observations of exposure of these latter groups to aircraft noise have been reported. One

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Table 5. Some possible negative effects of noise on amphibians, reptiles, and invertebrates.

Species	Type of noise	Effect
Amphibians:		
Spadefoot toad	Recorded motorcycle sounds (95 dBA) (Brattstrom and Bondello 1983)	Elicited emergence from burrows, a potentially detrimental impact on the population if occurs outside the normal breeding season
Reptiles:		
India browntree snake	Airplane passing overhead (Yahya 1978)	Alert behavior
Desert iguana	ORV noise (114 dB for 1 and 10 hr) (Bondello 1976)	Shift in hearing threshold; permanent hearing sensitivity loss
Mojave fring-toed lizard	Taped dune buggy sounds(95 dB) (Bondello et al. 1979)	Hearing loss after less than 9-min exposure

Invertebrates:		
Brown shrimp	Aquarium noise (25-400 Hz, 30 dB) (Lagardere 1982)	Decreased food uptake, growth, and reproduction; increased cannibalism and mortality
Indian-meal moth	General noise (120-2,000 Hz) (Kirkpatrick and Harein 1965)	75% reduction in emerging adults when larval stage was exposed
	General noise (2-40 kHz) (Tsao 1969)	Cessation of movement
Corn earworm/flour moth	Pulsed sound (50 kHz, 65 dB SPL) (Cutkomp 1969)	50% reduction in longevity; 59%% reduction in the number of eggs per female
Honey bee	General noise (200-2,000 Hz, 107-119 dB SPL) (Frings and Little 1957; Little 1959)	Cessation of movement
Locusts	General noise (4 kHz, 80 dB SPL) (Shulov 1969)	Flying response
Midges	General noise (125 Hz, 13-18 dB above ambient noise) (Frings and Frings 1959)	Swarming of males around source

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such incidental observations was Yahya's (1978) observation of a India browntree snake (Dendrelaphis tristis) that appeared to respond to the sound of an airplane passing overhead. As soon as Yahya (1978) heard the sound, the snake lifted up its head ("as if trying to see the source of the sound"), made a 90-degree angle with its body, and remained in this position until the sound faded. The plane was not visible to Yahya through the canopy cover. Dr. Carl Gans, commenting on Yahya's (1978) observation, stated that snakes can hear quite well to15,000 Hz, but that "it would be surprising if the snake did indeed present an obvious behavioral response" to the sound of a passing plane. Dr. Gans recommended that the incidental observation be checked out by experiment because the snake might have responded to wind movements or chemical cues, which Yahya (1978) could not have observed. Reporting in the literature of other incidences of possible behavioral reactions of reptiles, amphibians, and invertebrates to aircraft would add to the knowledge of the effects of noise on these groups and provide further direction for future behavioral research in this area.

3.4.1 Amphibians

Sound unquestionably influences the activities of most anurans (i.e., frogs and toads) and plays a significant role in the reproductive behavior of many, but not all, species. However, literature concerning hearing ability of anurans is lacking for most species (Bogert 1960). The anuran ear shows a complex, frequency-dependent directionality; the wide coupling of the two middle cavities via the mouth leads to acoustic interactions that enhance interaural time and intensity differences (Fay and Feng 1983). Modifications of the ear of anurans may be associated with specializations in the sound transmitting apparatus (Bogert 1960; Schmidt 1971).

The vocalizations of closely related anuran species, or even local populations of those with disjunct distributions, are known to differ in dominant frequencies, relative intensities of the harmonics, duration of individual calls, their rates of repetition, and trill or pulsation rates (Bogert 1960). A positive motor response seemingly depends more on pulse rates or utterance rates rather than on dominant frequencies or harmonics, although the intensity of the sound may determine the maximum distance at which the sound is an effective stimulus. Griffin and Hopkins (1974) measured sound levels of bullfrog (Rana catesbieana) choruses at about 20 dB SPL in the 1.5- to 2.5-kHz frequency band up to 965 m above small ponds; however, sound travels upward much farther and more predictably than along the surface. To be effective, the sound serving as the stimulus probably must be within relatively narrow

limits of variation in one or more characteristics peculiar to the voice of individual species (Bogert 1960).

Acoustic avoidance behavior was demonstrated in a natural population of the neotropical treefrog (Eleutherodactylus coqui) (Zelick and Narins 1980). The threshold for acoustic avoidance at different frequencies varied from 230 to 3,420 Hz. Tones of 605-2,000 Hz were uniformly above threshold when presented at 60-70 dB SPL. Below 665 Hz, threshold dropped at 14 dB per octave to a maximum sensitivity of 41 dB SPL at 230 Hz. Tones of 3,420 Hz (approximately the third harmonic of the first note of the advertisement call) failed to elicit a response even at high levels (over 81 dB SPL in one case).

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Single-tone stimuli (1- to 2-sec duration), spaced at the frogs spontaneous call interval (2 to 3 sec), were presented to frogs. The frogs redistributed their calls in time such that the calls fell almost exclusively within the brief time window between tone bursts, thereby avoiding overlap with the tone. The average background noise level at the frogs' calling site was 39 dB SPL at 500 Hz, 59 dB SPL at 1,000 Hz, and 66 dB SPL at 2,000 Hz. Thus, the avoidance behavior was observed at stimulus levels barely exceeding the noise floor of the frogs' environment.

The spadefoot toad (Scaphiopus couchi) is a primative anuran that inhabits the arid regions of the southwestern United States. Reception of airborne sound is achieved by means of a poorly differentiated region of skin on the head, which serves as an eardrum. Spadefoot toads appear to use auditory cues (thunderstorms) to emerge from hibernation. Recorded motorcycle sounds of intermediate intensity (95 dBA) elicited emergence of spadefoot toads from their burrows, a potentially deleterious impact on the toad population (Brattstrom and Bondello 1983). The induced emergence of these toads during a season when water is not available is a potentially detrimental impact on spadefoot toad populations. Recently emerged toads are stressed because their fat reserves are depleted, and they are dehydrated. The act of emerging further depletes their energy reserves. If intense sounds, such as ORV's and low-altitude aircraft, cause the toads to emerge at a time when food and water are not available, chances are likely they will not survive, let alone be able to reproduce.

3.4.2 Reptiles

Sound perception appears to be subordinate in importance to vision or chemoreception in the activities of most reptiles (Bogert 1960; Dufour 1980). Sound-producing mechanisms are absent in the majority of species, but occur in some or all members of the four orders of reptiles. Studies have shown that certain desert reptiles are sensitive to low-intensity sound. Sounds may be of more adaptive significance for nocturnal species, such as crocodilians, the tuatara (Sphenodon punctatum), and nearly all geckos, because full use cannot be made of photoreceptors or vision. The optimal acoustical sensitivity of various species of desert iguanid lizards varies between 700-3,000 Hz (Wever and Peterson 1963; Campbell 1969; Bondello 1976). Critical environmental sounds are often of relatively low intensity (e.g., movement of insect prey and predators such as snakes and owls); sensitive hearing acuity is essential to the survival of these desert vertebrates. The temperature of maximum auditory sensitivity of lizards varies as a function of the natural thermal preference for each species (Campbell 1969; Werner 1972). Sensitivity decreases as temperature varies either above or below the range of preferred temperatures for normal activity. Average sensitivity loss of 10-20 dB/10 ·C can be found in the region of maximum sensitivity. Hearing appears to be best at ecologically optimal temperatures.

The effects of ORV noise (114 dB for 1 and 10 hr) on the desert iguana (Dipsosaurus dorsalis), whose optimal acoustical sensitivity is between 900 and 3,000 Hz, were studied in the laboratory (Bondello 1976). Animals tested for acoustical sensitivity immediately after sound exposure had a greater loss of hearing sensitivity than those tested 7 days later. Results indicated that

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a shift in the hearing threshold had occurred. Permanent sensitivity losses were experienced by lizards exposed to both 1 and 10 hours of sounds. Animals exposed for 10 hours suffered the greatest permanent losses. The destructive dose was less than 1 hour. The time it took for sensitivity loss to recover exceeded 7 days. Duration of exposure affected the degree of recovery.

The Mohave fringe-toed sand lizard (Uma scoparia) inhabits the quiet, protected dunes of the California desert and has also evolved the ability to hear low-intensity, low-frequency sounds (Brattstrom and Bondello 1983). Bondello et al. (1979) tested the effects of dune buggy sounds on the hearing of this lizard in the laboratory. Lizards were exposed to taped dune buggy sounds of 95 dB, representative of a dune buggy at 5 m. All noise-exposed lizards suffered actual hearing loss after exposure to 510 seconds of 95-dB dune buggy sounds. Shallow burial in sand was not considered an adequate escape from ORV sounds. Because the animals were sacrificed immediately after the experiment, it could not be determined whether they had suffered a permanent or temporary threshold shift. Dune buggies can penetrate deep into the interior of sand dune ecosystems. Therefore, many areas within the dune periphery are exposed to repeated episodes of high intensity sounds. Also, intense ORV activities in the spring and summer coincide with the reproductive season of all three Uma species occurring in California, which may have adverse biological effects. Bondello et al. (1979) suggested that during times of stress, such as drought and subsequent lack of food and shelter retreats, all unnecessary disturbances, including ORV activity, mining, repeated low-altitude jet overflights, and gunnery, should be restricted from the immediate area of the dune systems.

3.4.3 Invertebrates

Growth and reproduction of brown shrimp (Crangon crangon) reared in a soundproof box that reproduced acoustical conditions similar to those prevailing in the shrimps' natural environment were compared to those of shrimp from the same source but reared in acoustical conditions prevailing in a thermo-regulated aquarium where noise levels reached 30 dB in the 25 to 400 Hz range (Lagardere 1982). This permanently high sound level resulted in a significant reduction in growth and reproductive rates. To a lesser degree, noise also appeared to increase aggression (cannibalism) and mortality, and to decrease food uptake. Symptoms were extremely similar to those induced by adaption to stress.

Several studies on the effects of noise on insects have resulted from efforts to protect stored grain from destruction by insects (Fletcher et al. 1971). Tsao (1969) reported that Indian-meal moths (Plodia interpuctella) ceased moving when stimulated by loudspeakers, bells, and whistles. Kirkpatrick and Harein (1965) reported a 75% reduction in emerging Indian-meal moth adults following exposure to 120- to 2,000-Hz sound during 4 days of the larval stage. Lindgren (1969) used a variety of frequencies and intensities to study effects of sound on pupal and adult Indian-meal moths and flour beetles (Tribolium spp.). Few effects on reproduction were noted, with the exception of mated flour beetles continuously exposed to 40 kHz. Even though large numbers of insects were used in many replications, effects of sound

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exposure were difficult to demonstrate, because of variability in egg production. The discrepancy between Kirkpatrick and Harein's (1965) data and Lindgren's (1969) data possibly can be explained by stimulation at different stages of the insect's life cycles (larval vs. pupal and adult, respectively) as well as by differences in the sound itself (Fletcher et al, 1971).

Cutkomp (1969) reported that a 72-hr exposure to a pulsed sound (50 kHz), 25 pulses per second at 65 dB SPL, reduced longevity of corn earworm moths (Heliothis zea) and flour moths (Epestia kuehniella) from 20 to 10 days. In addition, the mean number of eggs per female was reduced 59% in the noise-exposed group.

Honey bees (Apis mellifera) ceased moving for up to 20 minutes in response to frequencies between 200 and 2,000 Hz with intensities varying from 107-119 dB (Frings and Little 1957; Little 1959) and did not appear to habituate to the sound. Increased movement due to noise has been noted in locusts (Lucustidae) exposed to tones of 1, 4, and 10 kHz at 80 dB SPL (Shulov 1969) and in midges (Chironomidae) exposed to 125 Hz at 13-18 dB above ambient noise (Frings and Frings 1959).

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4.0 DISCUSSION

The literature on the hearing ability of animals demonstrates the wide variation among individual species, even within various classes. An animal's ability to detect different sounds has been shown to play a key role in survival of individual species.

Research into the effects of aircraft noise and sonic boom on hearing has involved only a few quantitative descriptions of the normal auditory ability of species and measures of hearing loss caused by exposure to noise. Past research in this area primarily has been confined to experiments performed in strictly controlled laboratory conditions to obtain accurate measures of noise levels and changes in species response. Experiments using wildlife rarely can be done in highly controlled noise conditions, and application of results to wildlife in the field is questionable.

The literature concerning the effects of noise on animals, particularly farm and laboratory mammals, leaves little doubt that most physiological systems can be influenced by environmental sound. With the probability of increased supersonic flights, a number of animal studies during the 1960's and early 1970's involved exposure to sonic booms; however, the majority of these studies were behavioral studies using domestic animals. Only a few involved observations of wildlife. In almost all of these behavioral studies, domestic animals and wildlife exhibited a startle response. This behavioral response of wildlife has been fully described, but the accompanying physiological response to aircraft noise has not been well studied, due primarily to the difficulty of assessing these effects in the field. Without a controlled environment or control population, it is extremely difficult to pinpoint certain physiological changes as due solely to noise stress. The study of noise as a stressor should be continued, with emphasis on linking the observed behavioral response to the physiological changes occurring in the animal. This is the vital information link that is missing in understanding the effects of noise on wildlife. In addition, it is not easy to predict the consequences of noise in natural animal habitats. Adverse effects to be considered include predator-prey relationships, reproductive failure, intra- and interspecies behavior patterns, and nutritional deficiencies.

Noise has been shown to affect the reproduction of various groups of animals. Negative reproductive effects of aircraft noise could potentially decrease populations of wildlife species. However, few studies have examined the effects of noise on wildlife at the population level. Fletcher (1980) stated that further research is needed to answer critical questions about the effects of noise on animals, including long- and short-term noise effects, and the effect of noise on a declining animal population, regardless of the cause of the population decline. The sensitivity of natural populations to

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environmental noise is largely determined by their response to transient perturbations (Shepherd and Horwood 1979). The most important features of the transient response are described by the return time, which is the characteristic time taken for the population to return to equilibrium after perturbation. The return time may either increase or decrease when a population is exploited, depending on the nature of the mechanisms that regulate population size. Unfortunately, the limited literature concerning noise effects on populations is inadequate to formulate management plans based on projected impacts of noise for most species.

Historical and preimpact data for a particular population provides useful information for comparing populations before and after noise disturbance. However, few studies have had this type of information available to use for comparison with data collected during noise disturbance to a population. An exception to this includes work done on the Channel Islands in California (Jehl and Cooper 1980). Concern that the intense sonic booms from proposed space shuttle flights might have adverse effects on the resources of the Channel Islands prompted a number of field,' laboratory, and library investigations undertaken from 1978-1980.

Large data gaps exist on the behavioral and resultant population impacts. This deficiency is due to a lack of experimentally controlled studies on the subject, as well as to the inherent problems of wildlife field research. Occasionally, researchers monitoring behavioral changes due to aircraft noise can become a probable cause of behavioral change themselves (Black et al. 1984). Research studies must be designed to ensure that wild animals are not aware of observers or that observation is not incorporated into the experimental design in such a way as to negate or account for potential adverse researcher effects.

Literature on the effects of aircraft noise and sonic boom on animals indicates that effects are variable from species to species. Thus, further research is needed to fully quantify noise impact on individual domestic and wildlife species (Boutelier 1968; Bond 1971; Bender 1977). A number of incidents have been recorded that indicate the effects may be more detrimental to wildlife than to domestic animals (Bond 1971).

Further research needed to answer critical questions about the effects of noise on animals includes: (1) studies of individual species, as individual animals and in social groups (e.g., herds, flocks) to examine the acoustic nature (e.g., frequency, intensity, temporal patterns) of critical events (e.g., mating, territoriality, alarm, nurture); (2) more complete investigation of the spectrum of environmental sound and of an animal's hearing sensitivity; (3) effects of noise on a declining animal population, regardless of the cause of the population decline; (4) stressor effects of noise combined with other stresses on an animal; (5) long- and short-term noise effects; and (6) further studies of possible critical sound propagation in the field (Fletcher 1980).

Due to scarcity of data, environmental impact assessments rarely consider noise effects on wildlife. A complete and accurate assessment of a given impact should include an assessment of how animals will react (both physically and behaviorally) to various noise levels of varying frequencies produced by

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the impact (Bender 1977). However, this type of information is presently unavailable for most situations; at best, information can only be surmised from laboratory experiments and limited field observations. In addition, the hearing ability of many species has not been investigated. More studies to determine the hearing ability of species are needed to improve the ability to accurately assess the potential effects of noise on individual species.

The advent of jet aviation resulted in increased interest in developing a sound-level scale that more closely correlates with the human ear's response to aircraft noise. While propeller engine aircraft engines generally produce low-frequency noise, jet engines produce a large amount of noise in the middle- and high-frequency range. Therefore, jet aircraft are typically judged to be more

noisy and annoying, at least to human listeners. This principle also may apply to some, if not most, species of wildlife.

In addition to a generally higher noise frequency range, the presence of discrete tones tends to make jet engine noise more annoying and thus more impacting than it would be without these tones. To deal effectively with the noise analysis problem with regard to animals, models need to be developed to approximate more closely individual species' or groups of species' (e.g., raptors) subjective response to aircraft engine noise in terms of relative noisiness or annoyance. The models should involve the addition, in a nonlinear manner, of the noise component of each frequency band in the noise frequency spectrum.

In general, the perceived noisiness and resultant annoyance to sound increases with the duration of the noise event as well as with its loudness. For this reason, an animal noise impact assessment methodology must account for both the magnitude and duration of aircraft noise exposure. Thus, two different types of noise measurement are essential to assess aircraft noise and sonic boom impacts on wildlife: one to measure the noise from individual sorties (aircraft missions) and another to measure or describe the cumulative effect of numerous sorties over a specified time period. Such models need to consider not only the duration and intensity of individual aircraft noise events, but also any synergistic effects that may occur as the number of sorties reaches some species threshold, such as one that would cause animals to leave areas critical to their survival.

As useful as these aircraft noise measures may be, it is still essential to employ an environmental noise description to assess the animal, population, or community response to a variety of aircraft noise events throughout a desired period. Such noise impact descriptors also should make suitable allowances not only for the effect of a single noise event but also for the number, time of day, and season of such events.

All of the above considerations should be taken into account in any methodology for assessing the probable impact of aircraft noise on a wide variety of wildlife species over different geographic areas.

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DRAFT

FTHL Interagency Coordinating Committee Meeting Minutes
June 27, 2007 at AGFD, Yuma

In Attendance:

Tyler Grant (FWS-Carlsbad)
Daniel Steward (BLM-El Centro)
Fred Wong (BLM-Yuma)
Jim Rorabaugh (USFWS-Tucson)
Robert Palmer (Navy-San Diego)
Rob Lovich (Navy-San Diego)
Julian DeSantiago (BR-Yuma)
Amanda Espino (BR-Yuma)
Elizabeth Kennett (BR-Yuma)
Sandy Vissman (FWS-Carlsbad)
Jack Crayon (CA DFG-Bermuda Dunes)
Eric Hollenbeck (CA DPR-OW)
Joe Hopkins (CA DPR-OW)
Mikele Painter (AZ GFD-Research)
Lin Piest (AZ GFD-Yuma)
Ramses Rodriguez (Alto Golfo Reserve)
Martha Gomez (Alto Golfo Reserve)
Jose Campoy (Alto Golfo Reserve)

- **Meeting began at 9:45.** ICC president Rob Palmer facilitating and secretary Lin Piest taking notes. Introduction, then discussion of the purpose and agenda. Jim reported that Brian Wooldridge has accepted a position in the Flagstaff office and will be replaced on the ICC.

- **Review previous meeting minutes.** Minutes of the ICC/MOG meeting from 3/7/07 were approved with no revisions.

- **Review of action items.** Jim reported that the pedestrian barrier along the border was initiated through an exemption of environmental laws. It has been constructed eastward from San Luis, AZ, at least as far as the Boundary Hills. It includes slots for lizards at each post, about every 5 m; there are also gaps underneath that would allow lizard passage. There did not seem to be a lot of excessive disturbance during construction. Jose pointed out that he's been reviewing a proposal for a 3-fence barrier to be built along most of the U.S. border with Mexico. This has different funding and so different time tables and review process.

- **Elections.** Julian DeSantiago volunteered to be Secretary; Dan Steward volunteered to be Chair and Tyler agreed to co-chair; Jim suggested establishing a Treasurer, for which Fred volunteered.

- **Status of land acquisitions.** This is a continuing item to use compensation funds from the Area Service Highway in Arizona to buy land in the East Mesa MA. Daniel reported that they are still in negotiation with IID regarding compensation for the AAC lining. BLM has applied the same compensation as was applied for the ASH. The cost per acre has increased to about $500/acre, plus 15% for acquisition cost. IID did not balk at this increase. The project has already begun even though no compensation has yet been paid. Total acreage is about 1,200. Daniel also reported on the Stirling Solar plant. They haven't submitted their application yet, so BLM doesn't know what the eventual compensation will be. The entire project, about 6000 acres, will be outside MAs. He

would like to do before/after surveys for FTHL to assess the impact. Daniel also reported that they haven't received money yet from ADOT for the ASH; they are eventually expecting $4.5 million. BLM is trying to fund 1 or 2 positions that would work entirely on land acquisitions. They may run out of willing sellers before they run out of money. Rob L. asked about using third party facilitators to buy land. BLM investigated several opportunities but decided it would be more efficient to hire a position.

- **Research and monitoring.** Tyler summarized the current year efforts. Dan has started one demographic plot on East Mesa, using a FWS team that he hired. That is going well – they have found 20 FTHL, which is near the statistical goal of 25-30, and they're only half done. Eric completed one demographic plot and found 4 FTHL. He will complete another plot later this summer. Eric has completed 17 occupancy plots. Rob P. reported that there wasn't much Navy money this year and so there are no projects on MCAS or NAF. Dan suggested hiring a monitoring team that could work on all MAs. There was discussion about how to staff this team. Volunteers or trainees could be used for occupancy plots, but demographic plots would require more of a commitment. Housing would have to be provided, adding expense. Jack suggested using SCA help. Rob L. suggested PARC volunteers. Tyler will coordinate with agencies next year to try to centralize the monitoring effort. Tyler is completing the monitoring plan. Rob L. suggested that this should be translated into Spanish. Ramses said he would like to participate in surveys in the U.S. to learn the new methodology. Daniel suggested an ICC monitoring day to demonstrate to all ICC members.

- **Relocation study.** Mikele reported that fieldwork for this year will start tomorrow. She is finalizing the report from last year and will send it out to the ICC. In response to a comment from Rob L., she reported that they will take a voucher photo of each FTHL captured this year. They plan to capture 10 control and 10 treatment FTHL this year. BR contributed $30K this year, which will fund work through August. Jim said that he sent out a solicitation to the MOG for more funding but had no response. AGFD will probably not seek funding for additional years, but perhaps this work could be dovetailed with relocation efforts for some of the large upcoming projects.

- **Other research and monitoring.** Lin reported that the report from the UA genetics study is due out soon. Eric said that a 3-year summary of monitoring at OWSVRA did not reveal a correlation with disturbance. Several of the AZ biologists completed disturbance monitoring transects in the Yuma Desert MA this spring. Traci Allen and Brian Wooldridge are working on the report. Jim said that there seemed to be less disturbance, probably because of the border barriers.

- **Develop research project list.** Tyler presented his list of research priorities for the next 3 years. Proposed for FY 2008 would be habitat modeling. The Redlands Institute submitted an estimate of $30K to model FTHL habitat using existing data. Field validation would be extra and may take a lot of time. Daniel suggested he could do field validation if he knew what data to collect. There was discussion about how valuable the model would be without field validation, which could be expensive and lengthy. We should know what the process and costs are going to be up front before we get caught on

a slippery slope. Jim questioned what the value would be for FTHL conservation, that it may be just a summation of what we already know. Tyler said that it would be useful for acquiring land, determining where to place projects (especially on the periphery of the range). We should make sure that we formulate deliverables and specify them in the contract. Ramses said that he has a lot of presence/absence data and thought maybe it could predict whether or not FTHL occurred in sand dunes in Mexico. Tyler pointed out some problems using occupancy data for the model, since FTHL are easier to detect in sandy areas. It was suggested that a conference call should be convened with Redlands Institute to determine what they need, costs, calendar, etc. Rob L. agreed to coordinate this.

Also proposed for FY 2008 were studies to determine impacts from projects. Before-after-control-impact studies could be done. Daniel said that sometimes we don't know what the impacts will be from projects if some habitat remains. Rob P. suggested taking this item off the list since these studies could be funded by the proponents.

Proposed for FY 2009 was another aerial disturbance mapping project. Tyler will investigate costs and suggested it be done again by FWS to remain consistent with the last effort. This should be moved to FY 2008. Also proposed are impact monitoring transects. Daniel will cost this out. We need to determine which is most important, this or the aerial mapping. Daniel suggested adding an OHV study for this FY. The study would involve fencing an area to exclude OHV and measuring the results using intensive before/after surveys with controls. Eric said there are already areas like this at OWSVRA, but not in high-density FTHL areas. Daniel suggested the Superstition Hills on NAF. Eric said this could be funded using the OHV grant provision for restoration.

Proposed for FY 2010 was a PVA analysis. There was discussion that this wouldn't be necessary for MAs since it is assumed that populations within MAs are permanently viable. It could be useful for areas outside MAs, e.g. Coachella Valley, that are isolated. Jim said that the Conservation Breeding Species Group could do a PVA for $4-5K. Tyler thought that for this small amount of money, this project could be moved to an earlier FY.

Other research. Fred brought up the idea of evaluating alternative fencing designs, which had been discussed previously. He was tasked with summarizing the state of our knowledge of fencing. Eric suggested that tests could be done at a geothermal plant.

Tyler will summarize these discussions and refine the list of proposed research.

- **Discussion from Mexico subteam.** Rob L. suggested several activities for Mexico, including training for monitors. He is contemplating convening a symposium on the status of herps in northern Mexico, with a session on FTHL and border issues. He stated a desire that monitoring in Mexico be comparable to that in the U.S., and asked how we could help. Jose discussed that the biosphere reserves are the primary entities responsible for FTHL conservation and that it is a priority species for monitoring. He supported formation of a Mexico subteam of the ICC. He said that each endangered species is

required to have a recovery plan, preceded by a PVA, and that perhaps the ICC could help with this. He was interested in having staff attend a training workshop. Eventual goals include the establishment of a FTHL MA. He would be interested in having translations of the monitoring plan, the video, and our new brochure. He is expecting more visitation to the Gran Desierto because of the new highway and we should work together to educate the visitors from the U.S. drawn by the new highway. Jim reported that a proposal he submitted to the Trilateral Committee in May for FTHL projects in Mexico was adopted. This makes it easier to get funding, permits, and approvals. Rob L. asked if there were any other Mexico entities we should invite. Jose didn't know of anyone else particularly involved with FTHL, but Jim suggested someone from CEDES. Ramses reported that he would like to come to the U.S. for monitoring training so that his techniques are compatible. They need a document that would implement the Strategy in Mexico. He pointed out that there is an item in our RMS that promotes development of a Strategy in Mexico. First, he said they need to update the information needed for a Strategy. Jose suggested convening a workshop to discuss needs, funding, etc. for work in Mexico. Dates of Sept. 13-14 were proposed, in San Luis. Jose, Rob, and Jim will put together an agenda. Ramses said they would like to redo their brochure, probably using their existing brochure.

- **Historical review.** Jim expressed concern about our proposed monitoring plan, that we seem to be reinventing the wheel and that our new protocol won't be compatible with previous efforts. He would like to see if previous data could be used to provide some baseline for future efforts. He thinks that our inconsistent monitoring methods make us more susceptible to litigation. We should also bring potential litigants into our review process so they have more ownership. Rob L. suggested that publishing our results would lend them more weight.

- **Use of compensation funds for research.** Jim explained that the MOG had previously discussed allowing use of compensation funds for research because so much money was accumulating and not being spent, and agency budgets were being cut. Lin asked if compensation funds could be used to provide emergency funding for the relocation study. This would require some rewording of the RMS but could be done so as to allow only specific situations such as this. Fred and others expressed concern that this would cause agencies to budget less for research in the future. Daniel said that they should know in a couple of years how many willing sellers there will be and how much land they'll be able to buy. This will determine whether there may eventually be excess money that could be used for other purposes. It was agreed to discuss this issue further at the next ICC meeting.

- **Lawsuit.** Tyler reported on the lawsuit protesting the 2006 listing decision. He said there was a hearing on 6/15 and there will be a determination 6 weeks from that date on whether the Service needs to reconsider their decision.

- **Training of monitors.** Daniel reported that there was a big demand this year for monitor training. He said there could have been as many as 200, but he only accepted 50 in 2 sessions. The groups were too large to provide much individual instruction. He said that

15 per day should be the limit and that we should do 3-4 sessions per year. They were mostly consultants. He said that he could do trainer training on July 12 and 13, and maybe also in Mexico in Sept. Jack complimented Daniel on his effort, indicating he did the best he could considering the situation. He said that the large number made quality control difficult and that he would have had trouble getting his superiors to agree to letters of permission for most of the trainees if the FTHL were a listed species. He suggested that trainees not be considered qualified until they have completed their volunteer duty. Daniel pointed out that the volunteer work would need to be in a good area to be beneficial, and its also a workload to coordinate the volunteers. Lin said that he would be willing to help out as a trainer. Daniel would like to get captive FTHL to show live lizards and their tracks. He said that in the future, dates should be set before Dec., and the training should be in mid-late April. He said that we need to train probably only about 50 per year. Rob L. thought there should be a database of people who have completed the training. Daniel and Lin will coordinate on training for next year.

- **Status of FTHL videos and kiosk.** Fred completed a white paper for the MOG on the value of kiosks for showing the FTHL video. He is proposing the purchase of 1 for AZ, 1 for CA, and maybe 1 for Mexico. It was agreed that compensation funds can be used to purchase kiosks, videos, and brochures. He reported that they are still working on closed-captioning of the Border Patrol video. The public video modifications are nearing completion and they can already be distributed. The Spanish is being redubbed on the public video. These modifications should be done by the end of Sept.

- **Brochure.** Kevin Young had recently produced a new brochure that he distributed to the ICC. Some comments were discussed and Rob P. directed us to send additional comments to Kevin. Fred will send Kevin a simpler version of the range map.

- **Other items.** Jim pointed out that the RMS implementation schedule expires this FY and operating on an expired schedule may make us more liable to litigation. Lin volunteered to send out a new schedule for comment. Rob P. will send out action items from this meeting.

- **Next Meeting:** Next meeting was set for 9:30 on Sept. 26 at BR-Yuma.

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NOTE:
To print data frame (right side), click on right frame before printing.

1971 - 2000

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1971-2000 Normals (~3 KB)

1961 - 1990

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1961-1990 Normals (~3 KB)

Period of Record

- Station Metadata
- Station Metadata Graphics

General Climate Summary Tables
- Temperature
- Precipitation
- Heating Degree Days
- Cooling Degree Days
- Growing Degree Days

Temperature
- Daily Extremes and Averages
- Spring 'Freeze' Probabilities
- Fall 'Freeze' Probabilities
- 'Freeze Free' Probabilities
- Monthly Temperature Listings
  - Average
  - Average Maximum
  - Average Minimum

Precipitation
- Monthly Average
- Daily Extreme and Average

- Daily Average
- Precipitation Probability by Duration.
- Precipitation Probability by Quantity.
- Monthly Precipitation Listings
  - Monthly Totals

Snowfall

- Daily Extreme and Average
- Daily Average
- Monthly Snowfall Listings
  - Monthly Totals

Snowdepth

- Daily Extreme and Average
- Daily Average

Heating Degree Days

- Daily Average

Cooling Degree Days

- Daily Average

Period of Record Data Tables

- Daily Summary Stats (~55 KB)
- Monthly Tabular data (~2 KB)

Western Regional Climate Center,
wrcc@dri.edu

EL CENTRO 2 SSW, CALIFORNIA

Monthly Total Precipitation (inches)

(042713)

File last updated on Apr 5, 2010
*** Note *** Provisional Data *** After Year/Month 200912
a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,
z = 26 or more days missing, A = Accumulations present
Long-term means based on columns; thus, the monthly row may not
sum (or average) to the long-term annual value.
MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5
Individual Months not used for annual or monthly statistics if more than 5 days are missing.
Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1932	0.00 z	0.00 z	0.00	0.00	0.00	0.11	0.00	0.00	0.00	1.68	0.00	0.65	2.44
1933	0.50	0.02	0.00	0.72	0.00	0.00	0.33	0.04	0.02	0.00	0.06	0.06	1.75
1934	0.00	0.04	0.12	0.00	0.00	0.00	0.02	0.77	0.00	0.00	0.00	0.34	1.29
1935	0.54	2.06	0.05	0.00	0.00	0.00	0.20	0.52	0.03	0.00	0.00	0.60	4.00
1936	0.20	0.43	0.00	0.00	0.00	0.00	0.43	0.11	0.00	0.09	0.16	0.27	1.69
1937	0.03	0.14	0.74	0.00	0.02	0.00	0.22	0.00	0.23	0.00	0.00	0.03	1.41
1938	0.00	0.96	0.43	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	1.22	2.83
1939	0.56	0.57	0.06	0.13	0.00	0.00	0.00	0.03	5.13	0.00	0.32	0.00	6.80
1940	0.04	0.77	0.01	0.01	0.00	0.00	0.00	0.00	1.59	0.08	0.05	2.32	4.87
1941	0.93	0.33	1.73	0.16	0.00	0.00	0.04	0.77	0.06	1.33	0.10	0.74	6.19
1942	0.04	0.72	0.50	0.31	0.00	0.00	0.00	0.07	0.00	0.03	0.00	0.00	1.67
1943	0.41	0.14	0.16	0.00	0.00	0.00	0.00	0.60	0.01	0.00	0.00	2.56	3.88
1944	0.00	1.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.69	0.89	2.78
1945	0.63	0.05	0.18	0.07	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.61	2.31
1946	0.00	0.00	0.03	0.00	0.00	0.00	0.00	1.84	0.08	0.26	0.11	0.46	2.78
1947	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.02	0.41	0.59
1948	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00	0.00	0.00	1.02	0.00	0.37	1.39
1949	1.78	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.01	0.20	2.34
1950	0.00	0.21	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.07	0.95
1951	0.29	0.01	0.00	0.14	0.00	0.00	0.10	2.49	0.00	0.00	0.35	0.36	3.74
1952	0.63	0.20	0.47	0.46	0.00	0.00	0.12	0.23	0.00	0.00	0.28	0.14	2.53
1953	0.00	0.03	0.31	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.04	0.00	0.45
1954	1.72	0.00	0.24	0.00	0.00	0.00	0.06 a	0.00	0.00	0.00	0.02	0.00	2.04
1955	1.71	0.00	0.06	0.00	0.00	0.00	0.59	1.05	0.00	0.00	0.00	0.09	3.50

1956	0.20	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.25
1957	0.70	0.09	0.02	0.00	0.00	0.00	0.00	0.74	0.00	2.09	0.00	0.05	3.69
1958	0.07	1.25	0.44	0.60	0.12	0.00	0.12	0.00	0.00	0.00	0.30	0.00	2.90
1959	0.16	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.10	0.49	0.00	0.69	1.90
1960	0.32	0.14	0.02	0.00	0.00	0.00	0.06	0.22	0.01	0.00	0.03	0.07	0.87
1961	0.15	0.00	0.00	0.00	0.00	0.00	0.02	0.75	0.00	0.00	0.05	0.81	1.78
1962	0.92	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	1.99
1963	0.00	0.07	0.15	0.00	0.00	0.00	0.00	0.13	1.02	0.00 b	0.42 a	0.00	1.79
1964	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.24	0.02	0.69
1965	0.00	0.16	0.20	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.24	1.88	3.09
1966	0.29	0.21	0.12	0.00	0.00	0.00	0.00	0.00	0.13	0.82	0.06	0.00	1.63
1967	0.26	0.00	0.20	0.00	0.00	0.00	0.00	0.00	1.47	0.00	1.69	0.77	4.39
1968	0.00	0.00	0.50	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	1.55
1969	0.79	0.05	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	1.52	0.03	3.33
1970	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.02	0.05	1.06
1971	0.03	0.03	0.00	0.08	0.00	0.00	0.00	0.04	0.24	0.02	0.00	0.00	0.44
1972	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	1.86	0.36	0.00	2.32
1973	0.00	0.29	0.00 z	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
1974	0.98	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.00 z	0.00	0.37	1.42
1975	0.00	0.00	0.20	0.40	0.00	0.00	0.07	0.00	0.27	0.00	0.00	0.03	0.97
1976	0.00	0.67	0.00	0.33	0.21	0.00	0.04	0.00	2.40	0.02	0.51	0.18	4.36
1977	0.11	0.00	0.00	0.00	0.00	0.00	0.00	2.98	0.00	0.37	0.00	1.08	4.54
1978	1.11	0.35	0.30	0.05	0.00	0.00	0.00	0.00	0.00	1.04	1.20	0.83	4.88
1979	1.20	0.12	0.38	0.00	0.06	0.00	0.43	0.88	0.00	0.00	0.00	0.00	3.07
1980	1.01	1.57	1.31	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	4.06
1981	1.26	0.40	0.57	0.00	0.21	0.00	0.00	1.15	0.00	0.00	0.27	0.00	3.86
1982	0.05	0.09	0.63	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.15	2.72	4.92
1983	0.21	1.64	1.33	0.04	0.00	0.00	0.00	1.71	0.09	0.00	0.00	0.48	5.50
1984	0.21	0.00	0.00	0.00	0.00	0.00	0.34	0.09	0.00	0.00	0.36	1.33	2.33
1985	0.06	0.20	0.00	0.00	0.00	0.00	0.04	0.30	1.86	0.63	0.79	0.84	4.72
1986	0.14	0.54	0.11	0.01	0.00	0.00	0.26	0.16	0.07	2.41	0.17	0.04	3.91
1987	0.05	0.22	0.00	0.00	0.03	0.00	0.00	0.00	0.00	1.53	0.04	0.37	2.24
1988	1.30	0.30	0.00	0.11	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	2.43
1989	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.03	0.00	0.00	0.92
1990	0.18	0.00	0.00	0.02	0.00	0.08	0.25	0.91	0.53	0.00	0.00	0.00	1.97
1991	0.45	0.71	0.50	0.00	0.00	0.00	0.00	0.02	0.55	0.00	0.35	1.28	3.86
1992	0.49	1.09 a	1.96	0.05	0.19	0.00	0.00	0.28	0.00	1.88	0.00	1.40	7.34
1993	3.45	0.74	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.75	0.00	5.15
1994	0.13	0.50	0.67	0.00	0.14	0.00	0.00	0.00	0.15	0.00	0.20	0.71	2.50
1995	1.66	0.12	0.22	0.10	0.00	0.00	0.02	0.04	0.00	0.00	0.00	0.06	2.22
1996	0.00	0.15	0.00	0.00	0.00	0.00	0.09	0.02	0.00	0.00	0.00	0.00	0.26

1997	0.43	0.05	0.00	0.01	0.00	0.02	0.00	0.06	2.44	0.00	0.00	0.82	3.83
1998	0.08	0.97	0.43	0.00	0.00	0.00	0.00	0.02	0.28	0.00	0.04	0.20	2.02
1999	0.00	0.00	0.00	0.31	0.00	0.00	0.00 z	0.16	0.63	0.00	0.00	0.00	1.10
2000	0.00	0.06	0.09	0.00	0.09	0.00	0.00	0.01	0.00	0.54	0.00	0.00	0.79
2001	0.24	0.55	0.56	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	1.39
2002	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.26	0.01	0.36
2003	0.00	1.32	0.42	0.00	0.00	0.00	0.12	1.04	0.00	0.00	0.11	0.02	3.03
2004	0.06	1.34	0.17	0.43	0.00	0.00	0.00	0.34	0.04	0.83	0.65	0.52 b	4.38
2005	0.86	0.91	0.20	0.00	0.00 z	0.00	0.17	1.53	0.02	0.88	0.00	0.00	4.57
2006	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.42
2007	0.00 z	0.00	0.03	0.00 z	0.00	0.00	0.00	0.14	0.37	0.00	1.03	0.05	1.62
2008	0.37 c	0.00	0.00	0.00	0.02	0.00	0.12	0.47	0.06	0.00 z	0.00 z	1.05	2.09
2009	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.59
2010	2.06	0.42 a	0.62	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	0.00 z	3.10
Period of Record Statistics													
MEAN	0.43	0.35	0.24	0.07	0.01	0.00	0.08	0.33	0.27	0.27	0.18	0.41	2.67
S.D.	0.62	0.46	0.38	0.16	0.05	0.02	0.18	0.58	0.76	0.57	0.34	0.60	1.66
SKEW	2.25	1.63	2.62	2.62	3.38	4.79	3.27	2.48	4.25	2.25	2.65	2.01	0.60
MAX	3.45	2.06	1.96	0.72	0.21	0.11	1.05	2.98	5.13	2.41	1.69	2.72	7.34
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
NO YRS	76	77	77	76	76	77	77	78	78	76	77	78	70

498-G

Department of Fish and Game
Biogeographic Data Branch

The Vegetation Classification and Mapping Program

List of California Terrestrial Natural Communities Recognized by The California Natural Diversity Database

September 2003 Edition

Introduction:

This document supersedes all other lists of terrestrial natural communities developed by the Natural Diversity Database (CNDDB). It is based on the classification put forth in "A Manual of California Vegetation" (Sawyer and Keeler-Wolf 1995 and upcoming new edition). However, it is structured to be compatible with previous CNDDB lists (e.g., Holland 1986). For those familiar with the Holland numerical coding system you will see a general similarity in the upper levels of the hierarchy. You will also see a greater detail at the lower levels of the hierarchy. The numbering system has been modified to incorporate this richer detail. Decimal points have been added to separate major groupings and two additional digits have been added to encompass the finest hierarchal detail.

One of the objectives of the Manual of California Vegetation (MCV) was to apply a uniform hierarchical structure to the State's vegetation types. Quantifiable classification rules were established to define the major floristic groups, called alliances and associations in the National Vegetation Classification (Grossman et al. 1998). In this document, the alliance level is denoted in the center triplet of the coding system and the associations in the right hand pair of numbers to the left of the final decimal. The numbers of the alliance in the center triplet attempt to denote relationships in floristic similarity. For example, the Chamise-Eastwood Manzanita alliance (37.106.00) is more closely related to the Chamise-Cupleaf Ceanothus alliance (37.105.00) than it is to the Chaparral Whitethorn alliance (37.205.00). However, due the rigidity of the numerical system newly added alliances are not necessarily numerically adjacent to their closest relatives.

EXAMPLE OF CODE:

```
Denotes general physiognomic and physical location (e.g. riparian and bottomland habitat)
|    ____Denotes type of general habitat (riparian forest and woodland)
|    |           ___Denotes floristic vegetation alliance (Sycamore alliance)
|    |      _____|_____       _____Denotes association (California Sycamore/Soft Chess)
|    |      |    |    |       |   |
6 1. 3 1 1 .0 2
```

In portions of this list numbered place-holders have been added. These are not formal units of classification, but simply serve to further clarity relationships between some of the more complex vegetation types. For example, several vegetation alliances are characterized by having Chamise (*Adenostoma fasciculatum*) as a major component. Thus the code 37.100.00 chaparral with Chamise was erected to show that such alliances as 37.105.00 Chamise-Cupleaf Ceanothus, 37.106.00 Chamise-Eastwood Manzanita, etc- are included in this cluster of chaparral types characterized by high cover of chamise. Other examples in this vein are vegetation with pines dominant (87.000.00), vegetation with fir dominant (88.000.00), and vegetation dominated by tree oaks (71.000.00). Because the classification for California is incomplete, the detail in the finest resolution of the hierarchy, the associations, is not uniform. Associations are defined quantitatively through a classification procedure using numerical comparisons between related vegetation sampling plots. These comparisons have been made only for a

portion of all vegetation stands in California. For example the U.S. Forest Service has been active in defining associations. Thus, one will notice the rich detail of the classification in various forest alliances such as the Douglas-fir, Red fir, White fir, and Jeffrey pine.

Since the previous edition of this document large areas of the State including the Mojave Desert, Yosemite National Park, Point Reyes National Seashore, and other National Park lands have been widely sampled through vegetation mapping and classification projects. Identification of these alliances and associations will be possible in the second edition of The Manual of California Vegetation expected to be published in 2003. Details about the definitions of more long-established alliances (called series in the first edition), their species composition, distribution, and ecological requirements may be sought in the MCV. (*Available from The California Native Plant Society*)

The literature citations following the association name refer to the original authors who defined the particular association. These are analogous to the author's names following a plant species in a botanical flora. All the citations mentioned in this document prior to 1996 are listed as entered in the literature citations in The Manual of California Vegetation or if newly defined, will be cited in the second edition of the MCV.

The primary purpose of the CNDDB classification is to assist in the location and determinations of significance and rarity of various vegetation types. Thus, ranking of natural communities by their rarity and threat is an important facet of the classification. In this document, as in previous CNDDB community lists, asterisks (*) denote communities that are either known or believed to be of high priority for inventory in CNDDB. If an alliance is starred, this means that all of the associations within it will also be considered of high inventory priority.

A special issue arises as a result of the conversion of the classification. Because CNDDB has accumulated many location records for certain rare community types now considered differently in the classification, it is very important that this critical conservation information is not lost as a result of taxonomic change. Thus, in this document one will notice instances where a community is listed either at the alliance or association level with an accompanying bracketed number. This number is the Holland code, which was used for it in the older classification. (**e.g.** 52.100.00 Fresh-Brackish Water Marsh {52200}). Because, in some cases, we are unsure of how this community type relates to the new hierarchy (it has not been quantitatively defined), it is placed into the hierarchy in its most likely position. However, no information will be lost and it will continue to be maintained in CNDDB until all occurrences of the community can be properly placed into the quantitative hierarchy. This fact points to the need for assistance from field investigators to revisit these sites and provide information on the species cover so we can convert to the new classification.

As more information comes in on the relationships between associations in this classification it becomes clear where some of these should be placed in the classification. For example the concept of the montane or Sierra mixed conifer forest has been vastly altered as a result of cumulative analysis of data of many plots of montane coniferous forest throughout California. Thus, in this list you will note that many of the mixed conifer associations in the previous edition of this document have been moved to White fir-Douglas-fir, Douglas-fir – Canyon Live Oak, Douglas-fir – Incense-cedar Forest, White-fir –Sugar Pine, Ponderosa Pine- Incense Cedar, and other newly defined alliances that better describe the variation in the montane coniferous forests of the state. Vegetation classification is an active field in California and such relationships will continue to be refined for some time. Currently we define approximately 400 alliances and 1300 associations.

We ***relish*** information on communities, whether it is a new record or re-assessment of existing information. Please contact us at CNDDB (916) 324-6857, and we can help you determine the most useful way to collect information on communities.

20.000.00 DUNES

21.000.00 Coastal Dunes

21.010.00 Active Coastal Dunes {21100}

21.020.00 Coastal Foredunes {21200}

21.030.00 Central Foredunes {21220}

21.040.00 Southern Foredunes {21230}

*21.100.00 Sand-verbena-Beach Bursage [*Abronia villosa-Ambrosia chamissonis*] {21210}
- *21.100.01 Beach Morning Glory - Dune Sagebrush [*Calystegia soldanella- Artemisia pycnocephala*] (Bluestone 1981)
- *21.100.02 Seashore Bluegrass - Dune Sagebrush [*Poa douglasii- Artemisia pycnocephala*] (Duebendorfer 1989)
- *21.100.03 Beach Bursage-Seaside Woolly-sunflower-Yellow Bush Lupine [*Ambrosia chamissonis-Eriophyllum staechadifolium-Lupinus arboreus*] (Holton & Johnson 1979)
- *21.100.04 Seaside Woolly-sunflower - Yellow Bush Lupine [*Eriophyllum staechadifolium-Lupinus arboreus*] (Holton & Johnson 1979)
- *21.100.05 Active North Coastal Dunes (Johnson 1963)
- *21.100.06 Seashore Bluegrass - Beach Pea [*Poa douglasii-Lathyrus littoralis*] (Parker 1974 & Johnson 1977)
- *21.100.07 Strand (Williams & Potter 1972)
- *21.100.08 Northern Dune Scrub {21310}
- *21.100.09 Central Dune Scrub {21320}
- *21.100.10 Southern Dune Scrub {21330}

*21.110.00 Beach Bursage [*Ambrosia chamissonis*] (Keeler-Wolf, *et al*. 2001)
- *21.110.01 Dune Sagebrush - sandmat [*Artemisia pycnocephala- Cardionema ramosissimum*](Keeler-Wolf, *et al*. 2001)

21.200.00 Non-native Iceplant
- 21.200.01 Iceplant - Fig-marigold [*Mesembryanthemum* spp.- *Carpobrotus* spp.] (Keeler-Wolf, *et al*. 2001)

22.000.00 Cismontane and Desert Interior Dunes

*22.010.00 Active Desert Dunes and Sand Fields {22000}

*22.100.00 Desert Sand-verbena [*Abronia villosa*]

*22.200.00 Antioch Dunes Unique Stands {23100}

22.300.00 Stabilized and Partially Stabilized Desert Dunes {22200}

22.400.00 Stabilized and Partially Stabilized Desert Sand Fields {22300}

*22.500.00 San Joaquin Valley Dunes (residual dunes of Holland)

30.000.00 SCRUB AND CHAPARRAL

31.000.00 Coastal Bluff Scrub {31000}

*31.100.00 Northern Coastal Bluff Scrub {31100}

*31.200.00 Southern Coastal Bluff Scrub {31200}

32.000.00 Coastal Scrub {32000}

32.005.00 Riversidian Sage Scrub {32700}
- 32.005.01 Upland Riversidian Sage Scrub {32710}
- *32.005.02 Riversidian Alluvial Fan Sage Scrub {32720}
- 32.005.03 Riversidian Desert Scrub

32.010.00 California Sagebrush Scrub [*Artemisia californica*]
- 32.010.01 California Sagebrush [*Artemisia californica*] (Kirkpatrick & Hutchinson 1977, Gordon & White 1994)
- 32.010.02 California Sagebrush - Deer Weed [*Artemisia californica-Lotus scoparius*] (DeSimone & Burk 1992)
- 32.010.03 California Sagebrush - Bush Penstemon [*Artemisia californica-Keckiella cordifolia*] (Gordon & White 1994)
- 32.010.04 California Sagebrush - Purple Sage [*Artemisia californica-Salvia leucophylla*] (Gordon & White 1994)

32.020.00 Black Sage Scrub [*Saliva mellifera*]
- 32.020.01 Black Sage - Laurel Sumac [*Salvia mellifera-Malosma laurina*] (Kirkpatrick & Hutchinson 1977)
- 32.020.02 Black Sage - California Buckwheat [*Saliva mellifera-Eriogonum fasciculatum*] (Kirkpatrick & Hutchinson 1977)
- 32.020.03 Black Sage [*Salvia mellifera*] (Malanson 1984)
- 32.020.04 Black Sage - California Encelia [*Salvia mellifera-Encelia californica*] (Malanson 1984)
- *32.020.05 Black Sage - Coast Prickly-pear [*Saliva mellifera-Opuntia littoralis* and hybrids] (Mooney 1977)

*32.030.00 White Sage Scrub [*Salvia apiana*]

32.040.00 California Buckwheat Scrub [*Eriogonum fasciculatum*]
- 32.040.01 California Buckwheat - California Figwort - Phacelia [*Eriogonum fasciculatum-Scrophularia californica-Phacelia ramosissima*] (Kirkpatrick & Hutchinson 1977)
- 32.040.02 California Buckwheat [*Eriogonum fasciculatum*] (Gordon & White 1994)
- *32.040.03 California Buckwheat - Big Sagebrush [*Eriogonum fasciculatum-Artemisia tridentata*] (Gordon & White 1994)
- *32.040.04 California Buckwheat Alluvial Fan [*Eriogonum fasciculatum*] (Gordon & White 1994)
- 32.040.05 California Buckwheat-White Bursage [*Eriogonum fasciculatum-Ambrosia dumosa*] (Keeler-Wolf *et al* 1998)
- 32.040.06 California Buckwheat - Bladder Sage [*Eriogonum fasciculatum-Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)

*32.041.00 Wright's Buckwheat Dwarf Scrub [*Eriogonum wrightii*] (Keeler-Wolf *et al* 1998)

*32.050.00 California Encelia Scrub [*Encelia californica*]
- 32.050.01 California Encelia - California Sagebrush [*Encelia californica-Artemisia californica*] (Kirkpatrick & Hutchinson 1977)
- *32.050.02 California Encelia [*Encelia californica*] (Malanson 1984)

32.060.00 Coyote Brush Scrub and Dwarf Scrub [*Baccharis pilularis*] {32110}

*32.060.01 Coyote Brush/Seaside Woolly-sunflower [*Baccharis pilularis/Eriophyllum staechadifolium*] (Baxter 1992)

*32.060.02 Coyote Brush / Tufted Hairgrass [*Baccharis pilularis/Deschampsia caespitosa*] (Elliott & Wehausen 1974)

*32.060.03 Coyote Brush / Creeping Ryegrass [*Baccharis pilularis/Leymus triticoides*] (Fiedler & Leidy 1987)

*32.060.04 Coyote Brush / Sword Fern [*Baccharis pilularis/Polystichum munitum*] (Grams *et al.* 1977)

32.060.05 Coyote Brush - California Sagebrush [*Baccharis pilularis-Artemisia californica*] (Heady *et al*. 1977)

32.060.06 Coyote Brush – Dune Lupine -Yellow Bush Lupine [*Baccharis pilularis-Lupinus chamissonis – Lupinus arboreus*] (Parker 1974 in Barbour & Johnson 1977 modified by Keeler-Wolf *et al.* 2001)

32.060.07 Coyote Brush / European Beachgrass [*Baccharis pilularis/Ammophila arenaria*] (Parker 1974 in Barbour & Johnson 1977)

32.060.08 Coyote Brush / California Figwort [*Baccharis pilularis/Scrophularia californica*] (Parker 1974 in Barbour & Johnson 1977)

32.060.09 Coyote Brush / Annual Grasses [*Baccharis pilularis-Bromus* spp.] (Keeler-Wolf, *et al*. 2001)

*32.060.10 Coyote Brush / Purple Needlegrass [*Baccharis pilularis /Nassella pulchra*] (Keeler-Wolf, *et a.l* 2001)

*32.060.11 Coyote Brush / California Oatgrass [*Baccharis pilularis /Danthonia californica*] (Keeler-Wolf, *et a.l* 2001)

*32.060.12 Coyote Brush / Ocean Spray [*Baccharis pilularis / Holodiscus discolor*] (Keeler-Wolf *et al.* 2001)

*32.060.13 Coyote Brush / Slough Sedge – Common Rush [*Baccharis pilularis /Carex obnupta - Juncus patens*] (Keeler-Wolf *et al.* 2001)

32.060.14 Coyote Brush – Blueblossom [*Baccharis pilularis – Ceanothus thyrsiflorus*] (Keeler-Wolf *et al*. 2001)

32.060.15 Coyote Brush – California Blackberry/ Weedy herb [*Baccharis pilularis -Rubus ursinus*/weedy herb] (Keeler-Wolf *et al.* 2001)

32.060.16 Coyote Brush – Coffeeberry [*Baccharis pilularis -Rhamnus californicus*] (Keeler-Wolf *et al.* 2001)

32.060.17 Coyote Brush – Poison Oak [*Baccharis pilularis -Toxicodendron diversilobum*] (Keeler-Wolf *et al.* 2001)

32.060.18 Coyote Brush – California Sagebrush – Poison Oak/ Coyotemint [*Baccharis pilularis - Artemisia californica-Toxicodendron/Monardella villosa*] (Keeler-Wolf et al. 2001)

*32.070.00 Scalebroom Scrub [*Lepidospartum squamatum*] (Keeler-Wolf *et al.* 1998)

*32.070.01 California Buckwheat - Scalebroom [*Eriogonum fasciculatum-Lepidospartum squamatum*] (Gordon & White 1994)

*32.070.02 Scalebroom - Hairy Yerba Santa - Chaparral Yucca [*Lepidospartum squamatum-Eriodictyon crassifolium-Yucca whipplei*] (Kirkpatrick & Hutchinson 1977)

*32.070.03 Scalebroom / mixed ephermeral herbs [*Lepidospartum*/mixed ephemeral Mojave Desert], (Barbour & Wirka 1997)

32.080.00 Yellow Bush Lupine Scrub [*Lupinus arboreus*]

32.080.01 Yellow Bush Lupine - Ripgut Brome [*Lupinus arboreus-Bromus diandrus*] (Duebendorfer 1989)

32.080.02 Yellow Bush Lupine [*Lupinus arboreus*] (Holton & Johnson 1979)

*32.080.03 Yellow Bush Lupine-Heather Goldenbush [*Lupinus arboreus-Ericameria ericoides*] (Holton & Johnson 1979)

32.080.04 Yellow Bush Lupine - Vernal Grass [*Lupinus arboreus-Anthoxanthum odoratum*] (Hektner & Foin 1977)

32.080.05 Yellow Bush Lupine - California Figwort [*Lupinus arboreus-Scrophularia californica*] (Parker 1974)

32.081.00 Silver Bush Lupine Scrub [*Lupinus albifrons*] (Keeler-Wolf and Moore 2001)
32.081.01 Silver Bush Lupine [*Lupinus albifrons*] (Keeler-Wolf and Moore 2001)

32.090.00 Purple Sage Scrub [*Salvia leucophylla*]
32.090.01 Purple Sage - California Sagebrush [*Salvia leucophylla-Artemisia californica*] (Kirkpatrick & Hutchinson 1977)
32.090.02 Purple Sage - Laurel Sumac [*Salvia leucophylla-Malosma laurina*] (Kirkpatrick & Hutchinson 1977)

*32.100.00 California Buckwheat - White Sage Scrub [*Eriogonium fasciculatum-Salvia apiana*] (Gordon & White 1994)
*32.100.01 California Buckwheat - White Sage [*Eriogonum fasciculatum-Salvia apiana*] (Gordon & White 1994)

32.110.00 California Sagebrush - California Buckwheat Scrub [*Artemisia californica-Eriogonum fasciculatum*]
32.110.01 California Sagebrush - California Buckwheat - Sugar Bush [*Artemisia californica-Eriogonum fasciculatum-Rhus ovata*] (Gordon & White 1994)
32.110.02 California Sagebrush - California Buckwheat - White Sage [*Artemisia californica-Eriogonum fasciculatum-Salvia apiana*] (Gordon & White 1994)

32.120.00 California Sagebrush - Black Sage Scrub [*Artemisia californica- Salvia mellifera*]
32.120.01 California Sagebrush - Black Sage [*Artemisia californica-Salvia mellifera*] (DeSimone & Burk 1992)
32.120.02 Black Sage - California Sagebrush [*Salvia mellifera-Artemisia californica*] (DeSimone & Burk 1992)

*32.130.00 Salal - Black Huckleberry Scrub and Dwarf Scrub [*Gaultheria shallon-Vaccinium ovatum*] {32120}

32.140.00 Mixed Sage Scrub [*Salvia* spp.]

*32.150.00 Coast Prickly Pear Succulent Scrub [*Opuntia littoralis*]

*32.160.00 Dune Lupine - Goldenbush Scrub [*Lupinus chamissonis-Isocoma menziesii*] {21330}
*32.160.01 Heather Goldenbush [*Ericameria ericoides*] (Bluestone 1981)
*32.160.02 Dune Lupine [*Lupinus chamissonis*] (Holton & Johnson 1979)
*32.160.03 Dune Lupine - Heather Goldenbush [*Lupinus chamissonis-Ericameria ericoides*] (Holton & Johnson 1979)

*32.170.00 Maritime Succulent Scrub {32400}

32.180.00 Broom Scrub [includes stands of *Cytisus* spp., *Spartium* spp.,*Genista* spp.]

32.185.00 Gorse Scrub [*Ulex europea*] (Keeler-Wolf, *et al*. 2001)

32.190.00 Venturan Coastal Sage Scrub {32300}

32.200.00 Diegan Coastal Sage Scrub {32500}

32.300.00 Coastal Sage Chaparral Scrub {37G00}

33.000.00 Sonoran and Mojavean Desert Scrub

33.010.00 Creosote Bush Scrub [*Larrea tridentata*] {33100}
33.010.01 Creosote Bush with disturbance [*Larrea tridentata*] (Minnich *et al*. 1993)

*33.010.02 Sonoran Dune Scrub (Spolsky 1979)
33.010.03 High Diversity Creosote Scrub (Spolsky 1979)
33.010.04 moved to within 33.027.00
*33.010.05 Saltbush - Creosote Bush [*Larrea tridentata-Atriplex polycarpa*] (Spolsky 1979)
33.010.06 Creosote Bush Wash Scrub [*Larrea tridentata*] (Keeler-Wolf *et al*. 1998)
*33.010.07 Creosote Bush-White Ratteny-Big Galleta [*Larrea tridentata-Krameria grayi-Pleuraphis rigida*] (Keeler-Wolf *et al*. 1998)
33.010.08 Creosote Bush - Cheesebush [*Larrea tridentata-Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)
33.010.09 Creosote Bush / Desert Trumpet [*Larrea tridentata/Eriogonum inflatum*] (Keeler-Wolf and Thomas 2000)
33.010.10 Creosote Bush - Nevada Ephedra [*Larrea tridentata-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
*33.010.11 Creosote Bush - Mojave Yucca - Desert Tea [*Larrea tridentata-Yucca schidigera-Ephedra californica*] (Keeler-Wolf and Thomas 2000)
33.010.12 Creosote Bush - Allscale [*Larrea tridentata-Atriplex polycarpa*] (Keeler-Wolf and Thomas 2000)
*33.010.13 Creosote Bush - Big Galleta [*Larrea tridentata-Pleuraphis rigida*] (Keeler-Wolf and Thomas 2000)
*33.010.14 Creosote Bush - Big Galleta - Anderson's Wolfberry [*Larrea tridentata-Pleuraphis rigida-Lycium andersonii*] (Keeler-Wolf and Thomas 2000)
33.010.15 Creosote Bush - Cheesebush - Woolly Brickellia [*Larrea tridentata-Hymenoclea salsola-Brickellia incana*] (Keeler-Wolf and Thomas 2000)
33.010.16 Creosote Bush - Desert-holly [*Larrea tridentata-Atriplex hymenelytra*] (Keeler-Wolf and Thomas 2000)
33.010.17 Creosote Bush - Shadscale [*Larrea tridentata-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)
*33.010.18 Creosote Bush - Shockley's Goldenhead [*Larrea tridentata-Acamptopappus shockleyi*] (Keeler-Wolf and Thomas 2000)

33.020.00 Blackbush High Desert Scrub [*Coleogyne ramosissima*] {34300}
*33.020.01 Sonoran Blackbush [*Coleogyne ramosissima*] (Spolsky 1979)
33.020.02 Blackbush - Shadscale [*Coleogyne ramosissima-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)
33.020.03 Blackbush - Nevada Ephedra [*Coleogyne ramosissima-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
33.020.04 Blackbush - Nevada Ephedra - California Buckwheat [*Coleogyne ramosissima-Ephedra nevadensis-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
33.020.05 Blackbush - California Buckwheat [*Coleogyne ramosissima-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
33.020.06 Blackbush - Creosote Bush - California Buckwheat [*Coleogyne ramosissima-Larrea tridentata-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
33.020.07 Blackbush - Creosote Bush - White Busage [*Coleogyne ramosissima-Larrea tridentata-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
33.020.08 Blackbush - Anderson's Wolfberry [*Coleogyne ramosissima-Lycium andersonii*] (Keeler-Wolf and Thomas 2000)
33.020.09 Blackbush - Bladder Sage [*Coleogyne ramosissima-Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)

33.025.00 Virgin River Encelia Scrub [*Encelia virginensis* var. *actonii*] (Keeler-Wolf and Thomas 2000)
33.025.01 Virgin River Encelia [*Encelia virginensis* var. *actonii*] (Keeler-Wolf and Thomas 2000)
33.025.02 Virgin River Encelia - Blue Sage [*Encelia virginensis* var. *actonii-Salvia dorrii*] (Keeler-Wolf and Thomas 2000)

33.027.00 Creosote Bush - Brittlebush Scrub [*Larrea tridentata-Encelia farinosa*] (Keeler-Wolf and Thomas 2000) Includes former 33.010.04 Creosote Bush - Brittlebush [*Larrea tridenata-Encelia farinosa*] (Spolsky 1979)

33.027.01 Creosote Bush - Brittlebush / Arizona Honeysweet [*Larrea tridentata-Encelia farinosa/Tidestromia oblongifolia*] (Keeler-Wolf and Thomas 2000)
33.027.02 Creosote Bush - Brittlebush - Sweetbush [*Larrea tridentata-Encelia farinosa-Bebbia juncea*] (Keeler-Wolf and Thomas 2000)
33.027.03 Creosote Bush - Brittlebush - White Bursage [*Larrea tridentata-Encelia farinosa-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
33.027.04 Creosote Bush - Brittlebush - Ocotillo [*Larrea tridentata-Encelia farinosa-Fouquieria splendens*] (Keeler-Wolf 2001)

33.030.00 Brittlebush Drought Deciduous Scrub [*Encelia farinosa*]
33.030.01 Brittlebush-succulent scrub [*Encelia farinosa*-succulent]
*33.030.02 Brittlebush-Desert Fir [*Encelia farinosa-Peucephyllum schottii*] (Keeler-Wolf *et al*. 1998)
*33.030.03 Brittlebush-California Buckwheat-Agave [*Encelia farinosa-Eriogonum fasciculatum-Agave deserti*] (Keeler-Wolf *et al*. 1998)

*33.031.00 Acton Encelia [*Encelia actoni*]

33.032.00 Desert Sunflower Drought Deciduous Scrub [*Viguiera parishii*] (Keeler-Wolf *et al.* 1998)
*33.032.01 Desert Sunflower-Agave [*Viguiera parishii-Agave deserti*] (Keeler-Wolf *et al.* 1998)
33.032.02 Desert Sunflower-California Buckwheat [*Viguiera parishii-Eriogonum fasciculatum*] (Keeler-Wolf *et al*. 1998)

*33.033.00 Net-veined Viguiera Scrub [*Viguiera reticulata*] (Keeler-Wolf and Thomas 2000)
*33.033.01 Net-veined Viguiera [*Viguiera reticulata*] (Keeler-Wolf and Thomas 2000)

33.040.00 Catclaw Acacia Thorn Scrub [*Acacia greggii*]
33.040.01 Catclaw Acacia-wash association [*Acacia greggii*] (Keeler-Wolf *et al.* 1998)
33.040.02 Catclaw Acacia Savanna [*Acacia greggii-Bromus madritensis*] (Keeler-Wolf *et al*. 1998)
33.040.03 Catclaw Acacia / Desert Lavender [*Acacia greggii-Hyptis emoryi*] (Keeler-Wolf and Thomas 2000)
33.040.04 Catclaw Acacia / Cheesebush [*Acacia greggii/Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)
33.040.05 Catclaw Acacia - Cheesebush - Virgin River Encelia [*Acacia greggii-Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)
33.040.06 Catclaw Acacia - Desert Sunflower [*Acacia greggii-Viguiera parishii*] (Keeler-Wolf and Thomas 2000)
33.040.07 Catclaw Acacia - Desert Almond [*Acacia greggii-Prunus fasciculatum*] (Keeler-Wolf and Thomas 2000)
*33.040.08 Catclaw Acacia - Woolly Bursage [*Acacia greggii-Ambrosia eriocentra*] (Keeler-Wolf and Thomas 2000)
33.040.09 Catclaw Acacia - Blue Sage [*Acacia greggii-Salvia dorrii*] (Keeler-Wolf and Thomas 2000)
33.040.10 Catclaw Acacia - Sweetbush [*Acacia greggii-Bebbia juncea*] (Keeler-Wolf 2001)
*33.040.11 Catclaw Acacia/Naked buckwheat [*Acacia greggii/Eriogonum nudum* var. *pauciflorum*] (Wirka and Barbour 1997)

*33.050.00 Teddy-bear Cholla Succulent Scrub [*Opuntia bigelovii*]

33.060.00 White Bursage Dwarf Scrub [*Ambrosia dumosa*]
*33.060.01 White Bursage -Rayless Goldenhead [*Ambrosia dumosa -Acamptopappus sphaerocephalus*] association (Keeler-Wolf *et al.* 1998)
*33.060.02 White Bursage [*Ambrosia dumosa*], terrace association (Keeler-Wolf *et al*. 1998)
33.060.03 White Bursage - Desert-holly [*Ambrosia dumosa-Atriplex hymenolytra*] (Keeler-Wolf and Thomas 2000)

*33.060.04 White Bursage - Big Galleta [*Ambrosia dumosa-Pleuraphis rigida*] (Keeler-Wolf 2001)
33.060.05 White Bursage - California Buckwheat [*Ambrosia dumosa-Eriogonum fasciculatum*] (Keeler-Wolf 2001)

*33.061.00 moved to 33.140.41

*33.062.00 Wand Holdback Unique Stands [*Caesalpinia virgata*]

33.070.00 Mojave Yucca Scrub [*Yucca schidigera*]
33.070.01 Mojave Yucca [*Yucca schidigera*] (Keeler-Wolf and Thomas 2000)

33.070.02 Mojave Yucca - Blackbush [*Yucca schidigera-Coleogyne ramosissima*] (Keeler-Wolf and Thomas 2000)
33.070.02 Mojave Yucca - Nevada Ephedra [*Yucca schidigera-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
33.070.03 Mojave Yucca - White Bursage [*Yucca schidigera-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
33.070.05 Mojave Yucca - Creosote Bush - White Bursage [*Yucca schidigera-Larrea tridentata-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
33.070.06 Mojave Yucca - Creosote Bush - Nevada Ephedra [*Yucca schidigera-Larrea tridentata-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
33.070.07 Mojave Yucca - California Buckwheat [*Yucca schidigera-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
*33.070.08 Mojave Yucca - Buckhorn Cholla [*Yucca schidigera-Opuntia acanthocarpa*] (Keeler-Wolf and Thomas 2000)
33.070.09 Mojave Yucca - Desert Sunflower [*Yucca schidigera-Viguiera parishii*] (Keeler-Wolf and Thomas 2000)
*33.070.10 Mojave Yucca - Creosote Bush - (Jojoba) [*Yucca schidigera-Larrea tridentata-(Simmondsia chinensis)*] (Keeler-Wolf and Thomas 2000)

*33.075.00 Desert Agave succulent-leaved scrub [*Agave deserti*]
*33.075.01 Desert Agave wash terrace [*Agave deserti*] (Keeler-Wolf *et al*. 1998)
*33.075.02 Desert Agave-Mojave Yucca [*Agave deserti-Yucca schidigera*] (Keeler-Wolf *et al*. 1998)

*33.080.00 Nolina [*Nolina* spp.]
*33.080.01 Parry's Nolina [*Nolina parryi*] (Keeler-Wolf and Thomas 2000)

*33.090.00 Ocotillo open-tall scrub [*Fouquieria splendens*]

*33.100.00 All-thorn Tall Scrub Unique Stands [*Koeberlinia spinosa*] {75300}

*33.110.00 Crucifixion-thorn Tall ScrubUnique Stands [*Castela emoryi*] {75200}

*33.120.00 Elephant Tree Unique Stands [*Bursera microphylla*] {75100}

33.130.00 Brittlebush - White Bursage Dwarf Scrub [*Encelia farinosa-Ambrosia dumosa*]

33.140.00 Creosote Bush - White Bursage Scrub [*Larrea tridentata-Ambrosia dumosa*]
33.140.01 Rocky sides of hills and mountains (McHargue 1973)
33.140.02 Rocky bajadas (McHargue 1973)
33.140.03 Gravelly bajadas (McHargue 1973)
33.140.04 Sonoran Creosote Bush Scrub [*Larrea tridentata*] (Spolsky 1979){33100}
33.140.05 Uniform Creosote Scrub [*Larrea tridentata*] (Spolsky 1979)
33.140.06 Mojave Creosote Bush Scrub [*Larrea tridentata*] {34100}

*33.140.07	Creosote bush-White bursage-Indigo Bush [*Larrea tridentata-Ambrosia dumosa-Psorothamnus schottii*] (Keeler-Wolf *et al*. 1998)
*33.140.08	Creosote bush-White bursage-California croton [*Larrea tridentata-Ambrosia dumosa-Croton californica*]
33.140.09	Creosote Bush-White Bursage-Desert-holly [*Larrea tridentata-Ambrosia dumosa-/Atriplex hymenelytra*] (Keeler-Wolf *et al*. 1998)
*33.140.10	Creosote Bush-White Bursage-Galium-Lyrocarpa [*Larrea tridentata-Ambrosia dumosa-Galium angustifolium-Lyrocarpa coulteri*] (Keeler-Wolf *et al*. 1998)
33.140.11	Creosote Bush - White Bursage - Mojave Yucca [*Larrea tridentata-Ambrosia dumosa-Yucca schidigera*] (Keeler-Wolf and Thomas 2000)
33.140.12	Creosote Bush - White Bursage - Desert Sunflower [*Larrea tridentata-Ambrosia dumosa-Viguiera parishii*] (Keeler-Wolf and Thomas 2000)
33.140.13	Creosote Bush - White Bursage - Spiny Senna [*Larrea tridentata-Ambrosia dumosa-Senna armata*] (Keeler-Wolf and Thomas 2000)
33.140.14	Creosote Bush - White Bursage - Bladder Sage [*Larrea tridentata-Ambrosia dumosa-Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)
33.140.15	Creosote Bush - White Bursage - Mojave indigo-bush [*Larrea tridentata-Ambrosia dumosa-Psorothamnus arborescens*] (Keeler-Wolf and Thomas 2000)
33.140.16	Creosote Bush - White Bursage - Fremont's indigo-bush [*Larrea tridentata-Ambrosia dumosa-Psorothamnus fremontii*] (Keeler-Wolf and Thomas 2000)
*33.140.17	Creosote Bush - White Bursage - Big Galleta [*Larrea tridentata-Ambrosia dumosa-Pleuraphis rigida*] (Keeler-Wolf and Thomas 2000)
33.140.18	Creosote Bush - White Bursage - Pencil Cactus [*Larrea tridentata-Ambrosia dumosa-Opuntia ramosissima*] (Keeler-Wolf and Thomas 2000)
33.140.19	Creosote Bush - White Bursage - Anderson's Wolfberry [*Larrea tridentata-Ambrosia dumosa-Lycium andersonii*] (Keeler-Wolf and Thomas 2000)
33.140.20	Creosote Bush - White Bursage - Nevada Ephedra [*Larrea tridentata-Ambrosia dumosa-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
33.140.21	Creosote Bush - White Bursage - Desert Peppergrass [*Larrea tridentata-Ambrosia dumosa-Lepidium fremontii*] (Keeler-Wolf and Thomas 2000)
33.140.22	Creosote Bush - White Bursage - White Rhatany [*Larrea tridentata-Ambrosia dumosa-Krameria grayi*] (Keeler-Wolf and Thomas 2000)
33.140.23	Creosote Bush - White Bursage Pima Rhatany [*Larrea tridentata-Ambrosia dumosa-Krameria erecta*] (Keeler-Wolf and Thomas 2000)
*33.140.24	Creosote Bush - White Bursage - Thurber's Sandpaper Plant [*Larrea tridentata-Ambrosia dumosa-Petalonyx thurberi*] (Keeler-Wolf and Thomas 2000)
33.140.25	Creosote Bush - White Bursage - Matchweed spp. [*Larrea tridentata-Ambrosia dumosa-Gutierrezia* spp.] (Keeler-Wolf and Thomas 2000)
33.140.26	Creosote Bush - White Bursage - Hop-sage [*Larrea tridentata-Ambrosia dumosa-Grayia spinosa*] (Keeler-Wolf and Thomas 2000)
33.140.27	Creosote Bush - White Bursage - Desert Trumpet [*Larrea tridentata-Ambrosia dumosa-Eriogonum inflatum*] (Keeler-Wolf and Thomas 2000)
33.140.28	Creosote Bush - White Bursage - California Buckwheat [*Larrea tridentata-Ambrosia dumosa-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
*33.140.29	Creosote Bush - White Bursage - Death Valley Ephedra [*Larrea tridentata-Ambrosia dumosa-Ephedra funerea*] (Keeler-Wolf and Thomas 2000)
*33.140.30	Creosote Bush - White Bursage - Desert Tea [*Larrea tridentata-Ambrosia dumosa-Ephedra californica*] (Keeler-Wolf and Thomas 2000)
*33.140.31	Creosote Bush - White Bursage - Virgin River Encelia [*Larrea tridentata-Ambrosia dumosa-Encelia virginensis*] (Keeler-Wolf and Thomas 2000)
33.140.32	Creosote Bush - White Bursage - Brittlebush [*Larrea tridentata-Ambrosia dumosa-Encelia farinosa*] (Keeler-Wolf and Thomas 2000)
*33.140.33	Creosote Bush - White Bursage - Barrel Cactus [*Larrea tridentata-Ambrosia dumosa-Echinocactus polycephalus*] (Keeler-Wolf and Thomas 2000)
*33.140.34	Creosote Bush - White Bursage - Downy Dalea [*Larrea tridentata-Ambrosia dumosa-Dalea mollissima*] (Keeler-Wolf and Thomas 2000)

*33.140.35 Creosote Bush - White Bursage - Cryptogrammic crust [*Larrea tridentata-Ambrosia dumosa*-Cryptogrammic crust] (Keeler-Wolf and Thomas 2000)

33.140.36 Creosote Bush - White Bursage - Sweetbush [*Larrea tridentata-Ambrosia dumosa-Bebbia juncea*] (Keeler-Wolf and Thomas 2000)

33.140.37 Creosote Bush - White Bursage - Fourwing Saltbush [*Larrea tridentata-Ambrosia dumosa- Atriplex canescens*] (Keeler-Wolf and Thomas 2000)

33.140.38 Creosote Bush - White Bursage -Allscale [*Larrea tridentata-Ambrosia dumosa-Atriplex polycarpa*] (Keeler-Wolf and Thomas 2000)

33.140.39 Creosote Bush - White Bursage - Shadscale [*Larrea tridentata-Ambrosia dumosa-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)

33.140.40 Creosote Bush - White Bursage - Fremont's Chaff-bush [*Larrea tridentata-Ambrosia dumosa-Amphipappus fremontii*] (Keeler-Wolf and Thomas 2000)

33.140.41 Creosote Bush - White Bursage -Fagonia [*Larrea tridentata-Ambrosia dumosa-Fagonia laevis*] (Keeler-Wolf *et al.* 1998*)*

*33.150.00 Foothill Palo Verde - Saguaro Tall Scrub [*Cercidum microphyllum-Carnegia gigantea*] {75400}

33.160.00 Bladderpod - California Ephedra - Narrowleaf Goldenbush Scrub [*Isomeris arborea-Ephedra californica-Ericameria linearifolia*] {23300}

*33.160.01 Monvero Dunes Association

*33.170.00 Joshua Tree Tall Scrub and Open Woodland [*Yucca brevifolia*]

*33.170.01 Joshua Tree Woodland [*Yucca brevifolia*] {73000}

*33.170.02 Joshua Tree / Blackbush [*Yucca brevifolia-Coleogyne ramosissima*] (Keeler-Wolf and Thomas 2000)

*33.170.03 Joshua Tree - California Juniper / Blackbush [*Yucca brevifolia-Juniperus californica/Coleogyne ramosissima*] (Keeler-Wolf 2001)

*33.170.04 Joshua Tree / Big Sagebrush - Shadscale [*Yucca brevifolia/Artemisia tridentata-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)

*33.170.05 Joshua Tree / Creosote Bush - Nevada Ephedra [*Yucca brevifolia/Larrea tridentata-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)

*33.170.06 Joshua Tree / Buckhorn Cholla [*Yucca brevifolia/Opuntia acanthocarpa*] (Keeler-Wolf and Thomas 2000)

*33.170.07 Joshua Tree / Galleta spp. [*Yucca brevifolia/Pleuraphis* sp.] (Keeler-Wolf and Thomas 2000)

*33.170.08 Joshua Tree / Anderson's Wolfberry [*Yucca brevifolia/Lycium andersonii*] (Keeler-Wolf and Thomas 2000)

*33.170.09 Joshua Tree / Bladder Sage [*Yucca brevifolia/Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)

*33.170.10 Joshua Tree / Mojave Yucca - Creosote Bush [*Yucca brevifolia/Yucca schidigera-Larrea tridentata*] (Keeler-Wolf and Thomas 2000)

*33.170.11 Joshua Tree / Creosote Bush - White Bursage - California Buckwheat [*Yucca brevifolia/Larrea tridentata-Ambrosia dumosa-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)

33.180.00 Hop-sage Scrub [*Grayia spinosa*]

33.180.01 Hop-sage [*Grayia spinosa*] (Keeler-Wolf and Thomas 2000)

33.180.02 Hop-sage - Shadscale [*Grayia spinosa-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)

33.180.03 Hop-sage - Creosote Bush [*Grayia spinosa-Larrea tridentata*] (Keeler-Wolf and Thomas 2000)

33.180.04 Hop-sage - Anderson's Wolfberry [*Grayia spinosa-Lycium andersonii*] (Keeler-Wolf and Thomas 2000)

*33.180.05 Hop-sage - Round-leaved Buckwheat [*Grayia spinosa-Eriogonum ovalifolium*] (Keeler-Wolf and Thomas 2000)

33.190.00 Desert Lavender Wash Scrub [*Hyptis emoryi*] (Keeler-Wolf *et al*. 1998)

33.200.00 Cheesebush Scrub [*Hymenoclea salsola*]
- 33.200.01 Cheesebush-wash association [*Hymenoclea salsola*] (Keeler-Wolf *et al.* 1998)
- 33.200.02 Cheesebush-California Buckwheat [*Hymenoclea salsola-Eriogonum fasciculatum*] (Keeler-Wolf *et al*. 1998)
- 33.200.03 Cheesebush - Blackstem Rabbitbrush [*Hymenoclea salsola-Chrysothamnus paniculatus*] (Keeler-Wolf and Thomas 2000)
- 33.200.04 Cheesebush - Shadscale [*Hymenoclea salsola-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)
- 33.200.05 Cheesebush - Sweetbush [*Hymenoclea salsola-Bebbia juncea*] (Keeler-Wolf and Thomas 2000)
- *33.200.06 Cheesebush -Woolly Bursage [*Hymenoclea salsola-Ambrosia eriocentra*] (Keeler-Wolf and Thomas 2000)
- 33.200.07 Cheesebush - Woolly Brickellia [*Hymenoclea salsola-Brickellia incana*] (Keeler-Wolf and Thomas 2000)
- 33.200.08 Cheesebush - Spiny Senna [*Hymenoclea salsola-Senna armata*] (Keeler-Wolf and Thomas 2000)

33.210.00 Sonoran Mixed Woody and Succulent Scrub {33220}

33.211.00 Mojave Mixed Woody Scrub {34210}

33.212.00 Mojave Mixed Steppe{34220}

33.213.00 Mojave Wash Scrub {34250}

*33.220.00 Desert Apricot [*Prunus fremontii*] (Keeler-Wolf *et al.* 1998){37400}

*33.225.00 Graythorn Unique Stand [*Ziziphus obtusifolia*] (Keeler-Wolf 2001)

*33.230.00 Hackberry Scrub [*Celtis laevigata*] (Keeler-Wolf and Thomas 2000)

*33.240.00 Stanbury's Antelope Brush Scrub [*Purshia mexicana*] (Keeler-Wolf and Thomas 2000)

*33.260.00 Sweetbush Riparian Scrub [*Bebbia juncea*] (Keeler-Wolf and Thomas 2000)

*33.270.00 California Ephedra [*Ephedra californica*] (Keeler-Wolf and Thomas 2000)
- 33.270.01 California Ephedra - Cheesebush [*Ephedra californica-Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)

33.280.00 Nevada Ephedra Scrub [*Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
- 33.280.01 Nevada Ephedra [*Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
- 33.280.02 Nevada Ephedra - Shadscale [*Ephedra nevadensis-Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)
- 33.280.03 Nevada Ephedra - Bladder Sage [*Ephedra nevadensis-Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)
- 33.280.04 Nevada Ephedra [*Ephedra nevadensis- Lyceum andersonii*] (Keeler-Wolf and Thomas 2000)

33.290.00 Spiny Menodora Scrub [*Menodora spinescens*] (Keeler-Wolf and Thomas 2000)

33.300.00 Desert Almond Scrub [*Prunus fasciculata*] (Keeler-Wolf and Thomas 2000)
- 33.300.01 Desert Almond [*Prunus fasciculata*] (Keeler-Wolf and Thomas 2000)

33.300.02 Desert Almond - Bladder Sage [*Prunus fasciculata-Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)
*33.300.03 Desert Almond - Skunkbrush [*Prunus fasciculata-Rhus trilobata*] (Keeler-Wolf and Thomas 2000)
*33.300.04 Desert Almond - Stanbury's Antelope Bush [*Prunus fasciculata-Purshia mexicana*] (Keeler-Wolf and Thomas 2000)
*33.300.05 Desert Almond - Woolly Bursage [*Prunus fasciculata-Ambrosia eriocentra*] (Keeler-Wolf and Thomas 2000)
*33.300.06 Desert Almond - Net-veined Viguiera - (Utah Mortonia) [*Prunus fasciculata-Viguiera reticulata-(Mortonia utahensis)*] (Keeler-Wolf and Thomas 2000)

33.310.00 Bladder Sage Scrub [*Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)
33.310.01 Bladder Sage [*Salazaria mexicana*] (Keeler-Wolf and Thomas 2000)

*33.320.00 Blue Sage Dwarf Scrubland [*Salvia dorrii*] (Keeler-Wolf and Thomas 2000)
*33.320.01 Blue Sage [*Salvia dorrii*] (Keeler-Wolf and Thomas 2000)

*33.330.00 Arizona Honeysweet Scrub [*Tidestromia oblongifolia*] (Keeler-Wolf and Thomas 2000)

*33.340.00 Chuparosa Scrub [*Justicia californica*] (Keeler-Wolf 2001)

*33.350.00 Chuckawallabush [*Tetracoccus hallii*] unique stands (Keeler-Wolf 2001)

33.360.00 Anderson's Wolfberry [*Lycium andersonii*] (Keeler-Wolf 2001)
33.360.01 Anderson's Wolfberry - Jojoba - Big Galleta [*Lycium andersonii-Simmondsia chinensis-Pleuraphis rigida*] (Keeler-Wolf 2001)

35.000.00 Great Basin Scrub

35.100.00 Sagebrush Scrub [*Artemisia* spp.] {35200}

35.101.00 Subalpine Sagebrush Scrub [*Artemisia* spp.] {35220}

35.102.00 Sagebrush Steppe [*Artemisia* spp.] {35300}

35.110.00 Big Sagebrush Scrub [*Artemisia tridentata*] {35210}
35.110.01 Big Sagebrush - Rubber Rabbitbrush [*Artemisia tridentata-Chrysothamnus nauseosus*] (Ferren & Davis 1991)
*35.110.02 Big Sagebrush [*Artemisia tridentata*] (Gordon & White 1994)
35.110.03 Desert Slope Sagebrush (Spolsky 1979)
35.110.04 Big Sagebrush - Desert Snowberry [*Artemisia tridentata-Symphoricarpos longiflorus*] (Taylor 1980)
35.110.05 Big Sagebrush - Blackbush [*Artemisia tridentata-Coleogyne ramosissima*] (Keeler-Wolf and Thomas 2000)
35.110.06 Big Sagebrush - Virgin River Encelia [*Artemisia tridentata-Encelia virginensis*] (Keeler-Wolf and Thomas 2000)
35.110.07 Big Sagebrush - Antelope Bitterbrush [*Artemisia tridentata-Purshia tridentata*] (Keeler-Wolf and Thomas 2000)
35.110.08 Big Sagebrush - Green Ephedra [*Artemisia tridentata-Ephedra viridis*] (Keeler-Wolf and Thomas 2000)
35.110.09 Big Sagebrush / Mountain Monardella [*Artemisia tridentata/Monardella odoratissima*] (Keeler-Wolf and Moore 2001)
35.110.10 Mountain Big Sagebrush / Shorthair Sedge [*Artemisia tridentata* var. *vaseyana/Carex filifolia*] (Keeler-Wolf and Moore 2001)

35.120.00 Low Sagebrush Dwarf Scrub [*Artemisia arbuscula*]

*35.120.01 Low Sagebrush / Mono Clover [*Artemisia arbuscula/Trifolium monoense*] (Major & Taylor 1977)
35.120.02 Low Sagebrush / Stemless Haplopappus [*Artemisia arbuscula/Stenotus acaulis*] (Major & Taylor 1977)
*35.120.03 Low Sagebrush / Idaho Fescue [*Artemisia arbuscula/Festuca idahoensis*] (Stillman 1980)
35.120.04 Low Sagebrush / Prickly Phlox [*Artemisia arbuscula/Leptodactylon pungens*] (Keeler-Wolf and Moore 2001)
*35.120.05 Low Sagebrush / slender buckwheat [*Artemisia arbuscula-Eriogonum microthecum*] (Keeler-Wolf and Moore 2001)

35.130.00 Black Sagebrush Dwarf Scrub [*Artemisia nova*] {47000}
*35.130.01 Southern Montane Black Sagebrush Pebble Plains [*Artemisia nova*]
*35.130.02 Black Sagebrush - Engelmann's Hedgehog Cactus [*Artemisia nova-Echinocereus engelmanii*] (Keeler-Wolf and Thomas 2000)
*35.130.03 Black Sagebrush - Cheesebush [*Artemisia nova-Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)

*35.140.00 Rothrock Sagebrush Scrub [*Artemisia rothrockii*]
*35.140.01 Rothrock Sagebrush / Heretic Penstemon [*Artemisia rothrockii/Penstemon heterodoxus*] (Benedict 1983)
*35.140.02 Rothrock Sagebrush / Mountain Monardella [*Artemisia rothrockii/Monardella odoratissima*] (Taylor 1984)
*35.140.03 Rothrock Sagebrush (*Artemisia rothrockii*) Holcomb Valley, San Bernardino Mtns (CNPS veg-fest 2000)

*35.150.00 Silver Sagebrush Scrub [*Artemisia cana*] (Keeler-Wolf and Moore 2001)

35.200.00 Antelope Bitterbrush Scrub [*Purshia tridentata*]
35.200.01 Antelope Bitterbrush - Big Sagebrush - Horesebush [*Purshia tridentata-Artemisia tridentata-Tetradymia canescens*] (Keeler-Wolf and Moore 2001)
35.200.02 Antelope Bitterbrush - Big Sagebrush / Indian Ricegrass [*Purshia tridentata-Artemisia tridentata/Achnatherum hymenoides*] (Keeler-Wolf and Moore 2001)
35.200.03 Antelope Bitterbrush - Big Sagebrush - Round-leaf Snowberry [*Purshia tridentata-Artemisia tridentata-Symphoricarpos rotundifolia*] (Keeler-Wolf and Moore 2001)
35.200.04 Antelope Bitterbrush / Nelson's Needlegrass [*Purshia tridentata/Achnatherum nelsonii*] (Keeler-Wolf and Moore 2001)
35.200.05 Antelope Bitterbrush / Sulphur-flower Buckwheat [*Purshia tridentata/Eriogonum umbellatum*] (Keeler-Wolf and Moore 2001)

35.300.00 Rabbitbrush Scrub [*Chrysothamnus* spp.]

35.310.00 Rubber Rabbitbrush Scrub [*Chrysothamnus nauseosus*]

*35.320.00 Parry Rabbitbrush Dwarf Scrub [*Chrysothamnus parryi*] {35410}

35.330.00 Needle-leaved Rabbitbrush [*Chrysothamnus teretifolius*] {39000}

35.340.00 Blackstem Rabbitbrush [*Chrysothamnus paniculatus*] (Keeler-Wolf and Thomas 2000)

36.000.00 Chenopod Scrub {36000}

36.100.00 Iodine Bush Succulent Scrub [*Allenrolfea occidentalis*]

*36.110.00 Great Valley Iodine Bush Scrub [*Allenrolfea occidentalis*]

*36.120.00 Desert Iodine Bush Scrub [*Allenrolfea occidentalis*]

- *36.120.01 Saltgrass - Iodine Bush [*Distichlis spicata- Allenrolfea occidentalis*] (Bradley 1970)
- *36.120.02 Bush Seepweed - Iodine Bush [*Suaeda moquinii-Allenrolfea occidentalis*] (Bradley 1970)
- *36.120.03 Alkali Sacaton - Iodine Bush [*Sporobolus airoides-Allenrolfea occidentalis*] (Odion *et al* 1992)
- *36.120.04 Iodine Bush [*Allenrolfea occidentalis*] (McHargue 1973)

36.200.00 Bush Seepweed Scrub [*Suaeda moquinii*]

- *36.200.01 Great Valley Bush Seepweed Scrub [*Suaeda moquinii*]
- *36.200.02 Desert Bush Seepweed Scrub [*Suaeda moquinii*]
- 36.200.03 Bush Seepweed - Iodine Bush [*Suaeda moquinii-Allenrolfea occidentalis*] (Bradley 1970)
- 36.200.04 Bush Seepweed - Fourwing Saltbush [*Suaeda moquinii-Atriplex canescens*] (Keeler-Wolf and Thomas 2000)

36.300.00 Saltbush Scrub and Dwarf Scrub [*Atriplex* spp.]

36.301.00 Desert Saltbush Scrub [*Atriplex* spp.] {36110}

36.302.00 Valley Saltbush Scrub [*Atriplex* spp.] {36220}

36.303.00 Interior Coast Range Saltbush Scrub [*Atriplex* spp.] {36320}

36.310.00 Fourwing Saltbush Scrub [*Atriplex canescens*]

- 36.310.01 Fourwing Saltbush [*Atriplex canescens*] (Keeler-Wolf 2001)

36.320.00 Shadscale Scrub [*Atriplex confertifolia*] {36140}

- *36.320.01 Greasewood - Shadscale [*Sarcobatus vermiculatus-Atriplex confertifolia*] (Ferren & Davis 1991)
- 36.320.02 Shadscale - Nevada Ephedra [*Atriplex confertifolia-Ephedra nevadensis*] (Ferren & Davis 1991)
- 36.320.03 Shadscale - White Bursage [*Atriplex confertifolia-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
- 36.320.04 Shadscale - Blackbush [*Atriplex confertifolia-Coleogyne ramosissima*] (Keeler-Wolf and Thomas 2000)
- 36.320.05 Shadscale - Sticky Snakeweed - Catclaw Horsebrush [*Atriplex confertifolia-Guterriezia microchephala-Tetradymia axillaris*] (Keeler-Wolf and Thomas 2000)
- 36.320.06 Shadscale - Fourwing Saltbush [*Atriplex confertifolia-Atriplex canescens*] (Keeler-Wolf and Thomas 2000)
- 36.320.07 Shadscale - Anderson's Wolfberry [*Atriplex confertifolia-Lycium andersonii*] (Keeler-Wolf and Thomas 2000)
- 36.320.08 Shadscale - Winter Fat [*Atriplex confertifolia-Krascheninnikovia lanata*] (Keeler-Wolf and Thomas 2000)
- 36.320.09 Shadscale - Virgin River Encelia - Hop-sage [*Atriplex confertifolia-Encelia virginensis-Grayia spinosa*] (Keeler-Wolf and Thomas 2000)

36.330.00 Desert-holly Scrub [*Atriplex hymenelytra*]

- 36.330.01 Desert-holly [*Atriplex hymenelytra*] (Keeler-Wolf and Thomas 2000)
- 36.330.02 Desert-holly - White Bursage [*Atriplex hymenelytra-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
- 36.330.03 Desert-holly - Creosote Bush - White Bursage [*Atriplex hymenelytra-Larrea tridentata-Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
- 36.330.04 Desert-holly - Arizona Honeysweet [*Atriplex hymenelytra-Tidestromea oblongifolia*] (Keeler-Wolf and Thomas 2000)

36.340.00 Allscale Scrub [*Atriplex polycarpa*] {23200}

*36.341.00 Great Valley Allscale Scrub [*Atriplex polycarpa*] {36220}

*36.342.00 Sierra-Tehachapi Saltbush Scrub [*Atriplex* spp.] {36310}

*36.350.00 Spinescale Scrub [*Atriplex spinifera*]

*36.351.00 Great Valley Spinescale Scrub [*Atriplex spinifera*] {36220}

36.360.00 Mixed Saltbush [*Atriplex* spp.]
- 36.360.01 Mixed Saltbush [*Atriplex* spp.] (McHargue 1973)
- 36.360.02 Allscale - Shadscale [*Atriplex polycarpa-Atriplex confertifolia*] (Yoder *et al*. 1983)

36.370.00 Quailbush Scrub [*Atriplex lentiformis*]
- 36.370.01 Big Saltbush - Allscale Scrub [*Atriplex lentiformis*] (Keeler-Wolf, Vaghti 2000)

*36.400.00 Greasewood Scrub [*Sarcobatus vermiculatus*] {36130}

*36.500.00 Winter Fat dwarf scrub [*Krascheninnikovia lanata*]

36.600.00 Valley Saltbush Scrub [*Atriplex* spp.]

36.700.00 Desert Sink Scrub {36210}

36.800.00 Valley Sink Scrub {36210}

37.000.00 Undifferentiated Chaparral Scrubs {37000}
- 37.000.01 Northern Mixed Chaparral {37110}
- *37.000.02 Gabbroic Northern Mixed Chaparral {37111}
- *37.000.03 Mafic Southern Mixed Chaparral {37122}
- 37.000.04 Semi-Desert Chaparral {37400}
- 37.000.05 Mixed Montane Chaparral {37510}
- *37.000.06 Mixed Serpentine Chaparral {37610}
- 37.000.07 Northern North Slope Chaparral {37E10}
- 37.000.08 Coastal Sage Chaparral Scrub {37G00}
- 37.000.09 Island Chaparral {37700}

37.100.00 Chaparral with Chamise with or without other codominant shrubs {37200}

37.101.00 Chamise Chaparral [*Adenostoma fasciculatum*]
- 37.101.01 Chamise - Bigberry Manzanita [*Adenostoma fasciculatum-Arctostaphylos glauca*] (Gordon & White 1994)
- 37.101.02 Chamise - Black Sage [*Adenostoma fasciculatum-Salvia mellifera*] (Gordon & White 1994)
- 37.101.03 Chamise - California Buckwheat - White Sage [*Adenostoma fasciculatum-Eriogonum fasciculatum-Salvia apiana*] (Gordon & White 1994)
- 37.101.04 Chamise - Chaparral Yucca [*Adenostoma fasciculatum-Yucca whipplei*] (Gordon & White 1994)
- 37.101.05 Chamise - Cupleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus greggii*] (Gordon & White 1994)
- *37.101.06 Chamise - Cupleaf Ceanothus - Mafic Soils [*Adenostoma fasciculatum-Ceanothus greggii*] (Gordon & White 1994)

37.101.07 Chamise - Eastwood Manzanita [*Adenostoma fasciculatum-Arctostaphylos glandulosa*] (Gordon & White 1994)
37.101.08 Chamise - Hoaryleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus crassifolius*] (Gordon & White 1994)
37.101.09 Chamise - Scrub Oak [*Adenostoma fasciculatum-Quercus berberidifolia*] (Gordon & White 1994)
37.101.10 Chamise - Wedgeleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus cuneatus*] (Gordon & White 1994)
37.101.11 Chamise - Woollyleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus tomentosus*] (Gordon & White 1994)
*37.101.12 Chamise / Bush Monkeyflower [*Adenostoma fasciculatum/Mimulus aurantiacus*] (Keeler-Wolf, *et al*. 2001)

37.102.00 Chamise - Black Sage Chaparral [*Adenostoma fasciculatum-Salvia mellifera*]
*37.102.01 Southern Maritime Chaparral {37C30}
37.102.02 Chamise - Black Sage / Herb [*Adenostoma fasciculatum-Salvia mellifera*/Herb] (Hogan & Sawyer 1996)
*37.102.03 Chamise - Black Sage - Mixed Shrub [*Adenostoma fasciculatum-Salvia mellifera*/Mixed Shrub] (Hogan & Sawyer 1996)

37.103.00 Chamise - White Sage Chaparral [*Adenostoma fasciculatum-Salvia apiana*]
37.103.01 Chamise - White Sage [*Adenostoma fasciculatum-Salvia apiana*] (Gordon & White 1994)

37.104.00 Chamise - Bigberry Manzanita Chaparral [*Adenostoma fasciculatum- Arctostaphylos glauca*]
37.104.01 Chamise - Bigberry Manzanita [*Adenostoma fasciculatum-Arctostaphylos glauca*] (Gordon & White 1994)
37.104.02 Chamise - Bigberry Manzanita - Chaparral Whitethorn [*Adenostoma fasciculatum-Arctostaphylos glauca-Ceanothus leucodermis*] (Gordon & White 1994)
37.104.03 Chamise - Bigberry Manzanita - Chaparral-Yucca [*Adenostoma fasciculatum-Arctostaphylos glauca-Yucca whipplei*] (Gordon & White 1994)
37.104.04 Chamise - Bigberry Manzanita - Cupleaf Ceanothus [*Adenostoma fasciculatum-Arctostaphylos glauca-Ceanothus gregii*] (Gordon & White 1994)
37.104.05 Chamise - Bigberry Manzanita - Hoaryleaf Ceanothus [*Adenostoma fasciculatum-Arctostaphylos glauca-Ceanothus crassifolius*] (Gordon & White 1994)
37.104.06 Chamise - Bigberry Manzanita - Scrub Oak [*Adenostoma fasciculatum-Arctostaphylos glauca-Quercus berberidifolia*] (Gordon & White 1994)
37.104.07 Chamise - Bigberry Manzanita - Wedgeleaf Ceanothus [*Adenostoma fasciculatum-Arctostaphylos glauca-Ceanothus cuneatus*] (Gordon & White 1994)

37.105.00 Chamise - Cupleaf Ceanothus Chaparral [*Adenostoma fasciculatum-Ceanothus greggii*]
37.105.01 Chamise - Cupleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus greggii*] (Gordon & White 1994)
*37.105.02 Chamise / Mafic Soils [*Adenostoma fasciculatum*] (Gordon & White 1994)

37.106.00 Chamise - Eastwood Manzanita Chaparral [*Adenostoma fasciculatum- Arctostaphylos glandulosa*]
37.106.01 Chamise - Eastwood Manzanita - Birchleaf Mountain-mahogany [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Cercocarpus betuloides*] (Gordon & White 1994)
37.106.02 Chamise - Eastwood Manzanita - Chaparral Whitethorn [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Ceanothus leucodermis*] (Gordon & White 1994)

37.106.03 Chamise - Eastwood Manzanita - Cupleaf Ceanothus [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Ceanothus greggii*] (Gordon & White 1994)

37.106.04 Chamise - Eastwood Manzanita - Hoaryleaf Ceanothus [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Ceanothus crassifolius*] (Gordon & White 1994)

37.106.05 Chamise - Eastwood Manzanita / Mafic Soils [*Adenostoma fasciculatum-Arctostaphylos glandulosa*] (Gordon & White 1994)

37.106.06 Chamise - Eastwood Manzanita - Birchleaf Mountain-mahogany [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Cercocarpus betuloides*] (Gordon & White 1994)

37.106.07 Chamise - Eastwood Manzanita - Wedgeleaf Ceanothus [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Ceanothus cuneatus*] (Gordon & White 1994)

37.106.08 Chamise - Eastwood Manzanita [*Adenostoma fasciculatum-Arctostaphylos glandulosa*] (Parker 1990)

37.106.09 Chamise - Eastwood Manzanita - Musk Brush / Serpentine Reed Grass [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Ceanothus jepsonii/Calamagrostis ophitidis*] (Keeler-Wolf, *et al*. 2001)

37.106.10 Chamise - Eastwood Manzanita - Interior Live Oak [*Adenostoma fasciculatum-Arctostaphylos glandulosa-Quercus wislizeni*] (Keeler-Wolf, *et al*. 2001)

37.107.00 Chamise - Hoaryleaf Ceanothus Chaparral [*Adenostoma fasciculatum-Ceanothus crassifolius*]

37.107.01 Chamise - Hoaryleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus crassifolius*] (Gordon & White 1994)

37.107.02 Chamise - Hoaryleaf Ceanothus-Black Sage [*Adenostoma fasciculatum-Ceanothus crassifolius-Salvia mellifera*] (Gordon & White 1994)

37.108.00 Chamise - Wedgeleaf Ceanothus Chaparral [*Adenostoma fasciculatum-Ceanothus cuneatus*]

37.108.01 Chamise - Wedgeleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus cuneatus*] (Gordon & White 1994)

*37.109.00 Chamise - Mission-manzanita - Woollyleaf Ceanothus Chaparral [*Adenostoma fasciculatum-Xylococcus bicolor-Ceanothus tomentosus*]

37.109.01 Chamise - Mission-manzanita [*Adenostoma fasciculatum-Xylococcus bicolor*] (Gordon & White 1994)

37.109.02 Chamise - Mission-manzanita-Woollyleaf Ceanothus [*Adenostoma fasciculatum-Xylococcus bicolor-Ceanothus tomentosus*] (Gordon & White 1994)

*37.109.03 Chamise - Mission-manzanita - Woollyleaf Ceanothus (mafic soils) [*Adenostoma fasciculatum-Xylococcus bicolor-Ceanothus tomentosus*] (Gordon & White 1994)

*37.109.04 Chamise - Woollyleaf Ceanothus [*Adenostoma fasciculatum-Ceanothus tomentosus*] (Gordon & White 1994)

37.200.00 Chaparral with *Ceanothus* spp. as principal indicator

37.201.00 Bigpod Ceanothus Chaparral [*Ceanothus megacarpus*] {37840}

37.201.01 Bigpod Ceanothus [*Ceanothus megacarpus*] (Borchert *et al*. 1993b)

37.201.02 Bigpod Ceanothus - Chamise / Black Sage [*Ceanothus megacarpus-Adenostoma fasciculatum/Salvia mellifera*] (Borchert *et al*. 1993b)

37.202.00 Bigpod Ceanothus - Birchleaf Mountain-mahogany Chaparral [*Ceanothus megacarpus-Cercocarpus betuloides*] (Borchert, *et al*. 2000)

37.203.00 Bigpod Ceanothus - Hollyleaf Redberry Chaparral [*Ceanothus megacarpus-Rhamnus ilicifolia*] (Borchert, *et al*. 2000)

37.204.00 Blue Blossom Chaparral [*Ceanothus thyrsiflorus*] {37820}
- 37.204.01 Blue Blossom Ceanothus - Coyote Brush - Poison Oak [*Ceanothus thyrsiflorus-Baccharis pilularis-Toxicodendron diversilobum*] (Keeler-Wolf, *et al.* 2001)

37.205.00 Chaparral Whitethorn Chaparral [*Ceanothus leucodermis*] {37532}
- 37.205.01 Chaparral Whitethorn [*Ceanothus leucodermis*] (Gordon & White 1994)

37.206.00 Deerbrush Montane Chaparral [*Ceanothus integerrimus*] {37531}
- 37.206.01 Deerbrush [*Ceanothus integerrimus*] (Gordon & White 1994)
- 37.206.02 Deerbrush - Canyon Live Oak - Blue Wildrye [*Ceanothus integerrimus-Quercus chrysolepis-Elymus glaucus*] (Stuart *et al.* 1993)
- 37.206.03 Tanoak - Madrone - Deerbrush [*Lithocarpus densiflora-Arbutus menziesii-Ceanothus integerrimus*] (Stuart *et al.* 1993)
- 37.206.04 Deerbrush - Whiteleaf Manzanita [*Ceanothus integerrimus-Arctostaphylos viscida*] (Keeler-Wolf and Moore 2001)

37.207.00 Hairyleaf Ceanothus Chaparral [*Ceanothus oliganthus*]
- 37.207.01 Hairyleaf Ceanothus [*Ceanothus oliganthus*] (Gordon & White 1994)

37.208.00 Hoaryleaf Ceanothus Chaparral [*Ceanothus crassifolius*] {37830}
- 37.208.01 Hoaryleaf Ceanothus [*Ceanothus crassifolius*] (Gordon & White 1994)

37.209.00 Mountain Whitethorn Montane Chaparral [*Ceanothus cordulatus*]
- 37.209.01 Mountain Whitethorn [*Ceanothus cordulatus*] (Keeler-Wolf and Moore 2001)

37.210.00 Tobacco Brush Montane Chaparral [*Ceanothus velutinus*] {37533}
- 37.210.01 Tobacco Brush [*Ceanothus velutinus*] (Keeler-Wolf and Moore 2001)
- 37.210.02 Tobacco Brush - Bitter Cherry [*Ceanothus velutinus-Prunus emarginata*] (Keeler-Wolf and Moore 2001)

37.211.00 Wedgeleaf Ceanothus Chaparral [*Ceanothus cuneatus*] {37810}
- 37.211.01 Wedgeleaf Ceanothus [*Ceanothus cuneatus*] Stuart *et al*. 1992)
- 37.211.02 Wedgeleaf Ceanothus - Incense-cedar [*Ceanothus cuneatus-Calocedrus decurrens*] (Stuart *et al*. 1992)
- 37.211.03 Wedgeleaf Ceanothus / Squirreltail [*Ceanothus cuneatus/Elymus elymoides*] (Taylor & Teare 1979b)
- 37.211.04 Wedgeleaf Ceanothus / Annual Grass [*Ceanothus cuneatus*/*Bromus* spp.-*Vulpia* spp.] (Keeler-Wolf and Moore 2001)

37.212.00 Cupleaf Ceanothus - Fremontia - Oak Chaparral [*Ceanothus greggii-Fremontodendron californicum-Quercus* sp.] {37J00}
- 37.212.01 Cupleaf Ceanothus [*Ceanothus greggii*] (Gordon & White 1994)
- 37.212.02 Birchleaf Mountain-mahogany - Chamise [*Cercocarpus betuloides-Adenostoma fasciculatum*] (Gordon & White 1994)
- 37.212.03 Birchleaf Mountain-mahogany - Flannelbush [*Cercocarpus betuloides-Fremontodendron californicum*] (Gordon & White 1994)
- *37.212.04 entry moved to 37.418.00

37.213.00 Bigpod Ceanothus - Hollyleaf Cherry Chaparral [*Ceanothus megacarpus-Prunus ilicifolia*] (Borchert, *et al*. 2000)

37.214.00 Greenbark Ceanothus Scrub [*Ceanothus spinosus*] (Borchert, *et al*. 2000)

*37.215.00 Siskiyou Mat dwarf scrub [*Ceanothus pumulus*] (Jimerson et al. 1995)
- *37.215.01 Siskiyou mat / Idaho Fescue [*Ceanothus pumilus/Festuca idahoensis*] (Jimerson et al. 1995)

37.300.00 Chaparral with Manzanita [*Arctostaphylos* spp.] as principal indicator {37B00}

37.301.00 Bigberry Manzanita Chaparral [*Arctostaphylos glauca*]
37.301.01 Bigberry Manzanita [*Arctostaphylos glauca*] (Gordon & White 1994)

37.302.00 Eastwood Manzanita Chaparral [*Arctostaphylos glandulosa*]
37.302.01 Eastwood Manzanita [*Arctostaphylos glandulosa*] (Gordon & White 1994)
37.302.02 Adams Manzanita [*Arctostaphylos glandulosa ssp. adamsii*]
37.302.03 Eastwood Manzanita-Mountain Mahogany [*Arctostaphylos glandulosa-Cercocarpus betuloides*]
37.302.04 Eastwood Manzanita - Interior Live Oak [*Arctostaphylos glandulosa-Quercus wislizeni*] (Keeler-Wolf, *et al*. 2001)

37.303.00 Greenleaf Manzanita Chaparral [*Arctostaphylos patula*]
37.303.01 Greenleaf Manzanita [*Arctostaphylos patula*] (Keeler-Wolf and Moore 2001)

*37.304.00 Ione Manzanita Chaparral [*Arctostaphylos myrtifolia*]

37.305.00 Whiteleaf Manzanita Chaparral [*Arctostaphylos viscida*]
37.305.01 Whiteleaf Manzanita [*Arctostaphylos viscida*] (Keeler-Wolf and Moore 2001)

*37.306.00 Sensitive Manzanita Scrub [*Arctostaphylos nummularia*] (Keeler-Wolf, *et al*. 2001)
*37.306.01 Sensitive Manzanita – Black Huckleberry- Giant Chinquapin (*A. nummularia-Vaccinium ovatum-Chrysolepis chrysophylla)*(Keeler-Wolf et al. 2001)

*37.307.00 Mount Tamalpais Manzanita [*Arctostaphylos hookeri* ssp. *montana*] Unique Stands (Keeler-Wolf, *et al*. 2001)

*37.308.00 Woollyleaf Manzanita Chaparral [*Arctostaphylos tomentosa* spp. *tomentosa*]
*37.308.01 Northern Maritime Chaparral {37C10}
*37.308.02 Central Maritime Chaparral {37C20}

*37.309.00 Ione Chaparral {37D00} (may include other associations and alliances compared to 37.304.00)

37.310.00 Pink-bracted Manzanita [*Arctostaphylos pringlei* ssp. *drupacea*] (Keeler-Wolf *et al*. 1998)

37.310.01 Pink-Bracted Manzanita -Point-leaf Manzanita [*Arctostaphylos pringlei ssp. drupacea- Arctostaphylos pungens*] (Keeler-Wolf *et al*. 1998)

37.400.00 Chaparral with Oak [*Quercus* spp.] as principal indicator

37.401.00 Interior Live Oak Chaparral [*Quercus wislizeni*] {37A00}

37.402.00 Interior Live Oak - Canyon Live Oak Chaparral [*Quercus wislizeni-Quercus chrysolepis*]
37.402.01 Interior Live Oak - Canyon Live Oak [*Quercus wislizeni-Quercus chrysolepis*] (Gordon & White 1994)

37.403.00 Interior Live Oak - Chaparral Whitethorn Chaparral [*Quercus wislizeni-Ceanothus leucodermis*]
37.403.01 Shrub Interior Live Oak - Chaparral Whitethorn [*Quercus wislizeni-Ceanothus leucodermis*] (Gordon & White 1994)
37.403.02 Shrub Interior Live Oak - Chaparral Whitethorn - Eastwood Manzanita [*Quercus wislizeni-Ceanothus leucodermis-Arctostaphylos glandulosa*] (Gordon & White 1994)

37.404.00 Interior Live Oak - Scrub Oak Chaparral [*Quercus wislizeni-Quercus berberidifolia*]

37.405.00 Leather Oak Chaparral [*Quercus durata*] {37620}

*37.405.01 Leather Oak - Eastwood Manzanita [*Quercus durata-Arctostaphylos glandulosa*] (Keeler-Wolf, *et al*. 2001)

37.406.00 Mixed Scrub Oak Chaparral

37.406.01 Scrub Oak - Bigberry Manzanita [*Quercus berberidifolia-Arctostaphylos glauca*] (Gordon & White 1994)

37.406.02 Scrub Oak - Deerbrush [*Quercus berberidifolia-Ceanothus integerrimus*] (Gordon & White 1994)

*37.406.03 Scrub Oak - Hairyleaf Ceanothus [*Quercus berberidifolia-Ceanothus oliganthus*] (Gordon & White 1994)

*37.406.04 Scrub Oak - Toyon [*Quercus berberidifolia-Heteromeles arbutifolia*] (Gordon & White 1994)

37.406.05 Scrub Oak - Wedgeleaf Ceanothus [*Quercus berberidifolia-Ceanothus cuneatus*] (Gordon & White 1994)

37.406.06 Scrub Oak - Woollyleaf Ceanothus [*Quercus berberidifolia-Ceanothus tomentosus*] (Gordon & White 1994)

37.407.00 Scrub Oak Chaparral [*Quercus berberidifolia*] {37900}

37.407.01 Scrub Oak / California Buckeye [*Quercus berberidifolia/Aesculus californica*] (Newton 1987)

37.407.02 Scrub Oak [*Quercus berberidifolia*] (Gordon & White 1994)

37.407.03 Scrub Oak - (Chamise - Eastwood Manzanita) [*Quercus berberidifolia-(Adenostoma fasciculatum-Arctostaphylos glandulosa)*] (Gordon & White 1994)

37.407.04 Scrub Oak - (Toyon) [*Quercus berberidifolia- (Heteromeles arbutifolia)*] (Gordon & White 1994)

37.407.05 Scrub Oak - (Chaparral Whitethorn) [*Quercus berberidifolia-(Ceanothus leucodermis)*] (Gordon & White 1994)

37.407.06 Scrub Oak - (Birchleaf Mountain-mahogany) [*Quercus berberidifolia-(Cercocarpus betuloides)*] (Gordon & White 1994)

37.408.00 Scrub Oak - Birchleaf Mountain-mahogany Chaparral [*Quercus berberidifolia-Cercocarpus betuloides*]

37.408.01 Scrub Oak - Birchleaf Mountain-mahogany [*Quercus berberidifolia-Cercocarpus betuloides*] (Gordon & White 1994)

37.408.02 Scrub Oak - Birchleaf Mountain-mahogany - Cupleaf Ceanothus [*Quercus berberidifolia-Cercocarpus betuloides-Ceanothus greggii*] (Gordon & White 1994)

*37.408.03 Foothill Ash - Birchleaf Mountain-mahogany - Scrub Oak [*Fraxinus dipetala-Cercocarpus betuloides-Quercus berberidifolia*] (Gordon & White 1994)

*37.408.04 Scrub Oak - Birchleaf Mountain-mahogany - Palmer Ceanothus [*Quercus berberidifolia-Cercocarpus betuloides-Ceanothus palmeri*] (Gordon & White 1994)

37.409.00 Scrub Oak - Chamise Chaparral [*Quercus berberidifolia-Adenostoma fasciculatum*]

37.409.01 Scrub Oak - Chamise - Hoaryleaf Ceanothus [*Quercus berberidifolia-Adenostoma fasciculatum-Ceanothus crassifolius*] (Gordon & White 1994)

37.409.02 Scrub Oak - Chamise - Cupleaf Ceanothus [*Quercus berberidifolia-Adenostoma fasciculatum-Ceanothus greggii*] (Gordon & White 1994)

37.410.00 Scrub Oak - Chaparral Whitethorn Chaparral [*Quercus berberidifolia-Ceanothus leucodermis*]

37.410.01 Scrub Oak - Chaparral Whitethorn [*Quercus berberidifolia-Ceanothus leucodermis*] (Gordon & White 1994)

37.411.00 Brewer Oak Chaparral [*Quercus garryana* var. *breweri*] {37541}

*37.411.01 Oregon White Oak - Brewer Oak / California Fescue [*Quercus garryana* var. *garryana-Quercus garryana* var. *breweri/Festuca californica*] (Jimerson 1993)
*37.411.02 White Fir / Huckleberry Oak [*Abies concolor/Quercus vaccinifolia*] (Sawyer 1981b)

*37.412.00 Sadler Oak Montane Scrub [*Quercus sadleriana*]

37.413.00 Canyon Live Oak Chaparral [*Quercus chrysolepis*]
37.413.01 Canyon Live Oak Shrub [*Quercus chrysolepis*] (Gordon & White 1994)
37.413.02 Canyon Live Oak - (Deerbrush - Chaparral Whitethorn) Shrub [*Quercus chrysolepis-(Ceanothus integerrimus-Ceanothus leucodermis)*] (Gordon & White 1994)
*37.413.03 Canyon Live Oak - Silk Tassle Bush [*Quercus chrysolepis-Garrya flavescens*] (Keeler-Wolf and Thomas 2000)
37.413.04 Canyon Live Oak - Holly-leaf Redberry [*Quercus chrysolepis-Rhamnus illicifolia*] (Gordon & White 1994)

37.414.00 Huckleberry Oak Chaparral [*Quercus vaccinifolia*] {37542}
37.414.01 Huckleberry Oak [*Quercus vaccinifolia*] (Keeler-Wolf and Moore 2001)
37.414.02 Huckleberry Oak - Bush Chinquapin [*Quercus vaccinifolia-Chrysolepis sempervirens*] (Keeler-Wolf and Moore 2001)
37.414.03 Huckleberry Oak - Greenleaf Manzanita [*Quercus vaccinifolia-Arctostaphylos patula*] (Keeler-Wolf and Moore 2001)

37.415.00 Muller Oak [*Quercus cornelius-mulleri*]
37.415.01 Muller Oak - Sugarbush [*Quercus cornelius-mulleri-Rhus ovata*] (Keeler-Wolf *et al.* 1998)
37.415.02 Muller Oak - Brittlebush-Narrowleaf Goldenbush [*Quercus cornelius-mulleri-Eriogonum fasciculatum-Ericameria linearifolia*] (Keeler-Wolf *et al.* 1998)
37.415.03 Muller Oak - Mountain Mahogany [*Quercus cornelius-mulleri-Cercocarpus betuloides*] (Keeler-Wolf *et al.* 1998)

37.416.00 Island Scrub Oak Chaparral [*Quercus pacifica*] (Landis, 1997)

37.417.00 Giant Chinquapin Scrub [*Chrysolepis chrysophylla*] (Keeler-Wolf, *et al*. 2001)
37.417.01 Giant Chinquapin / Black Huckleberry [*Chrysolepis chrysophylla /Vaccinium ovatum*] (Keeler-Wolf, *et al*. 2001)

37.418.00 Tucker Oak Scrub [*Quercus john-tuckeri*] (Borchert, 2000)

37.500.00 Chaparral with Red Shank [*Adenostoma sparsifolium*] as principal indicator

*37.501.00 Red Shank Chaparral [*Adenostoma sparsifolium*]
*37.501.01 Red Shank [*Adenostoma sparsifolium*] (Gordon & White 1994)

37.502.00 Red Shank - Birchleaf Mountain-mahogany Chaparral [*Adenostoma sparsifolium-Cercocarpus betuloides*]
*37.502.01 Red Shank - Birchleaf Mountain-mahogany [*Adenostoma sparsifolium-Cercocarpus betuloides*] (Gordon & White 1994)

*37.503.00 Red Shank - Chamise Chaparral [*Adenostoma sparsifolium-Adenostoma fasciculatum*]
*37.503.01 Red Shank - Chamise - Birchleaf Mountain-mahogany [*Adenostoma sparsifolium-Adenostoma fasciculatum-Cercocarpus betuloides*] (Gordon & White 1994)

*37.503.02 Red Shank - Chamise - Cupleaf Ceanothus [*Adenostoma sparsifolium-Adenostoma fasciculatum-Ceanothus greggii*] (Gordon & White 1994)
*37.503.03 Red Shank - Chamise - Pointleaf Manzanita [*Adenostoma sparsifolium-Adenostoma fasciculatum-Arctostaphylos pungens*] (Gordon & White 1994)

*37.504.00 Red Shank Chaparral {37300}

37.600.00 Birchleaf Mountain-mahogany - California buckwheat Chaparral [*Cercocarpus betuloides-Eriogonum fasciculatum*]
37.600.01 Birchleaf Mountain-mahogany - California Buckwheat [*Cercocarpus betuloides-Eriogonum fasciculatum*] (Gordon & White 1994)

37.610.00 Birchleaf Mountain-mahogany Woodland [*Cercocarpus betuloides* var. *betuloides*] (Keeler-Wolf and Moore 2001)
37.610.01 Birchleaf Mountain-mahogany [*Cercocarpus betuloides* var. *betuloides*] (Keeler-Wolf and Moore 2001)

37.700.00 Bush Chinquapin Montane Chaparral [*Chrysolepis sempervirens*] {37540}
37.700.01 Bush Chinquapin [*Chrysolepis sempervirens*] (Keeler-Wolf and Moore 2001)

37.800.00 Sumac Scrub [*Rhus* sp., *Malosma laurina*]

*37.801.00 Sugarbush Scrub [*Rhus ovata*] (Keeler-Wolf et al. 1998)

*37.802.00 Skunkbush [*Rhus trilobata*] (Keeler-Wolf et al., 1998)

37.900.00 Bitter Cherry Scrub [*Prunus emarginata*] (Keeler-Wolf and Moore 2001)
37.900.01 Bitter Cherry [*Prunus emarginata*] (Keeler-Wolf and Moore 2001)

37.910.00 Holly-leaf Cherry [*Prunus illicifolia*] (Borchert, *et al*. 2000)
37.910.01 Holly-leaf Cherry - Sanicle [*Prunus illicifolia-Sanicula crassicaulis*] (Keeler-Wolf, *et al*. 2001)

37.915.00 Toyon – Hollyleaf Cherry Scrub [*Heteromeles arbutifolia-Prunus ilicifolia*] (Borchert, *et al*. 2000)

37.920.00 Coffeeberry Scrub [*Rhamnus californica*] (Keeler-Wolf, *et al*. 2001)
37.920.01 Coffeeberry - Coyote Brush / California Figwort [*Rhamnus californica-Baccharis pilularis/Scrophularia californica*] (Keeler-Wolf, *et al*. 2001)

37.930.00 California Wax Myrtle Scrub [*Myrica californica*] (Keeler-Wolf, *et al*. 2001)
37.930.01 California Wax Myrtle [*Myrica californica*] (Keeler-Wolf, *et al*. 2001)

37.940.00 Poison Oak Scrub [*Toxicodendron diversalobum*] (Keeler-Wolf, *et al*. 2001)
37.940.01 Poison Oak - Coyote Brush - Thimbleberry [*Toxicodendron diversilobum-Baccharis pilularis-Rubus parviflorus*] (Keeler-Wolf, *et al*. 2001)

37.950.00 Hazel Scrub [*Corylus cornuta*] (Keeler-Wolf, *et al*. 2001)
37.950.01 Hazel / Western Sword Fern [*Corylus cornuta/Polystichum munitum*] (Keeler-Wolf, *et al*. 2001)

38.000.00 Subalpine Upland Shrub

38.100.00 Sierra Subalpine Upland Shrub
38.100.01 Shrub Cinquefoil Dwarf Scrub [*Potentilla fruticosa*] (Burke 1982)
38.100.02 Compact Phlox - Stemless Haplopappus - Alpine Ipomopsis dwarf scrub [*Phlox pulvinata-Stenotus acaulis-Ipomopsis congesta*] (Major & Taylor 1977)

38.100.03 Granite-gilia / King Ricegrass Dwarf Scrub [*Leptodactylon pungens/Ptilagrostis kingii*] (Major & Taylor 1977)
38.100.04 entry moved to 38.120.02
38.100.05 Podistera - Pygmy Fleabane [*Podistera-Eriogonum pygmaeus*] (Major & Taylor 1977)
38.100.06 Wax Currant / Purple Reedgrass [*Ribes cereum/Calamagrostis purpurascens*] (Major & Taylor 1977)
*38.100.07 Red Elderberry - Congdon Sedge [*Sambucus racemosa-Carex congdonii*] (Taylor 1984)
38.100.08 entry moved to 41.211.01
38.100.09 entry moved to 38.100.01

*38.110.00 Shrubby Cinquefoil [*Potentilla fruticosa*] (Keeler-Wolf and Moore 2001)
38.110.01 Shrub Cinquefoil - One-seeded Oatgrass [*Potentilla fruticosa-Danthonia unispicata*] (Taylor 1984)
38.110.02 Shrub Cinquefoil - One-seeded Oatgrass [*Potentilla fruticosa-Danthonia intermedia*] (Keeler-Wolf and Moore 2001)

38.120.00 Alpine Goldenbush - Nuttall Sandwort [*Ericameria discoidea-Minuartia nuttallii*] (Keeler-Wolf and Moore 2001)
38.120.01 Nuttal Sandwort [*Minuartia nuttallii*] (Taylor 1984)
38.120.02 Granite-gilia / Alpine Goldenbush [*Leptodactylon pungens/Ericameria discoidea*] (Major & Taylor 1977)
38.120.03 Alpine Goldenbush - Timberline Phacelia [*Ericameria discoidea-Phacelia frigida*] (Taylor 1984)

39.000.00 *Holodiscus* Scrub and Dwarf Scrub with *Holodiscus* spp.

39.100.00 *Holodiscus* Scrub and Dwarf Scrub
39.100.01 Ocean Spray / Suksdorf Monkeyflower [*Holodiscus discolor var. microphyllus/Mimulus suksdorfii*] (Burke 1982)
39.100.02 Western Needlegrass - Nude Buckwheat [*Stipa occidentalis-Eriogonum nudum*] (Burke 1982)
39.100.03 Ocean Spray / Greenleaf Manzanita [*Holodiscus discolor/Arctostaphylos patula*] (Sawyer & Thornburgh 1997)
39.100.04 Ocean Spray / Wedgeleaf Keckiella [*Holodiscus discolor/Keckiella corymbosa*] (Taylor & Teare 1979a)
39.100.05 Ocean Spray / Sierra Stonecrop - Parsley Fern [*Holodiscus discolor/Sedum obtusatum-Cryptogramma acrostichoides*] (Keeler-Wolf and Moore 2001)

40.000.00 GRASS & HERB DOMINATED COMMUNITIES

41.000.00 Native Grassland

*41.010.00 Alkali Sacaton Bunchgrass Grassland [*Sporobolus airoides*] {42120}
*41.010.01 Alkali Sacaton Grassland [*Sporobolus airoides*] (Keeler-Wolf and Thomas 2000)

*41.020.00 Ashy Ryegrass Bunchgrass Grassland [*Leymus cinereus*]

*41.030.00 Big Galleta Bunchgrass Grassland [*Pleuraphis rigida*]
*41.030.01 Big Galleta [*Pleuraphis rigida*] (Keeler-Wolf and Thomas 2000)
*41.030.02 Big Galleta - Rayless Goldenhead [*Pleuraphis rigida-Acamptopappus sphaerocephalus*] (Keeler-Wolf and Thomas 2000)
*41.030.03 Big Galleta - Cooper's Goldenbush [*Pleuraphis rigida-Ericameria cooperi*] (Keeler-Wolf and Thomas 2000)

*41.030.04 Big Galleta - Downy Dalea [*Pleuraphis rigida-Dalea molissima*] (Keeler-Wolf and Thomas 2000)

*41.040.00 Bluebunch Wheatgrass Bunchgrass Grassland [*Pseudoroegneria spicata spp. spicata*]

*41.050.00 California Oatgrass Bunchgrass Grassland [*Danthonia californica*]
- *41.050.01 California Oatgrass - Tall-oatgrass [*Danthonia californica-Arrhenatherum elatius*] (Grenier 1989)
- *41.050.02 Squirreltail - California Oatgrass [*Elymus elymoides-Danthonia californica*] (Stuart *et al*. 1992)
- *41.050.03 California Oatgrass - Pull-up Muhly [*Danthonia californica-Muhlenbergia filiformis*] (Helms & Ratliff 1987)
- 41.050.04 California Oatgrass - Silver European Hairgrass [*Danthonia californica-Aira caryophyllea*] (Keeler-Wolf, *et al*. 2001)

*41.051.00 Intermediate Oatgrass Grassland [*Danthonia intermedia*] (Keeler-Wolf and Moore 2001)

41.060.00 Grasslands with Common Reed [*Phragmites australis*]

41.061.00 Alkali Common Reed [*Phragmites australis*]

*41.070.00 Cordgrass Saline/Alkaline Grassland [*Spartina* spp.]
- *41.070.01 California Cordgrass [*Spartina foliosa*] (Atwater *et al*. 1979)
- *41.070.02 Dense-flowered Cordgrass [*Spartina densiflora*] (Eicher 1987)
- *41.070.03 Alkali Cordgrass - Alkali Sacaton [*Spartina gracilis-Sporobolus airoides*] (Oidon *et al*. 1992)

*41.080.00 Creeping Ryegrass Grassland [*Leymus triticoides*] {42140}

*41.090.00 Desert Needlegrass Grassland [*Achnatherum speciosum*]

*41.110.00 Foothill Needlegrass [*Nassella lepida*]

*41.120.00 Indian Ricegrass [*Achnatherum hymenoides*]

*41.130.00 Needle-and-thread [*Hesperostipa comata*]

*41.140.00 Nodding Needlegrass [*Nassella cernua*]

*41.150.00 Purple Needlegrass [*Nassella pulchra*]
- *41.150.01 Italian Ryegrass - Purple Needlegrass [*Lolium mutiflorum-Nassella pulchra*] (Fiedler & Leidy 1987)
- *41.150.02 Wild Oats - Purple Needlegrass [*Avena fatua-Nassella pulchra*] (Parker 1990)
- *41.150.03 Purple Needlegrass / Purple Sanicle [*Nassella pulchra/Sanicula bipinnatafida*] (Stuart *et al*. 1993)

*41.160.00 Lemmon's Needlegrass [*Achnatherum lemmonii*]

*41.170.00 Valley Needlegrass Grassland [*Achnatherum* spp.] {42110}

*41.180.00 One-sided Bluegrass [*Poa secunda*] {42150}

*41.181.00 One-sided Bluegrass Pebble Plains

*41.190.00 Pacific Reedgrass [*Calamagrostis nutkaensis*]

*41.190.01 Pacific Reedgrass - Coyote Brush [*Calamagrostis nutkaensis-Baccharis pilularis*] (Keeler-Wolf, *et al*. 2001)

*41.190.02 Pacific Reedgrass - Slough Sedge - Rush [*Calamagrostis nutkaensis-Carex obnupta*. - *Juncus* spp.] (Keeler-Wolf, *et al*. 2001)

41.200.00 Saltgrass [*Distichlis spicata*]

*41.200.01 Saltgrass - Iodine Bush [*Distichlis spicata-Allenrolfea occidentalis*] (Bradley 1970)

*41.200.02 Saltgrass - Cooper Rush [*Distichlis spicata-Juncus cooperi*] (Bradley 1970)

*41.200.03 Greasewood - Saltgrass [*Sarcobatus vermiculatus-Distichlis spicata*] (Ferren & Davis 1991)

*41.200.04 Saltgrass - Alkali Rabbitbrush [*Distichlis spicata-Chrysothamnus albidus*] (Odion *et al*. 1992)

41.200.05 Baltic Rush - Saltgrass [*Juncus balticus-Distichlis spicata*] (Odion *et al*. 1992)

*41.200.06 Jaumea - Saltgrass [*Jaumea carnosa-Distichlis spicata*] (Peinado *et al*. 1994)

*41.200.07 Saltgrass - Alkali Heath - Jaumea [*Distichlis spicata-Frankenia salina-Jaumea carnosa*] (Keeler-Wolf, *et al*. 2001)

*41.200.08 Alkali Saltgrass

41.210.00 Shorthair Reedgrass [*Calamagrostis breweri*]

41.210.01 Shorthair Reedgrass - Alpine Aster [*Calamagrostis breweri-Aster alpigenus*] (Benedict 1983)

41.210.02 Shorthair Reedgrass - Spike Trisetum [*Calamagrostis breweri-Trisetum spicatum*] (Benedict 1983)

41.210.03 Shorthair Reedgrass - Bilberry [*Calamagrostis breweri-Vaccinium caespitosum*] (Major & Taylor 1977)

41.210.04 Drummond Rush - Shorthair Reedgrass [*Juncus drummondii-Calamagrostis breweri*] (Taylor 1984)

41.210.05 Shorthair Reedgrass - Mountain Laurel [*Calamagrostis breweri-Kalmia polifolia*] (Taylor 1984)

41.211.00 Purple Reedgrass [*Calamagrostis purpurascens*] (Keeler-Wolf and Moore 2001)

41.211.01 Purple reedgrass - Granite-gilia [*Calamagrostis purpurascens-Leptodactylon pungens*] (Taylor 1984)

41.211.02 Purple reedgrass- Parry rabbitbrush- Granite-gilia [*Calamagrostis purpurascens-Chrysothamnus parryi* ssp. *Monocephalus-Leptodactylon pungens*] (Taylor 1984)

41.220.00 Tufted Hairgrass [*Deschampsia caespitosa*]

41.220.01 Tufted hairgrass - Nebraska Sedge [*Deschampsia caespitosa-Carex nebrascensis*] (Allen-Diaz 1991)

*41.220.02 Tufted Hairgrass - Brewer Bitter-cress [*Deschampsia caespitosa-Cardamine breweri*] (Benedict 1983)

41.220.03 Tufted Hairfrass - Sierra Ragwort [*Deschampsia caespitosa-Senecio scorzonella*] (Benedict 1983)

41.220.04 Tufted Hairgrass - Sierra Ragwort - Yarrow [*Deschampsia caespitosa-Senecio scorzonella-Achillea millefolium*] (Benedict 1983)

*41.220.05 Vernal Grass - Tufted Hairgrass [*Anthoxanthum odoratum-Deschampsia caespitosa*] (Heady *et al*. 1977)

41.220.06 Mt. Dana Sedge - Tufted Hairgrass [*Carex subnigricans-Deschampisia caespitosa*] (Major & Taylor 1977)

41.220.07 Tufted Hairgrass - Northern Goldenrod [*Deschampsia caespitosa-Solidago multiradiata*] (Taylor 1984)

*41.220.08 Tufted Hairgrass [*Deschampsia caespitosa*] (Keeler-Wolf and Moore 2001)
41.220.09 Tufted Hairgrass - California Oatgrass [*Deschampsia caespitosa-Danthonia californica*] (Keeler-Wolf, *et al*. 2001)
*41.220.10 Tufted Hairgrass - Longstalk Clover [*Deschampsia caespitosa-Trifolium longipes*] (Ratliff 1982, 1985)

41.222.00 Tall Mannagrass [*Glyceria elata*] (Keeler-Wolf and Moore 2001)
41.222.01 Tall Mannagrass [*Glyceria elata*] (Keeler-Wolf and Moore 2001)
41.222.02 Tall Mannagrass - Small-fruited Bulrush [*Glyceria elata-Scirpus microphyllus*] (Halpern 1986)
41.222.03 Tall Mannagrass - Stream Deervetch [*Glyceria elata-Lotus longifolius*] (Halpern 1986)

41.224.00 Canadian Reedgrass [*Calamagrostis canadensis*] (Keeler-Wolf and Moore 2001)
41.224.01 Canadian Reedgrass [*Calamagrostis canadensis*] (Keeler-Wolf and Moore 2001)

41.224.00 Sierra Ricegrass [*Ptilogrostis kingii*] (Keeler-Wolf and Moore 2001)
41.224.01 Sierra Ricegrass [*Ptilogrostis kingii*] (Keeler-Wolf and Moore 2001)

41.230.00 Squirreltail [*Elymus elymoides*]

41.240.00 Green Fescue [*Festuca viridula*]

*41.250.00 Idaho Fescue [*Festuca idahoensis*]

*41.255.00 Red Fescue [*Festuca rubra*] (Keeler-Wolf, *et al*. 2001)

*41.260.00 Native Dunegrass [*Leymus mollis*] {21210}
*41.260.01 Native dunegrass - Hottentot-fig [*Leymus mollis-Carpobrotus edulis*] (Bluestone 1981)
*41.260.02 Native Dunegrass - European Beachgrass [*Leymus mollis-Ammophila arenaria*] (LaBanca 1993)
*41.260.03 Native Dunegrass - Sea Rocket [*Leymus mollis-Cakile sp*.] (Parker 1974)

*41.270.00 Coastal Terrace Prairie{41100}

*41.280.00 Serpentine Bunchgrass {42130}

*41.290.00 Wildflower Field {42300}

*41.300.00 Great Basin Grassland {43000}

41.340.00 MOVED TO 42.051.00

*41.600.00 Eureka Valley Dunegrass [*Swallenia alexandrae*] (Keeler-Wolf and Thomas 2000) Unique stands

*41.610.00 Little Galleta Grassland [*Pleuraphis jamesii*] (Keeler-Wolf and Thomas 2000)
*41.610.01 Little Galleta - California Buckwheat [*Pleuraphis jamesii-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
*41.610.02 Little Galleta - Anderson's Wolfberry [*Pleuraphis jamesii-Lycium andersonii*] (Keeler-Wolf and Thomas 2000)
*41.610.03 Little Galleta - Nevada Ephedra [*Pleuraphis jamesii-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)

*41.640.00 Blue Wildrye Grassland [*Elymus glaucus*] (Keeler-Wolf and Moore 2001)

*41.640.01 Blue Wildrye [*Elymus glaucus*] (Keeler-Wolf and Moore 2001)

*41.640.02 Blue Wildrye - Woolly Sedge [*Elymus glaucus-Carex lanuginosa*] (Keeler-Wolf and Moore 2001)

*41.640.03 Blue Wildrye - Feta Sedge [*Elymus glaucus-Carex feta*] (Keeler-Wolf and Moore 2001)

*41.640.04 Blue Wildrye - Cow-parsnip [*Elymus glaucus-Heracleum lanatum*] (Halpern 1986)

42.000.00 Non-native Grassland

42.010.00 European Beachgrass [*Ammophila arenaria*]

42.010.01 European Beachgrass - Australian Fireweed [*Ammophila arenaria-Erechtites minima*] (Parker 1974)

42.010.02 Beachgrass [*Ammophila* sp.] (Duebendorfer 1989)

42.010.03 European Beachgrass - sandmat [*Ammophila arenaria-Cardionema ramosissimum*] (Keeler-Wolf, *et al*. 2001)

42.020.00 Cheatgrass [*Bromus tectorum*]

42.020.01 Cheatgrass [*Bromus tectorum*] (Stuart *et al*. 1993)

42.020.02 Cheatgrass - Ripgut [*Bromus tectorum-Bromus diandrus*] (White 1994a)

42.025.00 Red Brome [*Bromus madritensis* ssp. *rubens*]

42.026.00 Annual Brome [*Bromus (diandrus, hordeaceus)*] (Keeler-Wolf and Moore 2001)

42.026.01 Ripgut Brome - Soft Chess - Annual Clover - Wild Carrot [*Bromus diandrus-Bromus hordeaceus-Trifolium* spp.-*Daucus* spp.] (Keeler-Wolf and Moore 2001)

42.026.02 Soft Chess - Rattail Fescue [*Bromus hordeaceus-Vulpia hirsuta*] (Kopecko & Lathrop 1975)

42.026.03 Slender Oat - Soft Brome [*Avena barbata-Bromus hordeaceus*](Kopecko & Lathrop 1975)

42.026.04 Soft Chess – Silver hairgrass – Fileree [*Bromus hordaceus – Aira carryophyllea – Erodium* spp.] (Jimerson et al. 2001)

42.026.05 Soft Chess – Meadowfoam – Clover [*Bromus hordaceus – Limnanthes douglasii – Trifolium* sp.] (Jimerson et al. 2001)

42.026.06 Soft Chess - Silver hairgrass – Blue Dicks [*Bromus hordaceus – Aira carryophyllea-Dichelostemma capitatum* ssp. *capatatum]* (Jimerson et al. 2001)

42.026.07 Soft Chess – Medusahead – Fileree [*Bromus hordaceus- Taeniantherum caput-medusae-Erodium botrys*] (Jimerson et al 2001)

42.026.08 Soft Chess – Cheatgrass [*Bromus hordaceus-Bromus tectorum*] (Jimerson et al. 2001)

42.026.09 Soft Chess – Fileree [*Bromus hordaceus-Erodium botrys*] (Jimerson et al 2001)

42.026.10 Soft Chess – Blue Dicks – Gumplant [*Bromus hordaceus – Dichelostemma multiflorum – Grindelia camporum]* (Jimerson et al. 2001)

42.030.00 Crested Wheatgrass [*Agropyron desertorum*]

42.040.00 California Annual Grassland {42200}

42.040.01 European Hairgrass [*Aira caryophyllea*] (Schlising & Sanders 1982)

42.040.02 Soft Brome - Storkbill [*Bromus hordeaceus-Erodium botrys*] (Schlising & Sanders 1982)

42.040.03 Brachypodium [*Brachypodium distachyon*] (Keeler-Wolf, *et al*. 2001)

42.041.00 Dogtail Grass [Cynosurus cristatus] (Jimerson et al. 2001)

- 42.041.01 Dogtail – Hareleaf//rocky [*Cynosurus cristatus-Lagophylla glandulosa//rocky*] (Jimerson 1993, Jimerson et al. 2001)
- 42.041.02 Dogtail - Soft Chess - Dandelion [*Cynosurus cristatus-Bromus hordeaceus-Taraxacum officinale*] (Jimerson 1993, Jimerson et al 2001)
- 42.041.03 Dogtail - Soft Chess – Cheatgrass [*Cynosurus cristatus-Bromus hordeaceus-Bromus tectorum*] (Jimerson et al. 2001)
- 42.041.04 Dogtail - Soft Chess – Medusahead [*Cynosurus cristatus-Bromus hordeaceus-Taeniantherum caput-medusae*] (Jimerson et al. 2001)
- 42.041.05 Dogtail - Soft Chess – Wild oat [*Cynosurus cristatus-Bromus hordeaceus-Avena fatua*] (Jimerson et al. 2001)
- 42.041.06 Dogtail – Tarplant [*Cynosurus cristatus-Hemizonia congesta-Madia* spp.] (Jimerson et al 2001)

42.050.00 Introduced Perennial Grassland

- 42.050.01 Hairy Oatgrass - Vernal Grass [*Danthonia pilosa-Anthoxanthum odoratum*] (Hektner & Foin 1977)
- 42.050.02 Foothill Sedge - Tall-oatgrass [*Carex tumulicola-Arrhenatherum elatius*] (Grenier 1989)
- 42.050.03 Vernal Grass - Tufted Hairgrass [*Anthoxanthum odoratum-Deschampsia caespitosa*] (Heady *et al*. 1977b)
- 42.050.04 moved to 42.041.01
- 42.050.05 moved to 42.041.02
- 42.050.06 Tall-oatgrass - Dogtail – Blue dicks [*Arrhenatherum elatius- Cynosurus cristatus- Dichelostemma capitatum* ssp. *capitatum*] (Jimerson 1993, re-named; Jimerson et al. 2001)
- 42.050.07 Creeping Bent - Tall-oatgrass [*Agrostis stolonifera-Arrhenatherum elatius*] (Saenz & Sawyer 1986)

42.051.00 Harding Grass [Phalaris aquatica] (Keeler-Wolf and Vaghti 2000, Jimerson et al 2001)

- 42.051.01 Harding Grass – Soft Chess – Yellow star thistle [*Phaleris aquatica – Bromus hordaceus – Centaurea solstitialis*] (Jimerson et al. 2001)

42.060.00 Kentucky Bluegrass [*Poa pratensis*]

- 42.060.01 Kentucky Bluegrass - Sedge [*Poa pratensis-Carex* spp.] (Allen-Diaz 1991)
- 42.060.02 Kentucky Bluegrass - Silver Cinquefoil [*Poa pratensis-Potentilla gracilis*] (Allen-Diaz 1991)
- 42.060.03 Narrow Sedge - Kentucky Bluegrass [*Carex angustata-Poa pratensis*] (Allen-Diaz 1991)
- 42.060.04 Kentucky Bluegrass - Spreading Rush - Hairy Woodrush [*Poa pratensis-Juncus patens-Luzula comosa*] Stuart *et al*. 1993)
- 42.060.05 Kentucky Bluegrass [*Poa pratensis*] (Keeler-Wolf and Moore 2001)

42.070.00 Pampas Grass [*Cortaderia* spp.] (Keeler-Wolf & Vaghti, 2000)

42.080.00 Giant Reed [*Arundo donax*]

42.090.00 *Schismus* spp.

- 42.090.01 Schismus Playa assocation (Keeler-Wolf et al., 1998)

42.100.00 Tall Wheatgrass [*Elytrigia pontica*] (Keeler-Wolf, Vaghti 2000)

41.310.00 Knotweed-Echinochloa Riparian Grassland [*Polygonum* spp. - *Echinochloa* spp.] (Keeler-Wolf, Vaghti 2000)

- 41.310.01 Echinocloa-Polygonum-Xanthium Riparian Grassland [*Echinochloa* spp. - *Polygonum* spp.- *Xanthium* spp.] (Keeler-Wolf, Vaghti 2000)

41.320.00 Rough Bentgrass Riparian Grassland [*Agrostis scabra*] (Keeler-Wolf, Vaghti 2000)
41.321.00 Italian Ryegrass [*Lolium multiflorum*] (Keeler-Wolf and Vaghti 2000)

44.000.00 Vernal Pools

44.100.00 Northern Vernal Pools

*44.110.00 Northern Hardpan Vernal Pools {44110}
*44.110.01 Fremont Goldfields [*Lasthenia fremontii*] (Schlising & Sanders 1982)

44.120.00 Northern Claypan Vernal Pools {44120}
*44.120.01 Coyote-thistle - Alkali Heath Pools [*Eryngium castrense-Frankenia salina*] (Taylor *et al*. 1990)
*44.120.02 Fremont Goldfields - Saltgrass Pools [*Lasthenia fremontii-Distichlis spicata*] (Taylor *et al*. 1990)

44.130.00 Northern Volcanic Vernal Pools

44.131.00 Northern Basalt Flow Vernal Pools {44131}

*44.132.00 Northern Volcanic Mudflow Vernal Pools {44132}
*44.132.01 California Goldfields - Two-crowned Downingia Pools [*Lasthenia californica-Downingia bicornuta*] (Taylor *et al*. 1990)
*44.132.02 Whiteflower Navarretia - Dwarf Blennosperma Pools [*Navarretia leucocephala-Blennosperma nana*] (Taylor *et al*. 1990)

*44.133.00 Northern Volcanic Ashflow Vernal Pools {44133}

44.300.00 Southern Vernal Pools {44300}

*44.310.00 Santa Rosa Plateau Vernal Pools {44310}
*44.310.01 Dry Marsh Bed Zone (Kepecko & Lathrop 1975)

*44.320.00 San Diego Mesa Vernal Pools {44321}

*44.330.00 San Jacinto Valley Vernal Pools

45.000.00 Meadows and Seeps not dominated by grasses

45.100.00 California Annual Herb-land (Keeler-Wolf and Moore 2001)
45.100.01 Deervetch - Annual Clover - Lessengia [*Lotus* spp.- *Trifolium* spp.- *Lessengia* spp.] (Keeler-Wolf and Moore 2001)

45.110.00 Sedge [*Carex* spp.]
45.110.01 Longbeak Sedge - Shortbeak Sedge [*Carex rostrata-Carex simulata*] (Burke 1987)
45.110.02 Shortbeak Sedge - Inflated Sedge [*Carex simulata-Carex vesicaria*] (Burke 1987)
*45.110.03 Primrose Monkeyflower - Shore Sedge [*Mimulus primuloides-Carex limosa*] (Beguin & Major 1975)
*45.110.04 Skyline Bluegrass - Beaked Sedge [*Poa cusickii-Carex utriculata*] (Beguin & Major 1975)
45.110.05 Many-nerved Sedge - Yarrow [*Carex heteroneura-Achillea lanulosa*] (Benedict 1983)
45.110.06 Slough Sedge - Salt Rush [*Carex obnupta-Juncus lesueurii*] (Duebendorfer 1989)

*45.110.07	Serrate Sedge - Leafly Sedge [*Carex subfusca-Carex ampilifolia*] (Fiedler & Leidy 1987)
45.110.08	Alpine Pussytoes - Vernacular Sedge [*Antennaria alpina-Carex vernacula*] (Major & Taylor 1977)
*45.110.09	entry moved to 45.150.02
45.110.10	entry moved to 45.145.01
*45.110.11	Mount Dana Sedge - Little Elephant's Head [*Carex subnigricans-Pedicularis attollens*] (Major & Taylor 1977)
45.110.12	entry moved to 45.164.01
45.110.13	Diego Bentgrass - Ribbed Sedge [*Agrostis diegoensis-Carex multicostata*] (Stillman 1980)
45.110.14	entry moved to 45.164.02
45.110.15	entry moved to 45.150.01
45.110.16	entry moved to 45.145.02
45.110.17	Luzulaleaf Sedge - Water-plantain Buttercup [*Carex luzulifolia-Ranunculus alismifolius*] (Taylor 1984)
45.110.18	Mount Dana Sedge - Alpine Shootingstar [*Carex subnigricans-Dodecatheon alpinum*] (Taylor 1984)
45.110.19	Mount Dana Sedge - Alpine Pussytoes [*Carex subnigricans-Antennaria alpina*] (Taylor 1984)
45.110.20	entry moved to 45.155.01
*45.110.21	entry moved to 45.160.01
45.110.22	Vernacular Sedge - Alpine Pussytoes [*Carex vernacula-Antennaria alpina*] (Taylor 1984)
45.110.23	Western Yellow Cress - Dewey Sedge [*Rorippa curvisiliqua-Carex deweyana*] (Taylor 1984)
45.110.24	White-tipped Sedge - Junegrass [*Carex albonigra-Koeleria cristata*] (Taylor 1984)
45.110.25	Slough Sedge - Spreading Rush Tidal [*Carex obnupta-Juncus patens*] (Keeler-Wolf, *et al*. 2001)

45.120.00 Rocky Mountain Sedge [*Carex scopulorum*]

45.120.01	Rocky Mountain Sedge [*Carex scopulorum*] (Major & Taylor 1977)
45.120.02	Rocky Mountain Sedge - Elephant's Head [*Carex scopulorum-Pedicularis groenlandica*] (Taylor 1984)
*45.120.03	Rocky Mountain Sedge - Cotton-grass [*Carex scopulorum-Eriophorum criniger*] (Taylor 1984)
45.120.04	Rocky Mountain Sedge - Few-flowered Spikerush [*Carex scopulorum-Eleocharis pauciflora*] (Keeler-Wolf and Moore 2001)

45.130.00 Nebraska Sedge [*Carex nebrascensis*]

45.130.01	Nebraska Sedge [*Carex nebrascensis*] (Beguin & Major 1975)
45.130.02	Nebraska Sedge - Sierra Ricegrass [*Carex nebrascensis-Ptilagrostis kingii*] (Halpern 1986)

45.140.00 Shorthair Sedge [*Carex filifolia*]

45.140.01	Shorthair Sedge - Spike Trisetum [*Carex filifolia-Trisetum spicatum*] (Benedict 1983)
45.140.02	Shorthair Sedge - Sierra Ricegrass [*Carex filifolia-Ptilagrostis kingii*] (Benedict 1983)
45.140.03	Pussypaws - Shorthair Sedge [*Calyptridium umbellatum-Carex filifolia*] (Burke 1982)
45.140.04	Nude Buckwheat - Shorthair Sedge [*Eriogonum nudum-Carex filifolia*] (Burke 1982)
45.140.05	Talus fleabane - Shorthair Sedge [*Erigeron algidus-Carex filifolia*] (Burke 1982)
45.140.06	Shorthair Sedge [*Carex filifolia*] (Major & Taylor 1977)

45.140.07 Shorthair Sedge - Saxifrage [*Carex filifolia-Saxifraga aprica*] (Taylor 1984)
45.140.08 Shorthair Sedge - Heretic Penstemon [*Carex filifolia-Penstemon heterodoxus*] (Keeler-Wolf and Moore 2001)

45.145.00 Heller Sedge [*Carex helleri*] (Keeler-Wolf and Moore 2001)
45.145.01 Heller Sedge - Parry Rush [*Carex helleri-Juncus parryi*] (Major & Taylor 1977)
45.145.02 Heller Sedge - Club-moss Ivesia [*Carex helleri-Ivesia lycopodioides*] (Taylor 1984)

45.150.00 Brewer Sedge [*Carex breweri*] (Keeler-Wolf and Moore 2001)
45.150.01 Brewer Sedge [*Carex breweri*] (Taylor 1984)
*45.150.02 Brewer Sedge - Wheeler Bluegrass [*Carex breweri-Poa wheeleri*] (Major & Taylor 1977)

45.155.00 Showy Sedge [*Carex spectabilis*] (Keeler-Wolf and Moore 2001)
45.155.01 Showy Sedge - Sibbaldia [*Carex spectabilis-Sibbaldia procumbens*] (Taylor 1984)

45.160.00 Congdon Sedge - Streambank Arnica [*Carex congdonii-Arnica amplexicaulis*] (Keeler-Wolf and Moore 2001)
*45.160.01 Streambank Arnica - Congdon Sedge [*Arnica amplexicaulis-Carex congdonii*] (Taylor 1984)

45.162.00 Jones' Sedge [*Carex jonesii*] (Keeler-Wolf and Moore 2001)

45.164.00 Blackish Sedge [*Carex nigricans*] (Keeler-Wolf and Moore 2001)
45.164.01 Bilberry - Blackish Sedge [*Vaccinium caespitosum-Carex nigricans*] (Major & Taylor 1977)
45.164.02 Blackish Sedge - Mountain-laurel [*Carex nigricans-Kalmia polifolia*] (Taylor 1984)

45.166.00 Woolly Sedge [*Carex lanuginosa*] (Keeler-Wolf and Moore 2001)

45.168.00 Water Sedge [*Carex aquatilis*] (Keeler-Wolf and Moore 2001)

45.170.00 Inflated Sedge [*Carex vesicaria*] (Keeler-Wolf and Moore 2001)
45.170.01 Inflated Sedge [*Carex vesicaria*] (Keeler-Wolf and Moore 2001)

45.200.00 Spikerushes [*Eleocharis* spp.]

45.210.00 Spikerush [*Eleocharis* spp.]
45.210.01 Nevada Rush - Spikerush [*Juncus nevadensis-Eleocharis* spp.] (Beguin & Major 1975)
45.210.02 Few-flowered Spikerush [*Eleocharis pauciflora*] (Benedict 1983)
*45.210.03 Few-flowered Spikerush - Primrose Monkeyflower [*Eleocharis* pauciflora- *Mimulus primuloides*] (Benedict 1983)
45.210.04 Mountain Spikerush - Cowbane [*Eleocharis montevidensis-Oxypolis occidentalis*] (Halpern 1986)
45.210.05 Mountain Spikerush - Moss [*Eleocharis montevidensis*-Moss] (Halpern 1986)
*45.210.06 Pale Spikerush - Water-starwort [*Eleocharis macrostachya-Callitriche hermaphroditica*] (Kepecko & Lathrop 1975)
*45.210.07 Spikerush - Water Pygmy [*Eleocharis* spp.-*Crassula aquatica*] (Kepecko & Lathrop 1975)

45.210.08 Littlebeak Spikerush - Common Three-square [*Eleocharis rostellata-Scirpus americanus*] (Odion *et al*. 1992)
*45.210.09 Littlebeak Spikerush - Alkali Muhly [*Eleocharis rostellata-Muhlenbergia asperifolia*] (Odion *et al*. 1992)

45.300.00 Meadow and Seep Habitats {45000}

45.310.00 Montane Meadow
45.310.01 entry moved to 41.640.04
45.310.02 Bluejoint Reedgrass - Small-fruited Bulrush [*Calamagrostis canadensis-Scirpus microphyllus*] (Halpern 1986)
45.310.03 Rough Bentgrass [*Agrostis scabra*] (Halpern 1986)
45.310.04 entry moved to 41.222.02
45.310.05 entry moved to 41.222.03
45.310.06 Bracken Fern- Pale Hedge-nettle [*Pteridium aquilinum-Stachys rigida*] (Palmer 1979)
45.310.07 Gentian - Alpine Aster [*Gentiana newberryi-Aster alpigenus*] (Ratliff 1982, 1985)
45.310.09 Carpet Clover [*Trifolium monathum*] (Ratliff 1982, 1985)
45.310.10 Angelica - Indian Paintbrush [*Angelica tomentosa-Castilleja miniata*] (Stillman 1980)
45.310.11 Diego Bentgrass - Ribbed Sedge [*Agrostis diegoensis-Carex multicostata*] (Stillman 1980)
45.310.12 Wet Montane Meadow {45110}
45.310.13 Dry Montane Meadow {45120}

45.312.00 Bigleaf Lupine alliance [*Lupinus latifolius*] (Keeler-Wolf and Moore 2001)
45.312.01 Bigleaf Lupine [*Lupinus latifolius*] (Keeler-Wolf and Moore 2001)

45.320.00 Subalpine Meadow
45.320.01 Skyline Bluegrass - Smooth-beaked Sedge [*Poa cusickii* spp.*epilis-Carex integra*] (Beguin & Major 1975)
45.320.02 Heretic Penstemon - Yarrow [*Penstemon heterodoxus-Achillea lanulosa*] (Benedict 1983)
45.320.03 Many-nerved Sedge - Yarrow [*Carex multicostata-Achillea lanulosa*] (Benedict 1983)
45.320.04 Tawny Buckwheat - Woolly Mountain-parsley [*Eriogonum incanum-Oreonana vestita*] (Benedict 1983)
45.320.05 Davis Knotweed - Tawny Buckwheat [*Polygonum davisiae-Eriogonum incanum*] (Major & Taylor 1977)
45.320.06 Pussypaws - Heretic Penstemon [*Calyptridium umbellatum-Penstemon heterodoxus*] (Major & Taylor 1977)
45.320.07 Jeffrey Shooting Star - Mertens Rush [*Dodecatheon jeffreyi-Juncus mertensianus*] (Palmer 1979)
45.320.08 Wet Subalpine or alpine meadow

45.400.00 Mountain Heather - Bilberry [*Phyllodoce* spp.-*Vaccinium caespitosum*]
45.400.01 Sierra Primrose [*Primula suffrutescens*] (Burke 1982)
45.400.02 Bilberry - Blackish Sedge [*Vaccinium caespitosum-Carex nigricans*] (Major & Taylor 1977)
45.400.03 Drummond Cinquefoil - Brewer Cinquefoil [*Potentilla drummondii-Potentilla breweri*] (Major & Taylor 1977)

45.405.00 Sierra Bilberry Scrub [*Vaccinium (caespitosum, scoparium)*] (Keeler-Wolf and Moore 2001)

45.410.00 Western Blueberry Scrub [*Vaccinium uliginosum*] (Keeler-Wolf and Moore 2001)

45.410.01 Western Blueberry [*Vaccinium uliginosum*] (Keeler-Wolf and Moore 2001)

45.415.00 Mountain Pride Penstemon [*Penstemon newberryi*] (Keeler-Wolf and Moore 2001)

45.415.01 Mountain Pride Penstemon - Mountain Jewelflower [*Penstemon newberryi-Streptanthus tortuosus*] (Taylor 1984)

45.415.02 Mountain Spiraea / Mountain Pride Penstemon - Mountain Jewelflower [*Spiraea densiflora/Penstemon newberryi-Streptanthus tortuosus*] (Keeler-Wolf and Moore 2001)

45.420.00 Canada Goldenrod [*Solidago canadensis*] (Keeler-Wolf and Moore 2001)

45.420.00 Canada Goldenrod - Yarrow [*Solidago canadensis-Achillea millefolium*] (Keeler-Wolf and Moore 2001)

45.421.00 Alpine Aster [*Aster alpigenus* spp. *andersonii*] (Keeler-Wolf and Moore 2001)

45.422.00 Cordilleran Arnica [*Arnica mollis*] (Keeler-Wolf and Moore 2001)

45.423.00 White Corn-lily [*Veratrum californicum*] (Keeler-Wolf and Moore 2001)

45.423.01 White Corn-lily - Arrowhead Butterweed [*Veratrum californicum-Senecio trangularis*] (Taylor 1984)

45.500.00 Alkali Meadow {45310}

45.550.00 Cocklebur Riparian Grassland [*Xanthium strumarium*] (Keeler-Wolf, Vaghti 2000)

45.555.00 Fennel [*Foeniculum vulgare*] (Keeler-Wolf, Vaghti 2000)

45.560.00 Rush Riparian Grassland [*Juncus* spp.] (Keeler-Wolf, *et al*. 2001)

45.561.00 Common Rush Riparian Grassland [*Juncus effusus* var. *brunneus*] (Keeler-Wolf, *et al*. 2001)

45.562.00 Baltic Rush Riparian Grassland [*Juncus balticus*] (Keeler-Wolf, Vaghti 2000)

45.562.01 Baltic Rush - Poison Hemlock [*Juncus balticus-Conium maculatum*] (Keeler-Wolf, Vaghti 2000)

45.562.02 Baltic Rush - (Mexican Rush) [*Juncus balticus-(Juncus mexicana)*] (Keeler-Wolf and Moore 2001)

*45.563.00 Cooper Rush Riparian Grassland [*Juncus cooperi*] (Keeler-Wolf and Thomas 2000)

45.564.00 Spreading Rush [*Juncus patens*] (Keeler-Wolf, *et al*. 2001)

45.565.00 Mexican Rush Riparian Grassland [*Juncus mexicanus*] (Keeler-Wolf and Thomas 2000)

45.566.00 Parry Rush [*Juncus parryi*] (Keeler-Wolf and Moore 2001)

45.566.01 Parry Rush - Vagus Buckwheat [*Juncus parryi-Eriogonum incanum*] (Taylor 1984)

*45.567.00 Sierra Rush [*Juncus nevadensis*] (Keeler-Wolf and Moore 2001)

45.600.00 Alkali Seep {45320}

45.700.00 Freshwater Seep {45400}

*46.000.00 Alkali Playa Community {46000}

50.000.00 BOG AND MARSH {50000}

51.000.00 Bog and Fen {51000}

*51.100.00 Fen Habitat {51110}{51200}

*51.200.00 Darlingtonia Seep [*Darlingtonia californica*] {51120}
52.200.01 California pitcher plant-California cone flower [*Darlingtonia californica-Rudbeckia californica*] (re-named from Jimerson et al. 1995)

52.000.00 Marsh

52.100.00 Fresh - Brackish Water Marsh {52200}
52.100.01 Coastal and Valley Freshwater Marsh {52410}
52.100.02 Coastal Brackish Marsh {52200}
52.100.03 Montane Freshwater Marsh {52430}
52.100.04 Vernal Marsh {52500}

*52.101.00 Bulrush [*Scirpus* spp.]
*52.101.01 California Bulrush Wetland [*Scirpus californicus*] (Atwater *et al*. 1979)
*52.101.02 moved to 52.111.04
*52.101.03 moved to 52.111.05
*52.101.04 Moved to 52.112.00
52.101.05 moved to 52.112.01
52.101.06 California Bulrush / Tule [*Scirpus californicus/S. acutus*] (Keeler-Wolf, Vaghti 2000)
52.101.07 Small-fruited Bulrush [*Scirpus microcarpus*] (Keeler-Wolf, *et al*. 2001)

52.102.00 Bulrush - Cattail Wetland [*Scirpus* spp.-*Typha* spp.]
52.102.01 Bulrush - Cattail [*Scirpus* spp.-*Typha* spp.] (Atwater *et al*. 1979)
52.102.02 Common Tule - Southern Cattail [*Scirpus acutus* - *Typha domingensis*] (Odion *et al*. 1992)
*52.102.03 moved to 52.112.02
*52.102.04 Brackish Bulrush – Cattail [*Scirpus* spp. - *Typha* spp.] {52200}

52.103.00 Cattail Wetland [*Typha* spp.]
*52.103.01 Brackish Cattail [*Typha* spp.]
52.103.02 Broad-leafed Cattail [*Typha latifolia*] (Keeler-Wolf, *et al*. 2001)

52.104.00 Bur-reed Wetland [*Sparganium* spp.]
52.104.01 Narrowleaf Bur-reed [*Sparganium angustifolium*] (Keeler-Wolf and Moore 2001)

52.105.00 Duckweed Wetland [*Lemma* spp.]

52.106.00 Mosquito Fern Wetland [*Azolla filiculoides*]

*52.107.00 Pondweeds with floating leaves Wetland [*Potamogeton* spp.]

*52.108.00 Pondweeds with submerged leaves Wetland [*Potamogeton* spp.]

*52.109.00 Quillwort Wetland [*Isoetes* spp.]
52.109.01 Western Spikerush [*Isoetes occidentalis*] (Keeler-Wolf and Moore 2001)

*52.110.00 Yellow Pond-lily Wetland [*Nuphar luteum*]

52.111.00 Common Three-square [*Scirpus americanus*] (Keeler-Wolf and Thomas 2000)
- *52.111.01 Common Three-square - Cooper Rush - Yerba Mansa [*Scirpus americanus-Juncus cooperi-Anemopsis californica*] (Keeler-Wolf and Thomas 2000)
- *52.111.02 Common Three-square/ Silverleaf Cinqufoil [*Scirpus americanus/Potentilla anserina*] (Keeler-Wolf, Vaghti 2001)
- 52.111.03 Common Three-square/Perennial Pepperweed [*Scirpus americanus/Lepidium latifolium*] (Keeler-Wolf, Vaghti 2001)
- 52.111.04 Common Three-square [*Scripus americanus*] (Bradley 1970)
- *52.111.05 Common Three-square - Littlebeak Spikerush [*Scripus americanus-Eleocharis rostellata*] (Odion *et al*. 1992)

*52.112.00 Alkali Bulrush [*Scirpus maritimus*] (Keeler-Wolf, Vaghti 2000)
- *52.112.01 Alkali Bulrush / Pickleweed [*Scirpus maritimus/Salicornia* spp.] (Keeler-Wolf, Vaghti 2000)
- *52.112.02 Alkali Bulrush – Cattail [*Scirpus maritima. - Typha* spp.] (Keeler-Wolf, Vaghti 2000)

52.120.00 Beaked Sedge Wetland [*Carex utriculata*]
- 52.120.01 Beaked Sedge [*Carex utriculata*] (Taylor 1984, Halpern 1986, Potter 2000)

52.200.00 Salt - Alkali Marsh

*52.201.00 Pickleweed Wetland [*Salicornia* spp.]
- *52.201.01 Common Pickleweed [*Salicornia virginica*] (Atwater *et al*. 1979)
- *52.201.02 Common Pickleweed - Gumplant [*Salicornia virginica-Grindelia stricta*] (Atwater *et al*. 1979)
- *52.201.03 Common Pickleweed - Saltgrass [*Salicornia virginica-Distichlis spicata*] (Atwater *et al*. 1979)
- *52.201.04 Common Pickleweed - Jaumea - Saltgrass [*Salicornia virginica-Jaumea carnosa*] (Eicher 1987)
- *52.201.05 Bigelow Pickleweed [*Salicornia bigelovii*] (Peinado *et al*. 1994)
- 52.201.06 Northern Coastal Salt Marsh {52110}
- *52.201.07 South Coastal Pickleweed Salt Marsh
- *52.201.08 Alkali Pickleweed
- 52.201.09 Southern Coastal Salt Marsh {52120}
- 52.201.10 Common Pickleweed - Bigelow Pickleweed / Western Sea Purslane [*Salicornia virginica - Salicornia bigelovii / Sesuvium verrucosum*] (Keeler-Wolf, Vaghti 2000)
- 52.201.11 Common Pickleweed - Bigelow Pickleweed / Saltbush [*Salicornia virginica - Salicornia bigelovii* / *Atriplex* spp.] (Keeler-Wolf, Vaghti 2000)
- 52.201.12 Common Pickleweed - Bigelow Pickleweed / Saltgrass [*Salicornia virginica - Salicornia bigelovii / Distichlis spicata*] (Keeler-Wolf, Vaghti 2000)
- 52.201.13 Common Pickleweed - Bigelow Pickleweed / Beardgrass [*Salicornia virginica - Salicornia bigelovii / Polypogon* spp.] (Keeler-Wolf, Vaghti 2000)
- 52.201.14 Common Pickleweed - Saltgrass - Jaumea [*Salicornia virginica-Distichlis spicata-Jaumea carnosa*] (Keeler-Wolf, *et al*. 2001)

*52.202.00 Ditch-grass Wetland [*Ruppia* spp.]

52.203.00 Cismontane Alkali Marsh {52310}

52.204.00 Transmontane Alkali Marsh {52320}

52.205.00 Perennial Pepperweed [*Lepidium latifolium*] (Keeler-Wolf, Vaghti 2000)

52.205.01 Pepperweed - Saltgrass [*Lepidium latifolium - Distichlis* spp.] (Keeler-Wolf, Vaghti 2000)

52.206.00 Gumplant [*Grindelia stricta stricta*] (Keeler-Wolf, Vaghti 2000)

52.208.00 Birdfoot Trefoil [*Lotus corniculatus*] (Keeler-Wolf, Vaghti 2000)

52.209.00 Brass Buttons [*Cotula coronopifolia*] (Keeler-Wolf, Vaghti 2000)

52.210.00 Western Sea Purslane [*Sesuvium verrucosum*] (Keeler-Wolf, Vaghti 2000)

52.211.00 Spearscale [*Atriplex triangularis*] (Keeler-Wolf, Vaghti 2000)

52.500.00 Alkali Heath Dwarf Scrub [*Frankenia salina*] (Keeler-Wolf, Vaghti 2000)

60.000.00 RIPARIAN AND BOTTOMLAND HABITAT

61.000.00 Riparian Forest and Woodland

61.100.00 Cottonwood and Aspen Woodlands and Forests [*Populus* spp.]

61.111.00 Aspen Upland and Riparian Forests and Woodlands

*61.111.01 Riparian Aspen Forest (Talley 1977)

*61.111.02 Aspen [*Populus tremuloides*] (Potter 1994)

*61.111.03 Aspen / White Corn-lily [*Populus tremuloides/Vertrum californicum*] (Riegel *et al*. 1990, Potter 1994)

*61.111.04 Aspen / Upland [*Populus tremuloides*]

*61.111.05 Aspen / Leafy Aster [*Populus tremuloides/Aster foliaceus*] (Riegel *et al*. 1990)

61.111.06 Aspen / Big Sagebrush [*Populus tremuloides/Artemisia tridentata*] (Keeler-Wolf and Moore 2001)

61.111.07 Aspen / Big Sagebrush / Mountain Monardella - Kelloggia [*Populus tremuloides/Artemisia tridentata/Monardella odoratissima-Kelloggia galioides*] (Keeler-Wolf and Moore 2001)

61.111.08 Aspen / Mountain Monardella [*Populus tremuloides/Monardella odoratissima*] (Potter 1994)

61.111.09 Aspen / Jeffrey Pine [*Populus tremuloides/Pinus jeffreyi*] (Keeler-Wolf and Moore 2001)

61.111.10 Aspen / Woods Rose [*Populus tremuloides/Rosa woodsii*] (Keeler-Wolf and Moore 2001)

61.111.11 Aspen - Lodgepole Pine / Big Sagebrush / Kentucky blue-grass [*Populus tremuloides-Pinus contorta/Artemisia tridentata/Poa pratensis*] (Keeler-Wolf and Moore 2001)

*61.120.00 Black Cottonwood Riparian Forests and Woodlands [*Populus balsamifera*] {61110}

*61.120.01 North Coast Black Cottonwood [*Populus balsamifera*]

*61.120.02 Montane Black Cottonwood [*Populus balsamifera*] {61530}

61.120.03 Black Cottonwood - Jeffrey Pine [*Populus balsamifera-Pinus jeffreyi*] (Keeler-Wolf and Moore 2001)

*61.130.00 Fremont Cottonwood Riparian Forests and Woodlands [*Populus fremontii*]

- *61.130.01 Great Valley Cottonwood Riparian [Populus spp.] {61410}
- *61.130.02 Southern Cottonwood - Willow Riparian [*Populus* spp.-*Salix* spp.] {61330}
- *61.130.03 Modoc - Great Basin Cottonwood - Willow Riparian [*Populus* spp.-*Salix* spp.]
- *61.130.04 Mojave Riparian {61700}
- *61.130.05 Sonoran Cottonwood - Willow Riparian [*Populus* spp.-*Salix* spp.] {61810}
- 61.130.06 Fremont Cottonwood [*Populus fremontii*] Sacramento River association (Vaghti 2003)
- 61.130.07 Fremont Cottonwood /Box-elder [*Populus fremontii/Acer negundo]* (Vaghti 2003)
- 61.130.08 Fremont Cottonwood/Box-elder/Hymalian Blackberry [Populus fremontii/Acer negundo/Rubus discolor] (Vaghti 2003)
- 61.130.09 Fremont Cottonwood/Douglas' Mugwort [Populus fremontii/Artemisia douglasiana] (Vaghti 2003)
- 61.130.10 Fremont Cottonwood/Common bedstraw [Populus fremontii/Gallium aparine] (Vaghti 2003)
- 61.130.11 Fremont Cottonwood/California Blackberry [Populus fremontii/Rubus ursinus] (Vaghti 2003)
- 61.130.12 Fremont Cottonwood-Gooddings Black Willow [Populus fremontii-Salix gooddingii] (Vaghti 2003)
- 61.130.13 Fremont Cottonwood/California Wild Grape [Populus fremontii/Vitis californica] (Vaghti 2003)

61.200.00 Willow Riparian Forests and Woodlands [*Salix* spp.]

*61.201.00 Arroyo Willow Riparian Forests and Woodlands [*Salix lasiolepis*]

- *61.201.01 Central Coast Arroyo Willow Riparian [*Salix lasiolepis*] {61230}
- *61.201.02 Southern Arroyo Willow Riparian [*Salix lasiolepis*]
- 61.201.03 Arroyo Willow / Blackberry Riparian [*Salix lasiolepis/Rubus* spp.] (Keeler-Wolf, *et al*. 2001)
- 61.201.04 Arroyo Willow - Shining Willow [*Salix lasiolepis-Salix lucida*] (Keeler-Wolf, *et al*. 2001)

*61.202.00 Black Willow Riparian Forests and Woodlands [*Salix gooddingii*]

*61.203.00 Hooker Willow Riparian Forests [*Salix hookeriana*]

*61.204.00 Pacific Willow Riparian Forests [*Salix lucida* ssp. *lasiandra*]

- 61.204.01 Shining Willow/Dwarf Nettle-Stinging Nettle [Salix lucida/Urtica urens-U. dioica] (Vaghti 2003)

*61.205.00 Red Willow Riparian Forests [*Salix laevigata*]

- 61.205.01 Red Willow [*Salix laevigata*] (Keeler-Wolf and Moore 2001)
- 61.205.02 Red Willow / Arroyo Willow [*Salix laevigata / Salix lasiolepis*] (Keeler-Wolf, Vaghti 2000)

*61.206.00 Sitka Willow Riparian Forests [*Salix sitchensis*]

*61.207.00 Mixed Willow Riparian Forests and Woodlands [*Salix* spp.]

*61.208.00 Southern Willow Scrub [*Salix* spp.]

61.209.00 Narrow-leaf Willow Riparian Scrub [*Salix exigua*] (Keeler-Wolf, Vaghti 2000)

- 61.209.01 Narrow-leaf Willow [*Salix exigua*] Sacramento River Stands (Vaghti 2003)

61.209.02 Narrow-leaf Willow /Giant Reed [*Salix exigua-Arundo donax*] (Vaghti 2003)
61.209.03 Narrow-leaf Willow –Dusky Willow [Salix exigua-Salix melanopsis] (Vaghti 2003)

61.210.00 Yellow Willow Riparian Scrub [*Salix lutea*] (Keeler-Wolf & Moore 2001)

61.211.00 Gooding Willow Woodland [*Salix goodingii*] (Keeler-Wolf 2001)
61.211.01 Gooding Willow [*Salix goodingii*] (Keeler-Wolf 2001)

61.300.00 Sycamore [*Platanus* spp.]

*61.310.00 California Sycamore [*Platanus racemosa*]

*61.311.00 Central California Sycamore Alluvial Woodland [*Platanus* spp.] {62100}
*61.311.01 California Sycamore / Slender Wildoats [*Platanus racemosa/Avena barbata*] (Keeler-Wolf *et al*. 1994)
*61.311.02 California Sycamore / Soft Chess [*Platanus racemosa/Bromus hordeaceus*] (Keeler-Wolf *et al*. 1994)

*61.312.00 Southern Sycamore - Alder Riparian Woodland [*Platanus* spp.-*Alnus* spp.] {62400}
61.312.01 California Sycamore - Coast Live Oak [*Platanus racemosa-Quercus agrifolia*] (Keeler-Wolf *et al*. 1994)
*61.312.02 California Sycamore [*Platanus racemosa*] (Campbell 1980)

*61.313.00 Foothill Sycamore Riparian Woodland [*Platanus* spp.]
*61.313.01 California Sycamore / Mulefat [*Platanus racemosa/Baccharis salicifolia*] (Keeler-Wolf *et al*. 1994)

*61.314.00 Central Coast Cottonwood - Sycamore Riparian Woodland [*Populus* spp.-*Platanus* spp.] {61210}

61.400.00 Alder Riparian Forest [*Alnus* spp.]

61.410.00 Red Alder [*Alnus rubra*]
*61.410.01 Douglas-fir - Red Alder / Vine Maple /Candyflower [*Pseudotsuga menziesii/Alnus rubra/Acer circinatum/Claytonia sibirica*] (Jimerson 1993)
*61.410.02 Red Alder / Salal [*Alnus rubra/Gaultheria shallon*] (Stuart *et al*. 1986)
*61.410.03 Red Alder Riparian Forest [*Alnus rubra*] {61130}
*61.410.04 Red Alder Forest [*Alnus rubra]*{81A00}
*61.410.05 Red Alder / Arroyo Willow [*Alnus rubra/Salix lasiolepis*] (Keeler-Wolf, *et al*. 2001)
*61.410.06 Red Alder / Salmonberry - Blue Elderberry [*Alnus rubra/Rubus spectabilis-Sambucus racemosa*] (Keeler-Wolf, *et al*. 2001)

61.420.00 White Alder Forest and Woodland [*Alnus rhombifolia*] {61510}
*61.420.01 White Alder / California Polypody [*Alnus rhombifolia/Polypodium californicum*] (Borchert *et al*. 1988)
61.420.02 White Alder / Spikenard [*Alnus rhombifolia/Aruncus dioicus*] (Jimerson 1993)
61.420.03 White Alder - Bigleaf Maple [*Alnus rhombifolia/Acer macrophyllum*] (Stuart *et al*. 1992)
61.420.04 Douglas-fir - White Alder / Himalaya Berry [*Pseudotsuga menziesii-Alnus rhombifolia/Rubus discolor*] (Stuart *et al*. 1992)

61.420.05 White Alder / Indian Rhubarb [*Alnus rhombifolia/Darmera peltata*] (Taylor 1975a, b)
61.420.06 White Alder / Miner Dogwood [*Alnus rhombifolia/Cornus sessilis*] (Taylor & Teare 1979a)
61.420.07 White Alder / Red Osier [*Alnus rhombifolia/Cornus sericea*] (Taylor & Teare 1979a)
61.420.08 White Alder / Fragrant Bedstraw [*Alnus rhombifolia/Galium trifolium*] (Taylor & Teare 1979b)
61.420.09 White Alder / Mulefat [*Alnus rhombifolia/Baccharis salicifolia*] (White 1994a)
61.420.10 White Alder [*Alnus rhombifolia*] (Potter 2000)

61.500.00 Desert Wash Riparian Woodland

*61.510.00 Mesquite Woodland [*Prosopis* spp.]
*61.510.01 Mesquite Dune Scrub [*Prosopis* spp.] (Spolsky 1979)
*61.510.02 Acacia - Mesquite thickets [*Acacia* spp.-*Prosopis* spp.] (Spolsky 1979)
*61.510.03 Mesquite Dry Lake [*Prosopis* spp.] (Spolsky 1979)
*61.510.04 Great Valley Mesquite Scrub [*Prosopis* spp.] {63420}
*61.510.05 Mesquite Bosque [*Prosopis* spp.] {61820}
61.510.06 Mesquite Alkaline [*Prosopis* spp.], spring type (Keeler-Wolf *et al.* 1998)
61.510.07 Mesquite - Willow [*Prosopis* spp.-*Salix* spp.] (Keeler-Wolf *et al*. 1998)
61.510.08 Upper Desert Mesquite [*Prosopis* spp.], spring association (Keeler-Wolf *et al*. 1998)

*61.512.00 Honey Mesquite Scrub [*Prosopis glandulosa*] (Keeler-Wolf and Thomas 2000)
*61.512.01 Honey Mesquite [*Prosopis glandulosa*] (Keeler-Wolf and Thomas 2000)

*61.513.00 Tornillo Scrub [*Prosopis pubescens*] (Keeler-Wolf and Thomas 2000)

*61.520.00 Fan Palm Woodland [*Washingtonia filifera*]
*61.520.01 Desert Fan Palm [*Washingtonia filifera*] {62300}
*61.520.02 Fan Palm - Sycamore [*Washingtonia filifera-Platanus* spp.] (Spolsky 1979)

*61.530.00 Blue Palo Verde - Ironwood - Smoke Tree Woodland [*Cercidium floridum-Olneya tesota-Psorothamnus spinosus*]
*61.530.01 Mixed Wash Woodland (Spolsky 1979)

61.540.00 Blue Palo Verde Woodland [*Cercidium floridium*]
*61.540.01 Blue Palo Verde Wash Woodland [*Cercidium floridium*] (Spolsky 1979)
*61.540.02 Blue Palo Verde / Desert Lavender [*Cercicium floridum/Hyptis emoryi*] (Keeler-Wolf 2001)

61.550.00 Desert-willow Woodland [*Chilopsis linearis*]
*61.550.01 Desert-willow Woodland [*Chilopsis linearis*] (Spolsky 1979)
61.550.02 Desert-willow / Cheesebush [*Chilopsis linearis*/*Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)
*61.550.03 Desert-willow - Desert Almond - Cheesebush [*Chilopsis linearis-Prunus fasciculata-Hymenoclea salsola*] (Keeler-Wolf and Thomas 2000)
61.550.04 Desert-willow - Desert Almond [*Chilopsis linearis-Prunus fasciculata*] (Keeler-Wolf and Thomas 2000)
*61.550.05 Desert-willow - Blue Sage [*Chilopsis linearis-Salvia dorrii*] (Keeler-Wolf and Thomas 2000)
61.550.06 Desert-willow - Desert Sunflower [*Chilopsis linearis-Viguiera parishii*] (Keeler-Wolf and Thomas 2000)

61.550.07 Desert-willow - Blackstem Rabbitbrush [*Chilopsis linearis-Chrysothamnus paniculatus*] (Keeler-Wolf and Thomas 2000)

61.560.00 Ironwood Woodland [*Olneya tesota*]
*61.560.01 Ironwood Woodland [*Olneya tesota*] (Spolsky 1979)
61.560.02 Ironwood / Desert Lavender [*Olneya tesota, Hyptis emoryi*] (Keeler-Wolf 2001)

61.570.00 Smoke Tree Woodland and Scrub [*Psorothamnus spinosus*]
*61.570.01 Smoketree Wash Woodland [*Psorothamnus spinosus*] (Spolsky 1979)
61.570.02 Smoketree - Cheesebush - Sweetbush [*Psorothamnus spinosus-Hymenoclea salsola-Bebbia juncea*] (Keeler-Wolf and Thomas 2000)
*61.570.03 Smoketree / California Ephedra [*Psorothamnus spinosus/Ephedra californica*] (Keeler-Wolf and Thomas 2000)
61.570.04 Smoketree - Desert Lavender - Catclaw Acacia [*Psorothamnus spinosus-Hyptis emoryi-Acacia greggii*] (Keeler-Wolf and Thomas 2000)

*61.580.00 Desert Olive Scrub [*Forestiera pubescens*] (Keeler-Wolf and Thomas 2000)

*61.580.01 Desert Olive [*Forestiera pubescens*] (Keeler-Wolf and Thomas 2000)

*61.800.00 Walnut [*Juglans* spp.]

*61.810.00 Hind's Walnut Unique Stands [*Juglans californica* var. *hindsii*] {71120}
*61.810.01 Hinds Walnut/Mexican Elderberry [*Juglans hindsii/Sambucus mexicana*] (Vaghti 2003)

61.900.00 Mixed Riparian Forest and Woodland

*61.910.00 Great Valley Mixed Riparian Forest {61420}

*61.920.00 Southern Mixed Riparian Forest {61340}

*61.930.00 Southern Riparian Forest {61300}

*61.940.00 Mojave Riparian Forest {61700}

61.950.00 Desert Dry Wash Woodland {62200}

*61.960.00 Oregon Ash Riparian Forest [*Fraxinus latifolia*] (Keeler-Wolf, Vaghti 2000)
61.960.01 Oregon Ash [*Fraxinus latifolia*] (Potter 2000)

63.000.00 Low to High Elevation Riparian Scrub {63000}

63.100.00 Scrub Willow [*Salix* spp.]

*63.110.00 Narrowleaf Willow [*Salix exigua*] {63410}
63.110.01 Narrowleaf Willow - Desert Baccharis [*Salix exigua-Baccharis sergilloides*] (Keeler-Wolf and Thomas 2000)

63.111.00 Tealeaf Willow Riparian Scrub [*Salix planifolia*] (Keeler-Wolf and Moore 2001)
63.111.01 Tealeaf Willow [*Salix planifolia*] (Keeler-Wolf and Moore 2001)

63.112.00 Sierra Willow Riparian Scrub [*Salix eastwoodiae*] (Keeler-Wolf and Moore 2001)
63.112.01 Sierra Willow [*Salix eastwoodiae*] (Keeler-Wolf and Moore 2001)

63.113.00 Lemmon’s Willow Riparian Scrub [*Salix lemmonii*] (Keeler-Wolf and Moore

2001)

63.113.01 Lemmon's Willow [*Salix lemmonii*] (Keeler-Wolf and Moore 2001)

63.114.00 Dusky Willow Riparian Scrub [*Salix melanopsis*] (Keeler-Wolf and Moore 2001)

63.114.01 Dusky Willow [*Salix melanopsis*] (Keeler-Wolf and Moore 2001)

63.115.00 Grayleaf Sierra Willow Riparian Scrub [*Salix orestera*] (Taylor 1984)

63.115.01 Grayleaf Sierra Willow / Shorthair Reedgrass [*Salix orestera/Calamagrostis breweri*] (Taylor 1984)

63.115.02 Grayleaf Sierra Willow / Arrowhead Butterweed [*Salix orestera/Senecio triangularis*] (Taylor and Major & Taylor 1977)

63.116.00 Arctic Willow Dwarf Scrub [*Salix arctica*] (Keeler-Wolf and Moore 2001)

*63.116.01 Arctic Willow [*Salix arctica*] (Taylor 1984) {moved from 91.120.22}

63.116.02 Arctic Willow / Shorthair Reedgrass - Sierra Bilberry - Pussytoes [*Salix arctica/Calamagrostis breweri-Vaccinium caespitosum-Antennaria media*] (Keeler-Wolf and Moore 2001)

*63.117.00 Snow Willow Dwarf Scrub [*Salix reticulata*] (Keeler-Wolf and Moore 2001)

63.120.00 Sandbar Willow [*Salix sessifolia*]

*63.130.00 Southern Willow [*Salix* spp.] {63320}

*63.140.00 Great Valley Willow [*Salix* spp.]

*63.150.00 Montane Wetland Shrub Habitat

*63.160.00 Subalpine Wetland Shrub Habitat

63.160.01 Sierra Ragwort - Showy Sedge [*Senecio scorzonella-Carex spectabilis*] (Burke 1982)

*63.160.02 Sierra Willow / Arrowhead Butterweed [*Salix eastwoodiae/Senecio triangularis*] (Major & Taylor 1977)

*63.160.03 Grayleaf Willow - Meadow Onion [*Salix orestera-Allium validum*] (Taylor 1984)

*63.160.04 Grayleaf Willow - Shorthair [*Salix orestera-Carex filifolia*] (Taylor 1984)

*63.160.05 Mountain Spiraea [*Spiraea densiflora*] (Taylor 1984)

*63.160.06 Tealeaf Willow - Showy Sedge [*Salix planifolia-Carex spectabilis*] (Taylor 1984)

63.200.00 Alder Scrubs [*Alnus* spp.]

*63.210.00 Mountain Alder Scrub [*Alnus incana*] {63500}

*63.220.00 Sitka Alder Scrub [*Alnus viridis*]

*63.300.00 Buttonbush Scrub [*Cephalanthus occidentalis*] {63430}

63.400.00 Elderberry Scrub and Savanna [*Sambucus* spp.]

63.410.00 Mexican Elderberry [*Sambucus mexicana*]

*63.410.01 Elderberry Savanna [*Sambucus mexicana*] {63440}

63.510.00 Mulefat Scrub [*Baccharis salicifolia*] {63310}

63.520.00 Emory Baccharis Scrub [*Baccharis emoryi*]

*63.530.00 Broom Baccharis Scrub [*Baccharis sergiloides*]
- *63.530.01 Broom Baccharis - Desert Almond [*Baccharis sergiloides-Prunus fasciculata*] (Keeler-Wolf and Thomas 2000)
- *63.530.02 Broom Baccharis - Desert Almond - Skunkbrush [*Baccharis sergiloides-Prunus fasciculata-Rhus trilobata*] (Keeler-Wolf and Thomas 2000)
- *63.530.03 Broom Baccharis / Deergrass [*Baccharis sergiloides/Muhlenbergia rigens*] (Keeler-Wolf and Thomas 2000)

63.600.00 Birch Scrub [*Betula* spp.]

*63.610.00 Water Birch Scrub [*Betula occidentalis*] {63510}

63.700.00 Arrow Weed Scrubs [*Pluchea* spp.] {63820}

63.710.00 Arrow Weed Scrub [*Pluchea sericea*]

63.800.00 Vegetation dominated by Tamarisk [*Tamarix* spp.] {63810}

63.810.00 Tamarisk Scrubs and Woodlands [*Tamarix* spp.]
- 63.810.01 Athel Tamarisk [*Tamarix aphylla*] type
- 63.810.02 Shrub Tamarisk [*Tamarix* spp.] type

*63.900.00 Southern Riparian Scrub {63300}

63.901.00 North Coast Riparian Scrub {63100}

63.902.00 Central Coast Riparian Scrub {63200}

63.903.00 Montane Riparian Scrub {63500}

63.904.00 Modoc-Great Basin Riparian Scrub {63600}

63.905.00 Mojave Desert Wash Scrub {63700}

63.906.00 Himalayan Blackberry Scrub [*Rubus discolor*] (Keeler-Wolf, Vaghti 2000)

63.907.00 California Rose Riparian Scrub [*Rosa californica*] (Keeler-Wolf, Vaghti 2000)
- 63.907.01 Rose / Baccharis Scrub [*Rosa* spp. / *Baccharis* spp.] (Keeler-Wolf, Vaghti 2000)

63.908.00 Salmonberry Scrub [*Rubus spectabilis*] (Keeler-Wolf, *et al*. 2001)

70.000.00 BROAD LEAFED UPLAND TREE DOMINATED

71.000.00 Oak Woodlands and Forests

71.010.00 Black Oak Forests and Woodland [*Quercus kelloggii*]
- 71.010.01 Black Oak - Canyon Live Oak / Poison-oak [*Quercus kelloggii-Quercus chrysolepis/Toxicodendron diversilobum*] (Allen *et al*. 1991)
- *71.010.02 Black Oak - Coast Live Oak - Pine / Ocean Spray [*Quercus kelloggii-Quercus chrysolepis/Holodiscus discolor*] (Allen *et al.* 1991)
- 71.010.03 Black Oak / Deerbush [*Quercus kelloggii/Ceanothus integerrimus*] (Allen *et al*. 1991)

71.010.04 Black Oak / Deerbush - Poison-oak / Bracken [*Quercus kelloggii/Ceanothus integerrimus-Toxicodendron diversilobum/Pteridium aquilinum*] (Allen *et al*. 1991)

71.010.05 Black Oak / Grass [*Quercus kelloggii/Trieleia* spp.] (Allen *et al*. 1991)

71.010.06 Black Oak / Greenleaf Manzanita [*Quercus kelloggii/Arctostaphylos patula*] (Allen *et al*. 1991)

*71.010.07 Black Oak - Madrone - Coast Live Oak [*Quercus kelloggii-Arbutus menziesii-Quercus chrysolepis*] (Allen *et al*. 1991)

71.010.08 Black Oak / Poison-oak [*Quercus kelloggii/Toxicodendron diversilobum*] (Allen *et al*. 1991)

71.010.09 Black Oak / Poison-oak / Grass [*Quercus kelloggii/Toxicodendron diversilobum/Trieleia* spp.] (Allen *et al*. 1991)

71.010.10 Black Oak / Poison-oak - Styrax / Grass Nut [*Quercus kelloggii/Toxicodendron diversilobum-Styrax officinalis/Trieleia laxa*] (Allen *et al*. 1991)

*71.010.11 Black Oak - Valley Oak [*Quercus kelloggii-Quercus lobata*] (Allen *et al*. 1991)

71.010.12 Canyon Live Oak - Black Oak [*Quercus chrysolepis-Quercus kelloggii*] (Allen *et al*. 1991)

71.010.13 Mixed Oak - Coast Live Oak / Poison-oak [*Quercus* spp.-*Quercus agrifolia/Toxicodendron diversilobum*] (Allen *et al*. 1991)

71.010.14 Coulter Pine - Black Oak [*Pinus coulteri-Quercus kelloggii*] (Keeler-Wolf 1986b, 1990b)

71.010.15 Black Oak [*Quercus kelloggii*] (Keeler-Wolf 1987f)

71.010.16 Black Oak - Douglas-fir - Bigleaf Maple [*Quercus kelloggii-Pseudotsuga menziesii-Acer macrophyllum*] (Jimerson 1993)

*71.010.17 Black Oak - Douglas-fir [*Quercus kelloggii-Pseudotsuga menziesii*] (Wainwright & Barbour 1984)

71.010.18 Black Oak Woodland [*Quercus kelloggii*] {71120}

71.010.19 Black Oak Forest [*Quercus kelloggii*] {81340}

71.010.20 Black Oak / Mewuk Manzanita / Mountain Misery [*Quercus kelloggii/Arctostaphylos mewukka/Chamaebatia foliosa*] (Keeler-Wolf and Moore 2001)

71.010.21 Black Oak - Incense Cedar [*Quercus kelloggii-Calocedrus decurrens*] (Keeler-Wolf and Moore 2001)

71.020.00 Blue Oak Woodland [*Quercus douglasii*] {71140}

71.020.01 Blue Oak - Coast Live Oak / Grass [*Quercus douglasii-Quercus agrifolia/*Grass] (Allen *et al*. 1991)

71.020.02 Blue Oak - Foothill Pine / Grass [*Quercus douglasii-Pinus sabinana/*Grass] (Allen *et al*. 1991)

71.020.03 Blue Oak - Foothill Pine / Wedgeleaf Ceanothus - Birchleaf Mountain-mahogany [*Quercus douglasii-Pinus sabinana/Ceanothus cuneatus-Cercocarpus betuloides*] (Allen *et a*l. 1991)

71.020.04 Blue Oak - Foothill Pine / Whiteleaf Manzanita / Grass [*Quercus douglasii-Pinus sabinana/Arctostaphylos viscida/*Grass] (Allen *et al*. 1991)

71.020.05 Blue Oak / Grass [*Quercus douglasii/*Grass] (Allen *et al*. 1991) (Includes Blue Oak / Bajada Lupine - Tree Clover,[*Quercus douglasii/Lupinus concinnus-Trifolium ciliolatum*], Blue Oak / Blue Larkspur-California Phacelia, [*Quercus douglasii/Delphinium parryi- Phacelia californica*], Blue Oak / Blue-eyed Mary-Rigiopappus, [*Quercus douglasii/Collinsia sparsiflora-Rigiopappus leptocladus*], Blue Oak / Chile Lotus - Purple Needlegrass, [*Quercus douglasii/Lotus wrangelianus-Stipa pulchra*], Blue Oak / Common Fiddleneck - Rusty Popcorn Flower, [*Quercus douglasii/Amsinckia intermedia-Plagiobothrys nothofulvus*], Blue Oak / Foxtail - Johnny-jump-up, [*Quercus douglasii/Hordeum leporinum-Viola*

pedunculata], Blue Oak / Phloxleaf Bedstraw - Bajada Lupine, [*Quercus douglasii/Galium andrewsii-Lupinus concinnus*], Blue Oak / Wand Buckwheat /Chile Lotus - California Plantain, [*Quercus douglasii/Eriogonum elongatum/Lotus wrangelianus-Plantago erecta*], Blue Oak / Wart Spurge - Goldenback Fern, [*Quercus douglasii/Euphorbia spathulata-Pentagramma triangularis*], Blue Oak / Whitestem Filaree - Foxtail,[*Quercus douglasii/Erodium moschatum-Hordeum leporinum*], of Borchert *et al*. 1993a, *Quercus douglasii* (and Blue Oak/Lemmon Needlegrass of Newton 1987) [*Quercus douglasii/Stipa lemmonii*]

71.020.06 Blue Oak - Interior Live Oak / Grass [*Quercus douglasii-Quercus wislizeni/*Grass] (Allen *et al*. 1991) (Includes Blue Oak - Interior Live Oak / Mission Star [*Quercus douglasii-Quercus wislizeni/Lithophragma cymbalaria*] of Borchert *et al*. 1993a)

71.020.07 Blue Oak - Interior Live Oak / Wedgeleaf Ceanothus /Grass [*Quercus douglasii-Quercus wislizeni/Ceanothus cuneatus*] (Allen *et al*. 1991)

71.020.08 Blue Oak - Linearleaf Goldenbush [*Quercus douglasii-Ericameria linearifolia*] (Allen *et al*. 1991)

71.020.09 Blue Oak - Understory Oak / Grass [*Quercus douglasii-Quercus* spp./Grass] (Allen *et al*. 1991)

*71.020.10 Blue Oak - Valley Oak - Coast Live Oak / Grass [*Quercus douglasii-Quercus lobata-Quercus agrifolia/*Grass] (Allen *et al*. 1991)

71.020.11 Blue Oak - Valley Oak / Grass [*Quercus douglasii-Quercus lobata/*Grass] (Allen *et al*. 1991)

71.020.12 Blue Oak / Wedgeleaf Ceanothus / Grass [*Quercus douglasii/Ceanothus cuneatus/*Grass] (Allen *et al*. 1991)

71.020.13 Interior Live Oak - Blue Oak - Foothill Pine / Grass [*Quercus wislizeni-Quercus douglasii-Pinus sabiniana/*Grass] (Allen *et al*. 1991)

*71.020.14 Blue Oak / Birchleaf Mountain-mahogany / Bowlesia [*Quercus douglasii/Cercocarpus betuloides/Bowlesia incana*] (Borchert *et al*. 1993a)

71.020.15 Blue Oak / Hillside Gooseberry / Ripgut Brome [*Quercus douglasii/Ribes californica/Bromus diandrus*] (Borchert *et al*. 1993a)

71.020.16 Blue Oak / Non-native Bromegrass - Wild Carrot [*Quercus douglasii/Bromus* sp.- *Daucus pusillus*] (Keeler-Wolf and Moore 2001)

71.020.17 Blue Oak - Interior Live Oak / Non-native Bromegrass - Wild Carrot [*Quercus douglasii-Quercus wislizeni/Bromus* sp.- *Daucus pusillus*] (Keeler-Wolf and Moore 2001)

*71.030.00 Oregon White Oak Woodland [*Quercus garryana* var. *garryana*]

*71.030.01 Oregon White Oak - Black Oak / Tall-oatgrass [*Quercus garryana* var. *garryana-Quercus kelloggii/Arrhenatherum elatius*] (Jimerson 1993)

*71.030.02 Oregon White Oak - Brewer Oak / California Fescue [*Quercus garryana* var. *garryana-Quercus garryana* var. *breweri/Festuca californica*] (Jimerson 1993)

*71.030.03 Oregon White Oak - Douglas-fir / California Fescue [*Quercus garryana* var. *garryana-Pseudotsuga menziesii/Festuca californica*] (Jimerson 1993)

*71.030.04 Oregon White Oak / Poison-oak [*Quercus garryana* var. *garryana/Toxicodendron diversilobum*] (Leitner & Leitner 1988)

*71.030.05 Oregon White Oak / Common Snowberry [*Quercus garryana* var. *garryana/Symphoricarpos albus*] (1987)

*71.030.06 Oregon White Oak / Dogtail [*Quercus garryana* var. *garryana/Cynosurus cristatus*] (Sugihara *et al*. 1987)

*71.030.07 Oregon White Oak / Klamath Gooseberry [*Quercus garryana* var. *garryana/Ribes roezlii*] (Sugihara *et al*. 1987)

*71.030.08 Oregon White Oak / Mock-orange [*Quercus garryana* var. *garryana/Philadelphus lewisii*] (Sugihara *et al*. 1987)
*71.030.09 Oregon White Oak / Poison Larkspur [Quercus garryana var. *garryana/Delphinium trollifolium*] (Sugihara *et al*. 1987)
*71.030.10 Oregon White Oak / Orchid Grass [*Quercus garryana* var. *garryana/Dactylis glomerata*] (Sugihara *et al*. 1987)
*71.030.11 Oregon White Oak / California Brome [*Quercus garryana* var. *garryana/Bromus californica*] (Taylor and Teare 1979a)
71.030.12 Oregon Oak Woodland [*Quercus garryana* var. *garryana*] {71110}

*71.040.00 Valley Oak Forests and Woodlands [*Quercus lobata*] {61430}
*71.040.01 Black Oak - Valley Oak / Grass [*Quercus kelloggii-Quercus lobata/*Grass] (Allen *et al*. 1991a)
*71.040.02 Blue Oak - Valley Oak / Grass [*Quercus douglasii-Quercus lobata/*Grass] (Allen *et al*. 1991a)
*71.040.03 Coast Live Oak - Valley Oak / Poison-oak [*Quercus agrifolia-Quercus lobata/Toxicodendron diversilobum*] (Allen *et al*. 1991a)
*71.040.04 Mixed Oak - Valley Oak / Poison-oak - California Coffeeberry [*Quercus* spp.- *Quercus lobata/Toxicodendron diversilobum-Rhamnus californica*] (Allen *et al*. 1991a)
*71.040.05 Valley Oak / Grass [*Quercus lobata/*Grass] (Allen *et al*. 1991a)
*71.040.06 Valley Oak - Coast Live Oak / Grass [*Quercus lobata-Quercus agrifolia/*Grass] (Allen *et al*. 1991a)
*71.040.07 Great Valley Valley Oak Riparian [*Quercus lobata*] {61430} (Vaghti 2003 as Q lobata/Aristolochia californica)
*71.040.08 Valley Oak Woodland [*Quercus lobata*] {71130}

71.050.00 Canyon Live Oak Forest and Woodland [*Quercus chrysolepis*]
71.050.01 Canyon Live Oak - Madrone - Tanoak [*Quercus chrysolepis-Arbutus menziesii-Lithocarpus densiflora*] (Campbell 1980)
*71.050.02 Sugar Pine - Canyon Live Oak [*Pinus lambertiana-Quercus chrysolepis*] (Griffin 1976a)
*71.050.03 Canyon Live Oak - Deerbrush [*Quercus chrysolepis-Ceanothus integerrimus*] (Gordon & White 1994)
71.050.04 Canyon Live Oak Woodland [*Quercus chrysolepis*] (Meier 1979)
71.050.05 Canyon Live Oak - Douglas-fir [*Quercus chrysolepis-Pseudotsuga menziesii*] (Mize 1973)
*71.050.06 Canyon Live Oak / Lemmon Catchfly [*Quercus chrysolepis/Silene lemmonii*] (NDDB)
*71.050.07 Canyon Live Oak- Oregon White Oak / Goldenback Fern [*Quercus chrysolepis-Quercus garryana* var. *garryana/Pentagramma triangularis*] (Sawyer & Stillman 1977)
71.050.08 Canyon Live Oak / Narrowleaf Sword Fern [*Quercus chrysolepis/Polystichum imbricans*] (Sawyer & Stillman 1977)
71.050.09 Canyon Live Oak / Mewuk Manzanita [*Quercus chrysolepis/Arctostaphylos mewukka*] (Taylor & Randal 1977a)
71.050.10 Moved to Douglas-fir – Canyon Live oak alliance
71.050.11 Canyon Live Oak [*Quercus chrysolepis*] Ravine forest (Holland 1986) {61350}
71.050.12 Canyon Live Oak Forest [*Quercus chrysolepis*] {81320}
71.050.13 Canyon Live Oak - California Bay [*Quercus chrysolepis-Umbellularia californica*] (Keeler-Wolf and Moore 2001)
71.050.14 Canyon Live Oak / Whiteleaf Manzanita [*Quercus chrysolepis-Arctostaphylos viscida*] (Keeler-Wolf and Moore 2001)
71.050.15 Canyon Live Oak / Greenleaf Manzanita [*Quercus chrysolepis/Arctostaphylos patula*] (Keeler-Wolf and Moore 2001)

71.050.16 Canyon Live Oak - Foothill Pine [*Quercus chrysolepis/Pinus sabiniana*] (Keeler-Wolf and Moore 2001)
71.050.17 Canyon Live Oak / Wood Fern [*Quercus chrysolepis/Dryopteris arguta*] (Keeler-Wolf and Moore 2001)
71.050.18 Canyon Live Oak - Ponderosa Pine [*Quercus chrysolepis/Pinus ponderosa*] (Keeler-Wolf and Moore 2001)
71.050.19 Canyon Live Oak - Incense Cedar [*Quercus chrysolepis/Calocedrus decurrens*] (Keeler-Wolf and Moore 2001)

71.060.00 Coast Live Oak Forest and Woodland [*Quercus agrifolia*]
71.060.01 Blue Oak - Coast Live Oak / Grass [*Quercus douglasii-Quercus agrifolia/*Grass] (Allen *et al*. 1991)
71.060.02 Coast Live Oak [*Quercus agrifolia*] (Allen *et al*. 1991)
71.060.03 Coast Live Oak - Bigleaf Maple / California Coffeeberry -Ocean Spray [*Quercus agrifolia-Acer macrophyllum/Rhamnus californica-Holodiscus discolor*] (Allen *et al*. 1991)
71.060.04 Coast Live Oak / Blackberry / Bracken [*Quercus agrifolia/Rubus* spp.*/Pteridium aquilinum*] (Allen *et al*. 1991)
71.060.05 Coast Live Oak - California Bay / Toyon - Scrub Oak [*Quercus agrifolia-Umbellularia californica/Heteromeles arbutifolia-Quercus berberidifolia*] (Allen *et al*. 1991)
71.060.06 Coast Live Oak / California Coffeeberry - Toyon [*Quercus agrifolia/Rhamnus californica-Heteromeles arbutifolia*] (Allen *et al*. 1991)
71.060.07 Coast Live Oak / Chamise - Black Sage [*Quercus agrifolia/Adenostoma fasciculatum-Salvia mellifera*] (Allen *et al*. 1991)
71.060.08 Coast Live Oak / California Sagebrush / Grass [*Quercus agrifolia/Artemisia californica/*Grass] (Allen *et al*. 1991)
71.060.09 Coast Live Oak / Grass [*Quercus agrifolia/*Grass] (Allen *et al*. 1991)
71.060.10 Coast Live Oak - Madrone / Hazel - Blackberry [*Quercus agrifolia-Arbutus menziesii/Corylus cornuta-Rubus* spp.] (Allen *et al*. 1991)
71.060.11 Coast Live Oak / Ocean Spray - Common Snowberry [*Quercus agrifolia/Holodiscus discolor-Symphoricarpos albus*] (Allen *et al*. 1991)
71.060.12 Coast Live Oak / Poison-oak / Grass [*Quercus agrifolia / Toxicodendron diversilobum/*Grass] (Allen *et al*. 1991)
71.060.13 Coast Live Oak / Poison-oak [*Quercus agrifolia/Toxicodendron diversilobum*] (Allen *et al*. 1991)
71.060.14 Coast Live Oak / Toyon / Grass [*Quercus agrifolia/Heteromeles arbutifolia/*Grass] (Allen *et al*. 1991)
71.060.15 Coast Live Oak / Toyon - Poison-oak [*Quercus agrifolia/Heteromeles arbutifolia-Toxicodendron diversilobum*] (Allen *et al*. 1991)
71.060.16 Coast Live Oak / Hairyleaf Ceanothus [*Quercus agrifolia/Ceanothus oliganthus*] (Gordon & White 1994)
71.060.17 Coast Live Oak /Common Snowberry [*Quercus agrifolia/Symphoricarpos albus*] (Keeler-Wolf 1994)
*71.060.18 Coast Live Oak - Black Oak [*Quercus agrifolia-Quercus kelloggii*] (Wainwright & Barbour 1984)
71.060.19 Coast Live Oak Woodland [*Quercus agrifolia*] {71160}
*71.060.20 Southern Coast Live Oak Riparian Forest [*Quercus agrifolia*] {61310}
71.060.21 Central Coast Live Oak Forest [*Quercus agrifolia*] {61220}
71.060.22 Coast Live Oak/Wright's Buckwheat [*Quercus agrifolia/Eriogonum wrightii*]
71.060.23 Coast Live Oak-Coulter Pine [*Quercus agrifolia-Pinus coulteri*]
71.060.24 Coast Live Oak - (Madrone) - California Bay [*Quercus agrifolia-(Arbutus menziesii)-Umbellularia californica*] (Keeler-Wolf, *et al*. 2001)

71.060.25 Coast Live Oak / Poison Oak - (Hazel) [*Quercus agrifolia/Toxicodendron diversilobum-(Corylus cornuta)*] (Keeler-Wolf, *et al*. 2001)

*71.070.00 Engelmann Oak Woodland [*Quercus engelmannii*]
- *71.070.01 Open Engelmann Oak Woodland [*Quercus engelmannii*] {71181}

71.080.00 Interior Live Oak Woodland [*Quercus wislizeni*]
- 71.080.01 Interior Live Oak - Blue Oak - Foothill Pine [*Quercus wislizeni-Quercus douglasii-Pinus sabiniana*] (Allen *et al*. 1991)
- 71.080.02 Interior Live Oak - Foothill Pine / Common Manzanita [*Quercus wislizeni-Pinus sabiniana/Arctostaphylos manzanita*] (Allen *et al*. 1991)
- 71.080.03 Interior Live Oak - Madrone / Poison-oak [*Quercus wislizeni-Arbutus menziesii/Toxicodendron diversilobum*] (Allen *et al*. 1991)
- 71.080.04 Interior Live Oak / Whiteleaf Manzanita [*Quercus wislizeni/Arctostaphylos viscida*] (Allen *et al*. 1991)
- 71.080.05 Interior Live Oak / Yerba Santa / Grass [*Quercus wislizeni/Eriodictyon californicum/*Grass] (Allen *et al*. 1991)
- 71.080.06 Interior Live Oak Woodland [*Quercus wislizeni*] {71150}
- 71.080.07 Interior Live Oak Forest [*Quercus wislizeni*] {81330}

*71.090.00 Island Oak Woodland [*Quercus tomentella*] {71190}

71.095.00 Shrub Live Oak Scrub [*Quercus turbinella*]
- 71.095.01 Shrub Live Oak - Singleleaf Pinyon [*Quercus turbinella-Pinus monophylla*] (Keeler-Wolf and Thomas 2000)
- 71.095.02 Shrub Live Oak - Desert Baccharis [*Quercus turbinella-Baccharis sergiloides*] (Keeler-Wolf and Thomas 2000)

71.100.00 Mixed Oak Woodland and Forest [*Quercus* spp.]
- 71.100.01 Black Oak - Valley Oak / Grass [*Quercus kelloggii-Quercus lobata/*Grass] (Allen *et al*. 1991)
- 71.100.02 Black Oak - Valley Oak - Coast Live Oak / Grass [*Quercus kelloggii-Quercus lobata-Quercus agrifolia/*Grass] (Allen *et al*. 1991)
- 71.100.03 Interior Live Oak / Toyon [*Quercus wislizeni/Heteromeles arbutifolia*] (Allen *et al*. 1991)
- 71.100.04 Mixed Oak - Black Oak / Grass [*Quercus* spp.-*Quercus kelloggii*/Grass] (Allen *et al*. 1991)
- 71.100.05 Mixed Oak - California Buckeye / Grass [*Quercus* spp.-*Aesculus californica/*Grass] (Allen *et al*. 1991)
- 71.100.06 Mixed Oak - Coast Live Oak / Poison-oak [*Quercus* spp.-*Quercus agrifolia/Toxicodendron diversilobum*] (Allen *et al*. 1991)
- 71.100.07 Mixed Oak - Foothill Pine / Grass [*Quercus* spp.-*Pinus sabiniana/*Grass] (Allen *et al*. 1991)
- 71.100.08 Mixed Oak / Grass [*Quercus* spp./Grass] (Allen *et al*. 1991)
- 71.100.09 Mixed Oak - Interior Live Oak - Foothill Pine [*Quercus* spp.-*Quercus wislizeni-Pinus sabinana*] (Allen *et al*. 1991)
- 71.100.10 Mixed Oak / Poison-oak - Coyote Brush [*Quercus* spp.*/Toxicodendron diversilobum-Baccharis pilularis*] (Allen *et al*. 1991)
- 71.100.11 Mixed Oak - Valley Oak / Poison-oak - California Coffeeberry [*Quercus* spp.-*Quercus lobata/Toxicodendron diversilobum-Rhamnus californica*] (Allen *et al*. 1991)
- 71.100.12 Oregon White Oak - Black Oak / Firecracker Flower [*Quercus garryana* var. *garryana-Quercus kelloggii/Dichelostemma ida-maia*] (Jimerson 1993)
- 71.100.13 Oregon White Oak - Black Oak / Tall-oatgrass [*Quercus garryana* var. *garryana-Quercus kelloggii/Arrhenatherum elatius*] (Jimerson 1993)

72.000.00 Upland Walnut Woodlands and Forests [*Juglans* spp.]

72.100.00 California Walnut Woodland and Forests [*Juglans californica* var. *californica*]
- *72.100.01 California Walnut Woodland [*Juglans californica* var. *californica*] {71210}
- *72.100.02 California Walnut Forest [*Juglans californica* var. *californica*] {81600}

73.000.00 Tanoak Forest and Woodland

73.100.00 Tanoak Forest and Woodland [*Lithocarpus densiflora*] {81400}
- 73.100.01 Sugar Pine - Tanoak / Poison-oak [*Pinus lambertina-Lithocarpus densiflora/Toxicodendron diversilobum*] (Griffin 1976)
- 73.100.02 Tanoak / California Coffeeberry [*Lithocarpus densiflora/Rhamnus californica*] (Sawyer 1981a)

73.200.00 Pacific Madrone [*Arbutus menziesii*] (Keeler-Wolf, *et al*. 2001)

*74.000.00 California Bay Forests and Woodlands [*Umbellularia californica*]

74.100.00 California Bay Forest and Woodland [*Umbellularia californica*] {81200}
- 74.100.01 California Bay [*Umbellularia californica*] (Campbell 1980)
- 74.100.02 Tanoak - California Bay [*Lithocarpus densiflora-Umbellularia californica*] (Fiedler & Leidy 1987)
- 74.100.03 California Bay - Madrone [*Umbellularia californica-Arbutus menzesii*] (Parker 1990)
- 74.100.04 California Bay - Blue Elderberry / Western Sword Fern [*Umbellularia californica-Sambucus racemosa/Polystichum munitum*] (Keeler-Wolf, *et al*. 2001)
- 74.100.05 California Bay - Coast Live Oak / Poison Oak - Hazelnut [*Umbellularia californica-Quercus agrifolia/Toxicodendron diversilobum-Corylus cornuta*] (Keeler-Wolf, *et al*. 2001)

75.000.00 California Buckeye Woodland [*Aesculus californica*]

*75.100.00 California Buckeye Woodland [*Aesculus californica*]

76.000.00 *Cercocarpus*-Mountain Mahogany Woodlands and Scrubs [*Cercocarpus* spp.]

76.100.00 Birchleaf Mountain-Mahogany Scrub [*Cercocarpus betuloides*]
- 76.100.01 Klamath Birchleaf Mountain-mahogany [*Cercocarpus* spp.] (Taylor 1979a)
- 76.100.02 Peninsular Range Birchleaf Mountain-mahogany [*Cercocarpus* spp.] (Gordon & White 1994)
- 76.100.03 Birchleaf Mountain Mahogany with Scrub
- 76.100.04 Birchleaf Mountain-mahogany-Bigberry Manzanita

76.200.00 Curlleaf Mountain-Mahogany Woodland and Scrub [*Cercocarpus ledifolius*]
- 76.200.01 Curlleaf Mountain-Mahogany - Big Sagebrush [*Cersocarpus ledifolius-Artemisia tridentata*] (Keeler-Wolf and Thomas 2000)
- 76.200.02 Curlleaf Mountain-Mahogany / Roundleaf Snowberry [*Cersocarpus ledifolius/Symphoricarpos rotundifolia*] (Keeler-Wolf and Thomas 2000)

*76.300.00 Littleleaf Mountain-Mahogany Scrub [*Cercocarpus intricatus*] (Keeler-Wolf and Thomas 2000)

*77.000.00 Catalina Ironwood Woodland Unique Stands [*Lyonothamnus floribundus*] {81700}

*78.000.00 Hollyleaf Cherry Woodland and Scrub Unique Stands [*Prunus ilicifolia*]

*78.100.00 Island Hollyleaf Cherry [*Prunus ilicifolia ssp. lyonii*] {81810}

*78.200.00 ~~Mainland Hollyleaf Cherry [*Prunus ilicifolia ssp. ilicifolia*]~~ {81820} entry obsolete; moved to 37.910.00

79.000.00 Eucalyptus Naturalized Forest [*Eucalyptus* spp.]

80.000.00 CONIFEROUS UPLAND FOREST AND WOODLAND

81.000.00 Cypress Scrubs, Woodlands and Forests [*Cupressus* spp.]

*81.100.00 Port Orford-cedar Forest [*Chamaecyparis lawsoniana*] {82500}

*81.100.01 Port Orford-cedar / Western Azalea [*Chamaecyparis lawsoniana/Rhododendron occidentale*] (Jimerson 1994)

*81.100.02 Port Orford-cedar - Douglas-fir / Huckleberry Oak [*Chamaecyparis lawsoniana-Pseudotsuga menziesii/Quercus vaccinifolia*] (Jimerson 1994)

*81.100.03 Port Orford-cedar - Shasta Fir / Sadler Oak - Thinleaf Huckleberry [*Chamaecyparis lawsoniana-Abies magnifica* var. *shastensis/Quercus sadleriana-Vaccinium membranaceum*] (Jimerson 1994)

*81.100.04 Port Orford-cedar / Rhododendron - Salal [*Chamaecyparis lawsoniana/Rhododendron macrophyllum-Gaultheria shallon*] (Jimerson 1994)

*81.100.05 Port Orford-cedar / Salal [*Chamaecyparis lawsoniana/Gaultheria shallon*] (Jimerson 1994)

*81.100.06 Port Orford-cedar - White Fir / Azalea [*Chamaecyparis lawsoniana-Abies concolor/Rhododendron* spp.] (Jimerson 1994)

*81.100.07 Port Orford-cedar - White Fir / Sadler Oak [*Chamaecyparis lawsoniana-Abies concolor/Quercus sadleriana*] (Jimerson 1994)

*81.100.08 Port Orford-cedar - White Fir / Herb [*Chamaecyparis lawsoniana-Abies concolor/*Herb] (Jimerson 1994)

*81.100.09 Port Orford-cedar - White Fir / Huckleberry Oak [*Chamaecyparis lawsoniana-Abies concolor/Quercus vaccinifolia*] (Jimerson 1994)

*81.100.10 Port Orford-cedar - Western White Pine / Huckleberry Oak [*Chamaecyparis lawsoniana-Pinus monticola/Quercus vaccinfolia*] (Jimerson 1994)

*81.100.11 Moved to Douglas-fir – Tanoak Alliance

*81.100.12 Moved to Douglas-fir – Tanoak Alliance

*81.100.13 Moved to Douglas-fir – Tanoak Alliance

*81.100.14 Moved to Douglas-fir – Tanoak Alliance

*81.100.15 Tanoak - Port Orford-cedar / Spikenard [*Lithocarpus densiflora-Chamaecyparis lawsoniana/Aruncus diocus*] (Jimerson 1994)

*81.100.16 Moved to Douglas-fir – Tanoak Alliance)

*81.100.17 Port Orford-cedar -Pine / Rhododendron [*Pinus* spp./*Rhododendron* spp.] (Simpson 1980)

*81.100.18 Port Orford-cedar -Douglas-fir / Spicebush [*Chamaeparis lawsoniana-Pseudotsuga menziesii/Calycanthus occidentalis*] (Jimerson et al. 1999)

*81.100.19 Port Orford-cedar - Mixed conifer/Western Azalea – dwarf tanbark oak [*Chamaeparis lawsoniana-Abies concolor-Calocedrus decurrens/Rhododendron occidentalis-Lithocarpus densiflorus* var. *echinoides*] (Jimerson et al. 1999)

*81.100.20 Port Orford-cedar - White fir /Sitka alder [*Chamaeparis lawsoniana-Abies concolor/Alnus sinuata]* (Jimerson et al. 1999)

*81.100.21 Port Orford-cedar - White fir /Vine maple [*Chamaeparis lawsoniana-Abies concolor/Acer circinatum*] (Jimerson et al. 1999)

*81.100.22 Port Orford-cedar - Brewer spruce/Sadler oak-Huckleberry oak [*Chamaeparis lawsoniana-Picea breweriana/Quercus sadleriana-Quercus vaccinifolia]* (Jimerson et al. 1999)

*81.100.23 Port Orford-cedar – Shasta Red Fir/Sitka Alder-Sadler Oak [*Chamaeparis lawsoniana-Abies magnifica ssp. Shastensis/Alnus sinuata-Quercus sadleriana]* (Jimerson et al. 1999)

*81.100.24 Port Orford-cedar – Shasta Red Fir/Sitka Alder/California Pitcher Plant [*Chamaeparis lawsoniana-Abies magnifica ssp. shastensis/Alnus sinuata/Darlingtonia californica]* (Jimerson et al. 1999)

*81.100.25 Port Orford-cedar -Douglas-fir /California Hazelnut [*Chamaeparis lawsoniana-Pseudotsuga menziesii/Corylus cornuta* var. *californica]* (Jimerson et al. 1999)

*81.100.26 Port Orford-cedar -Douglas-fir – Red Alder/Vine Maple [*Chamaeparis lawsoniana-Pseudotsuga menziesii-Alnus rubra/Berberis nervosa]* (Jimerson et al. 1999)

*81.100.27 Port Orford-cedar - Western White Pine / Western Azalea –Dwarf Tanbark oak – Labrador Tea [*Chamaeparis lawsoniana-Pinus monticola/Rhododendron occidentalis – Lithocarpus densiflorus* var. *echinoides*] (Jimerson et al. 1999)

*81.100.28 Port Orford-cedar - Western White Pine /Labrador Tea / California Pitcher Plant//coastal [*Chamaeparis lawsoniana-Pinus monticola/Ledum glandulosum/Darlingtonia californica*] (Jimerson et al. 1999)

*81.100.29 Port Orford-cedar - Mixed Conifer /Huckleberry Oak-Western Azalea [*Chamaeparis lawsoniana-Pseudotsuga menziesii –(Abies concolor-Pinus lambertiana)/Quercus vaccinifolia –Rhododendron occidentalis]* (Jimerson et al. 1999)

*81.100.30 Port Orford-cedar - White Fir / Western Azalea-Huckleberry Oak [*Chamaeparis lawsoniana – Abies concolor/Rhododendron occidentalis – Quercus vaccinifolia]* (Jimerson et al. 1999)

*81.100.31 Port Orford-cedar - White Fir / Sierra Laurel-Bush Chinquapin [*Chamaeparis lawsoniana – Abies concolor/Leucothoe davisiae-Chrysolepis sempervirens]* (Jimerson et al. 1999)

*81.100.32 Port Orford-cedar - White Fir / Bush Chinquapin-Western Azalea [*Chamaeparis lawsoniana – Abies concolor/ Chrysolepis sempervirens-Rhododendron occidentalis]* (Jimerson et al. 1999)

*81.100.33 Port Orford-cedar - Western White Pine / Labrador Tea/California Pitcher Plant //interior [*Chamaeparis lawsoniana-Pinus monticola/Ledum glandulosum/Darlingtonia californica//*interior*]* (Jimerson et al. 1999)

*81.100.34 Port Orford-cedar - Western White Pine /Sitka Alder [*Chamaeparis lawsoniana-Pinus monticola/Alnus sinuata]* (Jimerson et al. 1999)

*81.100.35 Port Orford-cedar - Western White Pine /Thinleaf Huckleberry [*Chamaeparis lawsoniana-Pinus monticola/Vaccinium membranaceum]*(Jimerson et al. 1999)

*81.100.36 Port Orford-cedar - Western White Pine //Wet Herb Complex [*Chamaeparis lawsoniana-Pinus monticola/Veratrum californicum-Lilium sp.*] (Jimerson et al. 1999)

*81.100.37 Port Orford-cedar - Western White Pine //Dry Herb Complex [*Chamaeparis lawsoniana-Pinus monticola// dry herb]* (Jimerson et al. 1999)

*81.100.38 Port Orford-cedar - Mountain Hemlock /Bush Chinquapin [*Chamaeparis lawsoniana-Tsuga mertensiana/Chrysolepis sempervirens]*(Jimerson et al. 1999)

*81.100.39 Port Orford-cedar - Mountain Hemlock /Labrador Tea [*Chamaeparis lawsoniana-Tsuga mertensiana/Ledum glandulosum]* (Jimerson et al. 1999)

*81.100.40 Port Orford-cedar - Mountain Hemlock /Sierra Laurel [*Chamaeparis lawsoniana-Tsuga mertensiana/Leucothoe davisiae]* (Jimerson et al 1999)

*81.200.00 Alaska Yellow-cedar Unique Stands [*Chamaecyparis nootkatensis*]

*81.300.00 McNab Cypress Woodland [*Cupressus macnabiana*]

*81.400.00 Pygmy Cypress Dwarf Woodland [*Cupressus goveniana* ssp. *goveniana*] {83161}

*81.400.01 Pygmy Cypress / Lichen [*Cupressus goveniana* ssp. *goveniana*/*Cladonia bellidiflora*] (Westman & Whittaker 1975)

*81.400.02 Pygmy Cypress / Lichen [Cupressus goveniana ssp. *goveniana*/*Cladina impexa*] (Westman & Whittaker 1975)

*81.400.03 Pygmy Cypress / *Ramalina tharusta* [*Cupressus goveniana* ssp. *goveniana*] (Westman & Whittaker 1975)

*81.400.04 Pygmy Cypress / *Usnea subfloridana* [*Cupressus goveniana* ssp. *goveniana*] (Westman & Whittaker 1975)

*81.500.00 Sargent Cypress Woodland [*Cupressus sargentii*]

81.600.00 Unique Stands of Cypress [*Cupressus* spp.]

*81.600.10 Baker Cypress Stands [*Cupressus bakeri*]

*81.600.20 Cuyamaca Cypress Stands [*Cupressus stephensonii*]

*81.600.30 Gowen Cypress Stands [*Cupressus goveniana* ssp. *goveniana*] {83162}

*81.600.40 Monterey Cypress Stands [*Cupressus macrocarpa*] {83150}

*81.600.50 Piute Cypress Stands [*Cupressus nevadensis*] {83230}

*81.600.60 Santa Cruz Cypress Stands [*Cupressus abramsiana*] {83220}

*81.600.70 Tecate Cypress Stands [*Cupressus forbesii*]

82.000.00 Coastal and Montane Douglas-fir Forests and Woodlands [*Pseudotsuga* spp.]

82.000.01 Mixed evergreen forest {82400}

*82.100.00 Bigcone Douglas-fir Forest [*Pseudotsuga macrocarpa*] {84150}

82.200.00 Douglas-fir Forest [*Pseudotsuga menziesii*]

*82.200.01 Douglas-fir - Bigleaf Maple / Hazel [*Pseudotsuga menziesii-Acer macrophyllum/Corylus cornuta*] (Fites 1993)

*82.200.02 Douglas-fir - Bigleaf Maple / Trail Plant [*Pseudotsuga menziesii-Acer macrophyllum/Adenocaulon bicolor*] (Fites 1993)

*82.200.03 Douglas-fir - Pacific Dogwood / Hazel [*Pseudotsuga menziesii-Cornus nuttallii/Corylus cornuta*] (Fites 1993)

*82.200.04 Douglas-fir / Hazel / Trail Plant [*Pseudotsuga menziesii/Corylus cornuta/Adenocaulon bicolor*] (Fites 1993)

*82.200.05 Douglas-fir - California Bay / Poison-oak [*Pseudotsuga menziesii-Umbellularia californica/Toxicodondron diversilobum*] (Jimerson 1993)

*82.200.06 Moved to Douglas-fir – Canyon live oak Alliance

*82.200.07 Moved to Douglas-fir - Canyon Live Oak Alliance

*82.200.08 Moved to Douglas-fir - Canyon Live Oak Alliance

*82.200.09	Douglas-fir - Chinquapin / Bear-grass [*Pseudotsuga menziesii-Chrysolepis chrysophylla/Xerophyllum tenax*] (Jimerson 1993)
*82.200.10	Douglas-fir - Chinquapin / Rhododendron - Little Oregon- grape [*Pseudotsuga menziesii-Chrysolepis chrysophylla/Rhododendron* spp.-*Berberis nervosa*] (Jimerson 1993)
*82.200.11	Douglas-fir - Chinquapin / Rhododendron - Sadler Oak /Bear-grass [*Pseudotsuga menziesii-Chrysolepis chrysophylla/Rhododendron* spp.-*Quercus sadleriana/Xerophyllum tenax*] (Jimerson 1993)
*82.200.12	Douglas-fir - Chinquapin - Tanoak [*Pseudotsuga menziesii-Chrysolepis chrysophylla-Lithocarpus densiflora*] (Jimerson 1993)
*82.200.13	Douglas-fir - Chinquapin - Tanoak / Little Oregon-grape [*Pseudotsuga menziesii-Chrysolepis chrysophyllum-Lithocarpus densiflora/Berberis nervosa*] (Jimerson 1993)
*82.200.14	Douglas-fir / Hazel [*Pseudotsuga menziesii/Corylus cornuta*] (Jimerson 1993)
*82.200.15	Douglas-fir / Huckleberry Oak [*Pseudotsuga meziesii/Quercus vaccinifolia*] (Jimerson 1993, Sawyer *et al.* 1978a)
*82.200.16	Douglas-fir / Huckleberry Oak - Bush Tanoak [*Pseudotsuga menziesii/Quercus vaccinifolia-Lithocarpus densiflora* var.*echinoides*] (Jimerson 1993)
*82.200.17	Douglas-fir - Incense-Cedar / California Fescue [*Pseudotsuga menziesii-Calocedrus decurrens/Festuca californica*] (Jimerson 1993)
*82.200.18	Douglas-fir / Yerba de Selva [*Pseudotsuga menziesii/Whipplea modesta*] (Jimerson 1993)
*82.200.19	Douglas-fir - Oregon White Oak / Grass [*Pseudotsuga menziesii-Quercus garryana* var. *garryana*/Grass] (Jimerson 1993)
*82.200.20	Douglas-fir / Vine Maple - Little Oregon-grape [*Pseudotsuga menziesii/Acer circinatum-Berberis nervosa*] (Jimerson 1993)
82.200.21	Douglas-fir - Bigleaf Maple / Sword Fern [*Pseudotsuga menziesii-Acer macrophyllum/Polystichum munitum*] (Jimerson 1993)
*82.200.22	moved to Port Orford-Cedar Alliance
*82.200.23	moved to Port Orford-Cedar alliance
*82.200.24	moved to Port Orford-Cedar alliance
*82.200.25	Moved to Red Fir Alliance
*82.200.26	Moved to White Fir Alliance
*82.200.27	moved to White Fir Alliance
*82.200.28	White Fir - Douglas-fir - Bigleaf Maple [*Abies concolor-Pseudotsuga menziesii-Acer macrophyllum*] (Jimerson 1993)
*82.200.29	White Fir - Douglas-fir - Black Oak [*Abies concolor-Pseudotsuga menziesii-Quercus kelloggii*] (Jimerson 1993)
*82.200.30	White Fir - Douglas-fir - Canyon Live Oak / White-veined Shinleaf [*Abies concolor-Pseudotsuga menziesii-Quercus chrysolepis/Pyrola picta*] (Jimerson 1993)
*82.200.31	White Fir - Douglas-fir - Canyon Live Oak [*Abies concolor-Pseudotsuga menziesii-Quercus chrysolepis*] (Jimerson 1993)
*82.200.32	White Fir - Douglas-fir - Canyon Live Oak / White-flower Hawkweed-Grass [*Abies concolor-Pseudotsuga menziesii-Quercus chrysolepis/Hieracium albiflorum*-Grass] (Jimerson 1993)
*82.200.33	White Fir - Douglas-fir - Canyon Live Oak / Little Oregon-grape [*Abies concolor-Pseudotsuga menziesii-Quercus chrysolepis/Berberis nervosa*] (Jimerson 1993)
*82.200.34	White Fir - Douglas-fir - Chinquapin / Little Oregon-grape / Vanilla Leaf [*Abies concolor-Pseudotsuga menziesii-Chrysolepis chrysophylla/Berberis nervosa/Achlys triphylla*] (Jimerson 1993)
82.200.35	Moved to White Fir alliance

82.200.36	White Fir - Douglas-fir / Sadler Oak - Huckleberry Oak [*Abies concolor-Pseudotsuga menziesii/Quercus sadleriana-Quercus vaccinifolia*] (Jimerson 1993)
82.200.37	White Fir - Douglas-fir / Sadler Oak - Pinemat Manzanita [*Abies concolor-Pseudotsuga menziesii/Quercus sadleriana-Arctostaphylos nevadensis*] (Jimerson 1993)
*82.200.38	White Fir - Douglas-fir / Grass [*Abies concolor-Pseudostuga menziesii/*Grass] (Jimerson 1993)
*82.200.39	White Fir - Douglas-fir / Hazel [*Abies concolor-Pseudotsuga menziesii/Corylus cornuta*] (Jimerson 1993)
82.200.40	White Fir - Douglas-fir / Huckleberry Oak [*Abies concolor-Pseudotsuga menziesii/Quercus vaccinifolia*] (Jimerson 1993)
*82.200.41	White Fir - Douglas-fir / Yerba de Selva [*Abies concolor-Pseudotsuga menziesii/Whipplea modesta*] (Jimerson 1993)
*82.200.42	White Fir - Douglas-fir / Rhododendron - Sadler Oak [*Abies concolor-Pseudotsuga menziesii/Rhododendron* spp.-*Quercus sadleriana*] (Jimerson 1993)
*82.200.43	White Fir - Douglas-fir - Tanoak / Little Oregon-grape [*Abies concolor-Pseudotsuga menziesii-Lithocarpus densiflora/Berberis nervosa*] (Jimerson 1993)
*82.200.44	White Fir - Douglas-fir / Thimbleberry [*Abies concolor-Pseudotsuga menziesii/Rubus parviflorus*] (Jimerson 1993)
*82.200.45	White Fir - Douglas-fir / Vine Maple [*Abies concolor-Pseudotsuga menziesii/Acer circinatum*] (Jimerson 1993)
*82.200.46	White Fir - Douglas-fir / Wild Rose / Twinflower [*Abies concolor-Pseudotsuga menziesii/Rosa gymnocarpa/Linnaea borealis*] (Jimerson 1993)
*82.200.47	Moved to White Fir alliance
*82.200.48	moved to Jeffrey Pine-fir alliance
*82.200.49	Douglas-fir / Vanilla Leaf [*Pseudotsuga menziesii/Achlys triphylla*] (Keeler-Wolf 1985a, 1987a, 1989b)
*82.200.50	Douglas-fir / Madrone [*Pseudotsuga menziesii/Arbutus menziesii*] (Laidlaw-Holmes 1981)
*82.200.51	Douglas-fir / Rattlesnake Plantain [*Pseudotsuga menziesii/Goodyera oblongifolia*] (Sawyer 1981a)
82.200.52	Douglas-fir / Huckleberry Oak [*Pseudotsuga menziesii/Quercus vaccinifolia*] (Sawyer *et al*. 1978)
82.200.53	Douglas-fir / Greenleaf Manzanita [*Pseudotsuga menziesii/Arctostaphylos patula*] (Sawyer & Stillman 1977)
*82.200.54	Douglas-fir / Prince's-pine [*Pseudotsuga menziesii/Chimaphlia umbellata*] (Sawyer & Stillman 1977)
*82.200.55	Douglas-fir / Twinflower [*Pseudotsuga menziesii/Linnaea borealis*] (Sawyer & Stillman 1977)
*82.200.56	Douglas-fir / Hazel [*Pseudotsuga menziesii/Corylus cornuta*] (Simpson 1980)
*82.200.57	Douglas-fir / Inside-out Flower [*Pseudotsuga menziesii/Vancouveria planipetala*] (Simpson 1980)
*82.200.58	Douglas-fir / Rhododendron [*Pseudotsuga menziesii/Rhododendron* spp.] (Simpson 1980)
*82.200.59	Douglas-fir / Salal [*Pseudotsuga menziesii/Gaultheria shallon*] (Simpson 1980)
*82.200.60	Black Oak - Douglas-fir [*Quercus kelloggii-Pseudotsuga menziesii*] (Stuart *et al*. 1992)
*82.200.61	Douglas-fir [*Pseudotsuga menziesii*] (Stuart *et al*. 1992)
*82.200.62	Douglas-fir - Jeffrey Pine - Incense-cedar [*Pseudotsuga menziesii-Pinus jeffreyi-Calocedrus decurrens*] (Stuart *et al*. 1992)

82.200.63 Douglas-fir - White Alder / Himalaya Berry [*Pseudotsuga menziesii-Abies concolor/Rubus discolor*] (Stuart *et al*. 1992)

*82.200.64 Douglas-fir / Little Oregon-grape [*Pseudotsuga menziesii/Berberis nervosa*] (Taylor 1975a, b)

*82.200.65 Douglas-fir / Pacific Dogwood [*Pseudotsuga menziesii/Cornus nuttallii*] (Taylor & Teare 1979a)

*82.200.66 Douglas-fir - California Bay [*Pseudotsuga menziesii-Umbellularia californica*] (Wainwright & Barbour 1984)

*82.200.67 Coastal Douglas-fir-Western Hemlock Forest [*Pseudotsuga menziesii-Tsuga heterophylla*] {82410}

82.200.68 Upland Douglas-fir forest [*Pseudotsuga menziesii*] {82420}

82.200.69 Douglas-fir - California Bay / Sword Fern [*Pseudotsuga menziesii-Umbellularia californica/Polystichum munitum*] (Keeler-Wolf, *et al*. 2001)

82.200.70 Douglas-fir - California Bay / California Coffeeberry [*Pseudotsuga menziesii-Umbellularia californica/Rhamnus californicus*] (Keeler-Wolf, *et al*. 2001)

82.200.71 Douglas-fir / Coast Live Oak [*Pseudotsuga menziesii/Quercus agrifolia*] (Keeler-Wolf, *et al*. 2001)

82.200.72 Douglas-fir / Coyote Brush [*Pseudotsuga menziesii/Baccharis pilularis*] (Keeler-Wolf, *et al*. 2001)

82.200.73 Douglas-fir - White Fir - Incense-cedar [*Pseudotsuga menziesii-Abies concolor-Calocedrus decurrens*] (Keeler-Wolf and Moore 2001)

*82.200.74 *Pseudotsuga menziesii/Quercus vaccinifolia - Rhododendron macrophyllum* association (Jimerson 1993)

*82.200.75 *Pseudotsuga menziesii/Rhododendron macrophyllum* association, (Simson 1980)

*82.300.00 Douglas-fir - Canyon Live Oak Forest [*Pseudotsuga menziesii-Quercus chrysolepis*]

*82.300.01 Douglas-fir - Canyon Live Oak / Sword Fern [Mixed Conifer-*Quercus chrysolepis/Polystichum munitum*] (Fites 1993)

*82.300.02 Douglas-fir - Canyon Live Oak - Madrone / Poison-oak [*Pseudotsuga menziesii-Quercus chrysolepis-Arbutus menziesii/Toxicodendron diversilobum*] (Jimerson 1993)

*82.300.03 Douglas-fir - Canyon Live Oak [*Pseudotsuga menziesii-Quercus chrysolepis*] (Taylor & Teare 1979a)

*82.300.04 Douglas-fir - Canyon Live Oak / Rockpile [*Pseudotsuga menziesii-Quercus chrysolepis*/Rockpile] (Jimerson 1993)

*82.300.05 Douglas-fir - Canyon Live Oak - Tanoak [*Pseudotsuga menziesii-Quercus chrysolepis-Lithocarpus densiflora*] (Jimerson 1993)

*82.400.00 Douglas-fir - Ponderosa Pine Forest [*Pseudotsuga menziesii-Pinus ponderosa*]

*82.400.01 Black Oak - Douglas-fir - Bigleaf Maple [*Quercus kelloggii-Pseudotsuga menziesii-Acer macrophyllum*] (Jimerson 1993)

*82.400.02 Douglas-fir - Ponderosa Pine - Incense-cedar [*Pseudotsuga menziesii-Pinus ponderosa-Calocedrus decurrens*] (Stuart *et al*. 1992)

*82.400.03 Douglas-fir - Ponderosa Pine - Jeffrey Pine / One-sided Bluegrass [*Pseudotsuga menziesii-Pinus ponderosa-Pinus jeffreyi/Poa secunda*] (Smith 1994)

*82.400.04 Douglas-fir - Ponderosa Pine [*Pseudotsuga menziesii-Pinus ponderosa*] (Taylor & Teare 1979b)

82.400.05 Douglas-fir -Ponderosa pine -Incense-cedar [*Pseudotsuga menziesii-Pinus ponderosa-Calocedrus decurrens*] (Keeler-Wolf & Moore 2001)

82.500.00 Douglas-fir - Tanoak Forest [*Pseudotsuga menziesii-Lithocarpus densiflora*]

*82.500.01	Douglas-fir - Tanoak / Prince's Pine [*Pseudotsuga menziesii-Lithocarpus densiflora/Chimaphila umbellata*] (Keeler-Wolf 1985a, 1987b, 1989b)
*82.500.02	Douglas-fir - Tanoak - Bigleaf Maple / Sword Fern [*Pseudotsuga menziesii-Lithocarpus densiflora-Acer macrophyllum/Polystichum munitum*] (Jimerson 1993)
*82.500.03	Douglas-fir - Tanoak - Black Oak / Wild Rose [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus kelloggii/Rosa gymnocarpa*] (Jimerson 1993)
82.500.04	Douglas-fir - Tanoak - California Bay / Poison-oak [*Pseudotsuga menziesii-Lithocarpus densiflora-umbellularia californica/Toxicodendron diversilobum*] (Jimerson 1993)
82.500.05	Douglas-fir - Tanoak - Canyon Live Oak - Black Oak /Poison-oak [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus chrysolepis-Quercus kelloggii/Toxicodendron diversilobum*] (Jimerson 1993)
82.500.06	Douglas-fir - Tanoak - Canyon Live Oak / Little Oregon-grape - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus chrysolepis-Berberis nervosa-Gaultheria shallon*] (Jimerson 1993)
*82.500.07	Douglas-fir - Tanoak - Canyon Live Oak / Little Oregon-grape [*Pseudotsuga menziesii-Lithocarpus densiflora/Berberis nervosa*] (Jimerson 1993)
*82.500.08	Douglas-fir - Tanoak - Canyon Live Oak / Black Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus chrysolepis/Vaccinium ovatum*] (Jimerson 1993)
*82.500.09	Douglas-fir - Tanoak - Canyon Live Oak / Black Huckleberry - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus chrysolepis/Vaccinium ovatum-Gaultheria shallon*] (Jimerson 1993)
82.500.10	Douglas-fir - Tanoak - Canyon Live Oak / Poison-oak [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus chrysolepis/Toxicodendron diversilobum*] (Jimerson 1993)
82.500.11	Douglas-fir - Tanoak - Canyon Live Oak / Rockpile [*Pseudotsuga menziesii-Lithocarpus densiflora-Quercus chrysolepis/*Rockpile] (Jimerson 1993)
82.500.12	Douglas-fir - Tanoak - Chinquapin / Bracken [*Pseudotsuga menziesii-Lithocarpus densiflora-Chrysolepis chrysophylla/Pteridium aquilinum*] (Jimerson 1993)
*82.500.13	Douglas-fir - Tanoak - Chinquapin / Little Oregon-grape [*Pseudotsuga menziesii-Lithocarpus densiflora-Chrysolepis chrysophylla/Berberis nervosa*] (Jimerson 1993)
*82.500.14	Douglas-fir - Tanoak - Chinquapin / Rhododendron / Beargrass [*Pseudotsuga menziesii-Lithocarpus densiflora-Chrysolepis chrysophylla/Rhododendron* spp.*/Xerophyllum tenax*] (Jimerson 1993)
*82.500.15	Douglas-fir - Tanoak - Chinquapin / Rhododendron - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora-Chrysolepis chrysophylla/Rhododendron* spp.*-Gaultheria shallon*] (Jimerson 1993)
*82.500.16	Douglas fir - Tanoak - Chinquapin / Salal [*Pseudotsuga menziesii-Lithocarpus densiflora-Chrysolepis chrysophylla/Gaultheria shallon*] (Jimerson 1993)
*82.500.17	Douglas-fir - Tanoak / Little Oregon-grape [*Pseudotsuga menziesii-Lithocarpus densiflora/Berberis nervosa*] (Thornburgh 1987, Jimerson 1993)
*82.500.18	Douglas-fir - Tanoak / Little Oregon-grape - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora/Berberis nervosa-Gaultheria shallon*] (Jimerson 1993)
*82.500.19	Douglas-fir - Tanoak / Black Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora/Vaccinium ovatum*] (Jimerson 1993)

*82.500.20	Douglas-fir - Tanoak / Black Huckleberry - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora/Vaccinium ovatum-Gaultheria shallon*] (Jimerson 1993)
*82.500.21	Douglas-fir - Tanoak / Hazel [*Pseudotsuga menziesii-Lithocarpus densiflora/Corylus cornuta*] (Jimerson 1993)
*82.500.22	Douglas-fir - Tanoak - Incense-cedar / California Fescue [*Pseudotsuga menziesii-Lithocarpus densiflora-Calocedrus decurrens/Festuca californica*] (Jimerson 1993)
*82.500.23	Douglas-fir - Tanoak / Poison-oak - Hairy Honeysuckle [*Pseudotsuga menziesii-Lithocarpus densiflora/Toxicodendron diversilobum-Lonicera hispidula*] (Jimerson 1993)
*82.500.24	Douglas-fir - Tanoak - Port Orford-cedar - California Bay /Black Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana-Umbellularia californica/Vaccinium ovatum*] (Jimerson 1993)
*82.500.25	Douglas-fir - Tanoak - Port Orford-cedar / Little Oregon-grape / Twinflower [*Pseudotsuga menziesii-Lithcarpus densiflora-Chamaecyparis lawsoniana/Berberis nervosa/Linnaea borealis*] (Jimerson 1993)
*82.500.26	Douglas-fir - Tanoak - Port Orford-cedar / Black Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana/Vaccinium ovatum*] (Jimerson 1993)
*82.500.27	Douglas-fir - Tanoak - Port Orford-cedar / Black Huckleberry - Western Azalea [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana/Vaccinium ovatum-Rhododendron occidentalis*] (Jimerson 1993)
*82.500.28	Douglas-fir - Tanoak - Port Orford-cedar / Red Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana/Vaccinium parvifolium*] (Jimerson 1993)
*82.500.29	Douglas-fir - Tanoak - Port Orford-cedar / Salal [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana/Gaultheria shallon*] (Jimerson 1993)
*82.500.30	Douglas-fir - Tanoak - Port Orford-cedar / Vine Maple [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana/Acer circinatum*] (Jimerson 1993)
*82.500.31	Douglas-fir - Tanoak - Port Orford-cedar - White Alder /Riparian [*Pseudotsuga menziesii-Lithocarpus densiflora-Chamaecyparis lawsoniana-Alnus rhombifolia/*Riparian] (Jimerson 1993)
*82.500.32	Douglas-fir - Tanoak / Rhododendron - Black Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora/Rhododendron* spp.-*Vaccinium ovatum*] (Jimerson 1993)
*82.500.33	Douglas-fir - Tanoak / Rhododendron - Huckleberry Oak [*Pseudotsuga menziesii-Lithocarpus densiflora/Rhododendron* spp.-*Quercus vaccinifolia*] (Jimerson 1993)
*82.500.34	Douglas-fir - Tanoak / Rhododendron - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora/Rhododenron* spp.-*Gaultheria shallon*] (Jimerson 1993)
*82.500.35	Douglas-fir - Tanoak / Salal [*Pseudotsuga menziesii-Lithocarpus densiflora/Gaultheria shallon*] (Jimerson 1993)
*82.500.36	Douglas-fir - Tanoak / Vine Maple [*Pseudotsuga menziesii-Lithocarpus densiflora/Acer circinatum*] (Jimerson 1993)
*82.500.37	Douglas-fir - Tanoak / Vine Maple - Salal [*Pseudotsuga menziesii-Lithocarpus densiflora/Acer circinatum-Gaultheria shallon*] (Jimerson 1993)
*82.500.38	Douglas-fir - Tanoak / Pacific Yew [*Pseudotsuga menziesii-Lithocarpus densiflora/Taxus brevifolia*] (Mize 1973)

*82.500.39 Douglas-fir - Tanoak - Sugar Pine [*Pseudotsuga menziesii-Lithocarpus densiflora-Pinus lambertiana*] (1973)

*82.500.40 Douglas-fir - Tanoak / Vanilla Leaf [*Pseudotsuga menziesii-Lithocarpus densiflora/Achlys triphylla*] (Mize 1973)

*82.500.41 Douglas-fir - Tanoak / Black Huckleberry [*Pseudotsuga menziesii-Lithocarpus densiflora/Vaccinium ovatum*] (Simpson 1980)

*82.500.42 Douglas-fir - Tanoak / Poison-oak [*Pseudotsuga menziesii-Lithocarpus densiflora/Toxicodendron diversilobum*] (Thornburgh 1987)

*82.500.43 Douglas-fir – Tanoak/Mountain Dogwood [*Pseudotsuga menziesii* – Mixed conifer -*Lithocarpus densiflora/Cornus nuttallii*] (Fites 1993)

*82.500.44 Douglas-fir – Tanoak/Iris [*Pseudotsuga menziesii* –Mixed conifer - *Lithocarpus densiflora/Iris* spp.] (Fites 1993)

*82.500.45 Douglas-fir – Tanoak/ Hazel [*Pseudotsuga menziesii* –Mixed Conifer – *Lithocarpus densiflora/Corulus cornuta*] (Fites 1993)

82.500.46 *Pseudotsuga menziesii - Lithocarpus densiflorus/Quercus vaccinifolia-Holodiscus discolor* association (Jimerson 1993)

*82.600.00 Douglas-fir – Incense-cedar Forest [*Pseudotsuga menziesii – Calocedrus decurrens*]

*82.600.01 Douglas-fir – Incense-cedar – California Bay/Poison Oak [*Pseudotsuga menziesii- Calocedrus decurrens - Umbellularia californica/ Toxicodendron diversiloba* association] (Jimerson 1993)

*82.600.02 Douglas-fir – Incense-cedar /California Fescue [*Pseudotsuga menziesii - Calocedrus decurrens/Festuca californica*] (Jimerson 1993)

*82.600.03 Moved to 87.020.29.

*82.600.04 *Pseudotsuga menziesii - Calocedrus decurrens/Quercus vaccinifolia* association (Jimerson 1993)

*82.600.05 Duplicated 82.200.16 so removed.

*82.600.06 Moved to 82.200.74.

*82.600.07 Duplicated 82.200.15 so removed, but added reference name there.

*82.600.08 Duplicated 82.200.51 so removed.

*82.600.09 Moved to 82.200.75.

*82.600.10 Duplicated 82.200.59 so removed.

*82.600.11 *Calocedrus decurrens - Pseudotsuga menziesii* association (Stuart *et al.* 1992):

83.000.00 Coastal and Montane Spruce Forests [*Picea* spp.]

*83.100.00 Engelmann Spruce Forest [*Picea engelmannii*]

*83.200.00 Sitka Spruce Forest [*Picea sitchensis*]

*83.200.01 Sitka Spruce / False Lily-of-the valley [*Picea sitchensis-Maianthemum dilatatum*] (Imper & Sawyer 1987)

*83.200.02 Sitka Spruce / Salmonberry [*Picea sitchensis/Rubus spectabilis*] (Imper & Sawyer 1987)

*83.200.03 Sitka Spruce / Sword Fern [*Picea sitchensis/Polystichum munitum*] (Imper & Sawyer 1987)

*83.200.04 Sitka Spruce - Western Hemlock [*Picea sitchensis/Tsuga heterphylla*] (Westman & Whittaker 1975)
*83.200.05 Sitka Spruce Forest {82110}

*83.300.00 Brewer Spruce Forest [*Picea breweriana*]

84.000.00 Coastal and Montane Hemlock Forests [*Tsuga* spp.]
84.100.00 Mountain Hemlock Forest [*Tsuga mertensiana*]
84.100.01 Mountain Hemlock / Cascade Heather [*Tsuga mertensiana /Phyllodoce empetriformis*] (Imper 1988a)
84.100.02 Mountain Hemlock / Parry Rush [*Tsuga mertensiana/Juncus parryi*] (Imper 1988a)
84.100.03 Mountain Hemlock / Sadler Oak [*Tsuga mertensiana/Quercus sadleriana*] (Jimerson 1993)
84.100.04 Mountain Hemlock [*Tsuga mertensiana*] (Potter 1994)
84.100.05 entry moved to 84.100.10
84.100.06 Mountain Hemlock / Dwarf Bilberry [*Tsuga mertensiana/Vaccinium caespitosum*] (Sawyer & Thornburgh 1977)
84.100.07 Mountain Hemlock / Huckleberry Oak [*Tsuga mertensiana/Quercus vaccinifolia*] (Sawyer & Thornburgh 1977)
84.100.08 Mountain Hemlock / White-veined Shinleaf [*Tsuga mertensiana/Pyrola picta*] (Sawyer & Thornburgh 1977)
84.100.09 Mountain Hemlock / Heartleaf Arnica [*Tsuga mertensiana/Arnica cordifolia*] (Taylor 1984)
84.100.10 Moutain Hemlock-Western White Pine / Broad-seeded Rock Cress [*Tsuga mertensiana- Pinus monticola/Arabis platysperma*] (*Sensu.* Potter 1994 *Tsuga mertensiana /*Steep) (Keeler-Wolf and Moore 2001)

84.100.11 Mountain Hemlock - Lodgepole Pine -Western White Pine [*Tsuga mertensiana-Pinus contorta* var. *murrayana-Pinus monticola*] (Parker 1988)
84.100.12 Mountain Hemlock - Lodgepole Pine / Mountain Heather [*Tsuga mertensiana-Pinus contorta* var. *murrayana/Phyllodoce brewerii*] (Keeler-Wolf and Moore 2001)
84.100.13 Mountain Hemlock - Lodgepole Pine / Ross Sedge [*Tsuga mertensiana-Pinus contorta* var. *murrayana/Carex rossii*] (Keeler-Wolf and Moore 2001)

*84.200.00 Western Hemlock Forest [*Tsuga heterophylla*] {82200}

85.000.00 Incense-cedar Forests [*Calocedrus* spp.]

*85.100.00 Incense-cedar Forest [*Calocedrus decurrens*]
*85.100.01 Incense-cedar / Twayblane [*Calocedrus decurrens/Listera convallarioides*] (Muldavin 1982)
*85.100.02 Incense-cedar - Douglas-fir [*Calocedrus decurrens-Pseudotsuga menziesii*] (Stuart *et al.* 1992)
85.100.03 Incense-cedar - White Alder [*Calocedrus decurrens-Alnus rhombifolia*] (Keeler-Wolf and Moore 2001)

86.000.00 Coastal and Montane Redwood Forests [*Sequoia sempervirens*] {82300}

*86.100.00 Redwood Forest [*Sequoia sempervirens*]
*86.100.01 Redwood - Bigleaf Maple / California Polypody / Gamboa [*Sequoia sempervirens-Acer macrophylla/Polypodium californicum/*Gamboa] (Borchert *et al.* 1988)

*86.100.02 Redwood / Bracken - Chain Fern / Streamsides [*Sequoia sempervirens/Pteridium aquilinum-Woodwardia fimbriata/*Streamsides] (Borchert *et al*. 1988)

*86.100.03 Redwood / Bracken - Trillium / Gamboa - Sur [*Sequoia sempervirens/Pteridium aquilinum-Trillium ovatum/*Gamboa-Sur] (Borchert *et al*. 1988)

*86.100.04 Redwood / Gamboa - Sur [*Sequoia sempervirens/*Gamboa-Sur] (Borchert *et al*. 1988)

*86.100.05 Redwood / Man Root - Common Vetch / Gamboa - Sur [*Sequoia sempervirens/Marah fabaceus-Vicia angustifolia*/Gamboa-Sur] (Borchert *et al*. 1988)

*86.100.06 Redwood - Tanoak / Round-fruited Sedge - Douglas Iris /Gamboa [*Sequoia sempervirens-Lithocarpus densiflora/Carex globosa-Iris douglasiana*] (Borchert *et al*. 1988)

*86.100.07 Redwood / Deer Fern [*Sequoia sempervirens/Blechnum spicant*] (Lenihan 1990)

*86.100.08 Redwood / Little Oregon-grape [*Sequoia sempervirens/Berberis nervosa*] (Lenihan 1990)

*86.100.09 Redwood / Madrone [*Sequoia sempervirens/Arbutus menziesii*] (Lenihan 1990)

*86.100.10 Redwood - Douglas-fir / Madrone [*Sequoia sempervirens-Pseudotsuga menziesii/Arbutus menziesii*] (Matthews 1986a, 1986b)

*86.100.11 Redwood - Douglas-fir / Salal [*Sequoia sempervirens-Pseudotsuga menziesii/Gaultheria shallon*] (Matthews 1986a, 1986b)

*86.100.12 Redwood - Douglas-fir / Black Huckleberry [*Sequoia sempervirens-Pseudotsuga menziesii/Vaccinium ovatum*] (Matthews 1986a, 1986b)

*86.100.13 Redwood / Redwood Oxalis [*Sequoia sempervirens/Oxalis oregana*] (Matthews 1986a, 1986b)

*86.100.14 North Coast Alluvial Redwood Forest {61120}

86.100.15 Upland Redwood Forest {82320}

86.100.16 Redwood - Tanoak / Black Huckleberry [*Sequoia sempervirens-Lithocarpus densiflora/Vaccinium ovatum*] (Keeler-Wolf, *et al*. 2001)

86.100.17 Redwood - Douglas-fir / California Bay [*Sequoia sempervirens-Pseudotsuga menziesii/Umbellularia californica*] (Keeler-Wolf, *et al*. 2001)

*86.200.00 Giant Sequoia Forest [*Sequoiadendron giganteum*] {84250}

86.200.01 Giant Sequoia - Sugar Pine / Pacific Dogwood [*Sequoiadendron giganteum-Pinus lambertiana/Cornus nuttalii*] (Keeler-Wolf and Moore 2001)

87.000.00 Pine Forests and Woodlands [*Pinus* spp.]

87.010.00 Ponderosa Pine Forest and Woodland [*Pinus ponderosa*]

*87.010.01 Ponderosa Pine / Antelope Bitterbrush / Bolander Bedstraw [*Pinus ponderosa/Purshia tridentata* var. *tridentata*] (Fites 1993)

*87.010.02 Ponderosa Pine / Mountain Misery [*Pinus ponderosa/Chamaebatia foliolosa*] (Taylor & Randall 1977, Fites 1993)

*87.010.03 Ponderosa Pine / Greenleaf Manzanita - Mountain Misery [*Pinus ponderosa/Arctostaphylos patula-Chamaebatia foliolosa*] (Fites 1993)

*87.010.04 Ponderosa Pine / Big Sagebrush [*Pinus ponderosa/Artemisia tridentata*] (Keeler-Wolf 1984c)

*87.010.05 Ponderosa Pine / Antelope Bitterbrush [*Pinus ponderosa/Purshia tridentata* var. *tridentata*] (Keeler-Wolf 1984c, Vora 1988)

*87.010.06 Ponderosa Pine / California Brome [*Pinus ponderosa/Bromus carinatus*] (Keeler-Wolf 1984c)

*87.010.07	Ponderosa Pine / Shrubby Bedstraw [*Pinus ponderosa/Galium angustifolium*] (Keeler-Wolf 1986e, 1988e)
*87.010.08	Ponderosa Pine/ Mahala Carpet [*Pinus ponderosa/Ceanothus prostratus*] (Sawyer & Thornburgh 1977)
*87.010.09	Ponderosa Pine / Wedgeleaf Ceanothus [*Pinus ponderosa/Ceanothus cuneatus*] (Simpson 1980)
*87.010.10	Ponderosa Pine / Antelope Bitterbrush / Arrowleaf Balsam Root [*Pinus ponderosa/Purshia tridentata* var. *tridentata/Balsamorhiza sagittata*] (Smith 1994)
*87.010.11	Ponderosa Pine / Antelope Bitterbrush - Choke Cherry /Orcutt Brome [*Pinus ponderosa/Purshia tridentata* var. *tridentata*] (Smith 1994)
*87.010.12	Ponderosa Pine / Antelope Bitterbrush / Columbia Needlegrass / Pumice [*Pinus ponderosa/Purshia tridentata* var. *tridentata/Stipa nelsonii/*Pumice] (Smith 1994)
*87.010.13	Ponderosa Pine / Antelope Bitterbrush - Greenleaf Manzanita / Columbia Needlegrass [*Pinus ponderosa/Purshia tridentata* var. *tridentata-Arctostaphylos patula/Stipa nelsonii*] (Smith 1994)
*87.010.14	Ponderosa Pine / Antelope Bitterbrush - Tobacco Brush [*Pinus ponderosa/Purshia tridentata* var. *tridentata-Ceanothus velutinus*] (Smith 1994)
*87.010.15	Ponderosa Pine / Antelope Bitterbrush / Tower Butterweed/ Granite [*Pinus ponderosa/Purshia tridentata* var. *tridentata/Senecio integerrimus/*Granite] (Smith 1994)
*87.010.16	Ponderosa Pine / Antelope Bitterbrush - Wax Currant /Orcutt Brome [*Pinus ponderosa/Purshia tridentata* var.*tridentata-Ribes cereum/Bromus orcuttii*] (Smith 1994)
*87.010.17	Ponderosa Pine - Black Oak / Curlleaf Mountain-mahogany [*Pinus ponderosa/quercus kelloggii/Cercocarpus ledifolius*] (Smith 1994)
*87.010.18	Ponderosa Pine / Columbia Needlegrass [*Pinus ponderosa/Stipa nelsonii*] (Smith 1994)
*87.010.19	Ponderosa Pine / Curlleaf Mountain-mahogany - Antelope Bitterbrush / Idaho Fescue [*Pinus ponderosa/Cercocarpus ledifolius-Purshia tridentata* var. *tridenata/Festuca idahoensis*] (Smith 1994)
*87.010.20	Ponderosa Pine / Curlleaf Mountain-mahogany / Blue Wheatgrass [*Pinus ponderosa/Cercocarpus ledifolius/Pseudoroegneria spicata*] (Smith 1994)
*87.010.21	Ponderosa Pine - Douglas-fir / Antelope Bitterbrush /Mule's Ears [*Pinus ponderosa-Pseudotsuga menziesii/Purshia tridentata* var. *tridentata/Wyethia mollis*] (Smith 1994)
*87.010.22	Ponderosa Pine - Interior Live Oak [*Pinus ponderosa-Quercus wislizeni*] (Smith 1994)
*87.010.23	Ponderosa Pine - Lodgepole Pine / Service Berry [*Pinus ponderosa-Pinus contorta* ssp. *murrayana/Amelanchier alnifolia*] (Smith 1994)
*87.010.24	Ponderosa Pine / Mountain Big Sagebrush / Idaho Fescue [*Pinus ponderosa/Artemisia tridentata* var. *vaseyana*/*Festuca idahoensis*] (Smith 1994)
*87.010.25	Ponderosa Pine / Mountain Big Sagebrush - Antelope Bitterbrush [*Pinus ponderosa/Artemisia tridentata* var. *vaseyana-Purshia tridentata* var. *tridentata*] (Smith 1994)
*87.010.26	Ponderosa Pine / Service Berry - Choke Cherry [*Pinus ponderosa/Amelanchier alnifolia-Prunus virginiana*] (Smith 1994)
*87.010.27	Ponderosa Pine / Service Berry - Creeping Oregon-grape /Heartleaf Arnica [*Pinus ponderosa/Amelanchier alnifolia-Berberis repens/Arnica cordifolia*] (Smith 1994)
*87.010.28	Ponderosa Pine / Tobacco Bush / Columbia Needlegrass [*Pinus ponderosa/Ceanothus velutinus/Stipa nelsonii*] (Smith 1994)

*87.010.29 Ponderosa Pine / Desert Snowberry [*Pinus ponderosa/Symphoricarpos longiflorus*] (Vora 1988)
*87.010.30 Ponderosa Pine - Canyon Live Oak [*Pinus ponderosa-Quercus chrysolepis*] (Waddell 1982)
*87.010.31 Maritime Coast Range Ponderosa Pine Forest {84132}
*87.010.32 Ponderosa Dune Forest {84221}
*87.010.33 Westside Ponderosa Pine Forest {84210}
*87.010.34 Eastside Ponderosa Pine Forest {84220}
87.010.35 Upland Coast Range Ponderosa Pine Forest {84131}
87.010.36 Ponderosa Pine / Whiteleaf Manzanita / Ripgut Brome [*Pinus ponderosa/Arctostaphylos viscida/Bromus diandrus*] (Keeler-Wolf and Moore 2001)

87.015.00 Ponderosa Pine - Incense Cedar Forest [*Pinus ponderosa-Calocedrus decurrens*] (Keeler-Wolf and Moore 2001)

87.015.02 Ponderosa Pine - Incense Cedar - Black Oak [*Pinus ponderosa-Calocedrus decurrens-Quercus kelloggii*] (Keeler-Wolf and Moore 2001)

87.015.03 Ponderosa Pine - Incense Cedar / Mountain Misery [*Pinus ponderosa-Calocedrus decurrens/Chamaebatia foliosa*] (Keeler-Wolf and Moore 2001)
87.015.04 Ponderosa Pine - Incense Cedar-Canyon Oak / Mountain Misery [*Pinus ponderosa-Calocedrus decurrens-Quercus chrysolepis/Chamaebatia foliosa*] (Fites 1993, re-named Keeler-Wolf and Moore 2001)
87.015.05 Ponderosa Pine –Incense-cedar /Huckleberry Oak [*Pinus ponderosa* Mixed Conifer */Quercus vaccinifolia*] (Fites 1993)
87.015.06 Ponderosa Pine - Incense Cedar - Canyon Live Oak / Bolander Bedstraw [Mixed Conifer-*Quercus chrysolepis/Galium bolanderi*] (Fites 1993)
87.015.07 Ponderosa pine- Incense Cedar/Bearclover/Bolander Bedstraw [Ponderosa pine-mixed conifer/*Chamaebatia foliosa/Galium bolanderi*] (Fites 1993)

87.020.00 Jeffrey Pine Forest and Woodland [*Pinus jeffreyi*]
87.020.01 Jeffrey Pine / Sadler Oak / Bear-grass [*Pinus jeffreyi/Quercus sadleriana/Xerophyllum tenax*] (Jimerson 1993)
*87.020.02 Jeffrey Pine - Douglas-fir / Huckleberry Oak / California Fescue [*Pinus jeffreyi-Pseudotsuga menziesii/Quercus vaccinifolia/Festuca californica*] (Jimerson 1993)
*87.020.03 Jeffrey Pine / Idaho Fescue [*Pinus jeffreyi/Festuca idahoensis*] (Duebendorfer 1987, Jimerson 1993)
87.020.04 Jeffrey Pine - Incense-cedar / Buckbrush [*Pinus jeffreyi-Calocedrus decurrens/Ceanothus cuneatus*] (Jimerson 1993)
87.020.05 Jeffrey Pine - Incense-cedar / Huckleberry Oak / Bear-grass [*Pinus jeffreyi-Calocedrus decurrens/Quercus vaccinifolia/Xerophyllum tenax*] (Jimerson 1993)
*87.020.06 moved to Jeffrey Pine-Fir alliance
87.020.07 Jeffrey Pine [*Pinus jeffreyi*] (Potter 1994)
87.020.08 Jeffrey Pine / Huckleberry Oak [*Pinus jeffreyi/Quercus vaccinifolia*] (Potter 1994)
87.020.09 Jeffrey Pine / Greenleaf Manzanita [*Pinus jeffreyi/Arctostaphylos patula*] (Potter 1994)
87.020.10 Jeffrey Pine / Mountain Whitethorn [*Pinus jeffreyi/Ceanothus cordulatus*] (Potter 1994)
87.020.11 Jeffrey Pine / Tailed Lupine [*Pinus jeffreyi/Lupinus caudatus*] (Riegel *et al*. 1990)

*87.020.12 Jeffrey Pine / Antelope Bitterbrush/ Mule's Ears [*Pinus jeffreyi/Purshia tridentata* var. *tridentata/Wyethia mollis*] (Smith 1994)

*87.020.13 Jeffrey Pine / Antelope Bitterbrush - Curlleaf Mountain-mahogany / Western Needlegrass [*Pinus jeffreyi/Purshia tridentata* var. *tridentata/Cercocarpus ledifolius/Stipa occidentalis*] (Smith 1994)

*87.020.14 Jeffrey Pine / Antelope Bitterbrush - Desert Snowberry / Wheeler Bluegrass [*Pinus jeffreyi/Purshia tridentata* var. *tridentata-Symphoricarpos longiflorus/Poa wheeleri*] (Smith 1994)

*87.020.15 Jeffrey Pine - Black Oak / One-sided Bluegrass [*Pinus jeffreyi-Quercus kelloggii/Poa secunda*] (Smith 1994)

*87.020.16 Jeffrey Pine - Black Oak / Basket Bush [*Pinus jeffreyi-Quercus kelloggii/Rhus trilobata*] (Smith 1994)

*87.020.17 Jeffrey Pine / Curlleaf Mountain-mahogany [*Pinus jeffreyi/Cercocarpus ledifolius*] (Smith 1994)

*87.020.18 Jeffrey Pine / Desert Snowberry / Wheeler Bluegrass [*Pinus jeffreyi/Symphoricarpos longiflorus/Poa wheeleri*] (Smith 1994)

*87.020.19 Jeffrey Pine / Mountain Big Sagebrush / Idaho Fescue [*Pinus jeffreyi/Artemisia tridentata* var.*vaseyana/Festuca idahoensis*] (Smith 1994)

*87.020.20 Jeffrey Pine / Bush Chinquapin [*Pinus jeffreyi/Chrysolepis sempervirens*] (Talley 1978)

*87.020.21 Jeffrey Pine / Antelope Bitterbrush [*Pinus jeffreyi/Purshia tridentata* var. *tridentata*] (Taylor 1980)

*87.020.22 Jeffrey Pine / Serpentine-Haplopappus [*Pinus jeffreyi/Ericameria ophitidis*] (Taylor & Teare 1979)

*87.020.23 Jeffrey Pine / Tufted Reedgrass [*Pinus jeffreyi/Calamagrostis koelerioides*] (Taylor & Teare 1979b)

87.020.24 Jeffrey Pine / Pinemat Manzanita [*Pinus jeffreyi/Arctostaphylos nevadensis*] (Waddell 1982)

87.020.25 Northern Ultramafic Jeffrey Pine Forest {84121}

87.020.26 Jeffrey Pine - Singleleaf Pinyon [*Pinus jeffreyi-Pinus monophylla*] (Keeler-Wolf and Moore 2001)

87.020.27 Jeffrey Pine/Huckleberry Oak-Pinemat Manzanita/Idaho Fescue [*Pinus jeffreyi/Quercus vaccinifolia-Arctostaphylos nevadensis/Festuca idahoensis*] (Jimerson et al. 1995)

87.020.28 Jeffrey Pine-Incense-cedar/Siskiyou mat [*Pinus jeffreyi-Calocedrus decurrens/Ceanothus pumila*] (Jimerson et al. 1995)

*87.020.29 *Pseudotsuga menziesii - Pinus jeffreyi/Festuca californica* association (Jimerson et al. 1995)

*87.020.30 Jeffrey Pine-Port Orford-cedar/Huckleberry Oak [*Pinus jeffreyi-Chamaecyparis lawsoniana/ Quercus vaccinifolia*] (Jimerson et al. 1999)

*87.030.00 Parry Pinyon Woodland [*Pinus quadrifolia*]

87.040.00 Singleleaf Pinyon Woodland [*Pinus monophylla*] {72122}

87.040.01 Mojavean Pinyon Woodland {72210}

87.040.02 Singleleaf Pinyon / Big Sagebrush [*Pinus monophylla/Artemisia tridentata*] (Keeler-Wolf and Thomas 2000)

87.040.03 Singleleaf Pinyon / Green Ephedra [*Pinus monophylla/Ephedra viridis*] (Keeler-Wolf and Thomas 2000)

87.040.04 Singleleaf Pinyon / Waxberry - Desert Gooseberry [*Pinus monophylla /Symphoricarpos rotundifolia-Ribes velutinum*] (Keeler-Wolf and Thomas 2000)

87.040.05 Singleleaf Pinyon / Silk Tassle Bush [*Pinus monophylla/Garrya flavescens*] (Keeler-Wolf and Thomas 2000)

87.040.06 Singleleaf Pinyon / Utah Juniper / Big Sagebrush - Blackbush [*Pinus monophylla/Juniperus osteosperma/Artemisia tridentata-Coleogyne ramosissisima*] (Keeler-Wolf and Thomas 2000)

87.040.07 Singleleaf Pinyon / Utah Juniper / Black Sagebrush [*Pinus monophylla/Juniperus osteosperma/Artemisia nova*] (Keeler-Wolf and Thomas 2000)

87.040.08 Singleleaf Pinyon / Muller Oak [*Pinus monophylla/Quercus cornelius-mulleri*] (Keeler-Wolf 2000)

87.040.09 Singleleaf Pinyon / Muller Oak / California Fiddleleaf [*Pinus monophylla/Quercus cornelius-mulleri/Nama californica*] (Keeler-Wolf and Thomas 2000)

87.040.10 Singleleaf Pinyon / Desert Almond [*Pinus monophylla/Prunus fasciculata*] (Keeler-Wolf and Thomas 2000)

87.040.11 Singleleaf Pinyon / Desert Gooseberry [*Pinus monophylla/Ribes velutinum*] (Keeler-Wolf and Thomas 2000)

87.040.12 Singleleaf Pinyon / Curl-leaf Mountain Mahogany / Big Sagebrush - Antelope Bitterbrush [*Pinus monophylla/Cercocarpus ledifolius/Artemisia tridentata-Purshia tridentata*] (Keeler-Wolf and Thomas 2000)

87.040.13 Singleleaf Pinyon / Utah Juniper / Antelope Brush [*Pinus monophylla/Juniperus osteosperma/Purshia mexicana*] (Keeler-Wolf and Thomas 2000)

*87.050.00 Twoleaf Pinyon Unique Stands [*Pinus edulis*]

*87.060.00 Beach Pine Forest [*Pinus contorta* ssp. *contorta*]

*87.060.01 Beach Pine Forest {83110}

*87.070.00 Bishop Pine Forests [*Pinus muricata*] {83120}

87.070.01 Bishop Pine - Pacific Madrone / Black Huckleberry [*Pinus muricata-Arbutus menziesii/Vaccinium ovatum*] (Keeler-Wolf, *et al*. 2001)

*87.071.00 Northern Bishop Pine Forest [*Pinus* spp.] {83121}

*87.071.01 Bishop Pine / Bear-grass [*Pinus muricata/Xerophyllum tenax*] (Westman & Whittaker 1975)

*87.071.02 Bishop Pine - Bolander Pine / Labrador-tea [*Pinus muricata-Pinus contorta* ssp. *bolanderi*] (Westman and Whittaker 1975)

*87.071.03 Bishop Pine - Bolander Pine / Rayless Arnica [*Pinus muricata-Pinus contorta* ssp. *bolanderi/Arnica discoidea*] (Westman & Whittaker 1975)

*87.071.04 Bishop Pine - Douglas-fir [*Pinus muricata-Pseudotsuga menziesii*] (Westman & Whittaker 1975)

*87.072.00 Southern Bishop Pine Forest [*Pinus* spp.] {83122}

87.080.00 Lodgepole Pine Forest and Woodland [*Pinus contorta* ssp. *murrayana*] {86100}

87.080.01 Lodgepole Pine [*Pinus contorta* ssp. *murrayana*] (Potter 1994)

87.080.02 Lodgepole Pine / Big Sagebrush [*Pinus contorta* ssp. *murrayana/Artemisia tridentata*] (Potter 1994)

87.080.03 Lodgepole Pine / Gray Lovage [*Pinus contorta* ssp. *murrayana/Ligusticum grayi*] (Potter 1994)

87.080.04 Lodgepole Pine / Open [*Pinus contorta* ssp. *murrayana/*Open] (Potter 1994)

87.080.05 Lodgepole Pine / Pussypaws [*Pinus contorta* ssp. *murrayana/Calyptridium monosperma*] (Taylor 1980)

87.080.06 Lodgepole Pine / Ross Sedge [*Pinus contorta* ssp. *murrayana/Carex rossii*] (Taylor 1984)

87.080.07 Lodgepole Pine / Fendler Meadow-rue [*Pinus contorta* ssp. *murrayana/Thalictrum fendleri*] (Taylor 1984)
87.080.08 Lodgepole Pine / Labrador-Tea [*Pinus contorta* ssp. *murrayana/Ledum glandulosum*] (Taylor 1984)
87.080.09 Lodgepole Pine / Western Blueberry [*Pinus contorta* ssp. *murrayana/Vaccinium uliginosum*] (Keeler-Wolf and Moore 2001)
87.080.10 Lodgepole Pine / Shorthair Sedge [*Pinus contorta* ssp. *murrayana/Carex filifolia*] (Keeler-Wolf and Moore 2001)
87.080.11 Lodgepole Pine - Whitebark Pine / Ross Sedge [*Pinus contorta* ssp. *murrayana-Pinus albicaulis/Carex rossii*] (Keeler-Wolf and Moore 2001)
87.080.12 Lodgepole Pine / Mountain Pride Penstemon [*Pinus contorta* ssp. *murrayana/Penstemon newberryi*] (Keeler-Wolf and Moore 2001)

87.090.00 Coulter Pine Woodland [*Pinus coulteri*] {84140}

87.092.00 Coulter Pine / Eastwood Manzanita Woodland [*Pinus coulteri/Arctostaphylos glandulosa*] (Borchert, *et al*. 2000)

87.100.00 Knobcone Pine Forest and Woodland [*Pinus attenuata*] {83210}
87.100.01 Knobcone Pine / Hairy Manzanita [*Pinus attenuata/Arctostaphylos columbiana*] (Imper 1991a)
87.100.02 Knobcone Pine / Greenleaf Manzanita [*Pinus attenuata/Arctostaphylos patula*] (Imper 1991b)
87.100.03 Knobcone Pine / Huckleberry Oak [*Pinus attenuata/Quercus vaccinifolia*] (Taylor & Teare 1979a)
87.100.04 Knobcone Pine / Chamise [*Pinus attenuata/Adenostoma fasciculata*] (Keeler-Wolf and Moore 2001)
87.100.05 Knobcone Pine / Whiteleaf Manzanita [*Pinus attenuata/Arctostaphylos viscida*] (Keeler-Wolf and Moore 2001)

*87.110.00 Monterey Pine Forest[*Pinus radiata*] {83130}

*87.120.00 Washoe Pine Woodland [*Pinus washoensis*] {85220}
*87.120.01 Washoe Pine / Tailed Lupine [*Pinus washoensis/Lupinus caudatus*] (Riegel *et al*. 1990)*
*87.120.02 Washoe Pine / Desert Snowberry / Sticky Starwort [*Pinus washoensis/Symphoricarpos longiflorus/Pseudostellaria jamesiana*] (Smith 1994)
*87.120.03 Washoe Pine / Pinemat Manzanita [*Pinus washoensis/Arctostaphylos nevadensis*] (Smith 1994)

87.130.00 Foothill Pine Woodland [*Pinus sabiniana*] {71300}
87.130.01 Serpentine Digger Pine Chaparral Woodland {71321}
87.130.02 Non-Serpentine Digger Pine Chaparral Woodland {71322}
87.130.03 Digger Pine-Oak Woodland {71410}
87.130.04 Foothill Pine - Interior Live Oak / Wedgeleaf Ceanothus [*Pinus sabiniana-Quercus wislizeni/Ceanothus cuneatus*] (Keeler-Wolf and Moore 2001)
87.130.05 Foothill Pine - Interior Live Oak / Whiteleaf Manzanita [*Pinus sabiniana- Quercus wislizeni/Arctostaphylos viscida*] (Keeler-Wolf and Moore 2001)

*87.140.00 Bristlecone Pine Woodland [*Pinus longaeva*] {86400}
*87.140.01 Bristlecone Pine [*Pinus longaeva*] (Taylor 1979)

*87.140.02 Bristlecone Pine / Littleleaf Mountain-mahogany [*Pinus longaeva/Cercocarpus intricatus*] (Taylor 1979)

87.150.00 Foxtail Pine Woodland [*Pinus balfouriana*] {86300}
- 87.150.01 Sierra Foxtail Pine Forest [*Pinus* spp.] (Ball 1976)
- 87.150.02 Foxtail Pine Forest / Drummond Windflower [*Pinus balfouriana/Anemone drummondii*] (Whipple & Cope 1979)

87.160.00 Limber Pine Forest and Woodland [*Pinus flexilis*] {86700}
- *87.160.01 Limber Pine / Curlleaf Mountain-mahogany [*Pinus flexilis/Cercocarpus ledifolius*] (Taylor 1979)

87.170.00 Western White Pine Woodland [*Pinus monticola*]
- *87.170.01 Western White Pine / Bush Tanoak [*Pinus monticola/Lithocarpus densiflora* var. *echinoides*] (Duebendorfer 1987)
- *87.170.02 Western White Pine / Ocean Spray [*Pinus monticola/Holodiscus discolor*] (Sawyer & Thornburgh 1977)
- *87.170.03 Pine / Bear-grass [*Pinus* spp./*Xerophyllum tenax*] (Simpson 1980)
- *87.170.04 Western White Pine / Angelica [*Pinus monticola/Angelica arguta*] (Whipple & Cope 1979)
- *87.170.05 Ultramafic White Pine Forest {84160}
- 87.170.06 Western White Pine / Western Needlegrass [*Pinus monticola/ Achnatherum occidentalis*] (Keeler-Wolf and Moore 2001)
- 87.170.07 Western White Pine - Lodgepole Pine [*Pinus monticola-Pinus contorta* var. *murrayana*] (Keeler-Wolf and Moore 2001)
- *87.170.08 Western White Pine –Del Norte Lodgepole Pine/Dwarf Tanbark-Pacific Rhododendron [Pinus monticola-Pinus contorta ssp contorta/Lithocarpus densiflorus ssp. echinoides] (Jimerson et al 1995)
- *87.170.09 Western White Pine-Sugar Pine/Huckleberry Oak-Dwarf Tanbark [Pinus monticola-Pinus lambertiana/Quercus vaccinifolia-Lithocarpus densiflorus ssp. echinoides] (Jimerson et al. 1995)
- *87.170.10 Western White Pine - Douglas-fir/Huckleberry Oak-Dwarf Tanbark [Pinus monticola-Pseudotsuga menziesii/Quercus vaccinifolia-Lithocarpus densiflorus ssp. echinoides] (Jimerson et al. 1995)

87.180.00 Whitebark Pine Woodland [*Pinus albicaulis*] {86600}
- 87.180.01 Whitebark Pine / California Needlegrass [*Pinus albicaulis/Stipa californica*] (Riegel *et al*. 1990)
- 87.180.02 Whitebark Pine / Slender Penstemon [*Pinus albicaulis/Penstemon gracilentus*] (Reigel *et al*. 1990)
- 87.180.03 Whitebark Pine / Woody Sandwort [*Pinus albicaulis/Arenaria pumicola*] (Reigel *et al*. 1990)
- 87.180.04 Whitebark Pine / Ocean Spray [*Pinus albicaulis/Holodiscus discolor*] (Sawyer & Thornburgh 1977)
- 87.180.05 Whitebark Pine / Wheeler Bluegrass [*Pinus albicaulis/Poa wheeleri*] (Taylor 1984)
- 87.180.06 Whitebark Pine / Davidson Penstemon [*Pinus albicaulis/Penstemon davidsonii*] (Taylor 1984)
- 87.180.07 Whitebark Pine - Mountain Hemlock [*Pinus albicaulis/Tsuga mertensiana*] (Keeler-Wolf and Moore 2001)
- 87.180.08 Whitebark Pine / Shorthair Sedge [*Pinus albicaulis/Carex filifolia*] (Keeler-Wolf and Moore 2001)

87.180.09 Whitebark Pine / Ross Sedge [*Pinus albicaulis/Carex rossii*] (Keeler-Wolf and Moore 2001)

*87.190.00 Torrey Pine Unique Stands [*Pinus torreyana*] {83140}

87.200.00 Jeffrey Pine - Ponderosa Pine Forest and Woodland [*Pinus jeffreyi-Pinus ponderosa*]

*87.200.01 Jeffrey Pine - Ponderosa Pine / Arrowleaf Balsam Root [*Pinus jeffreyi-Pinus ponderosa/Balsamorhiza sagittata*] (Smith 1994)

*87.200.02 Jeffrey Pine - Ponderosa Pine / Antelope Bitterbrush /Idaho Fescue [*Pinus jeffreyi-Pinus ponderosa/Purshia tridentata* var. *tridentata/Festuca idahoensis*] (Smith 1994)

*87.200.03 Jeffrey Pine - Ponderosa Pine / Antelope Bitterbrush /Idaho Fescue / Granite [*Pinus jeffreyi-Pinus ponderosa/Purshia tridentata* var. *tridentata/Festuca idahoensis/*Granite] (Smith 1994)

*87.200.04 Jeffrey Pine - Ponderosa Pine / Modoc Coffeeberry / One-sided Bluegrass [*Pinus jeffreyi-Pinus ponderosa/Rhamnus rubra/Poa secunda*] (Smith 1994)

*87.200.05 Jeffrey Pine - Ponderosa Pine / Huckleberry Oak [*Pinus jeffreyi-Pinus ponderosa/Quercus vaccinifolia*] (Smith 1994)

*87.200.06 Jeffrey Pine - Ponderosa Pine / Columbia Needlegrass / Oregon Ash [*Pinus jeffreyi-Pinus ponderosa/Stipa nelsonii/Fraxinus latifolia*] (Smith 1994)

*87.200.07 Jeffrey Pine - Ponderosa Pine / Creeping Snowberry /Mule's Ears [*Pinus jeffreyi-Pinus ponderosa/Symphoricarpos mollis/Wyethia mollis*] (Smith 1994)

87.205.00 Jeffrey Pine-White Fir Forest {85210}

87.205.01 Jeffrey Pine - Red Fir [*Pinus jeffreyi-Abies magnifica*] (Potter 1994)

87.205.02 Jeffrey Pine - White Fir / Big sagebrush/squirreltail[*Pinus jeffreyi-Abies concolor/Artemisia tridentata/Elymus elymoides*] (Keeler-Wolf and Moore 2001)

87.205.03 Jeffrey Pine - White Fir - Red Fir [*Pinus jeffreyi-Abies magnifica*] (Potter 1994)

87.205.04 White Fir - Jeffrey Pine / California Fescue [Abies concolor-Pinus jeffreyi/Festuca californica] (Jimmerson 1993)

87.205.05 Jeffrey Pine-White fir/Sadler oak [Pinus jeffreyi-Abies concolor/Quercus sadleriana] (Jimerson 1993)

87.205.06 Jeffrey Pine - White Fir / Del Norte Iris [*Pinus jeffreyi-Abies concolor/Iris innominata*] (Jimerson 1993)

87.206.00 Sugar Pine Forest and Woodland

87.206.01 Sugar Pine/Chinquapin/Huckleberry Oak-Sadler Oak [*Pinus lambertiana/Chrysolepis chrysophylla/Quercus vaccinifolia-Quercuys sadleriana*] (Jimerson et al. 1995)

87.206.02 Sugar Pine-Lodgepole Pine/Huckleberry oak-Dwarf Tanbark Oak [*Pinus lambertiana-Pinus contorta/Quercus vaccinifolia-Lithocarpus densiflora* var *echinoides*] (Jimerson et al. 1995)

87.206.03 Sugar Pine-Lodgepole Pine/Huckleberry oak-Pacific Rhododendron [*Pinus lambertiana-Pinus contorta/Quercus vaccinifolia-Rhododensron macrophyllum*] (Jimerson et al. 1995)

87.206.04 Sugar pine-Western White Pine/Huckleberry oak-Dwarf Silktassel [*Pinus lambertiana-Pinus monticola/Quercus vaccinifolia-Garrya buxifolia*] (Jimerson et al. 1995)

87.210.00 Coulter Pine - Canyon Live Oak Woodland [*Pinus coulteri-Quercus chrysolepis*]

87.220.00 Mixed Subalpine Forest [*Pinus* spp.]

87.220.01 Whitebark Pine Mountain Hemlock Forest {86210}

87.221.00 Southern California Subalpine Forest {86500}

*87.230.00 San Benito Unique Stands

88.000.00 Forest and Woodland dominated by Fir [*Abies* spp.]

*88.100.00 Grand Fir Forest [*Abies grandis*]

*88.100.01 Grand Fir Forest {82120}

88.200.00 Red Fir Forest [*Abies magnifica* var. *magnifica*] {85310}

88.200.01 Shasta Fir / Sadler Oak [*Abies magnifica* var. *shastensis/Quercus sadleriana*] (Imper 1988a)

*88.200.02 Shasta Fir / Thinleaf Huckleberry [*Abies magnifica* var. *shastensis/Vaccinium membranaceum*] (Imper 1988a)

88.200.03 Shasta Fir / Vanilla Leaf [*Abies magnifica* var.*shastensis/Achlys triphylla*] (Imper 1988a)

88.200.04 Shasta Fir / Pinemat Manzanita [*Abies magnifica* var. *shastensis/Arctostaphylos nevadensis*] (Imper 1988b)

88.200.05 Shasta Fir / Prince's-pine [*Abies magnifica* var. *shastensis/Chimaphila umbellata*] (Sawyer & Thornburgh 1977, Imper 1988b)

88.200.06 Shasta Fir / Slender Penstemon [*Abies magnifica* var. *shastensis/Penstemon gracilentus*] (Imper 1988b)

*88.200.07 Port Orford-cedar - Red Fir / Sadler Oak - Thinleaf Huckleberry [*Chamaecyparis lawsoniana-Abies magnifica* var.*magnifica/Quercus sadleriana-Vaccinium membranaceum*] (Jimerson 1993)

88.200.08 Red Fir / Sadler Oak [*Abies magnifica* var.*magnifica/Quercus sadleriana*] (Jimerson 1993)

88.200.09 Red Fir / Sadler Oak - Pinemat Manzanita [*Abies magnifica* var. *magnifica/Quercus sadleriana-Arctostaphylos nevadensis*] (Jimerson 1993)

*88.200.10 Red Fir - Incense-cedar [*Abies magnifica* var.*magnifica-Calocedrus decurrens*] (Jimerson 1993)

88.200.11 Red Fir / One-sided Shinleaf [*Abies magnifica* var. *magnifica/Orthilia secunda*] (Jimerson 1993)

*88.200.12 Red Fir / Rhododendron [*Abies magnifica* var. *magnifica /Rhododendron* spp.] (Jimerson 1993)

88.200.13 Red Fir / White-veined Shinleaf [*Abies magnifica* var. *magnifica /Pyrola picta*] (Jimerson 1993)

*88.200.14 Red Fir - Brewer Spruce / Sadler Oak -Thinleaf Huckleberry [*Abies magnifica* var. *magnifica-Picea breweriana/Quercus sadleriana-Vaccinium membranaceum*] (Jimerson 1993)

88.200.15 Red Fir -Mountain Hemlock / One-sided Shinleaf [*Abies magnifica* var. *magnifica-Tsuga mertensiana/Orthilia secunda*] (Jimerson 1993)

88.200.16 entry moved to 88.520.02

88.200.17 entry moved to 88.520.03

88.200.18 entry moved to 88.520.04

88.200.19 entry moved to 88.520.05

88.200.20 entry moved to 88.520.06

88.200.21 entry moved to 88.520.07

88.200.22 entry moved to 88.520.08

88.200.23 Red Fir [*Abies magnifica* var. *magnifica*] (Potter 1994)

88.200.24 Red Fir / Lodgepole Pine / Whiteflower Hawkweed [*Abies magnifica* var. *magnifica/Pinus contorta* ssp. *murrayana/Hieracium albiflorum*] (Potter 1994)
88.200.25 Red Fir / Lodgepole Pine [*Abies magnifica* var. *magnifica/Pinus contorta* ssp. *murrayana*] (Potter 1994)
88.200.26 Red Fir / Mule's Ears [*Abies magnifica* var. *magnifica/Wyethia mollis*] (Potter 1994)
88.200.27 Red Fir / Pinemat Manzanita [*Abies magnifica* var. *magnifica/Arctostaphylos nevadensis*] (Potter 1994)
88.200.28 Red Fir / Western White Pine / Pinemat Manzanita [*Abies magnifica* var. *magnifica/Pinus monticola/Arctostaphylos nevadensis*] (Potter 1994)
88.200.29 Red Fir - Western White Pine - Lodgepole Pine [*Abies magnifica* var. *magnifica-Pinus monticola-Pinus contorta* ssp. *murrayana*] (Potter 1994)
88.200.30 Red Fir - Western White Pine [*Abies magnifica* var. *magnifica-Pinus monticola*] (Potter 1994)
88.200.31 Red Fir / Western White Pine / Bush Chinquapin [*Abies magnifica* var. *magnifica/Pinus monticola/Chrysolepis sempervirens*] (Potter 1994)
88.200.32 entry moved to 88.520.01
88.200.33 entry moved to 88.520.09
88.200.34 entry moved to 88.510.02
88.200.35 Shasta Fir / Black-laurel [*Abies magnifica* var. *shastensis/Leucothoe davisiae*] (Sawyer & Thornburgh 1977)
88.200.36 Shasta Fir / Huckleberry Oak [*Abies magnifica* var. *shastensis /Quercus vaccinifolia*] (Sawyer & Thornburgh 1977)
88.200.37 Shasta Fir / Twinflower [*Abies magnifica* var. *shastensis/Linnaea borealis*] (Sawyer & Thornburgh 1977)
88.200.38 Shasta Fir / White-veined Shinleaf [*Abies magnifica* var. *shastensis/Pyrola picta*] (Sawyer & Thornburgh 1977)
88.200.39 Shasta Fir / Pinemat Manzanita [*Abies magnifica* var. *shastensis/Arctostaphylos nevadensis*] (Simpson 1980)
88.200.40 Shasta Fir / Sadler Oak [*Abies magnifica* var. *shastensis/Quercus sadleriana*] (Simpson 1980)
88.200.41 Red Fir / Silver Bush Lupine [*Abies magnifica* var. *magnifica/Lupinus albifrons*] (Waddell 1982)
88.200.42 Red Fir / White-veined Shinleaf [*Abies magnifica* var. *magnifica/Pyrola picta*] (Waddell 1982)

*88.300.00 Santa Lucia Fir Woodland [*Abies bracteata*] {84120}
88.300.01 Santa Lucia Fir / Santa Lucia Bedstraw [*Abies bracteata/Galium clementis*] (NDDB)
88.300.02 Santa Lucia Fir / Sword Fern [*Abies bracteata/Polystichum munitum*]

*88.400.00 Subalpine Fir Forest [*Abies lasiocarpa*]

88.500.00 White Fir Forest [*Abies concolor*] {85320}
88.500.01 White Fir / Bush Chinquapin [*Abies concolor/Chrysolepis sempervirens*] (Fites 1993)
88.500.02 White Fir / Creeping Snowberry / Kelloggia [*Abies concolor/Symphoricarpos mollis/Kelloggia galioides*] (Fites 1993)
88.500.03 White Fir - Pacific Dogwood / Bush Chinquapin [*Abies concolor-Cornus nuttallii/Chrysolepis sempervirens*] (Fites 1993)
88.500.04 White Fir - Pacific Dogwood / Hazel [*Abies concolor-Cornus nuttallii/Corylus cornuta*] (Fites 1993)
88.500.05 White Fir - Pacific Dogwood / Trail Plant [*Abies concolor-Cornus nuttallii*] (Fites 1993)
88.500.06 White Fir / Ross Sedge [*Abies concolor/Carex rossii*] (Fites 1993)
88.500.07 entry moved to 88.510.03

88.500.08	White Fir / Trail Plant [*Abies concolor/Adenocaulon bicolor*] (Fites 1993)
*88.500.09	White Fir / Vine Maple - Bush Chinquapin [*Abies concolor/Acer circinatum-Chrysolepis sempervirens*] (Fites 1993)
88.500.10	White Fir / Pinemat Manzanita [*Abies concolor/Arctostaphylos nevadensis*] (Imper 1988a)
88.500.11	White Fir / Prince's-pine [*Abies concolor/Chimaphila umbellata*] (Sawyer & Thornburgh 1977b, Imper 1988a)
88.500.12	White Fir / Vanilla Leaf [*Abies concolor/Achlys triphylla*] (Imper 1988a)
*88.500.13	moved to Port Orford Cedar Alliance
88.500.14	entry moved to 88.520.11
88.500.15	entry moved to 88.520.12
88.500.16	entry moved to 88.520.13
88.500.17	White Fir / Heartleaf Arnica [*Abies concolor/Arnica ordifolia*] (Jimerson 1993)
88.500.18	White Fir / Creeping Snowberry [*Abies concolor/Symphoricarpos mollis*] (Jimerson 1993)
88.500.19	White Fir - Douglas-fir / Bear-grass [*Abies concolor-Pseudotsuga menziesii/Xerophyllum tenax*] (Jimerson 1993)
88.500.20	White Fir - Douglas-fir / Bigleaf Maple [*Abies concolor-Pseduotsuga menziesii/Acer macrophyllum*] (Jimerson 1993)
88.500.21	White Fir - Douglas-fir / Heartleaf Arnica [*Abies concolor-Pseudotsuga menziesii/Arnica cordifolia*] (Jimerson 1993)
88.500.22	Moved to Douglas-fir alliance
88.500.23	White Fir - Douglas-fir / Sadler Oak [*Abies concolor-Pseudotsuga menziesii/Quercus sadleriana*] (Jimerson 1993)
88.500.24	Moved to Douglas-fir alliance
88.500.25	White Fir - Douglas-fir / Mountain Maple [*Abies concolor-Pseudotsuga menziesii/Acer glabrum*] (Jimerson 1993)
*88.500.26	moved to Douglas-fir alliance
88.500.27	White Fir - Douglas-fir / Vanilla Leaf [*Abies concolor-Pseudotsuga menziesii/Achlys triphylla*] (Jimerson 1993)
88.500.28	White Fir - Douglas-fir / Wild rose - Creeping Snowberry [*Abies concolor-Pseudotsuga menziesii/Rosa gymnocarpa-Symphoricarpos mollis*] (Jimerson 1993)
88.500.29	White Fir - Incense-cedar - Black Oak [*Abies concolor-Calocedrus decurrens-Quercus kelloggii*] (Jimerson 1993)
88.500.30	White Fir - Incense-cedar / Creeping Snowberry [*Abies concolor-Calocedrus decurrens/Symphoricarpos mollis*] (Jimerson 1993)
88.500.31	White Fir - Incense-cedar / White-veined Shinleaf [*Abies concolor-Calocedrus decurrens/Pyrola picta*] (Jimerson 1993)
88.500.32	White Fir / Little Prince's-pine - White-veined Shinleaf [*Abies concolor/Chimaphila menziesii-Pyrola picta*] (Jimerson 1993)
88.500.33	White Fir / Serviceberry [*Abies concolor/Amelanchier alnifolia*] (Jimerson 1993)
88.500.34	White Fir / Wild Rose [*Abies concolor/Rosa gymnocarpa*] (Jimerson 1993)
88.500.35	White Fir / Wild Rose - Creeping Snowberry [*Abies concolor/Rosa gymnocarpa-Symphoricarpos mollis*] (Jimerson 1993)
88.500.36	White Fir - Brewer Spruce / Sadler Oak - Thinleaf Huckleberry [*Abies concolor-Picea breweriana/Quercus sadleriana-Vaccinium membranaceum*] (Jimerson 1993)
*88.500.37	White Fir - Chinquapin [*Abies concolor-Chryoslepis chrysophylla*] (Jimerson 1993)
*88.500.38	White Fir - Chinquapin - Sugar Pine / Prince’s-pine [*Abies concolor-Chrysolepis chrysophylla-Pinus lambertiana/chimaphila umbellata*] (Jimerson 1993)

88.500.39 White Fir - Douglas-fir / Alaska Oniongrass [*Abies concolor-Pseudotsuga menziesii/Melica subulata*] (Jimerson 1993)
88.500.40 Moved to Douglas-fir alliance
88.500.41 Moved to Douglas-fir alliance
88.500.42 Moved to Douglas-fir alliance
88.500.43 Moved to Douglas-fir alliance
88.500.44 Moved to Douglas-fir alliance
88.500.45 White Fir - Douglas-fir / Wild Rose - Twinflower - Creeping Snowberry [*Abies concolor-Pseudotsuga menziesii/Rosa gymnocarpa-Linnaea borealis-Symphoricarpos mollis*] (Jimerson 1993)
88.500.46 White Fir - Douglas-fir / Wild Rose - Twinflower [*Abies concolor-Pseudotsuga menziesii/Rosa gymnocarpa-Linnaea borealis*] (Jimerson 1993)
88.500.47 entry moved to 88.520.14
88.500.48 entry moved to 88.520.15
88.500.49 entry moved to 88.520.16
88.500.50 White Fir / Huckleberry Oak [*Abies concolor/Quercus vaccinifolia*] (Laidlaw-Holmes 1981)
88.500.51 White Fir / Bracken [*Abies concolor/Pteridium aquilinum*] (Sawyer 1981b)
88.500.52 White Fir / Sadler Oak [*Abies concolor/Quercus sadleriana*] (Sawyer 1981b)
88.500.53 White Fir / American Vetch [*Abies concolor/Vicia americana*] (Sawyer & Thornburgh 1977)
88.500.54 White Fir / Little Oregon-grape [*Abies concolor/Berberis nervosa*] (Sawyer & Thornburg 1977)
88.500.55 White Fir / Prince's-pine [*Abies concolor/Chimaphila umbellata*] (Sawyer & Thornburgh 1977)
88.500.56 White Fir / Mahala Carpet [*Abies concolor/Ceanothus prostratus*] (Sawyer & Thornburgh 1977)
88.500.57 White Fir / Trillium [*Abies concolor/Trillium ovatum*] (Sawyer & Thornburgh 1977)
88.500.58 White Fir / Bitter Cherry [*Abies concolor/Prunus emarginata*] (Taylor & Randall 1977)
88.500.59 White Fir / Rattlesnake-plantain [*Abies concolor/Goodyera oblongifolia*] (Taylor & Randall 1977)
88.500.60 White Fir / Mountain Maple [*Abies concolor/Acer glabrum*] (Taylor & Teare 1979b)
88.500.61 White Fir / Sticky Starwort [*Abies concolor/Pseudostellaria jamesiana*] (Waddell 1982)
88.500.62 White Fir / White-veined Shinleaf [*Abies concolor/Pyrola picta*] (Waddell 1982)
*88.500.63 Desert Mountain White Fir Forest
88.500.64 Sierran White Fir Forest {84240}
88.500.65 Southern California White Fir Forest {85320}
88.500.66 White Fir / Mountain Whitehorn [*Abies concolor/Ceanothus cordulatus*] (Keeler-Wolf and Moore 2001)

88.510.00 White Fir - Sugar Pine Forest [*Abies concolor-Pinus lambertiana*] (Keeler-Wolf and Moore 2001)
88.510.01 White Fir - Sugar Pine [*Abies concolor-Pinus lambertiana*] (Keeler-Wolf and Moore 2001)
88.510.02 White Fir - Sugar Pine - Red Fir [*Abies concolor-Pinus lambertiana-Abies magnifica* var. *magnifica*] (Potter 1994)
88.510.03 White Fir - Sugar pine / False solomon's seal - Hooker fairybells [*Abies concolor-Pinus lambertiana/Smilacina racemosa-Disporum hookeri*] (Fites 1993)

88.510.04 White Fir - Sugar Pine - Jeffrey Pine [*Abies concolor-Pinus lambertiana-Pinus jeffreyi*] (Keeler-Wolf and Moore 2001)

88.510.05 White Fir - Sugar Pine - Incense Cedar / Pacific Dogwood / California Hazel [*Abies concolor-Pinus lambertiana-Calocedrus decurrens/Cornus nuttallii/ Corylus cornuta* var. *californica*] (Keeler-Wolf and Moore 2001)

88.510.06 White Fir - Sugar Pine - Incense Cedar / Trail Plant [*Abies concolor-Pinus lambertiana-Calocedrus decurrens/Adenocaulon bicolor*] (*Sensu.* Fites 1993 *Abies concolor*-Mixed Conifer/*Adenocaulon bicolor*) (Keeler-Wolf and Moore 2001)

88.510.07 White Fir - Sugar Pine - Incense Cedar / Bush Chinquapin / Multi-stemmed Sedge [*Abies concolor-Pinus lambertiana-Calocedrus decurrens/Chrysolepis sempervirens/Carex multicaulis*] (*Sensu.* Fites 1993 *Abies concolor*-Mixed Conifer/*Chrysolepis sempervirens*) (Keeler-Wolf and Moore 2001)

88.510.08 White Fir - Sugar Pine - Incense Cedar / Creeping Snowberry / Kelloggia [*Abies concolor-Pinus lambertiana-Calocedrus decurrens/Symphoricarpos mollis/Kelloggia galioides*] (*Sensu.* Fites 1993 *Abies concolor*-Mixed Conifer/*Symphoricarpos mollis/Kelloggia galioides*) (Keeler-Wolf and Moore 2001)

88.520.00 Red Fir - White Fir Forest [*Abies magnifica* var. *magnifica-Abies concolor*] (Parker 1984, Parker 1982)

88.520.01 Red Fir - White Fir [*Abies magnifica* var. *magnifica-Abies concolor*] (Potter 1994)

88.520.02 Red Fir - White Fir / Bracken [*Abies magnifica* var. *magnifica-Abies concolor/Pteridium aquilinum*] (Jimerson 1993)

88.520.03 Red Fir - White Fir / Heartleaf Arnica [*Abies magnifica* var. *magnifica-Abies concolor/Arnica cordifolia*] (Jimerson 1993)

88.520.04 Red Fir - White Fir / Creeping Snowberry / White-veined Shinleaf [*Abies magnifica* var. *magnifica-Abies concolor/Symphoricarpos mollis/Pyrola picta*] (Jimerson 1993)

88.520.05 Red Fir - White Fir / Creeping Snowberry - Wild Rose [*Abies magnifica* var. *magnifica-Abies concolor/Syphoricarpos mollis-Rosa gymnocarpa*] (Jimerson 1993)

88.520.06 Red Fir - White Fir / Sadler Oak [*Abies magnifica* var. *magnifica-Abies concolor/Quercus sadleriana*] (Jimerson 1993)

88.520.07 Red Fir - White Fir / Pinemat Manzanita [*Abies magnifica* var. *magnifica-Abies concolor/Arctostaphylos nevadensis*] (Jimerson 1993)

88.520.08 Red Fir - White Fir / Vanilla Leaf [*Abies magnifica* var. *magnifica-Abies concolor/Achlys triphylla*] (Jimerson 1993)

88.520.09 Red Fir - White Fir - Jeffrey Pine [*Abies magnifica* var. *magnifica-Abies concolor-Pinus jeffreyi*] (Potter 1994)

88.520.10 Red Fir - White Fir - Sugar Pine [*Abies magnifica* var. *magnifica-Abies concolor/Pinus lambertiana*] (Potter 1994)

88.520.11 Shasta Fir - White Fir / Mountain Maple [*Abies magnifica* var. *shastensis-Abies concolor/Acer glabrum*] (Jimerson 1993)

88.520.12 Shasta Fir - White Fir / Pinemat Manzanita [*Abies magnifica* var. *shastensis-Abies concolor/Arctostaphylos nevadensis*] (Jimerson 1993)

88.520.13 Shasta Fir - White Fir / Trail Penstemon - Mountain Monardella [*Abies magnifica* var. *shastensis-Abies concolor/Penstemon anguineus-Monardella odoratissima*] (Jimerson 1993)

88.520.14 White Fir - Shasta Fir / Sadler Oak [*Abies concolor-Abies magnifica* var. *shastensis/Quercus sadleriana*] (Jimerson 1993)

88.520.15 White Fir - Shasta Fir / White-veined Shinleaf [*Abies concolor-Abies magnifica* var. *shastensis/Pyrola picta*] (Jimerson 1993)

88.520.16 White Fir - Shasta Fir / Threeleaf Anemone [*Abies concolor-Abies magnifica* var. *shastensis/Anemone deltoidea*] (Jimerson 1993)

88.600.00 Mixed Conifer Forest {84230}

*88.600.01 Mixed Conifer / Bolander Bedstraw - Milkwort [Mixed Conifer/*Galium bolanderi-Polygala cornuta*] (Fites 1993)

88.600.02 Mixed Conifer / Huckleberry Oak [Mixed Conifer/*Quercus vaccinifolia*] (Fites 1993)

88.600.03 Mixed Conifer / Rosy Everlasting - Naked-stemmed Buckwheat [Mixed Conifer/*Antennaria rosea-Eriogonum latifolium*] (Fites 1993)

88.600.04 Mixed Conifer / Service Berry [Mixed Conifer/*Amelanchier alnifolia*] (Fites 1993)

88.600.05 moved to Ponderosa pine- Incense cedar alliance

*88.600.06 Mixed Conifer / Starflower [Mixed Conifer/*Trientalis latifolia*] (Fites 1993)

88.600.07 Mixed Conifer - Canyon Live Oak / Hazel [Mixed Conifer-*Quercus chrysolepis/Corylus cornuta*] (Fites 1993)??

88.600.08 moved to Ponderosa pine – Incense-cedar alliance

88.600.09 moved to Ponderosa pine – Incense-cedar alliance

88.600.10 Moved to Douglas-fir – Canyon live oak Alliance

*88.600.11 Mixed Conifer – Tanoak / Mountain Dogwood [Mixed Conifer-*Quercus chrysolepis/Cornus nuttallii*] (Fites 1993)

*88.600.12 Moved to White fir - Sugar Pine Alliance

88.600.13 Mixed Conifer / Little Oregon-grape [Mixed Conifer/*Berberis nervosa*] (Sawyer & Thornburgh 1977)

88.600.14 Mixed Conifer / Mahala Carpet [Mixed Conifer/*Ceanothus prostratus*] (Sawyer & Thornburgh 1977)

88.600.15 Southern Ultramafic Mixed Coniferous Forest {84182}

88.600.16 Coast Range Mixed Coniferous Forest {84110}

88.600.17 Ultramafic Mixed Coniferous Forest {84180}

88.600.18 Sierran Mixed Coniferous Forest {84230}

*88.700.00 Klamath Enriched Conifer Unique Stands {85400}{85410}{85420}

*88.800.00 Pacific Silver Fir Unique Stands [*Abies amabilis*]

89.000.00 Juniper Woodlands [*Juniperus* spp.]

89.100.00 California Juniper Woodland and Scrub [*Juniperus californica*]

*89.100.01 Juniper - Oak Cismontane Woodland {71430}

*89.100.02 Cismontane Juniper Woodland & Scrub {72400}

89.100.03 California Juniper - Desert Agave [*Juniperus californica-Agave deserti*] (Keeler-Wolf *et al*, 1998)

89.100.04 California Juniper / Blackbush [*Juniperus californica/Coleogyne ramosissima*] (Keeler-Wolf *et al*, 1998)

89.100.05 California Juniper - Muller Oak / Blackbush [*Juniperus californica-Quercus cornelius-mulleri/Coleogyne ramosissima*] (Keeler-Wolf and Thomas 2000)

89.100.06 California Juniper / Blackbush - Mojave Yucca [*Juniperus californica/Coleogyne ramosissima-Yucca schidigera*] (Keeler-Wolf and Thomas 2000)

89.100.07 California Juniper / Desert Needlegrass [*Juniperus californica/Achnatherum speciosum*] (Keeler-Wolf and Thomas 2000)

89.100.08 California Juniper - Mojave Yucca / Big Galleta [*Juniperus californica-Yucca schidigera/Pleuraphis rigida*] (Keeler-Wolf 2001)

89.100.09 California Juniper / Desert Needlegrass [*Juniperus californica/Achnatherum speciosum*] (Keeler-Wolf 2001)
89.100.10 California Juniper / California Buckwheat [*Juniperus californica/Eriogonum fasciculatum*] (Keeler-Wolf 2001)
89.100.11 California Juniper / Parry's Nolina [*Juniperus californica/Nolina parryi*] (Keeler-Wolf 2001)

*89.200.00 Mountain Juniper Woodland [*Juniperus occidentalis* ssp. *australis*]
89.200.01 Mountain Juniper [*Juniperus occidentalis* ssp. *australis*] (Potter 1994)
89.200.02 Mountain Juniper / Big Sagebrush [*Juniperus occidentalis* ssp. *australis*/*Artemisia tridentata*] (Potter 1994)
89.200.03 Mountain Juniper / Curl-leaf Mountain Mahogany / Big Sagebrush [*Juniperus occidentalis* ssp. *australis/Cercocarpus ledifolius/Artemisia tridentata*] (Keeler-Wolf and Moore 2001)
89.200.04 Mountain Juniper / Ocean Spray [*Juniperus occidentalis* ssp. *australis/Holodiscus discolor*] (Keeler-Wolf and Moore 2001)

89.300.00 Utah Juniper Woodland {72123}
89.300.01 Utah Juniper [*Juniperus osteosperma*] (Keeler-Wolf and Thomas 2000)
89.300.02 Utah Juniper / Big Sagebrush - Green Ephedra [*Juniperus osteosperma/Artemisia tridentata-Ephedra viridis*] (Keeler-Wolf and Thomas 2000)
89.300.03 Utah Juniper / Big Sagebrush - Desert Bitterbrush - Nevada Ephedra [*Juniperus osteosperma/Artemisia tridentata-Purshia glandulosa-Ephedra nevadensis*] (Keeler-Wolf and Thomas 2000)
89.300.04 Utah Juniper / California Buckwheat [*Juniperus osteosperma-Eriogonum fasciculatum*] (Keeler-Wolf and Thomas 2000)
89.300.05 Utah Juniper / Sticky Snakeweed [*Juniperus osteosperma/Gutierrezia microcephala*] (Keeler-Wolf and Thomas 2000)
89.300.06 Utah Juniper / Shadscale [*Juniperus osteosperma/Atriplex confertifolia*] (Keeler-Wolf and Thomas 2000)
89.300.07 Utah Juniper / White Bursage [*Juniperus osteosperma/Ambrosia dumosa*] (Keeler-Wolf and Thomas 2000)
89.300.08 Utah Juniper / Blackbush [*Juniperus osteosperma/Coleogyne ramosissima*] (Keeler-Wolf and Thomas 2000)
89.300.09 Utah Juniper / Blackbush / Galleta [*Juniperus osteosperma/Coleogyne ramosissima/Pleuraphis jamesii*] (Keeler-Wolf and Thomas 2000)
89.300.10 Utah Juniper / Spanish Bayonet [*Juniperus osteosperma*/*Yucca baccata*] (Keeler-Wolf and Thomas 2000)
89.300.11 Utah Juniper / Nevada Ephedra / Desert Needlegrass [*Juniperus osteosperma/Ephedra nevadensis/Achnantherium speciosum*] (Keeler-Wolf and Thomas 2000)

89.400.00 Western Juniper Woodland [*Juniperus occidentalis ssp. occidentalis*]
89.400.01 Northern Juniper Woodland {72110}

89.500.00 Singleleaf Pinyon - Utah Juniper Woodland [*Pinus monophylla-Juniperus* spp.] {72121}

89.600.00 Great Basin Woodlands {72100}

89.700.00 Mojave Juniper Woodland and Scrub {72220}

89.800.00 Peninsular Juniper Woodland and Scrub {72320}

90.000.00 ALPINE HABITATS

91.000.00 Boulder and Rock Field

91.100.00 Alpine Fell-field (= Alpine Habitat from book)

91.110.00 Klamath-Cascade Fell-field {91110}

91.120.00 Sierra Nevada Fell-field {91120}

*91.120.01 Sierra Primrose [*Primula suffrutenscens*] (Burke 1982)
91.120.02 Alpine Pussypaws - Heretic Penstemon [*Antennaria alpina-Penstemon heterodoxus*] (Major & Taylor 1977)
91.120.03 Alpine Pyrrocoma [*Haplopappus aparigoides*] (Major & Taylor 1977)
91.120.04 Dense Draba - Sweetwater Mountain Milkvetch [*Draba densiflora-Astragalus kentrophyta* var. *danaus*] (Major & Taylor 1977, Taylor 1984)
91.120.05 Hairy Draba - Inyo Rock-cress [*Draba oligosperma-Arabis inyoensis*] (Major & Taylor 1977)
91.120.06 Muir Ivesia [*Ivesia muirii*] (Major & Taylor 1977)
*91.120.07 Netted Willow [*Salix nivalis*] (Major & Taylor 1977)
91.120.08 Podistera - King Sandwort [*Podistera nevadensis-Arenaria kingii*] (Major & Taylor 1977)
91.120.09 Podistera - Pygmy Daisy [*Podistera nevadensis-Erigeron pygmaeus*] (Major & Taylor 1977)
*91.120.10 Sibbaldia - Merten Rush [*Sibbaldia procumbens-Juncus mertensianus*] (Major & Taylor 1977)
91.120.11 Silky Raillardella - Tawny Buckwheat [*Raillardella argentea-Eriogonum incanum*] (Major & Taylor 1977)
91.120.12 Stemless Haplopappus - Old Man's Whiskers [*Stenotus acaulis-Geum canescens*] (Major & Taylor 1977)
91.120.13 Watson Spikemoss - Round-leaved Buckwheat [*Selaginella watsonii-Eriogonum ovalifolium*] (Major & Taylor 1977)
91.120.14 Western Needlegrass - Nude Buckwheat [*Stipa occidentalis-Eriogonum nudum*] (Major & Taylor 1977)
*91.120.15 Alpine Alumroot - Fragile Fern [*Heuchera rubescens-Cystopteris fragilis*] (Taylor 1984)
91.120.16 entry moved to 38.120.03
*91.120.17 entry moved to 91.125.01
91.120.18 Alpine Sedum - Watson Spikemoss [*Sedum roseum-Selaginella watsonii*] (Taylor 1984)
91.120.19 Alpine Smartweed [*Polygonum minimum*] (Taylor 1984)
*91.120.20 Alpine Timothy - One-spike Oatgrass [*Phleum alpinum-Danthonia unispicata*] (Taylor 1984)
91.120.21 Baltic Rush [*Juncus balticus*] (Taylor 1984)
*91.120.22 entry moved to 61.216.00
91.120.23 Cordilleran Arnica - Davidson Arabis [*Arnica mollis-Arabis davidsonii*] (Taylor 1984)
91.120.24 Coville Phlox - Vagus Buckwheat [*Phlox pulvinata-Eriogonum incanum*] (Taylor 1984)
91.120.25 King Ricegrass - Sierra Ragwort [*Ptilagrostis kingii-Senecio scorzonella*] (Taylor 1984)
91.120.26 entry moved to 91.122.01
91.120.27 Merten Rush [*Juncus mertensianus*] (Taylor 1984)
*91.120.28 Moss Saxifrage [*Saxifraga bryophora*] (Taylor 1984)
91.120.29 Mountain Sedum - Mountain Muhly [*Sedum obtusatum-Muhlenbergia montana*] (Taylor 1984)
91.120.30 entry moved to 91.124.01
91.120.31 Nevada Claytonia [*Claytonia nevadensis*] (Taylor 1984)
91.120.32 Tiling Monkeyflower - One-sided Bluegrass [*Mimulus tilingii-Poa secunda*] (Taylor 1984)

91.120.33 entry moved to 38.120.01
91.120.34 entry moved to 41.560.01
91.120.35 Podistera - Pygmy Daisy [*Podistera nevadensis-Erigeron pygmaeus*] (Taylor 1984)
91.120.36 Showy Fescue - Davidson Penstemon [*Festuca minutiflora-Penstemon davidsonii*] (Taylor 1984)
91.120.37 Vagus Buckwheat - Silky Raillardella [*Eriogonum incanum-Raillardella argentea*] (Taylor 1984)
91.120.38 entry moved to 91.128.01

91.121.00 Alpine Hulsea [*Hulsea algida*] (Keeler-Wolf and Moore 2001)

91.122.00 Alpine Sorrel [*Oxyria digyna*] (Taylor 1984)
91.122.01 Lemmon Draba - Alpine Sorrel [*Draba lemmonii-Oxyria digyna*] (Taylor 1984)

91.123.00 Coville Phlox - Squirreltail [*Phlox covillei-Elymus elymoides*] (Taylor 1984)
91.123.01 Coville Phlox - Squirreltail - Alpine Podistera [*Phlox covillei-Elymus elymoides-Podistera nevadensis*] (Taylor 1984)
91.123.02 Coville Phlox - Squirreltail - Alpine Podistera - Pygmy Daisy [*Phlox covillei-Elymus elymoides-Podistera nevadensis-Erigeron pygmaeus*] (Taylor 1984)

91.124.00 Nested Saxifrage - Suksdorf Monkeyflower [*Saxifraga nidifica-Mimulus rubellus*] (Taylor 1984)
91.124.01 Nested Saxifrage - Suksdorf Monkeyflower [*Saxifraga nidifica-Mimulus suksdorfii*] (Taylor 1984)

91.125.00 Alpine Saxifrage [*Saxifraga tolmiei*] (Keeler-Wolf and Moore 2001)
*91.125.01 Alpine Saxifrage - Woodrush [*Saxifraga tolmiei-Luzula divaricata*] (Taylor 1984)

*91.130.00 Southern California Fell-field {91130}

91.140.00 White Mountains Fell-field {91140}
91.140.01 Mason's Sky Pilot - Vagus Fleabane [*Polemonium chartaceum-Erigeron vagus*] (Major & Taylor 1977)
91.140.02 Coville Phlox - Inyo Buckwheat [*Phlox pulvinata-Eriognoum gracilipes*] (Major & Taylor 1977)

91.150.00 Sweetwater Mountains Fell-field
91.150.01 Compact Phlox - Gordon Ivesia [*Phlox pulvinata-Ivesia muirii*] (Major & Taylor 1977)
91.150.02 Compact Phlox - Alpine Phoenicaulis [*Phlox pulvinata-Anelsonia eurycarpa*] (Major & Taylor 1977)
91.150.03 Compact Phlox - Small Haplopappus - Alpine Ipomopsis [*Phlox pulvinata-Ericameria suffrutenscens-Ipomopsis congesta*] (Major & Taylor 1977)
91.150.04 Compact Phlox - Sweetwater Lupine [*Phlox pulvinata-Lupinus montigenus*] (Major & Taylor 1977)

91.160.00 Subalpine Upland Shrub Habitat {<u>includes</u> 94000}

91.200.00 Alpine and Talus Scree Slope{91200}

91.210.00 Wet Alpine Talus and Scree Slope{91210}

	91.220.00	Dry Alpine Talus and Scree Slope{91220}
	91.300.00	Alpine Snowbank Margin {91300}
92.000.00	Alpine Snow and Ice Habitat	
	92.100.00	Alpine Snowfield {93100}
	92.200.00	Alpine Glacier {93200}
99.000.00	Non-Vegetated Desert	
	99.900.01	Sandy to Cobbly wash bottom
	99.900.02	Gypsum
	99.900.03	Mud hills
	99.900.04	Low Elevation Rock Outcrop
	99.900.05	Upper Elevation Rock Outcrop
	99.900.07	Playa

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Degradation of sandy arid shrubland environments: observations, process modelling, and management implications

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Field remote sensing, and modelling observations from a degraded Mojave Desert shrubland were used to develop a model of the progressive degradation of areas adjacent to sites of direct anthropogenic disturbance. Aeolian removal and transport and dust, sand, and litter are the primary mechanisms of degradation, killing plants by burial and abrasion, interrupting natural processes of nutrient accumulation, and allowing the loss of soil resources by abiotic transport. It is concluded that any arid shrubland with wind-erodible soils is susceptible to degradation, and where possible development of these lands should be avoided.

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Keywords: desertification; wind erosion; Mojave Desert; shrublands; paleolakes; agriculture

Introduction

The Manix Basin in the Mojave Desert of south-eastern California is the site of ancient Lake Manix (Buwalda, 1914; Meek, 1989, 1990; Dohrenwend *et al.*, 1991). Far from being a unique geological setting, the fine-grained lacustrine sediments in the basin are part of the Pleistocene legacy shared by depressions throughout the entire basin and Range and Mojave provinces (Smith & Street-Perrott, 1983). Morrison (1991*b*, 1991*a*) has reported that 'nearly all closed or formerly closed basins in the Great Basin have ancient strandlines marked by lacustrine bars, spits, embankments, terraces, deltas, and wave-cut cliffs at elevations well above the playas or permanent lakes of today'. The lacustrine sediments of Pleistocene age that form the floors of these basins share qualities that make them amenable for agriculture and other human activities: very low slopes, little or o relief, subsurface water resources, and fine-grained sediments suitable for farming or other activities. The intersection of the human uses of Pleistocene paleolakes with their geological history creates opportunities for land degradation much greater than typically recognized.

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Wind erosion in the Mojave Desert is the principle mechanism of land degradation. Agriculture, urban development, military maneuvers, pipeline, road and powerline construction, and recreational vehicles all destroy vegetation cover and expose the soil to wind erosion (Sharifi *et al.*, 1999). These activities can result in increased dust emission, blowing sand, and damage of native vegetation.

Although the processes of arid land degradation have been well-established elsewhere in the south-western U.S. (see for example, Schlesinger *et al.*, 1990), no published process model exists for shrubland degradation in the Mojave Desert or other shrublands. In this paper, we report on the importance of human-induced wind erosion in initiating and propagating land degradation in the Manix Basin of the Mojave Desert. Based on these observations, we develop a model of wind-driven desertification in sandy arid shrublands.

Arid land degradation has received significant attention in the technical and popular media over the past several decades. Much of this interest has been practical in nature owing to the facts that: (1) desertification is widespread throughout the south-western United States and globally (Mabbutt & Floret, 1980; Walker, 1982; Warren & Hutchinson, 1984; Verstraete & Schwartz, 1991; Khalaf & Al-Ajmi, 1993; Dregne, 1995); (2) it has severe financial and societal consequences including property damage, increased health and safety hazards, and decreased agricultural productivity (Clements *et al.*, 1963; Bowden *et al.*, 1974; Fryrear, 1981; Hyers & Marcus, 1981; Leathers, 1981; Leys & McTainsh, 1994; Bach, 1998); and (3) some forms of desertification are irremediable on human timescales at reasonable cost (Whitford, 1992; Dregne, 1995). The increasing use of desert shrublands by humans for habitation, agriculture, industry, and recreation increases the amount of arid land directly impacted (Verstraete & Schwartz, 1991). Thus, it is important to understand the processes of arid land degradation in these environments. Improved process understanding will allow improved identification of areas at heightened risk of desertification before serious damage has occurred.

History and features of the Manix Basin, California

Our observations are drawn from the Manix Basin in the Mojave Desert, about 25 miles ENE of Barstow in south-eastern California (centred around 34°56·5′N·116°41·5′ W at an elevation of about 540 m). The basin has an area of 40,700 ha and was the site of ancient Lake Manix which existed during the peak pluvial episode of the last glaciation and drained through Afton Canyon to the east (Smith & Street-Perrott, 1983; Meek, 1989). Much of the basin is filled with lacustrine, fluvial, and deltaic sediments capped by weak armoring (Meek, 1990). There is clear evidence of pre-modern wind erosion, indicating that wind erosion, transport, and deposition has long been a dominant geological process in the area (Evans, 1992).

The modern climate of the Manix Basin is arid with an average annual precipitation of 100 mm, falling mostly in the winter, although there can be significant summer precipitation in some years (Table 1). The average annual temperature is 19·6°C, the average

Table 1. *Average precipitation (cm) by season at Daggett Airport*

	Jan–Mar	Apr–Jun	Jul–Sept	Oct–Dec	Annual
1944–1997	3·7	0·9	2·9	2·4	10·0
1980–1989	4·5	1·1	3·1	3·1	12·7
1990–1997	6·0	0·3	2·8	2·0	11·1

Source: National Climate Data Center, U.S. Precipitation by State, California: http://www.ncdc.noaa.gov/ol/climate/online/coop-precip.html

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winter temperature of 9·1°C, and the average summer temperature is 31·4°C (Meek, 1990). The average wind speed at the airport in Daggett is 5·5 m s^{-1} at a height of 6·1 m and is typically from the west (National Climate Data Center, 1993).

The vegetation in undisturbed areas of the basin in dominated by an association of *Larrea tridentata* and *Ambrosia dumosa*, with minor occurrence of *Atriplex polycarpa, Atriplex hymenelytra, Atriplex canescens, Ephedra californica,* and *Opuntia* spp. *Prosopis glandulosa* occurs in some areas of the basin. Areas that have been disturbed directly by human activity are dominated by *A. polycarpa* with total cover often greater than that in undisturbed desert. *Schismus*, an exotic annual grass, in ubiquitous, but grass cover varies significantly with yearly precipitation.

There has been extensive human activity in the Manix Basin with several phases of agriculture utilizing ground-water recharged by the Mojave River. The basin was used for dryland farming in the 1800s (Tugel & Woodruff, 1978). Limited irrigated farming started in the basin in 1902 with the acreage of irrigated land increasing sharply after World War II (Tugel & Woodruff, 1978). Today alfalfa hay is the major agricultural product. In the Coyote Dry Lake sub-basin, square flood-irrigated fields and abandoned flood irrigation equipment are seen in early Landsat images. After the mid-1970s, central-pivot agriculture became the dominant form of land use in the area, but many fields have since been abandoned throughout the northern part of the basin due to increasing costs of ground-water pumping (Ray, 1995).

Methods

In this study a series of Landsat Multispectral Scanner (MSS) and Airborne Visible Infrared Imaging Spectrometer (AVIRIS) images from the Manix Basin from 1979, 1982, 1985, 1988, 1997, and 1998 were used in order to identify areas of blowing sand associated with central-pivot agriculture in the basin. AVIRIS measures the total upwelling spectral radiance in 224 bands from 400 to 2500 nm in 20-m ground pixels from a NASA ER-2 aircraft flying at 20-km altitude. Landsat MSS measured upwelling radiation in four visible-near infrared broad multispectral bands in 80-m ground pixels. Geographical information about the extent and locations of blowing sand were the object of the remote sensing analysis. Simple spatial information is readily available from uncalibrated remote sensing images. Therefore, no attempt was made to calibrate the images or correct for atmospheric scattering. The images were incorporated into a geographical information system.

A series of field trips between 1996 and 1999 were undertaken to the Manix Basin in order to verify remote-based observations of sand blow-outs. In 1998 and 1999, perennial vegetation cover was estimated at several sites in the Manix Basin by measuring individual plant diameters in circular plots with 5-m radii (12 replicates each) and assuming full, circular shrub canopies.

Finally, a quantitative assessment of observed wind erosion and deposition rates was undertaken in order to link observed phenomena with physical and mathematical wind erosion models.

Results and discussion

Remote observation from the Manix Basin

The Landsat MSS and AVIRIS images taken in Fig. 1 clearly indicate the growth of sand blow-outs downwind of abandoned agricultural fields in the Manix Basin. Deposition of sand downwind of the fields is a progressive process, with sand plumes lengthening in each successive image. No regrowth of perennial vegetation was observed in these

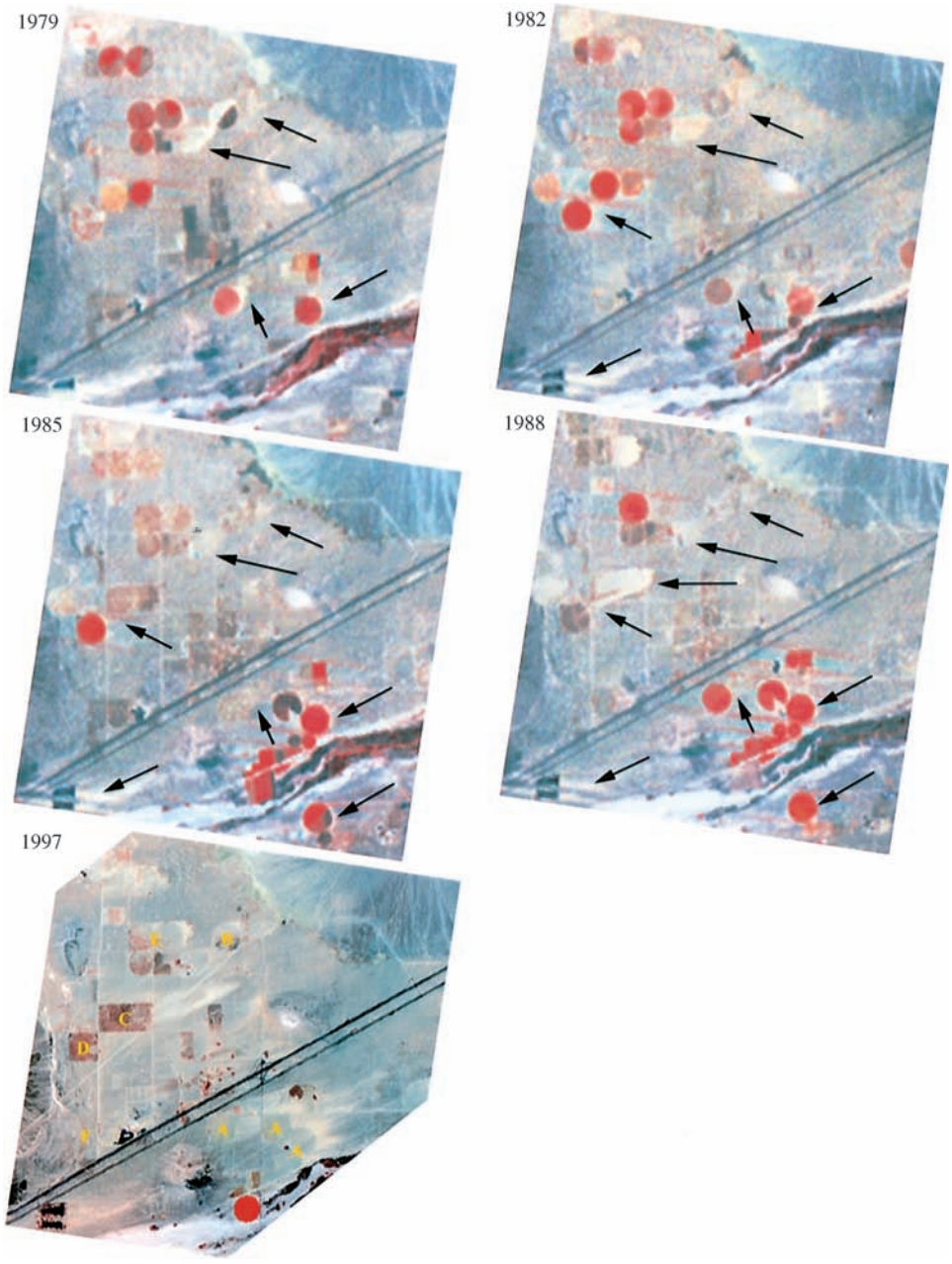

Figure 1. 1979–1988: Landsat Multispectral Scanner (MSS) images of the Manix Basin. Red is MSS band 4 (800–1100 nm), green in MSS band 2 (600–700 nm), and blue is MSS band 1 (500–600 nm). Interstate 15 goes diagonally through the centre of the images. North is up and active fields appear bright red in these images. The wind blows from west to east across the basin causing sand blowouts to appear as bright areas east of the fields. Arrows indicate the progressive appearance of sand mobilized from agricultural fields. 1997: An Airborne Visible Infrared Imaging Spectrometer (AVIRIS) image of the same area taken in 1997, and processed to display colours in the same way as in the MSS images. The relative sharpness of this image is due to the higher spatial resolution of the AVIRIS instrument. The dark-red area C consists of two fields covered with *A. polycarpa* while area A is an abandoned field with very little shrub cover. Both areas exhibit dramatic sand blowouts downwind.

Table 2. *Direct and indirect disturbance for some selected fields in the Manix Basin*

Location (see Fig. 1)	Total time cultivated (years)	Time since abandonment (years)	Soil Texture	Area subject to direct disturbance (ha)	Area subject to indirect disturbance (ha)	Indirect/direct (area ratio)
A	> 7	< 10	Sand/loamy sand	185	518	2·8
B	1	26	Sand/loamy sand	62	109	1·8
C	5	15, 17	Sand	182	241	1·3
D	6	11	Loamy sand	79	91	1·2
E	6 to 8	10, 14	Loamy sand	124	33	0·3

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sand plumes. Thus, the occasional darkening of the sand blow-outs is inferred to be due to annual vegetation related to winter rainfall. Annual cover can be relatively high in wet years, but seldom lasts through the spring and summer months.

Anthropogenic disturbance in the Manix Basin may be separated into two types: direct and indirect. Direct anthropogenic disturbance refers to human activities and the consequence of those activities in the area in which they were performed. This includes the actual fields, roads, pastures, corrals, trails, and so on that are affected by land use practices. Indirect disturbance refers to the consequences of direct disturbance in areas not directly disturbed. Our observations demonstrate that both direct and indirect disturbance are extensive in the Manix Basin, and that they are coupled by wind erosion and redeposition of wind-blown sediment.

Ray (1995) has reported that in 1985 agriculture in the Manix Basin reached its greatest extent with 37 active central-pivot irrigated fields accounting for 3062 ha of land in cultivation. Agricultural activity in the basin has decreased in the last decade. Thus, at least 3000 ha of land have been directly disturbed in the Manix Basin. By areal analysis of 1998 AVIRIS data, the relative areas of direct and indirect disturbance were identified in the form of sand blow-outs, for some of the fields in the Manix Basin (Table 2). No clear relationship was found between time of abandonment nor of cultivation with the magnitude of indirect disturbance. All fields were located in soils with sandy or loamy sand soils, the dominant soil textures in the basin (Tugel & Woodruff, 1978).

Sand may be blown several kilometres beyond the downwind boundary of a field and therefore the area of indirect disturbance can exceed the directly disturbed area by several-fold. With 3000 ha of land directly disturbed in the basin, 3000 to 9000 ha of land may be expected to be indirectly disturbed by agriculture. This sums to 6000–12,000 ha total disturbance or 15–30% of the total basin floor area, and approximately 23–45% of the non-playa area of the basin. Other disturbances, such as housing developments and roads are also present in the basin, while large areas of the basin are taken up by the Coyote and Troy playas. Anthropogenic degradation appears to have a major impact on land quality and status in the Manix Basin.

Field observations in the Manis Basin

Direct disturbance

Before the fields of the Manix Basin could be cultivated they were cleared of vegetation. Vegetation cover shelters the soil from the erosive force of the wind by: (1) reducing the force of the wind near the ground; (2) extracting momentum above the surface (Wolfe & Nickling, 1993); and (3) trapping soil particles in transport (Lancaster & Baas, 1998). Tillage destroys fragile surface armours, thereby reducing the threshold shear velocity (Gillette *et al.*, 1980; Gillette, 1988; Tegen & Fung, 1955; López, 1998). Vegetation removal and soil cultivation, therefore, have the combined effect of dramatically increasing soil erodibility in the Manix Basin (as seen in Fig. 1). Mechanical agriculture itself visibly mobilizes dust and sand on windy days and ensures that the soil surface is exposed for at least part of the year. Active fields, therefore, become sustained sources of material for aeolian transport immediately upon clearing.

The magnitude of deflation associated with wind erosion of agricultural fields in the Manix Basin is difficult to quantify. However, in one agricultural field in the Manix Basin abandoned about 30 years ago (Fig. 1, area F), wind erosion has led to an average deflation rate of more than 1·5 cm per year, as evidence by wind excavation of buried irrigation pipes. These pipes provide a rare field constraint on deflation, as the vertical feeder sections were once flush with the ground.

Areas that have been cleared to vegetation and then abandoned follow one of two principal trajectories with respect to their vegetative cover. Areas may be recolonized

Table 3. *Percent cover by species in undisturbed desert compared with areas on abandoned central-pivot agriculture fields*

	Undisturbed	On-field (low-cover)	On-field (high cover)
Larrea tridentata	4·8%	0·8%	0·0%
Ambrosia dumosa	1·1%	0·4%	0·0%
Atriplex polycarpa	0·8%	8·3%	32·5%
Total fractional cover	6·7%	9·5%	32·5%

Plant counts were carried out in February 1998 and April 1999 in 5-m radius circles.
The 'Undisturbed' plant cover data represent three sites with 12, 4, and 12 replicates, respectively.
The 'On-field (low cover)' data represent two sites with 12 replicates each. The 'On-field (high cover)' data represent one site with 8 replicates.

principally by *A. polycarpa*, a perennial shrub, and annual exotic grasses such as *Schismus*. Perennial vegetation cover estimates from various sites in the Manix Basin are shown in Table 3. We found 8 to 30% cover a *A. polycarpa* on abandoned fields, while undisturbed areas typically have approximately 5 to 7% cover, dominated by *L. tridentata*. In some cases, only the upwind portions of abandoned fields support a low cover of *A. polycarpa*, even after a decade or more of disuse. This may be due to the fact that fetch, and therefore, mass transport rate of the wind, is lowest here, minimizing plant abrasion and seed removal. These fields have only been abandoned for at most 30 years, and are nowhere near the 65 years Carpenter *et al.* (1986) estimate for a creosote bush scrup community to approach climax conditions nor the several hundred years estimated by Vasek *et al.* (1975). Stylinski & Allen (1999) have suggested that in arid shrublands, altered stable states can occur if a community is pushed beyond its threshold of resilience by anthropogenic disturbance. The dramatic differences between abandoned agricultural fields and undisturbed desert in the Manix Basin after several decades certainly argue for centuries for recovery, if it occurs at all.

Some of the abandoned fields in the Manix Basin do not support any native perennial vegetation, even after a decade or more of disuse. This may be explained by: (1) transport of sand by wind over the exposed soil surface killing young seedlings; and/or (2) absence of climatic or soil conditions suitable for plant germination (Lovich & Bainbridge, 1999). In an experiment aimed at restoring Mojave Desert farmland by seeding native plants in order to reduce dust emissions, Grantz *et al.* (1998) found *A. canescens* could be established in areas without deep sand. However, 'this revegetation was achieved in an anomalous year with above average and late rainfall that eliminated early competition from annual species and later fostered abundant shrub growth. This success was not reproducible in more normal years'. Thus, natural germination of native perennial vegetation on abandoned fields may be rare, explaining the lack of cover on some abandoned fields in the Manix Basin. The importance of germination conditions highlights the dramatic role of interannual climate variability and long-term regional climatic conditions on the response of these ecosystems to human disturbance. Bare fields in the Manix Basin may be expected to take much longer than the vegetated fields to approach climax conditions, if they recover at all.

Once fields are abandoned, they serve as sources of wind-borne sediment at least until a deflationary soil pavement is re-established or they are some how crusted (López, 1998). Landsat MSS and AVIRIS imaged in Fig. 1 depict the mobilization of sand from abandoned agricultural fields in the Manix Basin. Area C, which appears as dark red in the 1997 AVIRIS image, is a set of two fields abandoned in the early 1980s according to Landsat images of the basin from 1973 to 1992; area A was abandoned in 1988 (Ray,

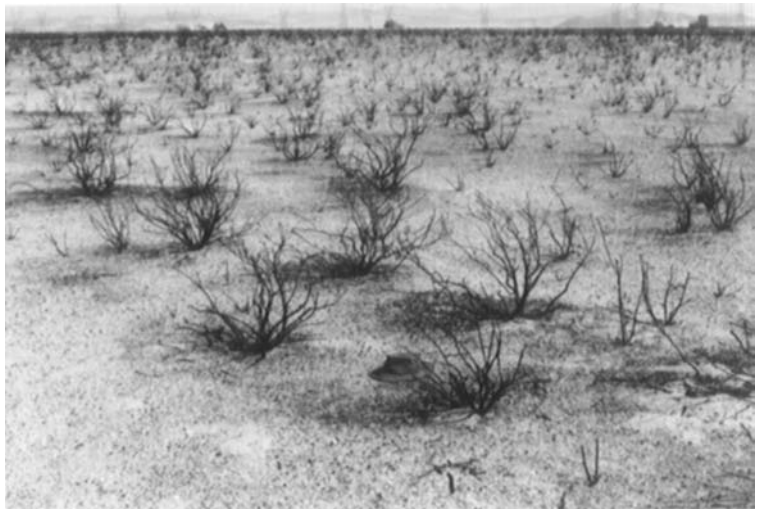

Figure 2. Photograph taken in an abandoned field in the Manix Basin after a fire in the summer of 1998 showing the response of highly disturbed areas to fire. Prior to the fire, this abandoned field had been covered with approximately 30% cover of *A. polycarpa*. Most individuals in the path of the fire in the area of high *A. polycarpa* cover were killed as shown here. Nearby, in adjacent undisturbed desert, only the annual grasses burned and perennial plant mortality was low.

1995). Areas downwind of both fields show significant sand encroachment even though area A has almost no cover and C has relatively high (~30%) *A. polycarpa* cover. Thus, even after regrowth of *A. polycarpa*, abandoned fields remain sources of aeolian sand. High *A. polycarpa* cover may increase roughness length and decrease boundary layer velocity, but once the soil crust was removed, these soils clearly remained.

A notable consequence of the trajectory that areas of direct disturbance follow is their potential response of fire. Lovich & Bainbridge (1999) have reported a 10-year average of 175 fires in the Mojave and Colorado deserts of California that affected an average of 10,927 ha annually. Besides this, there are no published definitive studies of fire return intervals or typical areas burned in individual fires in the Mojave Desert. Nonetheless, it is clear that fire has only recently become a factor in shaping the structure and dynamics of plant communities in the Mojave Desert. In prehistoric times, limited biomass, large intershrub spacing, low combustibility of some native plants and sparse ground cover to support and propagate combustion are thought to have led to very low fire frequencies. The recent proliferation of exotic annual plants has increased the fuel load and fire frequencies in many ecosystems around the world have increased in recent years (Lovich & Bainbridge, 1999).

A fire in the Manix Basin that occurred in June 1998 indicates that areas of high *A. polycarpa* cover have different fire responses than undisturbed areas or abandoned areas of direct disturbance with little or no vegetation regrowth. After the 1998 Manix Basin fire, the mortality of nearly all shrubs on the *A. polycarpa*-covered abandoned field was observed. The same fire burnt a nearby undisturbed area dominated by *L. tridentata* and *A. dumosa*. Here, the fire killed few shrubs and was only sustained in areas with a dense cover of exotic annual grasses as a type of under-storey fire. A fire in an abandoned field covered with *A. polycarpa*, therefore, re-exposed the soil surface to wind erosion while a fire in an undisturbed area has little effect on the landscape (Fig. 2). Disturbed areas that are subsequently burned therefore are likely to have much longer recovery times than their unburned neighbours, both due to fire mortality and the enhanced vulnerability of burnt landscapes to wind erosion.

Figure 3. Photograph taken downwind of an abandoned field in the Manix Basin in the spring of 1988 displaying evidence of active sand movement (sand ripples) and plant mortality. The plants in the foreground are *L. tridentata* and *A. dumosa* individuals that have been buried, abraded and ultimately killed by the encroaching sands.

Indirect disturbance

Indirect disturbance in the Manix Basin primarily takes the form of redeposition of wind-borne sediments onto previously undisturbed adjacent lands. Three types of material are removed from abandoned agricultural fields by wind erosion: saltation-sized particles, suspension-size particles, and organic litter. The removal of all three contributes to indirect disturbance. Saltation of large particles results in their redeposition wherever wind velocities drop, typically in adjacent, downwind vegetated areas or in the lee of plants growing on the field itself.

The encroachment of blowing sand into adjacent shrublands has dramatic consequences for the landscape. Field observations indicate that blowing sand abrades plants, resulting in leaf stripping and damage to the cambium and therefore to the plant's ability to distribute and use water. Young plants are especially vulnerable to the effect of blowing sand as they lack woody tissue. This results in the suppression of revegetation in bare areas and the loss of vegetation on adjacent lands. Nitrogen-fixing microbial communities and cryptobiotic crusts are buried by sand, reducing inputs of nitrogen to the soil (Belnap *et al.*, 1993; Evans & Belnap, 1999).

Blowing sand creates dunes in the wind-shadows of plants. Inspection reveals that these dunes typically have a coarser texture than the material from which they were derived, a result of the progressive removal of fines in a continual process of winnowing (Gibbens *et al.*, 1983; Hennessy *et al.*, 1986; Lyles & Tatarko, 1986). Dunes can grow and coalesce resulting in: (1) burial of large plants not able to grow fast enough to keep up with dune growth; (2) burial of all vegetation including very young shrubs in inter-shrub spaces; and (3) complete blanketing of the soil surface by sand. The persistence of branches and twigs from buried or abraded vegetation decreases the erodibility of the surface, but with time these disintegrate (Fig. 3). Since new vegetation growth is inhibited by blowing sand, the ability of vegetation in stem erosion is limited.

Anthropogenic additions

Chemical fertilizers or other soil amendments are often added to agricultural fields to increase productivity or soil workability. Inorganic salts also may be added inadvertently to the soil as irrigation water evaporates. The transportation of materials from an area of direct disturbance may be accompanied by the dispersal of these soil additives across the landscape. The dispersal of salts by wind onto adjacent undisturbed areas may contribute to the decreased plant growth on these areas by increasing osmolyte concentrations in soil solutions. Okin *et al.* (in press) have reported that Cl^-, SO_4^{-2}, and Na^+ are significantly elevated on and downwind of an abandoned field in the Manix Basin relative to the upwind areas as salts have spread with the moving sands. On the field, Cl^-, SO_4^{-2}, and Na^+ accumulated at average rates of approximately 9·9, 30, 29% per year, respectively over 7 years. This represents a dramatic addition of ions to the soil and may limit the usability of these areas for extended agriculture or influence the recovery of agricultural fields after abandonment.

Soil additives (including nitrate and phosphate) act as chemical tracers of mass flux and determine the relative effects of physical abrasion and nutrient loss in propagating desertification in arid shrublands. Okin *et al.* (in press) have reported significantly elevated concentrations of plant-available N and P on and downwind of an abandoned field in the Manix Basin. Fertilizer has been broadcast across the landscape as the soil from the field has been transported by wind. Despite elevated nutrient concentrations on the abandoned agricultural field at Manix, the absence of shrubs on this field indicates that recolonization of fields by native shrubs after their abandonment is not simply related to nutrient content of the soils, but is dependant more on germination conditions as suggested by Grantz *et al.* (1998). The area immediately downwind of the fertilized field has seen an increase in plant mortality and not a bloom in response to increased nutrient concentrations. This indicates that abrasion and burial of vegetation may dictate a landscape's response to wind erosion, especially in years without favourable germination conditions.

Quantitative assessment

Are the observed rates of deflation and burial of adjacent lands that are suggested quantitatively plausible in the Manix Basin? Using published threshold shear velocities and equations for the flux of wind-borne sediments, we conclude that observed deflation rates at the Manix basin are reasonable in light of literature values and theoretical considerations. Our quantitative assessment thus provides insight into the magnitude of deflation, redeposition of saltation-sized particles, and emission of nutrient-laden dust.

With erosion and transport processes have been reviewed many times in the literature (see for example Greeley & Iversen, 1985; Table 3·5). Here, the analysis of Bagnold (1941) will be followed because it is still prevalent in the modern literature of aeolian transport and because it provides a simple method for determining the magnitude of sand transport. From momentum considerations and simplifying assumptions about the path of saltating grains, Bagnold derived a relationship for the horizontal mass flux of saltating grains integrated over all heights:

$$q = C\sqrt{\frac{d}{D}}\,\frac{\rho_a}{g}\,U_*^3, \tag{1}$$

where q is the horizontal mass flux in g cm^{-1} s^{-1}, U_* is the shear velocity, d is the grain diameter of the sand in question, D is the grain diameter of a standard 0·25-mm sand,

ρ_a is density of air, g is the acceleration due to gravity, and C is 1·8 for a naturally graded sand. Assuming that $d = D$, Bagnold's equation simplifies to

$$q = 1{\cdot}5 \times 10^{-9}\,(U - U_t)^3, \tag{2}$$

where U is the wind velocity and U_t is the threshold wind velocity measured at 1 m height. U and U_t are related to shear velocity, U_*, and threshold shear velocity, U_{*t}, respectively, by Bagnold's formula:

$$U_z = \frac{U_*}{k} \ln\left(\frac{z}{z_0}\right), \tag{3}$$

where U_z is wind speed at height z, k is von Karmann's constant taken to be 0·4, and z_0 is the roughness length (Bagnold, 1941).

Shao & Raupach (1993) have shown from energetic considerations that vertical dust flux due to suspension, F, in mass per area per unit time is linearly related to q. Based on this, Gillette *et al.* (1997) have obtained a value for F/q of $5{\cdot}4 \times 10^{-4}\,\mathrm{m}^{-1}$ from wind tunnel experiments, which is of the order of that for sandier soils (Gillette, 1977; Shao & Raupach, 1993; Gillette *et al.*, 1997) and is therefore applicable here.

For a field with cross-wind diameter, x, and area, A:

$$\Delta\tau_{saltation} = \frac{q}{\rho_B}\frac{x}{A}, \tag{4}$$

where ρ_B is the bulk density of the soil and rate of deflation due to saltation, $\Delta\tau_{saltation}$, is expressed as cm year^{-1}. ρ_B is taken to be $1{\cdot}25\,\mathrm{Mg\,m}^{-3}$ for a dry, medium-texture mineral soil (Brady & Weil, 1999), x is taken to be 750 m, and $A = \frac{\pi}{4}x^2$ for a circular field. A/x is a equivalent to erosive fetch. The total average mass rate of erosion is:

$$F_{Total} = q\left(\frac{x}{A}\right) + F \approx q\left(\frac{x}{A}\right), \tag{5}$$

and the total deflation rate (in cm year^{-1}) is given approximately by:

$$\Delta\tau_{total} = \Delta\tau_{saltation} + \Delta\tau_{suspension} = \frac{q}{\rho_B}\left(\frac{x}{A} + \frac{F}{q}\right), \tag{6}$$

where the mass flux due to saltation, q, depends on a detailed wind record, z_0, and U_{*t} by equations (2) and (3).

The threshold shear velocity required to account theoretically for $\Delta\tau_{Total} = 1{\cdot}5$ cm year^{-1} in the Manix Basin was found iteratively using equation (6), Gillette *et al.*'s (1997) value for $F/q = 5{\cdot}4 \times 10^{-4}\,\mathrm{m}^{-1}$, $z_0 = 0{\cdot}04$ cm (an average of values reported by Gillette *et al.* (1980) for non-playa, uncrusted soil), and the wind conditions at Daggett Airport in the Manix Basin where wind speed has been collected hourly since 1961. U_{*t} was found to be 103 cm s^{-1}, well within the bounds of reported values for arid agricultural soils of 20–132 cm s^{-1} (Gillette, 1988). These results indicate that empirically-understood processes can account for observations in the Manix Basin and, therefore, that it is reasonable to invoke these processes to drive indirect disturbance in the conceptual model developed here.

The value $q = 8{\cdot}56$ Mg m^{-1} year^{-1} calculated from $U_{*t} = 103$ cm s^{-1} by equation (2) implies that the equivalent of 10^8–10^9 sand grains saltate through each metre of width per year. In fact, considering that the majority of wind erosion occurs during storms of a few days in duration, this constitutes an extremely concentrated attack on vegetation and is capable of overwhelming plants' self-healing capabilities.

The effect of abrasion acts in tandem with redeposition and dune formation to compromise vegetation in adjacent downwind areas. The total volume, V in m^3 $year^{-1}$, of soil moved by saltation from an abandoned agricultural field is given by:

$$V = \frac{qx}{\rho_B} T, \tag{7}$$

where T is the time in years before the re-establishment of an armoured surface. If the density of the soil is approximately the same after redeposition downwind, volume is conserved and the average depth of burial is given by V/A_b, where A_b is the area buried by the mobilized sand, which can be estimated from remote sensing imagery. Area C in the Manix Basin (Fig. 1, Table 2) has been abandoned for 16 years and has a sand plume downwind with an area of 241 ha. Using the value of q calculated above, we estimate that the average depth of this sand plume is 6·8 cm. However, mobilized sand usually accumulates in the wake of plants, leading to dunes larger than the average depth of burial. In the Manix Basins we have observed dunes greater than 1 m in height. There is currently no theory for determining dune height based on flux measurements or calculations.

Using Gillette *et al.*'s (1997) value for F/q, and reasonable values for x/A, $q(x/A)$ should always be greater than F, indicating that sand mobilization is more important as a wind erosion process than dust emission is terms of mass loss. However, dust emission represents the permanent removal of material from the regional ecosystem due to its potential for long-range transport. Nutrients, especially P, are often concentrated on small particles in soils (Avnimelech & McHenry, 1984; Leys & McTainsh, 1994). Assuming constant suspension flux, the removal of nutrient i from the bulk soil at time t may be written as:

$$F_i^d(t) = C_i^d(t) F, \tag{8}$$

where $C_i^d(t)$ is the concentration of soil nutrient i on the emitted dust and has units of mass of nutrient per mass dust. $F_i^d(t)$, therefore, is in units of mass of nutrient i lost per unit area per unit time. The mass per unit area of soil in a layer of depth, D, is:

$$M^D = \rho_B D, \tag{9}$$

and therefore, the reservoir of nutrients in this layer is $C_i^s(t) M^D$, where $C_i^s(t)$ is the concentration of nutrient i in the soil.

Conservation of mass gives:

$$M_i^{s,D}(t + \mathrm{d}t) - M_i^{s,D}(t) = C_i^d(t) F \mathrm{d}t, \tag{10}$$

where $M_i^{s,D}(t)$ is the mass of nutrient i at time t in a layer of soil of depth, D. Under the approximation that M^D is constant with time, we can divide equation (9) by M^D yielding:

$$C_i^{s,D}(t + \mathrm{d}t) - C_i^{s,D}(t) \approx C_i^d(t) \frac{F}{M^D} \mathrm{d}t, \tag{11}$$

where $C_i^{s,D}(t)$ is the concentration of nutrient i at time t in a layer of soil of depth, D. The ratio of $C_i^d(t)$ to $C_i^{s,D}(t)$ is assumed to be a constant, k_i, that is analogous to a chemical fractionation factor for nutrient i between dust and the bulk soil.

Rearranging equation (10) yields:

$$\frac{\mathrm{d}C_i^s}{\mathrm{d}t} \approx -k_i \frac{F}{\rho_B D} C_i^s. \tag{12}$$

Therefore, the time for the concentration of nutrient i in a layer of soil of depth D to drop by $1/e$ times its original value is given by t_i^D:

$$t_i^D = \frac{\rho_B D}{k_i F} = \frac{t^D}{k_i}, \tag{13}$$

where t^D is the time it takes to completely excavate a layer of depth D with a mass flux rate equal to F. For $D = 0{\cdot}05$ m (a typical sampling depth), $F = 4{\cdot}62$ kg m^{-2} year^{-1} (at $U_{*_t} = 103$ cm s^{-1}) and with a bulk density of 1·25 Mg m^{-3}, t^D is approximately 14 years. Reported values of nitrogen enrichment in Australian arid zone soils are in the order of 10 (Leys & McTainsh, 1994; Carter *et al.*, 1999), although Larney *et al.* (1998) have reported values as low as 1·1.

Talbot *et al.* (1986) have reported concentrations of water-soluble N and P in Saharan dust of 2·58 mg g^{-1} and 123 μg g^{-1} respectively. Using the inferred threshold shear velocity of 103 cm s^{-1} and equation (7), we calculate N and P losses of 1200 μg cm^{-2} year^{-1} (120 kg N ha^{-1} year^{-1}) and 57 μg cm^{-2} year^{-1} (5·7 kg P ha^{-1} year^{-1}), respectively. Typical concentration of N and P reported by Schlesinger *et al.* (1996) in undisturbed Mojave Desert soils are approximately 2 μg N g^{-1} and 0·66 μg P g^{-1}, respectively. Comparing these values with those of Talbot *et al.* (1986) implies that k_N and k_P may be as high as 10^1–10^3 and therefore that t_i^D may be as small as a few years.

Available N and P concentrations at a site in the Jornada Basin measured by Okin *et al.* (in press) indicate approximately a 5-fold net loss of available N and a 3-fold net loss of plant-available P in the 8 years since the establishment of the site. Thus, the e-folding times of N and P, t_N^D and t_P^D, in this surface soil undergoing active deflation and aerosol emission are inferred to be approximately 5–10 years. Wind erosion, therefore, impacts soil fertility in areas of both direct and indirect disturbance on short timescales. This has dramatic implications for nutrient availability in disturbed areas, especially for seed germination in surface soils where the degree of nutrient depletion will be greatest.

Conclusions

Anthropogenic desertification of arid shrublands

Extensive remote sensing, field, and quantitative assessment of arid land degradation in the Manix Basin leads us to conclude that in arid shrublands direct anthropogenic disturbance resulting in the destruction of soil crusts and vegetation cover can cause indirect disturbance of adjacent areas by initiating the disintegration of islands of fertility. Figure 4 illustrates a proposed model for the degradation of arid shrublands based on these observations. The inferred sequence can be visualized as:

(1) Transport of sand from disturbances resulting in deflation of the disturbed surface.
(2) Mobilization of dust and plant litter by wind, depleting the soils of nutrients in areas of direct disturbance.
(3) Damage to and burial of plants by saltating sand in adjacent downwind areas.
(4) Reduction of vegetation cover downwind, leading to an expanding area in which wind removes dust and litter material, depleting the soils of nutrients.

A feedback threshold may be reached when these mechanisms act to dramatically reduce shrub cover in previously undisturbed areas. The accessibility of this threshold is related to allogenic changes in regional climate and interannual variability. Reduced precipitation or increased temperature may exacerbate landscape vulnerability and cooler, wetter conditions may aid amelioration.

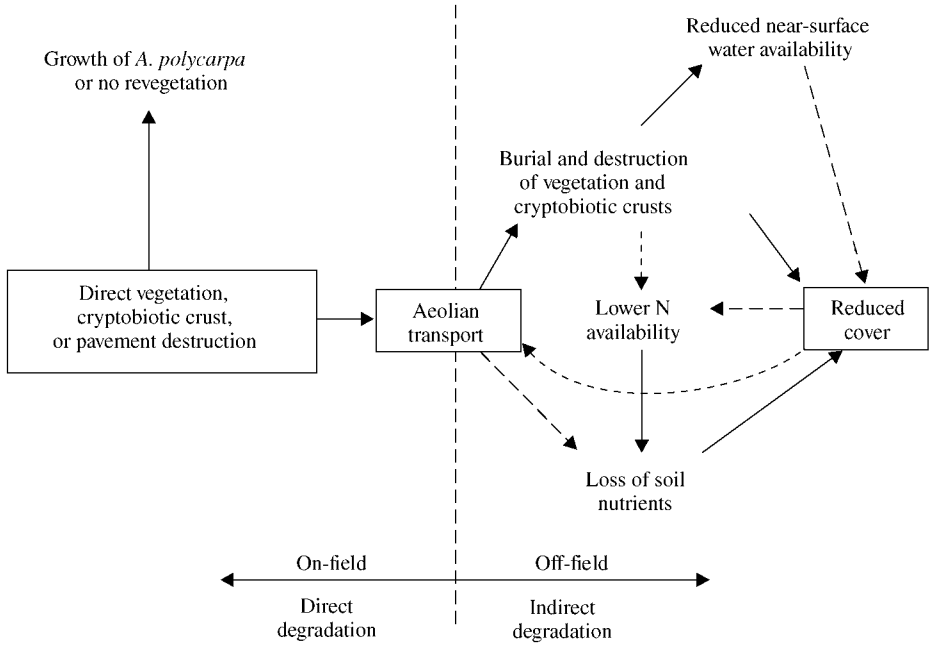

Figure 4. Process model for shrubland degradation developed from observations at the Manix Basin, California. Direct disturbance through vegetation, crust, or pavement destruction drives aeolian transport which leads to indirect degradation in the form of reduced cover in adjacent areas.

Nutrient relations and soil resources

Shrubs are the loci of nutrient accumulation and represent islands of fertility in shrubland ecosystems (Schlesinger *et al.,* 1990). How then does wind erosion affect soil resources in degraded shrublands?

Nutrient removal from islands of fertility has three main mechanisms: (a) physical removal of litter and organic matter by the wind; (2) wind suspension of dust particles with a high concentrations of plant nutrients (Leys & McTainsh, 1994); and (3) retarded accumulation of organic N due to increased surface and air temperatures (Post *et al.*, 1985). In areas of indirect disturbance, the mantle of winnowed dune sand may lead to decreased fertility of the surface soil, which is vital for seedling establishment. Areas of direct disturbance which are the sources for dune sand will also become less fertile through preferential removal of fines by wind. Removal of litter beneath shrubs limits the future availability of organic N and C to plants (Lyles & Tatarko, 1986; Schlesinger & Pilmanis, 1998).

Islands of fertility associated with shrubs are normally sites for recolonization by seedlings (Schlesinger & Pilmanis, 1998). These young plants are more vulnerable to sand abrasion and burial than their mature predecessors and their establishment may be limited. In many areas adjacent to abandoned agricultural fields in the Manix Basin, shrub sites are generally not recolonized and become areas of soil nutrient removal, effectively dismantling the islands of fertility. Schlesinger & Pilmanis (1998) have reviewed field experiments in which shrubs have been removed by cutting, herbicides, or fire. These studies show variable rates of soil degradation, but in each case, 'a loss of the local biogeochemical cycle associated with shrubs has allowed physical processes to

disperse soil nutrients across the landscape'. Thus, the progressive reduction in fertility acts in tandem with the mechanical action of sand to further decrease shrub cover which, in turn, increases the susceptibility of the land of wind erosion. The permanent removal of suspension-sized particles from the soil by wind erosion results in a change of the soil texture, which may also reduce soil binding properties, resulting in increased wind erodibility.

In a study aimed at determining the effect of wind erosion on nutrient availability, Okin *et al.* (in press) have measured available N and P at a disturbed site in the Jornada LTER site in south-central New Mexico. Their results indicated that surface soils upwind of the disturbance are richer in available N and P than those from downwind, if the soils from the upwind transect are considered representative of the original conditions throughout the study site. This indicates approximately a 5-fold net loss of available N and a 3-fold net loss of plant-available P from the soils blown off of the disturbed area. In addition, the site itself lost nearly 94% of its available N and nearly 79% of its plant-available P. Similar results have been reported by Leys & McTainsh (1994) in Australia.

The nutrient cycle may be further disrupted when soil microbial communities are buried or destroyed by blown sand, minimizing their ability to fix atmospheric nitrogen and add it to the nutrient reservoir of the soil. The burial of cryptobiotic crusts also reduces their ability to enhance infiltration of water leading to decreased near-surface soil moisture (Belnap *et al.*, 1993; Belnap, 1995).

It has been suggested by Gibbens *et al.* (1983), Lyles & Tatarko (1986), Hennessy *et al.* (1986), and Leys & McTainsh (1994) that permanent removal of suspension-size particles from the soil by wind erosion may reduce water-holding and cation-exchange capacities. This may result in less water in the surface soil, marginalizing the water balance of desert shrubs and increasing their susceptibility to drought and climate change. On short timescales, this may be particularly important for the establishment of annual grasses. In wet years, these grasses form a carpet that reduces the susceptibility of soils to wind erosion (Lancaster & Baas, 1998). In dry years, decreased near-surface soil moisture makes the landscape more vulnerable to wind erosion. Dust storm frequency has been correlated with reduced soil moisture, indicating that soil erosion and nutrient removal are accelerated by decreased soil moisture (Brazel & Nickling, 1987).

Lessons for land managers

Several aspects of the arid shrubland degradation observed at the Manix Basin can provide lessons for land management in these environments. Wind erosion is the principle mechanism of degradation in arid shrublands on basin floors. The principle consequences of land degradation are therefore:

(1) sand blasting of vegetation and equipment;
(2) burial of vegetation and equipment;
(3) dust emissions leading to decreased nutrient availability, cation-exchange capacity, water-holding capacity, and atmospheric pollution.

For virgin lands, not already converted to human uses, we stress that if possible, arid shrublands with sandy wind erodible soils should not be used for many activities. These are extremely fragile lands, the degradation of which could easily upset marginal economic gains from their cultivation or make recreation and habitation impossible. Furthermore, disturbance of arid shrubland landscapes may disturb successional processes, resulting in permanent landscape change. Where development is deemed necessary, planning must precede plowing. The principle consideration must be the wind erodibility of soils. In the United States, county-wide soil surveys typically provide information on soil texture. Soils of sandy or loamy sand textures, even when covered by

a thin layer of protective crust (deflationary crust, desert pavement, or cryptobiotic crusts), are very vulnerable to wind erosion. Activities which break up soil crusts and destroy vegetation are best avoided. High-risk activities include agriculture, grazing, ORV recreation, and military training. Roads, when necessary, should be situated to minimize the area of wind-erodible soils affected. The location of natural wind breaks such as trees, hills, and mountains should also be used to determine the location of planned developments.

For land already under cultivation or used for recreational purposes, we suggest technological and logistical methods for minimizing the effects of wind erosion in local vegetation, crops, and infrastructure. Equipment, sheds, and other buildings should be situated upwind of fields so that they are not sandblasted or buried. Fields, likewise, should not be situated such that one is close to and downwind of another, or else sand eroded from one will be deposited on another. Talbot (1947) has observed that uncultivated areas between fields in the extremely sandy western lowlands of the Cape Province, South Africa, may stem wind erosion and keep redeposition of sand from occurring in undesirable places. Other wind breaks, preferably indigenous plants which do not need to be watered after establishment, will also help stem erosion. Attempts must be made to keep vegetation on fields as much as possible. In light of this, nitrogen-fixing cover crops may be planted which would minimize erosion and add nitrogen when tilled back into the soil. Fallow periods, especially in the windiest time of the year should be avoided, and cover crops planted instead. Fertilizers may need to be added every few years, when significant nutrient loss is detected and when nitrogen-fixing cover crops are not sufficient to renew the soil resources. When abandoned, fields should be planted with a final, long-lived perennial indigenous cover that will help minimize wind erosion for years to come, and will allow natural succession processes to take place.

Novel management techniques may provide the best opportunities for sustainable management of arid shrublands. We suggest yearly monitoring of soil nitrogen and phosphorous in order to identify times or places where dust emission has significantly depleted the soil of nutrients. Where possible, use should be made of remote sensing and precision farming technologies to ascertain soil condition and to respond appropriately. Carter *et al.* (1999) have reported success in stemming erosion and improving soil conditions by adding clays of sub-soil origin to sandy soils in Western Australia. These and other techniques could be used to dramatically improve the sustainability of agriculture in arid lands.

Agriculture in the Manix Basin is a good example of unregulated and unmanaged human activities for short-term gain leading to long-term loss of value. As farming in the basin has became less profitable, farmers, simply abandoned the land to natural degradation processes without implementing long-term remediation strategies. A principal lesson from this area, therefore, is that policy mandates and financial incentives need to be put in place which promote soil conservation initiatives during land-use and require restoration of the landscape after cultivation stops. Efforts at remediation do not need to focus on restoring the environment to its pristine condition, although this is preferable. Instead, they can focus on halting or slowing soil erosion of planting long-lived, native, and perennial shrubs that will partially protect the surface. Funds for post-agriculture remediation should be earmarked before cultivation begins, and must be considered a part of the cost of business in vulnerable lands. In this way, remediation becomes the responsibility of the short-term land-user and not someone else's long-term problem.

Regional drivers and effects

In addition to the increasing intensity of human disturbance, arid lands are affected by changes in regional climate. How might climate change affect arid shrubland degradation?

The 1980s and 1990s—the decades in which large areas of the Manix Basin were abandoned from agriculture and in which the greatest land degradation has been seen—were neither unusually windy nor dry. The annual average wind speed for the period 1961 to 1990 was 5·5 m s^{-1}, identical to the period of 1980–1989 (National Climate Data Center, 1993). Annual precipitation was only slightly higher between 1970 and 1990 than for the period 1941 to 1997 (Table 1). When the decadal-scale regional climate in the Manix Basin shifts to a windier or drier period, the area affected by nutrient loss and aeolian sand mobilization may be expected to increase dramatically.

There has been much discussion about the relative importance of human *vs*. indirect climate drivers of desertification. Both can have a dramatic impact on the landscape (Schlesinger *et al*., 1990; Brown *et al*., 1997). Climate change may either increase or decrease anthropogenic effects on a landscape. For example, during wetter than average years, the presence of annual grass cover greater than about 15% halts wind erosion, and increased soil moisture leads to higher threshold shear velocities (Brazel & Nickling, 1987; Lancaster & Baas, 1998). In drier than average years, threshold shear velocity may be lower due to decreased soil moisture, and annual cover is greatly reduced leading to accelerated degradation. In the northern Mojave Desert, Schultz & Ostler (1993) have reported a dramatic decrease in total plant cover after only 4 years of drought. Clearly, resistance to climate-induced changes is dependent on the degree of anthropogenic disturbance and *vice versa*. Thus, regional decadal-scale climate conditions may be expected to dramatically influence the rate of arid shrubland degradation.

Extrapolation to other areas

The primary driving mechanism in the process model developed from observations in the Pleistocene paleolake Manix is the aeolian mobilization of sand, dust, and litter material as initiated by anthropogenic disturbance of the surface crust and vegetation cover. Any process that destroys the surface crust in an arid or semi-arid shrubland and increases the boundary layer velocity over a soil with saltation- and suspension-size particles will result in the progressive devegetation of the downwind area. Thus, our model can be extended to incorporate any arid or semi-arid shrubland with a source of wind-erodable material.

Other land forms in the arid south-west

Any arid shrubland with a source of wind-erodable, fine-grained material at the surface may be susceptible to anthropogenic degradation. Our study of the Manix Basin indicates that arid shrublands on Pleistocene paleolake beds are especially susceptible to anthropogenic degradation. Pleistocene lacustrine deposits are common in basin floors throughout the arid south-western United States, where large, shallow pluvia l lakes existed during the Last Glacial Maximum (Smith & Street-Perrott, 1983; Morrison, 1991*a*, *b*). Closed basins that were once Pleistocene lakes exist in many now-arid areas throughout the globe. The degradation observed in the Manix Basin is simply an example which can be applied to similar geological environments globally. They exhibit qualities that make them amenable for many human uses, such as very low slopes, little or no relief, subsurface water resources, and fine-grained sediments suitable for farming or other activities. Thus, the areas of greatest potential usefulness are also susceptible to serious degradation.

The armoured soils of desert bajadas—defined as broad, gently inclined alluvial surfaces extending from the base of mountain ranges to inland basins—may also be susceptible to a similar process of human-induced degradation. Although these soils are typically too gravelly or steep to be used for agriculture, these landforms may be wind

erodible when disturbed by human activities. When present, the soil armour has been argued to develop through the 'born at the top' model of McFadden *et al.* (1987), wherein fine, wind-mobilized particles are trapped by surface cobbles that float atop the accumulation of fine-grained material. Removal of the very stable desert pavement therefore exposes a layer of extremely wind-erodable wind-derived material, sometimes metres thick. Anthropogenic disturbance in these areas is likely to have profound consequences. Certainly, 'born at the top' pavements downwind of areas of active dunes will be at high risk of degradation should be cover of protective pebbles be disturbed. Other soils of aeolian origin, including stabilized dunelands, will similarly be susceptible to anthropogenic degradation of the type discussed here.

Cryptobiotic soil crusts—communities of cyanobacteria, lichens, and mosses—are found throughout the world's deserts. These crusts bind fine soil particles by linked cyanobacterial fibres which protect the soil from wind erosion. Belnap (1995), Williams *et al.* (1995), and Marticorena *et al.* (1997) have suggested that the presence of cryptobiotic crusts dramatically decreases wind and water erosion. When disturbed, cryptobiotic crusts lose most of their protective qualities allowing mobilization of the underlying mineral soils. Shrubland areas with widespread cryptobiotic crusts are thus also vulnerable to progressive degradation should human activities disturb these fragile soil crusts.

Global implications

The problem of wind-induced land degradation is not limited to the south-western United States. Greater use of mechanized agriculture in arid regions throughout the world, as well as other land-use demands, is increasing the amount of arid and semi-arid shrublands brought into cultivation or under human influence (see, for example, Luk, 1983; Kealah, 1989; Khalaf & Al-Ajmi, 1993; Zha & Gao, 1997; Kasusya, 1998; Khresat *et al.*, 1998; Koch & El Baz, 1998; Mitchell *et al.*, 1998). This trend, linked with political/economic instability or the marginal and water-limited nature of arid land agriculture, makes sustainable arid region agriculture especially challenging.

Nations with a large proportion of their territory situated in arid environments with wind-erodible soils are particularly vulnerable to the consequences of land degradation. Great care needs to be employed in the responsible stewardship of these lands to promote sustainable agricultural, and economic and social development.

Summary

Aeolian mobilization of dust, sand, and litter triggered by anthropogenic disturbance contributes to the destruction of islands of fertility by killing shrubs through burial and abrasion. This interrupts nutrient-accumulation processes and allows the loss of soil resources by abiotic transport processes. The resulting reduction of vegetation cover, in turn, increases susceptibility to wind erosion.

Land degradation processes necessarily exist in the context of regional climate and can either be bolstered or hindered by climatic conditions and changes, a fact that makes the rate of degradation ultimately climate-related. The process model developed here suggests various remediation techniques to halt shrubland degradation, but ultimately indicates that development of landscapes susceptible to wind erosion should be avoided where possible.

In the face of largely unsustainable socioeconomic factors, the vulnerability of arid lands to degradation argues for the development of linked degradation process models and monitoring strategies in order to minimize environmental damage and to promote sustainable management of human activities in arid lands. The dramatic landscape

changes that accompany arid shrubland degradation can be monitored using present and future remote sensing techniques and technologies. When informed by process models, such as the one presented here, remote monitoring tools may be used in the future to identify areas at risk of runaway degradation before large areas are adversely affected.

Globally, degradation of already-marginal arid lands represents a dramatic threat to local populations, food resources, and regional stability. Presently, the United Nations Convention to Combat Desertification is before the United States Senate for ratification. This treaty provides for scientific and technical exchange to combat desertification. The processes of arid land degradation must be understood, effective monitoring techniques developed, and effective remediation and management techniques implemented to avoid costly and prolonged environmental crises. The model presented here represents a small step in attaining these goals.

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Page 16/line 8	Okin *et al.* (in press) — pl. update.	
Page 46/line 20	Ref. 50 — National Climate Data Center. (1997). — not in text.	
Page 50	Is figure. 1 to be colour? If not, change caption.	

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3.3 HYDROLOGY AND WATER QUALITY

3.3.1 Introduction

This section is formatted in a slightly different manner than the other EIR/EIS evaluations in order to accommodate an analysis of hydrology issues that differ between the Plant and Quarry sites. Rather than one section describing the Affected Environment and one section on Standards, Impacts and Mitigation Measures there are two sections each (one set for the Plant hydrology analysis and one for the Quarry hydrology): because these facilities are in different hydrologic basins with substantially differing conditions. Sections 3.3.2 and 3.3.3 cover hydrology issues at the Plant; Sections 3.3.4 and 3.3.5 cover hydrology issues at the Quarry. Each of these sections addresses the Proposed Action and its various alternatives.

The section is organized as follows:

- 3.3.2 Plant Water Usage
- 3.3.3 Plant Water Usage: Standards of Significance, Environmental Impacts, and Mitigation Measures (starting at page 3.3-34)
- 3.3.4 Quarry Water Usage: Affected Environment (starting at page 3.3-9~~0~~4)
- 3.3-5 Quarry Water Usage: Standards of Significance, Environmental Impacts and Mitigation Measures (Starting at page 3.3-9~~5~~9)

The Proposed Action includes changes in the quantity of water to be used in both the wallboard manufacturing Plant and the Quarry. Water for the Plant is supplied by three wells located in Ocotillo. Water for the Quarry is proposed to be supplied by a new well to be drilled approximately three miles east of the Quarry along the narrow-gauge rail line right-of-way. Evaluation of the proposed increased water usage for the Plant is presented in Section 3.3.2. Evaluation of the proposed new well installation and increased water usage for the Quarry is presented in Section 3.3.4.

3.3.2 Plant Water Usage

The existing Plant operation and Proposed Action rely on three supply wells for water for potable domestic uses and processing and production of wallboard and other gypsum products. The three wells are located in the Ocotillo/Coyote Wells Groundwater Basin in the southwest part of Imperial County. Prior to implementation of the Proposed Action, USG pumped an average of 347 acre-feet per year (AF/yr) from 1994 to 1998. The Proposed Action anticipates increasing groundwater pumping from the existing wells up to a maximum of 767 AF/yr (the amount reported by USG in 1972).

The extracted groundwater is transported by 8 inch diameter pipeline to Plaster City. The location of the Ocotillo/Coyote Wells Groundwater Basin is shown in Figure 3.3-1, Groundwater Basin Location Map.

There are several communities in the Ocotillo/Coyote Wells Groundwater Basin, including Ocotillo, Coyote Wells, Nomirage, and Yuha Estates. These communities, USG and several other commercial/industrial and agricultural users, depend on the Ocotillo/Coyote Wells Groundwater Basin as their source of potable water. Surface water is not present in the Basin and there are no water imports into the Basin. The Ocotillo/Coyote Wells Groundwater Basin was designated as a "sole-source aquifer" by the Environmental Protection Agency (EPA) in 1996 (61 FR 47752, September 10, 1996) and is, thus, part of the Sole Source Aquifer Protection Program, authorized by Section 14245(e) of the Safe Drinking Water Act. The sole-source aquifer designation requires U.S. EPA review of proposed federally-assisted projects. The Proposed Action by USG is not a federally assisted project, and the designation only encourages coordination of federal, state, and local efforts for protection of groundwater resources under the Comprehensive State Ground Water Protection Program (CSGWPP).

Several studies involving the Ocotillo/Coyote Wells Groundwater Basin have been conducted. A partial list of these studies include:

- *Digital Model Evaluation of the Ground-Water Resources of the Ocotillo-Coyote Wells Basin, Imperial County, California*, U.S. Geological Survey Water-Resources Investigation 77-30, November 1977 (prepared by James A. Skrivan).
- *The Magnitude and Potential Effects of Declining Ground Water Elevations in the Ocotillo-Coyote Wells Basin*, prepared by David Huntley, October 1979.
- *Imperial County Groundwater Study – Final Report*, Montgomery Watson, December 1995.
- *Ocotillo/Coyote Wells Basin Hydrology and Groundwater Modeling Study*, Bookman-Edmonston Engineering, Inc., March 1996.
- *Geologic Review of the Ocotillo-Coyote Wells Basin, Imperial County California with Recommendations for Changes to the Proposed Groundwater Model*, Bookman-Edmonston memorandum from Ron Schnabel to Dick Rhone, March 13, 2003.
- *Ocotillo/Coyote Wells Hydrology and Groundwater Modeling Study*, Bookman-Edmonston, January 16, 2004.

Insert Figure 3.3-1

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These studies were reviewed in detail for this analysis, and are incorporated by reference. Copies of these studies can be reviewed at the office of the County Planning Department, Imperial County, California. In addition, rainfall data from the National Oceanic and Atmospheric Administration (NOAA) rain gauge in Ocotillo (the Ocotillo 2 gauge), pumping data from USG, and water level and water chemistry data from the U.S. Geological Survey (USGS) were obtained and reviewed. The USGS has been measuring water levels on a semi-annual basis and water chemistry on an annual basis in several wells throughout the basin since the 1970s. These data were obtained from the USGS WATSTOR database and are presented in Appendix B-1, USGS Hydrologic Data.

The 1996 and 2004 Bookman-Edmonston reports also include discussions of several additional studies conducted in the Ocotillo/Coyote Wells Groundwater Basin. These studies include several consultant reports and several unpublished Masters Theses from San Diego State University.

Section 3.3.2.1 presents a summary of the setting of the Ocotillo/Coyote Wells Groundwater Basin, a description of the baseline conditions developed for the Proposed Action, and an evaluation of the existing data. Section 3.3.2.2 presents the analysis of potential environmental impacts related to the extraction of groundwater from the Ocotillo/Coyote Wells Groundwater Basin for the Proposed Action, and the potential alternatives to the proposed increase in pumping from the existing wells within the Ocotillo/Coyote Wells Groundwater Basin.

3.3.2.1 Affected Environment

Climate

The Ocotillo/Coyote Wells Groundwater Basin is located in the southwestern part of Imperial County, approximately 25 miles from the city of El Centro (Figure 3.3-1), in a desert environment, marked by relatively high temperatures and relatively low precipitation. Average daytime high temperatures range from 70 degrees Fahrenheit (F) in January to in excess of 110 degrees F in July and August. Average low temperatures range from 40 degrees F to 80 degrees F. In the vicinity of the communities of Ocotillo, Coyote Wells, Nomirage, and Yuha Estates, the surface elevation varies from approximately 250 feet above mean sea level (ft amsl) to 600 ft amsl. The Basin is bounded on the west by the Jacumba Mountains and on the north by the Coyote Mountains. The Basin extends approximately 12 miles to 15 miles to the east of Ocotillo to the Westside Main Canal, across the southern projection of the Elsinore

Fault and the Laguna Salada Fault, and another unnamed fault zone. To the south, the basin continues across the international border into Mexico.

Table 3.3-1, Monthly Rainfall Data, 1971-2002, presents monthly rainfall data from 1971 through 2002, as measured at the NOAA Ocotillo 2 rainfall gauge, located in Ocotillo, CA. The raw data provided by NOAA are presented in Appendix B-1. Rainfall in the vicinity of the Ocotillo/Coyote Wells Groundwater Basin occurs from both Pacific storm fronts, which occur during the winter months, and from tropical monsoons, which occur during the summer months. To appropriately present the variation in rainfall over time, the annual precipitation is typically presented in terms of a water year. For the Project area, a water year extends from October of one year through September of the subsequent year. Table 3.3-2, Annual Water-Year Precipitation, presents the annual water-year precipitation for the Ocotillo area from 1948 through 2000. The data from 1948 through 1982 is taken from Table 7-3 of the 1996 Bookman-Edmonston report. The data from 1983 through 2000 are taken from the NOAA data presented in Table 3.3-1. Figure 3.3-2, Annual Water-Year Rainfall, presents the annual water-year precipitation for the Ocotillo area.

The average annual water-year precipitation for the time period represented in Table 3.3-2 is approximately 3.5 inches. The average annual precipitation is shown as a dashed line on Figure 3.3-2. The graph on Figure 3.3-2 indicates that rainfall was typically below average from 1949 through 1965. From 1975 through 1993, rainfall was typically above average, with 12 of 18 water years having above-average precipitation and only two water years having annual average precipitation that was less than 3.0 inches (i.e. one-half inch or more below the mean). Since 1993, rainfall has been average to below average.

The relatively high temperatures also result in a relatively high evaporation rate for the region. The California Department of Water Resources (Bulletin #113-3) reports a total evaporative demand for the area of approximately 100 inches per year, with a potential evapotranspiration rate of over 82 inches per year. The total evaporative demand is equivalent to the rate of evaporation from a Class A pan. The potential evapotranspiration is the rate of water lost to the atmosphere by irrigated agriculture.

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TABLE 3.3-1
MONTHLY RAINFALL DATA, 1971-2002
OCOTILLO 2 RAINFALL GAUGE

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1971	-	-	-	-	-	0	0	77	14	3	0	3	-
1972	0	0	0	0	0	37	0	2	0	149	32	10	-
1973	13	49	23	0	0	0	0	42	0	0	0	0	-
1974	149	0	3	0	0	0	14	0	4	6	0	8	-
1975	0	0	2	70	0	0	80	0	82	3	25	10	-
1976	0	152	20	25	7	0	10	0	293	0	42	10	-
1977	24	0	2	0	0	0	0	379	0	60	0	129	-
1978	139	57	29	14	0	0	0	0	10	6	110	143	-
1979	235	26	4	0	35	0	55	30	0	0	0	12	-
1980	378	202	88	10	100	0	0	0	0	0	0	0	-
1981	79	58	129	0	14	0	6	14	0	0	80	0	-
1982	95	0	-	-	-	-	1	31	169	0	19	584	-
1983	29	258	194	0	0	0	13	100	45	5	1	42	687
1984	17	0	0	1	0	0	216	39	24	0	40	186	523
1985	6	27	9	0	0	0	0	10	28	54	122	129	385
1986	21	115	33	4	0	0	41	0	0	127	15	24	380
1987	25	62	8	0	0	0	0	36	21	138	23	60	373
1988	53	122	2	0	0	60	0	117	0	7	0	0	361
1989	47	0	2	0	0	0	39	19	0	3	0	0	110
1990	11	0	1	22	0	108	93	0	0	15	0	0	250
1991	42	62	140	0	0	0	310	211	17	0	15	205	1002
1992	12	123	124	11	8	0	0	27	0	115	0	155	575
1993	503	86	0	0	9	0	0	71	0	0	94	0	763
1994	41	29	57	0	23	0	0	6	0	0	46	52	254
1995	154	22	5	0	0	0	0	56	0	0	0	11	248
1996	0	70	0	0	0	0	0	0	0	4	0	2	76
1997	30	2	0	4	0	9	86	0	210	0	11	146	498
1998	39	121	19	0	0	0	0	16	15	0	0	39	249
1999	0	26	0	15	0	0	13	0	28	0	0	0	82
2000	0	42	12	0	0	15	0	116	1	57	2	0	245
2001	12	186	43	0	-	0	0	0	0	0	0	0	-
2002	11	-	-	-	-	-	-	-	-	-	-	-	-

Note: Units are measured in 1/100th of an inch.

TABLE 3.3-2
ANNUAL WATER-YEAR PRECIPITATION
1948 THROUGH 2000

Water Year	Total (Inches)	Water Year	Total (Inches)
1948-49	5.64	1974-75	2.48
1949-50	0.75	1975-76	5.45
1950-51	2.73	1976-77	4.57
1951-52	3.3	1977-78	4.38
1952-53	1.85	1978-79	6.44
1953-54	-	1979-80	7.9
1954-55	-	1980-81	3
1955-56	0.5	1981-82	3.77
1956-57	1.93	1982-83	12.42
1957-58	2.74	1983-84	3.45
1958-59	0.73	1984-85	3.06
1959-60	2.4	1985-86	5.19
1960-61	0.9	1986-87	3.18
1961-62	2.75	1987-88	5.75
1962-63	2.76	1988-89	1.14
1963-64	0.98	1989-90	2.38
1964-65	1.71	1990-91	7.97
1965-66	4.09	1991-92	5.25
1966-67	3.28	1992-93	9.39
1967-68	8.61	1993-94	2.5
1968-69	0.69	1994-95	3.35
1969-70	-	1995-96	0.81
1970-71	-	1996-97	3.47
1971-72	0.45	1997-98	3.67
1972-73	3.18	1998-99	1.21
1973-74	1.7	1999-00	1.86

Geology

The Ocotillo/Coyote Wells Groundwater Basin is an alluvial basin that contains silts, sands, and gravels that have been eroded from the surrounding mountains and were deposited on Tertiary marine (i.e., ocean or shallow sea) sediments. These Quaternary alluvial deposits are highly permeable and contain groundwater of relatively good quality, as discussed below. Along the western and northern edges of the Basin, the Quaternary gravels overlie and abut the bedrock that forms the Jacumba and Coyote Mountains. In the central and eastern parts of the Basin, the gravels overly the Tertiary marine sediments. Based on the total depth of wells installed in the Basin, the thickness

of the gravels varies from zero along the mountain fronts to at least 600 feet in the Ocotillo area.

There are several prominent fault zones within the Basin. The Elsinore Fault forms the boundary between the alluvial sediments of the Basin and the bedrock of the Coyote Mountains (see Figure 3.3-3, Generalized Geology). South of Yuha Springs, the Laguna Salada Fault separates the alluvial basin sediments on the west from an area of primarily Tertiary marine sediments to the east.

The Tertiary marine sediments are believed to be present beneath the alluvial gravels throughout most of the Ocotillo/Coyote Wells Groundwater Basin. East of Coyote Wells and the Laguna Salada Fault, there are numerous areas where the Tertiary marine sediments crop out and are exposed on the surface of the basin, as shown in Figure 3.3-3. In general, the geology east of Coyote Wells and the Laguna Salada Fault zone is dominated by the marine sediments, although the alluvial gravels are present in many areas.

The Tertiary marine sediments also crop out in several areas west of Coyote Wells and the Laguna Salada fault zone. Exposures of the marine sediments occur over a large area east of Yuha Estates, and in smaller areas to the west and south of Nomirage and several miles to the northwest of Ocotillo.

Several previous studies have assumed that the Elsinore Fault and the Laguna Salada Fault are connected in the subsurface to the east of Coyote Wells (USGS, 1977; Bookman-Edmonston, 1996). These studies also assume that the subsurface fault zone acts as a hydraulic barrier to groundwater flow and assigned low-permeability properties to the fault zone in numerical groundwater models. The basis for this assumption is a change in the hydraulic gradient (i.e. the slope of the groundwater surface) and a change in the water chemistry across the assumed fault zone. As discussed in more detail below, however, little evidence exists that the fault zone in this case, if present, has properties that differ from the adjacent geologic deposits and that the fault zone acts as a barrier to groundwater flow. More recent field evaluations (Bookman-Edmonston, 2003) indicate that the Elsinore Fault and Laguna Salada faults are not connected as a continuous fault zone through the area east of Coyote Wells.

Hydrology

As discussed above, the Ocotillo/Coyote Wells Groundwater Basin contains appreciable quantities of potable water and, in fact, is the sole source of domestic and

commercial/industrial water supply for the area. Groundwater well locations are shown in Figure 3.3-4, Location of Wells. According to Bookman-Edmonston (1996), the watershed for the Basin consists of approximately 87 square miles of upland area within the Jacumba and Coyote Mountains and approximately 80 square miles of alluvial valley floor. Due to the relatively low precipitation and high evapotranspiration that occurs in the area, virtually all of the groundwater recharge that occurs in the Basin comes from runoff from the mountains.

The depth to groundwater varies depending on the ground surface elevation and the slope of the groundwater surface. In the Yuha Springs area, to the east of Yuha Estates, the water table is only a few feet below ground surface (ft bgs). Just east of Coyote Wells, the depth to groundwater ranges from 10 ft bgs to 25 ft bgs. However, the groundwater in these two areas could be perched. In the Ocotillo area, the depth to groundwater ranges from under 100 ft bgs to over 160 ft bgs. At some locations in Yuha Estates, the depth to groundwater may exceed 200 ft bgs.

A study conducted by the USGS (1964) suggests that recharge to the groundwater basin may consist of 0.5 inches per year of runoff from the mountains and 0.02 inches per year of direct recharge from precipitation that falls on the valley floor. As discussed below, however, the upper few feet of groundwater throughout the Ocotillo/Coyote Wells Groundwater Basin tends to be saline and have an elevated total dissolved solids (TDS) content. The presence of saline water at the water table indicates that there is no appreciable recharge of fresh, meteoric water from rainfall across the valley floor. Thus, the only significant source of recharge occurs at the base of the mountain front, where surface runoff reaches the alluvium.

Prior estimates of Basin recharge have ranged from 536 AF/yr to 7,200 AF/yr. The most recent groundwater modeling effort for the basin (Bookman-Edmonston, 2004), which is based on extensive review and input from the USGS and the preparers of this EIR/EIS, yields a calibrated recharge to the basin of approximately 1,077 AF/yr. The model estimated recharge of 1,077 AF/yr was used to calibrate the groundwater model and is a conservative recharge estimate. The recharge rate of 1,077 AF/yr is lower than most analytical estimates for the Basin. Mark (1987) estimates recharge using four methods and obtained results of 536, 1044, 1650, and 1820 AF/yr. Mark (1987) concluded that 536 AF/yr was unrealistic and used 1650 AF/yr for his work. Skrivan (1977) estimated the recharge at 2600 AF/yr. Huntley (1979) states that recharge is between 870 and 1672 AF/yr. Zipp (1982) suggests that the recharge rate may be as high as 4600 to 7200 AF/yr.

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Bookman-Edmonston (1996) estimates the recharge at 2400 AF/yr. The recharge to the Groundwater Basin may consist of 0.5 inches per year of runoff from the mountains (USGS), which suggests a total recharge of about 2,300 AF/yr. Nonetheless, as stated above, for the modeling efforts undertaken for this Project, a conservative recharge rate of 1,077 AF/yr was used.

The groundwater flow direction trends from the northwest toward the southeast. Figure 3.3-5, Simulated Water-Level Contours, and Figure 3.3-6, Simulated 1995 Contours, are contour maps of the groundwater surface developed by the USGS (1977) and Bookman-Edmonston (1996). In the upper part of the Basin, approximately four to five miles northwest of Ocotillo, the hydraulic gradient is approximately 30 feet per mile or greater, or about 0.006 ft/ft (i.e. $6x10^{-3}$ ft/ft). In the southern part of the Basin, near the international border with Mexico, the hydraulic gradient is only approximately six feet per mile, or about 0.001 ft/ft (i.e. $1x10^{-3}$ ft/ft). To the east of Coyote Wells, in the area of primarily Tertiary marine sediment outcrops, the hydraulic gradient is approximately 40 feet per mile, or about 0.0075 ft/ft (i.e. $7.5x10^{-3}$ ft/ft).

Groundwater Quality

The groundwater quality within the Ocotillo/Coyote Wells Groundwater Basin is variable at different locations. Some areas of the Basin produce waters of relatively good quality and other areas produce highly saline waters. Table 3.3-3A, Summary of Water Chemistry Data, presents a summary of water chemistry data for selected wells throughout the Basin, as reported in the USGS WATSTOR database. The general water quality of the Basin can be evaluated primarily based on the TDS content of the water (Table 3.3-3B, TDS Data Versus Time). The TDS is a measurement of the total amount of salts and other naturally-occurring minerals in the groundwater. The EPA secondary TDS standard for drinking water is 500 milligrams per liter (mg/L), which is equivalent to 500 parts per million (ppm). Thus, groundwater with TDS levels below 500 mg/L is considered high-quality, potable water. In general, water with a TDS level exceeding 1,000 mg/L is not considered potable, although it is not uncommon for local drinking water supplies to exceed this level in some areas of the country.

Figure 3.3-7, Groundwater Quality (TDS Concentrations in mg/L), taken from Bookman-Edmonston (1996), shows the distribution of TDS in the Ocotillo/Coyote Wells Groundwater Basin. The TDS levels range from about 300 mg/L to over 54,000 mg/L. By comparison, sea water has a TDS level of about 30,000 mg/L. In the area of

TABLE 3.3-3A
SUMMARY OF WATER CHEMISTRY DATA
OCOTILLO/COYOTE WELLS GROUNDWATER BASIN

Well		Date	PH	Ca mg/L	Mg mg/L	K mg/L	Na mg/L	Bicarb mg/L	Carb mg/L	Cl mg/L	Fl mg/L	SO4 mg/L	TDS mg/L	Boron ug/L	Fe ug/L
16S/9E	24B1	03/18/97	8.7	3.8	1.4	2.4	430	186	9	390	1.9	270	1220	744	210
	24D1	03/17/97	8.3	14	4.2	3.7	140	117	1	91	1.1	140	475	406	10
	25K2	03/18/97	8	24	5.7	4.6	81	136	0	78	0.9	41	342	211	<1
	25Q1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	26F1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	34B1	05/06/97	8.1	8.17	1.5	3.4	93	126	0	73	1.9	21	309	314	100
	35M1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	36C2	03/19/97	8.1	17	3.1	4.1	99	154	0	80	1.7	33	354	477	<1
	36D2	04/10/90	8.2	15	2.5	2.7	100	NM (115)	NM	82	1.9	27	347	660	100
	36D3	03/19/97	8.3	23	1.3	2.4	120	174	1	77	3.0	20	359	766	<1
	36G4	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	36H1	03/18/97	8.1	16	3.3	4	70	124	0	57	0.8	31	288	190	40
	27R1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	29H1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	29L1	03/17/88	8.5	7.9	3.6	3.3	240	NM (100)	NM	240	0.9	66	670	380	30
	29R2	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
16S/10E	30R1	03/19/97	7.8	42	13	5.1	140	150	0	190	0.9	60	582	447	20
	42A8	03/17/97	7.9	32	12	4.3	270	231	0	330	1.6	140	954	1210	<1
17S/10E	11B1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	11G1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	11G2	03/10/82	8.1	17	5	5	112	NM (135)	NM	99	0.4	67	392	20	<1
	11G4	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	11H1	No data	-	-	-	-	-	-	-	-	-	-	-	-	-
	11H2	04/04/86	8.1	20	4.5	4.4	75	NM (140)	NM	47	0.5	52	293	170	10
	11H3	03/17/97	8.1	19	4	3.9	82	137	0	53	0.6	58	309	178	<1

Notes:
NM = Not Measured

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TABLE 3.3-3B
TDS DATA VERSUS TIME
OCOTILLO/COYOTE WELLS GROUNDWATER BASIN

	R16S-T9E								R16S-T10E	R17S-T10E				
Date	24B1 (mg/L)	24D1 (mg/L)	25K2 (mg/L)	34B1 (mg/L)	36C2 (mg/L)	36D2 (mg/L)	36D3 (mg/L)	36H1 (mg/L)	29L1 (mg/L)	11G2 (mg/L)	11H2 (mg/L)	11H3 (mg/L)	30R1 (mg/L)	42A8 (mg/L)
06/27/59	-	-	-	-	-		-	-	-	-	-	-	527	-
02/08/61	-	-	-	-	299		-	-	-	-	-	-	-	-
03/05/62	-	-	-	-	325		-	-	-	-	-	-	391	-
11/09/62	-	-	-	-	277		-	-	-	-	-	-	-	-
02/07/63	-	-	-	-	-	-	-	288	-	-	-	-	-	-
12/01/72	-	-	325*	-	-	-	-	-	-	335	-	-	-	-
12/03/74	-	-	320*	-	-	-	-	-	-	-	-	-	-	-
06/26/75	-	-	307	-	-	356	-	-	-	-	-	-	479	-
04/28/77	1270	495	303	-	-	350	-	312	713	363	-	-	473	-
04/27/77	1210	471	304	-	-	358	-	300	690	369	-	-	479	-
03/15/79	1220	473	301	-	-	347	-	303	662	370	-	-	546	-
05/01/80	1240	476	305	-	-	353	-	300	667	377	-	-	579	-
04/30/81	1200	478	325	-	-	356	-	296	639	377	-	-	563	-
03/10/82	1210	487	383	-	-	361	-	294	656	392	-	-	572	-
03/29/83	1230	480	306	-	-	344	-	304	660	-	300	-	545	-
04/18/84	1260	479	-	-	-	375	-	294	665	-	291	-	560	-
04/26/85	1270	475	-	-	-	363	-	305	667	-	297	-	579	-
04/02/86	1340	467	-	-	-	349	-	296	640	-	293	-	609	-
04/03/87	1290	486	-	-	-	354	-	299	651	-	-	313	654	-
03/16/88	1300	486	405	-	-	351	-	301	670	-	-	311	757	-
03/15/89	1290	506	393	-	-	352	-	305	-	-	-	319	766	-
04/10/90	1270	492	337	-	-	347	-	-	-	-	-	-	-	-
05/11/90	-	-	-	-	-	-	-	-	-	-	-	-	801	-
04/04/91	-	-	-	-	367	-	-	299	-	-	-	316	-	-
04/06/92	1230	488	326	-	-	-	372	-	-	-	-	-	-	-
04/14/93	-	-	-	-	368	-	-	295	-	-	-	307	671	-
03/22/94	1240	485	337	-	362	-	364	298	-	-	-	315	664	886
03/29/95	1180	483	335	-	354	-	360	297	-	-	-	312	657	928
03/19/96	1200	464	334	-	352	-	351	290	-	-	-	306	582	906
03/18/97	1220	475	342	-	354	-	359	288	-	-	-	309	582	954
05/06/97	-	-	-	309	-	-	-	-	-	-	-	-	-	-
03/30/98	1190	472	330	309	346	-	350	300	-	-	-	307	574	946
06/28/98	-	-	-	349	-	-	-	-	-	-	-	-	-	-
03/22/99	1180	475	325	-	355	-	360	298	-	-	-	299	572	951
03/27/00	1210	476	313	310	355	-	358	321	-	-	-	307	557	910
03/22/01	1200	470	360	303	-	-	352	295	-	-	-	280	545	926

Notes:

- TDS Corrected for Silica not measured - solids residue number used

predominantly Tertiary marine sediment outcrops east of Coyote Wells, most wells have TDS levels exceeding 1,000 mg/L, although there is at least one location with a TDS level of 544 mg/L. West of the southern projections of the Elsinore Fault, the TDS

levels are generally below 500 mg/L, but there are several wells with TDS concentrations as high as 6,900 mg/L. The distribution of TDS appears to be controlled by two factors:

1. *Well depth*. The uppermost few feet of groundwater tend to have an elevated TDS level. This may be due to the concentration of salts near the water table due to evapotranspiration of groundwater in the past, when the water table was closer to the ground surface; and

2. *Proximity to the Tertiary marine sediments*. The Tertiary sediments were deposited in a marine environment. Thus, the connate water in the pores of the sediments, at the time of deposition, was saline.

The relatively high TDS levels east of Coyote Wells are most likely a result of the greater occurrence of the Tertiary marine sediments. Some of the wells with elevated TDS levels on the west side of the southern projections of the Elsinore Fault are near mapped outcrops of the marine sediments. A 1983 unpublished Masters Thesis from San Diego State University (Jansen, 1983) indicates that a transition in water quality occurs just east of Nomirage and that the available data do not support the theory of a distinct and singular groundwater boundary along a hypothetical connection of the Elsinore and Laguna Salada fault zones. The analysis conducted for this EIR/EIS is consistent with the findings of Jansen (1983).

Where high TDS levels are found, there are also several trace elements that could be of concern in the Ocotillo/Coyote Wells Groundwater Basin. These elements include fluoride, boron, and iron. The state drinking-water standard for fluoride is 1.4 mg/L, based on the local air temperatures. The California Department of Health Services drinking water action level for boron is 1.0 mg/L. Action Levels are advisory levels and not enforceable actions. Levels greater than the action level require a drinking water system to notify the governing body of the local agency in which users of the drinking water reside. The EPA drinking-water standard for iron is 0.05 mg/L. As shown in Table 3.3-3A, there are several wells in the Basin that have fluoride, boron, and/or iron levels that approach or exceed these standards.

Groundwater Use

Groundwater from the Ocotillo/Coyote Wells Groundwater Basin is used for domestic, commercial, industrial, and agricultural purposes for users in the Basin and outside of the Basin. Surface water is not present within the Basin and water is not imported into the Basin.

Domestic water users include the communities of Ocotillo, Coyote Wells, Nomirage, and Yuha Estates. Water is also piped to the community of Painted Gorge. Domestic water supply is provided by a combination of private wells and community water services. Table 3.3-4, Current and Historic Groundwater Use, presents current and historic water use for various users. In the 1996-1997 time period, community domestic water use is estimated to be approximately 110 AF/yr to 115 AF/yr. Changes in water use over time are based on the rate of population growth, as described by Bookman-Edmonston (1996). Current domestic water use is anticipated to be approximately 120 AF/yr to 125 AF/yr.

TABLE 3.3-4
CURRENT AND HISTORIC GROUNDWATER USE
OCOTILLO / COYOTE WELLS GROUNDWATER BASIN

Year	US Gypsum[1]			Estimated Community Use (AF/yr)	Export to Mexico	
	Based on Production (AF/yr)	*Reported to USGS (AF/yr)*	*Measured Extraction Rates*		*Clifford Well (AF/yr)*	*McDougal Well (AF/yr)*
1925	~~153~~	153	-	-	-	-
1926	~~153~~	153	-	-	-	-
1927	~~153~~	153	-	-	-	-
1928	~~153~~	153	-	-	-	-
1929	~~153~~	153	-	-	-	-
1930	~~153~~	153	-	-	-	-
1931	~~153~~	153	-	-	-	-
1932	~~153~~	153	-	-	-	-
1933	~~153~~	153	-	-	-	-
1934	~~153~~	153	-	-	-	-
1935	~~153~~	153	-	-	-	-
1936	~~153~~	153	-	-	-	-
1937	~~153~~	153	-	-	-	-
1938	~~153~~	153	-	-	-	-
1939	~~153~~	153	-	-	-	-
1940	~~153~~	153	-	-	-	-
1941	~~153~~	153	-	-	-	-
1942	~~153~~	153	-	-	-	-
1943	~~153~~	153	-	-	-	-
1944	~~153~~	153	-	-	-	-
1945	~~153~~	153	-	-	-	-
1946	~~153~~	153	-	-	-	-
1947	~~264~~	264	-	-	-	-
1948	~~264~~	264	-	-	-	-
1949	~~264~~	264	-	-	-	-
1950	~~306~~	306	-	-	-	-
1951	~~253~~	253	-	-	-	-
1952	~~255~~	255	-	-	-	-

Table 3.3-4 (Continued)

Year	US Gypsum[1]			Estimated Community Use	Export to Mexico	
	Based on Production	*Reported to USGS*	*Measured Extraction Rates*		*Clifford Well*	*McDougal Well*
1953	~~241~~	241	-	-	-	-
1954	~~278~~	278	-	58.2	-	-
1955	~~295~~	295	-	59.4	-	-
1956	~~274~~	274	-	60.6	-	-
1957	~~272~~	272	-	61.8	-	-
1958	~~353~~	353	-	63.0	-	-
1959	~~375~~	375	-	64.2	-	-
1960	~~395~~	395	-	65.4	-	-
1961	~~348~~	348	-	66.6	-	-
1962	~~422~~	422	-	67.8	-	-
1963	~~442~~	442	-	69.0	-	-
1964	~~480~~	480	-	70.2	-	-
1965	~~415~~	415	-	71.4	-	-
1966	~~451~~	451	-	72.6	-	-
1967	~~511~~	511	-	73.8	-	-
1968	~~552~~	552	-	75.0	-	-
1969	~~560~~	560	-	76.2	-	-
1970	393	668	-	77.4	-	-
1971	338	575	-	78.6	-	-
1972	451	767	-	79.8	-	-
1973	375	638	-	81.0	-	-
1974	406	691	-	82.2	138	-
1975	361	614	-	83.4	211	-
1976	414	-	-	84.6	213	-
1977	473	-	-	85.8	222	-
1978	491	-	-	87.0	137	143
1979	496	-	-	88.2	137	143
1980	469	-	-	89.4	137	143
1981	~~261~~	-	261	90.8	137	143
1982	~~456~~	-	456	92.1	137	143
1983	~~472~~	-	472	93.5	137	-
1984	~~472~~	-	472	94.8	137	-
1985	~~489~~	-	489	96.2	-	-
1986	~~521~~	-	521	97.6	-	-
1987	~~512~~	-	512	98.9	-	-
1988	~~518~~	-	518	100.3	-	-
1989	~~492~~	-	492	101.6	-	-
1990	~~476~~	-	476	103.0	-	-
1991	~~428~~	-	428	104.5	-	-
1992	~~379~~	-	379	106.0	-	-
1993	~~362~~	-	362	107.4	-	-
1994	~~378~~	-	378	108.9	-	-
1995	~~327~~	-	327	110.4	-	-
1996	~~367~~	-	367	112.1	-	-
1997	~~332~~		332			
1998	~~333~~		333			

Notes:

- ~~No data~~ 1. The source for reported water use from 1925 to 1970 is unknown . Water use from 1970 to 1980 was estimated by USG based on wallboard production records for this period. Water since 1981 is based on measured extraction rates.
- USGS Water Resources Investigation (WRI) 77-30 by J. A. Skrivan (1977)

The primary current commercial and industrial use of water is by USG at its wallboard Plant and Quarry. Groundwater is extracted from three wells in the Ocotillo area and piped approximately eight miles to Plaster City. There are several sources of information on the rate of water used by USG. These include a January 5, 1975 letter to the USGS, a January 9, 1997, letter to the Imperial County Public Works Department, a discussion by Bookman-Edmonston (1996), and annual groundwater reports made to the Imperial County Public Works Department by USG. The information from these sources is summarized in Table 3.3-4. The average pumping rate for the five-year period from 1994 through 1998 is 347 AF/yr.

For the period from 1925 through 1975, USG reported water use to the USGS for use in the USGS groundwater modeling study (USGS, 1977). The basis for the pumping rates reported over this time period are uncertain. For the period from 1970 through 1980, USG also provided Bookman-Edmonston estimates of water use based on wallboard production rates (Bookman-Edmonston, 1996, page 6-2). Bookman-Edmonston reports "Estimates of water use provided to USGS are 70 percent greater than estimates of water use based upon production records during 1970 to 1975 (the only years where these records overlap). This difference could not be reconciled." Table 3.3-4 shows the water use reported to the USGS and the values based on production rates for the period from 1970 to 1975. The rates reported to the USGS range from 575 AF/yr to 767 AF/yr. The rates based on production range from 338 AF/yr to 451 AF/yr. The difference between these two data sets is referred to as the "U.S. Gypsum Variance" on Figure 3.3-8, Annual Water Production.

Since 1981, the groundwater extraction rate has reportedly been measured at each well by USG. Thus, these data are considered the most reliable.

Other current commercial and industrial users include several gravel quarries located within the Basin, near Interstate Highway 8 and northwest of Ocotillo. According to the Ocotillo/Nomirage Community Area Plan (ONCAP), the Val Rock and Farmers Land Leveling quarries each use between six to eight AF/yr of water. Bookman-Edmonston (1996, page 6-3) also reports at least three other gravel quarries in the area. Based on these values, annual water use for gravel quarry operations could be as high as 35 AF/yr, or more.

As early as 1958, a well in Ocotillo was used in part to export water to Mexico. Estimates of early water export are not available. In 1979, the Imperial County Planning Department had a study prepared (Copley, 1979) to estimate the amount of water exported to Mexico from the well in Ocotillo (referred to as the Clifford well, or well

16S/9E-25K2), based on the rate of electricity used to pump the well. From 1974 through 1978, the estimated export reportedly ranged from 137 AF/yr to 222 AF/yr. Exports from this well reportedly continued until about 1984.

Water exports also occurred from a well in Yuha Estates (the McDougal well, or well 17S/10E-11G4). Export reportedly began in September 1977 and continued until September 1982. It is estimated that approximately 143 AF/yr were being pumped from the Clifford Well. Table 3.3-4 shows the presumed rate of water export from 1974 through 1984. The information presented in the table assumes that production from the Clifford well continued from 1979 through 1984 at the same rate as that which occurred in 1978 (137 AF/yr). Imperial County attempted to halt or limit the export of water from the basin as early as 1979 due to concerns regarding overdraft and degradation of water quality (Mitchell, 1979; Huntley, 1980). McDougal Water Company ceased groundwater extraction for export in 1984.

1998 Baseline Conditions

Partial implementation of the Proposed Action has resulted in variable but presumably increasing water consumption since approximately 2000, based on the annual groundwater reports provided to the County by USG.

Water level measurements have been made by the USGS at wells in the Basin since at least the 1970s. The USGS has also conducted water-quality sampling at some of these wells over the same time period. The USGS monitoring was established in the 1970s to evaluate suspected overdraft conditions and the threat of water quality degradation in the basin (Montgomery-Watson, 1995, page 2-1). Table 3.3-5, Summary of Well Data, lists the wells with available water level data and water quality data, the dates of the available data, and the well construction information. Well locations are shown on Figure 3.3-4. For some wells, water-quality sampling only occurred in the 1980s or 1990. For other wells, a complete analysis of all significant water-quality parameters (most notably the alkalinity) did not begin until 1997.

Insert Figure 3.3-8

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TABLE 3.3-5
SUMMARY OF WELL DATA
OCOTILLO / COYOTE WELLS GROUNDWATER BASIN

Well	Surface Elev (ft amsl)	Total Depth (ft bgs)	Perforated Interval (ft bgs)	Diameter (inches)	Use	Available Water-Level Data	Available Water Chemistry Data	Notes	Lat	Long
Yuha Estates Area										
17S/10E-11B1	376	301		7	Domestic	1975-76, 1978-01		McDougal	324138	1155529
17S/10E-11G1	380	300	160-300	8	Domestic/ Commercial	1976, 1971-72, 75-76, 78-01			324123	1155529
17S/10E-11G2	375	335	235-315	6.6	Domestic	1971, 1975-82, 1984	1972, 1977-82		324123	1155531
17S/10E-11G4	382	199/500		10.75	Unused	1978, 81-01			324119	1155532
17S/10E-11H1	380	329.9		8	Domestic	1968, 1978-91			324114	1155523
17S/10E-11H2	376	344		4		1973, 1978-87	1983-86		324118	1155521
17S/10E-11H3	380	348	202-333	5	Domestic	1987-2001	1987-89, 1991, 1993-2001		324117	1155520
Elsinore-Laguna Salada Fault Area										
16S/9E-24B1	385	129	125-128.5	2	Observation	1976-2001	1977-1990, 1992, 1994-01	USGS	324608	1155935
16S/9E-24D1	385	149	145.5-149	2	Observation	1976-2001	1977-1990, 1992, 1994-01	USGS	324558	1155952
16S/10E-27R1	300	104	102-104	2	Observation	1975-2001		USGS	324430	1155555
16S/10E-29H1	251	39	37-39	2	Observation	1975-2001		USGS	324458	1155703
16S/10E-29L1	280	48	44.5-48	2	Observation	1976-1988	1977-88	USGS	324440	1155743
16S/10E-29R2	258	30	28-30	2	Unused	1975-1989			324428	1155707
Ocotillo-Nomirage Area										
16S/9E-25K2	364	372	132-192, 242-372	10	Commercial	1972, 1975-01	1972-83, 1988-90, 1992, 1994-01	McDougal	324439	1155934
16S/9E-25Q1	372	128		8	Unused	1974, 1976, 1981-92			324426	1155936
16S/9E-35M1	616	535	415-495	8	Domestic	1962, 1975-89			324345	1160100
16S/9E-36D2	433	200	150-200	8	Domestic	1975-2001	1975-90		324422	1160003
16S/9E-36G4	382	560	340-560	10.75	Commercial	1975-2001		Westwind	324401	1155932
16S/9E-36H1 USGS	338	410	157-372	10.75	Industrial	1954, 60, 66, 74, 76-2001	1963, 1977-89, 1991, 1993-01	US Gypsum #5	324407	1155909

The variations in the time period of available and reliable data regarding water production, water levels, and water quality complicate the process of identifying the baseline conditions for the Project. For the pumping by USG, the baseline is considered the average water production for the period form 1994 through 1998, which is 347 AF/yr. Based on the available information, the appropriate baseline for water levels and water quality parameters is defined by the conditions that existed in 1996-1997, since that was the latest pre-Proposed Action data available. Thus, the data from this time period will be used as the point of comparison to evaluate potential future impacts from the proposed increase in groundwater extraction rates for the Project. The baseline data are summarized in Tables 3.3-6A, B and C, Depth to Groundwater and Groundwater Surface Elevation. It is important to note, however, that due to the limited information available for definition of the baseline, the evaluation of potential impacts must rely heavily on all of the available historical data for the Ocotillo/Coyote Wells Groundwater Basin, as reported in these table references.

3.3.3 Plant Water Usage: Thresholds of Significance, Environmental Consequences, and Mitigation Measures

3.3.3.1 Approach

The County and local water users have expressed concerns regarding the conditions and possible degradation of water quality in the Ocotillo/Coyote Wells Groundwater Basin. These concerns were the basis for initiating the USGS water-level measurement and water-quality sampling program, and the reason the 1977 USGS modeling study was conducted. Previous studies of the Ocotillo/Coyote Wells Groundwater Basin have relied primarily on water-balance calculations and numerical modeling to evaluate potential impacts to water quantity and water quality from existing or projected rates of groundwater pumping (e.g. USGS, 1977; Huntley, 1979; Montgomery-Watson, 1995; Bookman-Edmonston, 1996). Based on detailed review of these previous studies, the available data appreciably limits the usefulness of these methods for evaluating impacts to the Basin.

The water-balance calculations and numerical modeling conducted previously were regional in approach. In general, they address the entire Ocotillo/Coyote Wells Groundwater Basin. This regional, basin-wide perspective provides valuable information and insight into the hydrologic conditions and behavior of the groundwater basin on a large-scale basis. This perspective, however, limits the ability of the previous studies to address local impacts or the performance of individual wells or groups of wells. These limitations are acknowledged by Montgomery-Watson (1995) and Bookman-Edmonston (1996).

Table 3.3-6A
Depth to Groundwater and Groundwater Surface Elevation
Ocotillo-Nomirage Area

WELL	16S/9E-25K2			16S/9E-25Q1			16S/9E-36D2			16S/9E-36G4			16S/9E-36H1			16S/9E-35M1		
	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf
DATE	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)
03/21/54													68.5	338	269.5			
05/15/60													85		253			
03/15/62																321	616	295
06/15/64																		
08/15/66													81		257			
04/26/67																		
09/30/71																		
07/25/72																		
08/25/72	83	364	281															
03/15/73																		
12/01/74				104.24	372	267.76							80.07		257.93			
12/30/74				104.3		267.7												
05/12/75																		
05/14/75																		
06/01/75																		
06/28/75	129.5		234.5				157.9	433	275.1	136.47	382	245.53				323.16		292.84
07/27/75																		
12/09/75																		
01/08/76	99.7		264.3	104.38		267.62	158.16		274.84	126.36		255.64	80.21		257.79			
10/14/76	111.57		252.43				158.46		274.54	128.39		253.61				323.08		292.92
11/10/76																		
11/17/76																		
12/10/76																		
04/27/77	104.1		259.9				158.57		274.43	129.43		252.57	81.66		256.34	327.04		288.96
10/04/77	145.62		218.38				158.87		274.13	126.14		255.86	82.65		255.35	325.38		290.62
04/26/78	98.05		265.95				158.79		274.21	124.7		257.3	80.89		257.11			
05/24/78																324.01		291.99
06/19/78																		
06/24/78																		
06/25/78																		
07/05/78																		
07/06/78																		
08/02/78																		
10/04/78	144.07		219.93				159.15		273.85	128.15		253.85	83.21		254.79	323.66		292.34
03/15/79	101.47		262.53															
03/16/79																		
03/22/79							159.1		273.9	126.68		255.32	91.82		256.18	325.26		290.74
09/13/79	105.8		258.2				159.35		273.65	126.05		255.95	83.26		254.74	323.8		292.2
03/12/80	93.22		270.78										82.01		255.99			
03/20/80	144.85		219.15															
04/18/80	147.3		216.7															
05/02/80	93.93		270.07				159.3		273.7	124.1		257.9				323.84		292.16
09/25/80	145.3		218.7				159.58		273.42	126.53		255.47	82.67		255.33	323.89		292.11
04/29/81	95.04		268.96				159.73		273.27	125.23		256.77	81.25		256.75	324.11		291.89
11/06/81	95.56		268.44	106.89		265.11	160.1		272.9	124.24		257.76	82.72		255.28	323.98		292.02

03/13/82	95.11		268.89	106.41		265.59	160.1		272.9	123.66		258.34	81.65		256.35	324.17		291.83
10/06/82										134.95		247.05	82.89		255.11			
10/07/82	96.84		267.16	107.2		264.8	160.36		272.64	125.77		256.23				324.41		291.59
04/01/83	95.1		268.9	105.85		266.15	160.04		272.96	124.66		257.34	81.02		256.98	324.43		291.57
09/22/83																		
10/26/83	95.9		268.1	107.18		264.82	160.49		272.51	123.3		258.7				324.69		291.31
10/27/83	96.22		267.78										82.51		255.49			
04/11/84										124.95		257.05	82.32		255.68			
04/12/84	94.04		269.96	106.24		265.76	160.32		272.68	123.71		258.29				324.48		291.52
10/24/84	93.48		270.52	106.08		265.92	160.31		272.69	126.35		255.65	82.78		255.22	324.56		291.44
04/25/85	93.73		270.27	106.14		265.86	160.23		272.77	124.86		257.14	82.62		255.38	325.77		290.23
10/31/85	93.86		270.14	106.56		265.44	160.56		272.44	122.63		259.37	84.08		253.92	324.87		291.13
03/27/86	93.63		270.37	105.92		266.08	160.37		272.63	122.14		259.86	83.29		254.71			
04/03/86	93.54		270.46													325.81		290.19
10/23/86	94.24		269.76	106.72		265.28	160.68		272.32	122.61		259.39	84.19		253.81	329.06		286.94
10/24/86	94.03		269.97															
04/01/87	93.78		270.22	106.04		265.96	160.5		272.5	122.4		259.6	83.42		254.58	325.27		290.73
10/23/87	94.06		269.94	106.73		265.27	160.78		272.22	123.39		258.61	84.06		253.94	325.13		290.87
03/15/88	93.94		270.06	106.25		265.75	160.7		272.3	122.65		259.35	83.84		254.16	326.21		289.79
10/19/88	94.4		269.6	107.17		264.83	160.92		272.08				84.65		253.35	325.16		290.84
03/17/89	94.23		269.77	106.71		265.29	160.94		272.06	123.1		258.9	83.67		254.33	326.01		289.99
10/31/89	94.47		269.53	107.33		264.67	161.15		271.85	125.9		256.1	84.2		253.8			
03/20/90	94.46		269.54	107.18		264.82	161.19		271.81	126.93		255.07	84.04		253.96			
10/24/90	94.59		269.41	107.51		264.49	161.3		271.7	129.04		252.96	84.07		253.93			
04/02/91	94.47		269.53	107.11		264.89	161.29		271.71	128.39		253.61	83.45		254.55			
10/07/91	94.57		269.43	107.27		264.73	161.36		271.64	131.26		250.74	83.75		254.25			
04/07/92	94.46		269.54				161.35		271.65	127.85		254.15	83.96		254.04			
10/28/92	95.07		268.93				161.57		271.43	127.62		254.38	84.9		253.1			
04/14/93							161.56		271.44	126.52		255.48	84.32		253.68			
10/21/93	95.08		268.92				161.74		271.26	126.05		255.95						
03/14/94							161.71		271.29	125.11		256.89						
03/24/94	94.85		269.15										83.67		254.33			
10/27/94							161.84		271.16	126.11		255.89	84.69		253.31			
03/30/95	94.32		269.68										82.02		255.98			
05/24/95							162.02		270.98	138.36		243.64						
07/31/95																		
10/17/95							161.85		271.15	123.97		258.03	82.6		255.4			
03/20/96	94.61		269.39				161.75		271.25	128.5		254.5	82.11		255.89			
10/16/96							162.02		270.98	129.87		252.13						
03/24/97	96.59		267.41				161.9		271.1	125.38		256.62	82.39		255.61			
10/20/97							162.05		270.95	125.96		256.04	82.81		255.19			
03/23/98							162.06		270.94	125.2		256.8						
03/30/98																		
10/13/98							162.09		270.91	126.97		255.03	83.36		254.64			
03/23/99							162.24		270.76	128.16		253.84	83.04		254.96			
10/25/99							162.33		270.67	127.93		254.07	83.67		254.33			
03/29/00							162.54		270.46	132.6		249.4	84.24		253.76			
10/23/00							162.57		270.43	128.7		253.3	85.13		252.87			
03/26/01							162.87		270.13				85.54		252.46			

DTW = Depth to water
Surf El = Surface elevation to well casing
GW Surf = Groundwater surface elevation

ft bgs = feet below ground surface
ft amsl = feet above mean sea level

Table 3.3.6B
Depth to Groundwater and Groundwater Surface Elevation
Yuha Estates Area
Ocotillo/Coyote Wells Groundwater Basin

WELL	17S/10E-11H1			17S/10E-11H2			17S/10E-11H3			17S/10E-11G1			17S/10E-11G2			17S/10E-11G4			17S/10E-11B1		
	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf
DATE	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)
06/15/64	158.27	380	221.73																		
04/26/67										170	380	210									
09/30/71										150		230	158	375	217						
07/25/72										164		216									
03/15/73				165	376	211															
06/01/75													164		211						
06/28/75													164.25		210.75				156.8	376	219.2
07/27/75										164.94		215.06									
01/08/76										165.11		214.89							154.8		221.2
10/14/76													164.04		210.96						
04/27/77													163.68		211.32						
10/04/77													164.45		210.55						
05/24/78				179.02		196.98							164.91		210.09						
06/19/78	226.46		153.54										164.98		210.02						
06/24/78	195.36		184.64	182.7		193.3													157.9		218.1
06/25/78	164.2		215.8	169.4		206.6							164.8		210.2						
07/05/78										195.56		184.44	165.09		209.91	193.18	382	188.82			
07/06/78										195.58		184.42	165.09		209.91	193.12		188.88			
08/02/78																193.35		188.65			
10/04/78													165.58		209.42						
03/15/79	164.29		215.71	171.16		204.84				204.38		175.62	165.58		209.42				158.27		217.73
03/16/79	164.27		215.73																		
03/22/79	164.24		215.76	170.52		205.48							165.6		209.4				158.25		217.75
09/13/79	166.05		213.95	176.29		199.71				216.86		163.14	166.84		208.16				159.53		216.47
03/12/80	166.55		213.45							222.82		157.18									
03/20/80	166.59		213.41							218.29		161.71									
04/18/80	166.81		213.19							213.7		166.3									
05/02/80	167.65		212.35	176.6		199.4				216.6		163.4	167.64		207.36				159.96		216.04
09/25/80	170.46		209.54	180.36		195.64				225.64		154.36	168.93		206.07				161.06		214.94
04/29/81	170.69		209.31	182.35		193.65				226.73		153.27	170.25		204.75	199.37		182.63	161.47		214.53
11/06/81	173.35		206.65	184.43		191.57				232.8		147.2	172.38		202.62				162.47		213.53
03/13/82	177		203	185.44		190.56				228.15		151.85	172.92		202.08				162.47		213.53
10/07/82	180.83		199.17	189.87		186.13				221.2		158.8	178.03		196.97	206.21		175.79	163.03		212.97
04/01/83	174.12		205.88	185.95		190.05				205.99		174.01				203.14		178.86	163.03		212.97
10/26/83	174.33		205.67	187.34		188.66				195.86		184.14				199.31		182.69	163.37		212.63
04/12/84	172.39		207.61	186.39		189.61				191.17		188.83				196.28		185.72	163.34		212.66
10/24/84	171.79		208.21	186.75		189.25				187.63		192.37				193.25		188.75	163.49		212.51
04/25/85	171.87		208.13	186.77		189.23										191.9		190.1	163.1		212.9
10/31/85	171.69		208.31	190.27		185.73				185.31		194.69				189.71		192.29	163.29		212.71
04/03/86	171.37		208.63	185.06		190.94				182.92		197.08				188.26		193.74	162.99		213.01
10/23/86	171.33		208.67	187.41		188.59				182.68		197.32				187.22		194.78	163.3		212.7

Table 3.3.6B (Continued)

WELL	17S/10E-11H1			17S/10E-11H2			17S/10E-11H3			17S/10E-11G1			17S/10E-11G2			17S/10E-11G4			17S/10E-11B1		
	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf	DTW	Surf El	GW Surf
DATE	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)	(ft bgs)	(ft amsl)	(ft amsl)
04/01/87	171.01		208.99							182.73		197.27				186.69		195.31	163.14		212.86
10/23/87	173.39		206.61				179.29	380	200.71	182.48		197.52				185.92		196.08	163.82		212.18
03/15/88	172.18		207.82				178.81		201.19	181.34		198.66				185.21		196.79	163.29		212.71
10/19/88	171.02		208.98				180.11		199.89	180.5		199.5				184.26		197.74	164.05		211.95
03/17/89	170.45		209.55				177.99		202.01	180.95		199.05				183.91		198.09	163.79		212.21
10/31/89	169.84		210.16				179.08		200.92	181.22		198.78				183.47		198.53	163.84		212.16
03/20/90	169.55		210.45				177.73		202.27	179.61		200.39				182.79		199.21	163.36		212.64
10/24/90							178.57		201.43	179.45		200.55				182.14		199.86	163.72		212.28
04/02/91	172.44		207.56				176.64		203.36	178.21		201.79				181.45		200.55	163.29		212.71
10/07/91	170.39		209.61							177.59		202.41				180.7		201.3	163.72		212.28
04/07/92							175.57		204.43	176.73		203.27				179.76		202.24	163.13		212.87
10/28/92							176.84		203.16	178.03		201.97				180.08		201.92	163.65		212.35
04/14/93							175.47		204.53	176.97		203.03				179.46		202.54	163.21		212.79
10/21/93							176.35		203.65	178.89		201.11				180.1		201.9	163.87		212.13
03/24/94										178.02		201.98				179.56		202.44	163.34		212.66
10/27/94							176.36		203.64							179.58		202.42	163.56		212.44
03/30/95							175.64		204.36							178.97		203.03	163.18		212.82
07/31/95										177.16		202.84									
10/17/95							178.32		201.68	177.15		202.85				178.46		203.54			
03/20/96										176.94		203.06				178.12		203.88	163.2		212.8
10/16/96							178.53		201.47	177.52		202.48				178		204	163.62		212.38
03/24/97							175.69		204.31	176.78		203.22				177.74		204.26	163		213
10/20/97							176.69		203.31	176.35		203.65				177.34		204.66	163.05		212.95
03/23/98							175.29		204.71	175.42		204.58				176.82		205.18			
10/13/98							175.43		204.57	175.5		204.5				176.3		205.7			
03.23/99							176		204	174.97		205.03				176.06		205.94	162.51		213.49
10/25/99							176.39		203.61	174.59		205.41				175.66		206.34	162.53		213.47
03/29/00							175.89		204.11	174.14		205.86				175.34		206.66	163.33		213.67
10/23/00							176.53		203.47	174.03		205.97				174.94		207.06	162.47		213.53
03/26/01							174.26		205.74	173.38		206.62				174.48		207.52	162.02		213.98

DTW = Depth to water ft bgs = feet below ground surface
Surf El = Surface elevation to well casing ft amsl = feet above mean sea level
GW Surf = Groundwater surface elevation

Table 3.3.6C
Depth to Groundwater and Groundwater Surface Elevation
Area East of Coyote Wells
Ocotillo/Coyote Wells Groundwater Basin

WELL	16S/9E-24B1			16S/9E-24D1			16S/10E-29H1			16S/10E-29L1			16S/10E-29R2		
DATE	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)
03/15/62															
06/15/64															
04/26/67															
09/30/71															
07/25/72															
03/15/73															
05/12/75							22.2	251	228.8				9.74	258	248.26
05/14/75															
06/01/75															
06/28/75							22.03		228.97				9.95		248.05
07/27/75															
12/09/75							22.02		228.98						
01/08/76													9.95		248.05
10/14/76							22.04		228.96				9.94		248.06
11/10/76	105.35	385	279.65							23.32	280	256.68			
11/17/76	105.34		279.66							23.34		256.66			
12/10/76				131	385	254									
04/27/77	105.4		279.6	103.86			21.9		229.1	23.64		256.36	10.32		247.68
10/04/77	105.44		279.56	103.93			21.76		229.24	23.98		256.02	10.95		247.05
05/24/78	105.49		279.51	104.07			21.53		229.47	24.08		255.92	10.47		247.53
06/19/78															
06/24/78															
06/25/78															
07/05/78															
07/06/78															
08/02/78															
10/04/78	105.59		279.41	104.16		280.84	21.66		229.34	24.59		255.41	11.75		246.25
03/15/79	105.62		279.38	104.2		280.8	21.55		229.45	24.37		255.63			
03/16/79															
03/22/79													11.07		246.93
09/13/79	105.4		279.6	104.28		280.72	21.96		229.04	25.07		254.93	12.61		245.39
03/12/80															
03/20/80															
04/18/80															
05/02/80	105.74		279.26	104.4		280.6	22		229	25.27		254.73	12.49		245.51

Table 3.3.6C (Continued)

WELL	16S/9E-24B1			16S/9E-24D1			16S/10E-29H1			16S/10E-29L1			16S/10E-29R2		
DATE	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)	DTW (ft bgs)	Surf El (ft amsl)	GW Surf (ft amsl)
09/25/80	105.78		279.22	104.48		280.52	22.24		228.76	25.8		254.2	13.49		244.51
04/29/81	105.84		279.16	104.58		280.42	22.34		228.66	26.03		253.97	13.67		244.33
11/06/81	105.9		279.1	104.71		280.29	22.53		228.47	26.63		253.37	14.43		243.57
03/13/82	105.95		279.05	104.77		280.23	22.55		228.45	26.5		253.5	14.13		243.87
10/07/82	106.03		278.97	104.89		280.11	22.74		228.26	27.05		252.95	14.92		243.08
04/01/83	106.1		278.9	104.97		280.03				26.29		253.71	13.89		244.11
09/22/83										27.25		252.75			
10/26/83	106.16		278.84	105.1		279.9				27.33		252.67	15.65		242.35
04/12/84	106.22		278.78	105.2		279.8				27.49		252.51	15.66		242.34
10/24/84	106.29		278.71	105.27		279.73	22.99		228.01	27.94		252.06	16.24		241.76

Due to the regional perspective of the previous water balance calculations and numerical models, there is a concern that these previous studies are not focused enough to predict the potential local impacts of future increases in pumping with sufficient detail for this evaluation. Therefore, a different set of analyses have been performed for this Project. For this evaluation, the analyses selected include analytical calculations of Basin conditions and comparative analysis of water level and groundwater chemistry data. In addition, the numerical modeling recently conducted (Bookman-Edmonston, 2004) was intended to address issues and concerns specific to the Proposed Action, and received significant input and review from the USGS and the preparers of this EIR/EIS. These evaluations are presented below.

3.3.3.2 Basin Conditions

The hydrologic conditions within the Ocotillo/Coyote Wells Groundwater Basin can be defined using standard hydrologic equations, such as Darcy's Law. Darcy's Law states that:

$$Q = K \times I \times A,$$

where Q is the rate of groundwater discharge (units of volume per time, such as AF/yr), K is the hydraulic conductivity of the aquifer (units of length per time, such as feet per day), I is the hydraulic gradient, or slope of the groundwater surface (units of length per length, such as foot per foot), and A is the cross-sectional area of the aquifer across which the groundwater discharge, Q, is perpendicularly occurring (units of area, such as square feet).

In some instances, it is easier to estimate the transmissivity of the aquifer, T, as opposed to the hydraulic conductivity, K. The transmissivity is simply the hydraulic conductivity, K, multiplied by the aquifer thickness, b. The cross sectional area of the aquifer, A, can also be defined as the aquifer thickness, b, multiplied by the length of the cross-sectional area across the ground surface, L (if the cross-section is assumed as rectangular). With these terms, Darcy's Law may also be rewritten as:

$$Q = T \times I \times L.$$

The groundwater flow rate, or velocity, q (units of distance per time, such as feet per year) is also defined as:

$$q = (K \times I)/n,$$

where n is the effective porosity of the aquifer and the other terms are as defined above.

Figures 3.3-5 and 3.3-6 present groundwater contours of the Basin as interpreted by the USGS (1977) and Bookman-Edmonston (1996) for the years 1975 and 1995, respectively. These groundwater contours reflect the simulated output of two previous models. Groundwater contours derived from observed water levels are usually used to compare changes in the basin and estimate flow velocities and volumes. However de to the lack of observed data, both over space and time, preparing estimates based solely on observed data is not possible. The analyses of water levels, velocities, and flow in this section are included as an illustrative discussion of the groundwater system and the uncertainty of the simulated water levels and hydrologic properties. Comparison of these two figures indicates that the groundwater contours have been relatively consistent in the areas of the Basin that are more than a few miles from Ocotillo, Nomirage, and Yuha Estates. Thus, the hydraulic gradients that can be calculated from these figures can be used in the evaluation of Basin conditions.

~~Three lines extending across different parts of the Basin are indicated on Figures 3.3-5 and 3.3-6. These lines are drawn parallel to the groundwater contours. The first line is located in the upgradient part of the Basin, approximately three miles northeast of Ocotillo. A small embayment exists at this location where the bedrock of the Jacumba Mountains extends northward into the Basin, causing a narrowing of the alluvial aquifer. The second line exists in the downgradient part of the Basin located to the west of the Laguna Salada fault, north of the international border with Mexico. The third line extends across the downgradient part of the Basin that is present to the east of Coyote Wells and the Laguna Salada fault zone.~~

In the upgradient area of the aquifer, as indicated on Figures 3.3-5 and 3.3-6, the hydraulic gradient is approximately 30 feet per mile. The length across the alluvial basin is approximately 3.25 miles. For the recent numerical modeling (Bookman-Edmonston, 2004), the alluvial material in the basin was determined to have an average hydraulic conductivity of 15 ft/day, resulting in a transmissivity of about 1,000 ft^2/day. The effective porosity in the alluvium is uncertain. Estimates range from 8.3 percent to 30 percent. A value of 10 percent was used in the model. For this analysis the upper range (30 percent) was used. The effective porosity can be estimated at approximately 30 percent. Using these values and the equations presented above, the groundwater discharge, or amount of groundwater flowing through the upgradient area of the Basin, is approximately 800 AF/yr. The average groundwater velocity, or flow rate, is about 100 ft/yr, meaning that it takes over 50 years for the groundwater to flow one mile. It should be noted that the estimate of velocity is inversely proportional to the estimate effective porosity. Based on the range of possible porosity values, velocity could range from 100 to 375 ft/yr, or 50 years per mile and 14 years per mile respectively.

Figure 2 of the USGS (1977) model report and Figure 7-1 of the Bookman-Edmonston (1996) report each present a map of the mean annual precipitation across the Jacumba Mountains, Coyote Mountains, and the Ocotillo/Coyote Wells Groundwater Basin.

Based on the distribution of rainfall in the mountains, and the extent of the mountain front along the edge of the Basin, it is estimated that at least two-thirds of the groundwater recharge enters the Basin in the upgradient area of the aquifer. Thus, if the groundwater discharge from the upgradient area of the aquifer is approximately 800 AF/yr, the total recharge to the Basin may be as high as 1,200 AF/yr. As discussed in Section 3.3.1, the recharge to the Basin was calibrated to be approximately 1,077 AF/yr. These two estimates of recharge to the Basin differ by only about 10 percent. Thus, the average annual recharge to the Basin can be estimated to be between about 1,100 AF/yr and 1,200 AF/yr, given that the two estimates were calculated using completely different approaches (groundwater discharge versus model calibration) but yield similar results. It should be noted, however, that it takes several decades for the recharge that occurs along the mountain front to reach the communities of Ocotillo, Nomirage, and Yuha Estates. Although these estimates were derived from different approaches some of the same data was relied upon. The hydrologic conductivity of the area was the same used in the model. While the current model relied on some of the previous work for these models, the new model simulates a different conceptual model. So the gradients derived from previous model outputs, used in this illustrative analysis, provide a reasonable check on the model's calibrated recharge results.

In the downgradient area of the aquifer near the international border with Mexico, as indicated on Figures 3.3-5 and 3.3-6, the hydraulic gradient is approximately six feet per mile. The length across the alluvial basin is approximately 5.25 miles. Using the model-calibrated hydraulic conductivity of 15 ft/day, the transmissivity of the aquifer in this area of the Basin is about 2,100 ft^2/day. The effective porosity can be estimated at approximately 30 percent. Using these values and the equations presented above, the groundwater discharge, or amount of groundwater flowing through the downgradient area of the Basin and across the international border, is approximately 550 AF/yr. The average groundwater velocity, or flow rate, is about 20 ft/yr, meaning that it will take over 250 years for the groundwater to flow one mile. Using the lower range of porosity estimates (8.3 percent), the velocity would be 75 ft/year, or traveling 1 mile in 71 years.

In the downgradient area of the aquifer east of Coyote Wells and the Laguna Salada fault zone, as indicated on Figures 3.3-5 and 3.3-6, the hydraulic gradient is approximately 40 feet per mile. The length across the alluvial basin is approximately five miles. For the recent numerical modeling (Bookman-Edmonston, 2004), the Tertiary marine sediments in this area of the Basin were determined to have an average hydraulic conductivity of one ft/day, resulting in a transmissivity of about 500 ft^2/day. The effective porosity can be estimated at approximately 30 percent. Using these values and the equations presented above, the groundwater discharge, or amount of groundwater flowing through the downgradient area of the Basin to the east of the Elsinore-Laguna Salada fault zone, is approximately 840 AF/yr. The average groundwater velocity, or flow rate, is about 10 ft/yr, meaning that it will take over 500

years for the groundwater to flow one mile. However, as discussed in the groundwater study (Appendix B2), the alluvium is thin to non existence and the lower permeability Palm Springs Formation is close to ground surface. In previous groundwater studies this area was described as a fault zone, recent work as indicated the contact to these two geologic formations is a more reasonable conceptualization. This simple approach using a single hydrologic conductivity may not accurately capture the geologic complexities.

Based on the above calculations, the total groundwater discharge from the Basin is estimated to be approximately 1,300 AF/yr. This value is less than the total groundwater underflow of 1900 AF/yr to 1999 AF/yr estimated by the USGS (1977), Huntley (1979), and Bookman-Edmonston (1996) by approximately 33 percent, but is greater than the 990 AF/yr estimated by the recent groundwater model (Bookman-Edmonston, 2004) by approximately 31 percent. The numerical model used to evaluate this project, documented in Appendix B2, simulated an outflow of 515 AFY across the U.S./Mexico border. The illustrative analysis described above estimated outflow across the border at 550 AFY. These same previous studies indicate that historic natural evapotranspiration rates from the Basin in areas of shallow groundwater may have ranged from 250 AF/yr to 400 AF/yr. Thus, the total rate of natural groundwater loss from the Basin, exclusive of groundwater pumping for domestic, commercial, industrial, or agricultural purposes could have been between 1,550 AF/yr to 1,700 AF/yr.

~~Comparing these estimates of loss with the total recharge estimate of 1,100 AF/yr to 1,200 AF/yr indicates that the rate of groundwater outflow from the Basin may have been greater than the rate of recharge prior to the initiation of pumping. Similar conditions have been observed in other basins in Imperial County (see, for example, Section 3.3.3, below) due to long-term climatic changes. Specifically, if climatic conditions were much wetter several centuries or even millennia ago, it would take thousands of years for the recharge from the prior wetter periods to drain from the basin given the very slow rates of groundwater movement cited above. The rate of natural groundwater outflow will exceed the rate of recharge until the Basin drains to the point where the hydraulic gradients decrease and the recharge and outflow are once again in equilibrium. Until this equilibrium point is reached, water level elevations throughout much of the Ocotillo/Coyote Wells Groundwater Basin will decrease, even in the absence of pumping.~~

~~In many groundwater basins, removal of groundwater, for example by pumping, can cause an increase in the rate of recharge. This can occur by increasing the hydraulic gradient in areas where inflow occurs from an adjacent groundwater basin. It can also occur by lowering the water table near surface water bodies, resulting in a greater rate of percolation. In the Ocotillo/Coyote Wells Groundwater Basin, however, the only source of recharge is seasonal rainfall runoff from the adjacent mountains. The rate of recharge will fluctuate on an annual basis based on variations in the amount of rainfall. The average rate of recharge, however, is expected to remain constant unless there are major long-term shifts in climatic conditions. The long groundwater travel times across the basin (centuries to millennia) will tend to even out short-term (e.g. annual) fluctuations in rainfall amounts.~~

~~In the Ocotillo/Coyote Wells Groundwater Basin, pumping may reduce the rate of groundwater loss to some degree. For example, a drop in the water level to the east of Coyote Wells is believed to have reduced the rate of evapotranspiration by several hundred AF/yr (USGS, 1977). Pumping has also caused the hydraulic gradient near the international border with Mexico to flatten. The flatter hydraulic gradient reduces the rate of groundwater discharge. If the rate of pumping occurring in the Basin is approximately equal to the reduction in discharge, it is possible that the additional pumping will not accelerate the natural rate of water level decline, even though an increase in extraction rates occurs. This possibility is discussed further below.~~

~~To the east of Coyote Wells and the Laguna Salada fault, the hydrogeology of the Ocotillo/Coyote Wells Groundwater Basin is dominated by the occurrence of the Tertiary marine sediments. As discussed above, these sediments have a transmissivity that is less than one tenth that of the alluvial aquifer, which is present primarily to the west of the fault zone. The hydraulic gradient to the east of the fault zone is about five times greater (or steeper) than the hydraulic gradient in the Ocotillo area. Several previous studies attribute this difference in hydraulic gradient to some sort of barrier that may exist at the location of a postulated subsurface connection between the Elsinore fault and the Laguna Salada fault.~~

~~As part of this evaluation, specific evidence that the fault zone has its own material properties, and acts as a barrier, could not be identified. The change in gradient can be attributed solely to the difference in material types, and their respective properties (e.g., transmissivity), on either side of the fault. Furthermore, the magnitude of the gradient to the east of the fault is not unprecedented within the Basin. In the upgradient area of the Basin, as discussed above, the narrowing of the Basin results in a hydraulic gradient that is almost the same as it is to the east of Coyote Wells in the Tertiary marine sediments. Thus, variations in the Basin are most likely a result of features that cause a restriction in flow. These features can be a narrowing of the Basin, acting like a bottleneck, or a change of material types to one that has a lower transmissivity. In accordance with Darcy's Law, as described above, if the length across the Basin decreases and/or the transmissivity decreases, then the hydraulic gradient must increase to maintain discharge. This issue is discussed further below.~~

Initial evaluations conducted for this EIR/EIS prompted USG's consultant, Bookman-Edmonston, to conduct additional literature research and field observations. Bookman-Edmonston (2003, p. 2) concluded that "modeling the eastern boundary (of the alluvial material) as a less permeable linear zone representing the extension of the Elsinore fault to the Laguna Salada fault is clearly inconsistent with current geologic interpretation of the basin." As a result of this additional study (Bookman-Edmonston, 2003), the revised numerical model shows the transition from alluvial material to Tertiary marine sediments east of Coyote Wells as a simple upward fold of the underlying bedrock and Tertiary sediments. This folding that has removed the alluvial material and brought the Tertiary sediments to the surface. The interpretation of conditions east of Coyote Wells in the revised numerical model is significantly different than the conditions assumed in previous modeling efforts (USGS, 1977; Bookman-Edmonston, 1996).

3.3.3.3 Water Level Data

As discussed above, the USGS has been monitoring water levels in a number of wells within the Ocotillo/Coyote Wells Groundwater Basin since the early 1970s due to concerns regarding potential overdraft conditions and degradation of water quality. The data collected by the USGS is included in Appendix B and summarized in Tables 3.3-6A-C for selected wells within the Basin. For this analysis, water level data from three separate areas of the basin have been evaluated. These areas include Ocotillo/Nomirage, Yuha Estates, and the area east of Coyote Wells.

Ocotillo/Nomirage

The majority of the groundwater pumping in the Ocotillo/Coyote Wells Groundwater Basin occurs in the Ocotillo/Nomirage area. Figure 3.3-9, Ocotillo/Nomirage Area Hydrograph, is a hydrograph of the water level data from the Ocotillo/Nomirage area. A hydrograph shows the water level data as it changes over time. The wells within the Ocotillo/Nomirage area for which adequate data exist include:

- 16S/9E-25K2 (Clifford well/McDougal Water Co.)
- 16S/9E-25Q1
- 16S/9E-35M1
- 16S/9E-36D2
- 16S/9E-36G4 (Westwind)
- 16S/9E-36H1 (U.S. Gypsum No. 5)

Information regarding well construction and sampling history are presented in Table 3.3-5.

Well 16S/9E-25K2 was pumped for export of water to Mexico from 1974 to 1984. As indicated in Table 3.3-4 and in Figure 3.3-8, Annual Water Production, water production from this well increased from 138 AF/yr in 1974 to 222 AF/yr in 1977, and then is presumed to have decreased to 137 AF/y from 1978 to 1984. Actual production data after 1978, however, is uncertain. The pumping of this well is readily apparent on the hydrograph (Figure 3.3-9). Pumping of this well caused drops in the water level of 50 feet to 60 feet between 1975 and 1981. From 1984 to 1996, water levels in this well have returned to pre-pumping levels.

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Wells 16S/9E-35M1 and 16S/9E-36G4 serve one or more domestic users. The exact pumping rate for each of these wells is unknown. The hydrograph in Figure 3.3-9, however, shows occasional short-term drops in the water level in both of these wells that are most likely indicative of the effects of pumping these wells. The short-term drops in water level are on the order of 10 feet in both wells.

The hydrograph for USG well No. 5 (16S/9E-36H1) shows only minor long-term fluctuations of only a few feet from 1976 through 2001. The total pumping from all three USG wells during this time period varied from about 260 AF/yr to over 500 AF/yr, as shown in Table 3.3-4 and on Figure 3.3-8. The slight fluctuations shown on the hydrograph for USG well No. 5 generally correlate with changes in annual production rate. It is not known how the total water production is distributed among the three USG wells, and it is not possible to evaluate the overall impact of pumping by USG based on the hydrograph for well No. 5.

The hydrographs for all of the wells shown in Figure 3.3-9 indicates that the static (non-pumping) water levels in the Ocotillo/Nomirage area have steadily declined over the last 30 years. The total decline is about five to six feet, for an average rate of water level decline of one foot every five years. The hydrographs for several of the wells, but most notably 16S/9E-36D2, indicate that the decline has been very consistent over this time period. This is somewhat surprising because the rate of rainfall in the basin from 1976 to 1993 was generally above average (see Figure 3.3-2) and the rate of water production from the basin from 1979 to 1996 decreased by almost 45 percent (see Figure 3.3-8).

Yuha Estates

Yuha Estates is located approximately three to four miles southeast and downgradient of the Ocotillo/Nomirage area. The recent literature research and field observations conducted by Bookman-Edmonston (2003) indicate that the geologic conditions in the Yuha Estates area are markedly different than those in the Ocotillo/Nomirage area. The Yuha Estates area sits on both a topographic and structural ridge trending northeast-southwest across the Ocotillo/Coyote Wells Groundwater Basin. The structural ridge is formed by a concave-down curvature of the sedimentary beds referred to as an anticline. The combination of the topographic and structural ridges means that the Tertiary sediments occur at a much higher elevation in the Yuha Estates area than in the Ocotillo/Nomirage area. Bookman-Edmonston (2003) indicates that water from some of the deeper wells in the Yuha Estates area comes, at least partially, from the Tertiary sediments underlying the alluvial material.

Most of the pumping in Yuha Estates is for local domestic use. From 1978 to 1982, water was pumped from one well (17S/10E-11G1) for export to Mexico at a reported rate of approximately 143 AF/yr. Figure 3.3-10, Yuha Estates Area Hydrograph, is a hydrograph of the water level data from the Yuha Estates area. A hydrograph shows the water level data as it changes over time. The wells within the Yuha Estates area for which adequate data exists include:

- 17S/10E-11H1
- 17S/10E-11H2
- 17S/10E-11H3
- 17S/10E-11G1 (McDougal Water Co.)
- 17S/10E-11G2
- 17S/10E-11G4
- 17S/10E-11B1

Information regarding well construction and sampling history are presented in Table 3.3-5.

The hydrograph (Figure 3.3-10) for the Yuha Estates area is dominated by the pumping of well 17S/10E-11G1. Pumping of this well at 143 AF/yr from 1978 to 1982 resulted in a drawdown, or decline in water levels, of almost 70 feet. Drawdown was also observed in all of the other wells in the Yuha Estates area. The magnitude of drawdown in other wells ranged from approximately 8 feet to over 60 feet.

Pumping of well 17S/10E-11G1 ceased 20 years ago. Water levels, however, have still not recovered to their pre-pumping levels. The water levels in the Yuha Estates area are approximately five to 10 feet below the levels recorded in the early 1970s. As shown in Figure 3.3-10, the rate of recharge has been very slow. The water levels in several of the wells appear to have stabilized and suggest that Yuha Estates is experiencing the same long-term decline in water levels as that observed in the Ocotillo/Nomirage area. As discussed above, this decline has occurred despite periods of above-average precipitation and a significant reduction in the rate of pumping over the same time period.

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Area East of Coyote Wells

There are several wells that have been monitored on a regular basis in the area east of Coyote Wells. Figure 3.3-11, Area East of Coyote Wells Hydro-Graph, is a hydrograph of the wells in the area near the transition from alluvial material to Tertiary ~~marine~~ sediment outcrops. Wells located west of this transition include:

- 16S/9E-24D1
- 16S/10E-29L1
- 16S/10E-29R2

Wells located east of this transition include:

- 16S/9E-24B1
- 16S/10E-29H1

Wells 16S/10E-24D1 and 16S/10E-24B1 are located across the transition from each other, approximately 1.5 miles north of Ocotillo. As shown in Figure 3.3-11, the water levels in these two wells are nearly identical and have steadily declined over the last 25 years. The total amount of the decline is approximately three feet. The rate of decline is about one-half of the rate of decline in water levels in the Ocotillo/Nomirage area and the Yuha Estates area. The virtually-identical hydrographs for wells 16S/10E-24D1 and 16S/10E-24B1 indicate that the transition is not a fault zone or other geologic feature with unique properties that may inhibit groundwater movement, as discussed above, and does not have any hydrologic influence in the area north of Ocotillo.

Wells 16S/10E-29L1 and 16S/10E-29H1 are located across the transition from each other, to the east of Coyote Wells. Well 16S/10E-29R2 is located approximately one-half mile south of well 16S/10E-29H1. As shown in Figure 3.3-11, data from wells 16S/10E-29L1 and 16S/10E-29R2, both located west of the transition, is only available for about 10 years, from the late 1970s to the late 1980s. Data from well 16S/10E-29H1, located east of the transition, is available from 1975 to 2001. The three wells are shown on Figure 3.3-11 to be declining at the same rate.

Water levels in wells 16S/10E-29L1 and 16S/10E-29R2, to the west of the transition, decreased by approximately eight feet from the late 1970s to the late 1980s, as shown on Figure 3.3-11. As indicated in Figure 3.3-8, this time period corresponds to the period of the greatest amount of groundwater pumping from the Basin. The water level in well 16S/10E-29H1, to the east of the transition, decreased by about five feet from 1975 to

2001. This corresponds to an average rate of decline of one foot every five years, which is identical to the rate of decline for the Ocotillo/Nomirage area over the same time period, as discussed above. Thus, the trend in water levels appears to be similar on both sides of the transition in the Coyote Wells area.

3.3.3.4 Groundwater Chemistry Data

In addition to monitoring water levels, the USGS has also been collecting water quality samples from several wells within the Ocotillo/Coyote Wells Groundwater Basin since the early 1970s due to concerns regarding potential overdraft conditions and degradation of water quality. The water quality data collected by the USGS is included in Appendix B and summarized in Tables 3.3-3a and b for selected wells within the Basin. The number of wells for which water quality data are available is less than the number of wells for which water level measurements are available. As with the analysis of the water level data, above, the water quality data are evaluated for three separate areas of the basin, including Ocotillo/Nomirage, Yuha Estates, and the area east of Coyote Wells.

As discussed in Section 3.3.1, the general water quality of the Basin can be evaluated primarily based on the total dissolved solids (TDS) content of the water. The TDS is a measurement of the total amount of salts and other naturally-occurring minerals in the groundwater. EPA secondary standard for TDS in drinking water is 500 mg/L, which is equivalent to 500 ppm. Thus, groundwater with TDS levels below 500 mg/L is considered potable water. In general, water with a TDS level exceeding 1,000 mg/L is not considered potable, although it is not uncommon for local drinking water supplies to exceed this level in some areas of the country.

Ocotillo/Nomirage Area

Long-term water chemistry data is available from three wells in the Ocotillo/Nomirage area. These wells are:

- 16S/9E-25K2 (Clifford well/McDougal Water Co.)
- 16S/9E-36D2
- 16S/9E-36H1 (U.S. Gypsum No. 5)

The TDS concentrations measured over time in these three wells are shown in Figure 3.3-12, TDS Trends – Ocotillo/Nomirage Area.

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As discussed above, well 16S/9E-25K2 was pumped for export of water to Mexico from 1974 to 1984. As indicated in Table 3.3-4 and in Figure 3.3-8, water production from this well increased from 138 AF/yr in 1974 to 222 AF/yr in 1977, and then is presumed to have decreased to 137 AF/y for 1978 to 1984. Actual production data after 1978, however, is uncertain. Prior to pumping of this well, TDS levels were approximately 250 mg/L to 310 mg/L. Within a few years after pumping began, the TDS concentration increased to as high as 400 mg/L, which is a 60 percent increase from pre-pumping levels. TDS levels have subsequently decreased to between 320 mg/L to 360 mg/L. As shown in Figure 3.3-12, TDS Trends Ocotillo/Nomirage Area, the TDS concentration has not returned to the levels measured prior to pumping.

There are only 15 years of data for well 16S/9E-36D2, from 1975 to 1990. During this time period, there was no distinct trend in TDS concentrations.

The TDS data for USG well No. 5 (16S/9E-36H1) show only minor long-term fluctuations of less than 25 mg/L from 1976 through 2001 (Figure 3.3-12). During the same time, the total pumping from all three USG wells varied from about 260 AF/yr to over 500 AF/yr, as shown in Table 3.3-4 and in Figure 3.3-8. The slight fluctuations in TDS shown in Figure 3.3-12 for USG well No. 5 may correlate with changes in annual production rate.

Yuha Estates

Long-term water chemistry data is available from three wells in the Yuha Estates area. These wells are:

- 17S/10E-11H2
- 17S/10E-11H3
- 17S/10E-11G2

The TDS concentrations measured over time in these three wells are shown in Figure 3.3-13, TDS Trends – Yuha Estates Area.

The data set from the Yuha estates area is, unfortunately, limited, as indicated in Table 3.3-3 and Figure 3.3-13. Despite the limited amount of data, however, the impacts of pumping of well 17S/10E-11G1 (McDougal Water Co.) for export to Mexico is readily apparent. As discussed above and shown in Table 3.3-4, pumping of this well occurred from 1978 to 1982 at 143 AF/yr.

Water quality data are not available for well 17S/10E-11G1. Well 17S/10E-11G2, however, is located a few hundred feet from well 17S/10E-11G1. Prior to pumping for export to Mexico, the TDS level in well 17S/10E-11G2 was approximately 330 mg/L. From 1977 to 1982, however, the TDS level in this well increased steadily to almost 400 mg/L, as shown in Figure 3.3-13.

In addition, from 1987 to 2001, the TDS level in well 17S/10E-11H3 has shown a steady decrease, as indicated in Figure 3.3-13.

Area East of Coyote Wells

Long-term water chemistry data is available from three wells in the area east of Coyote Wells. These wells are:

- 16S/9E-24B1
- 16S/9E-24D1
- 16S/10E-29L1

Well 16S/9E-24B1 is located east of the transition from alluvial material to Tertiary marine sediments. Wells 16S/9E-24D1 and 16S/10E-29L1 are located west of the transition from alluvial material to Tertiary marine sediments. The TDS concentrations measured over time in these three wells are shown on Figure 3.3-14, TDS Trends – Area East of Coyote Wells.

As discussed above, wells 16S/9E-24B1 and 16S/9E-24D1 are located adjacent to each other, but on opposite sides of the transition from alluvial material to Tertiary marine sediments. As shown on Figure 3.3-11, the water levels in these two wells are nearly identical. The TDS levels, however, are very different, as shown on Figure 3.3-14. The TDS concentration in well 16S/9E-24B1 ranges from approximately 1200 mg/L to 1300 mg/L, indicative of the influence of the Tertiary marine sediments. The TDS concentration in well 16S/9E-24D1 ranges from approximately 450 mg/L to 500 mg/L, indicative of the water quality in the alluvial aquifer.

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3.3.3.5 Discussion of Water Quality Data

The water quality data discussed above indicates that pumping of wells for a period of several years at rates of 100 AF/yr to 200 AF/yr or more ~~can~~ in the Yuha area may have a measurable impact on water quality in adjacent wells ~~certain areas of the basin~~. This amount of pumping by USG in Well 36H1 in the Ocotillo area has not shown any increase in TDS. When it occurs, this impact appears rapidly and persists for many years after pumping ceases. The decrease in water quality may be due to lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediment, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

Figure 3.3-15, Piper Diagram of Groundwater Chemistry Data, is a Piper, or Tri-linear, diagram of water quality from the wells discussed above. A Piper diagram is a standard tool for analysis of water-quality data (USGS, 1989). The Piper diagram presents the water quality in terms of cations (positively-charged ions) in the triangle in the lower left corner, anions (negatively-charged ions) in the triangle in the lower right corner, and commonly associated chemical groupings in the central quadrilateral.

Many of the wells from the Ocotillo/Nomirage and Yuha Estates areas cluster together in the Piper diagram shown in Figure 3.3-15. Well 16S/9E-24B1 (labeled number "1" on the Piper diagram) stands apart from the other wells due to its elevated TDS concentration. Several other wells, however, show some TDS impact and plot in the areas between the larger cluster of wells and well 16S/9E-24B1. These wells include 16S/10E-29L1 (labeled number "6" on the Piper diagram), 16S/9E-24D1 (labeled number "2" on the Piper diagram), and 17S/10E-11G2 (labeled number "7" on the Piper diagram).

3.3.3.6 Thresholds of Significance

The significance criteria for this analysis were developed from Appendix G of the CEQA Guidelines. The Proposed Project would have a significant impact on hydrology and water quality if it would:

- Violate any water-quality standards or waste discharge requirements;
- Deplete groundwater supplies such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table (e.g. the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which a permit has been granted); or
- Otherwise substantially degrade water quality.

The impact analysis presented below is based upon the CEQA standards of significance. For the analysis of impacts caused by pumping from the USG wells in the Ocotillo area for the Proposed Project, a separate discussion is provided for impacts that may occur only to individual well owners as opposed to the Ocotillo/Coyote Wells Groundwater Basin resource.

3.3.3.7 Proposed Action: Impacts and Mitigation Measures

Impact 3.3-1: Water Depletion at Plant Affecting Individual Well Owners

Increased pumping of USG wells could reduce water levels, increasing the cost of pumping groundwater and, causing some wells to go dry.

Previous studies concluded that, since the total volume of water in the basin may range from over 600,000 AF to over 1.2 million AF, an annual overdraft of a few hundred AF/yr is nominal compared to the total volume of water in storage in the Basin. This view, however, may not be consistent with the conditions that occur in the Ocotillo/Coyote Wells Groundwater Basin.

The hydrographs of numerous wells from different locations in the Basin demonstrate that water levels have been steadily decreasing for at least the last 30 years. Periods of increased rainfall and a decreasing rate of groundwater pumping have not halted this long-term trend. However, a decrease of pumpage in USG wells from 1994 through 1998 did show groundwater levels recovered locally.

If water levels continue to drop, the maximum production rate of some shallower wells may be reduced due to the reduced available drawdown. The energy, and thus cost, necessary to pump groundwater, will increase in wells affected. These impacts are expected to occur without implementation of the increased pumping rates associated with the Proposed Action. The revised numerical groundwater model (Bookman-Edmonston, 2004) indicates that over the next 80 years, water levels may decline by up to 10 feet under baseline conditions, without any increase in pumping rates (Table 3.3-7). Thus, the baseline rate of water-level decline is approximately one foot every eight years.

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TABLE 3.3-7
LAYER 1 WELL DRAWDOWNS (FT) FOR BASELINE SCENARIO
(DRAWDOWN FROM GROUNDWATER ELEVATION AT THE END OF 2002)

	Well								
Years	42A5	36H1	36D2	24D1	29L1	29R2	25K2	25Q1	36 G4
	Drawdown (ft)								
10	-1.2	0.1	-1.4	-1.6	-1.3	-1.4	-1.3	-1.2	-0.2
20	-2.4	-1.2	-2.7	-3.1	-2.6	-2.6	-2.6	-2.6	-1.5
30	-3.6	-2.5	-4.0	-4.4	-3.8	-3.7	-3.9	-3.9	-2.8
40	-4.7	-3.7	-5.3	-5.7	-4.9	-4.8	-5.1	-5.1	-4.0
50	-5.8	-4.8	-6.5	-6.9	-6.0	-5.9	-6.3	-6.3	_5.1
60	-6.8	-5.8	-7.6	-8.1	-7.0	-6.9	-7.4	-7.4	-6.2
70	-7.7	-6.9	-8.6	-9.2	-8.0	-7.9	-8.5	-8.4	-7.2
80	-8.7	-7.8	-9.6	-10.2	-8.9	-8.8	-9.5	-9.4	-8.2

For the Proposed Action, USG plans to increase groundwater extraction rates by as much as 420 AF/yr over the average 1994 through 1998 baseline pumping rate of 347 AF/yr. This water demand is anticipated to continue for up to 80 years. The only empirical point of comparison to this magnitude of pumping over a long duration is the pumping that occurred in Ocotillo and Yuha Estates in the 1970s and 1980s for export to Mexico. In Ocotillo, groundwater was pumped at a rate of 137 AF/yr to 222 AF/yr for 11 years. Drawdowns of up to 60 feet occurred at or near the pumping well, and water levels did recover after pumping was suspended. At Yuha Estates, groundwater was pumped at an estimated rate of 143 AF/yr for five years. Drawdowns of nearly 70 feet occurred and nearby wells experienced drawdowns of several tens of feet. In addition, once the pumping ceased, water levels at Yuha Estates recovered very slowly and have not yet reached their pre-pumping levels. A review of the Basin's geology, however, suggests that the Ocotillo area consists of younger permeable alluvial material, whereas the Yuha Estates area is predominantly less permeable Tertiary sediments.

The revised numerical groundwater model (Bookman-Edmonston, 2004) evaluated the potential drawdown in the Ocotillo area from the Proposed Action, with pumping occurring at 767 AF/yr for 80 years. (See Appendix B-2). The total

drawdown in the alluvial aquifer after 80 years is predicted to be approximately 30 feet, which averages about 20 feet, but in two wells may be up to 23 feet, greater than the drawdown predicted to occur over the same time period under the baseline condition (Table 3.3-8, Layer 1 Well Drawdowns (ft) for 767 AF/yr Pumping Scenario).

TABLE 3.3-8
LAYER 1 WELL DRAWDOWNS (FT) FOR 767 AF/YR PUMPING SCENARIO
(DRAWDOWN FROM GROUNDWATER ELEVATION AT THE END OF 2002)

	Well								
Years	42A5	36H1	36D2	24D1	29L1	29R2	25K2	25Q1	36G4
	Drawdown (ft)								
10	-4.5	-7.0	-4.6	-2.9	-4.7	-4.3	-4.9	-5.0	-6.6
20	-8.0	-10.8	-8.3	-6.1	-8.3	-7.9	-8.5	-8.7	-10.4
30	-11.3	-14.2	-11.8	-9.4	-11.7	-11.2	-12.0	-12.3	-13.9
40	-14.5	-17.6	-15.3	-12.6	. -14.8	-14.3	-15.5	-15.8	-17.3
50	-17.6	-21.0	-18.9	-15.9	-18.0	-17.4	-19.0	-19.3	-20.7
60	-20.7	-24.4	-22.5	-19.3	-21.2	-20.5	-22.6	-22.9	-24.2
70	-23.8	-27.8	-26.2	-22.7	-24.3	-23.6	-26.2	-26.7	-27.7
80	-27.1	-31.4	-30.0	-26.2	-27.6	-26.8	-30.0	-30.5	-31.3

The revised numerical groundwater model (Bookman-Edmonston, 2004) also considered an intermediate project condition, where pumping rates are increased to only 650 AF/yr for 80 years, as opposed to the full 767 AF/yr for the Proposed Action. Under this intermediate condition, the total drawdown in the alluvial aquifer after 80 years is predicted to be up to 26 feet, which is up to 16 feet greater than the drawdown predicted to occur over the same time period under the baseline condition (Table 3.3-9, Layer 1 Well Drawdowns (ft) for 650 AF/yr Pumping Scenario).[1]

[1] The Applicant has provided estimates that indicate a typical residence using about one AF/yr would experience an increase in electrical energy of about 40 kilowatt hours (KWH) to pump water up this additional 20 feet to the surface. The current cost of electric energy in the area is about ten cents per KWH. This indicates an increase cost to a typical residence of approximately $4 per year in the 80th year. In the 40th year, assuming an increase pumping height of approximately 10 feet, the extra cost in the 40th year would be about $2 per year. The average increase cost over the life of the Proposed Action would be about $2 per year. The potential environmental impact from having to generate extra electricity needed to pump water from a greater depth over the life of the Project is speculative, but are not expected to be significant. The increased use of energy in Ocotillo by the increased pump lift is insignificant with respect to the total energy generation by IID. As an example the total increase energy use in 80 years by all affected wells, represents less than the amount of energy used by a single residence in a year. Assuming these estimates are accurate, then the *economic* impact of additional pumping would be insignificant.

TABLE 3.3-9
LAYER 1 WELL DRAWDOWNS (FT) FOR 650 AF/YR PUMPING SCENARIO
(DRAWDOWN FROM GROUNDWATER ELEVATION AT THE END OF 2002)

	Well								
Years	42A5	36H1	36D2	24D1	29L1	29R2	25K2	25Q1	36G4
	Drawdown (ft)								
10	-3.6	-5.1	-3.8	-2.5	-3.8	-3.5	-3.9	-4.0	4.9
20	-6.5	-8.2	-6.9	-5.3	-6.8	-6.5	-7.0	-7.1	8.0
30	-9.3	-11.1	-9.9	-8.1	-9.6	-9.2	-10.0	-10.2	-11.0
40	-12.0	-14.0	-12.9	-10.9	-12.3	-11.9	-13.0	-13.2	-13.9
50	-14.6	-16.9	-16.0	-13.8	-15.0	-14.5	-16.0	-16.3	-16.8
60	-17.3	-19.8	-19.2	-16.7	-17.7	-17.2	-19.2	-19.5	-19.8
70	-20.1	-22.8	-22.5	-19.7	-20.5	-19.9	-22.4	-22.7	-22.9
80	-22.9	-26.0	-25.9	-22.8	-23.4	-22.7	-25.7	-26.2	-26.1

The total potential drawdown in the alluvial aquifer, based on both the empirical data and the revised numerical groundwater model (Bookman-Edmonston, 2004), could lower the water level in some wells. Specifically, if the water level in a well drops to near the base of the screened interval, the ability to maintain current pumping rates in that well may be reduced. Wells in the Ocotillo area that are likely to experience this condition include the E. Annes and Property Construction wells and well 36D2, as shown in Figure 3.3-16, Ocotillo/Coyote Wells Groundwater Study Cross-Section of Screen Intervals.

Level of Significance Before Mitigation: Significant

Mitigation Measure: Mitigation Measure 3.3-1

If the water level in ~~a~~ an existing well in the Ocotillo area decreases at a rate faster than one foot every eight years and the average water levels in the surrounding wells also decrease for more than two years in a row due to the Proposed Action, as measured from the interpolated linear of one foot every eight years with a starting reference point being the date that pumping by USG increases above the baseline rate, and there is a documented reduction in the available water to the affected user, then USG, at its election will:

1. *Rehabilitate the well and/or install a new pump to restore the prior pumping rate; or*
2. *Provide an incremental replacement of water equivalent to the amount of the reduced rate of pumping by the affected party, of a like quantity and quality~~, and provide reimbursement for the incremental increase for the affected party to pump the remaining available groundwater~~; or*
3. *Provide a full replacement water supply to the affected party of a like kind and quality, at a cost that does not exceed the cost to the affected party at the time the impact occurred; or*
4. *Deepen the existing well or provide a new replacement well to the affected party, drilled to a depth that will not be affected by existing or future Project-related declines in the water table, and capable of providing an equivalent quantity and quality of water that existed prior to the impact~~, and provide reimbursement for incremental increase in cost for the affected party to pump the available water~~.*

The extent to which the Proposed Action will be considered ~~as contributing to~~ to be the cause of the decrease in water levels in the Ocotillo area will be determined only after a review of the water level data and a decision by the Imperial County Planning Commission ~~Groundwater Management Committee (ICGMC)~~.

~~The baseline condition in the Basin includes a declining water table, and existing data suggests that water levels recover slowly after significant drawdown occurs. Therefore, i~~If USG elects to provide replacement water or a replacement water supply, arrangements must be made to provide this mitigation until groundwater levels ~~stabilize at~~ return to a level equal to the projected baseline condition or ten years after USG reduces its pumping from the Basin to the baseline rate, whichever first occurs.

Level of Significance After Mitigation: Less than Significant

Although the Proposed Action would increase the rate of drawdown in the alluvial aquifer as compared to baseline conditions, the impact on existing individual affected wells will be mitigated to a level of insignificance through implementation of Mitigation Measure 3.3-1.

Insert Figure 3.3-16

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Impact 3.3-2: Water Depletion at Plant Affecting the Groundwater Basin

Increased pumping of USG wells could reduce water levels throughout broad areas of the Ocotillo/Coyote Wells Basin, reducing the total amount of water available in the basin.

Previous studies concluded that, since the total volume of water in the basin may range from over 600,000 AF to over 1.2 million AF, an annual overdraft of a few hundred AF/yr is nominal compared to the total volume of water in storage in the Basin. This view, however, may not be consistent with the conditions that occur in the Ocotillo/Coyote Wells Groundwater Basin. More recent assessments of the basin geology suggest that it is more complex, containing numerous uplifts of older sediments and large folds that bring the Tertiary ~~marine~~ sediments close to the surface. Thus, the available volume of water may be much less than previous estimates.

The hydrographs of numerous wells from different locations in the Basin demonstrate that water levels have been steadily decreasing for at least the last 30 years. Periods of increased rainfall and a decreasing rate of groundwater pumping have not halted this long-term trend. However, a decrease of pumpage in USG wells from 1994 through 1998 did show groundwater levels recovered locally.

The revised numerical groundwater model (Bookman-Edmonston, 2004) indicates that over the next 80 years, water levels may decline by up to 10 feet under baseline conditions, without any increase in pumping rates (Table 3.3-7). Thus, the baseline rate of water-level decline is approximately one foot every eight years.

For the Proposed Action, USG plans to increase groundwater extraction rates by as much as 420 AF/yr over the average 1994 through 1998 baseline pumping rate of 347 AF/yr. This water demand is anticipated to continue for up to 80 years. The only empirical point of comparison to this magnitude of pumping over a long duration is the pumping that occurred in Ocotillo and Yuha Estates in the 1970s and 1980s for export to Mexico. In Ocotillo, groundwater was pumped at a rate of 137 AF/yr to 222 AF/yr for 11 years. Drawdowns of up to 60 feet occurred at or near the pumping well, and water levels did recover after pumping was suspended. At Yuha Estates, groundwater was pumped at an estimated rate of 143 AF/yr for five years. Drawdowns of nearly 70 feet occurred and nearby wells experienced drawdowns of several tens of feet. In addition, once the pumping

ceased, water levels at Yuha Estates recovered very slowly and have not yet reached their pre-pumping levels. A review of the Basin's geology, however, suggests that the Ocotillo area consists of younger permeable alluvial material, whereas the Yuha Estates area is predominantly older less permeable formations.

The revised numerical groundwater model (Bookman-Edmonston, 2004) evaluated the potential drawdown in the Ocotillo area from the Proposed Action, with pumping occurring at 767 AF/yr for 80 years. (See Appendix B-2). The total drawdown in the alluvial aquifer after 80 years is predicted to be approximately 30 feet, which averages about 20 feet, but in two wells may be up to 23 feet, greater than the drawdown predicted to occur over the same time period under the baseline conditions (Table 3.3-8, Layer 1 Well Drawdowns (ft) for 767 AF/yr Pumping Scenario).

The revised numerical groundwater model (Bookman-Edmonston, 2004) also considered an intermediate project condition, where pumping rates are increased to only 650 AF/yr for 80 years, as opposed to the full 767 AF/yr for the Proposed Action. Under this intermediate condition, the total drawdown in the alluvial aquifer after 80 years is predicted to be up to 26 feet, which is up to 16 feet greater than the drawdown predicted to occur over the same time period under the baseline conditions (Table 3.3-9, Layer 1 Well Drawdowns (ft) for 650 AF/yr Pumping Scenario).

Because the depth to groundwater in the Ocotillo area currently ranges from about 100 ft bgs to 160 ft bgs, an additional 20-23 foot lowering of groundwater level over an 80 year period will not have an adverse effect on any rare, threatened, endangered, or sensitive species of plant or animal life or habitat.

The pumping from the alluvial aquifer for the Proposed Project, based on both the empirical data and the revised numerical groundwater model (Bookman-Edmonston, 2004), will lower the water level over a broad area of the Basin. As discussed above, this lowering of water level~~s~~ will be in addition to the existing condition in the basin where the water table is already declining. Periods of increased rainfall and decreased pumping have not resulted in a Basin-wide recovery of water levels. Thus, the additional decline in water levels caused by the additional pumping of up to 420 AF/yr for the Proposed Project can not be readily offset by decreases in pumping elsewhere in the Basin, enhancing recharge, or importing water.

Level of Significance Before Mitigation: This is a significant and unavoidable impact on the Basin-wide groundwater. This impact is also unmitigatable.

Mitigation Measures: None available

Impact 3.3-3: Water Quality Degradation at Plant Affecting Individual Well Owners

Increased pumping from USG wells could degrade water quality in individual wells due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

Increases in TDS were observed in wells in the Ocotillo area and the Yuha Estates area as a result of groundwater pumping for export to Mexico. In the Ocotillo area, TDS concentrations ~~have not~~ mostly recovered to their pre-pumping levels in the well that was pumped for export. At Ocotillo, groundwater was pumped at a rate of 137 AF/yr to 222 AF/yr for 11 years. At Yuha Estates, groundwater was pumped at an estimated rate of 143 AF/yr for only five years.

USG is proposing to increase groundwater extraction rates by as much as 420 AF/yr over the average baseline pumping rate of 347 AF/yr for the five-year period from 1994 through 1998. This water demand, under the Proposed Action, is anticipated to continue for 80 years. Based on a comparison with past impacts in the Basin, the proposed increased groundwater extraction rates for the Project could have an impact on water quality.

As discussed, water levels are decreasing throughout most of the Basin and are expected to decrease further from the Proposed Project. As the depth to groundwater decreases, the saline water that is present at the water table may eventually reach the screened interval of some wells. Several wells have relatively short screened intervals, so that the saline water present at the water table could appreciably affect the quality of the water in certain wells.

Groundwater flow directions during the Project duration were evaluated as part of the revised numerical groundwater model (Bookman-Edmonston, 2004). The numerical model indicates that groundwater will continue to flow from west to east across the transition from alluvial material to Tertiary marine sediments east of Ocotillo. Thus, there is not likely to be a significant potential for saline water

to migrate laterally from the area east of Coyote Wells into the Ocotillo area. The model did indicate that there is a small potential for upward migration of saline water from Tertiary marine sediments underlying the alluvial aquifer in the Ocotillo area. Due to geologic complexities related to fault blocks and elevated areas of Tertiary marine sediments, however, the model was not able to accurately reproduce the change in water quality caused in both Ocotillo and Yuha Estates by the pumping for export to Mexico.

Level of Significance Before Mitigation: Significant

Mitigation Measure: Mitigation Measure 3.3-2

USG will provide an alternative or replacement source of water if the water quality significantly deteriorates in any existing well in the Ocotillo area and such deterioration is caused by the Proposed Action. As discussed above, the secondary drinking water standard for TDS is 500 mg/L and water with a TDS level in excess of 1,000 mg/L is considered non-potable. Therefore, if the Proposed Action causes the TDS level in any existing well to exceed~~s~~ 500 mg/L, or causes the concentration of ~~any other measured parameter~~ sulfate, chloride or boron, as described in the ~~Mitigation~~ Groundwater Monitoring Program ~~below,~~ to exceed~~s~~ its drinking-water standard that is in force at the time ~~of the measurement,~~ the Proposed Action is approved, then USG will provide the affected party or parties with an alternative supply of water for drinking and cooking, at no cost to the affected party or parties. This alternative supply could be bottled water or a hookup to a replacement water source. If the TDS level in any well exceeds 1,000 mg/L and is caused by the Proposed Action, then the water quality will be such that use of the water for any domestic purpose will be significantly affected due to scale buildup, damage to plumbing, corrosion, and other similar impacts. If the TDS level exceeds 1,000 mg/L and is caused by the Proposed Action, USG will provide the affected party or parties with a hookup to a replacement supply of water. This replacement supply may be a hookup to an existing municipal district or other appropriate drinking water supply system. USG will bear the full cost of the hookup. The affected party or parties, however, would only be responsible for the annual cost of the replacement water equivalent to their costs to pump water prior to the occurrence of the impact. If the annual cost of water for the replacement supply exceeds the affected party or parties costs to pump water prior to the occurrence of the impact, USG will pay the incremental difference.

The extent to which the Proposed Action will be considered ~~as contributing~~ to be the cause of the decrease in water quality in the Ocotillo area, will be determined

only after a review of the water quality data and a decision by the Imperial County Planning Commission ~~Groundwater Management Committee (ICGMC)~~.

~~The existing data from Ocotillo and Yuha Estates indicates that, once the water quality decreases, it may take many decades for the water quality to recover once the pumping causing the impact has ceased. Therefore,~~ If USG ~~will need~~ is required to provide ~~the~~ alternative and/or replacement water supply pursuant to the terms of this mitigation measure, it must continue to do so until (1) concentrations of the above-listed constituents in excess of applicable water-quality standards return to levels below such standards or until the water quality parameters, for which there is data that currently exists, return to pre-Proposed Action levels, or (2) ten years after USG reduces its pumping from the Ocotillo/Coyote Wells Groundwater Basin to the baseline rate, whichever first occurs.

Level of Significance After Mitigation: Less than Significant

With implementation of Mitigation Measure 3.3-2, the potential impacts on individual wells will be mitigated, and the Proposed Action will not violate any water quality standard For these reasons, the impact of the Proposed Action on individual wells, after mitigation, will be less than significant.

The long-term affect to the Basin-wide groundwater resource, however, is still potentially significant and there are no feasible mitigation measures that would reduce the impact to less than significant.

Impact 3.3-4: Water Quality Degradation at Plant Affecting the Groundwater Basin

Increased pumping from USG wells could degrade water quality in the groundwater Basin due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

~~Relatively rapid i~~Increases in TDS were observed in wells in the Ocotillo area and the Yuha Estates area as a result of groundwater pumping for export to Mexico. In the Ocotillo area, TDS concentrations in affected wells ~~have not~~ mostly recovered to their pre-pumping levels in the well that was pumped for export. At Ocotillo, groundwater was pumped at a rate of 137 AF/yr to 222 AF/yr for 11 years. At Yuha Estates, groundwater was pumped at an estimated rate of 143 AF/yr for only five years.

USG is proposing to increase groundwater extraction rates by as much as 420 AF/yr over the average baseline pumping rate of 347 AF/yr for the five-year period from 1994 through 1998. This water demand, under the Proposed Action, is anticipated to continue for 80 years. The past water-quality impacts in the Basin were the result of much lower pumping rates and much shorter durations than the proposed increased groundwater extraction rates for the Project. Thus, the Proposed Project could have an impact on water quality.

Groundwater flow directions during the Project duration were evaluated as part of the revised numerical groundwater model (Bookman-Edmonston, 2004). The numerical model indicates that groundwater will continue to flow from west to east across the transition from alluvial material to Tertiary marine sediments east of Ocotillo. Thus, there is not likely to be a significant potential for saline water to migrate laterally from the area east of Coyote Wells into the Ocotillo area. The model did indicate that there is a small potential for upward migration of saline water from Tertiary marine sediments underlying the alluvial aquifer in the Ocotillo area. Due to geologic complexities related to fault blocks and elevated areas of Tertiary marine sediments, however, the model was not able to accurately reproduce the change in water quality caused in both Ocotillo and Yuha Estates by the pumping for export to Mexico.

The declining water levels in the Basin indicate that the amount of recharge is less than the amount of water being removed from the Basin. Therefore, if the water quality in areas of the Basin decreases to the point where the water is not suitable for its current use, then it is unlikely that there will be sufficient influx of non-saline water to improve the water quality.

Level of Significance Before Mitigation: Significant

Mitigation Measure: None available

> As part of the Proposed Project, USG will implement the Groundwater Monitoring Program described below. The data from the groundwater monitoring program will provide ~~an indication of a trend of progressively decreasing~~ information concerning water quality in individual wells and throughout the basin~~, if such a trend occurs and is a result of the increased pumping for the Proposed Project~~. If ~~such a trend is identified~~ the data indicates a trend of progressively decreasing water quality in only a few wells in close proximity to the USG pumping wells, and an impact subsequently occurs in any or all of those few wells, then USG can

mitigate the impacts in the individual wells as discussed above for Impact 3.3-2A: Water Quality Degradation at Plant Affecting Individual Well Owners. If, however, such a trend is identified in a larger number of wells, and these wells are located over a broader area of the basin and not just in the area of the USG pumping wells, it would not be possible to restore the Basin-wide water quality once it is degraded to concentrations at which the groundwater is no longer suitable for its current uses. There is insufficient recharge to restore the Basin and dilute the salts in the saline water. Therefore, it is not possible to mitigate the Basin-wide degradation of water quality. If such trends are detected by the Groundwater Monitoring Program, the only way to halt or reverse these trends would be to curtail pumping by reducing production at the Plant, or by implementing one or more Alternatives that reduce or eliminate withdrawals from the basin, prior to the groundwater quality being degraded to the point where it was no longer suitable for its current uses.

Level of Significance After Mitigation: Significant

Groundwater Monitoring Program

The Proposed Action includes a Monitoring Program to provide consistent, long-term data regarding the Ocotillo/Coyote Wells Groundwater Basin. The Monitoring Program will involve the measurement of water levels and the collection of groundwater samples for chemical analysis. As discussed above, the Proposed Action is predicted to accelerate the decline of the groundwater level in the Ocotillo/Coyote Wells Groundwater Basin, and may potentially cause the migration of saline water. As such, the primary objectives of the Monitoring Program are to:

1. Identify any increases in the rate of water-level decline greater than the baseline rate; and
2. Provide an early warning of potential degradation of groundwater quality from the Proposed Action.

The primary cause of the potential degradation of groundwater quality would be lateral migration of saline water from Tertiary marine sediments that crop out in the Ocotillo and Nomirage area and to the east of Coyote Wells, or vertical migration of saline water from the Tertiary marine sediments that are present at depth below the alluvial aquifer.

The USGS currently monitors water levels and water quality in a number of wells in the Ocotillo/Coyote Wells Groundwater Basin, as listed in Table 3.3-10, List of Current and Proposed Monitoring Wells in the Ocotillo/Coyote Wells Groundwater Basin. For the

Mitigation Monitoring Program, water chemistry and/or water levels will be monitored in the wells currently monitored by the USGS and in 10 additional wells, as shown in Table 3.3-10. Eight of the additional well locations are existing wells and the other two are new nested wells that will be installed by USG. Note that several of the additional wells listed in Table 3.3-10 are already monitored for water levels by the USGS but will also be sampled for water quality as part of this Monitoring Program. The additional monitoring locations were selected based on location, variation in depth and screened interval, and historic trends in water levels and TDS concentrations. In addition, any private currently operating well owner in the Ocotillo, Coyote Wells, and Nomirage areas that would like to include their well in the Monitoring Program may do so by notifying the County within one year after this document is certified. If the groundwater levels, or quality, in any of the monitoring wells included in this Monitoring Program show a declining trend greater than that specified in the Monitoring Program, then the private well owner(s) in the Ocotillo area indicating such a trend that has requested that their groundwater level and water quality be determined, will have their well tested until such time as the groundwater or water quality declines return to below levels of concern as specified in this Monitoring Program.

One new nested monitoring well (MW-1A and MW-1B) will be constructed approximately three-quarters of a mile east of USG Well No. 6 (see Figure 3.3-17, Current and Proposed Monitoring Wells in the Ocotillo Area). This monitoring well location, along with 29L1, 31B1, and 30R1, would show changes in the TDS levels as a result of the potential migration of saline water from the area east of Coyote Wells, and potential upward vertical migration. The deeper interval in this nested well will be screened just above the base of the alluvial aquifer, which is anticipated to be up to 400 ft bgs. The shallower interval will be screened in the same depth range as other wells in the area, which is typically 100 ft bgs to 200 ft bgs. The nested monitoring well will be drilled and constructed in accordance with applicable state and county requirements, including but not limited to those described in California Department of Water Resources Bulletins 74-81 and 74-90.

The second new nested monitoring well (MW-2A and MW-2B) will be constructed in the area between existing USG wells Nos. 4, 5, and 6. The approximate area is shown on Figure 3.3-17. This monitoring well location will provide information regarding the potential vertical migration of saline water from underlying Tertiary marine sediments. The deeper interval in this nested well should be screened just above the base of the alluvial aquifer, which is anticipated to be up to 700 ft bgs. The shallower interval

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TABLE 3.3-10
LIST OF CURRENT AND PROPOSED MONITORING WELLS IN THE OCOTILLO/COYOTE WELLS GROUNDWATER BASIN

Well Number	Owner	Water Level	Water Quality	Well Number	Owner	Water Level	Water Quality
Current Program				16S/11E-27F1	US Government	X	
15S/11E-32R1		X		16S/11E-42L1	US Government	X	
16S/9E-24B1		X	X	16S/10E-42A8	Alan Heinrich		X
16S/9E-24D1	US BLM	X	X	17S/10E-11B1	Samual Gallaghe	X	
16S/9E-25K2	Clifford Water Company		X	17S/10E-11G1	W.E. Simpson	X	
16S/9E-25M2	Ocotillo Mutual Water Co.	X		17S/10E-11G4		X	
16S/9E-26F1	Neil Emory	X	X*	17S/10E-11H3	James Harmon	X	X
16S/9E-34B1	Rick Hamilton	X	X	17S/11E-16J1	Frank Souza	X	
16S/9E-35N2		X		17S/11E-22E2		X	
16S/9E-36C2	Coyote Valley Mutual Water Co.		X	Proposed Additional Monitoring Wells - Existing Wells			
16S/9E-36C3	Coyote Valley Mutual Water Co.	X		16S/9E-24N1	US Government	X	X
16S/9E-36D2		X		16S/9E-24R1	US BLM	X	X
16S/9E-36D3			X	16S/10E-29L1		X	X
16S/9E-36G4	Westwind	X		16S/10E-31B1			X
16S/9E-36H1	USG #5	X	X	16S/9E-36B1	USG #6		X
16S/10E-27R1		X		16S/9E-36G3	USG #4		X
16S/10E-29H1		X		16S/9E-36R1			X
16S/10E-30R1			X	16S/10E-41M1	C. Smith		X
16S/10E-31B1		X		Proposed New Monitoring Wells			
16S/10E-32P1		X		USG MW 1A, 1B	USG	X	X
16S/11E-23B1		X		USG MW 2A, 2B	USG	X	X

* Alternate well; to be sampled in place of a primary well when necessary.

should be screened in the same depth range as other wells in the area, which is typically up to 500 ft bgs to 600 ft bgs. The nested monitoring well will be drilled and constructed in accordance with applicable state and county requirements, including but not limited to those described in California Department of Water Resources Bulletins 74-81 and 74-90.

Water levels will be measured semi-annually in each well listed in Table 3.3-10, so long as allowed by the well owner, with the exception of the two new nested wells. The two screened intervals in each of the two nested wells will each be monitored using a dedicated pressure transducer-data logger combination (e.g. *In-Situ* MiniTROLL; *Global Water* WL15; etc) that will allow the daily measurement and recording of water levels.

The measurement of water levels in the two screened intervals in each of the two nested wells using dedicated pressure transducer-data logger combinations will continue for 10 years, after which water levels will be measured by hand on the same schedule as the other wells listed in Table 3.3-10.

The water-level data will be posted on a map and groundwater contours will be plotted to evaluate potential changes in groundwater flow direction. As discussed under Impact 3.3-1, the Proposed Action, based on modeling, will result in an acceleration of the baseline rate of water-level decline, which was predicted by the revised numerical groundwater model to be 10 feet over the 80-year life of the Proposed Action, or one foot every 8 years. The water-level data will be evaluated to determine if the rate of decline at a specific location is less than or greater than the model-predicted baseline rate of decline. The water-level decline at a specific well will be considered significant, and subject to mitigation as described in the Mitigation Measure for Impact 3.3-1, if four consecutive semi-annual groundwater levels from that well show a declining trend that is at least 50 percent greater than the baseline trend identified in the revised numeric groundwater model (i.e. 15 feet over the 80-year life of the Proposed Action, or one foot every five years and four months), and all monitoring wells located between the affected well and USG wells Nos. 4, 5, and 6, if any, also show a declining trend that is greater than the baseline trend.

Water-quality samples will be collected from each well listed in Table 3.3-10 on a semi-annual basis. The water samples will be collected following accepted well-sampling protocols and standards of practice, and analyzed by a laboratory certified by the California Department of Health Services for the analyses being conducted. At a minimum, the analyses will include pH, electrical conductivity, TDS, alkalinity, sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate, carbonate, fluoride, bromide, boron, and iron.

A sufficient number of samples will be collected so that an adequate number of samples are present from each well listed in Table 3.3-10 to calculate the 95-percent upper confidence limit or other statistical estimate of the upper bound of the mean, such as those described in California Code of Regulations, Title 27, Section 20415(b). Subsequent groundwater monitoring data will be compared with the statistical estimate of the upper bound of the mean to determine if a significant change in concentration may be occurring at a specific well location, or area of the aquifer. A significant increasing trend in concentration will be determined to be present if a chemical constituent is detected at a concentration that exceeds its 95 percent one-sided tolerance limit as defined by Gibbons (Statistical Methods for Detection Monitoring, in

Groundwater Contamination and Analysis at Hazardous Waste Sites edited by Suzanne Lesage and Richard E. Jackson, Marcel Dekker, Inc., 1992, pp. 199-243) for four consecutive monitoring periods. If a significant increasing trend is determined to exist, the monitoring frequency for that well will be increased to quarterly, and any of the private well owner(s) adjacent to any well indicating such a trend that has requested that their groundwater level and water quality be determined at the time the Mitigation Monitoring Program is implemented, will have their well tested until such time as the water quality decline returns to below levels of concern as specified in this Mitigation Monitoring Program. No other specific mitigation action will be required other than an increase in monitoring frequency until the TDS level reaches 500 mg/L, or the concentration of any other monitored constituent exceeds their secondary drinking-water standard in force at the time of the measurement as described in the mitigation measure for Impact 3.3-2 for the Proposed Action, in Section 3.3.2.7 above.

The water-level data, water-quality data, and statistical analysis of trends will be submitted to the County and the USGS within 60 days after the end of each calendar monitoring period. The monitoring will be conducted at the expense of USG. The actual party conducting the monitoring and the financial arrangements will be approved by the County. If no impacts have been identified, the Monitoring Program will continue until the sooner of either the end of the Proposed Action (80 years), or such time as USG implements a Project Alternative that results in USG wells Nos. 4, 5, and 6 being pumped at rates no greater than pre-Proposed Action rates. If significant impacts to groundwater have been identified, then this Monitoring Program will continue until those impacts have been fully mitigated and water levels and/or water quality returns to baseline levels, but no longer than 10 years after the Plant ceases operation.

3.3.3.8 No Action Alternative: Impacts and Mitigation Measures

Impact 3.3-1: Water Depletion at Plant Affecting Individual Well Owners

Increased pumping of USG wells could reduce water levels, increasing the cost of pumping groundwater and, causing some wells to go dry.

The No Action Alternative assumes the rate of water usage at the Plaster City Plant would not increase above pre-Proposed Action levels. As discussed above in Section 3.3.3, the water levels in the Basin are declining at the rate of approximately one foot every eight years under baseline conditions. This rate of water-level decline would continue under the No Action Alternative, but there

would not be any additional increment of water-level decline associated with the Proposed Action since there would not be any additional increment of pumping above the historic level, and therefore no increased impact to individual well owners. Therefore, the No Action Alternative would maintain the pre-Project conditions in the Basin.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-2: Water Depletion at Plant Affecting the Groundwater Basin

Increased pumping of USG wells could reduce water levels throughout broad areas of the Ocotillo/Coyote Wells Basin, reducing the total amount of water available in the basin.

The No Action Alternative assumes, the rate of water usage at the Plaster City Plant would not increase above pre-Proposed Action levels. As discussed above in Section 3.3.3, the water levels in the Basin are declining at the rate of approximately one foot every eight years under baseline conditions. This rate of water-level decline would continue under the No Action Alternative, but there would not be any additional increment of water-level decline associated with the Proposed Action since there would not be any additional increment of pumping above the historic level. Therefore, the No Action Alternative would maintain the pre-Project conditions in the Basin.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-3: Water Quality Degradation at Plant Affecting Individual Well Owners

Increased pumping from USG wells could degrade water quality in individual wells due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

The No Action Alternative assumes, the rate of water usage at the Plant would not increase above pre-Proposed Action levels. As discussed above, the

pumping that has occurred in the Basin since the mid-1920s has not caused any measurable decrease in groundwater quality. There would not be any potential for the No Action Alternative to change groundwater quality beyond the baseline level since there would not be any additional increment of pumping above the baseline level, and therefore no increased impact to individual well owners. Therefore, the No Action Alternative would maintain the baseline conditions in the basin.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-4: Water Quality Degradation at Plant Affecting the Groundwater Basin

Increased pumping from USG wells could degrade water quality in the groundwater Basin due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

The No Action Alternative assumes, the rate of water usage at the Plant would not increase above pre-Proposed Action levels. As discussed above, the pumping that has occurred in the Basin since the mid-1920s has not caused any measurable decrease in groundwater quality. There would not be any potential for the No Action Alternative to change groundwater quality beyond the baseline level since there would not be any additional increment of pumping above the baseline level. Therefore, the No Action Alternative would maintain the baseline conditions in the basin.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

3.3.3.9 Partial Use of Water from Imperial Irrigation District: Impacts and Mitigation Measures

Impact 3.3-1: Water Depletion at Plant Affecting Individual Well Owners

Increased pumping of USG wells could reduce water levels, increasing the cost of pumping groundwater, causing some wells to go dry.~~, and reducing the amount of available water in the Basin.~~

This alternative would supply the Plant with a portion of the water needed for operations from USG's existing wells in Ocotillo. The balance of the water needed for operations would be supplied by the IID. Under this alternative, water from IID would be blended with water from the Ocotillo/Coyote Wells Groundwater Basin as needed to achieve the level of water quality and consistency necessary for use in manufacturing wallboard without the need for further treatment of the process water. The quality of IID water, which comes from the Colorado River, varies over time. Thus, the amount of water that would need to be extracted from USG's wells in Ocotillo would vary over time. However, this alternative assumes that over the life of the Project, the amount of water extracted from the existing wells at Ocotillo would not increase above pre-Proposed Action levels. Water in excess of the pre-Proposed Action amount would be provided by IID under a water service agreement with USG. Payment of the required user fees and water rates to IID would contribute to any mitigation that IID conducts for use of Colorado River water, maintenance of the distribution system, and disposal of any waste or tail water.

The rate of pumping from the three USG wells in the Ocotillo/Coyote Wells Groundwater Basin would remain at the baseline rate. The baseline rate, as discussed above, is an average of 347 AF/yr over a five-year period. As discussed above, the modeled water levels in the Basin are declining at the rate of approximately one foot every eight years under baseline conditions. This rate of water-level decline would continue under this alternative, but there would not be any additional increment of water-level decline since there would not be any additional increment of pumping above the baseline level. Therefore, this alternative would maintain the baseline conditions in the Ocotillo/Coyote Wells Groundwater Basin.

Level of Significance Before Mitigation: Potentially Significant

Implementation of this partial use of IID water alternative will reduce USG's consumption of water from the Ocotillo/Coyote Wells Groundwater Basin to pre-Project levels. However, as discussed above, implementation of this alternative is not expected to occur until about 2008, or later. Thus, usage of groundwater above the pre-Project levels from 2000 until this alternative is implemented has the potential to adversely affect other wells in the Basin.

Mitigation Measures: Same as Proposed Action (See Mitigation Measure 3.3-1)

Level of Significance After Mitigation: Less than Significant

Impact 3.3-2: Water Depletion at Plant Affecting the Groundwater Basin

Increased pumping of USG wells could reduce water levels throughout broad areas of the Ocotillo/Coyote Wells Basin, reducing the total amount of water available in the basin.

Under the Partial IID Water Supply Alternative, USG's consumption of water from the basin would be reduced to pre-project levels. Increased long-term affects to the basin groundwater table would be avoided.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-3: Water Quality Degradation at Plant Affecting Individual Well Owners

Increased pumping from USG wells could degrade water quality in individual wells due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

Under the Partial IID Water Supply Alternative, USG's consumption of water from the basin would be reduced to pre-project levels. The potential for the Project to exacerbate drawdown that could influence migration of higher-TDS water would be avoided.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-4: Water Quality Degradation at Plant Affecting the Groundwater Basin

Increased pumping from USG wells could degrade water quality in the groundwater Basin due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

Under the Partial IID Water Supply Alternative, USG's consumption of water from the basin would be reduced to pre-project levels. The potential for the Project to exacerbate drawdown that could influence migration of higher-TDS would be avoided.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

3.3.3.10 Full Use of IID Water Alternative: Impacts and Mitigation Measures

Impact 3.3-1: Water Depletion at Plant Affecting Individual Well Owners

Increased pumping of USG wells could reduce water levels, increasing the cost of pumping groundwater, causing some wells to go dry~~, and reducing the amount of available water in the Basin~~.

This alternative would provide essentially the full water supply for the Plant from the IID. Under this alternative, water from IID would be piped to the Plant for use in wallboard processing. This alternative assumes that over the life of the Project, groundwater would not be extracted from the existing USG wells at Ocotillo. Therefore, the total pumping in the Ocotillo/Coyote Wells Groundwater Basin would be reduced by the baseline amount. Payment of the required user fees and water rates to IID would contribute to any mitigation that IID conducts for use of Colorado River water, maintenance of the distribution system, and disposal of any waste or tail water.

As discussed above, the water levels in the Basin are declining at the rate of approximately one foot every eight years under baseline conditions. Under the

Full IID Alternative, this rate of water-level decline would be reduced or even reversed, possibly resulting in restoration of water-levels in the Ocotillo area.

Level of Significance Before Mitigation: Potentially Significant

Implementation of this full use of IID Water Alternative will reduce USG's consumption of water from the Ocotillo/Coyote Wells Groundwater Basin to zero. However, as discussed above, implementation of this alternative is not expected to occur until about 2008, or later. Thus, usage of groundwater above pre-Project levels from 2000 until this alternative is implemented has the potential to adversely affect other wells in the Basin.

Mitigation Measures: Same as Proposed Action (see Mitigation Measure 3.3-1)

Level of Significance After Mitigation: Less than Significant

Impact 3.3-2: Water Depletion at Plant Affecting the Groundwater Basin

Increased pumping of USG wells could reduce water levels throughout broad areas of the Ocotillo/Coyote Wells Basin, reducing the total amount of water available in the basin.

Under the Full IID Water Supply Alternative, USG's consumption of water from the basin would be reduced below baseline consumption levels. Long term effects to the basin groundwater table would therefore be avoided.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-3: Water Quality Degradation at Plant Affecting Individual Well Owners

Increased pumping from USG wells could degrade water quality in individual wells due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

Under the Full IID Water Supply Alternative, USG's consumption of water from the basin would be reduced below baseline consumption levels. The potential

for the Project to exacerbate drawdown that could influence migration of higher-TDS water would be avoided.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-4: Water Quality Degradation at Plant Affecting the Groundwater Basin

Increased pumping from USG wells could degrade water quality in the groundwater Basin due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the basin.

Under the Full IID Water Supply Alternative, USG's consumption of water from the basin would be reduced below baseline levels. The potential for the Project to exacerbate drawdown that could influence migration of higher-TDS water would be avoided.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

3.3.4 Quarry Water Usage

As part of the Proposed Action, USG is proposing to drill a new water supply well, known as Quarry Water Well No. 3, near the Quarry. (See Figure 3.3-18, Proposed Location of Quarry Water Well Number 3). Approximately 26 AF/yr are needed from this new well for dust control in the quarrying, crushing, and screening operations. Quarry Water Well No. 1, located near the main entrance to the Quarry, was installed in 1983 under an Imperial County Conditional-Use Permit (CUP) limiting maximum withdrawal to 7,000 gallons per day.

Insert Figure 3.3-18

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For comparison purposes, the current permit limit of 7,000 gallons per day is approximately equivalent to 7.8 AF/yr, or 4.9 GPM assuming that the pump is operated continuously. The needed 26 AF/yr is approximately equivalent to 23,000 gallons per day, or 16.1 GPM assuming that the pump is operated continuously. Thus, the Proposed Action will result in an increase in the rate of groundwater extraction of approximately 18.2 AF/yr.

The existing and proposed Quarry water wells are located along the southwestern boundary of the Ocotillo Valley Groundwater Basin. This basin is distinctly different from the Ocotillo/Coyote Wells Groundwater Basin in which the USG production wells for the Plant are located.

Quarry Water Well No. 1 could not achieve the original permitted extraction rate due to the limited presence of groundwater in the penetrated aquifer and severe scale buildup in the well casing due to high TDS levels. In 1993, Quarry Water Well No. 2 was installed. Quarry Water Well No. 2 is not capable of producing the current permit limit of 7,000 gallons per day.

In 2001, USG drilled a test hole approximately three miles east-northeast of the Quarry on company-owned land along the USG railroad right-of-way. Pumping tests indicate that a production rate of 25 gpm to 50 gpm may be sustainable at the test-hole location. The TDS level of the water sampled from the test hole was 1,066 ppm. USG is proposing to install Quarry Water Well No. 3 within one-half mile of the successful test hole.

The following studies and reports were reviewed for this analysis of the proposed installation of Quarry Water Well No. 3 and the increase in annual pumping from 7.8 AF/yr to 26 AF/yr:

- *Imperial County Groundwater Study – Final Report*, Montgomery Watson, December 1995;
- *California's Ground Water*, California Department of Water Resources Bulletin 118-75, September 1975, reprinted January 1994;
- *Hydrogeologic Investigation for Allegretti Farms, Western Imperial County, California*, Krieger & Stewart, Incorporated, February 7, 1997; and
- *Potential Impacts of Pumping the Proposed Quarry Water Well No. 3*, Bookman Edmonston memorandum from John Rotert to Richard Rhone, March 28, 2003.

The information presented in the following section was obtained from these references, and copies of these studies can be reviewed at the office of the County Planning Department, Imperial County, California.

3.3.4.1 Affected Environment

The Ocotillo Valley Groundwater Basin is located to the west of the southwestern corner of the Salton Sea. This area is also commonly referred to as the Borrego Valley. It is bounded on the southwest by the Vallecito and Fish Creek Mountains, on the west by the Peninsular Ranges, on the north by the Borrego badlands, and on the east by the Salton Sea. The climate is comparable to that of the Ocotillo/Coyote Wells Groundwater Basin described above.

The Ocotillo Valley consists of sedimentary deposits derived from the surrounding mountain ranges, similar to the sedimentary deposits of the Ocotillo/Coyote Wells Groundwater Basin. The Coyote Creek fault trends northwest near the southwestern margin of the basin. The proposed location of Quarry Water Well No. 3 is approximately 4 miles southwest of the Coyote Creek fault. The surface deposits in the lower part of the Ocotillo Valley are reported to consist of the remnant shoreline of ancient Lake Cahuilla, which likely filled on several occasions in the Pliestocene due to meandering of the Colorado River. As the ancient lake dried out, saline evaporite deposits were left behind in the sediments.

The primary drainage in the Ocotillo Valley is San Felipe Creek. San Felipe Creek extends from the Peninsular Ranges to the Salton Sea. In the area of proposed Quarry Water Well No. 3, the primary surface drainage is the Fish Creek Wash. San Felipe Creek and Fish Creek Wash only flow seasonally, when runoff occurs from the upper reaches of their respective watersheds. In Section 32, T12S, R10E, approximately 10 miles northeast of the proposed location for Quarry Water Well No. 3, groundwater discharges from two springs near the confluence of San Felipe Creek and Fish Creek Wash. Prior to 1984, flow from these springs only occurred intermittently. Since 1984, however, flow from these two springs has occurred year round. These two springs, the San Felipe Creek Spring and the Fish Creek Spring, support the habitat for a population of Desert Pupfish (Cyprinodon mascularius, see Section 3.5, Wildlife), an endangered species.

Groundwater is reported to occur in two aquifers. The shallow aquifer is present at depths above approximately 100 ft bgs in the center of the basin and contains water with TDS levels reported in the range of 8,000 ppm. The elevated TDS levels are most

likely due to leaching of the saline evaporite deposits in the surficial sediments. An aquitard that may be 100 to 200 feet thick separates the shallow aquifer from the lower aquifer. The lower aquifer extends to at least 650 ft bgs at some locations and contains water with TDS levels reported in the range of 1,400 ppm. Groundwater from the lower aquifer is used for agricultural purposes. According to DWR (Bulletin 118-75), the Ocotillo Valley groundwater basin covers an area of about 410 square miles, with a storage capacity of 5,800,000 AF and a usable groundwater capacity of 1,900,000 AF.

Groundwater is reported to be discharging to the Salton Sea at rates of 2,200 AF/yr to 4,500 AF/yr. The rate of outflow from the Ocotillo Valley Groundwater Basin is greater than the rate of inflow, as evidenced by declining water levels in the lower aquifer. Water levels are decreasing at the rate of three feet per year. Approximately one-third to one-half of this decline is due to agricultural pumping and the balance is due to natural outflow. The naturally-occurring groundwater deficit is most likely due to long-term climatic changes and/or drainage of the lower aquifer due to the lowering of the hydrologic base level caused by the disappearance of ancient Lake Cahuilla.

Water-quality data and the timing of the change in flow from intermittent to year-round indicate that the discharges at San Felipe Creek Spring and Fish Creek Spring are due to increased rates of irrigation to the west. Excess irrigation water percolates to the shallow aquifer and raises the water table. The elevated water table intersects the surface at the location of the springs. From 1983 through 1996, irrigation rates have ranged from approximately 9,250 AF/yr to over 12,000 AF/yr, based on reported groundwater production.

Stream gauge data along San Felipe Creek show that, beginning in 1984, the base flow averaged several cubic feet per second (cfs). Seasonal peak flow generally occurs in late summer or early fall and may reach 50 cfs. If it is assumed that the base flow averages two cfs, then the minimum annual discharge of San Felipe Creek Spring is approximately 1,500 AF/yr. The actual discharge is likely to be appreciably greater due to seasonal peak flows.

3.3.5 Quarry Water Usage: Thresholds of Significance, Environmental Consequences, and Mitigation Measures

3.3.5.1 Thresholds of Significance

The significance criteria for analysis of proposed Quarry Water Well No. 3 were developed from Appendix G of the CEQA Guidelines. The Proposed Action would have a significant impact on hydrology and water quality if it would:

- Violate any water-quality standards or waste discharge requirements;
- Deplete groundwater supplies such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which a permit has been granted, or the rate of discharge at San Felipe Creek Spring or Fish Creek Spring would decrease to the point that it would degrade the Desert Pupfish habitat); or
- Otherwise substantially degrade water quality.

3.3.5.2 Proposed Action: Impacts and Mitigation Measures

Impact 3.3-5: Water Depletion at Quarry

The increased pumping rate in the Quarry vicinity from 7.8 AF/yr to 26 AF/yr could reduce water levels in other areas of the Basin, increasing the cost to pump groundwater, reducing the amount of available water in the Basin, or decreasing flow at springs that support Desert Pupfish habitat.

The nearest supply wells are located several miles to the north of the proposed Quarry Water Well No. 3 location. In addition, these wells typically pump at the rate of several hundred to over 1,000 gpm. The average pumping rate for the proposed well will be 16 gpm. The natural discharge from the Basin is 2,200 AF/yr to 4,500 AF/yr and the agricultural pumping ranges from 9,250 AF/yr to over 12,000 AF/yr. The maximum annual production from the proposed well will increase from 7.8 AF/yr to 26 AF/yr. The pumping rate and annual production for the proposed Quarry Water Well No. 3 are miniscule in comparison to agricultural pumping rates, and the rate of natural discharge of both groundwater and surface water. Therefore, the proposed well will not have any perceptible affect on the existing water levels or on the current rate of decline of the water table.

The proposed increase in pumping is also small compared to the minimum base flow from San Felipe Creek Spring of 1,500 AF/yr. Water quality data from the USG test hole also demonstrate that the new well would tap groundwater that is part of the lower aquifer. Discharge at San Felipe Creek Spring and Fish Creek Spring is from the shallow aquifer. Therefore, the proposed increase in pumping from 7.8 AF/yr to 26 AF/yr will not affect the flow at springs that support Desert pupfish habitat.

Level of Significance Before Mitigation: Less Than Significant

Mitigation Measures: None required

Impact 3.3-6: Water Quality Degradation at Quarry

The increased pumping rate in the Quarry vicinity from 7.8 AF/yr to 26 AF/yr could degrade water quality due to vertical migration of saline water from the shallow aquifer.

Based on the test hole drilling results, the shallow aquifer is not present in the area of proposed Quarry Water Well No. 3. In addition, the incremental increase in pumping from 7.8 AF/yr to 26 AF/yr is miniscule compared to the agricultural pumping rates from the lower aquifer in the central part of the basin.

Level of Significance Before Mitigation: Less Than Significant

Mitigation Measures: None required

Impact 3.3-7: Surface Water Flow at Quarry

Under normal flow conditions, there could be a negative impact on, or disruption of, existing flows of surface water at the Quarry site, as a result of expanded mining.

According to hydrology reports (Joseph E. Bonadiman & Associates 2004), a study was made of approximately 6,856 acres of the drainage area tributary to Fish Creek Wash natural channel. It was estimated that a maximum peak flow-rate for the area is approximately 5,204 cubic feet/second (cfs) for the 3-hrs-100-year storm frequency. It was concluded that the proposed Quarry expansion will not produce a significant reduction of runoff tributaries to Fish Creek because: 1) the Quarry expansion is adjacent to a mountain range that provides the smallest contribution of rainfall in the entire drainage area due to topographic and geologic conditions; and 2) rainfall east of the Quarry or within the Quarry will percolate into the ground, recharging the water table. The proposed Quarry expansion will have no effect on the natural groundwater process, therefore groundwater will transmigrate towards Fish Creek along the standard pattern. However, the main drainage patterns from the western mountain range of the drainage area produces the largest flow rate tributary to Fish Creek, potentially causing a disruption of periodic flows at the Quarry site.

Level of Significance Before Mitigation: Significant

Mitigation Measures: Mitigation Measure 3.3-7

An earthen berm will be constructed along the west side of the Quarry in order to preserve the natural drainage pathway. The berm would work as a natural earth channel, to preserve existing flow characteristics in the drainage area and protect the Quarry from flood waters by diverting water away from the Quarry and towards the Fish Creek Wash. This channel requires a minimum 50-foot bottom width for the floodway and 2:1 channel side slopes. The graded channel only requires an earthen berm of approximately 5 feet high, assuming 2 feet of freeboard. The berm would be 5 feet high by 20 feet wide, and would provide an adequate solution to contain and divert run-off.

Level of Significance After Mitigation: Less than Significant

3.3.5.3 No Action Alternative: Impacts and Mitigation Measures

Impact 3.3-5: Water Depletion at Quarry

The increased pumping rate in the Quarry vicinity of 7.8 AF/yr to 26 AF/yr could reduce water levels in other areas of the Basin, increasing the cost to pump groundwater, reducing the amount of available water in the Basin, or decreasing flow at springs that support Desert Pupfish habitat.

The nearest supply wells are located several miles to the north of the proposed Quarry Water Well No. 3 location. In addition, these wells typically pump at the rate of several hundred to over 1,000 gpm. The average pumping rate for the No Action Alternative is 4.9 gpm. The natural discharge from the Basin is 2,200 AF/yr to 4,500 AF/yr and the agricultural pumping ranges from 9,250 AF/yr to over 12,000 AF/yr. The maximum annual production from the No Action Alternative is 7.8 AF/yr. The pumping rate and annual production for the No Action Alternative are equivalent to the existing baseline conditions and are miniscule in comparison to agricultural pumping rates, and the rate of natural discharge of both groundwater and surface water. Therefore, the proposed well will not have any perceptible affect on the existing water levels or on the current rate of decline of the water table.

The No Action Alternative pumping rate is also small compared to the minimum base flow from San Felipe Creek Spring of 1,500 AF/yr. Water quality data from the USG test hole also demonstrate that the existing well taps groundwater that

is part of the lower aquifer. Discharge at San Felipe Creek Spring and Fish Creek Spring is from the shallow aquifer. Therefore, the No Action Alternative will not affect the flow at springs that support Desert Pupfish habitat.

Level of Significance Before Mitigation: Less Than Significant

Mitigation Measures: None required

Impact 3.3-6: Water Quality Degradation at Quarry

The increased pumping rate in the Quarry vicinity of 7.8 AF/yr to 26 AF/yr could degrade water quality due to vertical migration of saline water from the shallow aquifer.

Based on the test hole drilling results, the shallow aquifer is not present in the area of the existing Quarry Water Well No. 2. In addition, the pumping of 7.8 AF/yr is miniscule compared to the agricultural pumping rates from the lower aquifer in the central part of the basin.

Level of Significance Before Mitigation: Less Than Significant

Mitigation Measures: None required

Impact 3.3-7: Surface Water Flow at Quarry

Under normal flow conditions, there could be a negative impact on, or disruption of, existing flows of surface water at the Quarry site, as a result of expanded mining.

Under the No Action Alternative, existing mining would not expand as outlined in the Proposed Action. Therefore, baseline conditions of surface flows would be maintained.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

3.3.5.4 Partial IID Water Supply Alternative

Impact 3.3-5: Water Depletion at Quarry

The increased pumping rate in the Quarry vicinity of 7.8 AF/yr to 26 AF/yr could reduce water levels in other areas of the Basin, increasing the cost to pump groundwater, reducing the amount of available water in the Basin, or decreasing flow at springs that support Desert Pupfish habitat.

This alternative does not affect water pumping or usage at the Quarry, therefore the partial IID alternative does not change impacts or mitigation measures, as compared to the Proposed Action.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-6: Water Quality Degradation at Quarry

Increasing the pumping rate in the Quarry vicinity of 7.8 AF/yr to 26 AF/yr could degrade water quality due to vertical migration of saline water from the shallow aquifer.

Partial use of IID water affects the water usage from the three USG wells in the Ocotillo/Coyote Wells Groundwater Basin. This alternative does not affect water pumping or usage at the Quarry, therefore the partial IID alternative does not change impacts or mitigation measures, as compared to the Proposed Action.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-7: Surface Water Flow at Quarry

Under normal flow conditions, there could be a negative impact on, or disruption of, existing flows of surface water at the Quarry site, as a result of expanded mining.

Under this alternative, mining would expand at the Quarry as outlined in the Proposed Action, therefore there is the possibility that natural drainage patterns from the western mountain range of the drainage area could be disrupted at the Quarry site.

Level of Significance Before Mitigation: Significant

Mitigation Measures: Same as Proposed Action (See Mitigation Measure 3.3-3)

Level of Significance After Mitigation: Less than Significant

3.3.5.5 Full IID Water Supply Alternative

Impact 3.3-5: Water Depletion at Quarry

The increased pumping rate in the Quarry vicinity of 7.8 AF/yr to 26 AF/yr could reduce water levels in other areas of the Basin, increasing the cost to pump groundwater, reducing the amount of available water in the Basin, or decreasing flow at springs that support Desert Pupfish habitat.

Full use of IID water affects the water usage from the three USG wells in the Ocotillo/Coyote wells Groundwater Basin. This alternative does not affect water pumping or usage at the Quarry, therefore the full IID alternative does not change impacts or mitigation measures, as compared to the Proposed Action.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-6: Water Quality Degradation at Quarry

Increasing the pumping rate in the Quarry vicinity of 7.8 AF/yr to 26 AF/yr could degrade water quality due to vertical migration of saline water from the shallow aquifer.

Full use of IID water affects the water usage from the three USG wells in the Ocotillo/Coyote Wells Groundwater Basin. This alternative does not affect water pumping or usage at the Quarry, therefore the full IID alternative does not change impacts or mitigation measures, as compared to the Proposed Action.

Level of Significance Before Mitigation: Less than Significant

Mitigation Measures: None required

Impact 3.3-7: Surface Water Flow at Quarry

Under normal flow conditions, there could be a negative impact on, or disruption of, existing flows of surface water at the Quarry site, as a result of expanded mining.

Under this alternative, mining would expand at the Quarry as outlined in the Proposed Action, therefore there is the possibility that natural drainage patterns from the western mountain range of the drainage area could be disrupted at the Quarry site.

Level of Significance Before Mitigation: Significant

Mitigation Measures: Same as Proposed Action (See Mitigation Measure 3.3-3)

Level of Significance After Mitigation: Less than Significant

3.3.6 Cumulative Impacts and Mitigation Measures

The revised groundwater model (Bookman-Edmonston, 2004) assumed a 1.4 percent constant annual population increase in the Ocotillo area based on U.S. Census data and information contained in the Ocotillo-Nomirage Community Area Plan and therefore considered potential cumulative impacts resulting from regional growth.

The County Board of Supervisors recently upheld the County Planning Commission's determination of historical water usage and water well registration terms for a commercial well (State Well #16S/9E-36G4, Westwind Water Company) in the vicinity of the USG wells, and limited future pumping from this well to 40 AF/yr. This maximum rate of pumping is higher than the rate assumed in the modeling conducted for the Proposed Action (Bookman-Edmonston, 2004). The combined effects of the Proposed Action and the proposed additional pumping from the Westwind well have the potential to cause cumulative impacts on water levels and water quality in the Groundwater Basin.

The Proposed Action itself is comprised of three separate components (Quarry, Plant, and Pipeline) that are somewhat separated geographically, reducing the potential for cumulative effects. For example, the existing and proposed Quarry water wells are located along the southwestern boundary of the Ocotillo Valley Groundwater Basin. This Basin is distinctly different from the Ocotillo/Coyote Wells Groundwater Basin in which the USG production wells for the Plant are located.

Impact 3.3-8: Cumulative Reduced Water Levels

Increased pumping of USG wells and the additional commercial pumping from the Westwind well could reduce water levels, increasing the cost of pumping groundwater, causing some wells to go dry, and reducing the amount of available water in the Groundwater Basin.

As discussed for Impact 3.3-1, the Proposed Action could result in a significant impact on water levels and water quantity in the Groundwater Basin. The cumulative impact of the additional commercial pumping has the potential to further exacerbate this impact.

Level of Significance Before Mitigation: Significant

Mitigation Measure: Same as Mitigation Measure 3.3-1. The Monitoring Program for this Mitigation Measure is the same as for Mitigation Measure 3.3-1, as described in Section 3.3.3.

Level of Significance After Mitigation: Less Than Significant as to individual wells; Significant as to Basin-wide impacts

Impact 3.3-9: Cumulative Water Quality Degradation

Increased pumping of USG wells and the additional commercial pumping from the Westwind well could degrade water quality due to lateral migration of higher-TDS water located to the east of Coyote Wells, lateral migration of higher-TDS water from areas near outcrops of Tertiary marine sediments, or vertical migration of water from or near Tertiary marine sediments underlying the alluvial aquifer throughout most areas of the Groundwater Basin.

As discussed for Impact 3.3-2, the Proposed Action could result in a significant impact on water quality in the Groundwater Basin. The cumulative impact of the additional commercial pumping has the potential to further exacerbate this impact.

Level of Significance Before Mitigation: Significant

Mitigation Measure: Same as Mitigation Measure 3.3-2. The Monitoring Program for this Mitigation Measure is the same as for Mitigation Measure 3.3-2, as described in Section 3.3.3.

Level of Significance After Mitigation: Less Than Significant as to individual wells; Significant as to Basin-wide impacts

498-J

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105-3901

MAY 12 2010

Colonel Thomas H. Magness
District Engineer, Los Angeles District
U.S. Army Corps of Engineers
P.O. Box 532711
Los Angeles, California 90053-2325

Subject: Public Notice (PN) SPL-2008-01244-MLM for the proposed Imperial Valley Solar Project, Tessera Solar North America, Imperial County, California

Dear Colonel Magness:

This letter is in response to your March 15, 2010 PN describing Tessera Solar North America's proposed 6,500 acre Imperial Valley Solar Project located in Imperial County, California. The project proposes discharges of dredged or fill material that would eliminate 167 acres of jurisdictional desert streams tributary to the New River and the Salton Sea. As proposed, these discharges may result in substantial and unacceptable impacts to "aquatic resources of national importance" (ARNI). The streams at this project site perform critical hydrologic, biogeochemical and habitat functions directly affecting the integrity and functional condition of the New River and Salton Sea, both listed as impaired waterbodies under the Clean Water Act (CWA) sect. 303(d). This letter identifies the permit action as a candidate for review by our respective headquarters pursuant to our agencies' established procedures.[i]

The 878 acres of jurisdictional desert streams on the project site are a critical part of the Salton Sea Transboundary Watershed. There has been significant federal, state and community investment in the protection and improvement of this watershed for its agricultural, environmental and recreational values. Since the mid-1960's, federal and state agencies have undertaken and funded efforts to address salinity and other water quality problems, including $1.5 million of EPA funding for water quality and wetland restoration projects at the Salton Sea, and $62 million of EPA funding for wastewater infrastructure to protect human health and improve water quality in the New River.

The streams that would be directly impacted by this project provide services such as sediment transport and deposition, energy dissipation, and ground water recharge. They provide hydrological, biological and geochemical connectivity to the New River and Salton Sea, including connectivity to the Salton Sea National Wildlife Refuge. These waters represent a critical stop on the Pacific Flyway for migrating birds, including several state and federal listed and threatened species. The project site also provides a variety of habitat types for reptiles and mammals, including the flat-tailed horned lizard (*Phrynosoma mcallii*), proposed for listing under the Endangered Species Act, and Peninsula bighorn sheep (*Ovus Canadensis nelsoni*), a listed endangered species. All of these important functions will be lost or degraded by the

proposed installation of 30,000 SunCatcher dish Stirling systems and their associated equipment and infrastructure. These impacts may result in an irreversible loss of biodiversity and ecosystem stability, and harm the State of California's efforts to control and reduce pollutants and stressors currently impairing the New River and Salton Sea, such as pesticides, nutrients, salinity and selenium. Wastewater, agricultural return flows and industrial discharges are likely sources of these impairments, and the modification of flow and sedimentation regimes upstream will further reduce watershed resiliency and impact beneficial uses throughout the watershed.

Section 404 of the Clean Water Act prohibits avoidable discharges of dredged or fill material to waters of the United States. Proposals for discharges must meet EPA's regulatory standards at 40 CFR 230.10, including a comprehensive evaluation of project alternatives that avoid and minimize impacts to the aquatic environment. The only permittable discharge is the "Least Environmentally Damaging Practicable Alternative" (LEDPA). The applicant has provided a preliminary draft 404(b)(1) alternatives analysis and we are anticipating additional information on offsite alternatives, and site design (*e.g.,* fencing and roads, additional avoidance of SunCatchers placed in desert streams, development of in holdings, alternative substation and building locations, etc.). On April 28, 2010, your staff met with us and the applicant to discuss the most recent project proposals which, if developed and approved, could further reduce impacts to aquatic resources. We are committed to continuing to work together to ensure authorization of the LEDPA and avoid elevation of this permitting decision to Washington DC.

If you wish to discuss this matter, please call me at (415) 972-3572 or have your staff contact Jason Brush, Supervisor of our Wetlands Office, at (415) 972-3483.

Sincerely,

Alexis Strauss 12 May 2010

Alexis Strauss, Director
Water Division

cc: USFWS, Carlsbad
RWQCB (7), Colorado River Basin Region
Tessera Solar North America

[i] This letter follows field level procedures outlined in the August 1992 Memorandum of Agreement between the EPA and the Department of the Army, Part IV, paragraph 3(a) regarding section 404(q) of the Clean Water Act.

498-K

Climate Change and the Sonoran Desert

Travis Huxman, Director, UA Biosphere 2 and B2 Earthscience, Associate Professor, Ecology and Evolutionary Biology, University of Arizona, Tucson, Arizona

Semi-arid and arid ecosystems should be rather responsive to different aspects of climate change, since plant function in these systems is primarily limited by water availability, and many global change factors (CO2 rise, alteration in precipitation, temperature rise, nitrogen deposition) impact surface water budgets on landscapes. The prediction of an increase in 'global warming type' droughts such as those early in 21st Century will increase rates of perennial plant mortality, especially in the Sonoran Desert, which has the highest relative productivity of the North American deserts and contains functional types at risk to such mortality. This should accelerate rates of erosion, and create opportunities for exotic plant invasions. The proliferation of non-native annual and perennial grass will predispose sites to fire resulting in a loss of native woody plants and charismatic mega flora and primarily impacting low elevation sites that will now experience climate-fire synchronization where none previously existed. The climate-driven dynamics of the fire cycle is likely to become the single most important feature controlling future plant distributions in U.S. arid lands. Arid land soils are deficient in nitrogen, so erosional losses of soil nitrogen will further restrict regional productivity; and vegetation, especially exotic grasses, will be very responsive to N-deposition associated with increasing anthropogenic activities. Land use change, increased nutrient availability, increasing human water demand, and the continued pressure from non-native species will act synergistically with climate warming to restructure the rivers and riparian of the southwestern US. Increases precipitation intensity and the proportion of precipitation that comes in high-intensity storms will increase water erosion from uplands and delivery of nutrient-rich sediment to riparian areas. Combined these issues are likely to produce emergent features at the regional scale that may impact our systems in yet to be determined manners.

Travis Huxman received a Bachelor of Science and Master of Science in biology from California State University, San Bernardino in 1996. He earned his doctorate in biological sciences from the University of Nevada, Las Vegas in 2000. He was a post-doctoral fellow at the University of Colorado before joining The University of Arizona in Tucson in 2001. Huxman is a broadly trained biologist who is interested in the evolution of plant traits and the impacts of climate change on ecosystems. He has worked in deserts, grasslands and forests throughout North America, studying the physiological underpinning of how plants grow and reproduce, how climate variability and change affects plant and ecosystem processes and how ecosystems services relate to the human endeavor. His current research focuses on understanding the role of deserts in global climate. How deserts acquire and process carbon from the atmosphere and use water on the landscape are important feedbacks on global change that affect resource availability for consumption by society. Some important aspects of this current research include how ecological phenomena such as non-native species invasions affect the relationship between ecosystem carbon balance, water use and climate.

498-L

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May 28, 2009

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Re: Biological Resource Survey Techniques for the Solar Two Project

Dear Mr. Meyer and Mr. Stobaugh:

California Unions for Reliable Energy (CURE) submits this letter in response to Staff's request at the May 7, 2009 data request workshop that CURE provide written comments on biological survey techniques used by Sterling Energy System Solar Two LLC (the applicant) for the Sterling Energy System Solar Two Project (Project). We prepared these comments with the technical assistance of biological resources consultant Scott Cashen. CURE requests that the Energy Commission and BLM Staff take these comments into consideration when evaluating the biological resources section of the Application for Certification (AFC) and all supplemental information submitted for the SES Two Project.

This letter focuses on: 1) the adequacy of the applicant's surveys in establishing the existing biological resources in the Project area (the "baseline"); and 2) the appropriateness of using the resulting baseline to analyze the Project's impacts. In conducting surveys, the applicant did not follow the survey protocols established by the resource agencies (e.g., California Department of Fish and Game,

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California Native Plant Society, Burrowing Owl Consortium). As a result, the survey data provided in the AFC and the applicant's supplemental documents is not adequate to inform the public and decision-makers about the Project area's existing biological resources or the Project's potentially significant impacts on those resources. Specifically, the survey is unreliable because:

1. The applicant failed to follow rare plant and burrowing owl survey protocols, rendering much of the data not credible and possibly misleading.
2. The applicant failed to dedicate the level of survey effort needed for an adequate impact assessment, which in turn reduces the possibility of effective mitigation.
3. The applicant used survey data to assume species absence even though some of the surveys were conducted outside of the time periods most conducive to detection of the organisms of concern.
4. Some surveyors had no prior experience with the surveyed species and evidence shows that the same individual surveyed in both Imperial County and San Bernardino counties on the same day.[1]

In the California Energy Commission's (CEC) siting process, the CEC acts as lead agency under the California Environmental Quality Act (CEQA).[2] In this proceeding, the Bureau of Land Management (BLM) acts as the lead agency under National Environmental Policy Act (NEPA).[3]

CEQA has two basic purposes. First, CEQA is designed to inform decision-makers and the public about the potential, significant environmental effects of a project.[4] CEQA requires "a sufficient degree of analysis to provide decision-makers with information which enables them to make a decision which intelligently takes

[1] *See* AFC for SES Solar Two, Table 5.6-2 and AFC for SES Solar One, Appendix A of Appendix Y.
[2] Pub. Resources Code, § 25519(c).
[3] *See* Memorandum of Understanding Between the U.S. Department of the Interior, Bureau of Land Management California Desert District and the California Energy Commission Staff, Concerning Joint Environmental Review For Solar Thermal Power Plant Projects, p. 4, available at http://www.energy.ca.gov/siting/solar/BLM_CEC_MOU.PDF ("[t]he assessments provided by the Parties must be sufficient to meet all federal and state requirements for NEPA and CEQA and shall be included as part of the joint Preliminary Staff Assessment/Draft Environmental Impact Statement and the Joint Final Staff Assessment/Final Environmental Impact Statement.")
[4] 14 Cal. Code Regs. ("CEQA Guidelines"), § 15002(a)(1).).

account of environmental consequences."[5] Further, in preparing an environmental document, "an agency must use its best efforts to find out and disclose all that it reasonably can."[6] Second, CEQA directs public agencies to avoid or reduce environmental damage when possible by requiring alternatives or mitigation measures.[7]

CEC siting regulations require that the applicant conduct biological resource surveys using appropriate field survey protocols during the appropriate season(s), and that State and federal agencies with jurisdiction be consulted for field survey protocol guidance prior to surveys if a protocol exists.[8] Of the species identified as having potential to occur on the Project site, survey protocols exist for the flat-tailed horned lizard, burrowing owl, and sensitive botanical resources. For these species there is insufficient information in the record to evaluate the Project's biological impacts.

The Applicant's Rare Plants' Surveys Are Not Adequate

Several special-status plant species have the potential to occur on the Project site. Thurber's pilostyles (*Pilostyles thurberi*) has been documented as occurring along the northern boundary of the Project site, and Harwood's milk-vetch (*Astragalus insularis var. harwoodii*) and annual rock nettle (*Eucnide rupestris*) have been documented as occurring approximately two miles west of the Project site.[9] Several other special-status species have been documented as occurring within approximately 10 miles of the Project site.[10] Many of the special-status species that have been documented as occurring in the Project region are associated with the general and microhabitat conditions present on the Project site.[11] [12]

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[5] CEQA Guidelines, § 15151.
[6] CEQA Guidelines, § 15144.
[7] CEQA Guidelines, § 15002(a)(2) and (3). *See also Citizens of Goleta Valley v. Board of Supervisors* (1990) 52 Cal.3d 553, 564; *Laurel Heights Improvement Ass'n v. Regents of the University of California* (1988) 47 Cal.3d 376, 400.
[8] California Energy Commission. 2007. Appendix B *of* Rules of practice and procedure & power plant site certification regulations. Document No. CEC-140-2007-003. Also see the updated Appendix B from July 2008 at http://www.energy.ca.gov/2008publications/CEC-140-2008-003/CEC-140-2008-003.PDF.
[9] California Natural Diversity Database. 2009. Rarefind [computer program]. Version 3.1.0. 2009 May 2. Sacramento (CA): Wildlife & Habitat Data Analysis Branch. California Department of Fish and Game.
[10] *Id.*
[11] *Id.*
[12] Reiser, C. 1994. Rare Plants of San Diego County. Imperial Beach, CA: Aquafir Press. Available at: http://sandiego.sierraclub.org/rareplants/.

The AFC did not report the methods that were used to conduct rare plant surveys. However, in response to one of CURE's data requests, the applicant indicated surveyors followed meandering transects to survey the entire Project area.[13] These surveys did not adhere to any of the established protocol survey guidelines (e.g., California Department of Fish and Game [CDFG], California Native Plant Society [CNPS], U.S. Fish and Wildlife Service [USFWS]).

Rare plant surveys were conducted in March and May of 2007, and again in March and May of 2008 due to low rainfall in 2007.[14] CDFG and CNPS survey protocols require botanical surveyors to possess experience conducting floristic field studies, knowledge of plant taxonomy, and familiarity with special-status species that occur in the region being surveyed.[15] [16] Most members of the Project survey team lacked this knowledge and experience, and based on their resumes, it appears several had never conducted botanical surveys.[17] The applicant has stated that biologists conducting the surveys were distributed into groups of two or three such that more experienced botanists were paired with less experienced surveyors.[18] A guide of rare plants that potentially occur in the Project vicinity was distributed to all members of the survey team.[19]

The applicant has stated that approximately 165 person-days were devoted to rare plant surveys in 2007 and 2008.[20] However, this number is misleading because: 1) the applicant conducted other surveys (e.g., flat-tailed horned lizard, general surveys, and site assessment) on the same days as rare plant surveys, and the applicant has not provided the total number of hours that were specifically

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[13] Applicant's response to CURE data request 31.
[14] AFC, p. 5.6-6.
[15] California Department of Fish and Game. 2000. Guidelines for Assessing the Effects of Proposed Projects on Rare, Threatened, and Endangered Plants and Natural Communities. (Revision of 1983 Guidelines.) Sacramento, CA.
[16] California Native Plant Society. 2001. CNPS botanical survey guidelines. Pages 38-40 *in* Conservation and management of rare and endangered plants: proceedings of a California conference on the conservation and management of rare and endangered plants (T.S. Elias, editor). California Native Plant Society, Sacramento, CA, 630 pp.
[17] Applicant's response to data adequacy request #1 *in* Supplemental information in response to CEC data adequacy requests and BLM minimum requirement comments. September 2008. Log #48223.
[18] Applicant's response to CURE data request 31.
[19] *Id.*
[20] *Id.*

dedicated to identification of rare plants (as opposed to lizards or other wildlife);[21] 2) teams of two or three individuals cannot devote the same level of effort as individuals working independently due to redundancy in effort; and 3) for the dates 11 and 12 March 2008, the applicant lists Michelle Balk as one of the Project surveyors.[22] However, Ms. Balk was also reported to be surveying the Solar One Project site in San Bernardino County on those days.[23]

The purpose of rare plant survey protocols is to establish when surveys are needed, who is qualified to conduct such surveys, how field surveys should be conducted, and what information should be contained in a survey report.[24] Because the protocols establish the minimum requirements for botanical surveys used to evaluate project impacts, resource agencies recommend that lead agencies not accept non-protocol survey data.

Specific flaws with the applicant's rare plant surveys include:

1. Surveyors did not visit a reference site to confirm target species were identifiable at the time of the surveys.
2. Many members of the survey team lacked appropriate qualifications. Specifically, surveyors lacked:
    a. Prior experience conducting floristic field surveys;
    b. Knowledge of plant taxonomy and plant community ecology and classification; and,
    c. Familiarity with the plants of the area, including special-status and locally significant plants.

Lack of surveyor experience is especially problematic given the similarity among potentially occurring rare plants and species reported to occur at the Project site (i.e., species contained on the applicant's site list).

3. The applicant's surveys were not conducted using systematic field techniques to ensure thorough coverage of potential impact areas.

[21] AFC, p. 5.6-7.
[22] Biological Resources Technical Report, p. 8.
[23] AFC for Solar One, Appendix A.
[24] California Department of Fish and Game. 2000. Guidelines for Assessing the Effects of Proposed Projects on Rare, Threatened, and Endangered Plants and Natural Communities. (Revision of 1983 Guidelines.) Sacramento, CA.

Meandering transects do not constitute a systematic technique unless routes are established before surveys are conducted.

4. Surveyors did not conduct the sufficient number of site visits necessary to make observations during the appropriate phenological stage of all target species.

5. The intent of rare plant surveys is to document <u>any</u> rare plants that occur, not simply the ones that were subjectively predetermined to have potential of occurring (and included on the photo guide made by the applicant).

6. Surveys efforts were improperly documented.

We recommended that the applicant conduct rare plants surveys in 2010 to obtain reliable data on the occurrence of rare botanical resources within the Project area. Surveys should adhere to protocol guidelines established by the CDFG, CNPS, and USFWS. Surveyors should have prior experience with botanical field surveys, possess knowledge of plant taxonomy, and be familiar with plant species that occur in the Colorado Desert (including but not limited to the target species). Surveys should be conducted using systematic sampling techniques. In addition to conducting supplemental surveys, the applicant should contact the California Native Plant Society and any local experts to obtain information that may assist in establishing baseline conditions. In the alternative, the existence of special-status plant species on the Project should be assumed.

<u>The Applicant's Burrowing Owl Surveys Are Not Adequate</u>

The AFC did not report the methods that the applicant used to survey the site for burrowing owls other than to say that the applicant characterized the site's vegetation to determine habitat suitability for the species.[25] In response to CURE data request 48, the applicant stated that protocol burrowing owl surveys were determined to be unnecessary due to the extensive coverage provided by other focused surveys conducted onsite during 2007 and 2008. Although the applicant did not provide any other information on its survey methods, the applicant's response to CURE's data request suggests that observations of burrowing owls (or sign of owls) were incidental, and that the applicant did not actively survey for owls or owl

[25] AFC, p. 5.6-6.

burrows. As a result, it is unclear how much of the site was passively surveyed for burrowing owls or how many hours were dedicated to identifying species presence. The majority of the applicant's survey efforts were devoted to detecting flat-tailed horned lizards (FTHL) within surveys plots that collectively covered 38% of the site.[26] As a result, any efforts to search for burrowing owls concurrent with FTHL surveys would have resulted in a survey of only 38% of the site. This level of effort is not adequate to establish baseline conditions, assess impacts, or propose effective mitigation for burrowing owls.

The AFC did not indicate the times of day when surveyors searched for burrowing owls. However, if the applicant searched for owls concurrent with FTHL, surveys were likely not conducted during the times of day conducive to owl detection. To meet protocol survey requirements, flat-tailed horned lizard surveys need to be conducted when the air temperature is between 75 and 100 °F.[27] This requirement has the tendency to conflict with the burrowing owl protocol requirement of conducting surveys in the hours around sunrise and sunset (i.e., when temperatures may be below 75 °F).[28]

The applicant did not follow established burrowing owl survey protocol or otherwise conduct focused surveys for the species. To mitigate impacts to burrowing owls, the applicant has proposed pre-construction clearance surveys.[29] This approach does not provide adequate information on the presence of owls on the Project site until ground disturbance is imminent. At that point there will be insufficient time to evaluate impacts to owls and establish compensatory mitigation.

In sum, specific flaws with the applicant's burrowing owl surveys include:

1. Because burrows are the essential component of burrowing owl habitat, habitat suitability cannot be determined solely by characterizing vegetation (as indicated in the AFC).[30]

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[26] *Id.*
[27] Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices.
[28] The California Burrowing Owl Consortium. 1993. Burrowing Owl Survey Protocol and Mitigation Guidelines. Available online at: http://www.dfg.ca.gov/wildlife/species/docs/boconsortium.pdf.
[29] AFC, p. 5.6-22.
[30] The California Burrowing Owl Consortium. 1993. Burrowing Owl Survey Protocol and Mitigation Guidelines. Available online at: http://www.dfg.ca.gov/wildlife/species/docs/boconsortium.pdf.

2. Surveys were not conducted during those times of day when owls are most detectable.
3. No winter surveys were conducted.
4. Surveyors did not implement recommended survey techniques (e.g., use of transects that provide 100% site coverage) or use methods conducive to owl detection.
5. Surveys did not include the recommended number of site visits.
6. Surveyors did not conduct follow-up burrow monitoring.
7. Survey efforts were improperly documented.
8. Several surveyors lacked prior burrowing owl survey experience.

CURE recommends that the applicant conduct focused surveys for the presence of burrowing owls during the 2009 breeding season. Surveys should adhere to the protocol guidelines issued by the California Burrowing Owl Consortium. In particular, the applicant must identify and map burrows within the Project area. The applicant has already proposed clearance surveys for burrowing owls before each phase of Project construction.[31] Clearance surveys require locating and inspecting burrows. As a result, there is considerable overlap between our recommendation and what the applicant has already proposed. Our recommendation simply shifts the timing of the applicant's proposal such that useful information on owl abundance can be evaluated during the information gathering and analysis phase of the siting process.

CURE also recommends follow-up burrow monitoring at all potentially occupied burrowing owl burrows. Monitoring should include multiple site visits to account for variation in burrowing owl activity (and as recommended by the protocol). Follow-up burrow monitoring will provide an estimate of abundance, use patterns, and detectability during the breeding season when the population is relatively stable.

Finally, CURE recommends winter surveys be conducted to obtain an index of abundance of wintering owls and to compare the relative abundance of breeding and wintering owls within the Project area. Once protocol surveys have been completed, the applicant should develop a mitigation and compensation plan that is

[31] AFC, p. 5.6-22.

consistent with the guidelines issued by the California Burrowing Owl Consortium and the California Department of Fish and Game. The applicant has stated that compensatory mitigation for the FTHL will mitigate for impacts to owls if they are detected during pre-construction surveys.[32] The applicant anticipates submitting its compensation proposal in December 2009.[33] Our recommendation for a burrowing owl mitigation and compensation plan based on protocol survey results fits within the applicant's anticipated schedule for submittal of the proposed compensation plan.

The Applicant's Surveys for FTHL Are Not Adequate

The applicant conducted FTHL sampling throughout the Project site and concluded that 20 to 30 FTHL occupy the site where suitable habitat is present.[34] It's currently unclear how this occupancy estimate will be applied to impact evaluation or mitigation.

The Distribution Monitoring Protocol used by the applicant is not the appropriate procedure for estimating FTHL abundance (or population size). In 2003, the Flat-tailed Horned Lizard Interagency Coordinating Committee recommended that the protocol be implemented on a trial basis because it was untested.[35] Use of this protocol to estimate that 20 to 30 FTHL occupy the Project site provides misleading information on the number of lizards potentially impacted by the Project.

The applicant's occupancy estimate hinges on the assumptions that surveys constituted a representative sample, were properly implemented, and provided a 25% detection rate. The last assumption is perhaps the most significant. The applicant stated that the 25% detection rate estimate was provided by the BLM, and that it is based on extensive experience in use of the Distribution Monitoring Protocol by the BLM and wildlife agency staff.[36] The 25% detection rate estimate represents a mean value that we presume accounts for variation among observers, years, sites, and individual lizards (among other variables). However, a 25% detection rate is not appropriate without consideration of statistical variance,

[32] Applicant's response to CURE data request 50.
[33] Applicant's response to CURE data request 23.
[34] AFC: Bio Tech report, p. 11.
[35] Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices.
[36] Applicant's response to CURE data request 24.

unless the applicant can demonstrate its survey variables exhibited the same range of values as those incorporated by the BLM. For example, FTHLs are a cryptic species that on average are more often detected by experienced surveyors. Therefore, use of BLM's estimate is only valid if BLM's surveyors had the same level of experience as the applicant's (i.e., no prior experience). This assumption appears to be invalidated by the applicant's statement that BLM's estimate is based on "extensive experience" conducting distribution surveys. By contrast, other than a one-day training, it does not appear that anyone on the applicant's survey team had any prior experience conducting surveys for flat-tailed horned lizards.[37] The distribution monitoring protocol implemented by the applicant requires the surveys to be conducted by personnel who have demonstrated competence at locating FTHLs.[38]

If the applicant's FTHL occupancy estimate will be used for impact assessment or proposed mitigation, then a more reliable estimate of FTHL abundance should be obtained through use of the appropriate sampling protocol.

The Applicant's Surveys for the American Badger Are Not Adequate

Suitable habitat for badgers is characterized by herbaceous, shrub, and open stages of most habitats with dry, friable soils.[39] These conditions exist on the Project site and badgers have been documented as occurring in the Project region.[40] The AFC indicates several potential badger burrows were observed on the Project site.[41]

The applicant indicated that the Project is not expected to have an impact on the American badger because no badgers or definitive evidence of badger presence was detected onsite during two years of field surveys. Although the applicant did not implement any specific methods for documenting American badgers, the

[37] Applicant's response to data adequacy request #1 *in* Supplemental information in response to CEC data adequacy requests and BLM minimum requirement comments. September 2008. Log #48223.
[38] Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed horned lizard rangewide management strategy, 2003 revision. 80 pp. plus appendices.
[39] California Wildlife Habitat Relationships System. 2005. California Department of Fish and Game. California Interagency Wildlife Task Group. CWHR version 8.1 personal computer program. Sacramento (CA).
[40] California Natural Diversity Database. 2009. Rarefind [computer program]. Version 3.1.0. 2009 May 2. Sacramento (CA): Wildlife & Habitat Data Analysis Branch. California Department of Fish and Game.
[41] AFC, p. 5.6-5.

applicant stated that it expected any potential burrows or other badger sign would have been documented through conduction of other survey efforts.[42]

The applicant's conclusion that badger burrows or sign would have been documented through other surveys is misleading for a number of reasons. First, several potential badger burrows were detected within the Project site, and the applicant did not implement the measures required to determine whether these burrows were built (or used) by badgers.[43] [44] Second, although not specified in the AFC, it appears that the applicant's survey efforts were limited to daytime hours when badgers are rarely observed (the American badger is primarily a nocturnal species). Third, identifying badger sign can be difficult. Badgers often occur below ground and they leave much of their scat in their burrows. Badger scats deposited above-ground may be difficult to distinguish from scats of other carnivores, and should be confirmed with DNA screening. Intact badger tracks are distinct, but tracks are often swept away by the badger as it walks. Fourth, badger burrows (or dens) are the most conspicuous indication of badger presence, but they may be difficult to differentiate from dens of other animals. Therefore, personnel familiar with identifying badger sign are essential for accurate results. Because badgers are rarely seen (even at night), remote cameras or hair snag stations are used to provide direct evidence of badger occurrence. It does not appear that the applicant's surveys applied any of these recommended techniques. Thus, given the extremely low likelihood of incidental badger detection during daytime surveys, and the apparent lack of personnel familiar with identifying badger sign, the applicant's surveys do not provide a reliable estimate of badger presence within the Project area.

To obtain reliable information on badger presence in the Project area, we recommend that the applicant conduct surveys specifically designed to detect badger presence. Efforts to detect badger sign (e.g., burrows, scat, tracks) should incorporate appropriately trained personnel that possess experience in badger sign identification. Alternatively, the applicant can make efforts to obtain direct evidence of badger presence through use of remote cameras and/or hair snag stations.

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[42] Applicant's response to CURE data request 40.
[43] AFC, p. 5.6-5.
[44] The Province of British Columbia, Ministry of Environment, Ecosystems Branch for the Resources Information Standards Committee. 2007. Inventory methods for medium-sized territorial carnivores: badger [electronic resource]. Available at: http://ilmbwww.gov.bc.ca/risc.

Conclusion

The applicant's survey data is unreliable to support an adequate description of the existing biological resource baseline or to support an adequate analysis of significant impacts and feasible mitigation measures under CEQA. Thus, CURE recommends reasonable and timely additional surveys as set forth herein.

Thank you for your consideration of these comments.

Sincerely,

/S/

Loulena Miles
Attorney for CURE

LAM:cnh

cc: Docket (08-AFC-5)
Proof of Service List (08-AFC-5)

DECLARATION OF SERVICE

I, Carol Horton, declare that on May 28, 2009, I served and filed copies of the attached CALIFORNIA UNIONS FOR RELIABLE ENERGY BIOLOGICAL RESOURCES LETTER, DATED May 28, 2009. The original document, filed with the Docket Unit is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: www.energy.ca.gov/sitingcases/solartwo. The document has been sent (1) electronically, and (2) via US Mail by depositing in the US mail at Sacramento, California, with first-class postage thereon fully prepaid and addressed as provided on the attached Proof of Service list to those addresses NOT marked "email preferred." It was sent for filing to the Energy Commission by sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address shown on the attached Proof of Service list.

I declare under penalty of perjury that the foregoing is true and correct. Executed at Sacramento, California, this 28th day of May, 2009.

/S/

Carol Horton

2218-023d

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498-M

Back to:

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NOTE:
To print data frame (right side), click on right frame before printing.

1971 - 2000

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1971-2000 Normals (~3 KB)

1961 - 1990

- Daily Temp. & Precip.
- Daily Tabular data (~23 KB)
- Monthly Tabular data (~1 KB)
- NCDC 1961-1990 Normals (~3 KB)

Period of Record

- Station Metadata
- Station Metadata Graphics

General Climate Summary Tables

- Temperature
- Precipitation
- Heating Degree Days
- Cooling Degree Days
- Growing Degree Days

Temperature

- Daily Extremes and Averages
- Spring 'Freeze' Probabilities
- Fall 'Freeze' Probabilities
- 'Freeze Free' Probabilities
- Monthly Temperature Listings
  - Average
  - Average Maximum
  - Average Minimum

Precipitation

- Monthly Average
- Daily Extreme and Average

- Daily Average
- Precipitation Probability by Duration.
- Precipitation Probability by Quantity.
- Monthly Precipitation Listings
  - Monthly Totals

Snowfall

- Daily Extreme and Average
- Daily Average
- Monthly Snowfall Listings
  - Monthly Totals

Snowdepth

- Daily Extreme and Average
- Daily Average

Heating Degree Days

- Daily Average

Cooling Degree Days

- Daily Average

Period of Record Data Tables

- Daily Summary Stats (~55 KB)
- Monthly Tabular data (~2 KB)

Western Regional Climate Center,
wrcc@dri.edu

EL CENTRO 2 SSW, CALIFORNIA

Monthly Total Precipitation (inches)

(042713)

File last updated on Apr 5, 2010
*** Note *** Provisional Data *** After Year/Month 200912
a = 1 day missing, b = 2 days missing, c = 3 days, ..etc..,
z = 26 or more days missing, A = Accumulations present
Long-term means based on columns; thus, the monthly row may not
sum (or average) to the long-term annual value.
MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5
Individual Months not used for annual or monthly statistics if more than 5 days are missing.
Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

YEAR(S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1932	0.00z	0.00z	0.00	0.00	0.00	0.11	0.00	0.00	0.00	1.68	0.00	0.65	2.44
1933	0.50	0.02	0.00	0.72	0.00	0.00	0.33	0.04	0.02	0.00	0.06	0.06	1.75
1934	0.00	0.04	0.12	0.00	0.00	0.00	0.02	0.77	0.00	0.00	0.00	0.34	1.29
1935	0.54	2.06	0.05	0.00	0.00	0.00	0.20	0.52	0.03	0.00	0.00	0.60	4.00
1936	0.20	0.43	0.00	0.00	0.00	0.00	0.43	0.11	0.00	0.09	0.16	0.27	1.69
1937	0.03	0.14	0.74	0.00	0.02	0.00	0.22	0.00	0.23	0.00	0.00	0.03	1.41
1938	0.00	0.96	0.43	0.00	0.00	0.00	0.07	0.15	0.00	0.00	0.00	1.22	2.83
1939	0.56	0.57	0.06	0.13	0.00	0.00	0.00	0.03	5.13	0.00	0.32	0.00	6.80
1940	0.04	0.77	0.01	0.01	0.00	0.00	0.00	0.00	1.59	0.08	0.05	2.32	4.87
1941	0.93	0.33	1.73	0.16	0.00	0.00	0.04	0.77	0.06	1.33	0.10	0.74	6.19
1942	0.04	0.72	0.50	0.31	0.00	0.00	0.00	0.07	0.00	0.03	0.00	0.00	1.67
1943	0.41	0.14	0.16	0.00	0.00	0.00	0.00	0.60	0.01	0.00	0.00	2.56	3.88
1944	0.00	1.01	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.69	0.89	2.78
1945	0.63	0.05	0.18	0.07	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.61	2.31
1946	0.00	0.00	0.03	0.00	0.00	0.00	0.00	1.84	0.08	0.26	0.11	0.46	2.78
1947	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.02	0.41	0.59
1948	0.00z	0.00z	0.00z	0.00z	0.00z	0.00z	0.00	0.00	0.00	1.02	0.00	0.37	1.39
1949	1.78	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.01	0.20	2.34
1950	0.00	0.21	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.07	0.95
1951	0.29	0.01	0.00	0.14	0.00	0.00	0.10	2.49	0.00	0.00	0.35	0.36	3.74
1952	0.63	0.20	0.47	0.46	0.00	0.00	0.12	0.23	0.00	0.00	0.28	0.14	2.53
1953	0.00	0.03	0.31	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.04	0.00	0.45
1954	1.72	0.00	0.24	0.00	0.00	0.00	0.06a	0.00	0.00	0.00	0.02	0.00	2.04
1955	1.71	0.00	0.06	0.00	0.00	0.00	0.59	1.05	0.00	0.00	0.00	0.09	3.50

1956	0.20	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.04	0.00	0.00	0.00	0.25
1957	0.70	0.09	0.02	0.00	0.00	0.00	0.00	0.74	0.00	2.09	0.00	0.05	3.69
1958	0.07	1.25	0.44	0.60	0.12	0.00	0.12	0.00	0.00	0.00	0.30	0.00	2.90
1959	0.16	0.23	0.00	0.00	0.00	0.00	0.00	0.23	0.10	0.49	0.00	0.69	1.90
1960	0.32	0.14	0.02	0.00	0.00	0.00	0.06	0.22	0.01	0.00	0.03	0.07	0.87
1961	0.15	0.00	0.00	0.00	0.00	0.00	0.02	0.75	0.00	0.00	0.05	0.81	1.78
1962	0.92	0.15	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	1.99
1963	0.00	0.07	0.15	0.00	0.00	0.00	0.00	0.13	1.02	0.00b	0.42a	0.00	1.79
1964	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.24	0.02	0.69
1965	0.00	0.16	0.20	0.61	0.00	0.00	0.00	0.00	0.00	0.00	0.24	1.88	3.09
1966	0.29	0.21	0.12	0.00	0.00	0.00	0.00	0.00	0.13	0.82	0.06	0.00	1.63
1967	0.26	0.00	0.20	0.00	0.00	0.00	0.00	0.00	1.47	0.00	1.69	0.77	4.39
1968	0.00	0.00	0.50	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	1.55
1969	0.79	0.05	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	1.52	0.03	3.33
1970	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.02	0.05	1.06
1971	0.03	0.03	0.00	0.08	0.00	0.00	0.00	0.04	0.24	0.02	0.00	0.00	0.44
1972	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	1.86	0.36	0.00	2.32
1973	0.00	0.29	0.00z	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29
1974	0.98	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.02	0.00z	0.00	0.37	1.42
1975	0.00	0.00	0.20	0.40	0.00	0.00	0.07	0.00	0.27	0.00	0.00	0.03	0.97
1976	0.00	0.67	0.00	0.33	0.21	0.00	0.04	0.00	2.40	0.02	0.51	0.18	4.36
1977	0.11	0.00	0.00	0.00	0.00	0.00	0.00	2.98	0.00	0.37	0.00	1.08	4.54
1978	1.11	0.35	0.30	0.05	0.00	0.00	0.00	0.00	0.00	1.04	1.20	0.83	4.88
1979	1.20	0.12	0.38	0.00	0.06	0.00	0.43	0.88	0.00	0.00	0.00	0.00	3.07
1980	1.01	1.57	1.31	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	4.06
1981	1.26	0.40	0.57	0.00	0.21	0.00	0.00	1.15	0.00	0.00	0.27	0.00	3.86
1982	0.05	0.09	0.63	0.00	0.00	0.00	0.00	0.00	1.28	0.00	0.15	2.72	4.92
1983	0.21	1.64	1.33	0.04	0.00	0.00	0.00	1.71	0.09	0.00	0.00	0.48	5.50
1984	0.21	0.00	0.00	0.00	0.00	0.00	0.34	0.09	0.00	0.00	0.36	1.33	2.33
1985	0.06	0.20	0.00	0.00	0.00	0.00	0.04	0.30	1.86	0.63	0.79	0.84	4.72
1986	0.14	0.54	0.11	0.01	0.00	0.00	0.26	0.16	0.07	2.41	0.17	0.04	3.91
1987	0.05	0.22	0.00	0.00	0.03	0.00	0.00	0.00	0.00	1.53	0.04	0.37	2.24
1988	1.30	0.30	0.00	0.11	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	2.43
1989	0.72	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.03	0.00	0.00	0.92
1990	0.18	0.00	0.00	0.02	0.00	0.08	0.25	0.91	0.53	0.00	0.00	0.00	1.97
1991	0.45	0.71	0.50	0.00	0.00	0.00	0.00	0.02	0.55	0.00	0.35	1.28	3.86
1992	0.49	1.09a	1.96	0.05	0.19	0.00	0.00	0.28	0.00	1.88	0.00	1.40	7.34
1993	3.45	0.74	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.75	0.00	5.15
1994	0.13	0.50	0.67	0.00	0.14	0.00	0.00	0.00	0.15	0.00	0.20	0.71	2.50
1995	1.66	0.12	0.22	0.10	0.00	0.00	0.02	0.04	0.00	0.00	0.00	0.06	2.22
1996	0.00	0.15	0.00	0.00	0.00	0.00	0.09	0.02	0.00	0.00	0.00	0.00	0.26

1997	0.43	0.05	0.00	0.01	0.00	0.02	0.00	0.06	2.44	0.00	0.00	0.82	3.83
1998	0.08	0.97	0.43	0.00	0.00	0.00	0.00	0.02	0.28	0.00	0.04	0.20	2.02
1999	0.00	0.00	0.00	0.31	0.00	0.00	0.00z	0.16	0.63	0.00	0.00	0.00	1.10
2000	0.00	0.06	0.09	0.00	0.09	0.00	0.00	0.01	0.00	0.54	0.00	0.00	0.79
2001	0.24	0.55	0.56	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	1.39
2002	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.26	0.01	0.36
2003	0.00	1.32	0.42	0.00	0.00	0.00	0.12	1.04	0.00	0.00	0.11	0.02	3.03
2004	0.06	1.34	0.17	0.43	0.00	0.00	0.00	0.34	0.04	0.83	0.65	0.52b	4.38
2005	0.86	0.91	0.20	0.00	0.00z	0.00	0.17	1.53	0.02	0.88	0.00	0.00	4.57
2006	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.42
2007	0.00z	0.00	0.03	0.00z	0.00	0.00	0.00	0.14	0.37	0.00	1.03	0.05	1.62
2008	0.37c	0.00	0.00	0.00	0.02	0.00	0.12	0.47	0.06	0.00z	0.00z	1.05	2.09
2009	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.59
2010	2.06	0.42a	0.62	0.00z	0.00z	0.00z	0.00z	0.00z	0.00z	0.00z	0.00z	0.00z	3.10
						Period of Record Statistics							
MEAN	0.43	0.35	0.24	0.07	0.01	0.00	0.08	0.33	0.27	0.27	0.18	0.41	2.67
S.D.	0.62	0.46	0.38	0.16	0.05	0.02	0.18	0.58	0.76	0.57	0.34	0.60	1.66
SKEW	2.25	1.63	2.62	2.62	3.38	4.79	3.27	2.48	4.25	2.25	2.65	2.01	0.60
MAX	3.45	2.06	1.96	0.72	0.21	0.11	1.05	2.98	5.13	2.41	1.69	2.72	7.34
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
NO YRS	76	77	77	76	76	77	77	78	78	76	77	78	70

498-N

EPA United States Environmental Protection Agency

Region 9 Ground Water Office (WTR-9) JUNE 2000

Sole Source Aquifer Designations in EPA, Region 9

The U.S. EPA's Sole Source Aquifer Program was established under Section 1424(e) of the U.S. Safe Drinking Water Act (SDWA.) Since 1977, it has been used by communities to help prevent contamination of groundwater from federally-funded projects. It has increased public awareness of the vulnerability of groundwater resources.

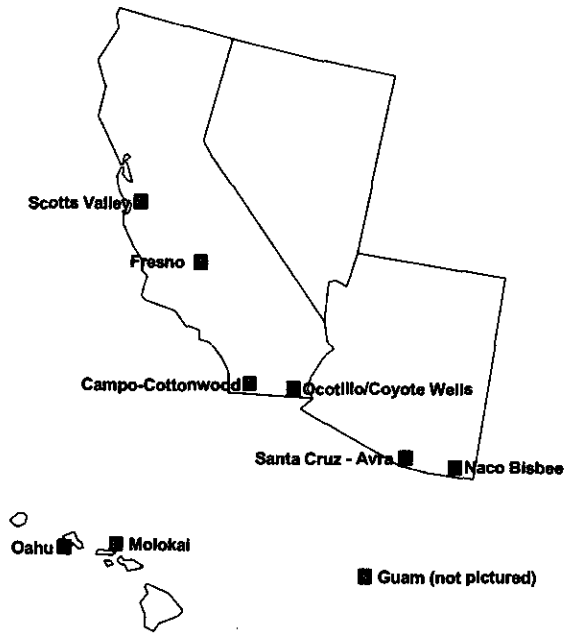
How did this program start? SDWA regulations implementing the sole source aquifer statute were first proposed in 1977 for the Edwards Underground Reservoir in San Antonio, Texas. These regulations guided U.S. EPA in the subsequent designation of 64 sole source aquifers across the United States.

What does the Sole Source Aquifer Program do? The Sole Source Aquifer program allows for EPA environmental review of any project which is financially assisted by federal grants or federal loan guarantees. These projects are evaluated to determine whether they have the potential to contaminate a sole source aquifer. If there is such a potential, the project should be modified to reduce or eliminate the risk, or federal financial support may be withdrawn. This doesn't mean that the Sole Source Aquifer program can delay or stop development of landfills, roads, publicly owned wastewater treatment works or other facilities. Nor can it impact any direct federal environmental regulatory or remedial programs, such as permit decisions.

The Sole Source Aquifer Program's review authority extends only to projects funded with **federal assistance** that are to be implemented in designated sole source aquifer areas. (For regulations applicable to new private development, you should consult with your local, county or state environmental health agency.)

Typical projects reviewed by the U.S. EPA include housing projects undertaken by Housing and Urban Development, and highway construction and expansion projects undertaken by the Federal Highway Administration. In 1991, the U.S. EPA reviewed 152 federal assistance projects totaling $571 million; of these projects, 25 had to be modified to prevent contamination of sole source aquifers. Modifications included the redesign of bridges and highways to prevent spills of hazardous materials.

How do you designate an aquifer as a "Sole Source" Aquifer? As the name implies, only a "sole source" aquifer can qualify for the program. To be a sole source, the aquifer must supply more than 50% of a community's drinking water. Any individual, corporation, association, or federal, state or local agency may petition the U.S. EPA for sole source aquifer designation, provided the petition includes sufficient hydrogeologic information. An outline describing how such petitions should be prepared is contained in *The Sole Source Aquifer Designation Petitioner Guidance*, copies of which are available at EPA Regional offices (see contact information below.)



What about Boundaries? Determination of sole source aquifer boundaries is a difficult aspect of the designation process since the "designated area includes the surface area above the aquifer and its recharge area." Thus, some sole source aquifers extend across state boundaries. The 10,000 square-mile Eastern Snake River Aquifer, for example, includes portions of Idaho, Nevada, Utah, and Wyoming.

In Region 9: nine sole source aquifers have been designated in the following areas as shown on the map: Upper Santa Cruz and Avra Basin Aquifer, covering parts of Pima, Pinal, and Santa Cruz Counties, Arizona; Naco-Bisbee Aquifer, Arizona; Ocotillo-Coyote Wells, Imperial County, California; Fresno Aquifer, California; Scotts Valley Aquifer, Santa Cruz County, California; Campo-Cottonwood Aquifer, San Diego County, California; Northern Guam Aquifer, Guam; Southern Oahu Aquifer, Hawaii; and Molokai Aquifer, Hawaii.

Region 9 SSA maps are on the web at www.epa.gov/safewater/ssanp.html. For more information about SSA designation and project reviews, please call David Albright, manager of the Ground Water Office, at (415) 972-3971 or email albright.david@epa.gov.

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The eastern boundary represents a band of low transmissivity. This boundary in T. 17 S., R. 11 E., coincides with the Elsinore fault, and in T. 16 S., R. 10 E., it coincides with an extension of the queried fault in figure 3.

On illustrations which follow, this queried fault extension is denoted a partial ground-water barrier. In 1975 a test hole was drilled on each side of the suspected location of the barrier near U.S. Highway 80 to determine the difference in water levels. This drilling indicated at least an 80-ft difference in water levels in 2 mi, which is indicative of a partial barrier to ground-water flow in the area.

The Westside Main Canal (fig. 2) is an unlined irrigation canal built in the early 1900's. Regional water levels indicate that ground-water flow crossing the eastern boundary of the model discharges to the canal.

The water level has probably had little change in the area between the east edge of the model and the canal since the canal was built. The 1975 water levels in four test holes in this area were not significantly different from those measured when the holes were drilled in 1962 and 1964 (Loeltz and others, 1975). Thus, water levels based on measurements in this area were held constant on the eastern boundary. The project area to the east of the boundary consequently was not modeled because of the invariance of water levels and the occurrence of highly saline ground water.

The constant-head boundary to the south in Mexico represents the major discharge from the aquifer. This discharge area is the Laguna Salada, which is approximately 20 mi southeast of Ocotillo. This is a large playa including an area of approximately 80 mi^2 below sea level, where evapotranspiration losses from the shallow ground water are great.

In illustrations and descriptions to follow, the modeled aquifer will not include that part south of the United States-Mexico border. Underflow across the border was estimated from calculated water levels in that vicinity, and the border was not a model boundary.

Transmissivity

Transmissivity (T) is a major factor controlling the rate at which water is transmitted through an aquifer. Besides the material characteristics such as average grain size and degree of sorting, transmissivity (T) is directly proportional to the saturated thickness.

The digital model has been generalized to use a fixed transmissivity and was not adjusted for changes in saturated thickness. Two reasons for this simplification are: (1) Little is known of the aquifer characteristics below the depths of existing wells; and (2) the historical changes in water levels are small in comparison with penetrated saturated thicknesses of 200 ft or more.

Estimates of T can be obtained from aquifer tests, where drawdown is plotted versus time. The specific capacity of a well, which is the pumping rate per foot of drawdown, can also be used to obtain estimates of T. One such estimate of T near Ocotillo was 6,700 ft^2/d based on a perforated interval of about 200 ft. Such an estimate is reasonable for sand and gravel aquifers.

An aquifer test in 1975 at a well about 3 mi northeast of Ocotillo and also northeast of the Elsinore fault yielded quite different results. The calculated T was 270 ft^2/d based on a perforated interval of about 60 ft. This transmissivity is more representative of fine-grained material such as fine sand and silt. A driller's log of this well shows that a preponderance of clay was penetrated.

The outcropping of Tertiary finer grained material to the east of the Elsinore fault (fig. 3) also supports the use of lower T estimates in this area.

Geophysical work by the University of California at Riverside (Shawn Biehler, written commun., 1974) and the U.S. Geological Survey has helped to improve estimates of transmissivity in the Ocotillo-Coyote Wells basin. Gravity surveys have been made that give approximate thicknesses of unconsolidated deposits in the basin. Because saturated thickness of the aquifer directly affects its transmissivity, these approximate thicknesses can be used to estimate transmissivities in regions where no other estimates are available.

The transmissivity distribution used in the calibrated model is shown in figure 8. These values of T, ranging from less than 20 ft^2/d to 10,700 ft^2/d, are based on estimates of saturated thickness, aquifer tests, and specific capacities as well as trial-and-error adjustments made during the calibration phase of modeling.

High transmissivities were estimated for parts of T. 16 S., R. 9 E.; T. 17 S., R. 10 E.; and T. 17 S., R. 11 E., because of suspected areas of great thickness of unconsolidated deposits compared with other areas of the basin. The thickness of alluvial deposits probably is not as great south of Pinto Wash in Mexico, and, consequently, lower transmissivity estimates were used there.

Low transmissivities were used to simulate the effects of faults on ground-water flow because the flow can be retarded by the faults. For example, Tyley (1971) found water-level drops of 30-250 ft across faults in the upper Coachella Valley. These ground-water gradients were much greater than those found in the rest of the valley, thus indicating retarded flow. Similar water-level gradients have been measured across the Elsinore fault and the extension of the queried fault (fig. 3) in T. 16 S., R. 10 E.

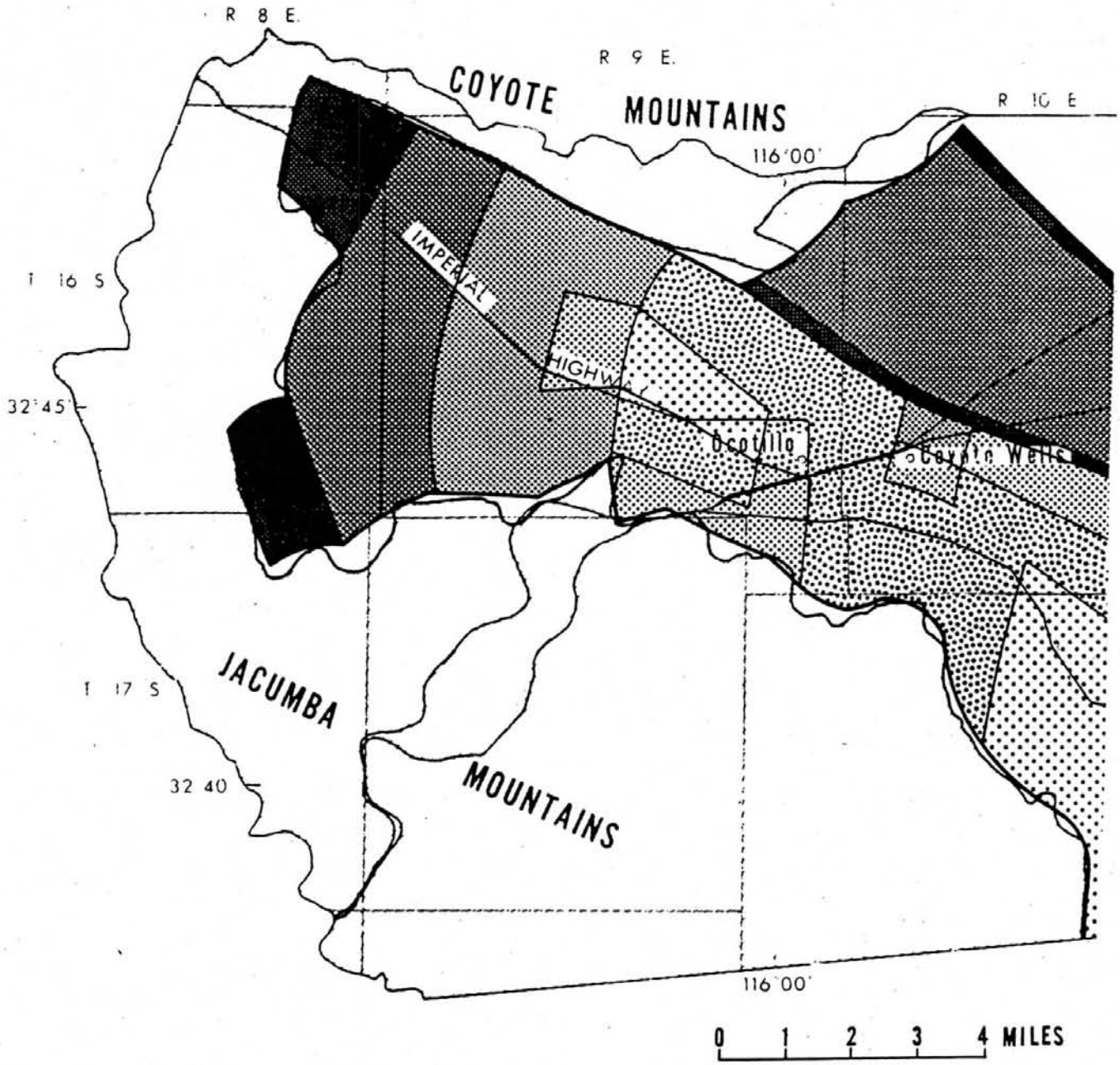
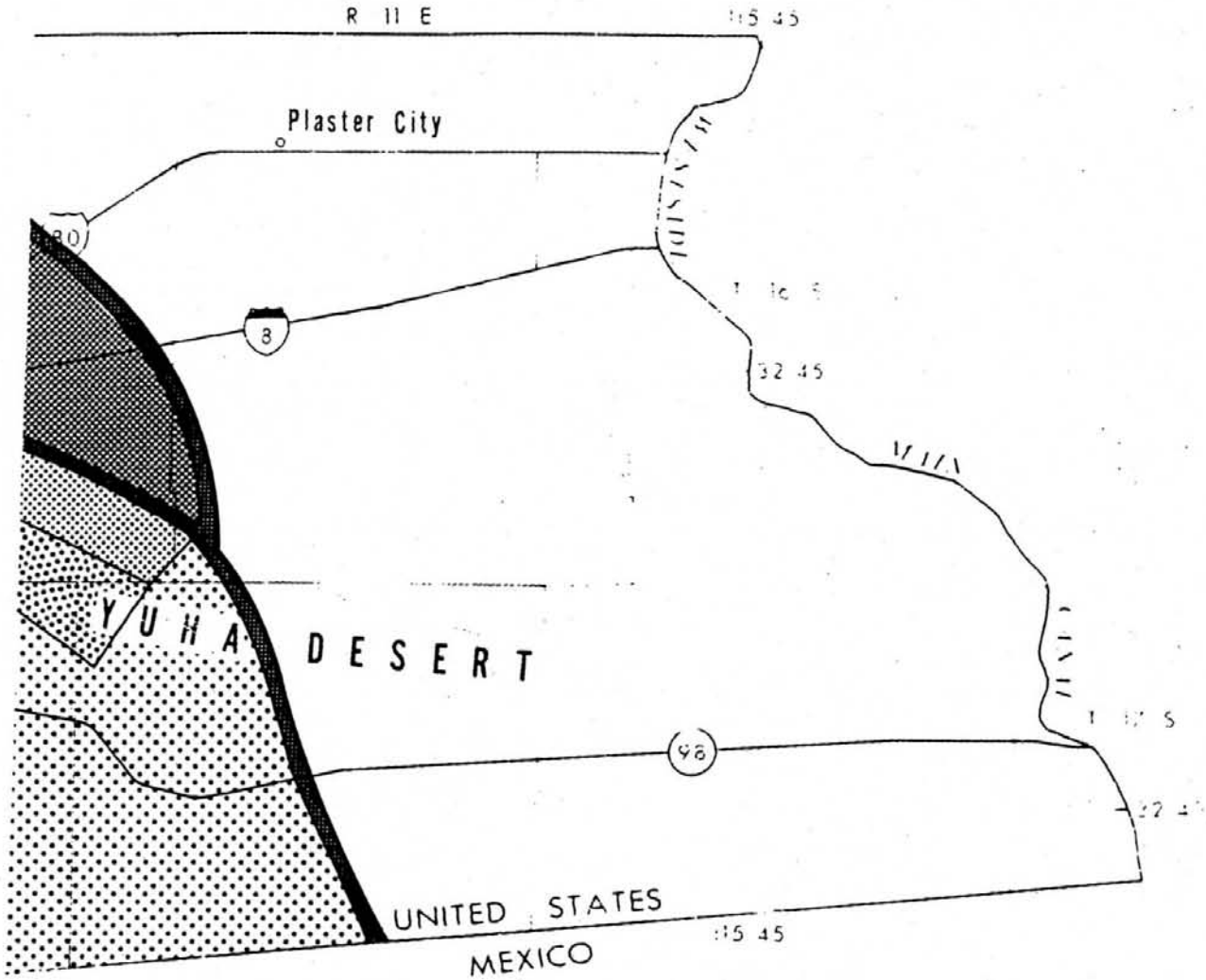


FIGURE 8.--Calibrated transmissivity distribution used in the digital model.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

MODEL BOUNDARY

TRANSMISSIVITY, IN FEET SQUARED PER DAY

6700-11,000

5400-6700

3300-5400

300-3300

20-300

Less than 20

FIGURE 8.--Continued.

The mechanism of retardation of flow across fault zones in the basin is not fully understood. One method could be by offsetting fine-grained beds which would decrease transmissivity. Drillers' logs of wells west of the Elsinore fault indicate mostly sand and gravel are penetrated the first 100-200 ft below land surface. Test drilling east of the fault, however, indicates the occurrence of much more clay and silt. Other possible mechanisms for this retardation of flow could be invasion of the fault zone by consolidated material such as a dike, or cementation along fractures.

Storage Coefficient

The storage coefficient is an important parameter that describes the aquifer's ability to release or store water.

The Ocotillo-Coyote Wells aquifer is unconfined as determined by the measured response of pumping wells and by geologic conditions. Commonly a continuous layer of clay may overlie a water-bearing formation and produce a confined, or artesian, aquifer. The silt and clay layers in the Ocotillo-Coyote Wells basin do not seem to be continuous; instead they occur as overlapping lenses, allowing the aquifer to have a water table or free surface over most or all of the area.

For an unconfined aquifer such as that in the Ocotillo-Coyote Wells basin, the storage coefficient (S) is, in effect, the specific yield--the ratio of the volume of water drained by gravity to the volume of aquifer material drained. Walton (1970) gave the following ranges for specific yield: Clay, 0.01-0.10; sand, 0.10-0.30; and gravel, 0.15-0.30. Estimates of S were made, using drillers' logs, by determining the percentage of different materials penetrated. Because an abundance of clay and silt was mentioned in these logs, the initial estimates of S ranged from 0.02 to 0.10.

In a fashion similar to that used to make transmissivity adjustments, the storage coefficient was varied by trial-and-error adjustments in the calibration phase. The final calibrated distribution of storage coefficient is shown in figure 9 and ranges from 0.04 to 0.08. Because of lack of data, the storage coefficient in the Mexican part of the model was estimated to be 0.08, which is equal to that used for a large area north of the border (fig. 9).

Calibration

The calibration of the digital model primarily involved adjusting aquifer transmissivities and storage coefficients to match computed and measured water levels reasonably well. The steady-state condition under which water levels virtually do not change with time was first analyzed. During this phase, transmissivities were adjusted because storage coefficient does not affect

steady-state water levels. Then the transient-state condition was studied where water levels have changed with time; during this phase, the storage coefficient was adjusted to match historical and computed water levels.

Steady State (1925)

Because man had little effect on ground water in the Ocotillo-Coyote Wells aquifer before 1925, natural recharge to the aquifer then nearly balanced natural discharge, and water levels were nearly steady with time. Because of variations in mean annual precipitation, water levels fluctuated somewhat from year to year, but the long-term effect was no change in ground water in storage.

Few historical records of water levels in the Ocotillo-Coyote Wells basin exist. The only measurements for 1925 are from the San Diego and Arizona Railway well, 16S/9E-36R1, and U.S. Gypsum Well No. 1, 16S/9E-36F2. These measurements are subject to question because the method is unknown, but they are assumed to be within 10 ft of the actual water level in 1925.

These measurements were used directly in the calibration process. Most later water levels for other parts of the basin were used indirectly for gross comparisons. The calculated depth to water was also checked to be sure it was not above ground nor below the bottom of the unconsolidated rocks.

Initial estimates of recharge and transmissivity were used in the digital model to simulate 1925 water levels. Then, primarily, the transmissivities were adjusted more often than the recharge in calibrating to steady-state conditions (see fig. 8 for the final distribution of the calibrated transmissivity).

The calibrated steady-state water levels are given in figure 10 together with two 1925 water-level measurements. The generalized direction of flow was from the recharge areas principally near the Jacumba Mountains eastward to Ocotillo and Coyote Wells. Ground water then flowed southward to the areas of present-day Nomirage and Yuha Estates and then across the Mexican border. There was also some flow eastward across the Elsinore fault.

Areas of ground-water discharge through evapotranspiration were near Coyote Wells and Yuha Springs (fig. 2). The steady-state ground-water budget is given in table 1.

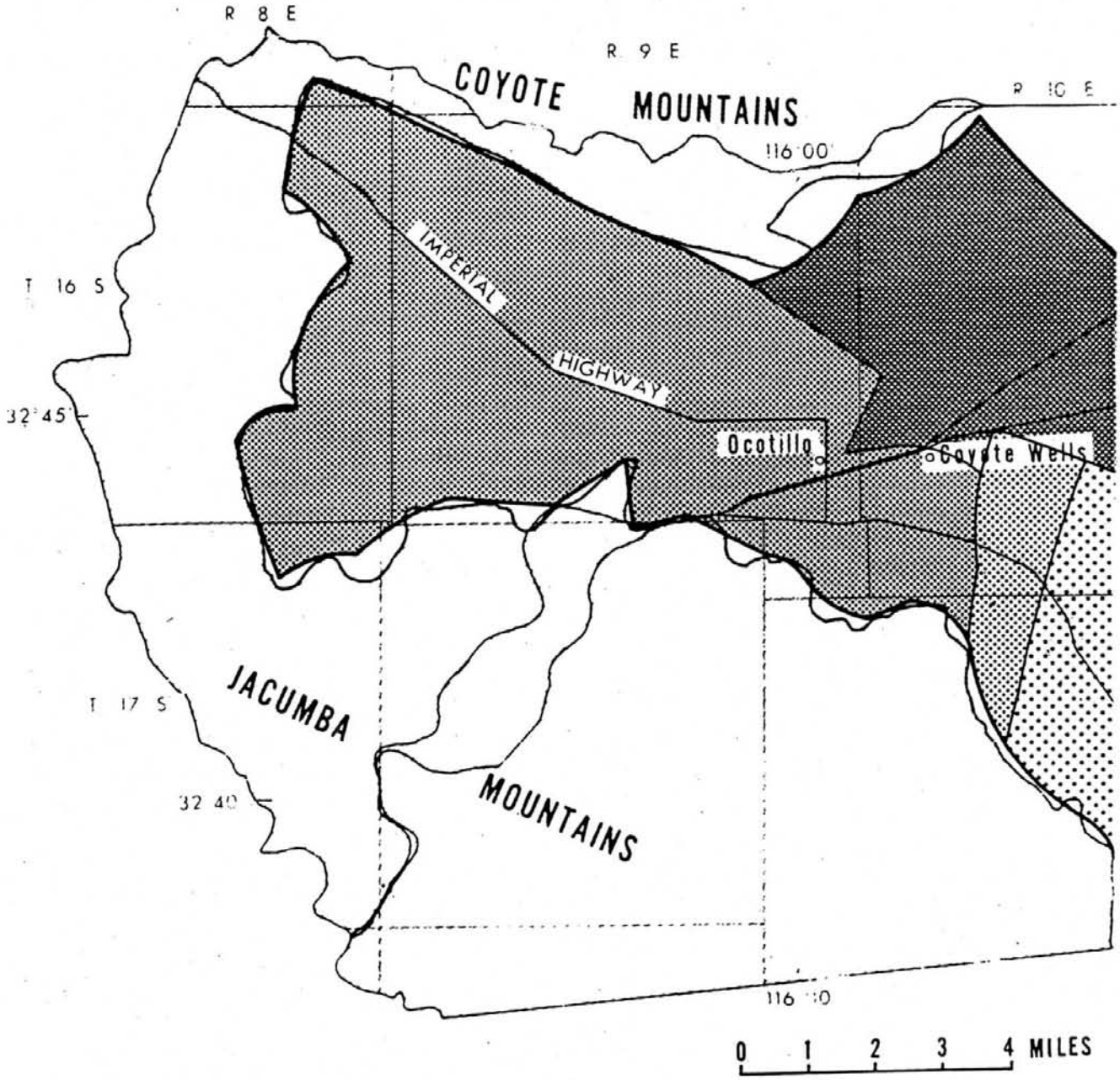
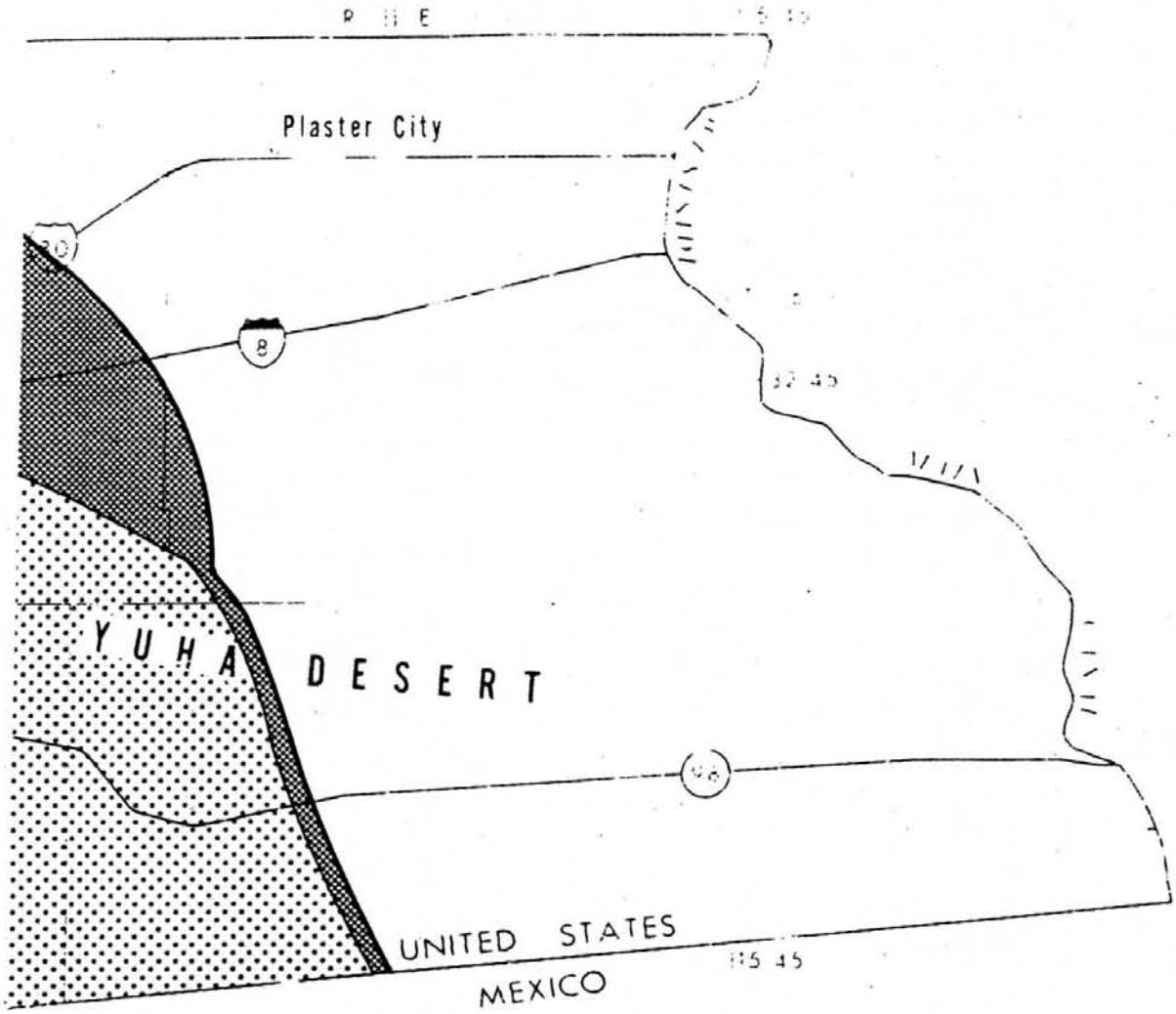


FIGURE 9.--Calibrated storage-coefficient distribution used in the digital model.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

STORAGE COEFFICIENT

0.04

0.05

0.06

0.08

MODEL BOUNDARY

FIGURE 9.--Continued.

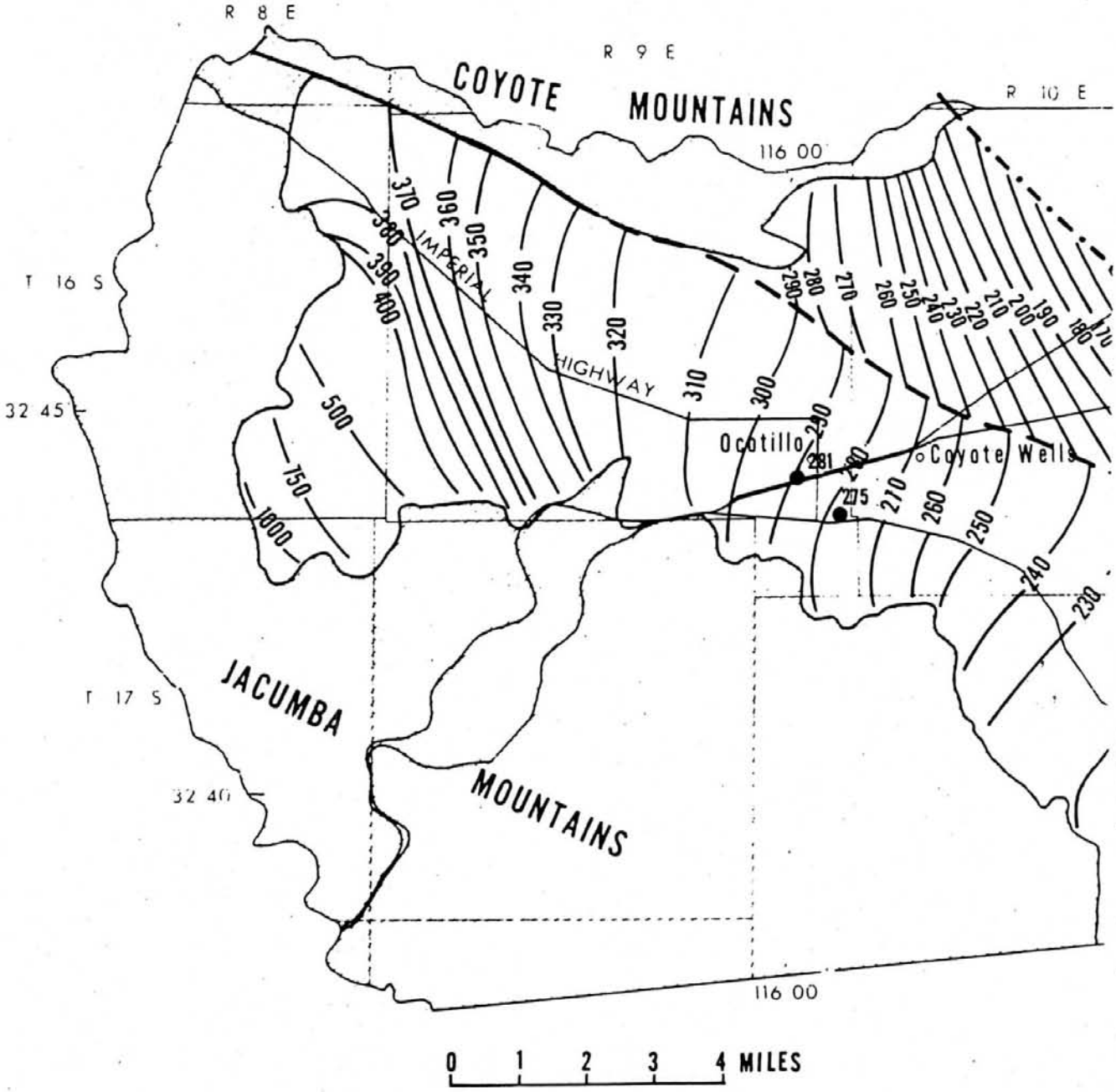
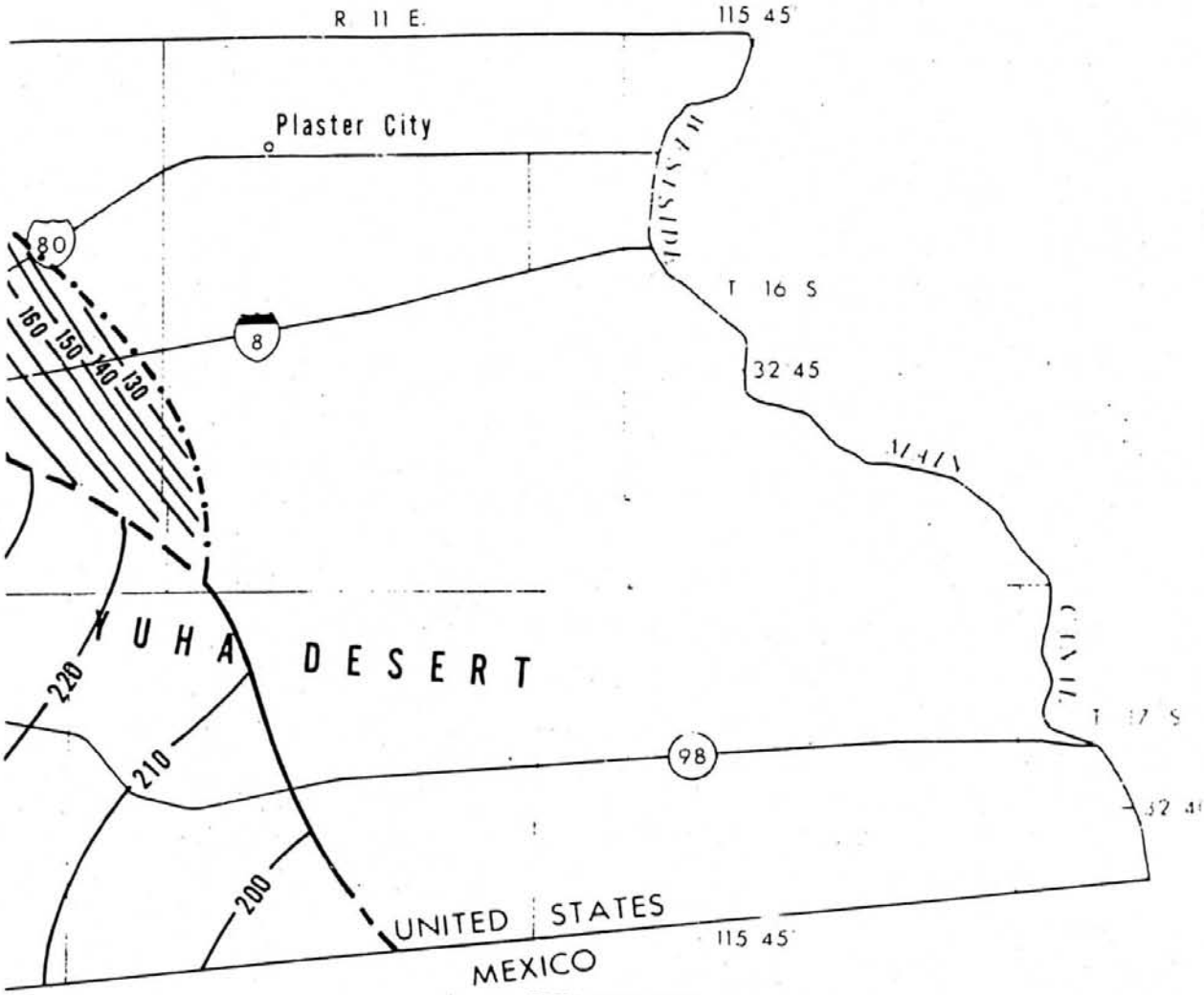


FIGURE 10.--Simulated water-level contours for steady state, 1925.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

FAULT--Dashed where approximately located and concealed

PARTIAL GROUND-WATER BARRIER

—290— WATER-LEVEL CONTOUR--Shows altitude of water level. Contour interval, in feet, variable. Datum is mean sea level

275 REPORTED 1925 WATER LEVEL IN FEET ABOVE MEAN SEA LEVEL

FIGURE 10.--Continued.

Transient State (1925-75)

Water levels probably began to drop with the first significant pumping in the Ocotillo-Coyote Wells basin. Pumping of wells in support of the Plaster City works, together with the San Diego and Arizona Railway supply well, began in 1925, and since that time pumpage has steadily increased (fig. 5). Water levels have continued to decline to the present time (1976), but few water-level measurements have recorded this decline. A few measurements were reported in the 1950's and 1960's, but the only accurate water levels available for operating wells in the project area are those made in the last several years.

Despite this lack of historical data, the period modeled in the transient-state analysis was from January 1925 to December 1975 in order to include the effects of all recorded significant pumpage. Estimates of this pumpage are assumed reasonable mainly due to records from U.S. Gypsum Co., the largest user of ground water in the project area. The total decline over this 51-year simulation period, as well as measured declines over the last few years, were utilized in the calibration. The storage coefficient was the primary aquifer parameter adjusted in the transient-state phase of calibration. (See fig. 9 for the calibrated distribution of storage coefficient.)

Figure 11 shows the simulated water-level contours as of December 1975 from the calibrated model. It also includes some 1974 and 1975 measured water levels for comparison with the computed water levels.

Thirty-one measurements were used to compare with computed water levels in calibration. The range in errors between computed and measured water levels was -9.3 to +12.0 ft.

Figure 12 shows the decline in water levels during the simulated period, January 1925 to December 1975. The calculated maximum decline of 15 ft occurred in Ocotillo, with almost all the modeled area experiencing some decline over the 51 years. The Nomirage and Yuha Estates subdivisions experienced simulated declines of about 9 ft and 4 ft respectively. Water levels east of Elsinore fault toward the Painted Gorge subdivision had calculated declines of only 3 ft or less in 51 years.

Hydrographs of calculated water-level decline from January 1925 to December 1975 are shown in figure 13 for eight nodes. The model nodes plotted are located in figure 12. In general, the hydrographs of nodes near Ocotillo show a gradual increase in yearly declines. This phenomenon is principally due to the increased pumpage shown in figure 5. The nodes around Ocotillo show a calculated decline of about 0.5 ft during 1975.

The estimated ground-water budget as of December 1975 is given in table 1. Underflow to Mexico has been reduced somewhat from steady-state conditions because of reduced hydraulic gradients near the United States-Mexico border. Underflow across the eastern boundary of the model has not changed significantly from 1925 to December 1975, however. Also, evapotranspiration losses have decreased significantly because of lowered water levels since steady-state conditions.

As of December 1975, the estimated ground-water discharge exceeds the recharge by about 500 acre-ft/yr, which represents water taken from storage. This constitutes mining of the ground water; unless conditions change, water levels will continue to decline.

PROJECTED DECLINE, 1976-95

One major use of the calibrated digital model of the Ocotillo-Coyote Wells basin is to simulate future water-level changes that might result from existing or proposed pumping distributions. Management plans, such as pumpage restrictions or pumping from new well fields, may also be evaluated by using the calibrated model. The reliability of such predictions is directly related to the persistence of the aquifer characteristics found in the calibration period. The digital model is calibrated to some magnitude of drawdown, for example, and proposed pumping should produce a similar range of drawdown to give reasonable simulation results.

Annual Pumpage of 1,000 Acre-Feet

Assuming the annual pumpage remains constant, the first rational question to be answered is, what will the future water levels be--say in 20 years? A projection period, 1976-95, was chosen to give a reasonable length of time over which to assess the long-term effects of pumping, but also short enough so that management of the ground-water resource would be effective and timely.

The largest annual pumpage to date in the project area was approximately 1,000 acre-ft in 1972. This magnitude and location of pumpage was used in the first projection. The calculated water-level decline from 1976 to 1995 is shown in figure 14. Additional drawdown over this period is about 6 ft in and west of Ocotillo, with about 4 ft being in Nomirage subdivision and 2.5 ft in Yuha Estates subdivision.

A maximum of 3 ft of decline is calculated to have occurred just east of the Elsinore fault. Hydrographs of nodes shown in figure 12 from 1976 to 1995 are given in figure 15.

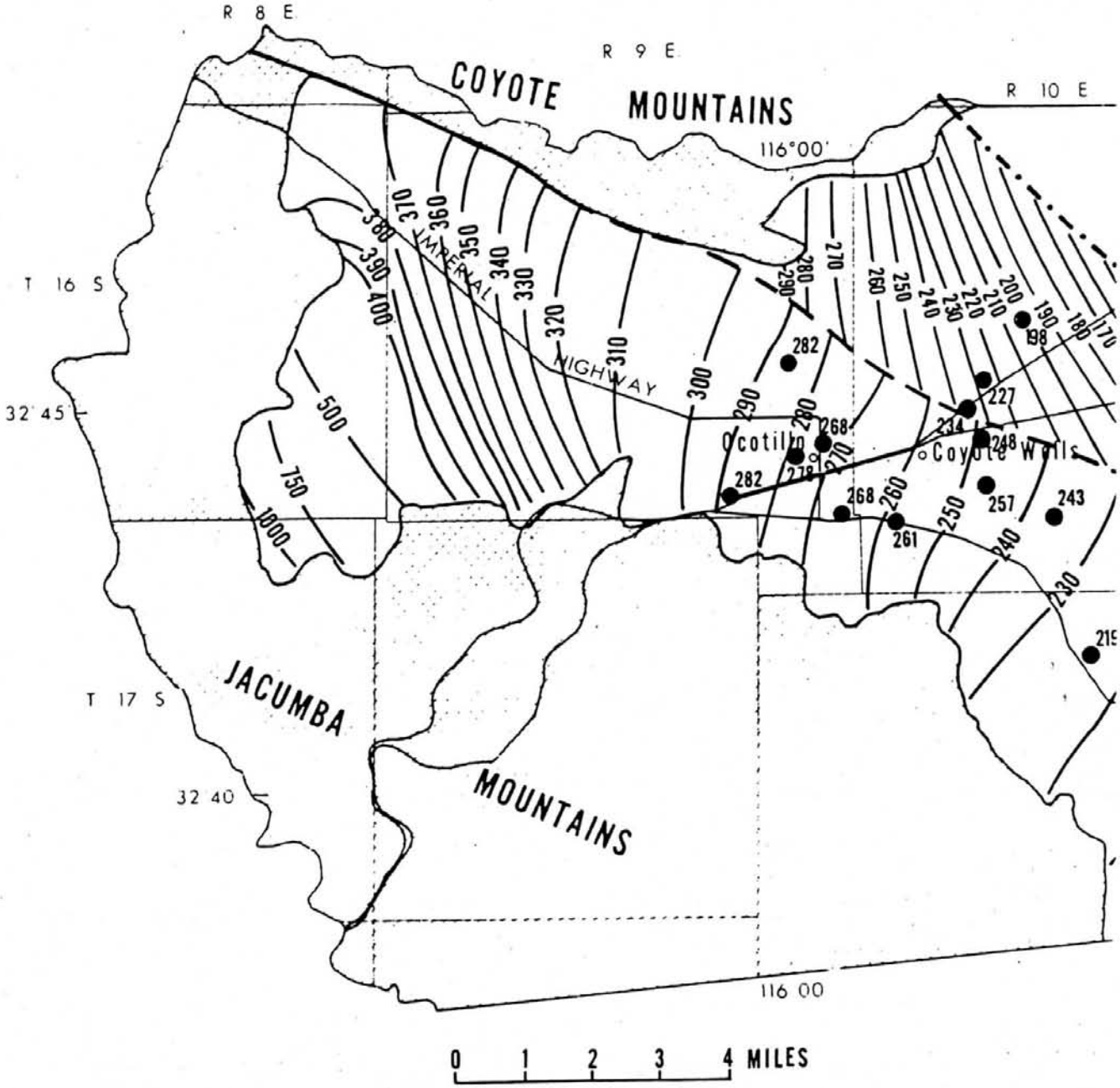
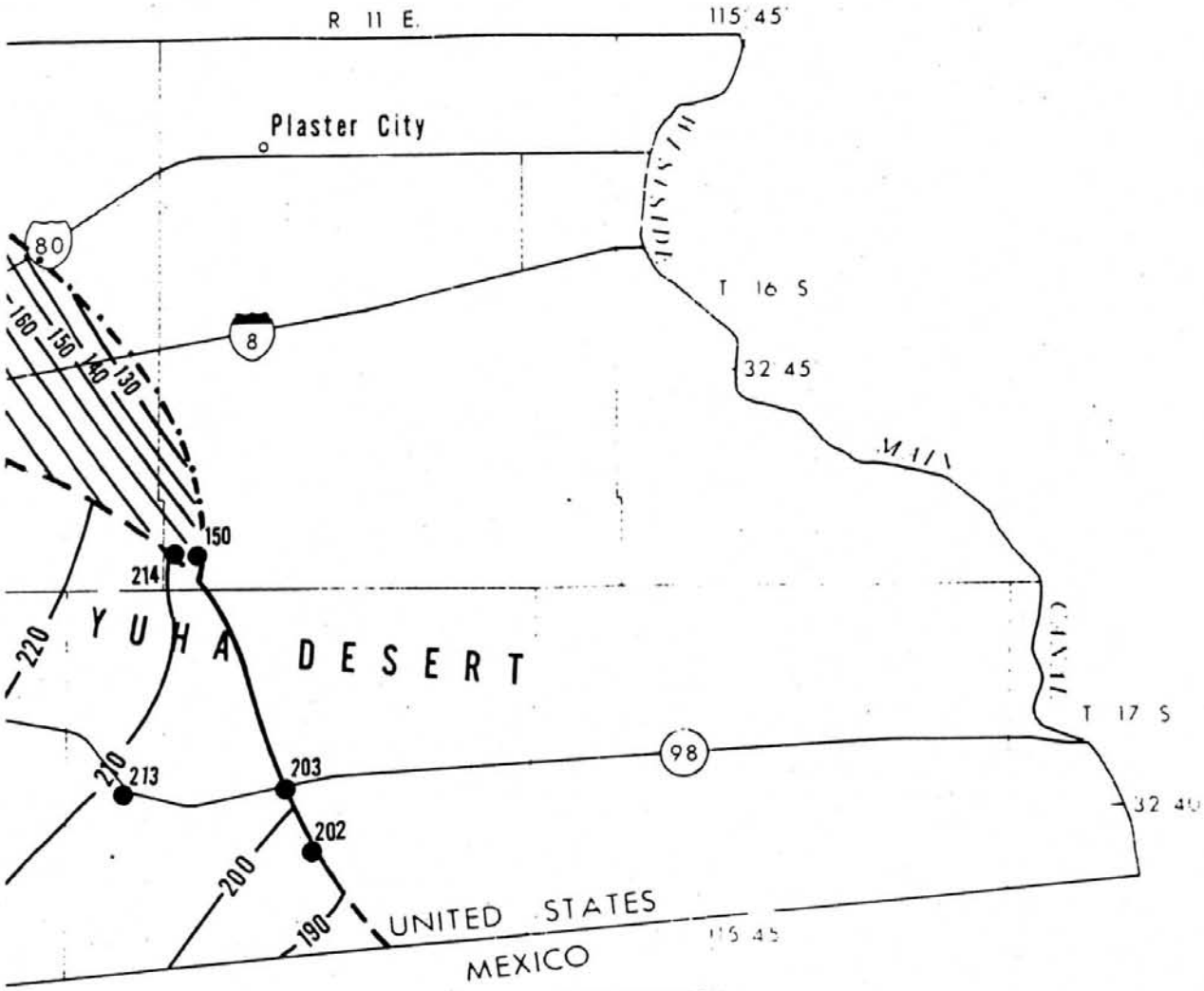


FIGURE 11.--Simulated water-level contours, December 1975.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

FAULT--Dashed where approximately located and concealed

PARTIAL GROUND-WATER BARRIER

280 WATER-LEVEL CONTOUR--Shows altitude of water level. Contour interval, in feet, variable. Datum is mean sea level

268 1974-75 MEASURED WATER LEVEL, IN FEET, ABOVE MEAN SEA LEVEL

FIGURE 11.--Continued.

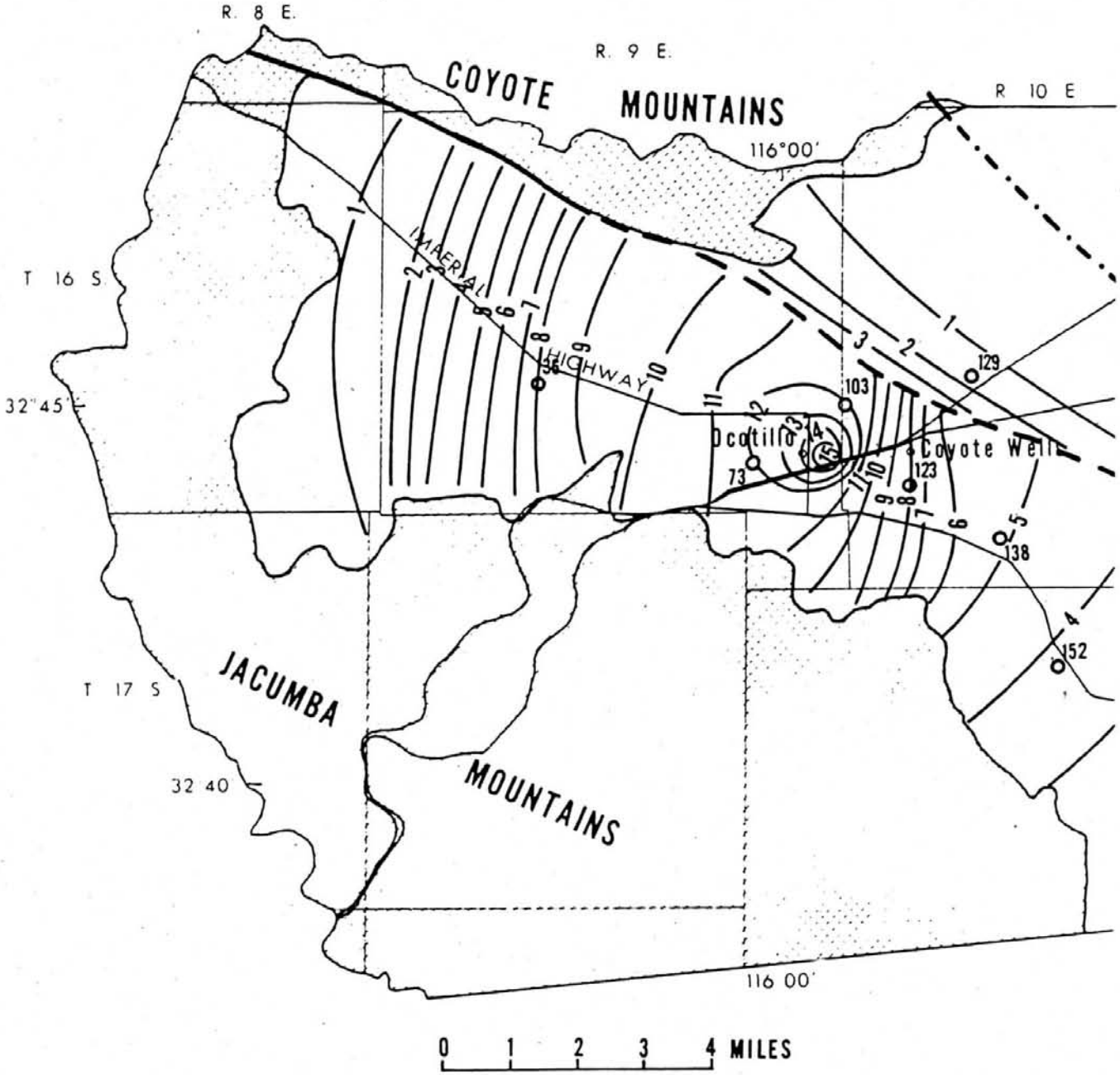
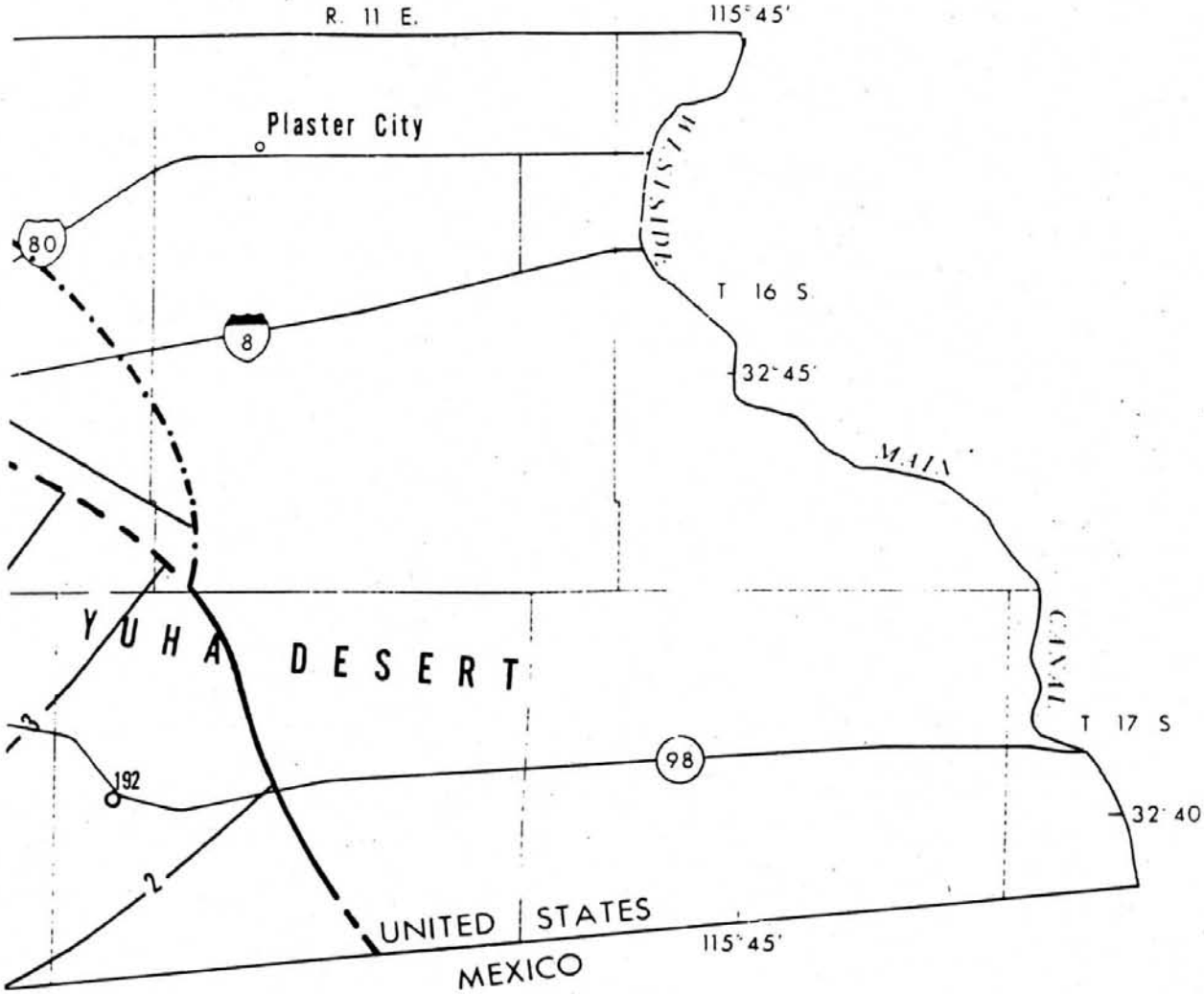


FIGURE 12.--Simulated water-level decline from January 1925 to December 1975.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

FAULT--Dashed where approximately located and concealed

PARTIAL GROUND-WATER BARRIER

2 LINE OF EQUAL WATER-LEVEL DECLINE--Interval 1 foot

138 NODE NUMBER

FIGURE 12.--Continued.

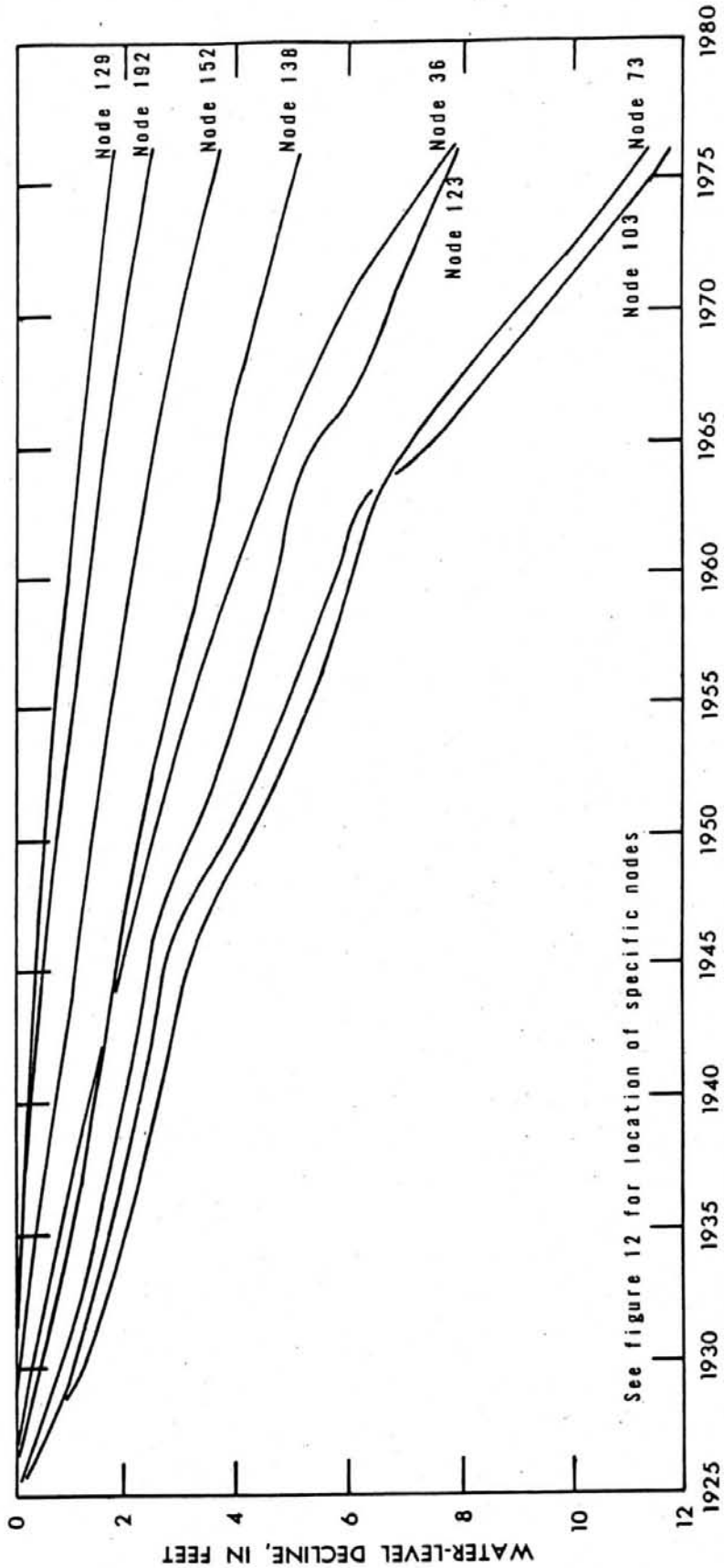


FIGURE 13.--Simulated hydrographs from January 1925 to December 1975.

This decline, projected from existing pumpage, represents loss from storage of about 11,000 acre-ft over 20 years. The hydraulic gradient has also been reduced across the Elsinore fault east of Ocotillo. The 1975 calculated water-level difference there averaged about 12 ft. This positive gradient means ground water flows from the areas of fresh water near Ocotillo toward the areas of saline water just east of the Elsinore fault. If the hydraulic gradient becomes negative, however, saline water could begin to flow westward across the fault.

The 1995 projection of water levels, using existing pumping rates, results in a calculated difference in water level of 9 ft across the Elsinore fault east of Ocotillo. Further reduction of this difference will probably occur past 1995 under annual pumpage of 1,000 acre-ft.

Annual Pumpage of 2,000 Acre-Feet

An additional water-level projection of interest is that from increased pumping in support of population growth in the Ocotillo-Coyote Wells basin. The Imperial County Planning Department has anticipated such growth to reach a maximum of 22,200 people, centered mostly around Ocotillo, by 1995 with increased maximum water requirements of 5,500 acre-ft/yr (S. H. Orfanos, Imperial County Dept. of Public Works, written commun., 1976).

To predict the effects of increased water use, a maximum withdrawal of 2,000 acre-ft/yr was used to calculate water levels in 1995. The pumpage used was 1,250 acre-ft/yr for the first 5 years of the projections, then 1,500 acre-ft/yr for years 6-10, 1,750 acre-ft/yr for years 11-15, and finally 2,000 acre-ft/yr for years 16-20 of the projection period 1976-95. The location of the additional pumping is mostly in and around Ocotillo to support the increased population there.

The declines in levels for this period ending with an annual pumpage of 2,000 acre-ft are shown in figure 16. Hydrographs of selected nodes shown in figure 12 are given in figure 17.

By 1995, using this projection, water levels across the Elsinore fault east of Ocotillo would be approximately equal, so that further pumpage in subsequent years may cause saline water east of the fault to flow toward Ocotillo and eventually degrade ground-water quality there.

POSSIBLE FUTURE STUDIES

The digital model of the Ocotillo-Coyote Wells basin utilizes all available hydrologic data, but it still remains a generalization of a more complex real system. With additional areal coverage of data on water levels

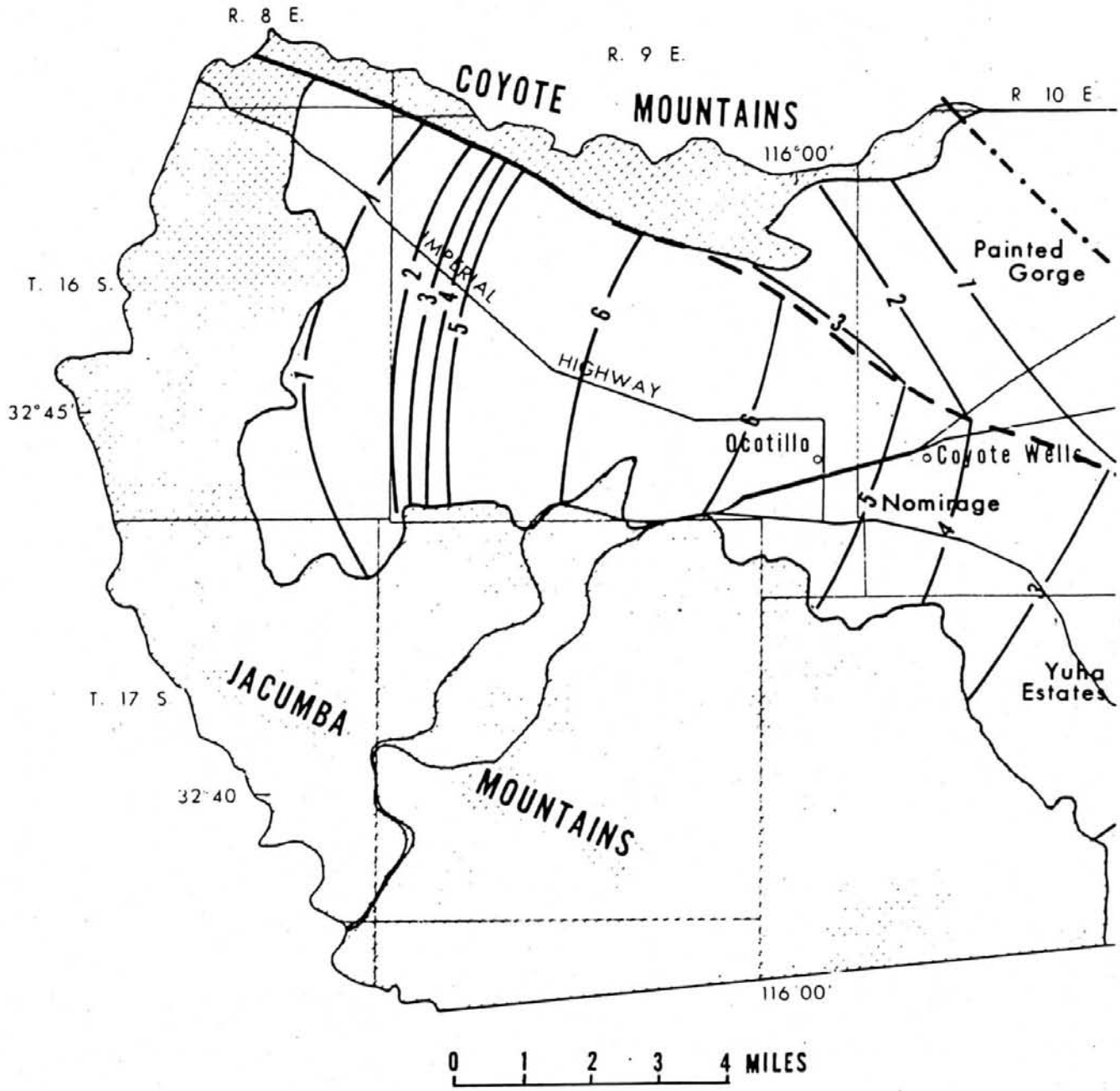
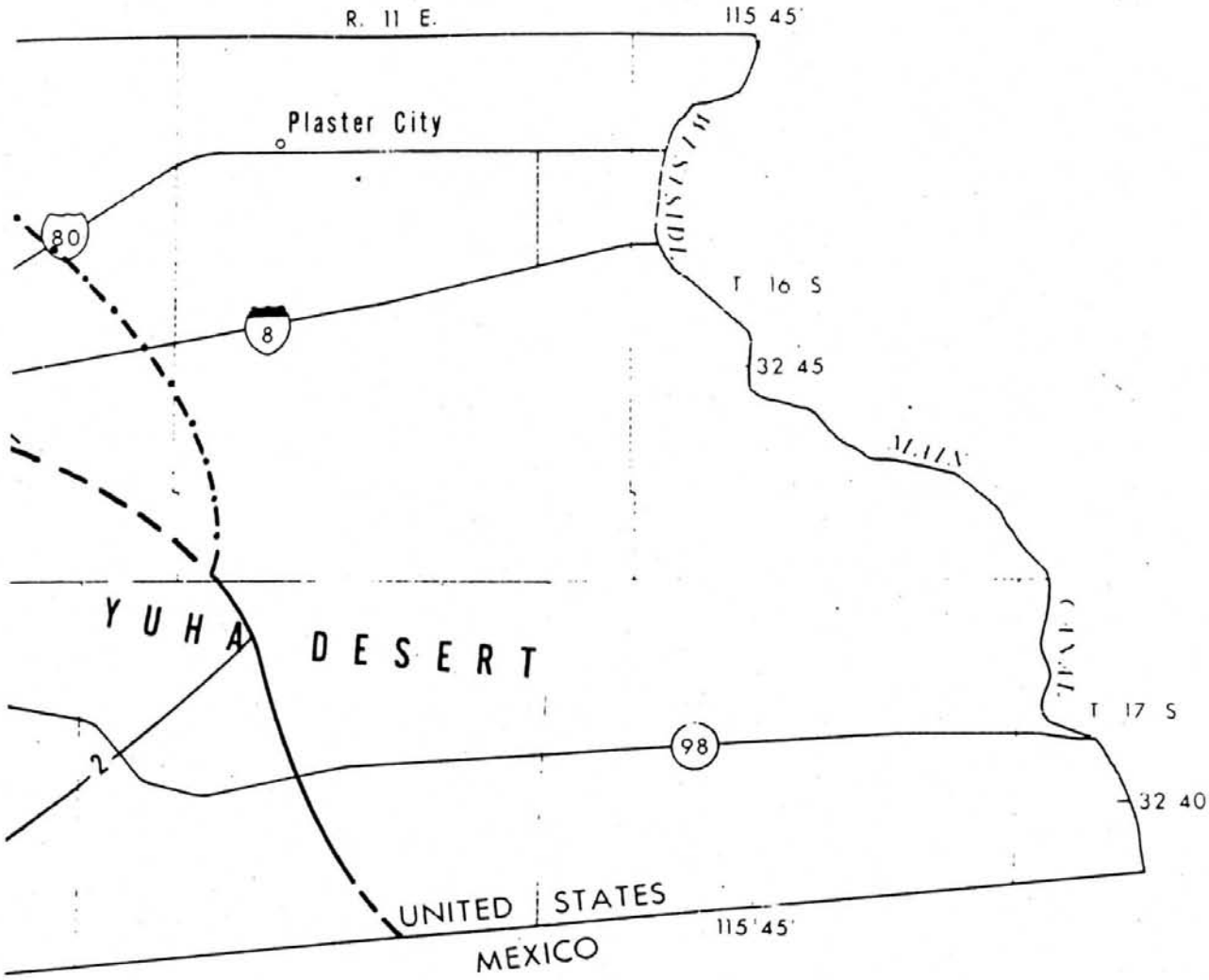


FIGURE 14.--Simulated water-level decline from January 1976 to December 1995 with pumpage of about 1,000 acre-feet per year.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

FAULT--Dashed where approximately located and concealed

PARTIAL GROUND-WATER BARRIER

6 LINE OF EQUAL WATER-LEVEL DECLINE--Interval 1 foot

FIGURE 14.--Continued.

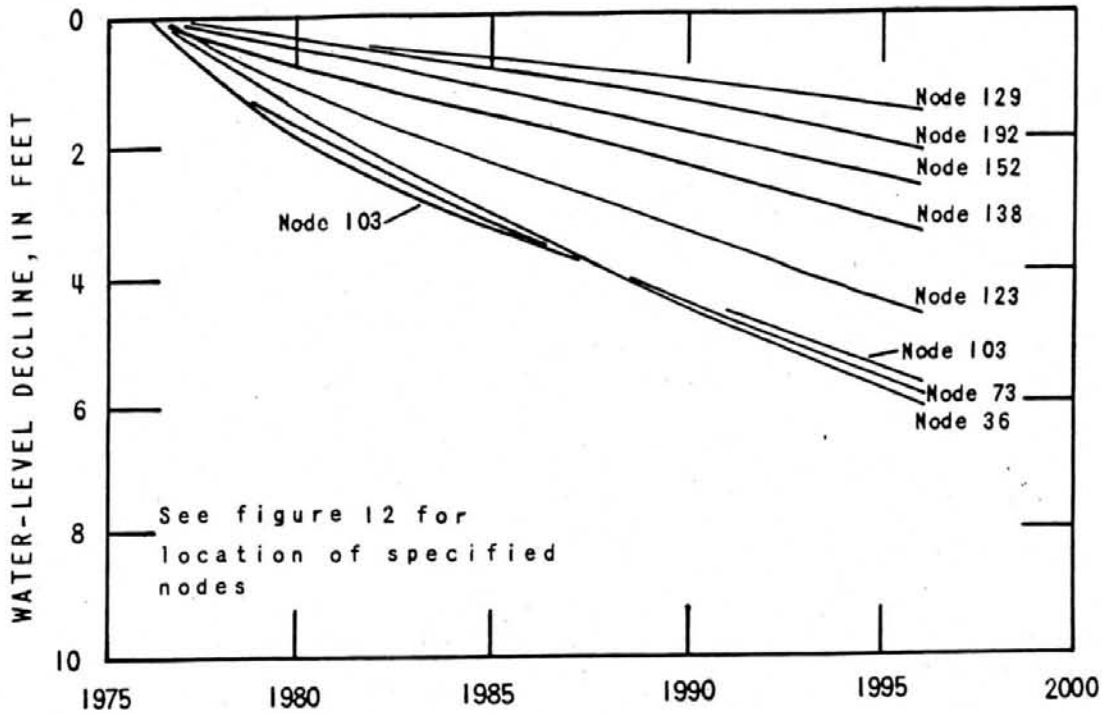


FIGURE 15.--Projected hydrographs from January 1976 to December 1995 with pumpage of about 1,000 acre-feet per year.

and on the quality of ground water, augmented by information about quality variation with depth, the model could be updated to better approximate ground-water flow in the basin.

Future monitoring of ground-water conditions in the Ocotillo-Coyote Wells basin could help to extend the life of the ground-water resource. Also, the potential hazard of drawing saline ground water westward toward Ocotillo across the Elsinore fault could be analyzed using future water levels and chemical analyses.

Additional test holes would better define the head differences across the fault east of Ocotillo as well as identify deteriorating quality in water samples from these and other nearby wells.

Possible uses of the digital model include not only determining the effects of future pumping, for example, but also investigating plans to recharge the aquifer through infiltration ponds. A possibility exists for capturing some runoff in ponds which could then infiltrate to the water table. The model could easily determine the effect of that additional recharge on surrounding water levels.

Potential new well fields might also be analyzed using the model. Evapotranspiration losses and underflow out of the basin could be reduced by the appropriate placement of wells. The effects of such new pumping on surrounding wells could then be determined using the digital model.

Another important use of the model could be to determine the effect of required spreading of proposed pumping over a larger area than in and around Ocotillo. This redistribution of pumping could reduce maximum declines and thereby lessen the possibility of drawing saline water westward across the Elsinore fault.

SUMMARY

A digital ground-water-flow model has been calibrated for the Ocotillo-Coyote Wells basin aquifer. Ground water is found in the saturated alluvial valley-fill deposits. The movement of ground water is from areas of recharge at the mountain fronts in the western and southwestern parts of the basin to areas of discharge across the Elsinore fault to the east and the Mexican border to the south.

Natural recharge from infiltration of precipitation is about 2,600 acre-ft/yr. Transmissivities for the aquifer range from 20 ft^2/d to at least 10,000 ft^2/d. Values of the storage coefficients based on calibration of the model range from 0.04 to 0.08. The estimated amount of ground water in storage is 640,000 acre-ft.

Pumpage in the basin parallels the economic development in the Ocotillo-Coyote Wells area. Prior to 1925, ground-water withdrawal was for domestic supply in the Coyote Wells area. In 1925 a railroad well was drilled for locomotive supply and an industrial well was drilled to support a gypsum plant in Plaster City. Since that time this industrial supply has been augmented by additional wells in Ocotillo.

Pumpage for public supply has also increased to support additional population. Throughout the years several wells have supplied water that was tanked to Mexicali bottling companies. Basinwide pumpage in 1975 was 880 acre-ft with about 90 percent of this pumpage centered in Ocotillo.

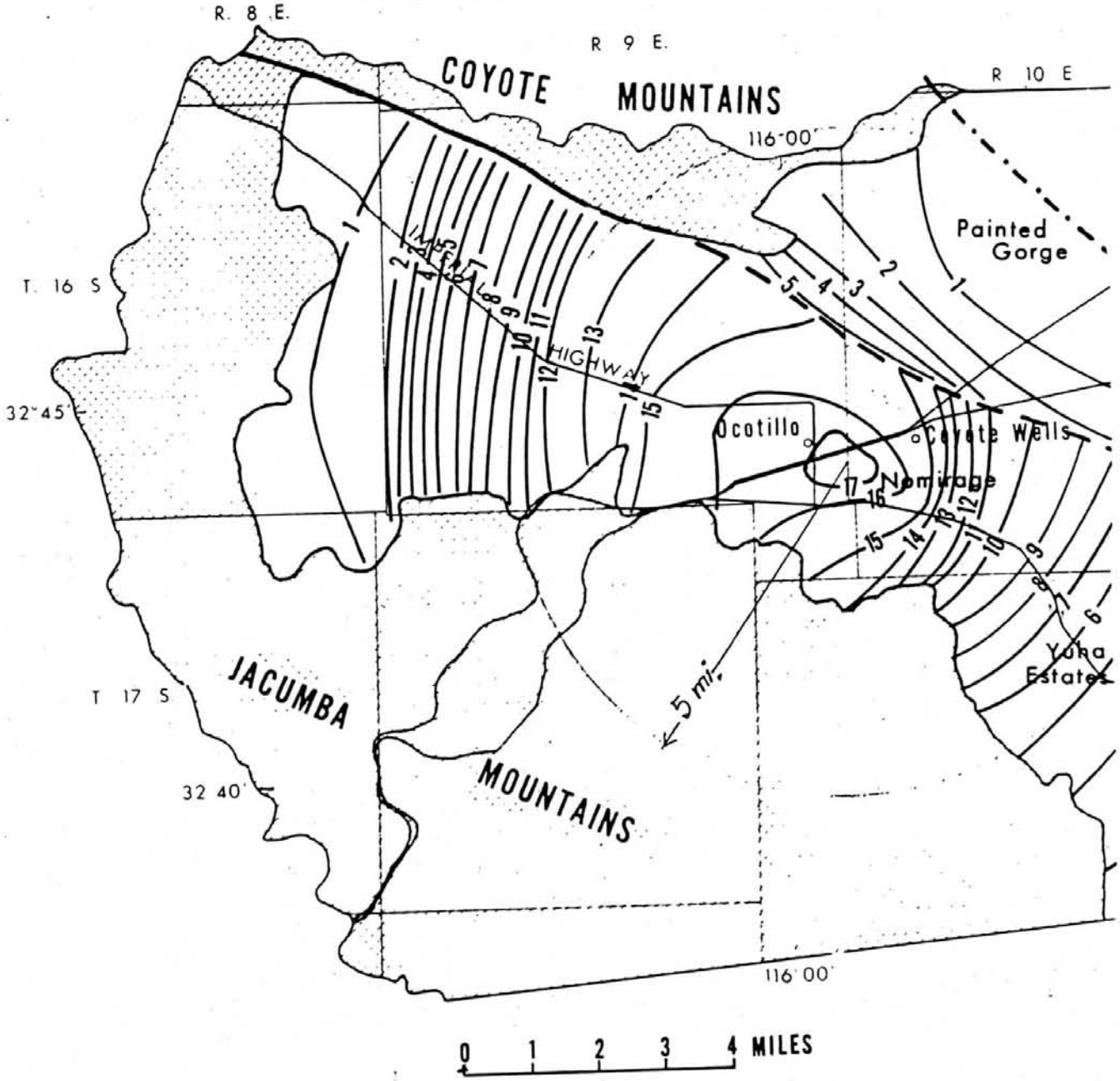
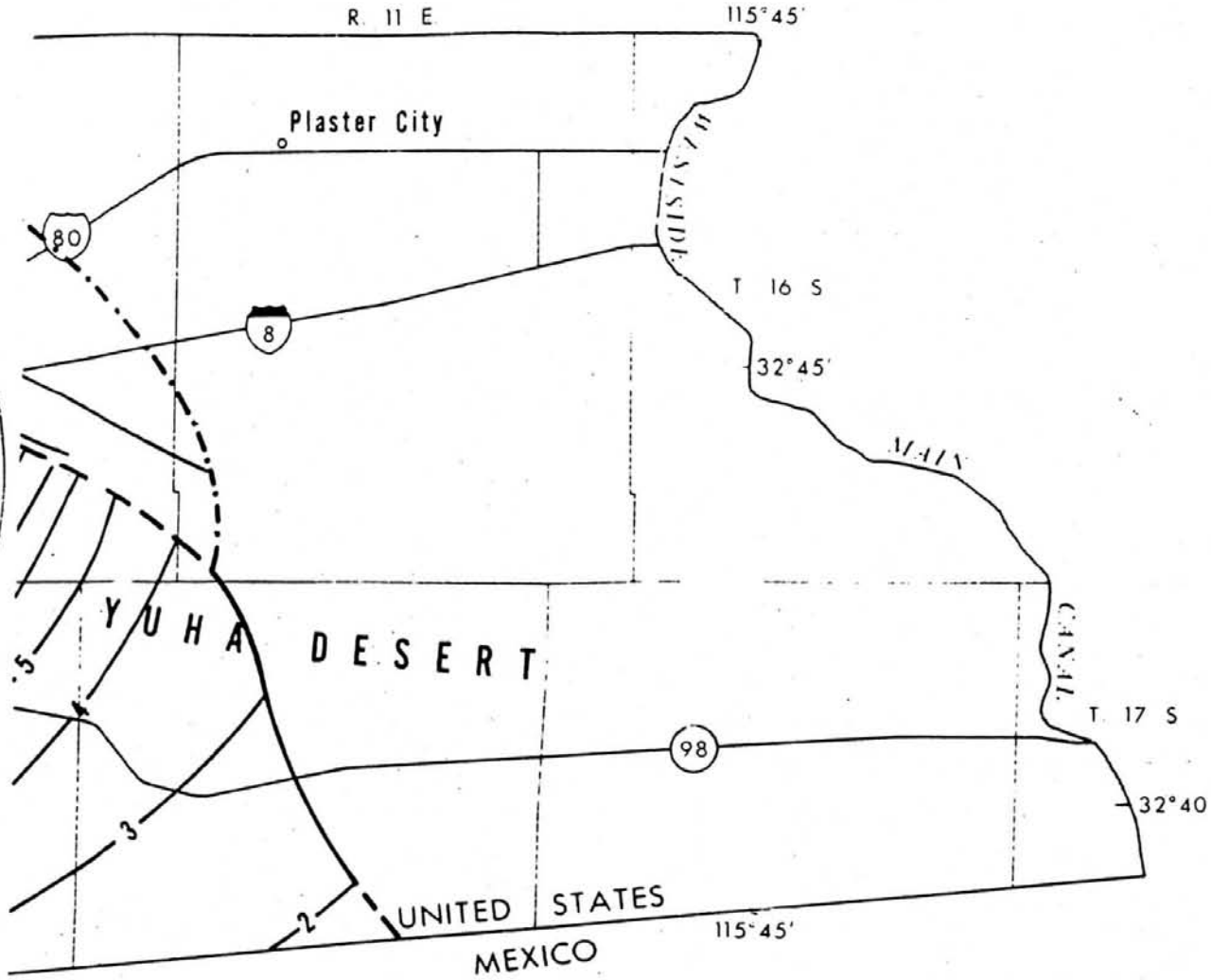


FIGURE 16.--Simulated water-level decline from January 1976 to December 1995 with pumpage reaching a maximum of about 2,000 acre-feet per year.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

FAULT--Dashed where approximately located and concealed

PARTIAL GROUND-WATER BARRIER

6 LINE OF EQUAL WATER-LEVEL DECLINE--Interval 1 foot

FIGURE 16.--Continued.

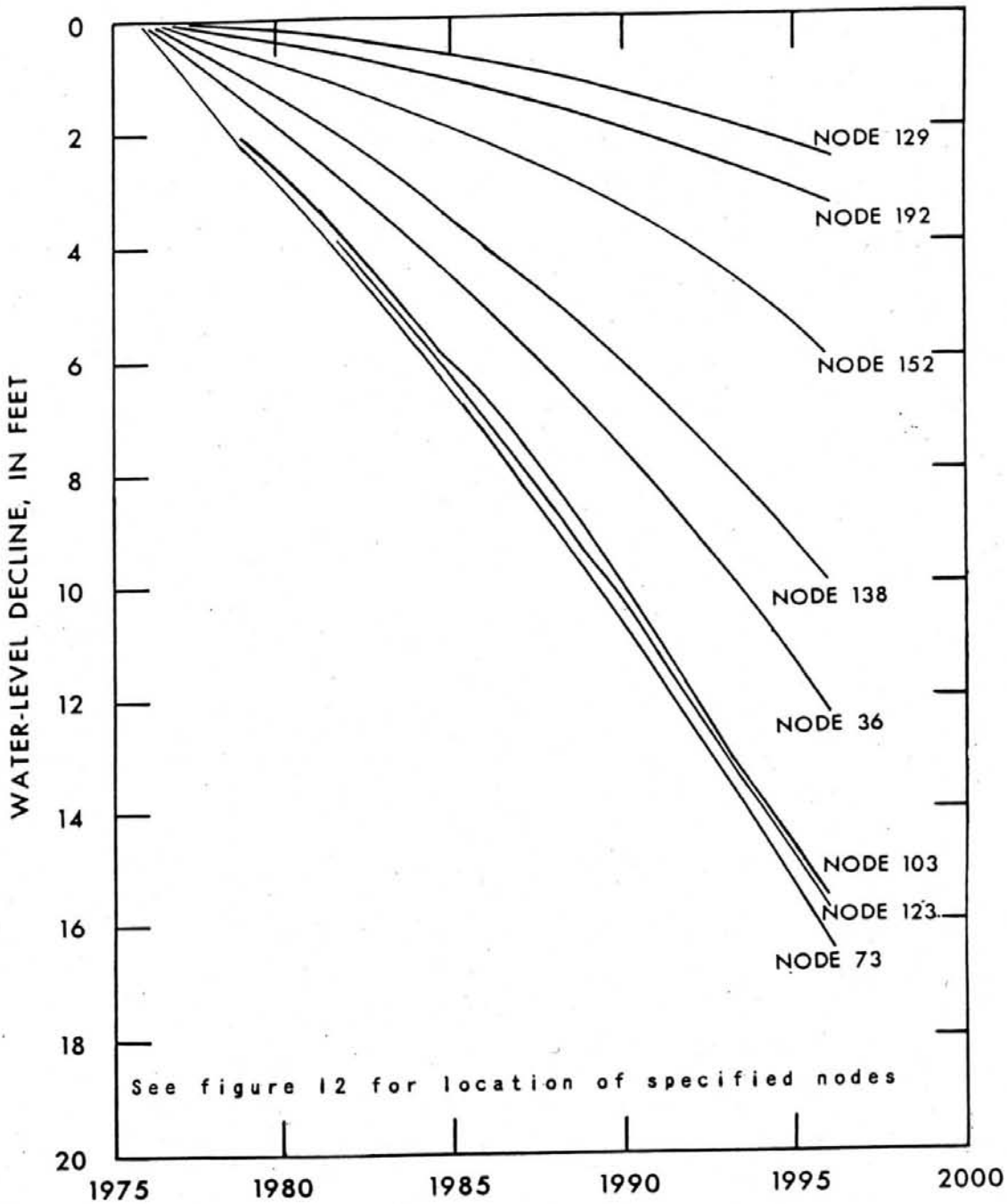


FIGURE 17.--Projected hydrographs from January 1976 to December 1995 with pumpage reaching a maximum of about 2,000 acre-feet per year.

The Elsinore fault separates fresh ground water in the Quaternary alluvium in the western part of the basin from saline water to the east. Analyses of ground-water samples west of the fault most often have dissolved-solids concentrations of less than 500 mg/L. This water is classified as a sodium bicarbonate type.

The saline water east of the fault is found in Tertiary sediments of both marine and nonmarine origin. Analyses of samples east of the fault often have dissolved-solids concentrations of over 2,000 mg/L. These samples are primarily sodium-chloride-sulfate type water.

Many chemical analyses from basinwide sampling of ground water showed dissolved fluoride greater than 2 mg/L. High fluoride content may be associated with proximity of the well to the consolidated rocks near the mountain flanks to the south and southwest. Also, wells penetrating shallow zones may contain higher fluoride and dissolved solids because of the concentration of constituents through evapotranspiration.

The calibration of the model involved simulating 51 years of pumping from January 1925 to December 1975. The maximum calculated decline over this period was 15 ft in Ocotillo.

A digital-model projection was made for annual pumpage of 1,000 acre-ft. This projection, 1976-95, revealed a maximum 20-year decline of 6 ft in Ocotillo. In this projection no saline water to the east of the Elsinore fault would flow toward the fresh ground water in Ocotillo.

Another 20-year projection was made with annual pumpage reaching a maximum of 2,000 acre-ft. In this projection the 1976-95 water-level decline reached a maximum of 17 ft in Ocotillo. Calculated 1995 water levels across the fault were about equal, indicating that further decline on the west after 1995 could cause the saline ground water to flow across the fault and degrade the ground water in and around Ocotillo.

The calibrated digital model is an effective tool for predicting water-level effects of variations in pumpage. The effects of well interference also can be evaluated. The model can aid in evaluating potential sources of additional water, such as infiltration ponds capturing runoff or new well fields in undeveloped areas. Other possibilities include reducing evapotranspiration or underflow from the basin by the appropriate location of new wells.

The digital model of the Ocotillo-Coyote Wells basin aquifer is a simplification of a complex flow system, but it reflects all geologic and hydrologic data currently available. To increase its effectiveness the model will require updating when further data are collected. The existing model, however, can be an aid in evaluating proposed water-management plans in the Ocotillo-Coyote Wells basin.

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DIGITAL-MODEL EVALUATION OF THE GROUND-WATER RESOURCES IN THE OCOTILLO-COYOTE WELLS BASIN IMPERIAL COUNTY, CALIFORNIA

U.S. GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS 77-30

Prepared in cooperation with the

Imperial County Department of Public Works

037

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A flow model using finite-element techniques has been constructed for an alluvial aquifer in the Ocotillo-Coyote Wells basin. Natural recharge is about 2,600 acre-feet per year, and estimated ground water in storage is 640,000 acre-feet. Pumpage totaled 880 acre-feet in 1975. The computed decline from steady-state conditions in 1925 to December 1975 was 15 feet in Ocotillo. The projected decline from 1976 to 1995 with annual pumpage of 1,000 acre-feet is 6 feet and with annual pumpage of 2,000 acre-feet is 17 feet in Ocotillo. In the latter projection, continued pumping after 1995 may cause saline water to flow toward the potable ground water in and around Ocotillo.

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By James A. Skrivan

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 77-30

Prepared in cooperation with the

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November 1977

UNITED STATES DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For those readers who prefer metric units rather than English units, the conversion factors for the terms used in this report are listed below:

Multiply English unit	*By*	*To obtain metric unit*
acres	4.047×10^{-1}	hectares
acre-ft (acre-feet)	1.233×10^{-3}	cubic hectometers
acre-ft/yr (acre-feet per year)	1.233×10^{-3}	cubic hectometers per year
ft (feet)	3.048×10^{-1}	meters
ft^2 (square feet)	9.290×10^{-2}	square meters
ft^2/d (feet squared per day)	9.290×10^{-2}	meters squared per day
ft^3/s (cubic feet per second)	2.832×10^{-2}	cubic meters per second
in (inches)	2.540×10	millimeters
in/yr (inches per year)	2.540×10	millimeters per year
mi (miles)	1.609	kilometers
mi^2 (square miles)	2.590	square kilometers

Degrees Fahrenheit are converted to degrees Celsius by using the formula: $°C = 5/9\ (°F-32)$.

DIGITAL-MODEL EVALUATION OF THE GROUND-WATER RESOURCES IN THE OCOTILLO-COYOTE WELLS BASIN, IMPERIAL COUNTY, CALIFORNIA

By James A. Skrivan

ABSTRACT

A digital model using finite-element techniques simulates ground-water flow in an alluvial aquifer in the Ocotillo-Coyote Wells basin. Calibrated transmissivities range from less than 20 feet squared per day to more than 10,000 feet squared per day. The calibrated storage coefficients range from 0.04 to 0.08.

Natural recharge through infiltration of precipitation is estimated to be 2,600 acre-feet per year, and estimated ground water in storage is 640,000 acre-feet. Pumpage totaled 880 acre-feet in 1975 and was predominantly for industrial use, with lesser amounts for water exported to Mexicali, Baja California, and domestic supply. About 90 percent of the annual pumpage is centered in Ocotillo.

The computed water-level decline from steady-state conditions in January 1925 to December 1975 was 15 feet in Ocotillo. Decline has accelerated in the last 10-12 years because of increased pumpage.

The projected water-level decline from 1976 to 1995 with annual pumpage of 1,000 acre-feet is 6 feet in Ocotillo. In this projection, flow is still eastward across the Elsinore fault which separates potable ground water in and around Ocotillo from saline water several miles east. When a maximum of 2,000 acre-feet of pumpage is used for the projection, the 20-year decline is 17 feet in Ocotillo, and water levels on either side of the fault are about the same. Continued pumping of this magnitude after 1995 may cause saline water to flow toward the potable ground water in Ocotillo.

Dissolved solids in ground-water samples from Ocotillo wells averaged less than 500 milligrams per liter. Dissolved fluoride in ground water in many places throughout the basin is more than 2 milligrams per liter.

The digital model may be used to evaluate water-management plans that could maximize ground-water withdrawal. For example, redistribution of pumping might minimize the threat of saline water degrading ground water in Ocotillo or reduce evapotranspiration or underflow from the basin. Also the model could be used to evaluate the effect of artificial recharge in various areas.

INTRODUCTION

The Ocotillo-Coyote Wells basin, or project area, includes about 300 mi^2 in western Imperial County, approximately 25 mi west of El Centro (fig. 1). The arid climate and desert scenery attract visitors from more urbanized areas.

The western boundary of the project area (fig. 2) is a surface-water drainage divide in the Jacumba Mountains. The drainage divide in the Coyote Mountains forms about half of the northern boundary, with the rest being the line between T. 15 S. and T. 16 S. The eastern boundary is the Westside Main Canal of the Imperial Irrigation District, and the southern boundary is the United States-Mexico border.

Total population of less than 1,000 is centered in Ocotillo and in several subdivisions east and southeast of Ocotillo. Coyote Wells, 1.5 mi east of Ocotillo, consists solely of a service station-grocery store. South of Coyote Wells 1 mi is the Nomirage subdivision of about 100 people. Southeast of Nomirage 3.5 mi is the Yuha Estates subdivision of about eight residences. A slightly larger area, the Painted Gorge subdivision, is northeast of Coyote Wells about 3 mi. Plaster City, 7 mi northeast of Coyote Wells, consists of a gypsum processing plant owned by U.S. Gypsum Co.

Ground water is the only source of industrial and domestic supply in the project area. Water levels have been dropping since significant pumping began in the 1920's. Ground water is potable in the Ocotillo area, but it is highly saline about 3 mi east of Coyote Wells. In addition, ground-water samples in and around Ocotillo have often had higher concentrations of dissolved fluoride than those recommended by the U.S. Environmental Protection Agency (1972).

The U.S. Geological Survey, in cooperation with the Imperial County Department of Public Works, made an appraisal of the ground-water resources in the project area to determine the effects of present and proposed pumping on the quantity and quality of the ground water. This report is the result of that study.

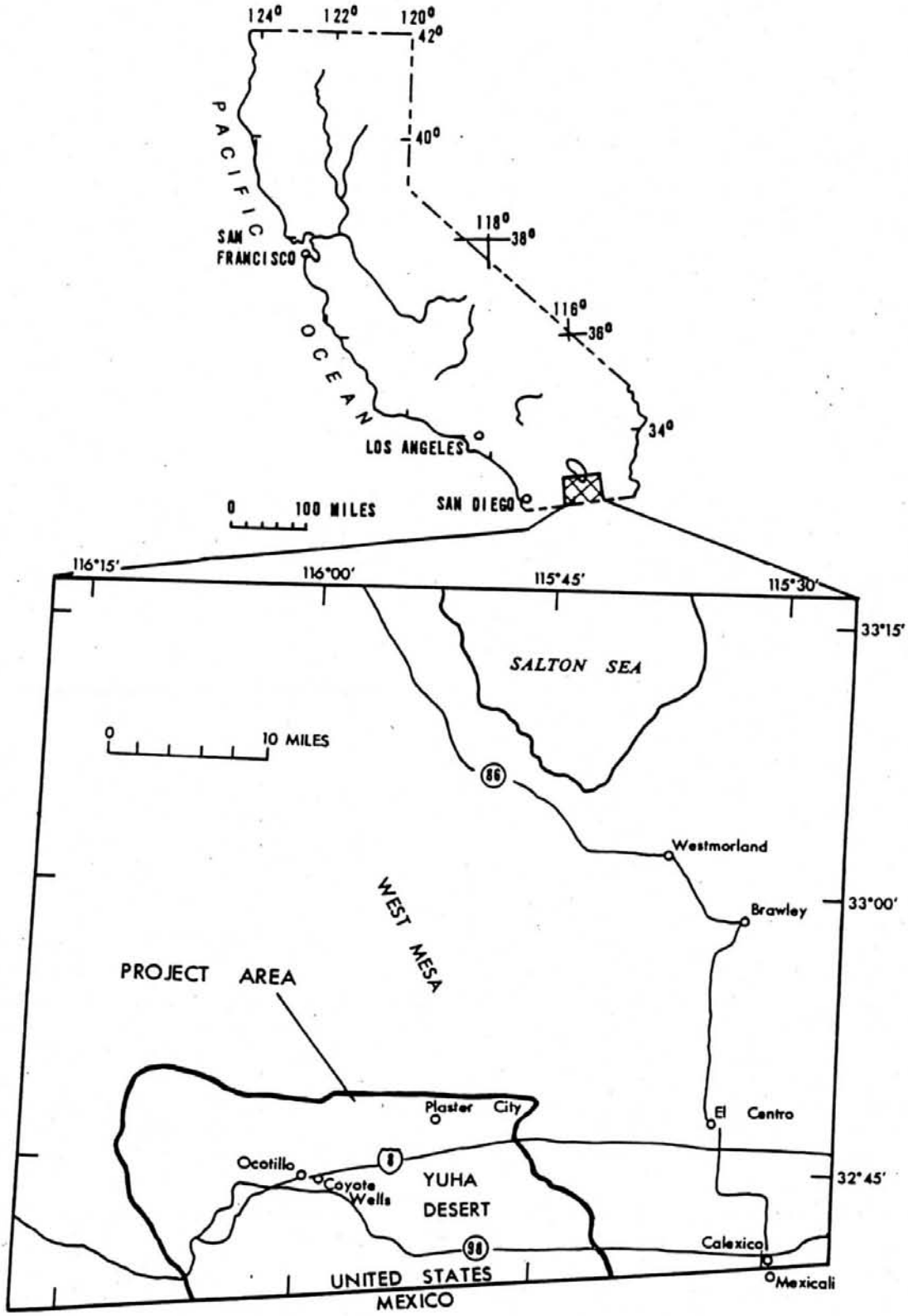


FIGURE 1.--Index map.

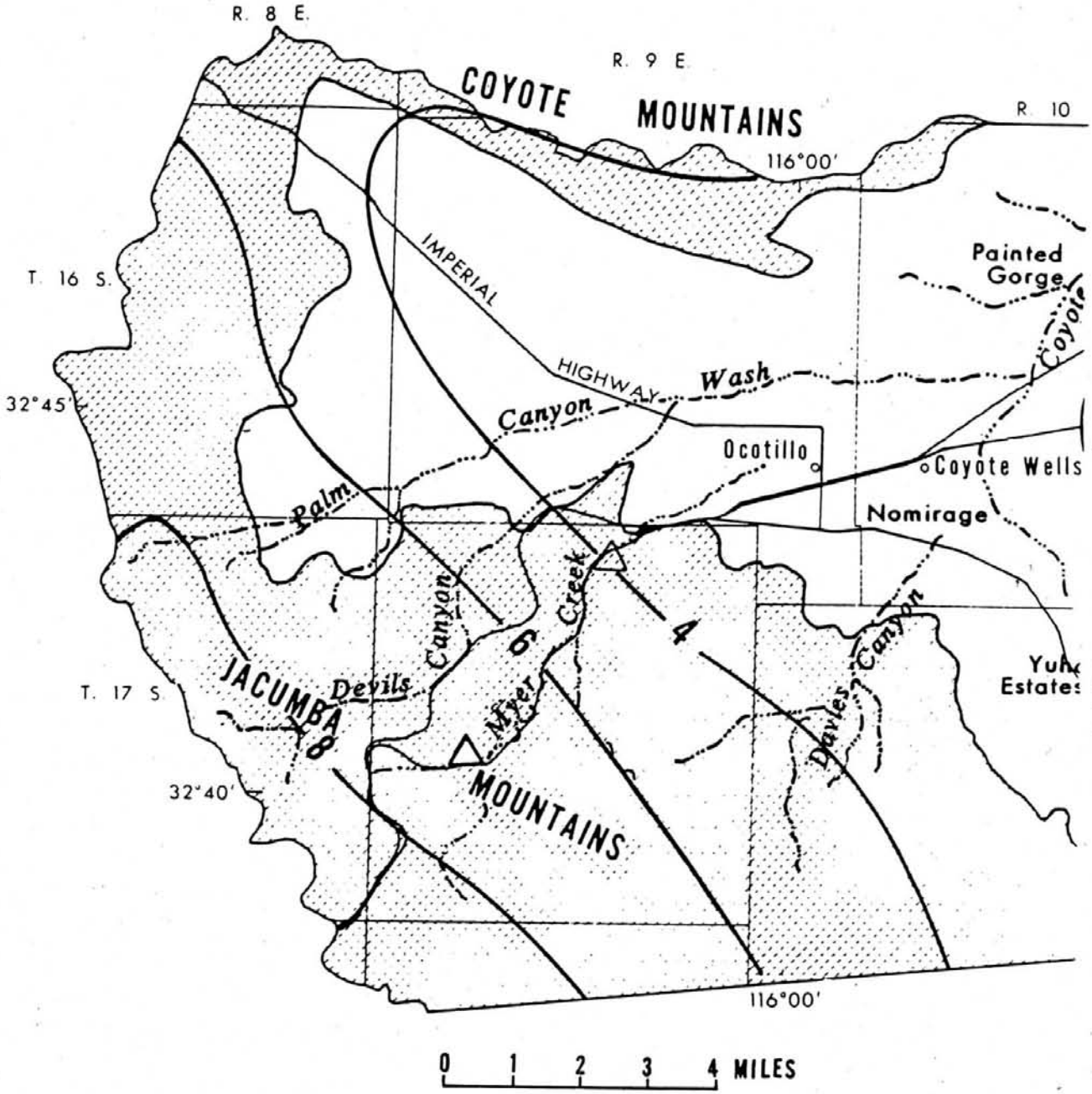
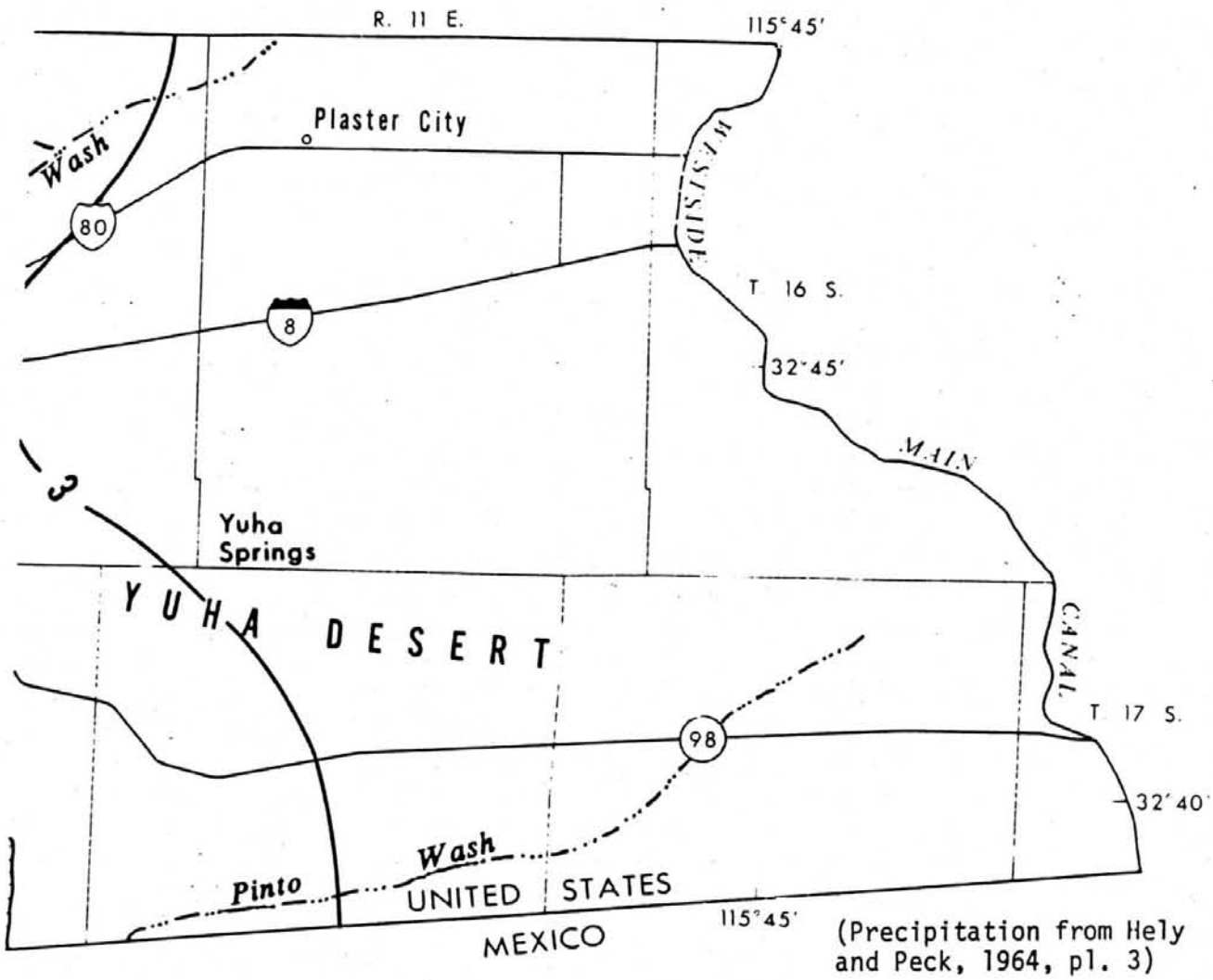


FIGURE 2.--Geographic setting and mean annual precipitation, 1931-60.



(Precipitation from Hely and Peck, 1964, pl. 3)

EXPLANATION

DESERT

MOUNTAINOUS AREA

—3— LINE OF EQUAL MEAN ANNUAL PRECIPITATION--Interval 1 and 2 inches

—··— EPHEMERAL STREAM

△ CREST-STAGE GAGE

FIGURE 2.--Continued.

Purpose and Scope

The purposes of this study were to (1) define the hydrology of the area, (2) determine the historical pumpage, (3) define the areal variation in ground-water quality, (4) calibrate a digital model of the Ocotillo-Coyote Wells basin aquifer, (5) estimate the future effects of current and proposed pumping on water levels and ground-water quality, and (6) prepare a report describing this effort.

The scope of the project involved collecting and collating geologic and hydrologic data for the project area. About 150 wells were field checked, and water levels were taken where possible. An additional 15 wells were drilled to a maximum depth of 150 ft in places where geohydrologic data were sparse or lacking.

Chemical analyses were made to determine dissolved constituents in ground-water samples throughout the area. A gravity survey was made to help determine the shape of the basin floor and the relative thickness of valley fill throughout the project area.

A finite-element digital model of ground-water flow was constructed and calibrated for the basin aquifer. The calibration process required simulation of water-level declines from 1925 to 1975. Projections of water levels in 1995 were then calculated for several hypothetical pumping distributions. Additional runs to show the effects of artificial recharge in specific areas were beyond the scope of this project.

The author thanks those agencies, businesses, and individuals who contributed to the completion of this project. The assistance of S. H. Orfanos and D. E. Pierson of the Imperial County Department of Public Works is greatly appreciated, as is the help from the U.S. Gypsum Co. which supplied pumpage data and water levels. Both the Ocotillo Mutual Water Co. and the Coyote Valley Mutual Water Co. gave data on their respective wells. Finally, the residents of the Ocotillo-Coyote Wells basin added to the study through their interest and assistance.

Well-Numbering System

Wells in the project area are numbered according to their location in the rectangular system for the subdivision of public land. In the well number 16S/9E-36G3, the part preceding the slash is the township (T. 16 S.), the part between the slash and the hyphen is the range (R. 9 E.), the number between the hyphen and the letter is the section (sec. 36), and the letter is the 40-acre subdivision of the section according to the following diagram. Within the 40-acre tract, wells are numbered serially by the final digit.

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

Springs are numbered similarly except that an S is placed between the 40-acre subdivision letter and the final digit as shown in the following spring number: 17S/8E-3RS1.

The numbering of half-townships is changed from that above by adding 36 to the section number and joining that section to the last township. For example, well 16½S/11E-6M1 will be renumbered 16S/11E-42M1.

All wells and springs in the project area lie east of the San Bernardino meridian and south of the San Bernardino base line.

GROUND WATER

The geology of the Ocotillo-Coyote Wells basin was discussed by Dibblee (1954), Brooks and Roberts (1954), and Loeltz and others (1975). The reader is referred to those publications for more detailed description.

Ground water in the project area is found principally in the saturated alluvial valley-fill deposits of Quaternary age. Such a saturated geologic formation, capable of yielding significant quantities of water to wells or springs, is termed an aquifer. The consolidated rock that forms the surrounding mountains (fig. 3) and underlies this alluvium contains no appreciable quantities of ground water.

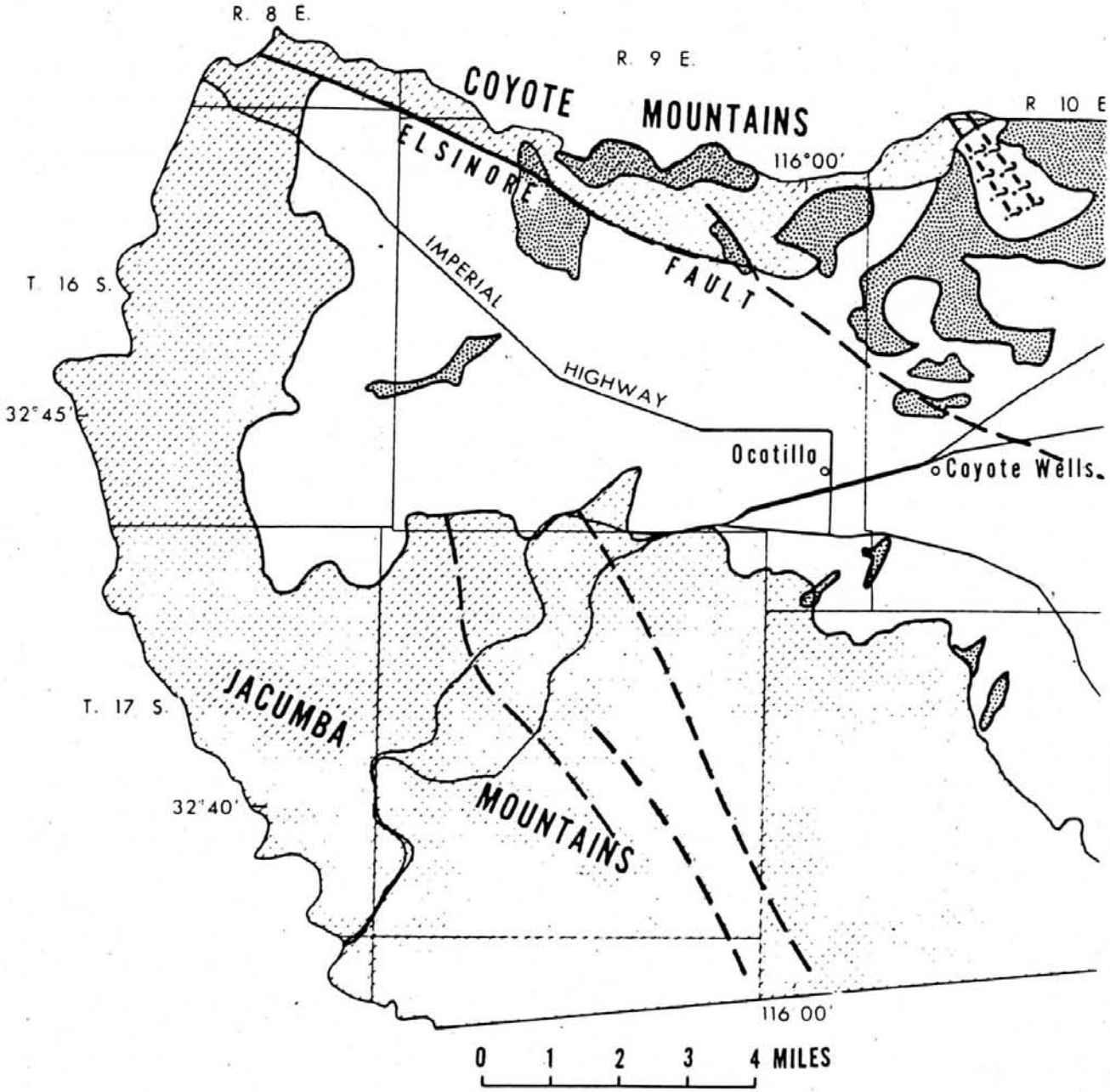
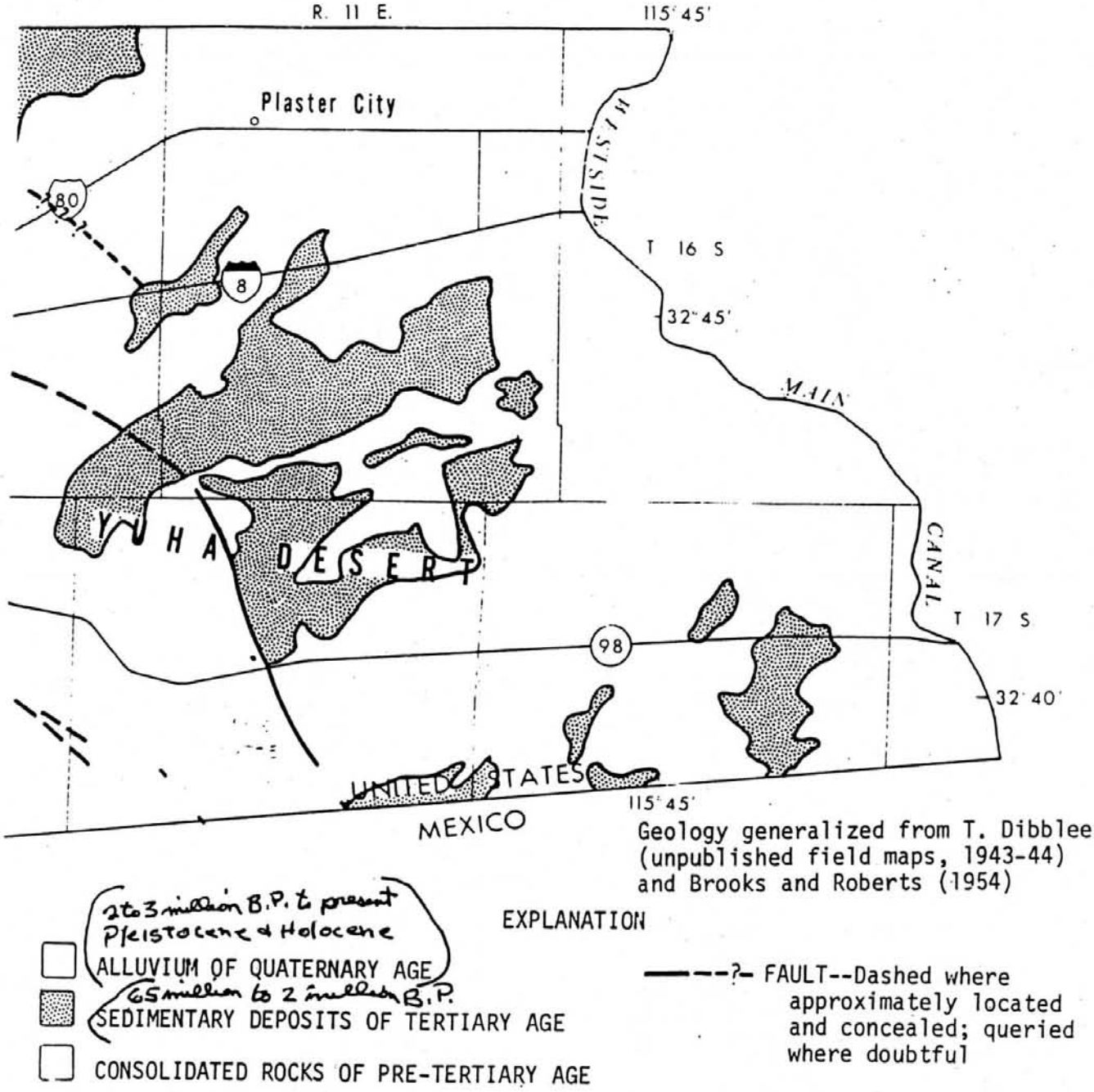


FIGURE 3.--Generalized areal geology.



Geology generalized from T. Dibblee (unpublished field maps, 1943-44) and Brooks and Roberts (1954)

EXPLANATION

2 to 3 million B.P. to present
Pleistocene & Holocene
ALLUVIUM OF QUATERNARY AGE

65 million to 2 million B.P.
SEDIMENTARY DEPOSITS OF TERTIARY AGE

CONSOLIDATED ROCKS OF PRE-TERTIARY AGE

—?— FAULT--Dashed where approximately located and concealed; queried where doubtful

FIGURE 3.--Continued.

The valley-fill materials are fine sand and gravel derived from the surrounding mountains. These materials are interspersed with silt and clay of varying thicknesses and areal extent.

Sedimentary deposits of Tertiary age crop out throughout the project area, primarily in the Yuha Desert and the Coyote Mountains (fig. 3). These deposits consist of marine and nonmarine clay and sandstone deposited during repeated inundations from the Gulf of California and the Colorado River, respectively (Dibblee, 1954). Oyster-shell reefs are also common. Ground water in these deposits typically is saline.

The Elsinore fault transects the Ocotillo-Coyote Wells basin in a southeastward direction along the south edge of the Coyote Mountains, passing slightly east of Coyote Wells (fig. 3). The fault is generally concealed in the alluvium-covered areas. It joins the Laguna Salada fault in Mexico (Loeltz and others, 1975). Most of the other faults in the project area (fig. 3) have traces that parallel the Elsinore fault and may be associated with its movement. Most of the usable ground water is from the alluvial deposits west of the Elsinore fault.

In the illustrations of this report the geology has been generalized to show only the water-bearing unconsolidated deposits and the consolidated rocks of the surrounding mountains.

Figure 4 is a conceptual cross section of the Ocotillo-Coyote Wells basin aquifer. The water table is the surface of the saturated material. An aquifer possessing a water table is an unconfined or water-table aquifer, and water levels in wells define the water table.

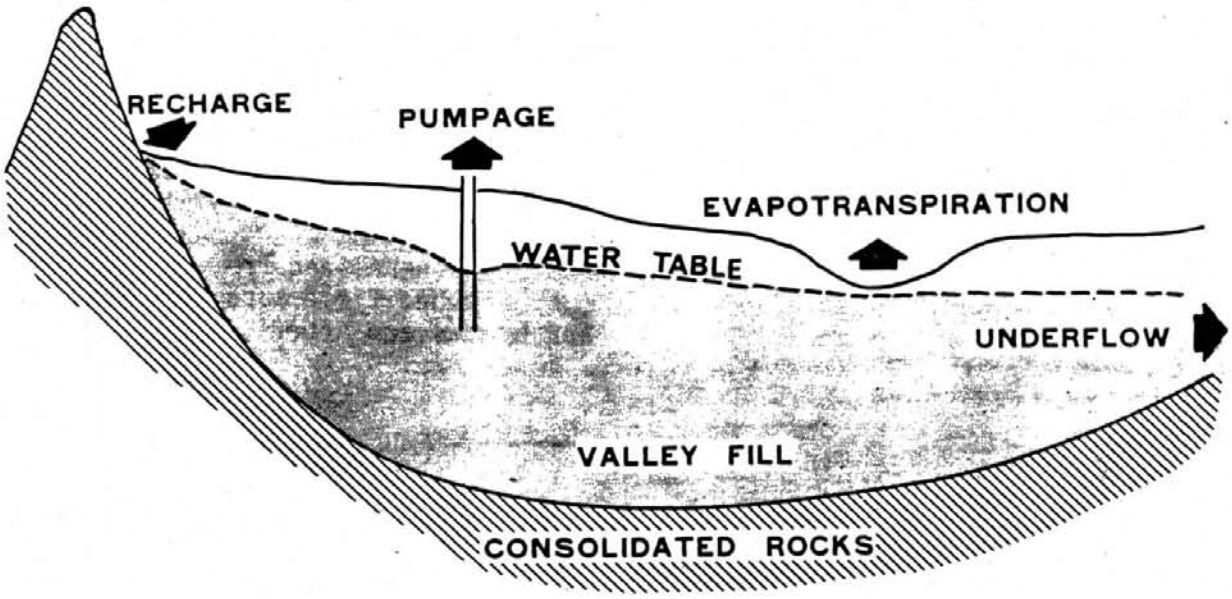


FIGURE 4.--Conceptual cross section, not drawn to scale, showing elements of ground-water recharge and discharge.

Ground water moves slowly through sand and gravel from areas of higher water levels to areas of lower water levels. This movement in Ocotillo, for example, is in tens of feet per year under natural or nonpumping conditions. The generalized direction of flow is from areas of ground-water recharge to areas of ground-water discharge. Recharge is primarily from infiltration of runoff at the mountain fronts and from stream channels. Discharge is from pumpage, underflow out of the project area, and evapotranspiration.

Recharge

The aquifer in the project area is recharged principally from precipitation within the basin. About 8 in of precipitation occurs annually in the Jacumba Mountains (fig. 2) where the highest altitude is 4,500 ft. The average rainfall in Ocotillo, based on 30 years of record (1931-60), is 3.5 in (Hely and Peck, 1964).

Precipitation occurs mainly as rainfall from frontal winter storms (October-April) coming from the Pacific Ocean. Summer storms (May-September) originating in the Gulf of Mexico contribute 1.0-1.5 in to the annual precipitation (Hely and Peck, 1964).

Because the relative variation in the annual precipitation is greatest where the mean annual precipitation is least (Hely and Peck, 1964), the Ocotillo-Coyote Wells basin can have periods of little or no precipitation, then have several years of relatively heavy rainfall.

All streams draining the project area are ephemeral, typically flowing only during and shortly after storms. The major stream channels originate in the mountains to the west and south and then traverse the alluvial fill of the valley.

Streamflow percolates to the water table mainly beneath the permeable alluvial fans at the mountain fronts, which may absorb all the runoff. These stream channels include Palm Canyon Wash, Devils Canyon, Myer Creek, Davies Canyon, and Pinto Wash (fig. 2).

Intense storms can produce streamflow on the valley floor. Some water may percolate to the water table in the valley, but the depth to water is considerably more than the depth on the upper fans. During these periods of increased streamflow, flow also leaves the basin, primarily via Coyote Wash to the northeast (fig. 2). Evaporation losses also increase during periods of streamflow on the valley floor.

The only streamflow measured in the project area is in two small tributaries of Myer Creek, approximately 4 and 7 mi southwest of Ocotillo (fig. 2). Both stations record peak stage near culverts under the eastbound lanes of Interstate Highway 8. The only flow at these sites is during the several storms that might occur annually. The highest recorded flow from 1960 to 1973 occurred August 12, 1965, at both stations. That flow was 21 ft^3/s at the station nearest Ocotillo and 41 ft^3/s at the other station.

Hely and Peck (1964) estimated annual runoff from the mountains in the project area to range from 0.02 to 0.50 in. These estimates are based on modifications to an empirical method of the U.S. Soil Conservation Service [no date] using precipitation data and soil types.

The quantity of recharge to the Ocotillo-Coyote Wells basin aquifer north of the Mexican border and west of the Elsinore fault was calculated to be 2,600 acre-ft/yr. This is equivalent to approximately 0.02 in on the drainage area of 225 mi^2.

U.S. Gypsum Co. is currently (1976) recharging ground water near Plaster City through infiltration ponds. Approximately 90 acre-ft of wastewater was discharged to ponds in 1973 (California Dept. of Water Resources, 1975). The actual quantity of recharge reaching the water table is unknown, however.

Discharge

Pumpage

The history of pumpage in the Ocotillo-Coyote Wells basin parallels the economic development of the region. Because ground water has been the sole source of water supply in the basin, most development has directly affected the ground-water resources. Figure 5 shows the estimated total pumpage in the project area since 1925.

Prior to 1925, the primary ground-water withdrawal was generally restricted to the Coyote Wells area. Adams (1915) mentioned two wells drilled by Henry E. Walker in Coyote Wells. A well 30 ft deep reportedly produced more saline water than a well 65 ft deep.

Brown (1923) described the development in Coyote Wells as including a combined store and post office, a service station, a railway station, and several ranch houses. No estimates are available for total basin pumpage in those early days, but the total can be assumed to be much less than in later years.

In 1925 the San Diego and Arizona Railway drilled a well for locomotive supply. That well was in operation until the early 1960's. Also in 1925, the Pacific Portland Cement Co. drilled a well at Plaster City for an industrial supply. The water, however, was saline, and the well was abandoned.

At about this same time a well for the Plaster City works was drilled in sec. 36, T. 16 S., R. 9 E. It was reported to be a good producer until its failure in 1955 (Imperial Irrigation District, 1958). The U.S. Gypsum Co. purchased the Plaster City facility about 1946 and has since drilled five

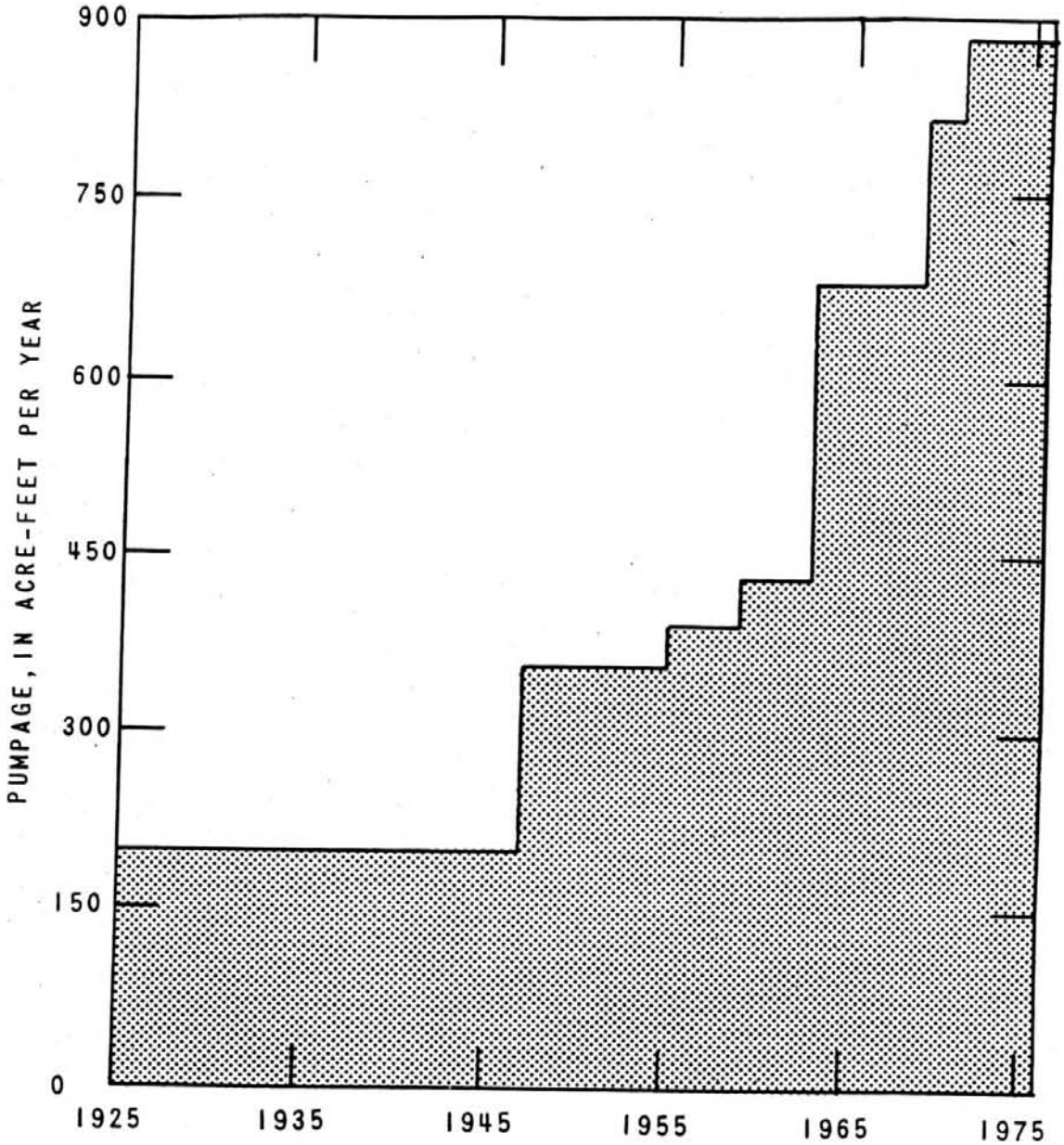


FIGURE 5.--Pumpage in the Ocotillo-Coyote Wells basin from January 1925 to December 1975.

production wells in the Ocotillo area. Two of the wells have been abandoned; the three remaining production wells are in sec. 36, T. 16 S., R. 9 E. Water from these wells is transported to Plaster City by pipeline.

The early domestic supply of water was from wells in Coyote Wells together with several wells in Ocotillo. The G. N. Root well, 16S/9E-26H1, supplied some Ocotillo residents beginning about 1930. The Coyote Valley Mutual Water Co. began supplying the increasing population in the early 1950's, and that company currently operates two wells, drilled in 1961 and 1970, to meet the demand of residents and the several businesses in the subdivision referred to as Ocotillo Unit No. 2. The wells are in sec. 36, T. 16 S., R. 9 E.

The Ocotillo Mutual Water Co. is the other principal source of public supply in Ocotillo and provides water to residents in the Ocotillo Unit No. 1 subdivision. This company has two operating wells that were drilled in about 1960 and 1970 in sec. 25, T. 16 S., R. 9 E.

Mr. T. Clifford operates a well, 16S/9E-25K2, to supply water for about 10 residences in Ocotillo Unit No. 3 subdivision. The original well meeting this demand was drilled in 1958, and the well currently in use was drilled in 1972.

Throughout the years various wells in the Ocotillo basin have supplied water that has been transported by water-tank trucks to Mexicali, Baja California, in Mexico (fig. 1), for sale as bottled water. One of the early wells supplying such water until 1958 was the C. Kelleher well, 16S/9E-35N2. Since that time, several other individuals have sold water to Mexicali bottling companies. The Clifford well, 16S/9E-25K2, has been supplying water for Mexicali since 1967 and is currently the sole source of such exported water in the Ocotillo-Coyote Wells basin.

The pumpage shown in figure 5 was calculated from records of the U.S. Gypsum Co., estimates from the water companies in Ocotillo and other records, and estimates for the remaining users. About 90 percent of the annual pumpage is from wells in Ocotillo. In 1975 the total pumpage in the project area was estimated to be 880 acre-ft. Of this total, U.S. Gypsum Co. pumped about 600 acre-ft; the Clifford well about 120 acre-ft; and Coyote Valley Mutual Water Co. and Ocotillo Mutual Water Co. combined, about 100 acre-ft.

Underflow

Ground-water underflow in the saturated materials generally is flow leaving or entering some area of interest. In the Ocotillo-Coyote Wells basin, significant underflow occurs across the United States-Mexico border. This underflow represents major discharge from the study area and is estimated to be 1,500 acre-ft/yr.

Additional underflow from the aquifer, primarily west of the Elsinore fault, is represented by eastward flow across an extension of the queried fault (fig. 3) in T. 16 S., R. 10 E., and the Elsinore fault in T. 17 S., R. 11 E. This eastward flow across faults is estimated to be 450 acre-ft/yr.

Both of the above estimates are based on calibration of the model (see p. 28-29), together with initial estimates for items in the aquifer's water budget (see table 1).

Evapotranspiration

Discharge of ground water by evaporation from the soil and use by plants is termed evapotranspiration. Such losses are directly affected by temperature, depth to water, and types of vegetation.

The project area experiences high temperatures (often more than 100°F, or 38°C) from May to September and more pleasant, moderate temperatures the rest of the year. The mean annual temperature in Ocotillo, based on 30 years of record, is about 70°F, or 21°C (Hely and Peck, 1964). Evaporation losses from surface-water bodies in similar climates were estimated by Hely and Peck (1964) to be 80 in/yr.

In general, evapotranspiration becomes significant when the water table is within about 10 ft of land surface. This condition occurs in an area slightly southeast of Coyote Wells and in the Yuha Springs area in sec. 42, T. 16 S., R. 11 E. (fig. 2). Plants transpiring water in these areas include saltgrass (*Distichlis stricta*), mesquite (*Prosopis juliflora*), creosotebush (*Covillea tridentata*), bursage (*Franseria dumosa*), and brittlebush (*Encelia farinosa*).

Estimates of evaporation rates were obtained through the model calibration process (see p. 28-29). The rate in the Coyote Wells region was estimated to have declined from 400 acre-ft/yr in 1925 to 50 acre-ft/yr in 1975. This reduction in evapotranspiration losses results from a lowering of the water table 5-10 ft in this area. Losses from evapotranspiration in the Yuha Springs area are estimated to be 250 acre-ft/yr. This rate has not changed significantly since 1925 because water levels have dropped only a few feet over that time period.

Budget

Estimates of recharge and discharge for the study area are summarized in table 1. Values given are for steady-state (1925) conditions as well as for 1975.

TABLE 1.--*Ocotillo-Coyote Wells basin water budget for steady state (1925) and 1975*

[Acre-feet per year]

Item	Steady state (1925)	1975
Recharge		
Infiltration of precipitation	2,600	2,600
Discharge		
Pumpage	0	900
Evapotranspiration	650	300
Underflow to Mexico	1,500	1,450
Underflow eastward across faults	450	450
Total discharge	2,600	3,100
Change in storage	0	-500

Quality

The development of ground-water resources depends not only on the quantity available and the depth to the water table, but also on the quality. Ocotillo is fortunate in having ground water with a dissolved-solids concentration of less than 500 mg/L (milligrams per liter). Table 2 shows the chemical analysis of a ground-water sample from Ocotillo (16S/9E-25K2). The water is a sodium bicarbonate type.

This sample is representative of ground water found in the alluvium west of the Elsinore fault (fig. 3). East of the fault, however, are extensive outcroppings of sediments of Tertiary age consisting mostly of clay, sandstone, and marine fossils (oyster reefs). Ground water in these sediments is commonly saline. Table 2 also shows a chemical analysis of a ground-water sample (16S/10E-16D1) in the Painted Gorge subdivision (fig. 2). This analysis shows high levels of dissolved constituents. This sample is classified as sodium-chloride-sulfate type water.

The Tertiary deposits also crop out west of the Elsinore fault (fig. 3) and most likely occur at depth throughout the study area. Consequently, the ground-water quality may deteriorate with depth west of the fault. Some 600-ft deep wells in Ocotillo tapping these lower levels of the aquifer, however, produce potable water. Exploratory test drilling in the study area would help to determine variations in quality of ground water with depth.

TABLE 2.--*Analyses of ground-water samples from Ocotillo and Painted Gorge subdivision*

[Results in milligrams per liter except pH]

Constituents	Ocotillo 16S/9E-25K2 6-26-75	Painted Gorge 16S/10E-16D1 6-23-75
Silica	36	11
Calcium	18	410
Magnesium	5.1	150
Potassium	4.8	15
Sodium	74	4,300
Bicarbonate	130	110
Sulfate	40	8,100
Chloride	56	2,200
Fluoride	.7	.6
Dissolved solids	307	15,200
pH	7.1	7.7
Hardness	66	1,600

Figure 6 shows an areal distribution of dissolved solids in ground water sampled in the Ocotillo-Coyote Wells basin. These analyses are for ground-water samples obtained from 1974 to 1976 at existing wells and at approximately 10 test holes augered as part of this study. Also included are four samples taken in 1962 and 1964 (Loeltz and others, 1975).

Local variations in dissolved solids shown in figure 6 probably reflect differences in depth of perforated intervals of wells. Some samples are from wells with perforated intervals less than 40 ft below land surface. These analyses generally have higher dissolved solids than neighboring wells in which the upper intervals are cased off. Evapotranspiration may cause the concentration of constituents in the ground water.

Figure 6 indicates that most of the potable ground-water samples are from west of the Elsinore fault. Figure 6 also shows that fluoride concentrations in samples from many wells west of the fault are higher than the U.S. Environmental Protection Agency (1972) recommended maximum fluoride concentration of 1.4 mg/L based on the annual average of maximum daily air temperatures. Dissolved fluoride in the ground-water samples is highest south of Ocotillo, closer to the mountain front.

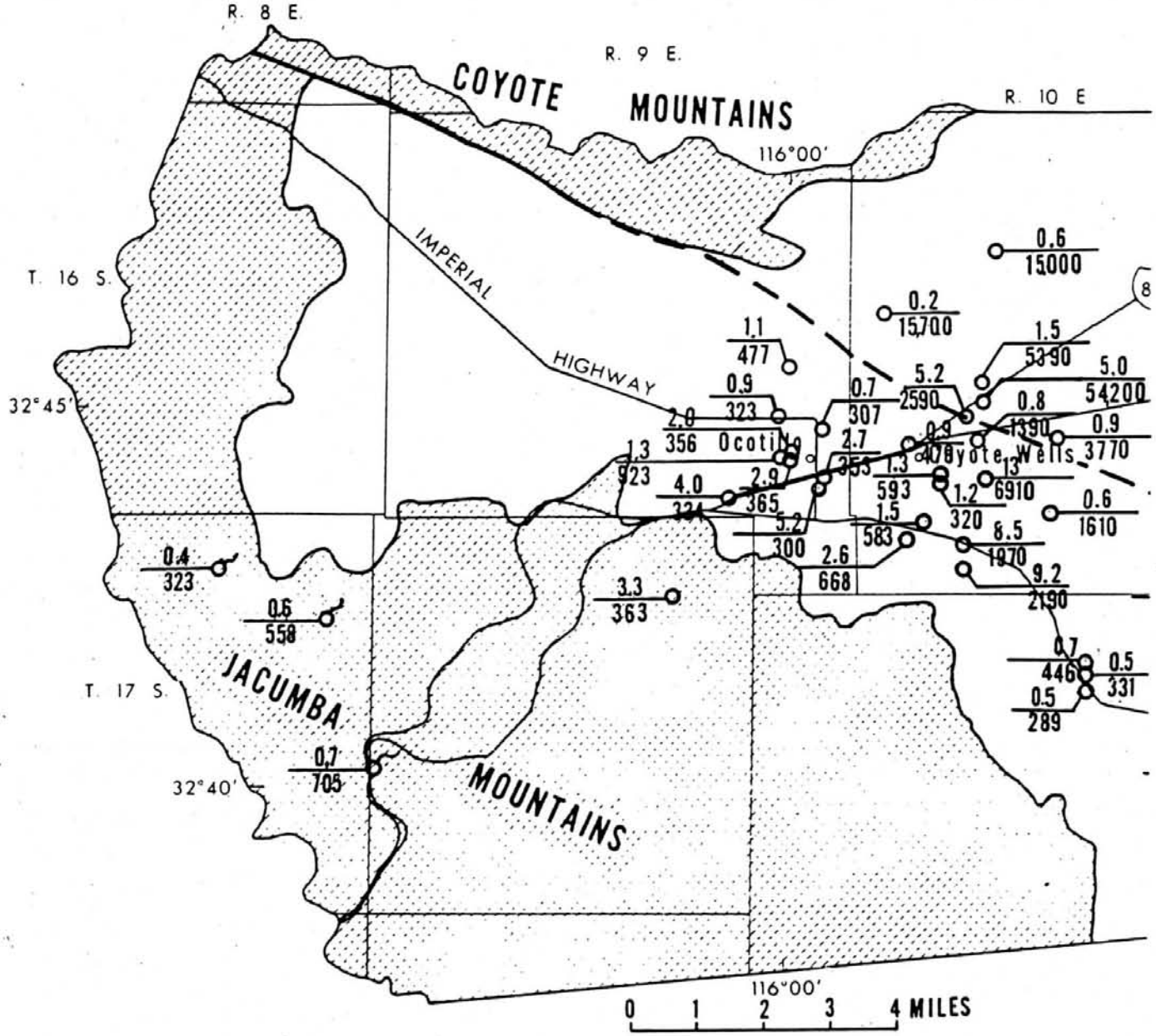
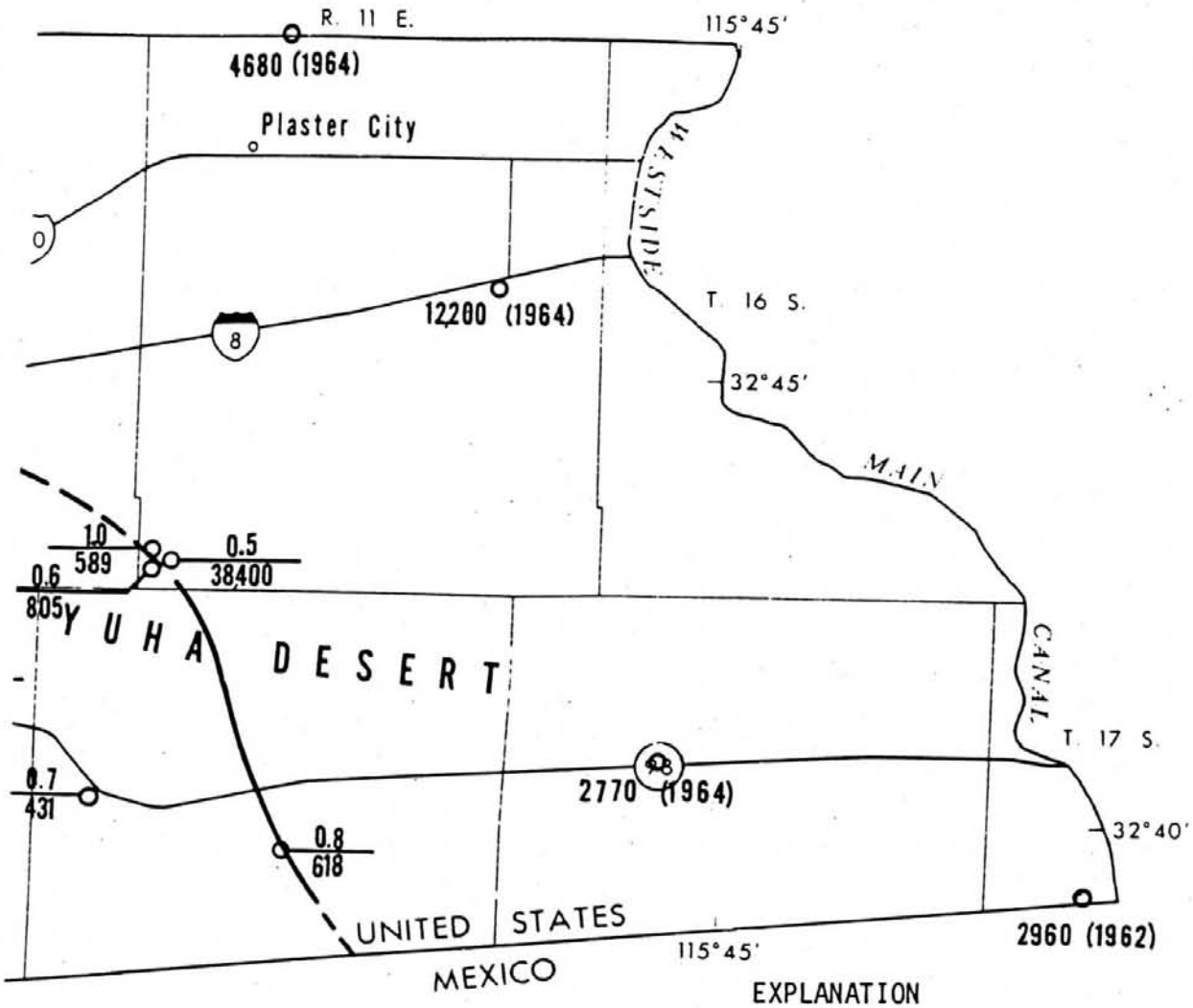


FIGURE 6.--Distribution of fluoride and dissolved solids in ground-water samples.



EXPLANATION

UNCONSOLIDATED DEPOSITS

CONSOLIDATED ROCKS--Non-water-bearing

FAULT--Dashed where approximately located and concealed

1.2 / 320 — DISSOLVED FLUORIDE / DISSOLVED SOLIDS --Milligrams per liter. Samples from 1974-76

12,200 (1964) — DISSOLVED SOLIDS--Milligrams per liter. Sample from year shown

WELL

SPRING

FIGURE 6.--Continued.

The source of the dissolved fluoride in ground water in the study area is not fully understood. Hem (1970) stated: "Ground water containing fluoride concentrations exceeding 1.0 mg/L is found in many places in the United States and is obtained from a wide variety of geologic terranes." Chemical analyses of ground water sampled in the project area indicate no appreciable change over time in either dissolved fluoride or dissolved solids.

Potential Problems

Residents of the Ocotillo-Coyote Wells basin, as well as officials of Imperial County and the State of California, are vitally concerned with the future supply of ground water in the basin. Potential problems involve both the quantity of this supply and its quality.

Future Quantity

An aquifer is analogous to a surface-water reservoir in that water is in storage for possible later use. If discharge exceeds recharge, then the water level drops and water is taken from storage. Water levels in the project area have been declining since significant pumping began in the 1920's. Water levels will continue to decline if aquifer discharge continues to exceed recharge. Potential problems from a declining water table include the necessity of lowering pumps, pump bowls, or even deepening wells. Pumping ground water from greater depths increases power costs.

The total amount of ground water in storage in the upper 200 ft of saturated thickness is about 640,000 acre-ft. This is a conservative estimate but serves to indicate that the quantity of water in storage is great compared to the 1975 annual pumpage of about 880 acre-ft. More importantly, the quality of ground water rather than quantity may pose a greater problem in the future.

Future Quality

Wells in Ocotillo typically penetrate the upper 200-600 ft of alluvium, producing potable water. Ground water mainly in the Tertiary deposits east of the Elsinore fault contains concentrations of dissolved solids ranging from about 4,000 mg/L to about 50,000 mg/L (fig. 6).

At the present time (1976), ground water moves eastward across the Elsinore fault east of Ocotillo. With continued lowering of water levels around Ocotillo, the possibility exists for a reversal of direction of flow. If this occurs, saline ground water could flow westward across the fault and degrade the ground water in the Ocotillo area.

Water quality at levels deeper than those tapped by existing wells in the project area is unknown. Some wells in Ocotillo are more than 600 ft deep and produce fresh water; however, Tertiary deposits probably occur at depth west of the Elsinore fault. These deposits may contain saline water, as do similar deposits east of the fault.

THE DIGITAL MODEL

To understand the aquifer system better, as well as to make predications of future water levels, a digital model can be used to simulate ground-water flow. Such a model uses a digital computer to solve the mathematical equation that describes the flow system.

The model, however, is a simplification of the real system which is undoubtedly more complex than can be simulated. A more detailed model would require more supportive data on aquifer characteristics than is currently available.

The digital model requires estimates of aquifer characteristics initially based on pertinent hydrologic and geologic data. Water levels are calculated and compared to field measurements. If calculated water levels are in error, then the parameters are varied--within reasonable limits--to give a better match of computed and measured water levels. Adjustments of aquifer parameters constitute the calibration phase of digital modeling.

The model can be used as a predictive tool to describe what may happen to future water levels. The premise of prediction is that if a past history of actual water-level changes can be duplicated in the model, then future water-level changes can be predicted. Estimates of historical pumpage are used in the calibration phase to help duplicate a 50-year history of water-level changes, for example. When the model is calibrated, anticipated pumpage can easily be used in the digital model to predict future water levels.

Mathematical Description

Flow of ground water can be described mathematically by the following equation:

$$\frac{\partial}{\partial x}\left(T\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(T\frac{\partial h}{\partial y}\right) = S\frac{\partial h}{\partial t} + q \qquad (1)$$

where h = water level, feet
T = transmissivity, feet squared per day
S = storage coefficient, dimensionless
q = unit rate of withdrawal, feet per day
x, y = space coordinates, feet
t = time, days.

Water levels are calculated as a function of time and location based on estimates of aquifer parameters. Drawdown or water-level-change maps can then be calculated by using these computed water levels and the initial levels. Hydrographs, or plots of water levels at a particular point at various times, can also be calculated.

The finite-element method of solution is a particular numerical technique to solve equation 1. (See Pinder and Frind, 1972, for a complete description.) The computer program used was developed by G. F. Pinder (written commun., 1974).

Grid Network

The method requires that the model of the aquifer be overlain with a grid network of four-sided elements (fig. 7). The corner of each element is a node; additional nodes are specified points on the sides to allow for more curved shapes.

The selection of grid size is based on the location of existing data as well as on the required detail of the model application. Thus, smaller grid size might be used in areas of existing and proposed pumpage. In this way a better definition of the effects of such pumping can be obtained. On the other hand, grid size can be much larger for areas sparse in existing or proposed ground-water development. Narrow elements have been used to simulate faults because of the need to calibrate water-level differences over distances as short as 500 ft.

The Ocotillo-Coyote Wells model was constructed with 136 elements and 246 nodes. The size of the elements ranges from 0.05 to 7.4 mi^2. The average area of an element is 1.5 mi^2.

Aquifer transmissivity and storage coefficient must be specified for each element, and recharge or discharge is given at nodes where applicable. Once boundary conditions are given (see below) and initial water levels are specified for each node, the digital model will then calculate water levels at all nodes as a function of time.

Boundary Conditions

Boundary conditions must also be specified on the edges of the modeled area. Figure 7 shows a no-flow boundary around most of the area, plus constant head or nonchanging water levels along the east and south edges. The no-flow boundary approximates the lateral extent of the alluvium where it pinches out at bedrock.

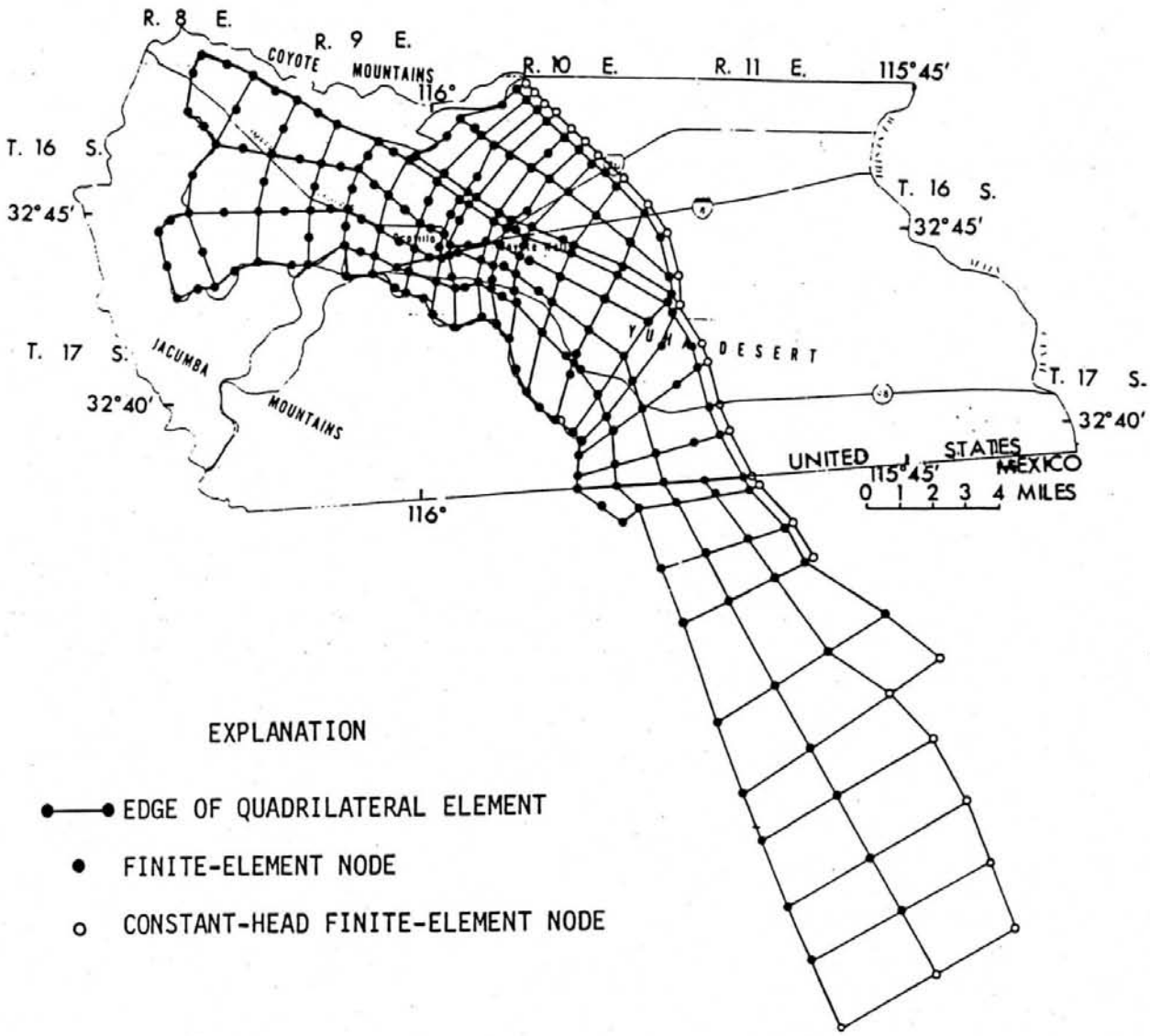


FIGURE 7.--Finite-element grid used in the digital model.

498-Q

STATE OF CALIFORNIA
California Energy Commission

In the Matter of:	
The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

REBUTTAL TESTIMONY OF DR. VERNON C. BLEICH ON BEHALF OF CALIFORNIA UNIONS FOR RELIABLE ENERGY ON BIOLOGICAL RESOURCES FOR THE IMPERIAL VALLEY SOLAR PROJECT

May 17, 2010

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Attorneys for the CALIFORNIA UNIONS FOR RELIABLE ENERGY

2218-112a

In the Applicant's supplemental and rebuttal biology testimony filed on May 10, 2010, Dr. Patrick Mock testified that:

> The CEC, USFWS, CDFG and BLM biologists are in agreement that the sighting of bighorn sheep on the site in spring of 2009 was an unusual occurrence and is unlikely to occur again. Therefore, it is not anticipated that the project will adversely affect the bighorn sheep.

Dr. Mock's opening testimony also claims that:

> "[B]ighorn sheep specialists" from the U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), and Bureau of Land Management (BLM) are in agreement that the observation of 5 bighorn sheep on the project site in March 2009 was unusual and unexpected.

Notably, Dr. Mock fails to identify those "specialists" by name in his testimony. His claims are contradicted by the bighorn specialists that I have been in contact with from CDFG and USFWS. Among the individuals I have spoken with from CDFG (Mr. Steve Torres[1]; Mr. Randy Botta[2]) or from USFWS (Dr. Guy Wagner[3]), none questioned the potential value of the project site to bighorn sheep.

In fact, bighorn expert Steve Torres, CDFG, refuted Patrick Mock's statement that bighorn sheep are unlikely to occur on the Project site:

> I have not spoken with [Patrick Mock]. The quote is clearly taken out of context if a bighorn sheep (BHS) biologist did state this. We have been working very hard to learn more about the habitat use and distribution of sheep in the southernmost part of the Peninsular Ranges. As such, last Fall we collared several BHS with GPS receivers that were reported in the areas adjacent to I-8. Seeing BHS in this

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[1] S. Torres, California Department of Fish and Game, personal communication on March 23, 2010.

[2] R. Botta, California Department of Fish and Game, personal communication on March 24, 2010.

[3] G. Wagner, U.S. Fish and Wildlife Service, during a conference call on April 1, 2010.

> area could be described as "unusual and unexpected" because: 1) we have not rigorously looked for sheep in this area; and 2) this may represent a range expansion back into historic habitat...similar to what we have found adjacent to (and South of I-8). As you know, BHS are wide-ranging terrestrial mammals that occur at low density relative to the areas that they use. So regardless of the quoted statements made, all BHS biologists recognize that sightings of BHS using a specific area are very significant.[4]

Thus, Mr. Steve Torres believes that the sighting of bighorn sheep on the Project site is significant and could represent range expansion into historic habitat. Obviously this is something that should be encouraged and could be critically important to the viability of the distinct population segment. Moreover, Mr. Torres indicates that the observation of sheep on the Project site may only be unusual and unexpected because agencies have not rigorously looked for sheep in this area.

Mr. Randy Botta, also from CDFG, remembers being contacted by URS Corporation on behalf of the Applicant. At that time Mr. Botta did indicate that the observation was unusual, but that was possibly because data were scarce due to staffing and funding limitations. Specifically, Mr Botta said:

> I was contacted by URS and asked if CDFG had any observation or telemetry location points for sheep in the project area. I responded that CDFG had no such observations (ground or from aerial survey) or telemetry location points due to past and on-going staffing and funding limitations. I believe the sighting is "unusual and unexpected" given CDFG's current limited knowledge of sheep distribution, movement and habitat use in the southern most sub-populations. I am not in agreement with the "Bighorn sheep specialists." If the general information and/or responses I provided to URS was used in concluding more than the above then the information was used out of context. Additionally, I did not participate in CDFG project review or

[4] See email from S. Torres, May 13, 2010, attached as an Exhibit to this rebuttal testimony.

comment preparation in any way and did not participate in any related site visits or meetings with project proponents or other agency staff.[5]

Although Dr. Mock's testimony implies that all the agencies have clearly decided that bighorn will not be adversely impacted by development of the Project, this is simply not true. In addition to the communications from the California Department of Fish and Game bighorn experts quoted above, the USFWS has also not concurred in the decision that the Project is not likely to adversely affect bighorn sheep. We have learned from speaking with Ms. Felicia Sirchia, primary project contact at USFWS, and Dr. Guy Wagner (a bighorn sheep expert at USFWS), and from an email communication with Felicia Sirchia on May 11, 2010, that USFWS has not yet concluded anything about the Project's potentially significant impacts on bighorn sheep as Dr. Mock would have you believe.[6] Both Dr. Wagner and Ms. Sirchia indicated that they did not inform the Applicant the observation of bighorn sheep on the Project site was not likely to occur again. It is not clear whom Dr. Mock was speaking with, but the top bighorn specialists at the USFWS and CDFG and the primary project contact at USFWS apparently did not make such statements. All of this is documented in attached copies of email correspondence.

I concur that the observation of bighorn sheep on the project site in March 2009 was unexpected, in part because no one was looking specifically

[5] See email from R. Botta, May 14, 2010, attached as an exhibit to this rebuttal testimony.
[6] See email from Felicia Sirchia, May 11, 2010, attached as an exhibit to this rebuttal testimony.

for evidence of bighorn sheep. I disagree strongly, however, with the conclusion of the Applicant that the observation should be dismissed as being insignificant. The Project site may represent part of an important movement corridor, or potential movement corridor, in a designated Recovery Area and, thus, any obstructions that would occur as a result of project implementation could have substantial impacts on the potential for movement by bighorn sheep through the area, and thereby compromise metapopulation function.

The recent observation of bighorn sheep on the Project site is encouraging in the context of increased utilization of such areas by those large, specialized mammals. In fact, the "transient" use of the project site by bighorn sheep, which was dismissed in the Staff Assessment as insignificant, could be essential to their recovery in the region. The bighorn sheep photographed on the project site were females or young, and female bighorn sheep are inherently conservative in their behavior and are slow to colonize vacant areas, so the presence of female bighorn sheep on the project site suggests those animals were moving from one area to another within the recovery area.

Although the Applicant dismisses the project site "as providing only marginal foraging habitat for the animals," it is my professional opinion that the bighorn sheep could have been at that location because of the presence of high quality forage. Unfortunately, the Applicant failed to analyze the significance of the potential nutritional benefits incurred by PBHS on the

project site and chose, simply, to dismiss the occurrence of bighorn sheep on site as "unusual and unexpected" rather than to acknowledge the potential importance of lower elevation habitats, such as that found on the project site, in terms of the nutritional benefits available to bighorn sheep. Failure to properly acknowledge the potential value of the project site as foraging habitat is inexplicable, because the project site is in a low-lying area with a number of significant desert washes, which are among the most productive habitats in the Sonoran Desert and support higher cover of vegetation and far greater plant biomass than surrounding upland areas.

I can only wonder if the failure to recognize the potential value of such sites reflects the Applicant's lack of familiarity with the biology of bighorn sheep in general and, specifically, with the ecology of bighorn sheep inhabiting desert environments. Such areas likely are not used on a year-round basis but they are, at times, critically important to bighorn sheep in terms of nutrient acquisition or movement among areas of more stereotypical bighorn sheep habitat. Moreover, it is not so much the amount of use an area receives, but the nutritional benefits accrued by bighorn sheep while utilizing such locations that is biologically meaningful; such use may be of short duration, and at only certain times of the year, but can be critically important to individual animals and, therefore, to persistence of populations.

It is my professional opinion that development of the Project will significantly impact the peninsular bighorn sheep recovery in the Project

area and that this impact must be analyzed and mitigated. Notably, California Department of Fish and Game bighorn specialist Randy Botta provided a concrete recommendation for mitigating the impacts to 6,000+ acres of land in the Project area:

> Based on your figure of the loss of 6,000 acres of foraging habitat I would recommend that an equal amount of habitat be protected in fee title and then transferred to CDFG or an appropriate agency such as state parks. It likely will be difficult to find that acreage in the southern portion of the range so replacement throughout the range would be required. Habitat to be purchased should first be approved by the wildlife agencies. Additionally, funding for a specified number of years (minimum of 5) should be allocated for telemetry monitoring (telemetry equipment and capture time) and survey (helicopter time) in and adjacent to the project area.[7]

The mitigation recommended by Mr. Botta should be seriously considered by the California Energy Commission in the subsequent analysis regarding currently unmitigated significant impacts to the bighorn sheep from Project development. I reserve the right to provide additional testimony on mitigation once this analysis is completed.

[7] See email from R. Botta , May 14, 2010, attached as an exhibit to this rebuttal testimony.

498-R

Declaration of Vernon C. Bleich
Imperial Valley Solar Project

Docket 08-AFC-5

I, Vernon C. Bleich, declare as follows:

1) I recently retired from the California Department of Fish and Game, where I worked extensively and primarily with large mammals in the arid ecosystems that characterize eastern and southeastern California. As a private citizen, I currently offer expertise with respect to natural resource conservation issues.

2) I hold an M.A. degree in biology, and a Ph.D. in wildlife biology. My relevant professional qualifications and experience are set forth in the attached *curriculum vitae* and the attached testimony, and are incorporated herein by reference.

3) I prepared the testimony attached hereto and incorporated herein by reference as it relates to the Staff Assessment/Draft Environmental Impact Statement and the Applicant's opening and supplemental rebuttal testimony as they relate to the project known as Imperial Valley Solar in western Imperial County.

4) It is my professional opinion that the attached testimony is true and accurate.

5) I am personally familiar with the facts and conclusions described within the attached testimony and if called as a witness, I could testify competently thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Dated: 5-17-2010 Signed: [signature]

At: DICKINSON, ND

498-S

----- Original Message -----
From: "Steve Torres" <STorres@dfg.ca.gov>
To: "Randy Botta" <RBOTTA@dfg.ca.gov>; "Vern Bleich" <vbleich@ndsupernet.com>
Sent: Thursday, May 13, 2010 10:27 AM
Subject: Re: IMPORTANT - peninsular sheep

Vern:

I have not spoken with this individual. The quote is clearly taken out of context if a bighorn sheep (BHS) biologist did state this. We have been working very hard to learn more about the habitat use and distribution of sheep in the southernmost part of the Peninsular Ranges. As such, last Fall we collared several BHS with GPS receivers that were reported in the areas adjacent to I-8. Seeing BHS in this area could be described as "unusual and unexpected" because: 1) we have not rigorously looked for sheep in this area; and 2) this may represent a range expansion back into historic habitat...similar to what we have found adjacent to (and South of I-8). As you know, BHS are wide-ranging terrestrial mammals that occur at low density relative to the areas that they use. So regardless of the quoted statements made, all BHS biologists recognize that sightings of BHS using a specific area are very significant.

I hope this clarifies this issue.

Regards,

Steve

Steven G. Torres
Wildlife Investigations Lab, Supervisor
Wildlife Branch
(916) 358-1987 (Voice)
(916) 358-2814 (Fax)

California Department of Fish and Game
Wildlife Investigations Lab
1701 Nimbus Road, Suite D Rancho Cordova, CA 95670

>>> "Vern Bleich" <vbleich@ndsupernet.com> 5/13/2010 6:51 AM >>>
Steve and Randy... You two are the individuals most knowledgable about sheep in the peninsular ranges of any CDFG employees. Pat Mock, of URS Corporation, the consultants for the Solar Two plan east of the Coyote Mountains is on written record and quoted below as stating, "Bighorn sheep specialists from USFWS, CDFG, and BLM are in agreement that the sighting of these [5] sheep [in the middle of the project site] was an unusual and unexpected occurrence. I agree with their conclusion. The site provides only marginal forage habitat for these animals." He has failed to name the specialists that he makes reference

to. Whereas you two guys are the most knowledgeable individuals in the Department, can you confirm that you either were in agreement with USFWS and BLM biologists on that point, or that you did not discuss that subject with Mock?

All the best... Vern.

498-T

----- Original Message -----
From: "Randy Botta" <rbotta@dfg.ca.gov>
To: "Steve Torres" <STorres@dfg.ca.gov>; "Vern Bleich" <vbleich@ndsupernet.com>
Sent: Friday, May 14, 2010 2:44 PM
Subject: Re: IMPORTANT - peninsular sheep- PLEASE RESPOND

Vern,

I was contacted by URS and asked if CDFG had any observation or telemetry location points for sheep in the project area. I responded that CDFG had no such observations (ground or from aerial survey) or telemetry location points due to past and on-going staffing and funding limitations. I believe the sighting is "unusual and unexpected" given CDFG's current limited knowledge of sheep distribution, movement and habitat use in the southern most sub-populations. I am not in agreement with the "Bighorn sheep specialists". If the general information and/or responses I provided to URS was used in concluding more than the above than the information was used out of context. Additionally, I did not participate in CDFG project review or comment preparation in any way and did not participate in any related site visits or meetings with project proponents or other agency staff.

Based on your figure of the loss of 6,000 acres of foraging habitat I would recommend that an equal amount of habitat be protected in fee title and then transferred to CDFG or an appropriate agency such as state parks. It likely will be difficult to find that acreage in the southern portion of the range so replacement throughout the range would be required. Habitat to be purchased should first be approved by the wildlife agencies. Additionally, funding for a specified number of years (minimum of 5) should be allocated for telemetry monitoring (telemetry equipment and capture time) and survey (helicopter time) in and adjacent to the project area.

Hope this information is of assistance.

Randy Botta
Associate Wildlife Biologist
Department of Fish and Game
South Coast Region
Wildlife Management-South
4949 Viewridge Avenue
San Diego, CA 92123
Phone/Fax: 760-751-4023

>>> "Vern Bleich" <vbleich@ndsupernet.com> 5/13/2010 6:51 AM >>>
Steve and Randy... You two are the individuals most knowledgable about sheep in the peninsular ranges of any CDFG employees. Pat Mock, of URS Corporation, the consultants for the Solar Two plan east of the Coyote Mountains is on written record and quoted below as stating, "Bighorn sheep specialists from USFWS, CDFG,

and BLM are in agreement that the sighting of these [5] sheep [in the middle of the project site] was an unusual and unexpected occurrence. I agree with their conclusion. The site provides only marginal forage habitat for these animals." He has failed to name the specialists that he makes reference to. Whereas you two guys are the most knowledgeable individuals in the Department, can you confirm that you either were in agreement with USFWS and BLM biologists on that point, or that you did not discuss that subject with Mock?

All the best... Vern.

498-U

Loulena, we have not yet made our determination regarding the effects of the Solar Two project on bighorn sheep.

You are correct, neither Guy nor I made that statement.

****

Felicia M. Sirchia
Fish & Wildlife Biologist
USFWS, Carlsbad Field Office
6010 Hidden Valley Road
Carlsbad, CA 92011
Phone 760.431.9440 x231
Fax 760.431.5902

"Loulena A. Miles" <lmiles@adamsbroadwell.com>		To
	"Felicia_Sirchia@fws.gov" <Felicia_Sirchia@fws.gov>	
05/11/2010 01:28 PM		cc
		Subject
	Question re PBHS on Imperial Valley Solar	

Hi Felicia:
Has the USFWS determined whether it will or will not submit a concurrence letter to BLM regarding whether the Imperial Valley/Solar Two Project is likely to affect Peninsular Bighorn Sheep? The Applicant indicated in testimony yesterday that USFWS is in agreement that the PBHS occurrence on the Project site is unlikely to occur again. I remember that you and Guy Wagner told us on during our conference call that neither you nor Guy Wagner had made that statement. Am I remembering that correctly?
Cheers,
Loulena

Loulena A. Miles
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498-V

STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

TESTIMONY OF BRIDGET NASH-CHRABASCZ ON CULTURAL RESOURCES FOR THE IMPERIAL VALLEY SOLAR PROJECT

May 17, 2010

Loulena A. Miles
Tanya A. Gulesserian
Adams Broadwell Joseph & Cardozo
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Attorneys for the CALIFORNIA UNIONS FOR RELIABLE ENERGY

I, Bridget Nash-Chrabascz, declare as follows:

1. I have earned both my BA and MA in Anthropology and meet the qualifications as an archaeologist as set forth by the Secretary of the Interior.

2. I am presently employed by the Quechan Indian Tribe as the Historic Preservation Officer within the Historic Preservation Office. Prior to working for the Tribe I worked for a cultural resources management firm, Old Pueblo Archaeology, in Tucson, Arizona, and for the State of Indiana at the Indiana State Museum. A copy of my professional qualifications and experience is attached.

3. As the Tribe's Historic Preservation Officer, I work closely with the Tribe's Cultural Committee, as well as numerous elders and community members, and have gained valuable insight into the Tribal perspective in regards to the management of cultural resources. Through the course of my work I have had the opportunity to visit numerous sites within the Tribe's traditional land area, and have been taught first-hand how the Tribe's Creation story relates to certain landforms, as well as the archaeological sites visible on the ground, to form a larger cultural landscape. As defined by the National Park Service, a cultural landscape is "a geographic area (including both cultural and natural resources and the wildlife or domestic animals therein), associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values."

4. The Quechan Tribe, who was here prior to the arrival of the Spaniards or Europeans, had several villages scattered throughout what is now Arizona and California. Prior to the creation of the reservation in 1884, the Quechan traditionally utilized lands as far east as Gila Bend, AZ, west to Octotillo, CA, south into Mexico and north to Blythe, CA and Quartzsite, AZ. The Colorado River corridor from just north of Laughlin, NV, into Mexico is also part of the Quechan's traditional land as it is integral to the Creation of the Tribe.

5. The cultural landscape of the Quechan consists of a myriad of natural and cultural features; intaglios, geoglyphs, petroglyphs, trails and pottery and lithic scatters are just a few of the types of physical remains visible today from the past activities of the Tribe. While each of these features is impressive in its own right, collectively they are part of a larger landscape that includes ceremonial, travel, habitation and battle site locations, as well as sacred places. Unlike archaeologists, who are often limited by project boundaries, the Tribe views all of the landforms, such as mountains, and archaeological sites as being interconnected.

6. The current standard operating procedure for archaeology maintains that archaeologists need to identify and evaluate cultural resources. Once cultural resources have been identified, it is necessary to evaluate them. Per the Secretary of Interior's Standards for Evaluation, evaluation "is the process of determining whether identified properties meet defined criteria of significance and therefore should be included in an inventory of historic properties determined to meet the criteria." Significant properties "possess

integrity of location, design, setting, materials, workmanship, feeling, and association" and also meet one or more of the four eligibility criteria: a) sites associated with significant events; b) sites associated with significant people; c) sites that embody a type, period, or method of construction, or represent a master's work, or possess high artistic values, or represent a significant, distinguishable entity; d) sites that have yielded, or may be likely to yield, information important in prehistory or history."

7. Establishing the boundaries of the identified cultural resources is part of the process as well. The National Park Service has established guidelines for selecting boundaries for archaeological sites and districts. "The selection of boundaries for archaeological sites and districts depends primarily on the scale and horizontal extent of the significant features." Often subsurface testing, surface observation and the observation of topographic features and land alterations aid in this decision. The National Park Service also notes that "absolute boundary definition is often not achievable, especially for archaeological properties."

8. Within the last few years, archaeologists have seen a shift within the paradigm occur. In 2008, at the Society for California Archaeology's annual conference several presentations included archaeologist and Tribal members discussing their partnerships. Later that year the Native American Land Conservancy held a seminar, Lifeways and Landforms Stewarding Sacred Lands. The Society for California Archaeology Native American Programs Committee circulated the White Papers for comments from Native Americans on how to improve the practice of archaeology in California. In 2009, the Arizona State Historic Preservation Office organized a Traditional Cultural Properties workshop. We are beginning to see more archaeologists reaching out to the Tribe's to partner in the identification and evaluation of the cultural resources.

9. Based on my knowledge of the archaeological process and my experience in the field, as well as my knowledge of the Quechan Tribe and an understanding of the tribal perspective in regards to cultural resources, here is my opinion:

    a. The current paradigm in which archaeologists in the Imperial Valley Solar Project identified, bound and evaluated cultural resources for their significance has not allowed for Tribal input.

    b. The area proposed for the Project area is rich in cultural resources. Damages to one or more sites within the project area affect all sites within the Project area, which in turn damage the landscape in which the sites in question are located as well as the other sites within the area (ie. the Yuha Desert). Cultural landscapes cannot be piecemealed and need to be considered in their entirety.

c. As defined by the National Park Service, a cultural landscape is "a geographic area (including both cultural and natural resources and the wildlife or domestic animals therein), associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values." The Tribes cultural landscape contains not only the visible remains of activities located on the grounds' surface, or areas in which traditional plant or clay gathering occurred, but a spiritual component as well. The Tribe's Creation story tells the Creation of the Tribe and specifies numerous animals and their role within the story. The lizard, for example, lit the pyre for Kwikumats', cremation. As such, the Tribe is concerned about the impact the project will have on the flat-tail horned lizard.

d. The cultural significance of the project area was previously described in the discussion of the proposed Plaster City ACEC in the 1980 Draft California Desert Conservation Area Plan Alternatives and EIS. The proposed ACEC, which included the current project area, was described as having "8,320 acres of high sensitivity/significance and 26,680 acres of high to very high buried site potential that could be severely impacted. In addition, possibly 1,125 prehistoric sites and 2 National Register properties (including 8 linear miles of historically significant trails) also stand to be disturbed and/or destroyed." The cultural value of this landscape has been well known for years. The proposed solar project would significantly impact this cultural landscape.

e. As currently defined, the APE is the project area. The APE is too narrow as it fails to take into account the visual impacts to adjacent ceremonial sites and TCPs, like Coyote Mountain. The indirect impacts to sites such as this need to be considered. The cultural and ceremonial use of the landscape will be impaired when tens of thousands of solar pedestals are visible from these areas.

f. The analysis thus far has been heavily focused on archaeological resources. Given the concerns in regards to adjacent land areas and TCPs, an ethnographic study should be done to inform this process.

g. BLM has not engaged in government-to-government consultation with the Tribe regarding the impacts of this project on cultural resources. Nor has the Tribe received any of the reports that identify cultural resources within the Project Area. The Tribe has identified certain statements in the DEIS that may be inaccurate and that would benefit from consultation with the Tribe. However, due to the lack of consultation or the provision of cultural reports or maps, it is not possible to provide additional meaningful comments on this topic at this time.

h. The Programmatic Agreement developed by the BLM defers the formulation of mitigation to a time when the project alternative will have already been chosen and the project will be permitted. This deferral removes the option of rejecting the

project within the proposed project area based on what is learned in consultation with the Tribes

I am sponsoring the following exhibits:

Exhibit 498-Y	Quechan Indian Tribe Comments on Staff Assessment/Draft Environmental Impact Statement, May 17, 2010.
Exhibit 498-Z	Comment letters on Draft Programmatic Agreement for Imperial Valley Solar Project from consulting parties.

498-W

Declaration of Bridget Nash-Chrabascz

Imperial Valley Solar Project

Docket 08-AFC-5

I, Bridget Nash-Chrabascz, declare as follows:

1. I have been the Historic Preservation Officer for the Quechan Indian Tribe since July of 2006.
2. I hold a Masters degree in Anthropology and have worked in the field of archaeology for over ten years. My relevant professional qualifications and experience are set forth in the attached CV.
3. I prepared the testimony, attached hereto and incorporated herein by reference, relating to the cultural resources impacts of the Imperial Valley Solar Project.
4. It is my expert opinion that the attached testimony and exhibits are true and accurate with respect to the information that they portray.
5. I am personally familiar with the facts and conclusions described within the attached testimony and exhibits, and if called as a witness, I could testify competently thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

5/17/10 Bridget Nash-Chr
(Date) (Signed)

HPO @ Quechan Tribe Bridget Nash-Chrabascz
(Location) (Printed)

498-X

2646 S GARDENIA AVE • YUMA, AZ 85365
PHONE 928-317-9107 • E-MAIL BRIDGET_NASH@YAHOO.COM

BRIDGET R. NASH-CHRABASCZ

RESEARCH EMPHASES & PROFESSIONAL INTERESTS

Public Education
- Public Education and Outreach in Archaeology

North American Prehistory
- Prehistoric American Southwest

EDUCATION

B.A. Anthropology (December 1999)
University of Arizona, Tucson, AZ
Major: Anthropology
Minor: Classics

M.A. Anthropology (July 2009)
Ball State University, Muncie, IN

WORK EXPERIENCE

2006 - present

Historic Preservation Officer, Quechan Indian Tribe, Winterhaven, CA

- As the Historic Preservation Officer I am responsible for developing and managing the Historic Preservation Office budget and writing routine reports and correspondence. I have created and continue to maintain an electronic database to track cultural resource projects both on and off of the reservation, and have developed and implemented the Cultural Resource Ordinances for the department.

- I am also responsible for coordinating and supervising Tribal monitors for projects on the reservation and on traditional Tribal lands. I have coordinated and monitored contractors for the Ft. Yuma restoration project, developed and presented education programs to students throughout Yuma and Imperial counties about Ft. Yuma, Archaeology, and the Tribe, developed and led walking tours of Ft. Yuma and continue to monitor community issues that may affect the preservation of resources affiliated with the Tribe.

- As the Historic Preservation Officer I work closely with both the Quechan Cultural Committee and the Tribal Council, schedule and run weekly meetings with the Cultural Committee, and schedule and run meetings between the Cultural Committee and federal or state agencies, or local governments. I also establish and maintain relationships with federal/state agencies, local governments, and private land owners, as

well as with other Tribes and museums/historical societies to ensure the preservation of cultural resources affiliated with the Tribe.

- I am also responsible for conducting reviews of federal, state, county and city undertakings to determine the presence of cultural resources affiliated with the Tribe, viewing and commenting on cultural resource reports and environmental reports (EA's and EIS's), as well as programmatic agreements from federal/state agencies, local governments, and CRM firms.

- I serve as the Tribal liaison in Section 106 consultation and have assisted in the drafting of EA's, and other necessary documents, for lead agencies (Indian Health Services and Bureau of Indian Affairs) on behalf of the Tribe.

- I conduct surveys both on the reservation and on traditional Tribal lands, complete site forms, prepare maps and location information, and take photographs of the sites. I research and write narratives for National Register of Historic places nominations, and coordinate with federal/state agencies, local governments, and CRM firms for the return of resources affiliated with the Tribe to the Quechan Museum under NAGPRA.

2006 - present

Adjunct Faculty, Arizona Western College, Yuma, AZ

- Courses taught include:

  - Anth 100 – Introduction to Anthropology

    An introductory, general service course for both anthropology and non-anthropology majors. Covers physical anthropology, linguistics, archaeology, and cultural anthropology.

  - Anth 120 – Introduction to Prehistoric Archaeology

    Surveys the evolution of humans and cultures from the earliest beginnings to the development of the first civilizations.

  - Anth 130 – Cultural Anthropology

    The basic concepts of social and cultural anthropology are discussed using the social, economic, political, family and religious systems of a variety of societies for illustration.

  - Anth 140 – Introduction to Native American Studies

    Covers the origins and development of the Indian populations from prehistoric to modern times in North America and Mexico. Origins of the major tribes of the greater Southwest are emphasized.

- Along with one other faculty, I conducted a program review for the Anthropology Department in which long-term strategic goals were identified

- Assisted administrators in the development of a Native American Studies program

- I serve as a liaison between the college and local high schools, speaking with students about how anthropology can fit into their program study and/or recruiting students into the anthropology program

- I organize and facilitate representation for the Anthropology Department at various campus activities

2005 - 2006

Community Center Director, Cocopah Indian Tribe, Yuma, AZ

- As the Community Center Director I was ultimately responsible for providing the mission, vision, leadership, and sustainable success to ensure that the Center became and remained the Center of the Cocopah Community. As such, I planned the goals and direction for the Center in conjunction with the Administration, maintained an environment that encouraged achievement for community youths, and continuously surveyed and evaluated the community's needs in an effort to develop and/or present meaningful programs and services.

- As the Community Center Director, I developed and implemented programming (art, science, culture, and recreation) for children, adults, and families; coordinated instructors for, and led, activities in the Center; developed Center rules and regulations; and, increased the visibility of Center programs, services, and activities. I was also ultimately responsible for the care, maintenance, and security of the Center's building and grounds.

- As the Community Center Director, I was also responsible for developing and managing the Center budget, writing routine reports and correspondence, and coordinating preparation and publishing of Center affairs. I directly supervised seven employees by training personnel in various job related tasks, directing work, appraising performance, and addressing complaints and solving problems.

2005 - 2005

Distance Learning Coordinator, Indiana State Museum, Indianapolis, IN

- As the Distance Learning coordinator, I developed and presented programs in the areas of collections, cultural and natural history, and art, for a variety of special interest groups including K-12 students, teachers, adult learners, retirement communities, and libraries. I was responsible for creating and distributing teacher activity packets for each program that were centered around the State of Indiana's Academic Standards; training museum staff on how to operate equipment and on presentation techniques; and planning, as well as scheduling, a yearly programs schedule. I served as the liaison to local area schools, as well as throughout the United States.

- As the Distance Learning coordinator, I was responsible for planning the goals and direction for the distance learning program at the museum; working within an operating budget and facilitating all related billing; maintaining a tracking system for user demographics; initiating needs assessment in program planning; tracking program evaluation and data analysis; and, working with marketing, CILC, IDSolutions, and the Education Manager to promote distance learning programs to schools and the community.

- As the Distance Learning coordinator, I was also responsible for training museum staff on how to operate equipment and on the best techniques for presenting programs.

2004 - 2005

Distance Learning Instructor, Indiana State Museum, Indianapolis, IN
- As the Distance Learning Instructor, I developed and presented programs in the areas of collections, cultural and natural history, and art, for a variety of special interest groups including K-12 students, adult learners, retirement communities, and libraries. I was responsible for creating teacher activity packets for each program that are centered around the State of Indiana's Academic Standards; for operating cameras, television monitors and all related equipment for programs, as well as for providing production setup for programs.

2003 - 2004

Museum Presenter/Collections Maintenance Technician, Indiana State Museum, Indianapolis, IN

- As a Museum Presenter, I presented programs in the areas of cultural and natural history, and art; assisted with public programming such as GeoFest, Archaeology Day, Arbor Day, and Day of the Dead; developed evaluations for the institutions educational workshops; established a database of teachers; and served as point person on project teams such as Genome, Archaeology Day, and GeoFest.

- As a Collections Maintenance Technician, I assisted collections and exhibits staff with the maintenance of exhibit galleries, including the cleaning of objects within the galleries.

2000 - 2002

Lead Instructor & Program Coordinator, Old Pueblo Archaeology Center, Tucson, AZ
- As the lead instructor of Old Pueblo's education programs, my responsibilities included developing educational programs; hiring and supervising a crew and it's activities; program evaluation; liaison with southern Arizona school systems and educators; promotion of Old Pueblo's programs; teaching classes to young people and members of the general public; field supervision of a public excavation and research program at Sedentary/Classic Hohokam village sites; maintaining the mock excavation site; and direct supervision of students and fostering their understanding of Arizona's prehistoric past.

- As the program coordinator for the center, I was responsible for coordinating all school and local area groups participation in the educational programs; distributing literature regarding the programs; planning the itinerary, sometimes working in conjunction with the Arizona State Museum and Arizona Historical Society, for the school; arranging for school funding from our grants, if applicable; and maintaining an educational events calendar.

2000 - 2002

Administrative Assistant, Old Pueblo Archaeology Center, Tucson, AZ
- As the administrative assistant, I kept track of all the cultural resource projects. I performed site file checks when needed, maintained the mailing list and center calendar, and responded to public and volunteer inquiries.

2000 - 2002 *Field Crew and Laboratory Assistant*, Old Pueblo Archaeology Center, Tucson, AZ

- As a field crew member I assisted with the facing of trenches, excavated Hohokam and Archaic sites, and conducted numerous field surveys. In June 2002, I was the Project Director for a local cell tower site survey.

- As a laboratory assistant I inventoried, washed, and labeled, shell, bone, pottery, and both ground and chipped stone. I processed flotations, and assisted with the analysis of ceramics from the Yuma Wash site. I was also responsible for supervising volunteers and crew in the laboratory at the Sabino Canyon Ruin site, as well as, at the center's laboratory.

PUBLIC EDUCATION EXPERIENCE

2003 *Ball State University, PALS Project*
Developed and conducted a series of outreach presentations that focused on the schools' thematic unit, "The Cost of the American Dream," to Pat Irvin's 11th grade honors class at Delta High School, in Muncie, Indiana.

August 2001 Completed Facilitator certification for the Bureau of Land Management's *Project Archaeology* Teacher's Workshop.

RESEARCH EXPERIENCE

2002-2003 Research Assistant
Institution: Ball State University, PALS Project
Description: Reviewed project as the first year was coming to an end to decide where to lead the project during it's second year. Researched various aspects of anthropology and archaeology in a school classroom setting and interviewed several teachers as to how this could assist them with their curriculum needs.

INTERNSHIPS

September - December 2003 *Indiana State Museum*
Under the guidance of Rex Garniwiecz, Curator of Prehistoric Archaeology, I analyzed prehistoric lithics (a majority of which were projectile points) from the Yankeetown site in southern Indiana. The analysis included weight, measurements, rock type, tool type, and drawings of each individual projectile point, including the flakes.

June - August 2003 *Indiana State Museum*
As an archaeology education intern I was co-instructor for the Archaeology camp; I assisted with the facilitation of two Project Archaeology teacher

workshops; assisted with the excavation of the New Harmony project; and, I developed two education workshops for the fall semester.

January - December 1999

Arizona State Museum
As a docent with the Education program, I was in constant contact with the public. During my year as a docent, I conducted tours of the Paths of Life exhibits for grades 2-8. The cultures studied included the Paleo-Indians, Hohokam, Mogollon, Seri, Yaqui, Navajo, Hopi, Western Apache, and O'odham.

January - December 1999

Garbage Project, BARA (University of Arizona)
The Garbage Project seeks to understand the relationship between mental, behavioral, and material realities that constitute human consumption and disposal. As an intern with BARA I assisted with the sorting of trash from ethnically and economically distinct groups at local trash centers. I was also responsible for administering surveys to people as they disposed of their trash, and then recording what had actually been dumped.

May - December 1999

Old Pueblo Archaeology Center
Assisted with various laboratory procedures including processing flotations; washing, labeling, and inventorying artifacts; and site file checks. Most of my time as an intern was spent working as part of the crew for the mock excavation program, which included supervising K-12 students, assisting the students with the excavation process, and the analysis and interpretation of artifacts.

Spring 1998

Western Archaeological and Conservation Center
Assisted with various tasks including cataloging artifacts, arranging paperwork for loans and gifts, maintaining a temperature log to determine humidity levels, researching artifacts in the library archives, photocopying, and filing.

PUBLICATIONS

2009

Nash-Chrabascz, Bridget R.
Cultural Resources Survey for the Sapphire Lane Improvement Project, Ft. Yuma Indian Reservation. Report No. HPO-QT-007, 7 pp.

2009

Nash-Chrabascz, Bridget R.
Damage Assessment for the Quechan Environmental Office Open-Dump Clean-Up, Ft. Yuma Indian Reservation. Report No. HPO-QT-006, 35 pp.

2009

Nash-Chrabascz, Bridget R.
Cultural Resources Survey for Jackson Homesite on Picacho Road, Ft. Yuma Indian Reservation. Report No. HPO-QT-005, 10 pp.

2008 Nash-Chrabascz, Bridget R.
Cultural Resources Survey for Quick Road Water Line, Ft. Yuma Indian Reservation. Report No. HPO-QT-004, 9 pp.

2007 Nash-Chrabascz, Bridget R.
Addendum To: Cultural Resources Survey for the New Casino at I-8 and Hwy. 186, Ft. Yuma Quechan Indian Reservation. Report No. HPO-QT-003. Quechan Indian Tribe, 10 pp.

2007 Nash-Chrabascz, Bridget R.
Cultural Resources Survey for the New Casino at I-8 and Hwy. 186, Ft. Yuma Quechan Indian Reservation. Report No. HPO-QT-002. Quechan Indian Tribe, 19 pp.

2007 Nash-Chrabascz, Bridget R.
Cultural Resources Survey for the New Housing Subdivision on Sapphire Lane, Ft. Yuma Quechan Indian Reservation. Report No. HPO-QT-001. Quechan Indian Tribe, 10 pp.

2002 Nash, Bridget R. and Allen Dart
Cultural Resources Survey of a Proposed Communications Tower Location at Grant Road and Alvernon Way (3900 East Grant Road) in Tucson, Arizona. Letter Report No. 2002.026. Old Pueblo Archaeology Center. 13 pp.

2002 Nash, Bridget R.
The Forests for the Future Project. In *Public Anthropology*,. edited by Eric Lassiter. Ball State University Departmental Newsletter issue no. 4.

PARTICIPATION IN PROFESSIONAL MEETINGS

2009 Do You See What I See: Is the Determination of Eligibility Necessary? Paper presented at the 7th Annual Statewide Historic Preservation Partnership Conference, Phoenix, AZ.

2008 Mining for Gold: The Imperial Project. Paper presented at the Forty-Second Annual Meeting for the Society for California Archaeology, Burbank, California.

2007 Redefining the Consideration of the Tribal Perspective in Cultural Resource Management. Paper presented at the Fifth Annual Showcase for Archaeology and History, Imperial, California.

2003 The Future of PALS: Taking it to the Students. Paper presented at the Annual Meeting of the Society for Applied Anthropology, Portland, Oregon.

PROFESSIONAL MEMBERSHIPS

Old Pueblo Archaeology Center
Society for Applied Anthropology
Society of American Archaeology
The Archaeological Conservancy

JOB RELATED TRAININGS

November 2008	Introduction to Landscape Preservation
July 2008	Tribal Cultural and Historic Preservation: An Overview of Federal Laws Protecting Sacred Lands, Artifacts and Graves
May 2008	Stopping the Thieves of Time Archaeological Law Enforcement Course
December 2007	Identification and Management of Traditional Cultural Places
March 2007	California Environmental Quality Act (CEQA) and Historic Resources Workshop
February 2007	Senate Bill 18 Seminar

498-Y

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May 17, 2010

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Bureau of Land Management
PO Box 12000
Reno, Nevada 89520

Christopher Meyer, Project Manager
Siting, Transmission and Environmental Protection
California Energy Commission
1516 Ninth Street, MS-15
Sacramento, CA 95814

Re: Quechan Indian Tribe Comments on Staff Assessment/Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment for Imperial Valley Solar Project (SES Solar Two)

Dear Mr. Stobaugh and Mr. Meyer:

On behalf of the Quechan Indian Tribe, we submit these comments on the Staff Assessment/Draft Environmental Impact Statement (herein, "DEIS") and the Draft California Desert Conservation Area Plan Amendment for the Imperial Valley Solar Project (formerly known as Solar Two). At this time, given the significant presence of hundreds of cultural resources on the lands at issue, the inadequate efforts to identify cultural resources, and the improper deferral of evaluation of cultural resources until after the record of decision, the Tribe supports No Action Alternative #1 (deny ROW application and not amend the CDCA Land Use Plan of 1980). The preferred alternative for development, and proposed plan amendment, would severely and permanently impact an undisturbed sensitive area for cultural resources, in exchange for an energy development with an anticipated 40-year life span. BLM and the CEC should not approve the permanent destruction of pre-historic and historic resources in exchange for development of a short-term energy source. Alternative locations that have been subject to prior disturbance and that lack the cultural significance of this area should be evaluated further.

I. Interest of the Quechan Indian Tribe

The Quechan Tribe's Fort Yuma Reservation at its current site was established in 1884 as a permanent homeland for the Quechan people. The Quechan people and their ancestors have inhabited the area surrounding the confluence of the Colorado and Gila Rivers for centuries. The Quechan Tribe's traditional lands extend well beyond the boundaries of the present day Fort

Yuma Indian Reservation. Traditionally, Quechan settlements, or rancherias, were scattered north and south along the Colorado River from the confluence area, and eastward along the Gila. Traditional lands to the west of the present day reservation were also utilized by the Quechan people. According to Quechan tradition, the northern territory extended to the vicinity of Blythe, California, the southern territory reached to Sonora, Mexico, the western territory extended to California's Cahuilla Mountains, and the eastern territory approached Gila Bend, Arizona. The lower Colorado River tribes, which include the Quechan, shifted up and down the Colorado and Gila rivers, utilizing the banks and floodplain on both sides of the rivers for subsistence and settlements at different historical periods. (Alfonzo Ortiz, *Handbook of North American Indians*, Volume 10, Southwest (Quechan)) (Smithsonian Institution, Washington D.C. 1982). The traditional use of the area near the proposed project by Native Americans, including the ancestors of the Quechan, is discussed and confirmed in the DEIS' discussion of the cultural and ethnographic history of the project area. DEIS, Cultural Resources, C.2-40 – C.2-45.

The Quechan cultural landscape consists of a myriad of natural and cultural features. Natural features include the Colorado desert and river, mountains, hills, rock outcrops, flora, and fauna. Cultural features include mythology locales, sacred places, settlement and battle site locations, trails, and other resource use areas, along with prehistoric and historic archaeological sites. The latter include rock art (geoglyphs, petroglyphs, and intaglios), trails (stamped paths), trail markers, rock alignments, rock cairns, cleared (tamped) circles (sleeping, teaching, prayer, and dance circles), milling areas, pot drops, and other site features. *See, e.g.,* Birnbam, Charles A., *Preservation Brief 36: Protecting Cultural Landscapes: Planning, Treatment, and Management*; Technical Preservation Services, National Park Service, Washington D.C. (1994); Russell, John C.; Woods, Clyde M.; and Jackson, Underwood, *An Assessment of the Imperial Sand Dunes as a Native American Cultural Landscape,* prepared for the California State Office of Bureau of Land Management, Sacramento, California, by EDAW, Inc., San Diego, California (2002). The project will also have impacts on the flat-tailed horned lizard. The lizard is part of the Quechan Tribe's creation story and is of cultural significance to the Tribe.

II. Comments on Staff Assessment/Draft Environmental Impact Statement

A. BLM/CEC Should Select the No-Action Alternative Given the Acknowledged Impacts to Cultural Resources and Biological Resources.

This project is located in an area confirmed to have high cultural sensitivity. The DEIS notes that 432 cultural resource sites have been previously recorded in the project area. DEIS, page C.2-65.[1] Development of the preferred alternative would result in significant adverse effects on "a presently unknown subset of 328 known pre-historic and historical surface archaeological resources and may have significant adverse effects under CEQA on an unknown number of buried archaeological deposits." DEIS, at ES-24; *see also* page C.2-1. On page C.2-106, there is an acknowledgement that the project "may wholly or partially destroy all

[1] Due to a numbering error in the DEIS, page numbers in both the biological and cultural resources sections begin with "C.2." The page numbers in the cultural resources section should have begun with the designation "C.3."

archaeological sites on the surface of the project area." See also page B.2-12 (acknowledging that construction of the project would lead to the whole and partial destruction of cultural resources). Yet, BLM and CEC are proceeding to make a decision on this project before completing required tribal consultation and evaluation of the significance of the resources.

The cultural significance of the project area was previously described in the discussion of the proposed Plaster City ACEC in the 1980 Draft California Desert Conservation Area Plan Alternatives and EIS. The proposed ACEC, which included the current project area, was described as having "8,320 acres of high sensitivity/significance and 26,680 acres of high to very high buried site potential that could be severely impacted. In addition, possibly 1,125 prehistoric sites and 2 National Register properties (including 8 linear miles of historically significant trails) also stand to be disturbed and/or destroyed." The cultural value of this landscape has been well known for years. The proposed solar project would significantly impact this cultural landscape.

Given the substantial amount of ongoing and proposed solar development on disturbed lands near the project area, the Tribe does not believe that this location is appropriate for the short term (40-year) solar project proposed by the applicant. At minimum, BLM and CEC should complete the cultural identification, evaluation, and mitigation processes as required by NEPA and NHPA Section 106 before making their final decisions on this project.

B. <u>The Analysis of Cultural Resource Impacts Is Incomplete and Based on Inadequate Data</u>.

Under NEPA, BLM is obligated to take a "hard look" at the potential environmental consequences of the proposed project. *Klamath-Siskiyou Wildlands Center v. Bureau of Land Management*, 387 F.3d 989 (9th Cir. 2004). BLM must ensure the scientific integrity of the discussions and analysis in its EIS. *Native Ecosystems Council v. U.S. Forest Service*, 418 F.3d 953 (9th Cir. 2005). A Draft EIS must be as complete as possible and must not ignore or exclude important analysis or factual information. *See* 40 C.F.R. § 1502.9(a) ("the draft statement must fulfill and satisfy to the fullest extent possible the requirements established for final statements in section 102(2)(C) of NEPA").

In this case, the analysis of cultural resource impacts is based on incomplete and unreliable identification efforts. The DEIS describes the inadequate effort made by the applicant to document the cultural resources affected by the project. Throughout the cultural evaluations, BLM and the CEC have expressed numerous concerns with the completeness and accuracy of information provided by the applicant about cultural resources in the project area. *See* DEIS, pages C.2-57 and 58 (noting that documentation by the applicant of approximately 43% of the archaeological sites in the project area was probably inadequate, and noting conclusion of third-party consultant that extant documentation for the archaeological sites in the project area was inadequate for assessing either the historical significance of the resources or the effects that the proposed action would have on them). Although 432 cultural resource sites have been previously located in the project area, the inventory conducted for the DEIS definitively re-

located only two. DEIS, C.2-65. Overall, the survey effort identified 337 total cultural resources, which is far less than the 432 sites previously recorded. DEIS, C.2-85.

The inadequate identification of resources means that BLM and CEC cannot accurately evaluate the impact that this project will have on cultural resources. On page ES-15 of the DEIS, there is no summary of the short and long term adverse impacts to cultural resources. Instead, that discussion is "to be provided." The very same table on page ES-15 asserts there will be "no cumulative adverse impacts" to cultural resources and that the "level of significance after mitigation" will be "less than significant." It is not clear how BLM and CEC can determine the correct "level of significance" when the impact analysis has not yet been completed.

The DEIS states that the project would have "significant adverse effects" on a "presently unknown subset of approximately 328 known prehistoric and historical surface archaeological resources and . . . on an unknown number of buried archaeological deposits." ES-24. It is not apparent from the DEIS how many of the surface resources will actually be affected. The inadequate identification efforts make it impossible for the decisionmakers and interested public to reasonably evaluate the cultural significance of the area and the full extent of impacts that this project will cause to the cultural landscape. *Marsh v. Oregon Natural Resources Council*, 490 U.S. 360 (1989) (noting a primary purpose of NEPA is to foster both informed decision making and informed public participation). This also violates the obligation to make a good faith effort to identify cultural resources of concern to interested Indian tribes. *See* 36 C.F.R. § 800.4(b) (requiring agency to make reasonable and good faith effort to identify historic properties affected by undertaking).

There has been no evaluation of the eligibility of the cultural resources for listing on the National Register of Historic Places. This also makes it impossible to know the extent of impact that this project will have on the cultural landscape. As noted in the Tribe's May 4, 2010 letter commenting on the draft Programmatic Agreement (which is attached hereto as Exhibit A and incorporated in these comments by reference), the Tribe objects to BLM's proposal to defer all evaluation and mitigation development efforts until after the decision has been made on the right-of-way. Approving the right-of-way prior to evaluating the eligibility of the resources violates both NEPA and the NHPA. Both NEPA and the NHPA are intended to inform the decision-making process. Deferring evaluation of NHPA-eligibility until after the decision to permit the project has been made is inconsistent with these laws.

In addition to direct impacts to cultural sites in the project area, there will also be impacts to sites outside the project area due to visual and glare impacts. There are many culturally significant areas outside the project boundaries, as evidenced by the proposed Plaster City ACEC discussed above. The DEIS, page C.13-10, also notes the close proximity of culturally and historically significant areas. Several of the cultural sites and geoglyphs located in the Yuha area are ceremonial in nature and the presence of the Suncatchers will interfere with the use of these sites and ability to see from these sites to other landscapes nearby.

In sum, BLM and CEC must complete the cultural resource identification, consultation, and evaluation process before making a final decision on this Project.

C. The Cultural Resource Evaluation Has Occurred Without Required Government-to-Government Consultation with the Quechan Tribe.

BLM has not engaged in government-to-government consultation with the Tribe regarding the impacts of this project on cultural resources. Nor has the Tribe received any of the reports that identify cultural resources within the Project Area. Thus, at this time, the Tribe's (and other stakeholders) ability to comment on the impacts to cultural resources is impaired by lack of information.

The NHPA requires ongoing consultation with interested Indian tribes throughout the identification and evaluation of cultural resources and the resolution of adverse effects. 36 C.F.R. § 800.3(f)(2); 800.4(a)(4); 800.5(c)(2)(iii); 800.6(a); 800.6(b)(2), etc. Here, pursuant to the Draft Programmatic Agreement, all evaluation and resolution of effects will occur after the decision has been made. The Draft Programmatic Agreement fails to provide for the full level of tribal consultation required by 36 C.F.R. Part 800.

There are several federal laws that mandate ongoing consultation with Indian tribes where federally approved actions will affect tribal interests. *See* Executive Order 12875, Tribal Governance (Oct. 26, 1993) (the federal government must consult with Indian tribal governments on matters that significantly or uniquely affect tribal governments); Executive Order 12898, Environmental Justice (Feb. 11, 1994) (federal government must consult with tribal leaders on steps to ensure environmental justice requirements); Executive Order No. 13007, Sacred Sites (May 24, 1996) (federal government is obligated to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, avoid adversely impacting the physical integrity of sites, and facilitate the identification of sacred sites by tribes); Executive Order No. 13084, Consultation and Coordination with Indian Tribal Governments (May 14, 1998) (places burden on federal government to obtain timely and meaningful input from tribes on matters that significantly or uniquely affect tribal communities); Executive Order 13175, Consultation with Indian Tribal Governments (Nov. 6, 2000) (the federal government shall seek to establish regular and meaningful consultation with tribes in the development of federal policies affecting tribes).

The Tribe has identified certain statements in the DEIS that may be inaccurate and that would benefit from consultation with the Tribe. For example, pages C.2-110 and 111 contain a discussion of the Yuha Basin Discontiguous District. According to the Tribe, it is likely that the sites within the project area are directly related to those within the Yuha area. However, due to the lack of consultation or the provision of cultural reports or maps, it is not possible to provide additional meaningful comments on this topic at this time.

To date, BLM has failed to fulfill its obligation to consult on a government-to-government basis with the Quechan Tribe. BLM must fulfill this obligation prior to issuance of

the ROD. Also, the Draft PA should be amended to require ongoing consultation with the Tribe, and tribal monitoring, if the development process goes forward.

Consultation under state law may also be required pursuant to California Government Code § 65562.5, because the project land is currently designated as open space under Imperial County zoning. Section 65562.5 requires local governments to consult with tribes "for the purpose of developing treatment with appropriate dignity of the place, feature, or object in any corresponding management plan." This section suggests that consultation may be required when development is proposed to occur in open space lands containing cultural resources of significance to tribes.

D. The DEIS Fails to Thoroughly Evaluate Cumulative Impacts to Cultural Resources Associated With the Extensive Plans for Renewable Energy Development in Southern California and Arizona.

An EIS must examine the cumulative impacts of proposed actions. *Neighbors of Cuddy Mtn. v. Alexander*, 303 F3d 1059, 1071 (9th Cir. 2002). A cumulative impact is "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such actions." 40 CFR § 1508.7. Failure to properly analyze cumulative impacts violates NEPA. *See Lands Council v. Powell*, 395 F.3d 1019 (9th Cir. 2004) (reversing EIS for failure to properly analyze cumulative impacts); *Ocean Advocates v. United States Army Corps of Engineers*, 402 F.3d 846 (9th Cir. 2005) (overturning FONSI due, in part, to failure to properly analyze cumulative impacts.

The DEIS contains no real analysis of the impact to cultural resources that will result from the extensive proposed development of renewable energy projects throughout the Southwestern United States. The DEIS notes that approximately one million acres of land are proposed for solar and wind energy development just in the southern California desert lands alone. ES-31. The DEIS offers an extremely cursory analysis of cumulative impacts to cultural resources on pages C.2-144 and 145. This analysis is nothing more than a statement of the obvious that more renewable energy developments will likely result in more impacts to cultural resources. This simplistic analysis does not satisfy NEPA requirements. *City of Carmel-By-The-Sea v. United States Department of Transportation*, 123 F.3d 1142 (1997).

The DEIS also fails to comprehensively list the full extent of proposed solar projects within the area. For example, there are four proposed solar projects on abandoned agricultural lands near the project that do not appear to be addressed in the DEIS:

i) Centinela Solar Energy (proposed 125 MW solar facility east of the Imperial Valley substation on approximately 1170 acres)

ii) Sunrise Gateway West Solar farm (proposed 250 MW facility located along I-8 west of El Centro on approximately 1130 acres)

iii) Sunrise Gateway South Solar farm (proposed 200 MW facility located south of I-8 on eastern edge of Yuha desert, along Mexico border, on approx. 903 acres)

iv) USS Imperial PV Solar project (proposed 136 MW facility located south of I-8 on eastern edge of Yuha desert, on approximately 1400 acres).

There are also two proposed solar projects on BLM land near the proposed project that do not appear to be addressed in the DEIS:

i) Sunpeak Solar (proposed 500 MW facility located west-northwest of the City of Westmoreland, on approximately 5,517 acres of BLM land)

ii) SDG&E solar project proposed for 351 acres of BLM land adjacent to Imperial Valley substation in the Yuha desert.

We understand that Solar Millenium is also currently evaluating several potential sites for a solar facility. One of the proposed locations is on approximately 7,000 acres land in the Plaster City area, to the north of the project.

Given the number of projects in the immediate area proposed for already disturbed lands, there is simply no basis to approve the use of this sensitive cultural area, and the permanent destruction of hundreds of cultural resources, for temporary solar development.

In addition to the direct destruction of cultural resources that will result from the development of one million acres of land for solar and wind projects, there will also be indirect visual impacts. For example, the Tribe is concerned that certain ceremonial areas located in the Yuha, just south of the project area, would be affected by the view of this project. The cultural and ceremonial use of the landscape will be impaired when tens of thousands of solar pedestals are visible from these areas.

The cumulative glint/glare impacts associated with the anticipated solar development projects is also inadequately addressed. The glint/glare study performed for the DEIS is not adequate because it fails to account for the cumulative effect of the entirety of solar projects proposed in the broader area. The cumulative glint/glare from the proposed solar developments will not only affect driving conditions along the I-8 corridor, but will also affect the ability of tribal people to use ceremonial sites nearby. In sum, the cumulative visual impacts resulting from the project and other developments have been inadequately addressed.

Cumulative impacts on flat-tailed horned lizard habitat also deserve additional attention. DEIS, Biological Resources, page C.2-21 acknowledges that "the FTHL populations have declined throughout their range because of loss and degradation of habitat caused by urbanization, agricultural development, military activities, recreational OHV use, and Border Patrol and illegal drive-through traffic." The *Flat-tailed Horned Lizard Rangewide Management Strategy*, page 45, confirms that it is necessary to "maintain or establish effective habitat corridors between naturally adjacent populations." The DEIS fails to adequately address how the

development of approximately one million acres of renewable energy projects in this area will impact the FTHL and its habitat.

E. The DEIS Relies On A Programmatic Agreement That Fails to Provide Mitigation for Cultural Resources and That Fails to Comply With the Requirements of the National Historic Preservation Act and the Advisory Council Regulations.

The DEIS proposes one condition of certification relating to cultural resource protection, which would require the applicant to abide by the terms of a not-yet-completed programmatic agreement. The Tribe has filed a separate comment letter, dated May 4, 2010, which details how the use of a programmatic agreement in this proceeding is inappropriate. The Tribe's letter (which is attached hereto as Exhibit A and incorporated in these comments by reference) argues that BLM is improperly deferring the required Section 106 process until after its decision on the right-of-way is made, and that the current draft of the programmatic agreement fails to provide sufficient mitigation. The draft programmatic agreement, page 3, states that BLM will incorporate the mitigation measures and performance standards from the Staff Assessment/Draft EIS. The only "mitigation" for cultural resources provided in the Draft EIS is a reference back to the programmatic agreement. In other words, the programmatic agreement and DEIS simply cross-reference each other, but neither document provides for mitigation.

F. The Inadequate Cultural Resource Identification, Evaluation, and Mitigation Efforts Also Violate California Law.

CEQA requires development of appropriate mitigation measures. "Formulation of mitigation measures should not be deferred until some future time. However, measures may specify performance standards which would mitigate the significant effect of the project and which may be accomplished in more than one specified way." CEQA Guidelines, § 15126.4(a). The DEIS fails to development appropriate mitigation measures relating to cultural resources. The only mitigation referenced is the Draft PA, which as discussed above, does not contain any actual mitigation measures or performance standards.

California law also favors the preservation of cultural resources in place and the avoidance of impacts to such resources. Appendix K to the CEQA Guidelines states that "public agencies should seek to avoid damaging effects on an archaeological resource whenever feasible." The commentary on Appendix K states that "an important principle in this appendix is the emphasis on avoidance of archaeological sites. . . where the proposed project includes a potential impact on a site, avoidance is suggested as a preferred mitigation measure where all other factors are equal." Here, hundreds of resources will be directly or indirectly impacted. Yet, the rush to issue certification and approve the right-of-way forecloses a meaningful opportunity to design the project in a way that will avoid resources or to consider whether an alternative location should be selected.

G. The Staff Assessment Fails to Comport With CEQA Provisions Addressing Disposition of Discovered Human Remains.

The project area is known to contain sites containing human cremations of potentially historic origin. The full extent of the cremation sites is not currently known to the Quechan Tribe due to the lack of consultation and lack of a cultural resource report. CEQA Guidelines Section 15.064.5(d) states that "when an initial study identifies the existence of, or the probable likelihood, of Native American human remains within the project, a lead agency shall work with the appropriate Native Americans as identified by the Native American Heritage Commission as provided in Public Resource Code 5097.98." Public Resource Code 5097.98 provides a process for identifying the most likely descendants of the remains and provides for inspections, consultations, and development of agreements with the most likely descendants for the appropriate treatment of the remains. It does not appear that the CEC or the applicant have complied with these provisions. Due to the lack of consultation, the Quechan Tribe lacks sufficient information at this time to know whether its people are the most likely descendants of the discovered remains. Further investigation and consultation with affected tribes (including the Quechan) is required before approving any project impacting these sacred cremation sites.

H. The Project Will Have Unacceptable Impacts to the Flat-Tailed Horned Lizard.

The DEIS acknowledges that the Flat-Tailed Horned Lizard (FTHL) is known to exist in the project area. DEIS, Biological Resources, C.2-22. The FTHL is proposed for listing on the Endangered Species Act and final action on the proposed listing is likely to occur this year. The lizard is also culturally significant to the Quechan Tribe, as it is part of the Tribe's creation story. The DEIS acknowledges that this Project could result in direct mortality, injury, and harassment of lizards. DEIS, at C.2-40. This is another reason why the Tribe supports a no-action alternative here.

The mitigation proposed in the DEIS for impacts to the FTHL requires removal surveys to occur prior to construction activities. DEIS, C.2-83. However, the *Flat-tailed Horned Lizard Rangewide Management Strategy* notes that once the FTHLs are relocated to another area, their rate of mortality often increases due to the change in environment. Thus, while removal of the lizards may avoid direct mortality resulting from the construction and operation of this project, it may result in indirect mortality due to the change in habitat.

In light of the need to conduct the removal surveys, no construction should be permitted to occur until Fall of 2011, at the earliest, to allow for completion of surveys. Removal surveys are to be performed betweeen April 1 and September 30 to account for the time period when the lizards are most active and out of hibernation. Since no decision will be made on this project until at least September 2010, the removal surveys would need to occur the following year, between April 1 and September 30, 2011, with no construction beginning until after that date.

III. Comments regarding Amendment to California Desert Conservation Plan.

A. The Amendment Should Be Rejected Because the Project Will Permanently and Adversely Affect Cultural and Biological Resources.

The California Desert Conservation Plan (herein "CDCA") lists certain criteria to be used when evaluating future applications for energy-related projects. One of the decision criteria is that sensitive resources should be avoided wherever possible. In this case, due to the significant and comprehensive presence of cultural resources throughout the project area, the project cannot be developed in a way that will avoid damage to sensitive cultural resources, or to the sensitive Flat-tailed Horned Lizard population. The analysis of this criteria in the DEIS, at p. A-9, fails to address impacts to the FTHL or cultural resources, which will not be avoided in project development. A major goal of the CDCA is to protect and preserve the sensitive resources in the desert environment. This proposed amendment is inconsistent with that goal and with the requirements of FLPMA.

B. The Amendment Should Be Rejected Because the Project Does Not Conform to the Local Land Use Plan for Imperial County.

Another CDCA decision criteria requires "conformance to local plans wherever possible." Here, the applicable local Imperial County land use designation for the project area is "Open Space Preservation Zone." See DEIS, p. A-5. This designation does not allow use for electric power generation projects. DEIS, p. A-5. Page A-10 of the DEIS asserts that the project is in conformance with the Imperial County General Plan, but fails to acknowledge the lack of compliance with applicable zoning. Amendment of the CDCA to permit a large-scale power development in an area zoned by the local government for open space preservation is not appropriate. *See* DEIS, page C.8-18 ("the proposed project would not be consistent with the intent of the S-2 zone within the county's Land Use Ordinance"); *see also* 43 U.S.C. § 1712(c) ("land use plans of the Secretary . . . shall be consistent with State and local plans to the maximum extent he finds consistent with Federal law and the purposes of [FLPMA]").

C. The Plan Amendment Should Be Rejected Because This Large-Scale Solar Development, In Conjunction with the Cumulative Impacts of Nearby Developments, Will Unreasonably Shift the Multiple-Use Balance in the California Desert Conservation Area In Favor of Power Production and Could Result in Permanent Impairment of Resources In Violation of FLPMA.

The Plan Amendment process requires BLM to determine the environmental effects of granting the applicant's request and also to evaluate the effect of the proposed amendment on BLM's desert-wide obligation to achieve and maintain a balance between resource use and resource protection. Approving the plan amendment here would unreasonably shift the multiple use balance in favor of resource use/development. *See also* 43 U.S.C. § 1712(c)(1) (requiring the Secretary to use and observe the principles of multiple use and sustained yield when developing or revising land use plans).

The record is clear that this project is proposed in an extremely sensitive area, that there are numerous solar developments in and around the project area on BLM and private/non-federal lands, and that this area is designated as open space by local land use officials. A balanced, multiple-use, approach to land management mandates that this parcel not be developed for large-scale solar. This project, combined with the cumulative effect of one million or more acres of other renewable projects would dramatically shift the use of BLM's California Desert lands toward energy development at the direct expense of resource protection. Development of the project on this site could also result in the permanent impairment of the land's resources in conflict with 43 U.S.C. § 1702 (defining "multiple use" to require "coordinated management of the various resources without permanent impairment of the productivity of the land and the quality of the environment").

IV. Conclusion.

In conclusion, the Tribe urges the BLM/CEC to revise the DEIS in accordance with these comments, to properly consult with the Tribe as required by law, and to ultimately select the no-action alternative, deny the ROW application, and not amend the CDCA Land Use Plan, based on the project's anticipated impacts to an area of high cultural sensitivity. Thank you for your consideration to these comments.

Sincerely yours,

MORISSET, SCHLOSSER & JOZWIAK

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cc: President Mike Jackson, Sr.
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Pauline Jose, Chairperson, Quechan Cultural Committee
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Nancy Brown, Advisory Council of Historic Preservation
Wayne Donaldson, California State Historic Preservation Officer
Dave Singleton, Native American Heritage Commission

Attachment A: Quechan Tribe's Comments on Draft Programmatic Agreement

EXHIBIT A

May 4, 2010 Letter to Carrie L. Simmons, Comments on Draft Programmatic Agreement

QUECHAN INDIAN TRIBE
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May 4, 2010

Carrie L. Simmons, Archaeologist
El Centro Field Office
Bureau of Land Management
1661 S. 4th Street
El Centro, CA 92243

Re: Comments on Draft Programmatic Agreement regarding Tessera Solar Imperial Valley Solar Project (formerly Solar Two)

Dear Ms. Simmons:

The Quechan Indian Tribe submits the following comments on the Draft Programmatic Agreement Regarding the Tessera Solar – Imperial Valley Solar Project ("Draft PA"). In summary, the Tribe believes that the Draft PA is inconsistent with the National Historic Preservation Act (NHPA) Section 106 process, and not adequate to evaluate and mitigate effects on cultural resources in and around the project area. The Draft PA defers a substantial majority of the Section 106 process, including all evaluation, treatment, and mitigation until after BLM has granted the right-of-way to the applicant. BLM has failed to adequately explain why a PA is necessary or appropriate here. The only apparent basis for deferring the evaluation of cultural resources, and development of an appropriate treatment plan, until after approval of the right-of-way is the artificial timeline imposed by the applicant.

I. The Draft PA Is Inconsistent With Section 106 of the NHPA.

Section 106 of the National Historic Preservation Act, 16 U.S.C. § 470f, requires that BLM "shall, *prior to the approval* of the expenditure of any Federal funds on the undertaking or *prior to the issuance of any license*, as the case may be, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register." (emphasis added). Only "nondestructive project planning activities may be completed before completing compliance with Section 106." 36 C.F.R. § 800.1(c). Similar to NEPA, the NHPA is designed to ensure that federal decision-makers thoroughly evaluate the impacts of their proposed actions on NHPA-eligible resources *prior to* taking action.

Prior to the approval of a federal undertaking, the federal agency must engage in a four-part process. First, the agency must identify the "historic properties" within the area of potential effects. 36 C.F.R. § 800.4. Second, the agency must evaluate the potential effects that the undertaking may have on historic properties. 36 C.F.R. § 800.5. Third, the agency must resolve the adverse effects through development of mitigation measures. 36 C.F.R. § 800.6. Fourth,

throughout all of these processes, BLM must consult with interested Indian tribes that might attach religious and cultural significance to properties within the area of potential effects. 36 C.F.R. §§ 800.3(f)(2); 800.4(a)(4); 800.5(c)(2)(iii); 800.6(a); 800.6(b)(2), etc.

Instead of completing this required process, BLM is opting to use a programmatic agreement to defer evaluation, mitigation, and treatment until after approval of the right-of-way. 36 C.F.R. § 800.14(b) authorizes the Advisory Council and the agency to negotiate programmatic agreements to govern programs, complex project situations, or multiple undertakings. 36 C.F.R. § 800.14(b)(1) specifies the circumstances under which a programmatic agreement may be used. None of those circumstances exist in this case. Nor does the Draft PA identify any element of 36 C.F.R. § 800.14(b)(1) that justifies the use of a PA here.

There is no reasonable basis to depart from the standard Section 106 process. There is no valid reason why the effects on historic properties cannot be fully determined prior to approval of this undertaking. The only apparent reason why BLM is choosing to use a programmatic agreement is to allow the applicant to obtain its right-of-way approval before the end of the calendar year, in an effort to qualify for federal funding. *See* Draft PA, p. 5. Absent this arbitrary deadline being imposed by the applicant, there is no reason to believe that BLM could not complete the standard Section 106 process before it makes its decision on right-of-way issuance.

To the extent that the Advisory Council regulations authorize the deferral of the Section 106 process until after approval of the undertaking, those regulations are inconsistent with the plain language of 16 U.S.C. § 470f and invalid. The statute is clear that the agency must consider the effect of its undertaking on historic properties prior to approval. *See Corridor H Alternatives, Inc., v. Slater*, 166 F.3d 368 (D.C. Cir. 1999) (rejecting agency's use of PA to defer Section 106 process until after issuance of ROD); *City of Alexandria v. Slater*, 198 F.3d 862 (D.C. Cir. 1999) (approving PA where agency only deferred identification of sites that might be impacted by small number of ancillary activities, and distinguishing from case where the entire Section 106 process is deferred). While the Advisory Council has discretion to determine how the effects on historic properties are evaluated, it does not have authority to permit the approval of undertakings prior to the completion of that evaluation. *Chevron v. Natural Resources Defense Council, Inc.*, 467 U.S. 837 (1984) (ruling that the judiciary must reject administrative interpretations that are contrary to clear congressional intent).

In summary, this is not an appropriate case for use of a programmatic agreement. This case involves a straightforward proposal to issue a right-of-way on BLM lands for a single solar development project. There is no "program" at issue, no significant complexity, and no reason why the standard identification, evaluation, and resolution process cannot occur prior to approval of the undertaking. BLM must complete the cultural resource evaluation required by Section 106 prior to approving the right-of-way for this project.

II. BLM Has Not Fulfilled Its Government-to-Government or Section 106 Tribal Consultation Obligations.

The NHPA and the Advisory Council regulations contain detailed requirements for consultation with Indian tribes who attach religious and/or cultural significance to historic properties that may be affected by an undertaking. *See* NHPA, Section 101(d)(6)(B). This

consultation obligation applies "regardless of the location of the historic property." 36 C.F.R. § 800.2(c)(2)(ii). "The agency official shall ensure that consultation in the section 106 process provides the Indian tribe . . . a reasonable opportunity to identify its concerns about historic properties, including those of religious and cultural importance, articulate its views on the undertaking's effects on such properties, and participate in the resolution of adverse effects." 36 C.F.R. § 800.2(c)(2)(ii)(A). "Consultation should commence early in the planning process, in order to identify and discuss relevant preservation issues and resolve concerns about the confidentiality of information on historic properties." *Id.*

There are also several federal laws that mandate ongoing government-to-government consultation with Indian tribes where federally approved actions will affect tribal interests. *See* Executive Order 12875, Tribal Governance (Oct. 26, 1993) (the federal government must consult with Indian tribal governments on matters that significantly or uniquely affect tribal governments); Executive Order 12898, Environmental Justice (Feb. 11, 1994) (federal government must consult with tribal leaders on steps to ensure environmental justice requirements); Executive Order No. 13007, Sacred Sites (May 24, 1996) (federal government is obligated to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, avoid adversely impacting the physical integrity of sites, and facilitate the identification of sacred sites by tribes); Executive Order No. 13084, Consultation and Coordination with Indian Tribal Governments (May 14, 1998) (places burden on federal government to obtain timely and meaningful input from tribes on matters that significantly or uniquely affect tribal communities); Executive Order 13175, Consultation with Indian Tribal Governments (Nov. 6, 2000) (the federal government shall seek to establish regular and meaningful consultation with tribes in the development of federal policies affecting tribes).

The Advisory Council regulations make it clear that consultation with interested tribes is to occur throughout the entire Section 106 process. 36 C.F.R. § 800.4(a)(4) requires BLM to consult with interested tribes "to assist in identifying properties, including those off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register." 36 C.F.R. § 800.5(a) requires BLM to consult with interested tribes when assessing adverse effects. 36 C.F.R. § 800.6(a) requires BLM to consult with interested tribes when developing and evaluating alternatives that could avoid, minimize, or mitigate adverse effects on historic properties.

Here, BLM has not complied with the tribal consultation regulations. Since BLM is proposing to defer the identification, evaluation, and impact mitigation until after it approves the right-of-way, the Quechan Tribe and other tribes are being deprived of their ability to provide meaningful input prior to BLM's decision. In addition, the Tribe has not yet received a final cultural resources report for this project, further impairing its ability to consult.

The tribal consultation provisions in the Draft PA are also inconsistent with the Advisory Council regulations. Appendix A, Section I(d) of the Draft PA requires BLM to consult with tribes to identify traditional cultural places within the APE. However, this is narrower than the regulations' requirement to consult for the purpose of identifying properties, "which may be of religious and cultural significance." 36 C.F.R. § 800.4(a)(4). Likewise, Appendix A, Section II of the Draft PA requires consultation with tribes in the resource evaluation phase, but only for the purpose of determining whether or not a resource is NRHP-eligible. In contrast, the ACHP

regulations also require consultation with tribes in the assessment of effects to the properties. 36 C.F.R. § 800.5(a). The Draft PA does not provide for this phase of tribal consultation.

Appendix B of the Draft PA requires the applicant to develop a Treatment Plan in consultation only with BLM and other *signatories* to the PA. Thus, if the Tribe does not sign the PA, it loses its right to consult on the resolution of adverse effects required by 36 C.F.R. § 800.6(a). BLM can not condition tribal consultation on execution of a PA that the Tribe objects to. If the Tribe declines to sign the PA, BLM and the applicant must still comply with the tribal consultation provisions in 36 C.F.R. § 800.6(a) and consult with the Tribe in development and implementation of the Treatment Plan. This should be made clear in the PA.

In summary, BLM has failed to comply with its tribal consultation obligations. In addition, the Draft PA does not provide for the level of tribal consultation required by the Advisory Council regulations. At minimum, the Draft PA should be revised to provide for tribal consultation in a manner consistent with 36 C.F.R. Part 800. No work should be authorized until tribal consultation on the evaluation and resolution of effects is completed

III. Specific Comments on Draft PA

As noted above, the Tribe believes that use of a programmatic agreement in this case violates both the letter and spirit of the NHPA by deferring evaluation and resolution of effects until after approval of the undertaking. In addition, the programmatic agreement is woefully inadequate in terms of specifying appropriate mitigation measures. The following are specific comments on the Draft PA:

- The Draft PA, page 3, states that BLM will incorporate the mitigation measures and performance standards from the Staff Assessment/Draft EIS ("SA/DEIS") for the SES Solar Two Project. However, the only Condition of Certification contained in the SA/DEIS is that the applicant shall comply with the terms of the programmatic agreement. In other words, the Draft PA and SA/DEIS simply cross-reference each other, but neither document provides any substantive mitigation measures or performance standards.

- The Draft PA, page 6, states that BLM has determined that a "phased (tiered) process for compliance with section 106 of the NHPA is appropriate for the undertaking." BLM fails to explain why a phased approach is appropriate in this case. Even if a phased approach was appropriate, there is no valid reason why BLM should not complete the Section 106 process for at least Phase I of the Project prior to approval of the undertaking. BLM is not just deferring evaluation of effects for Phase II of this Project, but is deferring the entire Section 106 process for all phases until after approval of the undertaking. This is not consistent with NHPA requirements.

- The Draft PA, page 6, asserts that BLM has "comparatively examined the relative effects of the alternatives [in the SA/DEIS] on known historic properties." However, there has not actually been any evaluation of the identified historic properties to date. The DEIS simply assumes that effects on cultural resources can be adequately mitigated through the PA, but the Draft PA lacks any actual mitigation measures or performance standards.

- The Draft PA, page 6, states that identification, determination of effects, and consultation on mitigation will occur prior to issuance of any "Notice to Proceed." This is misleading and inaccurate. Stipulation IX of the Draft PA, on page 11, confirms that BLM does intend to authorize construction activities while the Section 106 evaluations take place. Permitting construction to proceed prior to concluding the Section 106 process (including the identification and evaluation of affected resources) conflicts with clear language in the NHPA.

- The Draft PA, pages 6-7, notes BLM's obligation to consult with interested Indian tribes. To date, BLM has not formally consulted on a government-to-government basis with the Quechan Tribe. It would be inappropriate to sign the Draft PA prior to formal consultation with the Tribe. In addition, the Tribe's ability to meaningfully consult in this matter has been, and continues to be, impaired since it has not yet received any cultural resources report specifically identifying the resources discovered to date. The tribal consultation requirements of Section 106 and the ACHP regulations have not been complied with.

- The Draft PA, page 7, contains a definition of "cultural resource," but then fails to use that definition consistently throughout the document. The term "cultural resource" as defined on page 7 should be incorporated throughout the substantive terms of the agreement.

- The area of potential effects (APE) is coterminous with the project boundary. However, there are many other sensitive areas adjacent to the project area. It may be appropriate to broaden the APE to consider the indirect effects that this project will have on the adjacent areas. Further consultation with the Tribe is necessary on this issue.

- Stipulation VI discusses the need to treat Native American burials and related items discovered during implementation of the Agreement in compliance with NAGPRA. The Tribe is aware that cremation sites have been located in the project area, yet the Tribe has not been consulted or provided with specific information about the nature or extent of these cremation sites. The Tribe is very concerned with a ROD being issued until full identification and evaluation of cremation sites in compliance with NHPA and NAGPRA takes place.

- Stipulation VIII, on page 10, states that BLM will ensure preparation and distribution of a report to consulting parties that documents the results of implementing the evaluation and treatment plan efforts referenced in Stipulations III and IV. This report will be circulated within 18 months after all fieldwork required by Stipulations III "or" IV is complete. This stipulation should be modified to require the preparation of two reports; one that addresses evaluation of resources and a second that addresses treatment. The first report, which would document evaluation efforts, should be subject to comments of consulting parties and other interested Indian tribes prior to preparation of a treatment plan. The evaluation report would help inform development of the treatment plan. There should be consultation throughout the evaluation process, and throughout the development and implementation of the treatment plan.

- Stipulation IX authorizes BLM to commence "construction activities such as grading, buildings, and installation of Sun Catchers" prior to completion of the evaluation of resources and the development and implementation of a treatment plan. The Tribe objects to this as inconsistent with the requirements of the NHPA. BLM should not authorize any construction until the evaluation of resources, and development of a treatment plan, occurs.

- Stipulation XI discusses dispute resolution in the event there is disagreement about how the terms of the PA are being implemented. BLM's authority to revoke its right-of-way, or to impose additional conditions on the project for failure to comply with the PA, should be made clear in this section. If BLM proceeds with the PA, and defers the Section 106 process until after it issues the right-of-way, it must also retain the authority to revoke or condition the project in the event that the applicant violates the PA. The Draft PA does not contain clear language that ensures BLM will have authority to meaningfully enforce the terms of the Agreement.

- Stipulation XII discusses termination of the Agreement, but fails to clearly state that if the agreement is terminated, then the applicant must stop work on the project. Again, BLM is deferring the Section 106 process through the proposed agreement. Compliance with mitigation measures developed through the Section 106 process should be an express condition of the right-of-way approval. In other words, it should be clear both in the PA and in the ROD that termination of the PA, or other failure to comply with prescribed mitigation measures, means that work must stop pending full compliance with any unfulfilled obligations under the NHPA.

- Stipulation XIV is unclear. Section (a) states that the PA will expire if the undertaking or the Stipulations have not been performed within five years. "At such time," says the PA, the BLM shall either execute an MOA or request comments from the ACHP. Does this mean that the PA will change into an MOA at the end of the five year period? If the applicant fails to agree to the MOA, does this result in revocation of the right to continue with the undertaking? Section (b) then indicates that the undertaking may proceed even though the PA is terminated. This section should make it clear that, if the PA is terminated, all work must cease until the development of a new PA or MOA.

- Stipulation XV(b) states that execution and implementation of the PA is evidence that BLM has afforded the ACHP a reasonable opportunity to comment on the undertaking. However, even if this is true, implementation of the PA is not evidence that BLM has satisfied its consultation obligations to interested Indian tribes.

- Appendix A, Section I(b) states that an inventory report, containing 100% survey of the APE, has been submitted to BLM. The Tribe has not received a copy of that report from BLM, nor has it been consulted as to the contents of that report. This has limited the ability of the Tribe to effectively consult and comment in this process.

- Appendix A, Section I(d) states BLM shall consult with Tribes to identify traditional cultural places, but does not require this consultation to occur prior to issuance of the ROD. BLM is violating Section 106 and the Advisory Council regulations by failing to provide meaningful consultation with the Tribes prior to issuance of the ROD in this proceeding.

- Appendix A, Section II discusses evaluation of historic properties. The Tribe disagrees with the presumption in Section (e) that isolated artifacts may not be considered eligible under the NRHP. The Tribe also disagrees with Section (f), which states that cultural resources that can be "avoided" will not be evaluated. This is inconsistent with the NHPA and the Advisory Council Regulations. BLM must evaluate all of the identified cultural resources for NRHP eligibility. The mere fact that the project footprint will not directly damage a resource does not mean that a resource will not be affected by the development of the project. This is

especially true for resources that have cultural or religious significance to tribes, which can suffer impacts from the presence of adjacent commercial developments. Development activities may affect the cultural setting in which resources lie, even if the project does not directly impact them. Thus, all identified resources should be evaluated for NRHP eligibility. The Section 106 process is intended to inform BLM and the public of how sensitive a project area is. An analysis of how many eligible resources are located on the site should occur before any decision is made to permit the project.

- Appendix B states that the treatment plan will be developed among Signatory Parties. BLM cannot deprive the Tribe of its rights as a consulting party if the Tribe chooses not to be a signatory party. As discussed above, the regulations require consultation with the Tribe in the resolution of adverse effects, and the Draft PA should clarify that such consultation is required. No work should be authorized until resources are evaluated and the HPTP is completed.

In conclusion, the Tribe objects to the use of a programmatic agreement in this proceeding. The Section 106 process, and the evaluation of impacts to cultural resources is being arbitrarily rushed to the detriment of tribal input and protection of the resources. To the extent that a programmatic agreement is adopted, the current draft is inadequate and should be revised in accordance with the comments above. We look forward to continue working with BLM as this process continues. Please contact me if you have any questions.

Sincerely,

QUECHAN INDIAN TRIBE

Bridget Nash-Chrabascz
Quechan Tribe Historic Preservation Officer

cc: President Mike Jackson, Sr.
Vice-President Keeny Escalanti, Sr.
Members of the Quechan Tribal Council
Pauline Jose, Chairperson, Quechan Cultural Committee
Kenneth Salazar, Department of the Interior, Secretary of the Interior
Jim Abbott, Bureau of Land Management, Acting State Director
Teri Rami, Bureau of Land Management, California Desert District Manager
Daniel Steward, Bureau of Land Management, El Centro
Brian Turner, National Trust for Historic Preservation, Regional Attorney, Western Office
Jim Bartel, Fish and Wildlife, Field Supervisor
Michelle Mattson, US Army Corps of Engineers
Nancy Brown, Advisory Council on Historic Preservation
Chris Meyer, California Energy Commission Project Manager
Wayne Donaldson, California State Historic Preservation Officer
Dave Singleton, Native American Heritage Commission

498-Z

Imperial Valley Solar Project Draft PA (3/26/10)

ACHP Comments

5/13/10

Please consider these our preliminary comments on the draft. One of our staff archaeologists is reviewing the document and we will provide more substantive comments after he returns from travel and completes his review.

General Comments

The BLM needs to better describe the process it plans to follow for Section III. Identification and Evaluation and Section IV. Treatment of Historic Properties (for both Historic Property Treatment Plan and Historic Property Management Plan). BLM also needs to develop a clearer consultation process for these sections. BLM should clarify that per the regulations the federal agency identifies and evaluates historic properties in III, but lay out a process for Indian tribes and other consulting parties to participate in identification and evaluation, the HPTP, and HPMP.

Also, to the degree possible, BLM should consult with all the parties to avoid, minimize, and mitigate the currently known adverse effects on specific historic properties within this PA. That work can later be referenced in the HPTP when it is developed.

Clarify the use of cultural resources v. historic properties. While I understand your interest in using cultural resources to capture them all, whether or not they are eligible for the National Register, it is confusing when in Section III.(a) line 283 you discuss evaluating cultural resources for National Register status. Also, use consistent terms for traditional cultural properties (line 680), as this is defined by the National Register, and not traditional cultural places (line 678).

Revise to eliminate the passive voice and make clear who will be responsible for each action. For example, Section XII.(b) line 527 should start with something like: The BLM shall initiate a review of this Agreement...

Specific Comments

The whereas clause starting on line 183 includes too much information. I recommend breaking this into several clauses, such as one to define federal responsibilities to the tribes, one to identify consultation parties for this undertaking that names the tribes and states they will be invited as Concurring Parties, and one that describes the on-going tribal consultation process.

The Now, Therefore statement seems overly cumbersome and it is not clear what "to the extent of their respective legal authorities" means. ACHP's model states: Now, Therefore, [list abbreviations for Signatories] agree that the undertaking shall be implemented in accordance with the following

stipulations in order to take into account the effect of the undertaking on historic properties. If you want to also list Invited Signatories, you can do that.

Under Section I. Definitions, include historic properties, Signatories, Invited Signatories, Concurring Parties, consulting parties, and traditional cultural properties as these are used and/or defined elsewhere in the PA.

Under Section II. Area of Potential Effect, (a)(ii) addresses indirect effects. Does this mean that (a)(i) only addresses direct effects? Also, indirect effects should be defined. II.(b) says BLM shall consult with/notify the Signatories and appropriate Invited Signatories. BLM should treat Invited Signatories consistently, and not make decisions about which ones are appropriate in each situation. II.(b)(iv) refers disputes to Stipulation XI, but it should be IX.

Under Section III. Identification and Evaluation, BLM should describe the process it anticipates in (b) for changing the identification and evaluation process, as well as state that changes to the appendices will not require the PA to be amended.

Section IV. Treatment of Historic Properties refers to the Historic Property Treatment Plan but not the Historic Property Management Plan. The reference to Appendix B includes both.

Under Section V. Standards and Qualification, broaden the areas of expertise to include ethnography and historical landscape architects, since sites of religious and cultural significance and landscapes are included in the definition of cultural resource.

Under Section VI. Reporting Requirements, in (b) BLM should state a minimum number of parties that will receive the final report and drop "as appropriate." In (c) clarify line 381 regarding other consulting and concurring parties. Concurring parties are consulting parties.

Under Section VII. Implementation of the Undertaking (a)(3) should use parallel construction so that the sentence reads: such as grading, constructing buildings, and installing SunCatchers.

Under Section VIII. Amendments to the Agreement delete the wording "at the conclusion of the consultation period, or before if agreement on the amendment is reached" and simplify to something like: The agreement may be amended when such an amendment is agreed to in writing by all Signatories.

Under Section X. Termination, (a) should include Invited Signatories, as per the regulations they have the right to terminate an agreement. Delete them from (b). Add SHPO to (d), as they can also terminate.

Under Section XI. Withdrawal or Addition of Parties from/to the Agreement, delete Invited Signatories as they can terminate the agreement, not just their participation.

Under Section XII. Duration of this Agreement, (a) and (c) seem to contradict each other. In (a) it says the agreement expires in 5 years, (c) says the agreement is in effect for the life of the ROW grant and that Signatories and Invited Signatories will review the agreement every 10 years.

In Appendix A Section II.(b) rewrite the run-on sentence as the meaning is currently unclear. State somewhere in Appendix A that direct, indirect, and cumulative effects will be considered at all phases of the identification and evaluation. Spell out CRHR at the first use of the acronym. Use traditional cultural properties (line 680), and not traditional cultural places (line 678).

Under Appendix B, in Section I.(a)(ii) line 792 clarify what is meant by "individually specify how the Applicant will avoid, minimize, or resolve [sic] the adverse effects." Also reword to "avoid, minimize, or mitigate." In Section I.(d) line 851 drop the reference to the Council's Treatment of Archaeological Properties (1980) and add a reference to the ACHP's online archaeological guidance at http://www.achp.gov/archguide/. On line 900 write out HABS/HAER and add HALS. Also add that before this documentation is started, people need to check with NPS regarding the level of documentation. On line 955 add that the Applicant will submit the training program to BLM and SHPO for review. On line 964 define workers as anyone coming on the site as an employee, contractor, or subcontractors, or in any other capacity to complete work for the Applicant.

~~PROGRAMMATIC AGREEMENT~~
~~AMONG THE~~
~~BUREAU OF LAND MANAGEMENT-CALIFORNIA,~~
~~THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,~~
~~THE ADVISORY COUNCIL ON HISTORIC PRESERVATION,~~
~~THE UNITED STATES ARMY CORPS OF ENGINEERS,~~
~~THE NATIONAL PARK SERVICE,~~
~~THE CALIFORNIA ENERGY COMMISSION,~~
~~AND THE TESSERA SOLAR COMPANY,~~
~~REGARDING THE TESSERA SOLAR - IMPERIAL VALLEY SOLAR PROJECT, IMPERIAL COUNTY, CALIFORNIA~~

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~~INDEX (to be completed as document evolves)~~

~~INTRODUCTION~~

~~PROJECT DESCRIPTION~~

~~PROGRAMMATIC AGREEMENT~~

~~APPENDIX A: IDENTIFICATION AND EVALUTION~~

~~APPENDIX B: HISTORIC PROPERTIES TREATMENT PLAN AND HISTORIC PROPERTIES MANAGEMENT PLAN~~

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~~INTRODUCTION~~

~~The intent of this Programmatic Agreement (Agreement) is to provide processes whereby the Bureau of Land Management (BLM) and the California Energy Commission (Energy Commission), in consultation with the California State Historic Preservation Officer, the Advisory Council on Historic Preservation, Indian Tribes and other consulting parties, shall determine the steps the agencies shall follow to take into account effects on historic properties as required by section 106 of the National Historic Preservation Act and satisfy the requirements of the California Environmental Quality Act.~~

~~The Energy Commission and the BLM, in consultation with the consulting parties to this Agreement, will consider and incorporate within the section 106 consultation process the mitigation measures and performance standards of the *Staff Assessment and Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project, Application for Certification (08-AFC-5) Imperial County (2010)* as adopted by the Energy Commission and the BLM in any decision to permit the Imperial Valley Solar Project. The BLM and the Energy Commission will endeavor to make the historic properties management provisions of this Agreement as consistent as possible with the objectives and terms of the Supplemental Staff Assessment/Final Environmental Impact Statement.~~

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~~Government agencies, consulting parties, and the public identified in the scoping and public notification process for Staff Assessment/Environmental Impact Statement will be advised in the Supplemental Staff Assessment/Final Environmental Impact Statement that historic properties associated with the undertaking would be treated consistent with the mitigation measures or performance standards identified in the final Supplemental Staff Assessment/Final Environmental Impact Statement and adopted by the agencies, and consistent with the stipulations of this Agreement. A proposed final draft of this Agreement will be circulated for public comment as an attachment to the Final Supplemental Staff Assessment/Final Environmental Impact Statement. The Signatories have consulted with the Invited Signatories and Concurring Parties to this Agreement, and have taken into consideration applicable public comments, if any, received regarding the draft Agreement in preparing this final Agreement. Additionally, the BLM has made written requests to Indian Tribes to provide comments regarding the proposed final draft Agreement and has consulted with the other Signatories and Invited Signatories to take into consideration applicable comments received from the Indian Tribes in making this final Agreement.~~

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~~**PROJECT DESCRIPTION**~~

~~a)The proposed undertaking includes the following components:~~

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~~i)The Imperial Valley Solar Project would consist of a solar thermal power plant facility approximately 14 facility approximately 14 miles west of El Centro, California in Imperial County. The proposed project proposed project would be constructed in two phases utilizing SunCatcher (Sterling Engine) technology, technology, and would include approximately 30,000 25 kilowatt (kW) solar power dishes with a generating capacity of approximately 750 megawatts (MW).~~

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~~(1)The first phase would consist of up to 12,000 SunCatchers configured in arrays of 200 1.5 mW solar groups (60 SunCatchers/1.5 MW group) with a generating capacity of about 300 MW.~~

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~~(2)The second phase would consist of approximately 18,000 SunCatchers configured in 500 1.5 MW groups (60 SunCatchers/1.5 MW group) with a net generating capacity of 450 MW.~~

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~~ii)Each SunCatcher system consists of a 38x40 foot wide solar concentrator dish that supports an array of curved glass mirror facets designed to automatically track the sun and focus solar energy onto a Power Conversion Unit which generates electricity.~~

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~~iii)Related structures include a main services complex, assembly buildings, a 230 kilovolts (kV) electrical substation, a ten (10) mile transmission line, access roads, supply water line, and a ten (10) mile 230 kV transmission line from the project site to the existing substation.~~

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~~iv)The project would be located on approximately 6,500 acres of land, including approximately 6,180 acres of public land administered by the Bureau of Land Management and 320 acres of privately owned land.~~

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~~v)An off-site 6-inch-diameter water supply pipeline will be constructed a distance of approximately 12 miles from the Seeley Water Treatment Plant to the project boundary.~~

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~~vi)An off-site double-circuit generation interconnection transmission line will be constructed a distance of approximately 10 miles to connect the Imperial Valley Solar Project to the San Diego Gas and Electric Electric Imperial Valley Substation.~~

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~~vii)A site access road will be constructed from Dunaway Road to the eastern boundary of the project site and generally follow an existing road.~~

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PROGRAMMATIC AGREEMENT
AMONG THE
BUREAU OF LAND MANAGEMENT-CALIFORNIA,
THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,
THE ADVISORY COUNCIL ON HISTORIC PRESERVATION,
THE UNITED STATES ARMY CORPS OF ENGINEERS,
~~THE NATIONAL PARK SERVICE,~~
THE CALIFORNIA ENERGY COMMISSION,
AND THE TESSERA SOLAR COMPANY,
REGARDING THE TESSERA SOLAR - IMPERIAL VALLEY SOLAR PROJECT,
IMPERIAL COUNTY, CALIFORNIA

WHEREAS, ~~Tessera Solar (Applicant) has applied~~the Bureau of Land Management (BLM) and the U.S. Army Corps of Engineers (COE) have determined that issuing~~for~~ a right of way (ROW) and permit, respectively, ~~grant on public lands managed by the Bureau of Land Management (BLM) and proposes to~~allowing or facilitating the construction, operateion and ~~maintain~~ maintenance of a solar energy electrical generating facility (hereinafter referred to as the Imperial Valley Solar Project or Project~~, or "the undertaking"~~) to generate power, including construction of associated transmission lines and other facilities and infrastructure ~~in accordance with the Federal Land Policy and Management Act (FLPMA) (Public Law 940-579; 43 USC 1701) and the BLM pursuant to 36 CFR 800.2(a) has determined that the Imperial Valley Solar Project is~~ constitutes an "undertaking" as defined at 36 C.F.R § 800.16(y); and

~~**WHEREAS,** in August 2005, the United States Congress enacted the Energy Policy Act of 2005 (Public Law 109-58). In section 211 of this Act, Congress directed that the Secretary of the Interior (the "Secretary") should, before the end of the 10-year period beginning on the date of enactment of the Act, seek to have approved non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity; and~~

~~**WHEREAS,** by Secretarial Order No. 3285 issued March 11, 2009, the Secretary stated as policy that encouraging the production, development, and delivery of renewable energy is one of the Department of Interior's (DOI) highest priorities and that agencies and bureaus within the DOI will work collaboratively with each other, and with other Federal agencies, departments, states, local communities, and private landowners to encourage the timely and responsible development of renewable energy and associated transmission while protecting and enhancing the Nation's water, wildlife, and other natural resources; and~~

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WHEREAS, in February 2009, the United States Congress enacted the American Reinvestment and Recovery Act of 2009 (ARRA)(Public Law 111-5) for the purpose of expanding the use of clean and renewable energy. In section 1603 of this Act, Congress appropriated funds for payments to reimburse eligible applicants for a portion of expenses who place in service specified energy properties during 2009 or 2010, and the Applicant has notified BLM that it intends to apply for such funds; and

WHEREAS, historic properties and cultural resources on public lands administered by the BLM are managed according to the National Historic Preservation Act (NHPA) (P.L. 89-665, as amended) as amended, Archaeological Resources Protection Act (ARPA)(P.L. 96-95, as amended), National Environmental Policy Act (NEPA)(P.L. 91-190, as amended), American Indian Religious Freedom Act (AIRFA)(P.L. 95-341, as amended), and Native American Graves Protection and Repatriation Act (NAGPRA)(P.L. 101-601), applicable regulations (e.g., 36 C.F.R. Parts 60, 63, 296, and 800; 43 C.F.R. Part 10), and applicable Executive Orders (e.g., 13007, 13175, and 13287), and these have been considered during consultation for this Programmatic Agreement (Agreement); and

WHEREAS, the BLM and COE- have consulted with the California State Historic Preservation Officer (SHPO), pursuant to 36 C.F.R. § 800.14(b)(3) about this undertaking and have notified and invited the Advisory Council on Historic Preservation (ACHP) per 36 C.F.R. § 800.6(a)(1)(C) to participate in consultation to resolve the potential effects of the undertaking on h~~H~~istoric p~~P~~roperties; and

WHEREAS, the BLM is the lead Federal agency for the undertaking for the purpose of complying with Section 106 of the NHPA and its implementing regulations found at 36 CFR Part 800, and the BLM shall be responsible for managing historic properties within the Area of Potential Effects (APE) for the undertaking pursuant to the NHPA; and

WHEREAS, BLM has consulted with the California State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP), pursuant to 36 CFR 800.14(b)(3) and following the procedures outlined at 36 CFR 800.6, and is in the process of considering different alternatives for the undertaking that may have the potential to adversely affect historic properties and may reach a decision regarding approval of the undertaking before the effects of the undertaking's implementation on historic properties have been fully determined, the BLM chooses to continue its assessment of the undertaking's potential adverse effect and resolve any such effect through the implementation of this Programmatic Agreement (Agreement); and

WHEREAS, the California Energy Commission (Energy Commission) shall be responsible for managing all historical resources within the APE for the Project pursuant to the California Environmental Quality Act (CEQA; California Public Resources Code, Division 13, Sections 21000–21177, as amended) on lands outside public lands, and the Energy Commission shall consult with the BLM as the lead federal agency regarding the management of historic~~al~~ properties~~resources~~ on public lands; and

WHEREAS the BLM and the COE in consultation with the SHPO have determined that a phased approach for compliance with NHPA Section 106 is appropriate for the undertaking

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because all effects of the undertaking on historic properties cannot be known prior to the approval of the Project (36 C.F.R. § 800.14(b)(1)(ii)) and there is the potential to encounter unanticipated historic properties during the life of the Project (36 C.F.R. § 800.13(a)(1)), and that the completion of the identification of historic properties, determinations of specific effects on historic properties, and consultation concerning measures to avoid, minimize, or mitigate any adverse effects will be carried out as part of planning for and prior to implementing any specific Project activities that have the potential to cause adverse effects on historic properties; and

WHEREAS, the BLM may grant a ROW for the Project on BLM administered lands pursuant to the Federal Land Policy and Management Act (P.L. 94-579) of 1976, as amended, which statute authorizes the BLM to permit the occupancy, use, or traversing of National Forest lands for generation, transmission, and distribution of electrical power; and

WHEREAS, the COE may issue permits for portions of the Project pursuant to Section 404 of the Clean Water Act (CWA), and the COE has participated in this consultation and is a Signatory to this Agreement; and

~~**WHEREAS**, the BLM, in consultation with the SHPO and the ACHP and pursuant to 36 CFR 800.4(b)(2), has determined that a phased (tiered) process for compliance with section 106 of the National Historic Preservation Act (NHPA) is appropriate for the undertaking, such that completion of the identification of historic properties, determinations of specific effects on historic properties, and consultation concerning measures to avoid, minimize, or mitigate any adverse effects will be carried out as part of planning for and prior to any Notice to Proceed and for any specific project implementation; and~~

WHEREAS, the Juan Bautista de Anza National Historic Trail ~~and jurisdictional waters as defined by Section 404 of the Clean Water Act are~~is located within the APE for this undertaking and the National Park Service (NPS) ~~and the U.S. Army Corps of Engineers (Corps)~~ intends to use this Agreement to comply with section 106 of the NHPA~~, and~~ haves ~~agreed to~~ participated in this~~e section 106~~ consultation, and is an ~~regarding the undertaking under the terms of this Agreement and are~~ Invited ~~Signatories~~ Signatory to this Agreement; and

WHEREAS, the Energy Commission is the lead State agency for compliance with the CEQA and has certain responsibilities under State laws and regulations to take into account and mitigate the effects of this Project on historical resources eligible for or included on the California Register of Historical Resources (CRHR) and is coordinating compliance with State law with federal agency responsibilities to comply with Section 106 of the NHPA, and has participated in this consultation and is an Invited Signatory to this Agreement; and

~~**WHEREAS**, the California Energy Commission (Energy Commission), may certify the Imperial Valley Solar Project located on both public and private lands pursuant to Section 25519, subsection (c) of the Warren-Alquist Act of 1974 and for the purposes of consistency proposes to manage all historical resources in accordance with the stipulations of this Agreement; and~~

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WHEREAS, the BLM and the Energy Commission have prepared the *Final Supplemental Staff Assessment and Draft Final Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project, Application for Certification (08-AFC-5) Imperial County (2010)* to identify the general alternatives for purposes of the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and have comparatively examined the relative effects of the alternatives on known historic properties; and

WHEREAS, the ApplicantTessera Solar Company, as grantee of the proposed ROW, hashas participated in this consultation per 36 C.F.R. § 800.2(c)(4), will be the entity to whom the BLM grants a ROW and the COE issues a permit related to Project activities, and and shall provide will have the responsibility for carrying out specific terms of this Agreement, all cultural resources documentation required by the BLM in support of the stipulations to this Aagreement and is willing to carry out the stipulations of this Agreement under the oversight of BLM, and is an Invited Signatory to this Agreement; andso therefore Tessera Solar Company (Applicant) is an Invited Signatory to this Agreement; and

WHEREAS, pursuant to section 101(d)(6)(B) of the NHPA, 36 C.F.R. § 800.2(c)(2)(ii), the American Indian Religious Freedom Act (AIRFA), Executive Order 13175, and section 3(c) of the Native American Graves Protection and Repatriation Act (NAGPRA), the BLM is responsible for government-to-government consultation with Federally recognized Indian Tribes and is the lead Federal agency for all Native American consultation and coordination, and has formally notified and invited the Campo Kumeyaay Nation, the Cocopah Indian Tribe, the Quechan Indian Tribe, the Ewiiaapaayp Band of Kumeyaay Indians, the Jamul Indian Village, the Kwaaymii Laguna Band of Indians, the La Posta Band of Kumeyaay Indians, the Manzanita Band of Kumeyaay Indians, the San Pasqual Band of Diegueno Indians, and the Santa Ysabel Band of Diegueno Indians (Tribes), and the Ah-Mut Pipa Foundation and Kumeyaay Cultural Repatriation Committee (Tribal Organizations) to consult on this undertaking and participate in this Agreement as a Concurring Party, with the further understanding that, notwithstanding any decision by these Tribes or Tribal Organizations to not participate in this Agreement, BLM shall continue to consult with these Tribes and Tribal Organizations throughout the implementation of this Agreement regarding the potential effects on historic properties to which they attach religious and cultural significance. Through consultation, Tribes and Tribal Organizations have expressed their views and concerns about the importance and sensitivity of cultural resources within and near the project area and attach significance to the broader cultural landscape; and

WHEREAS, the National Trust for Historic Preservation, the Anza Society, the California Unions for Reliable Energy, and the Sacred Lands Institute, as organizations, and Edie Harmon and Greg Smestad as individuals, have been invited to consult on this undertaking and this Agreement, have been afforded consulting party status pursuant to 36 C.F.R. § 800.4, and have been invited to be Concurring Parties to this Agreement; and

NOW, THEREFORE, the BLM, the COE, the SHPO, and the ACHP (hereinafter "Signatories") and the NPS, the U.S. Army Corps of Engineers, the Energy Commission, and the Applicant (hereinafter "Invited Signatories"), agree that the Signatories and Invited Signatories, to the extent of their respective legal authorities, shall ensureadminister the undertaking in accordance

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~~with~~ that the following stipulations to this Agreement are implemented to take into account the effects of the undertaking on historic properties ~~to satisfy the federal agencies' section 106 responsibilities for this undertaking~~.

STIPULATIONS

The Signatories and Invited Signatories~~BLM~~ shall ensure that the following ~~stipulations~~ measures are ~~carried out~~implemented.~~:~~

I. DEFINITIONS

The definitions found at 36 C.F.R. §800.16 apply throughout this A~~a~~greement except where another definition is offered in this Agreement.

a) ***Concurring P~~p~~arties***. Concurring Parties may propose amendments to this Agreement. Amendments proposed by Concurring Parties may be considered at the discretion of the Signatories.

~~a)~~b) ~~"~~***Cultural R~~r~~esource.e***~~" is a~~ A cultural resource is an object or definite location of human activity, occupation, or use identifiable through field inventory, historical documentation, or oral evidence. Cultural resources are prehistoric, historic, archaeological, or architectural sites, structures, buildings, places, or objects and definite locations of traditional cultural or religious importance to specified social and/or culture groups. Cultural resources include the entire spectrum of resources, from artifacts to cultural landscapes, without regard to eligibility for listing on the National Register of Historic Places (NRHP) or California Register of Historical Resources (CRHR).

~~a)~~

~~b)~~c) ~~"~~***Day***~~,"~~. S~~s~~ingular or plural~~,~~ refers to a calendar, rather than a business, day.

~~b)~~

d) ***Historic P~~p~~roperty***. Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the NRHP maintained by the Secretary of the Interior and per the eligibility criteria at 36 C.F.R. § 60.4. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the NRHP criteria. The term *eligible for inclusion in the National Register* includes both properties formally determined as such in accordance with regulations of the Secretary of the Interior and all other properties that meet the NRHP criteria.

e) ***Invited Signatories***. Invited Signatories to this Agreement are the National Park Service, Energy Commission and Applicant. Invited Signatories have specific responsibilities as defined in this Agreement and may propose amendments to this Agreement. Amendments proposed by Invited Signatories may be considered at the discretion of the Signatories.

f) ***Lands Administered by the U.S. Department of Interior, Bureau of Land Management*** (BLM) means any Federal lands under the administrative authority of the BLM.

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g) ***Lands Regulated by the U.S. Army Corps of Engineers*** means any lands subject to regulation by the COE pursuant to section 404 of the Clean Water Act (33 U.S.C. section 1344) or other law, and for which the COE has issued a Department of the Army permit.

~~e)~~h) ***Signatories.*** Signatories to this Agreement are the BLM, COE, SHPO, and ACHP. Signatories have the exclusive authority to amend or terminate this Agreement.

~~e)~~i) "***Tribes***" mean the federally recognized and non-federally recognized Indian Tribes that BLM has invited to consult on this undertaking and participate and concur in this Agreement.

~~e)~~

~~e)~~

i) ***Undertaking.*** Issuing any ROW/permit(s) individually or collectively by the BLM or COE allowing or facilitating construction, operation or maintenance activities related to the Project on BLM administered or COE regulated lands constitutes an "Undertaking" as defined at 36 C.F.R. § 800.16(y) and is the Undertaking addressed by this Agreement.

II. AREA OF POTENTIAL EFFECTS

~~a)The area of potential effects (APE) for the proposed undertaking is defined as follows:~~

~~i)~~a) Prior to and during construction of the ~~undertaking~~Project, the APE shall include all areas in which:

(1) Historic P~~p~~roperties could sustain direct effects as a result of the U~~u~~ndertaking and is defined to include:

~~(1)~~

~~(a)~~(i) All areas subject to the BLM's ROW decision for the Phase I 300 megawatt (M~~m~~~~Mw~~W) and the Phase II 450 M~~m~~W portions of the P~~p~~roject area and the Imperial Valley substation.

~~(a)~~

(ii) A 50-foot buffer on either side of the center line of any access road or other linear facility (100 foot corridor)~~The APE for linear elements of the undertaking~~, such as the water supply line.

~~(b) and the access road, is defined by a 50-foot buffer on either side of the center line of each linear facility (100 foot corridor).~~

(iii) A 150-foot buffer on either side of the center of the transmission line (300 foot corridor.~~The APE for the transmission line alignment is defined as~~

~~(c)a 150-foot buffer on either side of the center of the transmission line (300 foot corridor).~~

(iv) The entire area of COE-regulated lands associated with the Project plus a 100-foot-
wide buffer around all such lands.

~~ii)~~(2) Any area within which ~~h~~Historic ~~p~~Properties could sustain indirect effects as a result of the U~~U~~ndertaking.

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b) The APE encompasses an area sufficient to accommodate all of the proposed and alternative project components under consideration as of the date of the execution of this Agreement. If BLM determines in the future that unforeseen changes to the U~~u~~ndertaking may cause alterations in the character or use of H~~h~~istoric ~~p~~Properties, if any such properties exist, in a geographic area or areas beyond the extent of the original APE above, then the BLM, in consultation with the other Signatories, and ~~other~~ Invited Signatories as appropriate, shall modify the size of the APE using the process set forth ~~in stipulation~~ below.

~~i)~~(1) Any party to this A~~a~~greement may propose that the APE established hereunder be modified. The BLM shall notify the other Signatories and appropriate Invited Signatories of the proposal and consult for no more than 15 days to reach agreement on the proposal.

~~ii)~~(2) If the Signatories agree to the proposal, then the BLM will prepare a description and a map of the modification to which the Signatories agree. The BLM will keep copies of the description and the map on file for its administrative record and distribute copies of each to the other Signatories and Invited ~~s~~Signatories within 30 days of the day upon which agreement was reached.

~~iii)~~(3) Upon agreement to a modification to the APE that adds a new geographic area, the BLM shall follow the processes set forth in Stipulation III to identify and evaluate H~~h~~istoric P~~p~~roperties in the new APE, assess the effects of the U~~u~~ndertaking on any H~~h~~istoric ~~p~~Properties in the APE, and provide for the resolution of any adverse effects to such properties, known or subsequently discovered.

~~iv)~~(4) If the Signatories cannot agree to a proposal for the modification of the APE, then they will resolve the dispute in accordance with Stipulation X~~I~~.

III. IDENTIFICATION AND EVALUATION

a) The BLM ~~and the Energy Commission~~ shall ensure that cultural resources located within the APE are identified and evaluated for the NRHP ~~and the CRHR~~ pursuant to Appendix A of this Agreement.

b) Amendment of the identification and evaluation process as set forth hereunder will not require amendment of this Agreement if all Signatories do so agree.

IV. TREATMENT OF HISTORIC PROPERTIES

a) BLM shall ensure that a Historic Property Treatment Plan (HPTP), developed in accordance with Appendix B of this Agreement, is implemented and completed.

b) Amendment of the HPTP as set forth hereunder will not require amendment of this Agreement if all Signatories do so agree.

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V. DISCOVERIES AND UNANTICIPATED EFFECTS

a)If the BLM determines during implementation of the HPTP that either the HPTP or the Uundertaking will affect a previously unidentified property that may be eligible for the NRHP, or affect a known Hhistoric P-property in an unanticipated manner, the BLM will address the discovery or unanticipated effect in accordance with those provisions of the HPTP that relate to the treatment of discoveries and unanticipated effects. BLM at its discretion may hereunder assume any discovered property to be eligible for inclusion in the National Register. BLM compliance with this stipulation shall satisfy the requirements of 36 C.F.R. § 800.13(a)(2).

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VI. TREATMENT OF HUMAN REMAINS OF NATIVE AMERICAN ORIGIN

a) The parties to this Agreement agree that Native American burials and related items discovered on BLM-administered lands during implementation of the terms of the Agreement will be treated in accordance with the requirements of the NAGPRA. The BLM will consult with concerned Indian Tribes, Tribal Organizations, or individuals in accordance with the requirements of §§ 3(c) and 3(d) of the NAGPRA and implementing regulations found at 43 C.F.R. Part 10 to address the treatment of Native American burials and related cultural items that may be discovered during implementation of this Agreement.

a)b) The BLM shall ensure that Native American burials and related cultural items on private lands are treated in accordance with the requirements of §§ 5097.98 and 5097.991 of the California Public Resources Code, and § 7050.5(c) of the California Health and Human Safety Code.

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VII. STANDARDS AND QUALIFICATIONS

a) PROFESSIONAL QUALIFICATIONS. All actions prescribed by this Agreement that involve the identification, evaluation, analysis, recordation, treatment, monitoring, and disposition of hHistoric Pproperties and that involve the reporting and documentation of such actions in the form of reports, forms or other records, shall be carried out by or under the direct supervision of a person or persons meeting, at a minimum, the Secretary of the Interior's Professional Qualifications Standards (PQS) for archaeology, history, or architectural history, as appropriate (48 FR- 44739). However, nothing in this stipulation may be interpreted to preclude any party qualified under the terms of this paragraph from using the services of properly supervised persons who do not meet the PQS.

b) DOCUMENTATION STANDARDS. Reporting on and documenting the actions cited in Stipulation III and IV of this stipulation shall conform to every reasonable extent with the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (48 FR. 44716-44740), as well as, the BLM 8100 Manual, the California Office of Historic Preservation's Preservation Planning Bulletin Number 4(a) December 1989, Archaeological Resource Management Reports (ARMR): Recommended Contents and

Format (ARMR Guidelines) for the Preparation and Review of Archaeological Reports, and any specific county or local requirements or report formats as necessary.

c) CURATION STANDARDS. On BLM-administered land, all records and materials resulting from the actions cited in Stipulation III and IV of this Agreement shall be curated in accordance with 36 C.F.R. Part 79, and the provisions of the NAGPRA, 43 C.F.R. Part 10, as applicable. To the extent permitted under §§ 5097.98 and 5097.991 of the California Public Resources Code, the materials and records resulting from the actions cited in Stipulation III and IV of this Agreement for ~~non-federal~~private lands shall be curated in accordance with 36 C.F.R. Part 79. The BLM will seek to have the materials donated through a written donation agreement to be curated with other cultural materials. The BLM will attempt to have all collections curated at one location unless otherwise agreed to by the consulting parties. ~~Where Federal lands are involved, all records and materials resulting from the actions cited in Stipulation III and IV of this Agreement shall be curated in accordance with 36 CFR Part 79 and the provisions of the NAGPRA, 43 CFR Part 10, as applicable. Curation and disposition of cultural materials obtained from state-owned lands and records pertaining to cultural resources on state-owned lands will be curated with materials obtained from federal lands. If cultural materials are recovered from private lands, the BLM will seek to have the materials donated through a written donation agreement to be curated with other cultural materials. The BLM will attempt to have all collections curated at one location unless otherwise agreed to by the consulting parties.~~

VIII. REPORTING REQUIREMENTS

a) Within eighteen (18) months after the BLM, in consultation with the Energy Commission, has determined that all fieldwork required by Stipulation III and IV has been completed, the BLM will ensure preparation, and concurrent distribution to the consulting parties as appropriate a written draft report that documents the results of implementing the requirements of Stipulation III or IV. The reviewing parties will be afforded 30 days following receipt of the draft report to submit any written comments to the BLM. Failure of these parties to respond within this time frame shall not preclude the BLM from authorizing revisions to the draft report as the BLM may deem appropriate. The BLM will provide the reviewing parties with written documentation indicating whether and how the draft report will be modified in accordance with any reviewing party comments. Unless the reviewing parties object to this documentation in writing to the BLM within 14 days following receipt, the BLM may modify the draft report as the BLM may deem appropriate. All objections shall be resolved pursuant to Stipulation XI. Thereafter, the BLM may issue the report in final form and distribute this document in accordance with Stipulation VIII(b).

b) Copies of the final report documenting the results of implementing the requirements of Stipulation III or IV, will be distributed by the BLM to the other parties as appropriate and to the appropriate California Historical Resources Information Survey (CHRIS) Regional Information Center.

c) The BLM shall ensure that any draft document that communicates, in lay terms, the results of implementing the requirements of Stipulation III or IV, to members of the interested public,

is distributed for review and comment concurrently with and in the same manner as that prescribed for the draft technical report prescribed by Stipulation VIII(a). If the draft document prescribed hereunder is a publication such as a report or brochure, publication shall upon completion be distributed by the BLM to the other consulting parties and Ceoncurring Pparties, and to any other entity that the consulting parties and Ceoncurring Pparties through consultation may deem appropriate.

~~**IMPLEMENTATION OF THE UNDERTAKING**~~

~~**/BLM**alresources~~

~~a)The BLM may authorize project activities, including but not limited to those listed in Stipulation IX(a)(1-3), to proceed in specific geographic areas of the undertaking's APE where there are no historic properties, where there will be no effect to historic properties, and where a monitoring and inadvertent discovery plan has been executed according to Stipulation V . Such construction activities may include:~~

~~(1) the demarcation, set up, and use of staging areas for the project's construction,~~
~~(2) the conduct of geotechnical boring investigations or other geophysical and engineering activities, and~~
~~(3) construction activities such as grading, buildings, and installations of Sun Catchers.~~

~~e) Initiation of these activities on federal lands would not occur until a ROW and Notices to Proceed have been issued by the BLM.~~

~~X.~~IX. AMENDMENTS TO THE AGREEMENT

a) This Agreement may be amended only upon written agreement of the Signatories.

b) Any party to this Agreement may at any time propose amendments.

(1) Upon receipt of a request to amend this Agreement, the BLM will immediately notify the other consulting parties and initiate a 30 day period to consult on the proposed amendment, whereupon all parties shall consult to consider such amendments.

(2) At the conclusion of the consultation period, or before if agreement on the amendment is reached, the Agreement may be amended. If agreement to the amendment cannot be reached within the 30 day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation X~~I~~.

c) Any party to this Agreement may at any time propose modifications to the Appendices.

(1) Each Appendix to the Agreement may be individually modified without requiring amendment of the Agreement, unless the Signatories through such consultation decide otherwise.

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(2) Upon receipt of a request to modify an Appendix, BLM will immediately notify the Signatories and determine the appropriate Invited Signatories and Concurring Pparties to consult on the proposed modifications and initiate a 30 day consultation period, whereupon all parties shall consult to consider such modification.

(3) At the conclusion of the consultation period, or before if agreement on the modification is reached, the Appendix may be modified. If agreement on the modification cannot be reached within the 30 day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation XI(c).

(4) Modifications to an Appendix shall take effect on the date that they are executed by the Signatories.

d) Amendments to this Agreement shall take effect on the dates that they are fully executed by the Signatories.

e) If the Agreement is not amended through the above process, any Signatory to this Agreement may terminate its participation in the Agreement in accordance with Stipulation XII.

XI.X. DISPUTE RESOLUTION

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a) Should any of the Signatories or Invited Signatories to this Agreement object, at any time, to the manner in which the terms of this Agreement are implemented they will make the objection to the BLM. The BLM will immediately notify the other Signatories and Invited Signatories, request comments on the objection within 30 days, and then proceed to consult with the SHPO for a period of no more than 30 days to resolve the objection. The BLM will take any comments provided by the other Signatories and Invited Signatories into account. If the Signatories and Invited Signatories resolve the objection within the consultation period, the BLM may authorize the disputed action to proceed in accordance with the terms of such resolution.

b) If, at the end of the 30 day consultation period, the Signatories determine that the objection cannot be resolved through such consultation, the BLM will forward all documentation relevant to the objection to the ACHP pursuant to 36 C.F.R. § 800.2(b)(2). Any comments provided by the ACHP within 45 days after its receipt of all relevant documentation will be taken into account by the Signatories in reaching a final decision regarding the objection. The BLM shall have the authority per the NHPA to make the final decision resolving the objection if the objection pertains to Historic Properties in the APE affected by the undertaking. The BLM will notify the SHPO, COE, the ACHP, and Applicant in writing of its final decision within 14 days after it is rendered.

c) The Signatories' and Invited Signatories' responsibility to carry out all other actions under this Agreement that are not the subject of the objection will remain unchanged.

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d) At any time during implementation of the terms of this Agreement, should a written objection pertaining to the Agreement be raised by a Concurring Party, the BLM shall immediately notify the SHPO about the objection and take the objection into account. The SHPO may comment on the objection to the other Signatories and Invited Signatories. The BLM shall consult with the objecting party for a period of no more than 30 days from the date of the objection. Within 14 days following closure of consultation, the BLM will render a decision regarding the objection and notify all parties of its decision in writing. In reaching its final decision the BLM will take into account all comments from the parties regarding the objection. Any dispute pertaining to the NRHP eligibility of Cultural Resources covered by this Agreement will be addressed by the Signatories pursuant to 36 C.F.R. § 800.4(c)(2). The Signatories shall determine if Stipulation X(a) and X(b) shall be implemented to resolve a dispute regarding the eligibility of such Historic Properties or Cultural Resources.

e) Any consultation period for resolving an objection may be extended by unanimous consent of the Signatories for such period as the Signatories shall declare in writing.

~~a) Should the Signatories or Invited Signatories object at any time to the manner in which the terms of this Agreement are implemented, the BLM will immediately notify the other Signatories and Invited Signatories and initiate a 30 day period in which to resolve the objection.~~

~~b) If the objection can be resolved within the consultation period, the BLM may authorize the disputed action to proceed in accordance with the terms of such resolution.~~

~~c) If at the end of the 30 day consultation period, the objection cannot be resolved through such consultation, the BLM will forward all documentation relevant to the objection to the ACHP per 36 CFR 800.2(b)(2). Any comments provided by the ACHP within 30 days after its receipt of all relevant documentation will be taken into account by the BLM in reaching a final decision regarding the objection. The BLM will notify the Signatories, Invited Signatories, and Concurring Parties in writing of its final decision within 14 days after it is rendered.~~

~~d) The BLM's responsibility to carry out all other actions under this Agreement that are not the subject of the objection will remain unchanged.~~

~~e) At any time during implementation of the terms of this Agreement, should an objection pertaining to the Agreement be raised by a Concurring Pparty or a member of the interested public, the BLM shall immediately notify the Signatories, Invited Signatories, and other Concurring Pparties, consult with SHPO about the objection, and take the objection into account. The other consulting parties may comment on the objection to the BLM. The BLM shall consult with the objecting party(ies) for no more than 30 days. Within 14 days following closure of consultation, the BLM will render a decision regarding the objection and notify all parties of its decision in writing. In reaching its final decision, the BLM will take~~

~~into account all comments from the parties regarding the objection. The BLM shall have the authority to make the final decision resolving the objection. Any dispute pertaining to the NRHP eligibility of historic properties or cultural resources covered by this Aagreement will be addressed by the BLM per 36 CFR 800.4(c)(2).~~

~~XII.~~XI. TERMINATION

a) The Signatories have the sole authority to terminate this Agreement. If this Agreement is not amended as provided for in Stipulation IX, or if a Signatory proposes termination of this Agreement for other reasons, the Signatory proposing termination shall notify the other Signatories in writing, explain the reasons for proposing termination, and consult for no more than 60 days to resolve the objection.

b) If an Invited Signatory or a Concurring Pparty seeks termination of this Agreement, they shall notify the Signatories and Invited Signatories in writing, explain the reasons for proposing termination, and consult for no more than 60 days to resolve the objection.

c) Should consultation result in an agreement to resolve the objection, the Signatories shall proceed in accordance with that agreement.

d) Should such consultations fail, ~~the BLM and the ACHP may~~the Signatory proposing terminate~~e~~ion may terminate it participation in this Agreement by notifying the other parties in writing.

e) Should the entire~~is~~ Agreement be terminated, then the BLM and COE shall -either separately consult in accordance with 36 C.F.R. § 800.14(b) to develop a new agreement or request the comments of the ~~Council~~ACHP pursuant to 36 C.F.R. §§ 800.4-800.6.

f) Beginning with the date of termination, the BLM and COE shall ensure that until and unless a new agreement is executed for the actions covered by this Agreement, such undertakings shall be reviewed individually in accordance with 36 C.F.R. §§ 800.4-800.6.

~~XIII.~~XII. WITHDRAWAL OR ADDITION OF PARTIES FROM/TO THE AGREEMENT

a) The BLM will respond to any written request for consulting party or Invited Signatory status pursuant to 36 C.F.R. § 800.2 and 36 C.F.R. § 800.3(f).

~~i)~~b) Should an Invited Signatory or Concurring Pparty determine that its participation in the Uundertaking and this Agreement is no longer warranted, the party may withdraw from participation by informing the BLM of its intention to withdraw as soon as is practicable. The BLM shall inform the other consulting parties to this Agreement of the withdrawal.

~~ii)~~c) Should conditions of the Uundertaking change such that other state, federal, or tribal entities not already party to this agreement request to participate, the BLM will invite the new party to sign the Agreement and notify the other consulting parties.

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~~XIV.~~XIII. DURATION OF THIS AGREEMENT

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a) This Agreement will expire if the U~~u~~ndertaking or the stipulations of this Agreement have not been implemented within five (5) years from the date of its execution. At such time, and prior to work continuing on the undertaking, the BLM and COE shall either (a) execute a memorandum of agreement pursuant to 36 C.F.R. § 800.6, or (b) request, take into account, and respond to the comments of the ACHP under 36 C.F.R. § 800.7. Prior to such time, the BLM and COE may consult with the other consulting parties to reconsider the terms of the Agreement and amend it in accordance with Stipulation IX. The BLM and COE shall notify the Signatories as to the course of action ~~it~~ they will pursue within 30 days.

b) The terms of this Agreement shall be reviewed by the parties to this Agreement not later than five (5) years following the date of execution by the Signatories to determine if the Agreement has been fully implemented or should be extended, modified, or terminated. In the event of termination, BLM and COE will comply with Stipulation XI~~I~~(e) if ~~it~~ either determines that the U~~u~~ndertaking will proceed notwithstanding termination of this Agreement.

c) ~~This Agreement is in effect for the life of the ROW grant unless extended by written agreement of the Signatories.~~ This PA expires 25 years from its effective date unless extended by written agreement of the Signatories. The Signatories and Invited Signatories shall consult ~~every~~ at year 10 ~~years~~ to review this Agreement. Additionally, the Signatories and Invited Signatories shall consult not less than one year prior to the expiration date to reconsider the terms of this Agreement and, if acceptable, have the Signatories extend the term of this Agreement. Reconsideration may include continuation of the Agreement as originally executed or amended, or termination. Extensions are treated as amendments to the Agreement under Stipulation IX.

~~XV.~~XIV. EFFECTIVE DATE

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This Agreement and any amendments ~~shall~~will take effect on the date that it has been fully executed by the Signatories~~. Attachments to this Agreement shall take effect on the dates they are fully executed by the Signatories, or such other self-executing dates as may be described in those attachments.~~. The Agreement and any amendments thereto shall be executed in the following order: (1) Applicant, (2) Energy Commission, (3) NPS, (4) COE, (5) BLM, (6) SHPO, and (7) ACHP. Execution and implementation of this Agreement is evidence that the BLM and COE has taken into account the effect of all these activities on H~~h~~istoric P~~p~~roperties, and that the BLM and COE has satisfied their responsibilities under section 106 of the NHPA~~-~~. The Signatories and Invited Signatories to this PA represent that they have the authority to sign for and bind the entities on behalf of whom they sign.

~~b) EXECUTION AND IMPLEMENTATION OF THIS Agreement is evidence that BLM has afforded the ACHP a reasonable opportunity to comment on the undertaking and its effects~~

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~~on historic properties. The Signatories to this agreement represent that they have the authority to sign for and bind the entities on behalf of whom they sign.~~

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SIGNATORY PARTIES:

U.S. BUREAU OF LAND MANAGEMENT

BY:_____ DATE_____
James Wesley Abbot
State Director

U.S. ARMY CORPS OF ENGINEERS, LOS ANGELES DISTRICT

BY:_____ DATE_____
~~TITLE:~~ David J. Castanon
Chief, Regulatory Division

CALIFORNIA STATE HISTORIC PRESERVATION OFFICER

BY:_____ DATE_____
Milford Wayne Donaldson, FAIA
State Historic Preservation Officer

ADVISORY COUNCIL ON HISTORIC PRESERVATION

BY:_____ DATE_____
John Fowler
Executive Director

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INVITED SIGNATORIES:

CALIFORNIA ENERGY COMMISSION

BY: _____ DATE _____
TITLE: _____

~~U.S. ARMY CORPS OF ENGINEERS~~

~~BY: _____ DATE _____~~
~~TITLE: _____~~

TESSERA SOLAR ~~L.L.C.~~COMPANY

BY: _____ DATE _____
TITLE: _____

NATIONAL PARK SERVICE

BY: _____ DATE _____
TITLE: _____

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CONCURRING PARTIES:

(This is a potential list only)
~~NATIONAL PARK SERVICE~~
CALIFORNIA UNIONS FOR RELIABLE ENERGY
NATIONAL TRUST FOR HISTORIC PRESERVATION
ANZA SOCIETY
EDIE HARMON
SACRED LANDS INSTITUTE
GREG SMESTAD

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~~NATIONAL PARK SERVICE~~

~~BY: _____ DATE _____~~
~~TITLE: _____~~

CALIFORNIA UNIONS FOR RELIABLE ENERGY

BY: _____ DATE _____
TITLE: _____

NATIONAL TRUST FOR HISTORIC PRESERVATION

BY: _____ DATE _____
TITLE: _____

ANZA SOCIETY

BY: _____ DATE _____
TITLE: _____

EDIE HARMON

BY: _____ DATE _____
TITLE: _____

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APPENDIX A: IDENTIFICATION AND EVALUATION

I. IDENTIFICATION

a) The BLM, in consultation with the Energy Commission, has authorized the ~~proponent~~ Applicant to carry out specific identification efforts for this U~~u~~ndertaking including a literature search, a BLM Class III inventory, ethnographic studies, or any other studies necessary to identify historic properties that might be located within the APE. The BLM, in consultation with the Energy Commission, may require additional field investigations to ensure the accuracy of site recordation and to provide additional information to support site evaluations and the assessment of effects. The BLM, COE, and the Energy Commission, separately or together, have the right and the discretion, under this A~~a~~greement, to request additional field studies.

b) An inventory report (URS December 2009) has been submitted by the Applicant that includes 100 percent survey of the APE to the BLM, COE, and the Energy Commission and is currently under review. The BLM, COE, and Energy Commission~~agencies~~ will assess whether the report conforms with the field methodology and site description template required under BLM Fieldwork Authorization CA-670-06-07FA09 and Fieldwork Authorization CA-670-06-07FA10 and Energy Commission transaction number -Data Requests Set 2, Part 2 #142, Docket number 08-AFC-5. Based upon the outcome of that review additional fieldwork by the Applicant may be required.

Comment [TT2]: Please ensure the COE gets a copy.

c) The BLM will ensure that all C~~c~~ultural ~~r~~Resources identified during Class III inventories are recorded on new or updated California Department of Parks and Recreation Form DPR 523 (Series 1/95), using the "Instructions for Recording Historical Resources" (Office of Historic Preservation, March 1995). The C~~c~~ultural ~~r~~Resources contractor will obtain permanent site numbers from California Historical Resources Information System (CHRIS) regional information center. The BLM, in consultation with the Energy Commission, COE, and the SHPO, shall review all site records for accuracy, adequacy of information, and completeness and determine whether they are sufficient to support agency determinations and findings. Final approved site records shall be submitted to the CHRIS. Permanent site numbers shall then be used in all final reports and other documents prepared pursuant to the requirements of this Agreement.

d) The BLM shall consult with Tribes, Tribal organizations or tribal individuals to identify traditional cultural places that may exist in the APE.

e) Previously unknown traditional cultural properties identified during Class III inventories and/or through consultations with Tribes may be recorded on the DPR Form 523 for resources in California, unless a Tribe or an individual from a Tribe objects. If such objection arises, the properties may be recorded on a form and in a manner that is in accordance with the recommendations of the Tribe or of the individual. If the traditional cultural property is also a historic or archaeological site, those components of site will be recorded on the appropriate DPR form and filed with CHRIS.

f) The BLM, in consultation with the COE and Energy Commission, will ensure that the Class III inventory report is responsive to d~~D~~ata ~~R~~requests.

II. EVALUATION

a) Subsequent to the approval of the complete complement of Class III Reports for the present U~~u~~ndertaking and prior to the initiation of fieldwork to evaluate the historical significance of the C~~c~~eultural ~~r~~Resources in the APE, the Applicant shall submit an analysis of the C~~c~~eultural ~~r~~Resources that the Undertaking appears likely to affect, as defined at 36 C.F.R. ~~Part~~ § 800.16(i). The analysis shall detail which C~~c~~eultural ~~r~~Resources that the U~~u~~ndertaking appears to have no potential to affect, which C~~c~~eultural ~~r~~Resources the Applicant commits to avoiding through the implementation of formal avoidance measures, and which C~~c~~eultural ~~r~~Resources the Applicant believes will be adversely ~~subject to undertaking e~~affectsed by the U~~u~~ndertaking. Subsequent to the final approval of the analysis, the Applicant shall be responsible to formally notify the BLM, COE, and the Energy Commission of any changes in the design or implementation of the Undertaking that would alter the original results of that analysis.

b) The Applicant, subject to the approval of the BLM, COE, and the Energy Commission, may prepare the analysis referenced here in phases that represent discrete geographic portions of the APE, provided that analyses are ultimately prepared for 100 percent of the APE and provided that the Applicant does not initiate field investigations under this stipulation for geographic portions of the APE for which no such analysis has been prepared.

c) The BLM shall, evidencing consideration of the results of the analysis or analyses prepared under section 1 of this stipulation, authorize field investigations that the Applicant shall prepare and conduct in accordance with the evaluation protocols developed by the BLM and the Energy Commission in consideration of the site types (but not limited to) listed below for the purpose of evaluating the historical significance of the C~~c~~eultural ~~r~~Resources in the ~~Undertaking's~~ APE.

Prehistoric Archaeological Resources
Potential Lake Cahuilla Shoreline District
Chipped Stone Deposits
Sparse Lithic Scatters
Chipped and Ground Stone Deposits
Ceramic Deposits
Archaeological Deposits that Include FAR Concentrations
Trail Segments

Historical Archaeological Resources
Potential Early Twentieth Century Sand and Gravel Mining Landscape
Surveying Monuments
Historic Refuse Deposits

Pebble and Cobble Concentrations

Unique Archaeological Resources
Ethnographic Resources

~~d)Properties formally determined eligible for inclusion in the NRHP will be treated as eligible for the CRHR.~~

~~e)~~d) The parties to this agreement agree that isolated artifacts shall be considered not eligible for inclusion in the NRHP~~ or the CRHR~~.

i) Isolated artifacts are defined in accordance with the California Office of Historic Preserviation (~~-~~OHP) -----as three or less artifacts that do not constitute a feature.

~~f)~~c) Where avoidance of C~~c~~eultural ~~r~~Resources within the APE can be achieved through project design, the C~~c~~eultural ~~r~~Resources will remain unevaluated and BLM may treat the C~~c~~eultural R~~r~~esource as eligible for the NRHP for purpose of project management. If a C~~c~~eultural R~~r~~esource cannot be avoided it must be evaluated.

~~g)~~f) Prior to consultation with the SHPO on the eligibility of any C~~c~~eulturalR~~r~~esource in the APE for inclusion in the NRHP, the BLM shall seek the views and comments as appropriate from the consulting parties on any such determination that the BLM may propose.

~~h)~~g) The BLM shall consult with Indian Tribes and seek the views and comments of Tribal Organizations and individual tribal members regarding places to which they attach religious or cultural significance in order to ascertain the status of these places relative to NRHP ~~and CRHR~~ eligibility criteria.

~~i)~~h) Where the U~~u~~ndertaking may affect a C~~c~~eultural R~~r~~esource, the BLM shall apply the criteria of the NRHP and make a determination of eligibility pursuant to 36 C.F.R. § 800.4(c)(1). The BLM will submit to the SHPO its determinations of eligibility and the SHPO will have 30 days in which to review and comment. Absent comments within this time frame, ~~The~~ the BLM may assume, and formally document for the record, that the SHPO has elected not to comment and concurs with BLM's determinations. The determinations will serve as the basis for the development of the HPTP to resolve the effects of the U~~u~~ndertaking.

~~j)~~i) The BLM shall notify all consulting parties of the agency's determinations and make those available for public inspection.

~~k)If cultural resources are determined not included or eligible for inclusion on the NRHP but are eligible for the CRHR, the BLM will, at the direction of the Energy Commission, provide all relevant information to and consult with the Energy Commission. The Energy Commission will coordinate its review of all submittals with the Signatories, Invited Signatories, and the Applicant. The Energy Commission has the authority to make a final determination regarding a cultural resource's eligibility to the CRHR. The consulting~~

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~~federal agencies may decline to participate in this review by written notification to the Energy Commission.~~

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APPENDIX B: HISTORIC PROPERTIES TREATMENT PLAN AND HISTORIC PROPERTIES MANAGEMENT PLAN

I. HISTORIC PROPERTIES TREATMENT PLAN

a) Prior to the issuance of a Notice to Proceed by BLM related to the implementation of the U~~u~~ndertaking, with the exception of the process set out in Stipulation IX of the Agreement, the Applicant shall develop, in consultation with the BLM and other S~~s~~signatories, a HPTP that shall include but is not limited to:

i) A list of the Historic Properties, determined or treated as eligible for project management purposes, in the ~~u~~Undertaking's APE that the construction of the Project will unconditionally avoid;~~.~~

ii) individually specify how the Applicant will avoid, minimize, or resolve the adverse effects on particular Historic Properties~~.~~;

iii) Provide a plan for monitoring during construction, which would include the treatment of inadvertent discoveries and the participation of tribal cultural specialists. The following should be considered during development of these plans:

(a) qualifications archaeological monitors
(b) participation of tribal cultural specialists in monitoring
(c) areas in the APE requiring monitoring
(d) authority of monitors to halt work
(e) protective measures for historic properties
(f) communication protocols
(g) safety and resource training
(h) procedures upon discovery
(i) evaluation of the inadvertent discoveries
(j) implementation of standard treatment measures
(k) field protocol upon discovery of human remains

iv) The proposed disposition of recovered materials and records ~~which shall include a discussion of curation per~~shall be curated in accordance with Stipulation VII(c) ~~36 C.F.R. Part 79~~.

v) The procedures for treatment and disposition of any human remains, funerary objects, sacred objects, and objects of cultural patrimony in accordance with NAGPRA and the California Health and Safety Code 7050.5 as appropriate.

vi) A research design which addresses significant themes and questions for the types of H~~h~~istoric P~~p~~roperties to receive treatment.

vii) A schedule for completing treatment measures, including analysis, reporting and disposition of materials and records, as well as a schedule for completing the draft and final data recovery report(s).

viii) In consultation with the NPS and BLM's National Trail Office, provide a plan for treating effects to the Juan Bautista de Anza National Historic Trail corridor.

ix) A description of alternative treatments for adverse effects that are not data recovery and that may include (but is not limited to):

(1) Placement of construction within portions of H~~h~~istoric ~~p~~Properties that do not contribute to the qualities that make the resource eligible
(2) Deeding cemetery areas into open-space in perpetuity and providing the necessary long-term protection measures
(3) Public interpretation including the preparation of a public version of the Ceultural R~~r~~esources studies and/or education materials for local schools
(4) Access by tribes to traditional areas in property after the project has been constructed
(5) Support by Applicant to cultural centers in the preparation of interpretive displays
(6) Consideration of other off-site mitigation

b) The HPTP will be implemented after the ROW is granted by the BLM and issuance of a CWA section 404 permit by the Corps but prior to the issuance of a Notice to Proceed by BLM for construction in those portions of the Project addressed by the HPTP.

c) The BLM may authorize the phased implementation of the HPTP or if appropriate the development of individual Ceultural ~~r~~Resources, issue oriented, or geographically focused HPTP consistent with the stipulations in this section.

d) Any treatment plan tiered from this Agreement or the HPTP shall reflect the guidance provided in the ~~Council's~~ *ACHP's Treatment of Archaeological Properties (1980), Council's Recommended Approach for Consultation on Recovery of Significant Information from Archeological Sites* (1999), the BLM 8100 Manual, and the Secretary of the Interior's Standards for the Treatment of Historic Properties and will be focused on the treatment of the ~~Project~~ Undertaking's effects.

e) BLM shall submit the HPTP to all parties to this Agreement for a 30 day review period. Absent comments within this time frame, the BLM may finalize the HPTP. BLM will provide the parties with written documentation indicating whether and how the draft HPTP will be modified in response to any timely comments received. If the HPTP is revised in response to comments, the BLM shall submit the revised HPTP to all parties for a 15 day review period. Absent comments within this time frame, the BLM will finalize the HPTP. The BLM will provide the parties a copy of the final HPTP.

~~II.COORDINATION WITH CEQA~~

~~a)Guidelines for implementation codified in the California Code of Regulations (CCR), Title 14, Chapter 3, Sections 15000 et seq., requires state and local public agencies to identify the environmental impacts of proposed discretionary activities or projects, determine if the impacts will be significant, and identify alternatives and mitigation measures that will substantially reduce or eliminate significant impacts to the environment. Pursuant to section 15126.4(a)(1), feasible measures which could minimize adverse impacts must be described in the environmental assessment.~~

~~i)Section 15221(b) provides that because NEPA does not require separate discussion of mitigation measures, these points of analysis will need to be added, supplemented, or identified before the EIS can be used as an EIR.~~

~~ii)Section 15126.4(a)(1)(B) states that formulation of mitigation measures should not be deferred until some future time, but that measures may specify performance standards which would mitigate the significant effect of the project and which may be accomplished in more than one specified way.~~

~~(1)Performance standards for professional qualifications, documentation, and curation and provided at Stipulation VII of the Agreement. Performance standards for inventory and documentation are also provided in Appendix A(I)(e) (Identification and Evaluation) and Appendix B(I)(e) (Historic Properties Treatment Plan and Appendix B(III) (b) (Management Plans).~~

~~b)CEQA cultural mitigation measures and performance standards considered within the section 106 consultation process include, but are not limited to:~~

~~i)Avoidance [Provided for in Appendix A(I)(a)(i and ii) above]~~

~~(1)For cultural resources, the preferred method of mitigation is avoidance of all cultural resources wherever possible. Mitigation measures are normally developed to reduce impacts to significant cultural resources.~~

~~ii)Archaeological Data Recovery [Provided for in Appendix A(I)(a-e) above]~~

~~(1)When data recovery through excavation is the only feasible mitigation, a data recovery plan, which makes provision for adequately recovering the scientifically consequential information from and about the historical resource, shall be prepared and adopted prior to any excavation being undertaken.~~

~~(2)Data recovery shall not be required for an historical resource if the lead agency determines that testing or studies already completed have adequately recovered the scientifically consequential information from and about the archaeological or historical resource.~~

~~iii)Built Environment Resources~~

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~~(1)HABS/HAER Documentation (need to develop proposed mitigation measures/performance standard)~~

~~iv)Properties of Sacred or Cultural Significance to Indian Tribes~~

~~(1)Need to develop proposed mitigation measures/performance standard.~~

~~v)Discoveries~~

~~(1)Following the discovery of significant resources, the Applicant shall ensure that the designated cultural resources specialist prepares a research design and a scope of work for any necessary data recovery or additional mitigation. The Applicant shall submit the proposed research design and scope of work to the BLM and the Compliance Project Manager (CPM) for review and approval.~~

~~(2)The proposed research design and scope of work shall include (but not be limited to): a discussion of the methods to be used to recover additional information and any needed analysis to be conducted on recovered materials; a discussion of the research questions that the materials may address or answer by the data recovered from the project, and; discussion of possible results and findings.~~

~~vi)Monitoring~~

~~(1)Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, the Applicant shall provide the designated cultural resources specialist and the CPM with maps and/or drawings showing the footprint of the power plant and all linear facilities. Maps provided will include USGS 7.5-minute topographic quadrangle maps. If the designated cultural resource specialist requests enlargements or strip maps for linear facility routes, the Applicant shall provide them. If the footprint of the power plant or linear facilities changes, the Applicant shall provide maps and drawings reflecting these changes, to the cultural resources specialist within five days. Maps shall show the location of all areas where surface disturbance may be associated with project-related access roads and any other project components.~~

~~(2)The designated cultural resource specialist shall be available at all times to respond within 24 hours after pre-construction or construction activities have been halted due to the discovery of a cultural resource(s). The specialist or representative of the Applicant shall have the authority to halt or redirect construction activities if previously undiscovered cultural resource materials are encountered during vegetation clearance or earth disturbing activities or project site preparation or construction. If such resources are discovered, the designated cultural resource specialist shall be notified and the Applicant or Applicant's representative shall halt construction in the immediate area in order to protect the discovery from further damage; project construction may continue elsewhere on the project.~~

~~vii)Qualifications~~

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~~(1)Prior to the start of construction-related vegetation clearance, or earth-disturbing activities or project site preparation; or the movement or parking of heavy equipment onto or over the project surface, the Applicant shall provide the CPM with the name and statement of qualifications for its designated cultural resource specialist and alternate cultural resource specialist, if an alternate is proposed, who will be responsible for implementation of all cultural resources conditions of certification. The statement of qualifications for the designated cultural resource specialist and alternate shall include all information needed to demonstrate that the specialist meets at least the minimum qualifications specified by the National Park Service, Heritage Preservation Services.~~

~~(2)Training~~

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~~(a)Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, the designated cultural resource specialist shall prepare an employee training program. The Applicant shall submit the cultural resources training program for review and written approval. If a video is used as part of the training program, the owner shall submit the script review and written approval.~~

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~~(b)Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, and throughout the project construction period as needed for all new employees, the Applicant shall ensure that the designated cultural resource trainer(s) provide(s) approved cultural resources training to all project managers, construction supervisors, and workers. The Applicant shall ensure that the designated trainer provides the workers with the approved a set of procedures for reporting any sensitive resources that may be discovered during project-related ground disturbance. In addition, the Applicant shall communicate the work curtailment procedures that the workers are to follow if previously undiscovered cultural resources are encountered during construction.~~

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~~III.~~II. HISTORIC PROPERTIES MANAGEMENT PLAN

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a) A Historic Properties Management Plan (HPMP) will be developed to further manage or prescribe additional treatment to H~~h~~istoric ~~p~~Properties within the APE during the future operation, maintenance and decommissioning of the Imperial Valley Solar Project and consider effects to H~~h~~istoric ~~p~~Properties in relation to those actions.

b) The BLM shall submit the HPMP to the consulting parties to the Agreement for a 60 day review period. Absent comments within this time frame, the BLM may finalize the HPMP. The BLM will provide the parties with written documentation indicating whether and how the draft HPMP will be modified in response to any timely comments received. If the HPMP is revised in response to comments, the BLM shall submit the revised HPMP to all parties for a 30 day review period. Absent comments within this time

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frame, the BLM will finalize the HPMP. The BLM will provide the parties a copy of the final HPMP.

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QUECHAN INDIAN TRIBE
Ft. Yuma Indian Reservation

P.O. Box 1899
Yuma, Arizona 85366-1899
Phone (760) 572-0213
Fax (760) 572-2102

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EL CENTRO, CA

May 4, 2010

Carrie L. Simmons, Archaeologist
El Centro Field Office
Bureau of Land Management
1661 S. 4th Street
El Centro, CA 92243

Re: Comments on Draft Programmatic Agreement regarding Tessera Solar Imperial Valley Solar Project (formerly Solar Two)

Dear Ms. Simmons:

The Quechan Indian Tribe submits the following comments on the Draft Programmatic Agreement Regarding the Tessera Solar – Imperial Valley Solar Project ("Draft PA"). In summary, the Tribe believes that the Draft PA is inconsistent with the National Historic Preservation Act (NHPA) Section 106 process, and not adequate to evaluate and mitigate effects on cultural resources in and around the project area. The Draft PA defers a substantial majority of the Section 106 process, including all evaluation, treatment, and mitigation until after BLM has granted the right-of-way to the applicant. BLM has failed to adequately explain why a PA is necessary or appropriate here. The only apparent basis for deferring the evaluation of cultural resources, and development of an appropriate treatment plan, until after approval of the right-of-way is the artificial timeline imposed by the applicant.

I. The Draft PA Is Inconsistent With Section 106 of the NHPA.

Section 106 of the National Historic Preservation Act, 16 U.S.C. § 470f, requires that BLM "shall, *prior to the approval* of the expenditure of any Federal funds on the undertaking or *prior to the issuance of any license*, as the case may be, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register." (emphasis added). Only "nondestructive project planning activities may be completed before completing compliance with Section 106." 36 C.F.R. § 800.1(c). Similar to NEPA, the NHPA is designed to ensure that federal decision-makers thoroughly evaluate the impacts of their proposed actions on NHPA-eligible resources *prior to* taking action.

Prior to the approval of a federal undertaking, the federal agency must engage in a four-part process. First, the agency must identify the "historic properties" within the area of potential effects. 36 C.F.R. § 800.4. Second, the agency must evaluate the potential effects that the undertaking may have on historic properties. 36 C.F.R. § 800.5. Third, the agency must resolve the adverse effects through development of mitigation measures. 36 C.F.R. § 800.6. Fourth,

throughout all of these processes, BLM must consult with interested Indian tribes that might attach religious and cultural significance to properties within the area of potential effects. 36 C.F.R. §§ 800.3(f)(2); 800.4(a)(4); 800.5(c)(2)(iii); 800.6(a); 800.6(b)(2), etc.

Instead of completing this required process, BLM is opting to use a programmatic agreement to defer evaluation, mitigation, and treatment until after approval of the right-of-way. 36 C.F.R. § 800.14(b) authorizes the Advisory Council and the agency to negotiate programmatic agreements to govern programs, complex project situations, or multiple undertakings. 36 C.F.R. § 800.14(b)(1) specifies the circumstances under which a programmatic agreement may be used. None of those circumstances exist in this case. Nor does the Draft PA identify any element of 36 C.F.R. § 800.14(b)(1) that justifies the use of a PA here.

There is no reasonable basis to depart from the standard Section 106 process. There is no valid reason why the effects on historic properties cannot be fully determined prior to approval of this undertaking. The only apparent reason why BLM is choosing to use a programmatic agreement is to allow the applicant to obtain its right-of-way approval before the end of the calendar year, in an effort to qualify for federal funding. *See* Draft PA, p. 5. Absent this arbitrary deadline being imposed by the applicant, there is no reason to believe that BLM could not complete the standard Section 106 process before it makes its decision on right-of-way issuance.

To the extent that the Advisory Council regulations authorize the deferral of the Section 106 process until after approval of the undertaking, those regulations are inconsistent with the plain language of 16 U.S.C. § 470f and invalid. The statute is clear that the agency must consider the effect of its undertaking on historic properties prior to approval. *See Corridor H Alternatives, Inc., v. Slater*, 166 F.3d 368 (D.C. Cir. 1999) (rejecting agency's use of PA to defer Section 106 process until after issuance of ROD); *City of Alexandria v. Slater*, 198 F.3d 862 (D.C. Cir. 1999) (approving PA where agency only deferred identification of sites that might be impacted by small number of ancillary activities, and distinguishing from case where the entire Section 106 process is deferred). While the Advisory Council has discretion to determine how the effects on historic properties are evaluated, it does not have authority to permit the approval of undertakings prior to the completion of that evaluation. *Chevron v Natural Resources Defense Council, Inc.*, 467 U.S. 837 (1984) (ruling that the judiciary must reject administrative interpretations that are contrary to clear congressional intent).

In summary, this is not an appropriate case for use of a programmatic agreement. This case involves a straightforward proposal to issue a right-of-way on BLM lands for a single solar development project. There is no "program" at issue, no significant complexity, and no reason why the standard identification, evaluation, and resolution process cannot occur prior to approval of the undertaking. BLM must complete the cultural resource evaluation required by Section 106 prior to approving the right-of-way for this project.

II. BLM Has Not Fulfilled Its Government-to-Government or Section 106 Tribal Consultation Obligations.

The NHPA and the Advisory Council regulations contain detailed requirements for consultation with Indian tribes who attach religious and/or cultural significance to historic properties that may be affected by an undertaking. *See* NHPA, Section 101(d)(6)(B). This

consultation obligation applies "regardless of the location of the historic property." 36 C.F.R. § 800.2(c)(2)(ii). "The agency official shall ensure that consultation in the section 106 process provides the Indian tribe . . . a reasonable opportunity to identify its concerns about historic properties, including those of religious and cultural importance, articulate its views on the undertaking's effects on such properties, and participate in the resolution of adverse effects." 36 C.F.R. § 800.2(c)(2)(ii)(A). "Consultation should commence early in the planning process, in order to identify and discuss relevant preservation issues and resolve concerns about the confidentiality of information on historic properties." *Id.*

There are also several federal laws that mandate ongoing government-to-government consultation with Indian tribes where federally approved actions will affect tribal interests. *See* Executive Order 12875, Tribal Governance (Oct. 26, 1993) (the federal government must consult with Indian tribal governments on matters that significantly or uniquely affect tribal governments); Executive Order 12898, Environmental Justice (Feb. 11, 1994) (federal government must consult with tribal leaders on steps to ensure environmental justice requirements); Executive Order No. 13007, Sacred Sites (May 24, 1996) (federal government is obligated to accommodate access to and ceremonial use of Indian sacred sites by Indian religious practitioners, avoid adversely impacting the physical integrity of sites, and facilitate the identification of sacred sites by tribes); Executive Order No. 13084, Consultation and Coordination with Indian Tribal Governments (May 14, 1998) (places burden on federal government to obtain timely and meaningful input from tribes on matters that significantly or uniquely affect tribal communities); Executive Order 13175, Consultation with Indian Tribal Governments (Nov. 6, 2000) (the federal government shall seek to establish regular and meaningful consultation with tribes in the development of federal policies affecting tribes).

The Advisory Council regulations make it clear that consultation with interested tribes is to occur throughout the entire Section 106 process. 36 C.F.R. § 800.4(a)(4) requires BLM to consult with interested tribes "to assist in identifying properties, including those off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register." 36 C.F.R. § 800.5(a) requires BLM to consult with interested tribes when assessing adverse effects. 36 C.F.R. § 800.6(a) requires BLM to consult with interested tribes when developing and evaluating alternatives that could avoid, minimize, or mitigate adverse effects on historic properties.

Here, BLM has not complied with the tribal consultation regulations. Since BLM is proposing to defer the identification, evaluation, and impact mitigation until after it approves the right-of-way, the Quechan Tribe and other tribes are being deprived of their ability to provide meaningful input prior to BLM's decision. In addition, the Tribe has not yet received a final cultural resources report for this project, further impairing its ability to consult.

The tribal consultation provisions in the Draft PA are also inconsistent with the Advisory Council regulations. Appendix A, Section I(d) of the Draft PA requires BLM to consult with tribes to identify traditional cultural places within the APE. However, this is narrower than the regulations' requirement to consult for the purpose of identifying properties, "which may be of religious and cultural significance." 36 C.F.R. § 800.4(a)(4). Likewise, Appendix A, Section II of the Draft PA requires consultation with tribes in the resource evaluation phase, but only for the purpose of determining whether or not a resource is NRHP-eligible. In contrast, the ACHP

regulations also require consultation with tribes in the assessment of effects to the properties. 36 C.F.R. § 800.5(a). The Draft PA does not provide for this phase of tribal consultation.

Appendix B of the Draft PA requires the applicant to develop a Treatment Plan in consultation only with BLM and other *signatories* to the PA. Thus, if the Tribe does not sign the PA, it loses its right to consult on the resolution of adverse effects required by 36 C.F.R. § 800.6(a). BLM can not condition tribal consultation on execution of a PA that the Tribe objects to. If the Tribe declines to sign the PA, BLM and the applicant must still comply with the tribal consultation provisions in 36 C.F.R. § 800.6(a) and consult with the Tribe in development and implementation of the Treatment Plan. This should be made clear in the PA.

In summary, BLM has failed to comply with its tribal consultation obligations. In addition, the Draft PA does not provide for the level of tribal consultation required by the Advisory Council regulations. At minimum, the Draft PA should be revised to provide for tribal consultation in a manner consistent with 36 C.F.R. Part 800. No work should be authorized until tribal consultation on the evaluation and resolution of effects is completed

III. Specific Comments on Draft PA

As noted above, the Tribe believes that use of a programmatic agreement in this case violates both the letter and spirit of the NHPA by deferring evaluation and resolution of effects until after approval of the undertaking. In addition, the programmatic agreement is woefully inadequate in terms of specifying appropriate mitigation measures. The following are specific comments on the Draft PA:

- The Draft PA, page 3, states that BLM will incorporate the mitigation measures and performance standards from the Staff Assessment/Draft EIS ("SA/DEIS") for the SES Solar Two Project. However, the only Condition of Certification contained in the SA/DEIS is that the applicant shall comply with the terms of the programmatic agreement. In other words, the Draft PA and SA/DEIS simply cross-reference each other, but neither document provides any substantive mitigation measures or performance standards.

- The Draft PA, page 6, states that BLM has determined that a "phased (tiered) process for compliance with section 106 of the NHPA is appropriate for the undertaking." BLM fails to explain why a phased approach is appropriate in this case. Even if a phased approach was appropriate, there is no valid reason why BLM should not complete the Section 106 process for at least Phase I of the Project prior to approval of the undertaking. BLM is not just deferring evaluation of effects for Phase II of this Project, but is deferring the entire Section 106 process for all phases until after approval of the undertaking. This is not consistent with NHPA requirements.

- The Draft PA, page 6, asserts that BLM has "comparatively examined the relative effects of the alternatives [in the SA/DEIS] on known historic properties." However, there has not actually been any evaluation of the identified historic properties to date. The DEIS simply assumes that effects on cultural resources can be adequately mitigated through the PA, but the Draft PA lacks any actual mitigation measures or performance standards.

- The Draft PA, page 6, states that identification, determination of effects, and consultation on mitigation will occur prior to issuance of any "Notice to Proceed." This is misleading and inaccurate. Stipulation IX of the Draft PA, on page 11, confirms that BLM does intend to authorize construction activities while the Section 106 evaluations take place. Permitting construction to proceed prior to concluding the Section 106 process (including the identification and evaluation of affected resources) conflicts with clear language in the NHPA.

- The Draft PA, pages 6-7, notes BLM's obligation to consult with interested Indian tribes. To date, BLM has not formally consulted on a government-to-government basis with the Quechan Tribe. It would be inappropriate to sign the Draft PA prior to formal consultation with the Tribe. In addition, the Tribe's ability to meaningfully consult in this matter has been, and continues to be, impaired since it has not yet received any cultural resources report specifically identifying the resources discovered to date. The tribal consultation requirements of Section 106 and the ACHP regulations have not been complied with.

- The Draft PA, page 7, contains a definition of "cultural resource," but then fails to use that definition consistently throughout the document. The term "cultural resource" as defined on page 7 should be incorporated throughout the substantive terms of the agreement.

- The area of potential effects (APE) is coterminous with the project boundary. However, there are many other sensitive areas adjacent to the project area. It may be appropriate to broaden the APE to consider the indirect effects that this project will have on the adjacent areas. Further consultation with the Tribe is necessary on this issue.

- Stipulation VI discusses the need to treat Native American burials and related items discovered during implementation of the Agreement in compliance with NAGPRA. The Tribe is aware that cremation sites have been located in the project area, yet the Tribe has not been consulted or provided with specific information about the nature or extent of these cremation sites. The Tribe is very concerned with a ROD being issued until full identification and evaluation of cremation sites in compliance with NHPA and NAGPRA takes place.

- Stipulation VIII, on page 10, states that BLM will ensure preparation and distribution of a report to consulting parties that documents the results of implementing the evaluation and treatment plan efforts referenced in Stipulations III and IV. This report will be circulated within 18 months after all fieldwork required by Stipulations III "or" IV is complete. This stipulation should be modified to require the preparation of two reports; one that addresses evaluation of resources and a second that addresses treatment. The first report, which would document evaluation efforts, should be subject to comments of consulting parties and other interested Indian tribes prior to preparation of a treatment plan. The evaluation report would help inform development of the treatment plan. There should be consultation throughout the evaluation process, and throughout the development and implementation of the treatment plan.

- Stipulation IX authorizes BLM to commence "construction activities such as grading, buildings, and installation of Sun Catchers" prior to completion of the evaluation of resources and the development and implementation of a treatment plan. The Tribe objects to this as inconsistent with the requirements of the NHPA. BLM should not authorize any construction until the evaluation of resources, and development of a treatment plan, occurs.

- Stipulation XI discusses dispute resolution in the event there is disagreement about how the terms of the PA are being implemented. BLM's authority to revoke its right-of-way, or to impose additional conditions on the project for failure to comply with the PA, should be made clear in this section. If BLM proceeds with the PA, and defers the Section 106 process until after it issues the right-of-way, it must also retain the authority to revoke or condition the project in the event that the applicant violates the PA. The Draft PA does not contain clear language that ensures BLM will have authority to meaningfully enforce the terms of the Agreement.

- Stipulation XII discusses termination of the Agreement, but fails to clearly state that if the agreement is terminated, then the applicant must stop work on the project. Again, BLM is deferring the Section 106 process through the proposed agreement. Compliance with mitigation measures developed through the Section 106 process should be an express condition of the right-of-way approval. In other words, it should be clear both in the PA and in the ROD that termination of the PA, or other failure to comply with prescribed mitigation measures, means that work must stop pending full compliance with any unfulfilled obligations under the NHPA.

- Stipulation XIV is unclear. Section (a) states that the PA will expire if the undertaking or the Stipulations have not been performed within five years. "At such time," says the PA, the BLM shall either execute an MOA or request comments from the ACHP. Does this mean that the PA will change into an MOA at the end of the five year period? If the applicant fails to agree to the MOA, does this result in revocation of the right to continue with the undertaking? Section (b) then indicates that the undertaking may proceed even though the PA is terminated. This section should make it clear that, if the PA is terminated, all work must cease until the development of a new PA or MOA.

- Stipulation XV(b) states that execution and implementation of the PA is evidence that BLM has afforded the ACHP a reasonable opportunity to comment on the undertaking. However, even if this is true, implementation of the PA is not evidence that BLM has satisfied its consultation obligations to interested Indian tribes.

- Appendix A, Section I(b) states that an inventory report, containing 100% survey of the APE, has been submitted to BLM. The Tribe has not received a copy of that report from BLM, nor has it been consulted as to the contents of that report. This has limited the ability of the Tribe to effectively consult and comment in this process.

- Appendix A, Section I(d) states BLM shall consult with Tribes to identify traditional cultural places, but does not require this consultation to occur prior to issuance of the ROD. BLM is violating Section 106 and the Advisory Council regulations by failing to provide meaningful consultation with the Tribes prior to issuance of the ROD in this proceeding.

- Appendix A, Section II discusses evaluation of historic properties. The Tribe disagrees with the presumption in Section (e) that isolated artifacts may not be considered eligible under the NRHP. The Tribe also disagrees with Section (f), which states that cultural resources that can be "avoided" will not be evaluated. This is inconsistent with the NHPA and the Advisory Council Regulations. BLM must evaluate all of the identified cultural resources for NRHP eligibility. The mere fact that the project footprint will not directly damage a resource does not mean that a resource will not be affected by the development of the project. This is

especially true for resources that have cultural or religious significance to tribes, which can suffer impacts from the presence of adjacent commercial developments. Development activities may affect the cultural setting in which resources lie, even if the project does not directly impact them. Thus, all identified resources should be evaluated for NRHP eligibility. The Section 106 process is intended to inform BLM and the public of how sensitive a project area is. An analysis of how many eligible resources are located on the site should occur before any decision is made to permit the project.

- Appendix B states that the treatment plan will be developed among Signatory Parties. BLM cannot deprive the Tribe of its rights as a consulting party if the Tribe chooses not to be a signatory party. As discussed above, the regulations require consultation with the Tribe in the resolution of adverse effects, and the Draft PA should clarify that such consultation is required. No work should be authorized until resources are evaluated and the HPTP is completed.

In conclusion, the Tribe objects to the use of a programmatic agreement in this proceeding. The Section 106 process, and the evaluation of impacts to cultural resources is being arbitrarily rushed to the detriment of tribal input and protection of the resources. To the extent that a programmatic agreement is adopted, the current draft is inadequate and should be revised in accordance with the comments above. We look forward to continue working with BLM as this process continues. Please contact me if you have any questions.

Sincerely,

QUECHAN INDIAN TRIBE

Bridget Nash-Chrabascz
Quechan Tribe Historic Preservation Officer

cc: President Mike Jackson, Sr.
Vice-President Keeny Escalanti, Sr.
Members of the Quechan Tribal Council
Pauline Jose, Chairperson, Quechan Cultural Committee
Kenneth Salazar, Department of the Interior, Secretary of the Interior
Jim Abbott, Bureau of Land Management, Acting State Director
Teri Rami, Bureau of Land Management, California Desert District Manager
Daniel Steward, Bureau of Land Management, El Centro
Brian Turner, National Trust for Historic Preservation, Regional Attorney, Western Office
Jim Bartel, Fish and Wildlife, Field Supervisor
Michelle Mattson, US Army Corps of Engineers
Nancy Brown, Advisory Council on Historic Preservation
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Dave Singleton, Native American Heritage Commission

Sol Ideas Technology Development
From the desk of Greg P. Smestad, Ph.D.
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Monday, May 3, 2010

Ms. Carrie L. Simmons
Cultural Resources
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Bureau of Land Management
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Dear Ms. Simmons;

This letter is in response to your submission of the first draft for the Programmatic Agreement (PA) for the Imperial Valley Solar Project (listed as docket CEC #08-AFC-5 and formally known as the SES Solar Two Project). The letter dated February 10, 2010 from the U.S. Department of the Interior BLM El Centro Field Office informed me that my request for consulting party status was granted. This is likely based in part on the fact that I am a descendent of the Juan Bautista de Anza expedition of 1775/1776 and due to the fact that I have written the JUBA NHT trail guide for the NPS and have 20 years of experience in the fields of solar energy and environmental studies.

My formal comments on the first draft of the PA are therefore as follows:

On page 4, lines 77 and 90, it is mentioned that there will be a 10 mile transmission line. It is mentioned twice in section iii and once in section vi. This is perhaps redundant and should be clarified on this page. It should be clear how many transmission lines there are, their purpose, voltage and approximate length.

On page 7, line 202, where it lists my name, one should add my middle initial, "P." There are two other Greg Smestad's and I differentiate myself in other legal documents by my middle initial.

On page 18, line 617, put in Greg P. Smestad, Ph.D. Likewise on page 19 around line 648, or as appropriate, you can add my name, Greg P. Smestad, as well as the "By:" and include a line for a date and title analogous to the other people and organizations.

On page 21, near line 738 and 739, I would strongly recommend including under Historical Archaeological Resources a listing that conveys, "Indications of Trails or Paths", or "Signs of Historic Trails or Routes". This is because there is a distinct possibility that trails that have been used over many years might be detected from soil compactness or via remote sensing. Since the Anza expedition was utilizing Native American guides from the region, and elsewhere, and since the trails on many of the segments of the Anza trail were also Native American trails that were used for many hundreds - if not thousands - of years, the PA should be written in such as way that such tools and techniques (in conjunction with the historic diaries of the expedition) could be suggested in order to more accurately and precisely locate the historic route of the Anza trail within the corridor. This might allow its possible preservation while utilizing the surrounding areas for activities such as solar power production.

All other aspects of the draft (PA) are sufficient and I have no further comment at this point. Subsequent drafts may call to mind other aspects that might later warrant comment. Thank you for allowing me to participate in this part of the process. If you have any questions, please do not hesitate to contact me.

Sincerely,

Greg P. Smestad
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"Jill McCormick" <culturalres@cocopah.com>
05/13/2010 11:28 AM
To
<Carrie_Simmons@blm.gov>
cc

bcc

Subject
Tessera Solar PA

Carrie,
The council asked me to slightly change a little of the wording from what I sent you earlier this week. I have edited my earlier comments and have provided them below.

Overall, we feel this PA is very limiting, from the tribal perspective, in the language that is used and the lack of input from the tribes in the creation of the APE and the effects of the project to the location. Also, the lack of tribal consultation on the determination of effects and determinations of eligibility are troubling. Specifically, the Cocopah have given the BLM information on the importance of this location to the tribe. Mt. Signal has been pointed out as a significant location in the tribe's history, and I know the BLM has already been made aware of the importance of Coyote Mountain. Also, this location is known to have been a long-term habitation area for the Cocopah among various other tribes. The Cocopah have songs and stories that reference significant landforms and oral histories within the project area as well that indicate its importance to the tribe. It is highly disturbing that the BLM will not show respect to the human remains that are located in the project area and value the concerns of the tribes regarding the continuation of this process. I hope that the BLM will enlist the help of the ACHP to address these issues and address the concerns of the tribes regarding the PA and corresponding documents.

Thanks,
Jill

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May 7, 2010

Via Email and US Mail

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Re: **CURE Comments on the Draft Programmatic Agreement for the Imperial Valley Solar Project, Imperial County, CA**

Dear Ms. Simmons:

On behalf of the California Unions for Reliable Energy ("CURE"), this letter provides comments on the March 26, 2010 draft Programmatic Agreement ("PA") for the 6,500-acre Imperial Valley Solar Project, formerly SES Solar Two ("Project") in Imperial County, California. The Bureau of Land Management ("BLM") and California Energy Commission ("CEC") may not approve the Project or grant any permits for the Project until an adequate agreement document (e.g. programmatic agreement ("PA")) is fully executed pursuant to Section 106 of the National Historic Preservation Act ("NHPA") and circulated for public review and comment pursuant to 36 CFR 800.3(d).

The CEC and BLM's Staff Assessment/Draft Environmental Impact Statement (SA/DEIS) disclosed that a PA is to be the primary document that will set forth mitigation measures for impacts under the National Environmental Policy Act ("NEPA") and California Environmental Policy Act ("CEQA") and to resolve adverse effects under NHPA. As is explained more fully below, the BLM's draft PA does not comply with the statutory requirements or intent of NEPA, CEQA or NHPA.

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This comment letter has been prepared with the assistance of cultural resource expert, Claudia Nissley, whose qualifications were previously provided to the BLM and other agencies.

I. Introduction

CURE is a coalition of unions whose members help solve California's energy problems by building, maintaining, and operating conventional and renewable energy power plants. Poorly designed renewable energy power plants may degrade the environment by destroying historic resources and wildlife habitat areas, causing noise and visual intrusion, and polluting water and soil. CURE is concerned that the methods for cultural resource identification, avoidance and mitigation may result in harm to irreplaceable cultural resources without adequate consideration pursuant to the NHPA and that the methodology developed in this proceeding will set a precedent for future fast-track power plant proposals. Additionally, union members live in and around this community and have a direct interest in protecting cultural and other historic resources.

Once executed, the PA will govern the treatment of hundreds of cultural resources on the Project site. The Project, if approved, would be one of the largest solar power plants in the world. It will be built on the fragile Colorado Desert, resulting in loss of desert pavement, vegetation, wildlife and habitat that makes up the natural communities sacred to local tribes. Once disturbed, desert landscapes cannot be restored to their natural conditions; they are lost forever.

The surveys of the area of potential effect ("APE") for cultural resources have identified over 300 known prehistoric and historic surface archeological resources and an unknown number of buried archeological deposits. Known surface resources include human cremation sites, habitation sites, lithic scatters, trails, ceramic scatters, ground stone and ground features.

Additionally, the proposed Project wholly obstructs one of the most undisturbed portions of the Juan Bautista de Anza National Trail administered by the National Park Service. There are identified historic campsites within close proximity to the Project site and it is known that the Anza party camped on the Project site. There will be significant impacts to the trail and viewshed from the proposed Project. The access to this section of the trail will be completely eliminated and the camping and exploration of the section of the trail on the Project site will not be possible once the Project is approved.

Further, the proposed Project abuts the Yuha Basin Area of Critical Environmental Concern, an area containing both cultural resources and other properties eligible for listing in the National Register. The industrial landscape and operations of the proposed project will directly impact the context of the Area of Critical Environmental Concern including visual and aural impacts.

Tribal members and local Native Americans have described other non-archeological cultural resources within the project boundaries including biological resources on the Project site that are sacred to local tribes and the impacts of the Project on the viewshed of sacred areas on or near the Coyote Mountains.

The SA/DEIS disclosed that a PA is to be the primary document that will mitigate impacts under NEPA and CEQA, and to resolve adverse effects under NHPA. This comment will analyze the adequacy of the PA pursuant to standards under each of these regulatory frameworks.

II. Project Alternatives Have Not Been Adequately Inventoried to Enable Section 106 Consultation to Address Adverse Effects

While the Advisory Council's regulations allow for programmatic agreements at 36 CFR §800.14(b)(3), it is our understanding from the available documentation, including the SA/DEIS, LSA's Ground-Truth Report and additional information from meetings and emails, that close to 100% of affected lands have been inventoried for archeological resources. It is possible at this time for the BLM and consulting parties to predict fairly accurately many of the environmental impacts and the undertaking's adverse effects including direct, indirect and cumulative effects on cultural resources and historic properties as defined at 36 CFR § 800.16.

With this amount of information before the agencies, it is fractious that the BLM is even considering a PA that for all practicable purposes has one substantial sentence in it that calls for a Historic Properties Treatment Plan (HPTP) after the ROD has been issued. Any possible discussion among the federal agencies, tribes and other consulting parties in regard to development of a HPTP that may occur in the future after the preferred alternative has been selected will be unnecessarily limited to avoidance of specific localized archeological resources. <u>This precludes the opportunity to avoid impacts to culturally significant landscapes so as to preserve the sense of place and the characteristic elements of integrity, such as feeling,</u>

association and setting.[1] According to the Guidelines for Evaluating and Documenting Historic Aids to Navigation to the National Register of Historic Places, feeling is the quality that a historic property has in evoking the aesthetic or historic sense of a past period of time.[2] Association is the direct link between a property and the event or person for which the property is significant. Setting is the physical environment of a historic property that illustrates the character of the place.

The issuance of the ROD clearly restricts any subsequent consideration of alternatives that would reduce these effects. The most effective consultation and consideration of historic properties, which is what Section 106 requires, ought to occur now and before the Final EIS and ROD are issued. With over 300 archaeological sites identified, and the Juan de Anza National Historic Trail adversely affected, there is still an opportunity for the BLM to comply with the legal requirements of both NEPA and NHPA.

A PA is designed to "govern the implementation of a particular program or the resolution of adverse effects from certain complex project situations or multiple undertakings." 36 CFR § 800.14. This provision requires that the consultation using a PA shall follow the requirements listed in 36 CFR § 800.6 that direct an agency to consult with all parties to "evaluate alternatives or modifications to the undertaking that could avoid, minimize or mitigate adverse effects on historic properties." To date, the BLM has not consulted on the alternatives or modifications to the undertaking other than providing a bare explanation of the alternatives in the NEPA/CEQA document. Therefore, the BLM should immediately begin discussing the potential adverse effects (archeological and non-archeological) on cultural resources and methods for resolution of those effects with all consulting parties. In fact, the regulations direct the agencies to "consider their section 106 responsibilities as early as possible in the NEPA process, and plan their public participation, analysis and review in such a way that they can meet the purposes and requirements of both statutes in a timely and efficient manner." 36 CFR § 800.8.

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[1] The National Register traditionally recognizes a property's integrity through seven aspects or qualities: location, design, setting, materials, workmanship, feeling, and association.
[2] Guidelines for Evaluating and Documenting Historic Aids to Navigation to the National Register of Historic Places, Accessed at: www.nps.gov/history/nr/publications/bulletins/nrb34/nrb34_8.htm on 5/7/2009.

Although the BLM has substantial survey information from archeological surveys on the Project site, the BLM should begin seeking information about traditional, religious and cultural resources on or near the Project site through interviews with tribal members and knowledgeable individuals and entities. The definition of historic properties in the regulations is much broader than just archeological resources and includes properties of traditional religious and cultural importance to an Indian Tribe that meet the National Register criteria. 36 CFR 800.16(l)(1). The BLM should conduct an ethnographic survey to study the value of the area as it relates to traditional cultural properties. The BLM has had two years to develop this information so that it could inform the consultation process. Now the BLM argues that the timeframes are too tight to do more than execute a PA prior to Project approval.

Further, the BLM has chosen to resolve the potential adverse effects of the subject undertaking on historic properties in accordance with § 800.14(b)(1)(ii) of the regulations where the effects of a project on historic properties cannot be fully determined prior to approval of the undertaking.[3] While it may be true that not all of the effects may be determined prior to the approval of the project, it is clear from the documentation submitted by the applicant that adverse effects will occur to a significant number of the historic properties within the APE. Adverse effects are determined by applying the *Criteria of Adverse Effects* and assessing if the undertaking will alter, directly or indirectly, any of the characteristics that qualify the properties for eligibility or listing on the National Register of Historic Places "...in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling or association." 36 CFR § 800.5(a)(1).

This determination of adverse effect should be explicitly made in the PA. For example, the elements of integrity that define the historical significance of the Juan Bautista de Anza Trail are setting, location, feeling and association that are still identifiable and present today but are also characteristic of why the trail was considered to be of national significance. A total of 30,000 reflective solar SunCatcher dishes and the mowing and construction required to install the dishes and associated infrastructure clearly will adversely affect and diminish the integrity of the historic property. Examination of the various project alternatives and whatever options might be available to scale down or decrease the adverse

[3] Letter from Terrence O'Brian to Vicki Wood, October 21, 2009, http://www.energy.ca.gov/sitingcases/solartwo/documents/2009-10-21_Letter_in_Response_to_Ms_Wood_TN-53720.PDF.

effects ought to be discussed now so that a good faith effort consultation may occur among the consulting parties, including the applicant, to determine any measures that might be feasible. Once the ROD is issued and the preferred alternative is selected, it is too late in the process to conduct any meaningful consultation that might avoid or minimize the adverse effects to the Trail (e.g. selecting a different alternative or a reduced acreage alternative.) The Project will also impact the integrity of other sacred sites in the Project vicinity, but these sites have not been documented or described in a way that would inform consulting parties and enable them to consider alternatives and minimization in the context of the alternatives analysis.

III. The Consultation Process Fails to Comply with the Intent of the NHPA and the "Good Faith Effort" as Required by the Implementing Regulations, 36 CFR Part 800

Consultation must provide Indian tribes a reasonable opportunity to identify concerns about historic properties, advise on the identification of historic properties, including those of traditional religious and cultural importance, articulate its views on the undertaking's effects on such properties, and participate in the resolution of such effects. 36 CFR § 800.2. Without a well defined APE, documentation about the resources on the site and time to review the documentation, the BLM has not provided the Tribes and other consulting parties an opportunity to meaningfully consult.

A. The Area of Potential Effects Has Not Been Defined

In order to identify cultural resources and historic properties for the proposed undertaking, an APE must be clearly defined. Developing the APE is the basis from which the consulting parties may begin to discuss the environmental impact and the undertaking's adverse effects including direct, indirect and cumulative effects on cultural resources and historic properties as defined at 36 CFR § 800.16(l)(1) and (2). Since approximately 100% of the archaeological surface deposits have already been identified, the BLM and CEC should be able to visually depict the APE on maps and describe the APE both in the text of the technical reports, any related documents, and in the draft PA "Whereas" clause. A visual and written description of the APE should also be shared with the consulting parties immediately.

When BLM was asked for a map of the APE during the consultation meeting on May 4, 2010, the consulting parties were shown a map of the Project area only,

without any designation of the APE. An anecdotal description was provided by Jim Stobaugh verbally to accompany the map. Mr. Stobaugh's description indicated that the APE includes a small buffer around the Project site and linears. However, no map has been created that depicts the APE, and no map was provided in the SA/DEIS or the draft PA. This oversight is evidence that the consultation process has not progressed very far in the two years that has elapsed since the BLM began processing the application in June of 2008.

The preliminary APE described at the May 4, 2010 meeting failed to include areas where the project may have visual, audible, or atmospheric effects on traditional, religious and cultural resources. At a minimum, the APE must include areas where it would have direct, indirect and cumulative impacts on the viewshed surrounding the property. Once the APE is extended, the BLM and CEC should do an analysis of the types of cultural properties that are located within the viewshed. The visual resources analysis that has been developed in the SA/DEIS should be expanded to evaluate the extent of the Project's visual impact on the surrounding cultural resources. Some traditional cultural properties have already been identified by Native Americans during meetings with the CEC and BLM regarding sacred sites to local tribes in the Coyote Mountains and across I-8 in the ACEC. The impacts of the Project on the viewshed of these historic properties should be taken into account early in the analysis of impacts to cultural resources, pursuant to NEPA and CEQA. Further refinements to the APE should be informed by an ethnographic study and interviews with local Native Americans and tribal representatives. These refinements should commence immediately to ensure compliance with the law.

B. The Consultation Process Has Not Met the Documentation Standards Pursuant to 36 CFR 800.11(a) and 36 CFR 800.6

In order to conduct a good faith consultation process, the BLM should provide the technical report for all parties to review and meet and discuss effects, avoidance and other mitigation strategies. This includes providing information regarding the APE, including photos, maps and other documentation, as necessary and required by NHPA regulations. 36 CFR §§ 800.6(a)(4) and 800.11(e). As stated in 36 CFR §800.6, consulting parties should be able to consult on avoidance, minimization and mitigation of adverse affects. Because the BLM is conducting this consultation pursuant to 800.14(b)(3), the BLM must follow the regulatory requirements for consultation related to a Memorandum of Agreement. 36 CFR § 800.6.

To date, the BLM has not provided a technical report or any information about the resources on the Project site or in the APE, other than that provided in the NEPA document. This document contains no information, other than general site descriptions that are disconnected from specific locations. In order for consulting parties to evaluate the alternatives so as to avoid impacts and provide preservation in place, a technical report must be provided in a timely manner that enables consulting parties to meaningfully consult. 36 CFR § 800.6. Failure to provide meaningful information regarding project impacts limits the consulting parties' ability to participate in the development of the PA, in violation of the NHPA, and limits their ability to participate in the development of Project alternatives pursuant to CEQA and NEPA. All available documentation of cultural resources that may be adversely affected by the Project should be shared with the consulting parties to facilitate meaningful consultation when Project alternatives can still be discussed and amended.

C. The Consultation Process is Truncated to the Point that it Violates the Requirements in 36 CFR Part 800

The consultation process required in all sections of 36 CFR Part 800 is severely truncated for this proposed project. The 30-day time frame is completely arbitrary on the part of BLM and does not reflect the full intentions of consultation on an agreement document to address adverse effects, particularly when there are over 300 properties and a nationally designated historic trail on the Project site.

Consultation is to commence "...at the early stages of project planning." 36 CFR § 800.1(a). At this point, there is no finalized technical resources report, and to our knowledge, no consulting party other than the Applicant, BLM and CEC have been able to review the technical report. Although we finally were able to get a copy of the report two days ago, CEC informed us that it took two months to provide a copy of the report because the BLM asked the CEC to not provide it to us. More importantly, the report was not provided to a consulting party until two days before the requested deadline to provide comments on the PA. This violates NHPA's intent to ensure meaningful evaluation of adverse impacts.

The Advisory Council for Historic Preservation ("ACHP") regulations define "consultation" as a process wherein the agency official seeks, discusses and considers the views of other participants. 36 CFR § 800.16(f). A mere opportunity to comment on a draft PA, in the absence of meaningful information about the Project already known by BLM and CEC, does not meet the intent and definition of

consultation as set forth in the **Secretary of Interior's Standards for Federal Agency Preservation Programs pursuant to the National Historic Preservation Act.** 36 CFR § 800.16(f). These Standards implement Section 110 of the NHPA and cross-reference Section 106 responsibilities.

Standard 4 of the Secretary's Guidelines states a federal agency "gives historic properties full consideration when planning or considering approval of any action that might affect such properties." **Standard 4(b)** specifies "*Full consideration* of historic properties includes *assessment of the widest range of preservation alternatives early in program or project planning,* coordinated to the extent feasible with other kinds of required planning and environmental review." (emphasis added.) **Standard 4(c)** continues the description of *full consideration* as including "...all kinds of effects on those properties: direct, indirect or secondary effects and cumulative effects. Effects may be visual, audible, or atmospheric. **Standard 4(d)** states, "Full consideration of historic properties includes an obligation to solicit and consider the views of others in planning..." Visual, auditory and atmospheric effects need to be discussed and given additional consideration in this consultation process.

Standard 5 and 5(a) of the Guidelines addresses consultation: "An agency consults with knowledgeable and concerned parties outside the agency about its historic preservation related activities." General Principles for consultation in Section 110 of NHPA define further that "[c]onsultation is built upon the exchange of ideas, not simply providing information." **Standard 5(c)** states "[c]onsultation should be undertaken early in the planning stage of any Federal action that might affect historic properties...*there should be no hard-and-fast time limit on consultation overall.* Consultation on a specific undertaking should proceed until agreement is reached or until it becomes clear to the agency that agreement cannot be reached."

The BLM has failed to establish an active consultation process early on that includes the tools parties need to adequately consult. Now the BLM is requesting that the parties develop a PA without the benefit of a technical report, maps of the site or a clearly defined APE in an artificially condensed timeframe. This is unrealistic and a violation of the NHPA.

IV. The Consultation Process Is Inconsistent with Standards Set by the ACHP

The ACHP has issued clear guidance on how to consult with tribes in: "Consultation with Indian Tribes in the Section 106 Review Process: A Handbook (2008)." While the guidance is directed solely to tribes, it may also be constructively used for other consulting parties as well. The Handbook poses the question, "What are the appropriate consultation methods for individual undertakings?" The answer is that face-to-face meetings and on-site visits may be the most practical way to conduct consultation (2008:9-10). The BLM's method of emailing a draft PA and expecting comments back in a 30-day time frame is totally arbitrary and not in accord with the "good faith effort" as specified at 36 CFR Sec. 800.2(c)(2)(ii)(A). Moreover, at least one THPO has commented that the draft PA has "nothing to comment on." (Personal communication Nissley 2010). Simply calling for a treatment plan to be developed after the project is approved does not allow for meaningful or engaging discussion. Silence or lack of response from the tribes or other consulting parties does not imply acceptance or approval. In this case, consulting parties are baffled as to what they would comment on since there is no substantive text upon which to comment.

The BLM must make a meaningful effort to consult with the consulting parties. We request an approach whereby all of the involved federal agencies, the tribes and other consulting parties are invited to review the draft technical report and meet to discuss Project configuration and alternatives. Further, the consulting parties should be given information about other non-archeological cultural resources that have been publicly identified, such as the Project's impacts on the viewshed of the Coyote Mountains and the Project's impacts on the biological resources in the APE that are sacred to Native American culture in the area.

V. The PA Must Stipulate Methods and Process to Avoid, Minimize and Mitigate Effects to Historic Properties

The proposed PA fails to stipulate to any terms of significance. The heart of the PA lies solely with Stipulation IV, the HPTP. Any effort to address an adverse effect to cultural resources and historic properties as contained in NEPA, 43 CFR Part 46, Section 106 of the NHPA, and 36 CFR Part 800, is wholly deferred to some unstated date in the future prior to the BLM issuing a Notice to Proceed.

The BLM's lack of transparency with respect to acknowledging adverse effects is troubling. A formal *Finding of Effect* is essential to inform the public and guide the resolution process. Instead, the BLM appears to be relying solely on the DEIS, a document that is inadequate because it fails to analyze all impacts on

cultural resources, to propose any mitigation for those effects, or meaningfully consider alternatives including project reconfiguration.

PAs, in general, are not mitigation documents. A PA is most useful when it is developed in conjunction with a federal agency's program of specified and sometimes repetitious actions such as operations and maintenance of a military base with an adjunct Integrated Cultural Resource Management Plan; the management of a national park as identified and developed in a general management plan; a municipality administered federal funds for improvement projects; a regional approach to a thematic type of historic property and consistency of treatment procedures for the preservation of such properties. While the type of PA chosen for the proposed project is aimed at multiple undertakings and complex projects with adverse effects, the requirements in the ACHP regulations refer to the development of MOAs (800.14(b)(3) and reference back to procedures at 800.6).

A MOA is generally very specific for a single project wherein it has been determined that adverse effects will occur to historic properties located within the APE. As such, an MOA calls for development of mitigation measures for the irretrievable loss or damage to historic properties. The draft PA poses no measures that would be considered "mitigation." In fact, in general practice and application of Section 106, a management plan for historic properties is developed first and then a PA is written to reflect and implement what is specified in the plan. The PA references an HPTP but nothing more. It does not define what "treatments" are or what might be included as "treatment." Are we, as consulting parties, to assume a treatment plan actually constitutes mitigation? Or should the public, even more removed from any discussion or explanation, assume an undefined HPTP will include avoidance, minimization or mitigation of any identified cultural resources or historic properties? The PA does not outline what should be contained in the HPTP or even list any measures that might be considered as mitigation in what is known to be a well-defined desert environment and ecosystem.

There isn't much to comment on in the draft PA as any developments that would be expressed in a plan are deferred to a later date. This approach is counter to the cultural resource methods utilized to develop PAs since their inception in the ACHP's previous regulations implementing Section 106 – the 1986 final version of 36 CFR Part 800. The 2004 regulations replacing the 1986 version of the regulations require substantive consultation with the ACHP, the SHPO, THPOs, federally recognized tribes, other consulting parties and the public.

Since the draft PA merely states that the undertaking "will affect historic properties," with no further detail, the record fails to show which effects, if any, have been "taken into account," as required by Section 106. In addition, the BLM has not made available surveys it has prepared of archaeological or cultural resources on which it has based its determination of effects. These serious procedural irregularities raise substantial questions about the consultation process, which likely cannot be reasonably resolved by the BLM's proposed signature deadline.

VI. The PA Defers Resolution of Adverse Effects to Historic Properties Until After Project Approval in Violation of the NHPA

The NHPA requires early resolution of effects to historic properties. This requirement is intended to preserve the opportunity to consider alternatives, avoidance, minimization, and mitigation at an early stage in the process prior to project approval.

The head of any Federal agency having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking in any State and the head of any Federal department or independent agency having authority to license any undertaking shall, prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license, as the case may be, take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register. 16 U.S.C. 470f.

Additionally, both the NHPA and the ACHP's implementing regulations, 36 CFR §800.1(a), state succinctly that the purpose of Section 106 is "...to accommodate historic preservation concerns with the needs of Federal undertakings through consultation among the agency official and other parties with an interest in the effects of the undertaking on historic properties, **commencing at the early stages of project planning.**" [emphasis added.]

BLM's proposal to defer all discussion of treatment of historic properties to a yet-to-be-developed Historic Properties Treatment Plan (HPTP) violates the NHPA and constitutes an improper application of the programmatic agreement provision in the NHPA because it wholly undermines the purpose and intent of the NHPA Section 106 consultation process.

The approach described in Stipulation IV (a) of the PA fails to address any treatment to avoid, minimize or mitigate adverse effects to historic.properties as required by both NEPA and NHPA until the Record of Decision ("ROD") is issued and a final alternative has been selected. The PA at this point does nothing in regard to addressing identified and known historic properties except to defer any treatment, mitigation or other actions to minimize the impact to an unknown date in the future and to rely solely on HPTP that is yet-to-be-developed. This is a transparent attempt on the part of the BLM to avoid engaging in meaningful consultation with regard to their federal legal responsibilities PRIOR to taking an action that would ultimately limit and block any additional consideration of historic properties. This approach fully undermines the direction given in the NHPA regulations.

> "The agency official must complete the section 106 process "prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license." This does not prohibit agency official from conducting or authorizing nondestructive project planning activities before completing compliance with section 106, ***provided that such actions do not restrict the subsequent consideration of alternatives to avoid, minimize or mitigate the undertaking's adverse effects on historic properties.*** The agency official shall ensure that the section 106 process is initiated early in the undertaking's planning, so that a ***broad range of alternatives may be considered*** during the planning process for the undertaking."

36 CFR 800.1(c) [emphasis added].

The PA is essentially a promissory note, which violates NHPA, NEPA and CEQA. By issuing the ROD with a PA that is promissory only and defers all consideration of minimization, avoidance and possible alternatives to a post-approval process, the BLM is precluding any meaningful discussion that might take place in regard to possible options for addressing adverse effects. With one or more HPTPs developed after the issuance of the ROD, any opportunity for productive and legally required consultation is eliminated by the ROD's selection of a preferred alternative.

VII. The PA Improperly Defers Resolution of Effects to Historic Properties Until After Project Approval in Violation of the NEPA

Section 101 of NEPA declares it is a matter of national policy to preserve important historic, cultural, and natural aspects of our national heritage. Section 102 continues with "all agencies of the Federal Government shall" among other listed items, "include in every recommendation or report on proposals...a detailed statement by the responsible official on...any adverse environmental effects which cannot be avoided should the proposal be implemented, and any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented." 42 USC § 4332.

The cultural resources section of the Draft EIS falls short of addressing the adverse effects to both cultural resources and historic properties. The adverse environmental impacts caused by the proposed action to both the geological phenomenon of desert pavement and the archaeological sites that are inherently linked to it will be irretrievable and irreversible effects. The fragile desert ecosystem that supported humans and their habitation patterns will be severely compromised, and there is no effective mitigation that can truly reverse the irreversible impacts. By not recognizing the significant environmental effects in the DEIS and further delaying any discussion regarding these non-renewable resources, the requirements of NEPA are not being addressed in either the DEIS or the PA.

Mitigation under NEPA includes proposals that avoid or minimize any potential significant effects of a proposed or alternative action on the quality of the human environment. 40 CFR § 1502.4. The definition of mitigation in the NEPA regulation includes the development of measures that would avoid, minimize, or rectify significant effects, progressively reduce or eliminate such effects over time, or provide compensation for such effects. 40 CFR § 1508.20. Because properties eligible for the national register and Indian sacred sites are being impacted, it is a violation of the spirit and letter of NEPA to defer the resolution of adverse effects until post-project approval.

Policy direction in BLM Manual 8100, section 8110.05D, further provides that BLM should "[i]ncorporate cultural resource considerations into all aspects of planning and decision making." The PA, as it is currently proposed, effectively excludes the cultural resource considerations from the development and weighing of project alternatives and mitigation.

The purpose of an EIS is to address any major federal action significantly affecting the quality of the human environment. 40 CFR § 1502.1. The definition of "human environment," as defined in the NEPA regulations, "shall be interpreted comprehensively to include the natural and physical environments and the relationship of people with that environment." 40 CFR § 1508.14. To put off any discussion, consultation or analysis and to simply state all of the above will be addressed in a PA is inadequate. It does not allow the public an opportunity to comment on any of the environmental impacts that will be occurring as a result of the proposed construction and associated building infrastructure. There has been no attempt to address any of the direct, indirect or cumulative effects on cultural resources when, at this point in time, it is known that adverse effects will occur as a result of introduction of visual, audible, atmospheric and other cumulative environmental consequences in the reasonably foreseeable project APE.

The BLM should consult with the parties now to develop stipulations to include in the PA regarding avoidance, minimization or mitigation plans for impacts to non-renewable culturally significant resources, such as the nationally significant historic trail and its' associated campsites, archaeological sites that represent culturally significant ancestral areas of traditional religious and cultural practice, and areas of critical ecological concern that are directly related to ancestral and traditional use patterns and cultural practices of Native Americans.

VIII. The PA Improperly Defers Resolution of Effects to Historic Properties Until After Project Approval in Violation of CEQA

CEQA exists to ensure that governmental decisionmakers consider the potential significant environmental effects of proposed projects <u>before</u> taking action. The lead agency is responsible for determining whether a significant adverse environmental impact may occur and whether it can be mitigated to a level of insignificance. When a proposed project may adversely affect a historical resource, CEQA requires the lead agency to carefully consider the possible impacts before proceeding. Pub. Res. Code §§ 21084 and 21084.1. Similar to the NHPA's requirement that agencies identify historic properties, CEQA requires the identification of historical resources. Historic properties determined eligible or listed on the National Register are also automatically eligible for listing on the California Register of Historic Resources ("CRHR"). The four criteria for which a property may be eligible for the National Register are mirrored by the four criteria for which a property may be considered eligible for the CRHR. It is the lead agency

that must make the determination as to whether a property contains historic resources.

The Commission's environmental review must describe mitigation measures to minimize significant effects. CEQA Guidelines §15126.4(a). "Formulation of mitigation measures should not be deferred until some future time. However, measures may specify performance standards which would mitigate the significant effect of the project and which may be accomplished in more than one specified way." *Id.* The PA, as proposed, does not address any of the irreversible effects on cultural resources in the project area nor does it address any mitigation measures. The PA does not include any mitigation measures at all; simply stating that a "treatment plan" will be developed prior to the Notice to Proceed, simply defers the formulation of mitigation without providing any enforceable performance standards. There is no assurance that feasible mitigation will be adequately considered or that any treatment that may be suggested or devised will actually address the adverse impacts.

Public agencies, whenever feasible, should seek to avoid damaging effects on any historical resource of an archaeological nature. CEQA Guidelines §15126.4(b). Further, an EIR equivalent document must first evaluate strategies for preservation in place as the preferred mitigation. *Id.* Preservation in place is recognized as the preferred option in NHPA as well. Guidance in the Secretary of Interior Standards for Treatment of Historic Properties ("NPS") ranks preservation in place as the first priority when evaluating treatment options.[4] If at all possible, the agency is required to seek and identify preservation in place as the preferred treatment option. The SA/DEIS does not even attempt to meet these standards.

IX. Conclusion

The draft PA does not comply with the requirements of the NHPA, NEPA or CEQA. The deferral of the consideration of Project effects and impacts until after Project approval fundamentally contradicts Section 106 of the NHPA, 40 CFR § 1502.16 of the NEPA Guidelines and §15126.4(a) of the CEQA Guidelines. BLM must undertake a good faith effort at consultation that includes providing all consulting parties with documentation about the Project and an opportunity to review the documentation and respond with information about cultural resources in the APE. Finally, if a PA is determined to be appropriate, after the consulting

[4] http://www.nps.gov/history/hps/tps/standguide/

parties have been given adequate information about the APE and project effects, the consulting parties should be given its legally required opportunity to weigh in on the development of a PA.

Sincerely,

Loulena Miles

Loulena A. Miles

LAM:bh

"Apple, Rebecca" <Rebecca.Apple@aecom.com>
05/07/2010 02:52 PM
To
"Carrie Simmons" <Carrie_Simmons@ca.blm.gov>
cc

bcc

Subject
Comments on 3-26-10 Imperial PA

History:

This message has been replied to and forwarded.

Hi Carrie,

Here are my (and Tessera's and URS's) comments on the Draft PA in track changes. In addition, can the provison for submittal and approval of a field compeletion letters be included. Not sure exactly where it should go. What I am referring to is the type of post field letter that the consultant submits usully a few days to a couple of weeks after completing
the field portion of the data recovery. Based on the successful completion of the field work, the agency then issues the NTP. Although this is usually employed for data recovery, a similar process also could be used for evlauation, except that the agency would only issue the NTP if
the resource were determined not eligible. Otherwise there could be a protracted length of time while the evaluation report is being prepared that construction would not be allowed at non-eligible sites. I would be happy to discuss.

URS is working on the PA translation and I will be meeting with them next week.

Rebecca

PROGRAMMATIC AGREEMENT
AMONG THE
BUREAU OF LAND MANAGEMENT-CALIFORNIA,
THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,
THE ADVISORY COUNCIL ON HISTORIC PRESERVATION
THE UNITED STATES ARMY CORPS OF ENGINEERS,
THE NATIONAL PARK SERVICE,
THE CALIFORNIA ENERGY COMMISSION,
AND THE TESSERA SOLAR COMPANY,
REGARDING THE TESSERA SOLAR - IMPERIAL VALLEY SOLAR PROJECT, IMPERIAL COUNTY, CALIFORNIA

DRAFT

INDEX (to be completed as document evolves)

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DRAFT

INTRODUCTION

The intent of this Programmatic Agreement (Agreement) is to provide processes whereby the Bureau of Land Management (BLM) and the California Energy Commission (Energy Commission), in consultation with the California State Historic Preservation Officer, the Advisory Council on Historic Preservation, Indian Tribes and other consulting parties, shall determine the steps the agencies shall follow to take into account effects on historic properties as required by section 106 of the National Historic Preservation Act and satisfy the requirements of the California Environmental Quality Act.

The Energy Commission and the BLM, in consultation with the consulting parties to this Agreement, will consider and incorporate within the section 106 consultation process the mitigation measures and performance standards of the *Staff Assessment and Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project, Application for Certification (08-AFC-5) Imperial County (2010)* as adopted by the Energy Commission and the BLM in any decision to permit the Imperial Valley Solar Project. The BLM and the Energy Commission will endeavor to make the historic properties management provisions of this Agreement as consistent as possible with the objectives and terms of the Supplemental Staff Assessment/Final Environmental Impact Statement.

Government agencies, consulting parties, and the public identified in the scoping and public notification process for Staff Assessment/Environmental Impact Statement will be advised in the Supplemental Staff Assessment/Final Environmental Impact Statement that historic properties associated with the undertaking would be treated consistent with the mitigation measures or performance standards identified in the final Supplemental Staff Assessment/Final Environmental Impact Statement and adopted by the agencies, and consistent with the stipulations of this Agreement. A proposed final draft of this Agreement will be circulated for public comment as an attachment to the Final Supplemental Staff Assessment/Final Environmental Impact Statement. The Signatories have consulted with the Invited Signatories and Concurring Parties to this Agreement, and have taken into consideration applicable public comments, if any, received regarding the draft Agreement in preparing this final Agreement. Additionally, the BLM has made written requests to Indian Tribes to provide comments regarding the proposed final draft Agreement and has consulted with the other Signatories and Invited Signatories to take into consideration applicable comments received from the Indian Tribes in making this final Agreement.

PROJECT DESCRIPTION

a) The proposed undertaking includes the following components:

i) The Imperial Valley Solar Project would consist of a solar thermal power plant facility approximately 14 miles west of El Centro, California in Imperial County. The proposed project would be constructed in two phases utilizing SunCatcher (~~Sterling~~ Stirling Engine) technology, and would include approximately 30,000 25 kilowatt (kW) solar power dishes with a generating capacity of approximately 750 megawatts (MW).

(1) The first phase would consist of up to 12,000 SunCatchers configured in arrays of 200 1.5 mW solar groups (60 SunCatchers/1.5 MW group) with a generating capacity of about 300 MW.

(2) The second phase would consist of approximately 18,000 SunCatchers configured in 500 1.5 MW groups (60 SunCatchers/1.5 MW group) with a net generating capacity of approximately 450 MW.

ii) Each SunCatcher system consists of a ~~38x40~~ 38-foot diameter~~foot wide~~ solar concentrator dish that supports an array of curved glass mirror facets designed to automatically track the sun and focus solar energy onto a Power Conversion Unit which generates electricity.

iii) Related structures include a main services complex, assembly buildings, a 230-kilovolts (kV) electrical substation~~, a ten (10) mile transmission line,~~ access roads, supply water line, and a ten (10) mile 230 kV transmission line from the project site to the existing Imperial Valley substation.

Comment [a1]: This is somewhat duplicative of iv, v, vi, and vii – suggest deleting from iii, or at least remove detail from her e (i.e., length of TL).

iv) The project would be located on approximately 6,500 acres of land, including approximately 6,180 acres of public land administered by the Bureau of Land Management and 320 acres of privately owned land.

v) An off-site 6-inch-diameter water supply pipeline will be constructed a distance of approximately 12 miles from the Seeley Water Treatment Plant to the project boundary.

vi) An off-site double-circuit generation interconnection transmission line will be constructed a distance of approximately 10 miles to connect the Imperial Valley Solar Project to the San Diego Gas and Electric Imperial Valley Substation.

vii) A site access road will be constructed from Dunaway Road to the eastern boundary of the project site and generally follow an existing road.

PROGRAMMATIC AGREEMENT
AMONG THE
BUREAU OF LAND MANAGEMENT-CALIFORNIA,
THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,
THE ADVISORY COUNCIL ON HISTORIC PRESERVATION
THE UNITED STATES ARMY CORPS OF ENGINEERS,
THE NATIONAL PARK SERVICE,
THE CALIFORNIA ENERGY COMMISSION,
AND THE TESSERA SOLAR COMPANY,
REGARDING THE TESSERA SOLAR - IMPERIAL VALLEY SOLAR PROJECT,
IMPERIAL COUNTY, CALIFORNIA

WHEREAS, Tessera Solar (Applicant) has applied for a right of way (ROW) grant on public lands managed by the Bureau of Land Management (BLM) and proposes to construct, operate and maintain a solar energy electrical generating facility (hereinafter referred to as the Imperial Valley Solar Project, or "the undertaking") to generate power, including construction of associated transmission lines and other facilities and infrastructure in accordance with the Federal Land Policy and Management Act (FLPMA) (Public Law 940-579; 43 USC 1701) and the BLM pursuant to 36 CFR 800.2(a) has determined that the Imperial Valley Solar Project is an undertaking as defined at 36 CFR 800.16(y); and

WHEREAS, in August 2005, the United States Congress enacted the Energy Policy Act of 2005 (Public Law 109-58). In section 211 of this Act, Congress directed that the Secretary of the Interior (the "Secretary") should, before the end of the 10-year period beginning on the date of enactment of the Act, seek to have approved non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity; and

WHEREAS, by Secretarial Order No. 3285 issued March 11, 2009, the Secretary stated as policy that encouraging the production, development, and delivery of renewable energy is one of the Department of Interior's (DOI) highest priorities and that agencies and bureaus within the DOI will work collaboratively with each other, and with other Federal agencies, departments, states, local communities, and private landowners to encourage the timely and responsible development of renewable energy and associated transmission while protecting and enhancing the Nation's water, wildlife, and other natural resources; and

WHEREAS, in February 2009, the United States Congress enacted the American Reinvestment and Recovery Act of 2009 (ARRA)(Public Law 111-5) for the purpose of expanding the use of clean and renewable energy. In section 1603 of this Act, Congress appropriated funds for payments to reimburse eligible applicants for a portion of expenses who place in service specified energy properties during 2009 or 2010, and the Applicant has notified BLM that it intends to apply for such funds; and

WHEREAS, BLM has consulted with the California State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP), pursuant to 36 CFR 800.14(b)(3) and following the procedures outlined at 36 CFR 800.6, and is in the process of considering different alternatives for the undertaking that may have the potential to adversely affect historic properties and may reach a decision regarding approval of the undertaking before the effects of the undertaking's implementation on historic properties have been fully determined, the BLM chooses to continue its assessment of the undertaking's potential adverse effect and resolve any such effect through the implementation of this Programmatic Agreement (Agreement); and

WHEREAS, the BLM, in consultation with the SHPO and the ACHP and pursuant to 36 CFR 800.4(b)(2), has determined that a phased (tiered) process for compliance with section 106 of the National Historic Preservation Act (NHPA) is appropriate for the undertaking, such that completion of the identification of historic properties, determinations of specific effects on historic properties, and consultation concerning measures to avoid, minimize, or mitigate any adverse effects will be carried out as part of planning for and prior to any Notice to Proceed and for any specific project implementation; and

WHEREAS, the Juan Bautista de Anza National Historic Trail and jurisdictional waters as defined by Section 404 of the Clean Water Act are located within the APE for this undertaking and the National Park Service (NPS) and the U.S. Army Corps of Engineers intend to use this Agreement to comply with section 106 of the NHPA and have agreed to participate in the section 106 consultation regarding the undertaking under the terms of this Agreement and are Invited Signatories to this Agreement; and

WHEREAS, the California Energy Commission (Energy Commission), may certify the Imperial Valley Solar Project located on both public and private lands pursuant to Section 25519, subsection (c) of the Warren-Alquist Act of 1974 and for the purposes of consistency proposes to manage all historical resources in accordance with the stipulations of this Agreement; and

WHEREAS, the BLM and the Energy Commission have prepared the *Staff Assessment and Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project, Application for Certification (08-AFC-5) Imperial County (2010)* to identify the general alternatives for purposes of the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and have comparatively examined the relative effects of the alternatives on known historic properties; and

WHEREAS, the Applicant, as grantee of the proposed ROW, has participated in consultation per 36 CFR 800.2(c)(4), and shall provide all cultural resources documentation required by the BLM in support of the stipulations to this agreement and is willing to carry out the stipulations of this Agreement under the oversight of BLM, and is an Invited Signatory to this Agreement; and

WHEREAS, pursuant to section 101(d)(6)(B) of the NHPA, 36 CFR 800.2(c)(2)(ii), the American Indian Religious Freedom Act (AIRFA), Executive Order 13175, and section 3(c) of the Native American Graves Protection and Repatriation Act (NAGPRA), the BLM is responsible for government-to-government consultation with Federally recognized Indian Tribes and is the lead agency for all Native American consultation and coordination, and has formally

notified and invited the Campo Kumeyaay Nation, the Cocopah Indian Tribe, the Quechan Indian Tribe, the Ewiiaapaayp Band of Kumeyaay Indians, the Jamul Indian Village, the Kwaaymii Laguna Band of Indians, the La Posta Band of Kumeyaay Indians, the Manzanita Band of Kumeyaay Indians, the San Pasqual Band of Diegueno Indians, and the Santa Ysabel Band of Diegueno Indians (Tribes), and the Ah-Mut Pipa Foundation and Kumeyaay Cultural Repatriation Committee (Tribal Organizations) to consult on this undertaking and participate in this Agreement as a Concurring Party, with the further understanding that, notwithstanding any decision by these Tribes or Tribal Organizations to not participate in this Agreement, BLM shall continue to consult with these Tribes and Tribal Organizations throughout the implementation of this Agreement regarding the potential effects on historic properties to which they attach religious and cultural significance. Through consultation, Tribes and Tribal Organizations have expressed their views and concerns about the importance and sensitivity of cultural resources within and near the project area and attach significance to the broader cultural landscape; and

WHEREAS, the National Trust for Historic Preservation, the Anza Society, the California Unions for Reliable Energy, and the Sacred Lands Institute, as organizations, and Edie Harmon and Greg Smestad as individuals, have been invited to consult on this undertaking and this Agreement, have been afforded consulting party status pursuant to 36 CFR 800.4, and have been invited to be Concurring Parties to this Agreement; and

NOW, THEREFORE, the BLM, the SHPO, and the ACHP (hereinafter "Signatories) and the NPS, the U.S. Army Corps of Engineers, the Energy Commission, and the Applicant (hereinafter "Invited Signatories"), agree that the Signatories and Invited Signatories, to the extent of their respective legal authorities, shall administer the undertaking in accordance with the following stipulations to satisfy the federal agencies' section 106 responsibilities for this undertaking.

STIPULATIONS

BLM shall ensure that the following stipulations are carried out:

I. DEFINITIONS

The definitions found at 36 CFR 800.16 apply throughout this agreement except where another definition is offered in this Agreement.

a) "Cultural resource" is an object or definite location of human activity, occupation, or use identifiable through field inventory, historical documentation, or oral evidence. Cultural resources are prehistoric, historic, archaeological, or architectural sites, structures, buildings, places, or objects and definite locations of traditional cultural or religious importance to specified social and/or culture groups. Cultural resources include the entire spectrum of resources, from artifacts to cultural landscapes, without regard to eligibility for listing on the National Register of Historic Places (NRHP) or California Register of Historical Resources (CRHR).

b) "Day," singular or plural, refers to a calendar, rather than a business, day.

c) "Tribes" mean the federally recognized and non-federally recognized Indian Tribes that BLM has invited to consult on this undertaking and participate and concur in this Agreement.

II. AREA OF POTENTIAL EFFECTS

a) The area of potential effects (APE) for the proposed undertaking is defined as follows:

i) Prior to and during construction of the undertaking, the APE shall include all areas in which:

(1) Historic properties could sustain direct effects as a result of the undertaking and is defined to include:

(a) All areas subject to the BLM's ROW decision for the Phase I 300 ~~mW~~ MW and the Phase II 450 ~~mW~~ MW portions of the project area and the Imperial Valley substation.

~~(b)~~The APE for direct effects for linear elements of the undertaking, such as the water supply line and the access road, is defined by a ~~50~~10-foot corridor~~buffer~~ on either side of the center line of each linear facility (~~100~~ 20 foot corridor).

(b)

(c) The APE for direct effects for the transmission line alignment is defined as a ~~150~~100-foot ~~buffer~~corridor on either side of the center of the transmission line (~~300~~ 200 foot corridor).

ii) Any area within which historic properties could sustain indirect effects as a result of the Undertaking. For built resources this is 0.5 mile.

b) The APE encompasses an area sufficient to accommodate all of the proposed and alternative project components under consideration as of the date of the execution of this Agreement. If BLM determines in the future that unforeseen changes to the undertaking may cause alterations in the character or use of historic properties, if any such properties exist, in a geographic area or areas beyond the extent of the original APE above, then the BLM, in consultation with the Signatories, and other Invited Signatories as appropriate, shall modify the size of the APE using the process set forth in stipulation below.

i) Any party to this agreement may propose that the APE established hereunder be modified. The BLM shall notify the Signatories and appropriate Invited Signatories of the proposal and consult for no more than 15 days to reach agreement on the proposal.

ii) If the Signatories agree to the proposal, then the BLM will prepare a description and a map of the modification to which the Signatories agree. The BLM will keep copies of the description and the map on file for its administrative record and distribute copies of each to the other Signatories and Invited signatories within 30 days of the day upon which agreement was reached.

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iii) Upon agreement to a modification to the APE that adds a new geographic area, the BLM shall follow the processes set forth in Stipulation III to identify and evaluate historic properties in the new APE, assess the effects of the undertaking on any historic properties in the APE, and provide for the resolution of any adverse effects to such properties, known or subsequently discovered.

iv) If the Signatories cannot agree to a proposal for the modification of the APE, then they will resolve the dispute in accordance with Stipulation XI.

III. IDENTIFICATION AND EVALUATION

a) The BLM and the Energy Commission shall ensure that cultural resources located within the APE are identified and evaluated for the NRHP and the CRHR pursuant to Appendix A of this Agreement.

b) Amendment of the identification and evaluation process as set forth hereunder will not require amendment of this Agreement if all Signatories do so agree.

IV. TREATMENT OF HISTORIC PROPERTIES

a) BLM shall ensure that a Historic Property Treatment Plan (HPTP), developed in accordance with Appendix B of this Agreement, is implemented and completed.

b) Amendment of the HPTP as set forth hereunder will not require amendment of this Agreement if all Signatories do so agree.

V. DISCOVERIES AND UNANTICIPATED EFFECTS

a) If the BLM determines during implementation of the HPTP that either the HPTP or the undertaking will affect a previously unidentified property that may be eligible for the NRHP, or affect a known historic property in an unanticipated manner, the BLM will address the discovery or unanticipated effect in accordance with those provisions of the HPTP that relate to the treatment of discoveries and unanticipated effects. BLM at its discretion may hereunder assume any discovered property to be eligible for inclusion in the National Register. BLM compliance with this stipulation shall satisfy the requirements of 36 CFR 800.13(a)(2).

VI. TREATMENT OF HUMAN REMAINS OF NATIVE AMERICAN ORIGIN

a) The parties to this Agreement agree that Native American burials and related items discovered during implementation of the terms of the Agreement will be treated in accordance with the requirements of the NAGPRA. The BLM will consult with concerned Indian Tribes, Tribal Organizations, or individuals in accordance with the requirements of §§ 3(c) and 3(d) of the NAGPRA and implementing regulations found at

43 CFR Part 10 to address the treatment of Native American burials and related cultural items that may be discovered during implementation of this Agreement.

VII. STANDARDS AND QUALIFICATIONS

a) PROFESSIONAL QUALIFICATIONS. All actions prescribed by this Agreement that involve the identification, evaluation, analysis, recordation, treatment, monitoring, and disposition of historic properties and that involve the reporting and documentation of such actions in the form of reports, forms or other records, shall be carried out by or under the direct supervision of a person or persons meeting, at a minimum, the Secretary of the Interior's Professional Qualifications Standards (PQS) for archaeology, history, or architectural history, as appropriate (48 FR. 44739). However, nothing in this stipulation may be interpreted to preclude any party qualified under the terms of this paragraph from using the services of properly supervised persons who do not meet the PQS.

b) DOCUMENTATION STANDARDS. Reporting on and documenting the actions cited in Stipulation III and IV of this stipulation shall conform to every reasonable extent with the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (48 FR. 44716-44740), as well as, the BLM 8100 Manual, the California Office of Historic Preservation's Preservation Planning Bulletin Number 4(a) December 1989, Archaeological Resource Management Reports (ARMR): Recommended Contents and Format (ARMR Guidelines) for the Preparation and Review of Archaeological Reports, and any specific county or local requirements or report formats as necessary.

c) CURATION STANDARDS. To the extent permitted under §§ 5097.98 and 5097.991 of the California Public Resources Code, the materials and records resulting from the actions cited in Stipulation III and IV of this Agreement for non-federal lands shall be curated in accordance with 36 CFR Part 79. Where Federal lands are involved, all records and materials resulting from the actions cited in Stipulation III and IV of this Agreement shall be curated in accordance with 36 CFR Part 79 and the provisions of the NAGPRA, 43 CFR Part 10, as applicable. Curation and disposition of cultural materials obtained from state-owned lands and records pertaining to cultural resources on state-owned lands will be curated with materials obtained from federal lands. If cultural materials are recovered from private lands, the BLM will seek to have the materials donated through a written donation agreement to be curated with other cultural materials. The BLM will attempt to have all collections curated at one location unless otherwise agreed to by the consulting parties.

VIII. REPORTING REQUIREMENTS

a) Within eighteen (18) months after the BLM, in consultation with the Energy Commission, has determined that all fieldwork required by Stipulation III and IV has been completed, the BLM will ensure preparation, and concurrent distribution to the consulting parties as appropriate a written draft report that documents the results of implementing the requirements of Stipulation III or IV. The reviewing parties will be afforded 30 days following receipt of the draft report to submit any written comments to

the BLM. Failure of these parties to respond within this time frame shall not preclude the BLM from authorizing revisions to the draft report as the BLM may deem appropriate. The BLM will provide the reviewing parties with written documentation indicating whether and how the draft report will be modified in accordance with any reviewing party comments. Unless the reviewing parties object to this documentation in writing to the BLM within 14 days following receipt, the BLM may modify the draft report as the BLM may deem appropriate. All objections shall be resolved pursuant to Stipulation XI. Thereafter, the BLM may issue the report in final form and distribute this document in accordance with Stipulation VIII(b).

b) Copies of the final report documenting the results of implementing the requirements of Stipulation III or IV, will be distributed by the BLM to the other parties as appropriate and to the appropriate California Historical Resources Information Survey (CHRIS) Regional Information Center.

c) The BLM shall ensure that any draft document that communicates, in lay terms, the results of implementing the requirements of Stipulation III or IV, to members of the interested public, is distributed for review and comment concurrently with and in the same manner as that prescribed for the draft technical report prescribed by Stipulation VIII(a). If the draft document prescribed hereunder is a publication such as a report or brochure, publication shall upon completion be distributed by the BLM to the other consulting and concurring parties, and to any other entity that the consulting and concurring parties through consultation may deem appropriate.

IX. IMPLEMENTATION OF THE UNDERTAKING

a) The BLM may authorize project activities, including but not limited to those listed in Stipulation IX(a)(1-3), to proceed in specific geographic areas of the undertaking's APE where there are no historic properties, where there will be no effect to historic properties, and where a monitoring and inadvertent discovery plan has been executed according to Stipulation V . Such construction activities may include:

(1) the demarcation, set up, and use of staging areas for the project's construction,
(2) the conduct of geotechnical boring investigations or other geophysical and engineering activities, and
(3) construction activities such as grading, buildings, and installations of Sun Catchers

b) Initiation of these activities on federal lands would not occur until a ROW and Notices to Proceed have been issued by the BLM.

X. AMENDMENTS TO THE AGREEMENT

a) This Agreement may be amended only upon written agreement of the Signatories.

b) Any party to this Agreement may at any time propose amendments.

i) Upon receipt of a request to amend this Agreement, the BLM will immediately notify the other consulting parties and initiate a 30 day period to consult on the proposed amendment, whereupon all parties shall consult to consider such amendments.

ii) At the conclusion of the consultation period, or before if agreement on the amendment is reached, the Agreement may be amended. If agreement to the amendment cannot be reached within the 30 day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation XI.

c) Any party to this Agreement may at any time propose modifications to the Appendices.

i) Each Appendix to the Agreement may be individually modified without requiring amendment of the Agreement, unless the Signatories through such consultation decide otherwise.

ii) Upon receipt of a request to modify an Appendix, BLM will immediately notify the Signatories and determine the appropriate Invited Signatories and Concurring parties to consult on the proposed modifications and initiate a 30 day consultation period, whereupon all parties shall consult to consider such modification.

iii) At the conclusion of the consultation period, or before if agreement on the modification is reached, the Appendix may be modified. If agreement on the modification cannot be reached within the 30 day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation XI(c).

iv) Modifications to an Appendix shall take effect on the date that they are executed by the Signatories.

d) Amendments to this Agreement shall take effect on the dates that they are fully executed by the Signatories.

e) If the Agreement is not amended through the above process, any Signatory to this Agreement may terminate the Agreement in accordance with Stipulation XII.

XI. DISPUTE RESOLUTION

a) Should the Signatories or Invited Signatories object at any time to the manner in which the terms of this Agreement are implemented, the BLM will immediately notify the other Signatories and Invited Signatories and initiate a 30 day period in which to resolve the objection.

b) If the objection can be resolved within the consultation period, the BLM may authorize the disputed action to proceed in accordance with the terms of such resolution.

c) If at the end of the 30 day consultation period, the objection cannot be resolved through such consultation, the BLM will forward all documentation relevant to the objection to the ACHP per 36 CFR 800.2(b)(2). Any comments provided by the ACHP within 30 days after its receipt of all relevant documentation will be taken into account by the BLM in reaching a final decision regarding the objection. The BLM will notify the Signatories, Invited Signatories, and Concurring Parties in writing of its final decision within 14 days after it is rendered.

d) The BLM's responsibility to carry out all other actions under this Agreement that are not the subject of the objection will remain unchanged.

e) At any time during implementation of the terms of this Agreement, should an objection pertaining to the Agreement be raised by a Concurring party or a member of the interested public, the BLM shall immediately notify the Signatories, Invited Signatories, and other Concurring parties, consult with SHPO about the objection, and take the objection into account. The other consulting parties may comment on the objection to the BLM. The BLM shall consult with the objecting party(ies) for no more than 30 days. Within 14 days following closure of consultation, the BLM will render a decision regarding the objection and notify all parties of its decision in writing. In reaching its final decision, the BLM will take into account all comments from the parties regarding the objection. The BLM shall have the authority to make the final decision resolving the objection. Any dispute pertaining to the NRHP eligibility of historic properties or cultural resources covered by this agreement will be addressed by the BLM per 36 CFR 800.4(c)(2).

XII. TERMINATION

a) The Signatories have the sole authority to terminate this Agreement. If this Agreement is not amended as provided for in Stipulation X, or if a Signatory proposes termination of this Agreement for other reasons, the Signatory proposing termination shall notify the other Signatories in writing, explain the reasons for proposing termination, and consult for no more than 60 days to resolve the objection.

b) If an Invited Signatory or a Concurring party seeks termination of this Agreement, they shall notify the Signatories and Invited Signatories in writing, explain the reasons for proposing termination, and consult for no more than 60 days to resolve the objection.

c) Should consultation result in an agreement to resolve the objection, the Signatories shall proceed in accordance with that agreement.

d) Should such consultations fail, the BLM and the ACHP may terminate this Agreement by notifying the other parties in writing.

e) Should this Agreement be terminated, then the BLM shall either consult in accordance with 36 CFR 800.14(b) to develop a new agreement or request the comments of the Council pursuant to 36 CFR 800.4-800.6.

f) Beginning with the date of termination, the BLM shall ensure that until and unless a new agreement is executed for the actions covered by this Agreement, such undertakings shall be reviewed individually in accordance with 36 CFR 800.4-800.6.

XIII. WITHDRAWAL OR ADDITION OF PARTIES FROM/TO THE AGREEMENT

a) The BLM will respond to any written request for consulting party or Invited Signatory status pursuant to 36 CFR 800.2 and 36 CFR 800.3(f).

i) Should an Invited Signatory or Concurring party determine that its participation in the undertaking and this Agreement is no longer warranted, the party may withdraw from participation by informing the BLM of its intention to withdraw as soon as is practicable. The BLM shall inform the other consulting parties to this Agreement of the withdrawal.

ii) Should conditions of the undertaking change such that other state, federal, or tribal entities not already party to this agreement request to participate, the BLM will invite the new party to sign the Agreement and notify the other consulting parties.

XIV. DURATION OF THIS AGREEMENT

a) This Agreement will expire if the undertaking or the stipulations of this Agreement have not been implemented within five (5) years from the date of its execution. At such time, and prior to work continuing on the undertaking, the BLM shall either (a) execute a memorandum of agreement pursuant to 36 CFR 800.6, or (b) request, take into account, and respond to the comments of the ACHP under 36 C.F.R. 800.7. Prior to such time, the BLM may consult with the other consulting parties to reconsider the terms of the Agreement and amend it in accordance with Stipulation X. The BLM shall notify the Signatories as to the course of action it will pursue within 30 days.

b) The terms of this Agreement shall be reviewed by the parties to this Agreement not later than five (5) years following the date of execution by the Signatories to determine if the Agreement has been fully implemented or should be extended, modified, or terminated. In the event of termination, BLM will comply with Stipulation XII(e) if it determines that the undertaking will proceed notwithstanding termination of this Agreement.

c) This Agreement is in effect for the life of the ROW grant unless extended by written agreement of the Signatories. The Signatories and Invited Signatories shall consult every 10 years to review this Agreement. Additionally, the Signatories and Invited Signatories shall consult not less than one year prior to the expiration date to reconsider the terms of this Agreement and, if acceptable, have the Signatories extend the term of this Agreement. Reconsideration may include continuation of the Agreement as originally executed or amended, or termination. Extensions are treated as amendments to the Agreement under Stipulation X.

XV. EFFECTIVE DATE

a) This Agreement shall take effect on the date that it has been fully executed by the Signatories. Attachments to this Agreement shall take effect on the dates they are fully executed by the Signatories, or such other self-executing dates as may be described in those attachments.

b) EXECUTION AND IMPLEMENTATION OF THIS Agreement is evidence that BLM has afforded the ACHP a reasonable opportunity to comment on the undertaking and its effects on historic properties. The Signatories to this agreement represent that they have the authority to sign for and bind the entities on behalf of whom they sign.

DRAFT

SIGNATORY PARTIES:

U.S. BUREAU OF LAND MANAGEMENT

BY:_____ DATE_____
James Wesley Abbot
State Director

CALIFORNIA STATE HISTORIC PRESERVATION OFFICER

BY:_____ DATE_____
Milford Wayne Donaldson, FAIA
State Historic Preservation Officer

ADVISORY COUNCIL ON HISTORIC PRESERVATION

BY: _____ DATE _____
John Fowler
Executive Director

DRAFT

INVITED SIGNATORIES:

CALIFORNIA ENERGY COMMISSION

BY: _____ DATE _____
TITLE: _____

NATIONAL PARK SERVICE

BY: _____ DATE _____
TITLE: _____

U.S. ARMY CORPS OF ENGINEERS

BY: _____ DATE _____
TITLE: _____

TESSERA SOLAR L.L.C.

BY: _____ DATE _____
TITLE: _____

DRAFT

CONCURRING PARTIES:

(This is a potential list only)
CALIFORNIA UNIONS FOR RELIABLE ENERGY
NATIONAL TRUST FOR HISTORIC PRESERVATION
ANZA SOCIETY
EDIE HARMON
SACRED LANDS INSTITUTE
GREG SMESTAD

DRAFT

CALIFORNIA UNIONS FOR RELIABLE ENERGY

BY: _____ DATE _____
TITLE: _____

NATIONAL TRUST FOR HISTORIC PRESERVATION

BY: _____ DATE _____
TITLE: _____

ANZA SOCIETY

BY: _____ DATE _____
TITLE: _____

EDIE HARMON

BY: _____ DATE _____
TITLE: _____

DRAFT

APPENDIX A: IDENTIFICATION AND EVALUATION

I. IDENTIFICATION

a) The BLM, in consultation with the Energy Commission, has authorized the proponent to carry out specific identification efforts for this undertaking including a literature search, a BLM Class III inventory, ethnographic studies, or any other studies necessary to identify historic properties that might be located within the APE. The BLM, in consultation with the Energy Commission, may require additional field investigations to ensure the accuracy of site recordation and to provide additional information to support site evaluations and the assessment of effects. The BLM and the Energy Commission, separately or together, have the right and the discretion, under this agreement, to request additional field studies.

b) An inventory report (URS December 2009) has been submitted that includes 100 percent survey of the APE to the BLM and the Energy Commission and is currently under review. The agencies will assess whether the report conforms with the field methodology and site description template required under BLM Fieldwork Authorization CA-670-06-07FA09 and Fieldwork Authorization CA-670-06-07FA10 and Energy Commission transaction number Data Requests Set 2, Part 2 #142, Docket number 08-AFC-5. Based upon the outcome of ~~that~~ a 30 day review additional fieldwork may be required.

c) The BLM will ensure that all cultural resources identified during Class III inventories are recorded on new or updated California Department of Parks and Recreation Form DPR 523 (Series 1/95), using the "Instructions for Recording Historical Resources" (Office of Historic Preservation, March 1995). The cultural resources contractor will obtain permanent site numbers from California Historical Resources Information System (CHRIS) regional information center. The BLM, in consultation with the Energy Commission and the SHPO, shall review all site records for accuracy, adequacy of information, and completeness and determine whether they are sufficient to support agency determinations and findings. Final approved site records shall be submitted to the CHRIS. Permanent site numbers shall then be used in all final reports and other documents prepared pursuant to the requirements of this Agreement.

d) The BLM shall consult with Tribes, Tribal organizations or tribal individuals to identify traditional cultural places that may exist in the APE.

e) Previously unknown traditional cultural properties identified during Class III inventories and/or through consultations with Tribes may be recorded on the DPR Form 523 for resources in California, unless a Tribe or an individual from a Tribe objects. If such objection arises, the properties may be recorded on a form and in a manner that is in accordance with the recommendations of the Tribe or of the individual. If the traditional cultural property is also a historic or archaeological site, those components of site will be recorded on the appropriate DPR form and filed with CHRIS.

f) The BLM in consultation with the Energy Commission will ensure that the Class III inventory report is responsive to Data Requests.

II. EVALUATION

a) Subsequent to the approval of the ~~complete complement of~~ Class III Reports for the present undertaking and prior to the initiation of fieldwork to evaluate the historical significance of the cultural resources in the APE, the Applicant shall submit an analysis of the cultural resources that the Undertaking appears likely to affect, as defined at 36 CFR Part 800.16(i). The analysis shall detail which cultural resources that the undertaking appears to have no potential to affect, which cultural resources the Applicant commits to avoiding through the implementation of formal avoidance measures, and which cultural resources the Applicant believes will be subject to undertaking effects. Subsequent to the final approval of the analysis, the Applicant shall be responsible to formally notify the BLM and the Energy Commission of any changes in the design or implementation of the Undertaking that would alter the original results of that analysis.

b) The Applicant, subject to the approval of the BLM and the Energy Commission, may prepare the analysis referenced here in phases that represent discrete geographic portions of the APE, provided that analyses are ultimately prepared for 100 percent of the APE and provided that the Applicant does not initiate field investigations under this stipulation for geographic portions of the APE for which no such analysis has been prepared.

c) The BLM shall, evidencing consideration of the results of the analysis or analyses prepared under section 1 of this stipulation, authorize field investigations that the Applicant shall prepare and conduct in accordance with the evaluation protocols developed by the BLM and the Energy Commission in consideration of the site types (but not limited to) listed below for the purpose of evaluating the historical significance of the cultural resources in the Undertaking's APE:

Prehistoric Archaeological Resources
Potential Lake Cahuilla Shoreline District
Chipped Stone Deposits
Sparse Lithic Scatters
Chipped and Ground Stone Deposits
Ceramic Deposits
Archaeological Deposits that Include FAR Concentrations
Trail Segments

Historical Archaeological Resources
Potential Early Twentieth Century Sand and Gravel Mining Landscape
Surveying Monuments
Historic Refuse Deposits
Pebble and Cobble Concentrations

Unique Archaeological Resources

Ethnographic Resources

d) Properties formally determined eligible for inclusion in the NRHP will be treated as eligible for the CRHR.

e) The parties to this agreement agree that isolated artifacts shall be considered not eligible for inclusion in the NRHP or the CRHR.
   i) Isolated artifacts are defined in accordance with OHP -----as three or less artifacts that do not constitute a feature.

f) Where avoidance of cultural resources within the APE can be achieved through project design, the cultural resources will remain unevaluated and BLM may treat the cultural resource as eligible for the NRHP for purpose of project management. If a cultural resource cannot be avoided it must be evaluated.

g) Prior to consultation with the SHPO on the eligibility of any cultural resource in the APE for inclusion in the NRHP, the BLM shall seek the views and comments as appropriate from the consulting parties on any such determination that the BLM may propose.

h) The BLM shall consult with Indian Tribes and seek the views and comments of Tribal Organizations and individual tribal members regarding places to which they attach religious or cultural significance in order to ascertain the status of these places relative to NRHP and CRHR eligibility criteria.

Comment [A2]: When will this occur?

i) Where the undertaking may affect a cultural resource, the BLM shall apply the criteria of the NRHP and make a determination of eligibility pursuant to 36 CFR 800.4(c)(1). The BLM will submit to the SHPO its determinations of eligibility and the SHPO will have 30 days in which to review and comment. Absent comments within this time frame, The BLM may assume, and formally document for the record, that the SHPO has elected not to comment and concurs with BLM's determinations. The determinations will serve as the basis for the development of the HPTP to resolve the effects of the undertaking.

j) The BLM shall notify all consulting parties of the agency's determinations and make those available for public inspection.

k) If cultural resources are determined not included or eligible for inclusion on the NRHP but are eligible for the CRHR, the BLM will, at the direction of the Energy Commission, provide all relevant information to and consult with the Energy Commission. The Energy Commission will coordinate its review of all submittals with the Signatories, Invited Signatories, and the Applicant. The Energy Commission has the authority to make a final determination regarding a cultural resource's eligibility to the CRHR. The consulting federal agencies may decline to participate in this review by written notification to the Energy Commission.

APPENDIX B: HISTORIC PROPERTIES TREATMENT PLAN AND HISTORIC PROPERTIES MANAGEMENT PLAN

I. HISTORIC PROPERTIES TREATMENT PLAN

a) Prior to the issuance of a Notice to Proceed related to the implementation of the undertaking, with the exception of the process set out in Stipulation IX of the Agreement, the Applicant shall develop, in consultation with the BLM and other signatories, a HPTP that shall include but is not limited to:

i) A list of the Historic Properties, determined or treated as eligible for project management purposes, in the undertaking's APE that the construction of the Project will unconditionally avoid,

ii) individually specify how the Applicant will avoid, minimize, or resolve the adverse effects on particular Historic Properties,

iii) Provide a plan for monitoring during construction, which would include the treatment of inadvertent discoveries and the participation of tribal cultural specialists. The following should be considered during development of these plans:

(a) qualifications archaeological monitors
(b) participation of tribal cultural specialists in monitoring
(c) areas in the APE requiring monitoring
(d) authority of monitors to halt work
(e) protective measures for historic properties
(f) communication protocols
(g) safety and resource training
(h) procedures upon discovery
(i) evaluation of the inadvertent discoveries
(j) implementation of standard treatment measures
(k) field protocol upon discovery of human remains

iv) The proposed disposition of recovered materials and records which shall include a discussion of curation per 36 CFR Part 79.

v) The procedures for treatment and disposition of any human remains, funerary objects, sacred objects, and objects of cultural patrimony in accordance with NAGPRA and the California Health and Safety Code 7050.5 as appropriate.

vi) A research design which addresses significant themes and questions for the types of historic properties to receive treatment.

vii) A schedule for completing treatment measures, including analysis, reporting and disposition of materials and records, as well as a schedule for completing the draft and final data recovery report(s).

viii) In consultation with the NPS and BLM's National Trail Office, provide a plan for treating effects to the Juan Bautista de Anza National Historic Trail corridor.

ix) A description of alternative treatments for adverse effects that are not data recovery and that may include (but is not limited to):

(1) Placement of construction within portions of historic properties that do not contribute to the qualities that make the resource eligible
(2) Deeding cemetery areas into open-space in perpetuity and providing the necessary long-term protection measures
(3) Public interpretation including the preparation of a public version of the cultural resources studies and/or education materials for local schools
(4) Access by tribes to traditional areas in property after the project has been constructed
(5) Support by Applicant to cultural centers in the preparation of interpretive displays
(6) Consideration of other off-site mitigation

b) The HPTP will be implemented prior to the issuance of a Notice to Proceed for construction in those portions of the Project addressed by the HPTP.

c) The BLM may authorize the phased implementation of the HPTP or if appropriate the development of individual cultural resources, issue oriented, or geographically focused HPTP consistent with the stipulations in this section.

d) Any treatment plan tiered from this Agreement or the HPTP shall reflect the guidance provided in the *Council's Treatment of Archaeological Properties (1980)*, *Council's Recommended Approach for Consultation on Recovery of Significant Information from Archeological Sites* (1999), the BLM 8100 Manual, and the Secretary of the Interior's Standards for the Treatment of Historic Properties and will be focused on the treatment of the Project effects.

e) BLM shall submit the HPTP to all parties to this Agreement for a 30 day review period. Absent comments within this time frame, the BLM may finalize the HPTP. BLM will provide the parties with written documentation indicating whether and how the draft HPTP will be modified in response to any timely comments received. If the HPTP is revised in response to comments, the BLM shall submit the revised HPTP to all parties for a 15 day review period. Absent comments within this time frame, the BLM will finalize the HPTP. The BLM will provide the parties a copy of the final HPTP.

II. COORDINATION WITH CEQA

a) Guidelines for implementation codified in the California Code of Regulations (CCR), Title 14, Chapter 3, Sections 15000 et seq., requires state and local public agencies to

identify the environmental impacts of proposed discretionary activities or projects, determine if the impacts will be significant, and identify alternatives and mitigation measures that will substantially reduce or eliminate significant impacts to the environment. Pursuant to section 15126.4(a)(1), feasible measures which could minimize adverse impacts must be described in the environmental assessment.

~~i)Section 15221(b) provides that because NEPA does not require separate discussion of mitigation measures, these points of analysis will need to be added, supplemented, or identified before the EIS can be used as an EIR.~~

~~ii)~~i)Section 15126.4(a)(1)(B) states that formulation of mitigation measures should not be deferred until some future time, but that measures may specify performance standards which would mitigate the significant effect of the project and which may be accomplished in more than one specified way.

(1) Performance standards for professional qualifications, documentation, and curation and provided at Stipulation VII of the Agreement. Performance standards for inventory and documentation are also provided in Appendix A(I)(c) (Identification and Evaluation) and Appendix B(I)(e) (Historic Properties Treatment Plan and Appendix B(III) (b) (Management Plans).

b) CEQA cultural mitigation measures and performance standards considered within the section 106 consultation process include, but are not limited to:

i) Avoidance [Provided for in Appendix A(I)(a)(i and ii) above]

(1) For cultural resources, the preferred method of mitigation is avoidance of all cultural resources wherever possible. Mitigation measures are normally developed to reduce impacts to significant cultural resources.

ii) Archaeological Data Recovery [Provided for in Appendix A(I)(a-e) above]

(1) When data recovery through excavation is the only feasible mitigation, a data recovery plan, which makes provision for adequately recovering the scientifically consequential information from and about the historical resource, shall be prepared and adopted prior to any excavation being undertaken.

(2) Data recovery shall not be required for an historical resource if the lead agency determines that testing or studies already completed have adequately recovered the scientifically consequential information from and about the archaeological or historical resource.

iii) Built-Environment Resources

(1) HABS/HAER Documentation (need to develop proposed mitigation measures/performance standard)

iv) Properties of Sacred or Cultural Significance to Indian Tribes

(1) Need to develop proposed mitigation measures/performance standard.

Comment [A3]: CEC and BLM are no longer preparing a joint environmental document.

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Comment [A4]: Will this be in the next version?

Comment [A5]: Will this be in the next version?

DRAFT

v) Discoveries

(1) Following the discovery of significant resources, the Applicant shall ensure that the designated cultural resources specialist prepares a research design and a scope of work for any necessary data recovery or additional mitigation. The Applicant shall submit the proposed research design and scope of work to the BLM and the Compliance Project Manager (CPM) for review and approval.

(2) The proposed research design and scope of work shall include (but not be limited to): a discussion of the methods to be used to recover additional information and any needed analysis to be conducted on recovered materials; a discussion of the research questions that the materials may address or answer by the data recovered from the project, and; discussion of possible results and findings.

vi) Monitoring

(1) Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, the Applicant shall provide the designated cultural resources specialist and the CPM with maps and/or drawings showing the footprint of the power plant and all linear facilities. Maps provided will include USGS 7.5-minute topographic quadrangle maps. If the designated cultural resource specialist requests enlargements or strip maps for linear facility routes, the Applicant shall provide them. If the footprint of the power plant or linear facilities changes, the Applicant shall provide maps and drawings reflecting these changes, to the cultural resources specialist within five days. Maps shall show the location of all areas where surface disturbance may be associated with project-related access roads and any other project components.

(2) The designated cultural resource specialist shall be available at all times to respond within 24 hours after pre-construction or construction activities have been halted due to the discovery of a cultural resource(s). The specialist or representative of the Applicant shall have the authority to halt or redirect construction activities if previously undiscovered cultural resource materials are encountered during vegetation clearance or earth disturbing activities or project site preparation or construction. If such resources are discovered, the designated cultural resource specialist shall be notified and the Applicant or Applicant's representative shall halt construction in the immediate area in order to protect the discovery from further damage; project construction may continue elsewhere on the project.

vii) Qualifications

(1) Prior to the start of construction-related vegetation clearance, or earth-disturbing activities or project site preparation; or the movement or parking of heavy equipment onto or over the project surface, the Applicant shall provide the CPM with the name and statement of qualifications for its designated cultural resource specialist and alternate cultural resource specialist, if an alternate is proposed, who will be responsible for implementation of all cultural resources conditions of

certification. The statement of qualifications for the designated cultural resource specialist and alternate shall include all information needed to demonstrate that the specialist meets at least the minimum qualifications specified by the National Park Service, Heritage Preservation Services.

(2) Training

(a) Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, the designated cultural resource specialist shall prepare an employee training program. The Applicant shall submit the cultural resources training program for review and written approval. If a video is used as part of the training program, the owner shall submit the script review and written approval.

(b) Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, and throughout the project construction period as needed for all new employees, the Applicant shall ensure that the designated cultural resource trainer(s) provide(s) approved cultural resources training to all project managers, construction supervisors, and workers. The Applicant shall ensure that the designated trainer provides the workers with the approved a set of procedures for reporting any sensitive resources that may be discovered during project-related ground disturbance. In addition, the Applicant shall communicate the work curtailment procedures that the workers are to follow if previously undiscovered cultural resources are encountered during construction.

III. HISTORIC PROPERTIES MANAGEMENT PLAN

a) A Historic Properties Management Plan (HPMP) will be developed to further manage or prescribe additional treatment to historic properties within the APE during the future operation, maintenance and decommissioning of the Imperial Valley Solar Project and consider effects to historic properties in relation to those actions.

b) The BLM shall submit the HPMP to the consulting parties to the Agreement for a 60 day review period. Absent comments within this time frame, the BLM may finalize the HPMP. The BLM will provide the parties with written documentation indicating whether and how the draft HPMP will be modified in response to any timely comments received. If the HPMP is revised in response to comments, the BLM shall submit the revised HPMP to all parties for a 30 day review period. Absent comments within this time frame, the BLM will finalize the HPMP. The BLM will provide the parties a copy of the final HPMP.

NATIONAL
TRUST
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HISTORIC
PRESERVATION®

May 7, 2010

VIA ELECTRONIC SUBMISSION (carrie_simmons@blm.gov)

Ms. Carrie Simmons
El Centro Field Office
Bureau of Land Management
1661 South 4th Street
El Centro, CA 92243-4561

Re: Comments on Draft Programmatic Agreement Regarding the Tessera Solar - Imperial Valley Solar Project, Imperial County, California

Dear Ms. Simmons:

The National Trust for Historic Preservation (National Trust) appreciates the opportunity to comment on the Bureau of Land Management's (BLM's) draft Programmatic Agreement (PA) for the Tessera Solar - Imperial Valley Solar Project in Imperial County, California. Our comments identify general and specific aspects of the PA that need improvement in order to adequately meet the requirements of Section 106 of the National Historic Preservation Act (NHPA). Two important themes discussed below are the need for more information about how the project may affect historic properties and more details about how BLM, through consultation with others, can or cannot avoid, minimize, or mitigate potential adverse effects to historic properties.

The National Trust commends BLM for its efforts to involve our organization and others in the process. We recognize and support the current Administration's renewable energy agenda and believe that proper planning by federal land managing agencies and other governmental entities can help to ensure that renewable energy projects are implemented in a way that grows the industry while also protecting important natural and cultural resources. We also understand the importance of this particular project as the first of its kind and, thus, the potential model for other "expedited" Department of Interior solar projects to follow.

GENERAL CONCERNS AND RECOMMENDATIONS

As a preliminary issue, the National Trust strongly encourages the BLM to resolve adverse effects to historic properties of which it is currently aware, or becomes aware, before the final Environmental Impact Statement (EIS) is published and/or the Record of Decision is signed. We understand that BLM is working to finalize a cultural resource inventory report that may yield detailed information about the location, nature and significance of historic properties in the area. We encourage BLM to use this information to resolve known adverse effects to those properties before approving the project. We are particularly concerned about those properties

whose historic integrity is tied to landscape qualities, e.g., traditional cultural properties (TCPs) defined in 16 U.S.C. § 470a(d)(6)(A)-(B), and the Juan Bautista de Anza National Historic Trail (Anza trail). The very nature of the proposed project would severely limit the range of alternatives for resolving such effects to landscape resources if dealt with after approval when the applicant has made financial commitments to the project.

Additionally, the National Trust recommends that BLM consider establishing a two-tiered approach in the PA as a way to address potential adverse effects associated with each of the two phases of the project. Adverse effects to be caused by Phase I could be addressed immediately, while adverse effects associated with the construction elements of Phase II could be proactively considered at a slightly later date. Because the applicant is seeking to split its project into two phases, BLM has an opportunity to establish two timelines for compliance with Section 106 process. Phase I would likely be initiated in the short-term and, therefore, would be on a quicker timeline for completing the necessary requirements spelled out in the PA. Phase II, however, would have a longer timeline to meet the PA requirements. A two-tiered approach could allow BLM to more thoroughly identify, evaluate, and resolve potential adverse effects to historic properties.

SPECIFIC CONCERNS AND SUGGESTIONS

1. <u>The PA Should Explain How the Project Could Adversely Affect Historic Properties</u>

The draft PA does not adequately describe the proposal's potential adverse effects on historic properties. The draft EIS clearly states that the proposed project "would create impacts to numerous cultural resources . . . [and] would affect 328 known archaeological sites." Draft EIS at B.2-12. It also states that "[a]lthough the nature of the installation of the SunCatcher technology allows for reduced ground disturbance relative to other solar technologies and flexibility in the location of the individual units, the construction of the project would, nonetheless, lead to the whole and partial destruction of a number of cultural resources." *Id.*; *see also id.* at C.2-129-130 (concluding that "[t]he construction of the proposed solar thermal power facility may wholly or partially destroy the majority of the surface archaeological resources in the proposed project area and may wholly or partially destroy other buried archaeological deposits that may be components of project area landforms"). While the draft PA suggests that the proposal will have potential adverse effects, it provides no details about what types of adverse effects BLM expects. Given the admission about the severity of impacts to historic properties and the nature of the project itself, i.e., it would transform the entire 6,500 acres into an industrial landscape, it seems odd that the draft PA would create a false impression that avoidance and mitigation is available for all or even many resources. In other words, the PA should

be more honest about the types and level of adverse effects associated with the project and the substantial limitations on BLM's ability to adjust the project in a way that avoids or mitigates harm to historic properties.

To accomplish this disclosure, the PA should provide information about the types of adverse effects likely to occur as a result of the various components of the proposed project. For example, the PA could provide a description of how the SunCatchers are aligned, the distances between them, and the method for preparing the area around them. Further, the PA could clarify how flexible or inflexible the specific alignments would be. Such disclosures would provide a glimpse into the types of physical and visual disruptions associated with the project and, thus, help to understand the types of impacts that could occur to historic properties and viewsheds. These disclosures also would lead to ideas about how such impacts may—or may not—be addressed. This information could be included in the project description, an appendix, and/or a "whereas" clause at the beginning of the PA.

Additionally, if the applicant and BLM have already identified the general layout of the SunCatchers and the siting of the project, this information should be disclosed through a written description of the project in a "whereas" clause and/or provided in a map showing the location of the project. Such information, together with the final cultural resource inventory report, should be included in the PA as information relevant to the document's established identification, evaluation, and resolution process.

Recommendation: We urge BLM to provide more information in the PA and/or project description about the proposed project and the likely effects to historic properties. This information should include details about the nature of direct and indirect disturbances to the landscape if the proposed project is implemented.

2. The BLM Should Consider Removing the Reference to the American Reinvestment and Recovery Act

BLM's description in the fourth "Whereas," beginning on line 134, that the project Applicant has notified BLM of its intent to use American Reinvestment and Recovery Act of 2009 funds for the project, seems misplaced. While we understand that politics are driving the expedited review and approval of solar and other renewable energy projects, we are concerned that the draft PA places undue attention on the timing for receiving federal funds. Section 1603 of ARRA does not indicate Congress' intention to exempt compliance with statutory requirements, such as Section 106 of the NHPA, and, thus, BLM should not point to ARRA in support of its decision to move through the process quickly. As we have indicated informally, we are concerned about the approach utilized in this project, i.e., preparing a PA and immediately approving the project rather than identifying and resolving the potential

adverse effects "prior to" approving the project. We recognize that the availability of ARRA funds results in unique circumstances, but overall we hope a "phased compliance" and use of a PA for solar projects does not become the standard approach.

Recommendation: Remove the fourth "Whereas" from the PA and focus on creating a document that adequately complies with the law, regardless of how long that takes.

3. **The BLM Should Provide Greater Detail about the Area of Potential Effects (APE)**

The PA provides inadequate explanation of how the APE was defined. Because the APE will help determine what resources could be impacted by the proposed project, readers of the PA must be able to understand how the BLM defined the APE. As recommended above, information about the project itself and the types of impacts resulting from it will help to shed light on how the APE was defined.

More specifically, however, we highlight the following issues with the definition of the APE provided in the draft PA. First, the APE is considered to include both areas in which historic properties could sustain direct effects as a result of the undertaking and areas in which historic properties could sustain indirect effects. Draft PA at Lines 240–256. Corridors for the direct effects APE are proposed to be 100 feet (50-ft buffer on either side of the center line) for linear elements and 300 feet (150-ft buffer on either side) for the transmission line alignment. However, no reason is provided for these widths.

Second, the definition of the indirect effects APE is too broad to be useful, and provides no guidance for identifying strategies to avoid, minimize, or mitigate indirect adverse effects to historic properties. Furthermore, Appendix A states that an inventory report that includes results of 100% survey of the APE has been submitted to the BLM and the Energy Commission. Presumably this is 100% of the direct effects APE. The PA should also provide information about how and where historic properties that may be indirectly affected by the project have been identified.

Third, the draft PA lacks visual aids that are vital for crafting and then implementing the PA's recommendations. Specifically, the PA should include a topographic map of the project area that clearly defines the boundaries of the APEs for both direct and indirect effects. Without this visual information, the consulting parties are unable to fully grasp the geographic and topographic contexts of the project and the potential effects on nearby historic properties.

Recommendation: The PA should include an explanation for the proposed 100- and 300-foot direct effects APEs for linear elements and transmission lines, respectively. The PA should also contain a more specific description of the area of potential indirect effects and an explanation of how historic properties that could be indirectly affected will be identified. Finally, the PA should contain a map showing the regional topography, proposed project boundaries, and direct and indirect APEs.

4. The Stipulation in Section IX of the Draft PA Could Foreclose Consideration of Avoidance Alternatives

We are uneasy about the stipulation in Section IX of the draft PA because it has the potential to foreclose BLM's ability to examine alternatives in order to avoid or mitigate adverse effects. Even if project activities within a particular geographic area are determined to have no effect on historic properties, the activities conducted there could potentially dictate activities in other geographic areas that do contain historic properties, in ways that foreclose alternatives. It seems that the applicant should not proceed on any aspects of the project until it has completed all of the aspects needed to receive the ROW and Notices to Proceed.

Recommendation: We suggest that BLM remove Section IX of the draft PA.

5. The BLM Should List or Cross-Reference the Cultural Resource Inventory Report in the PA

The draft PA contains only a brief reference to the historic properties that BLM and the applicant have already identified and documented in the draft EIS and the cultural resource inventory report. While Appendix A mentions that an inventory report includes a 100 percent survey of the APE, Section III of the draft PA does not mention the report at all. Furthermore, the draft PA contains no discussion of the findings of the report or the information identified in the draft EIS. *See, e.g.,* Draft EIS at C.2-78 through C.2-126. Providing information in the PA about the findings of the inventory report would help BLM and the consulting parties craft methods for avoiding, minimizing, or mitigating adverse effects to historic properties in the area.

Recommendation: We urge BLM to add to the PA a summary of the information it has obtained from the cultural resource inventory report. This information should include the types of historic properties that would likely be affected by the project, the nature of their significance, the kinds of adverse effects they might experience, and the potential of those effects to damage their integrity and significance.

6. BLM Should Clarify the Historic Property Identification and Evaluation Process Outlined in Appendix A

The draft PA is lacking in specific details about the identification and evaluation process for historic properties. Because the Applicant, BLM, and the Energy Commission have collected a fair amount of information about the resources that would potentially be affected by the proposed project, Appendix A should reflect that. Below are several specific recommendations for improving the appendix and the PA in general.

- ***BLM Should Place Greater Emphasis on the Identification and Evaluation of Landscape Level Historic Properties***

Landscape level historic properties, such as TCPs and the Anza trail, should receive more attention and greater detail in Appendix A. These historic properties will be the most difficult to identify, evaluate, and provide avoidance measures for.

- ***BLM Should Provide More Information About Tribal Consultation***

The draft PA gives little attention to how BLM plans to work with tribes. *See* Draft PA at Lines 683-684, 760-763. Given that some tribes may sign the PA, the document should provide more detail about how BLM intends to consult with tribes.

- ***BLM Should Provide the Consulting Parties an Opportunity to Review the Applicant's Analysis Regarding Cultural Resources to be Affected***

In paragraph (a) in the Evaluation section of Appendix A, the draft PA permits the Applicant to prepare an analysis that identifies cultural resources 1) unlikely to be affected by the project, 2) not affected by the project as a result of avoidance measures, and 3) likely to be affected by the project. *See* Draft PA at Lines 700-710. The consulting parties should have an opportunity to evaluate the Applicant's analysis, particularly regarding project modifications proposed by the Applicant to "avoid" adverse effects to specific resources.

- ***BLM Should Limit the Ability of the Applicant to Analyze Effects on Cultural Resources in Phases***

The Evaluations section under Appendix A allows the Applicant to complete its analysis of cultural resources to be affected by the project in phases. Draft PA at Lines 712-716. While we do not object to phased evaluation, we do believe that breaking the analysis into pieces could lead to a mischaracterization of potential impacts, i.e., it may not capture the cumulative impacts of the complete project on

cultural resources throughout the area. The PA should caution that the Applicant not break apart geographic areas in a way to avoid identifying broader impacts, especially as they relate to landscape level resources.

- ***BLM Should Clarify When Cultural Resources will be Evaluated for National Register Eligibility***

BLM should clarify when cultural resources will be evaluated for National Register eligibility. As currently written, the PA appears to contain contradictory information about the extent and timing of evaluation of cultural resources for National Register eligibility. For example, lines 283-285 state that cultural resources located within the APE will be identified and evaluated for the NRHP and the California Register of Historical Resources (CRHR) pursuant to Appendix A. Lines 751-754 of Appendix A state that all cultural resources within the APE that can be avoided will remain unevaluated and will be treated as eligible for the National Register of Historic Places (National Register), for the purpose of project management. Only those sites that cannot be avoided must be evaluated. However, lines 386-390 of the PA state that BLM may authorize project activities to proceed in specific areas in which there are no historic properties, or where there will be no effect to historic properties. Likewise, lines 799-800 of Appendix A state that adverse effects to particular historic properties will be avoided, minimized, or resolved. It is unclear how the aforementioned areas and historic properties will be identified if not all cultural resources within the APE are evaluated for eligibility.

<u>Recommendation</u>: Revise Appendix A to reflect the general and specific issues identified above.

7. <u>Include the State Historic Preservation Officer (SHPO) in Review of CRHR Properties</u>

Lines 776-783 of Appendix A state that the Energy Commission will make final determinations regarding cultural resources' eligibilities for the CRHR. This could lead to a conflict of interest, in that the Energy Commission also has a large stake in the project. An improved review process should include the SHPO, as occurs with determinations of eligibility for the National Register.

<u>Recommendation</u>: The California SHPO should be given at least 30 days to comment on recommendations for cultural resource listings on the CRHR.

8. The PA Should Clarify Required Elements of the Historic Properties Treatment Plan (HPTP)

- **Provide Examples of Methods to Avoid, Minimize or Mitigate Impacts**

Because of the scale of the proposed project, identifying ways to avoid, minimize or mitigate adverse effects to historic properties may be difficult. This is particularly true for landscape level properties such as TCPs and the Anza Trail. Therefore, the PA should specify that the HPTP include examples of concrete strategies for avoidance, minimization and mitigation of adverse effects from the project.

- **Specifically Address Visual and Indirect Effects**

Lines 795-797 of Appendix A state that a list of historic properties to be unconditionally avoided by the project will be included in the HPTP. We assume this refers only to avoidance of direct (i.e., physical) adverse effects. This leaves out potential visual and indirect effects, which will likely also be caused by the project even if physical avoidance is ensured. The PA should specify that the HPTP address how—or whether—all visual and indirect effects to these specific historic properties will be avoided

Recommendation: The PA should provide more specific guidance for the creation of the HPTP, including incorporation of ways in which direct, visual *and* indirect effects to historic properties will be avoided, minimized or mitigated.

9. Create Specific Plans for Mitigation and Monitoring Now

As discussed in multiple sections above, certain kinds of adverse effects to the Anza trail and to certain Native American cultural resources (e.g., TCPs) may be unmitigatable, so determining how these resources will be avoided or addressed is vital now, before the exact footprint of the project is finalized. The basic route of the Anza trail has already been identified, and during consultation already conducted by BLM, various tribes have told the agency about the significance and sensitivity of their cultural resources within and near the project area. As a result, BLM already has at least some information about the landscape level resources that could be affected by the project and the ways in which they could be affected. Yet, lines 832-833 and lines 909-910 of Appendix A state that treatment plans or mitigation measures for adverse effects to the Anza trail and to properties of sacred or cultural significance to Indian tribes must still be developed. Adverse effects to these historic properties will likely be the most difficult to avoid, minimize, or mitigate, so those plans must be developed now, while the project may still be adjusted. As seen in lines 907-908,

proposed mitigation measures for built-environment resources also need to be developed now.

Recommendation: Develop treatment plans or mitigation measures for adverse effects to the Anza trail, properties of significance to Indian tribes, and built-environment resources now, and include them in the PA.

Conclusion

In conclusion, the National Trust recognizes the importance of creating a strong PA for the Imperial Valley Solar project. The concerns and recommendations identified in this letter are intended to help accomplish that goal. We reiterate that the PA should be edited to reflect the level of information already available for this project. By incorporating project-specific information about construction methods, potentially affected historic properties and likely adverse effects, the PA will be a strong document that can effectively and efficiently guide this compliance process.

The National Trust looks forward to our continued participation in the consulting party process. Please let us know if you have any questions or concerns about our comments.

Respectfully submitted,

Michael Smith

Michael Smith
Associate General Counsel

Rebecca H. Schwendler

Rebecca Schwendler, PhD
Public Lands Advocate

Cc: Rolla Queen, California Desert District Bureau of Land Management
Nancy Brown, Advisory Council on Historic Preservation
M. Wayne Donaldson, California State Historic Preservation Officer

Steven Ross/OAKLAND/NPS@NPS
05/07/2010 04:36 PM
To
Carrie Simmons/CASO/CA/BLM/DOI@BLM
cc

bcc

Subject
PA Language

Hi Carrie,

Thanks again for hosting this morning's conference call, and also for your
follow-up call this afternoon. Below are my comments regarding the PA.

The PA currently contains the following language regarding the Anza NHT:

"In consultation with the NPS and BLM's National Trail Office, provide a plan for treating effects to the Juan Bautista de Anza National Historic Trail corridor."

Consistent with our conversation and with Greg Smestad's comments, I would
like the PA to include some language specifying that the archaeological evidence be examined with a specific goal of identifying traces or artifacts of the Anza NHT. He also asked whether special satellite imaging techniques might help to identify a primary path used by the expedition.

The cultural report documented many Indian trails through the site and within the APE. Because the Anza expedition relied heavily on Indian trails, it is very likely that they followed one or more of the trails through the area. If there is a dominant trail that might have been used
to travel through the site from Yuha Well (camp#47) to camp #48, and up to camp #49 (San Sebastian Marsh), it may be the one followed by the Anza party. If any archaeological data recovery work occurs along a likely travel corridor, special attention should be given to artifacts that could
have been left behind by the Anza party. In e-mail correspondence last Fall I mentioned that there is the potential on-site for bones from animals that may have died or been slaughtered, beads used for trading with Indians, or any other implements that could have been dropped. Archaeological data recovery work could potentially even recover footprints or animal prints left by the expedition. Please be sure that, where appropriate, the PA and/or Historic Properties Treatment Plan (HPTP)
identify this potential and explore this avenue of research. If any evidence of the Spanish presence is identified, it should be documented consistent with the standards applied to other historic properties.

One additional note:

Through my additional readings about the Anza Trail, I have learned that the same route was followed by at least one other Spanish colonizing expedition in 1781, which founded the Pueblo of Los Angeles. The number of people and livestock was substantial, similar to that of the Anza party. This expedition was guided as far as Yuma, AZ by Commander Fernando
Rivera y Moncada (he and some of his soldiers stayed behind in Yuma where they were killed in the Indian revolt that occurred there). The following
web page has a good summary. http://www.militarymuseum.org/Rivera.html

I hope this helps with your preparation of the PA. Don't hesitate to contact me for additional input.

Sincerely,

Steve

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Subject
Comment on Draft Programmatic Agreement Tessera Imperial Valley Solar Project

Dear Ms. Simmons:

The California Unions for Reliable Energy, a consulting party in the above-referenced matter, have asked my advice in preparing comments on the draft programmatic agreement (PA), and in the interests of efficiency have suggested that I forward my initial comments directly to you. I trust that you will distribute them to the other consulting parties. I attach a precis of my qualifications for your reference; suffice to say that I have been involved in the development and implementation of many PAs over the last forty years, and in the development of regulatory and other guidance for their preparation and use.

I have appended comments on specific sections to the attached PDF copy of the draft. In summary, I think this PA represents a deliberate though probably unwitting effort on BLM's part to circumvent both the letter and the intent of Section 106 of the National Historic Preservation Act. That section directs federal agencies to take into account the effects of their actions on historic properties PRIOR TO the issuance of any license. The PA rather explicitly provides for such effects to be taken into account -- to the extent they will be -- AFTER issuance of a license for the Tessera Solar - Imperial Valley Solar Project. It is a sort of promissory note: the consulting parties are expected somehow to trust BLM to comply with the requirements of Section 106 at a later date, after it has deliberately NOT complied with them at the point in its planning process at which Congress directed it to comply.

I am aware, of course, of the allowance made at 36 CFR 800.1(c) for "conducting or authorizing nondestructive project planning activities before completing compliance with section 106," but note that this allowance is subject to the caveat that such actions must not "restrict the subsequent consideration of alternatives to avoid, minimize, or mitigate the undertaking's adverse effects on historic properties." This PA would permit BLM to authorize far more than "nondestructive project

planning activities;" it would allow it to adopt an alternative and authorize its development, thus restricting the consideration of all other alternatives.

I am also aware of the provision at 36 CFR 800.14(b)(1)(ii) for a PA to be developed "when effects on historic properties cannot be fully determined prior to approval of an undertaking." This provision may well be relevant in this case, given the scale of the subject project and the dispatch with which BLM is expected to reach a decision about it. I do not believe, however, that this provision justifies entirely putting off all consideration of effects on historic properties until after BLM makes its decision. It may well be that BLM cannot identify every possibly affected historic property to the extent it thinks necessary to comply with Section 106, or to develop a detailed appreciation of every effect, before making its decision, but surely it can do SOMETHING to assess such effects. Simply adopting the applicant's "cultural resource" (sic: archaeological) survey reports and saying that further identification of historic properties, all effect determination, and all consideration of measures to avoid, minimize, or otherwise mitigate adverse effects will be done later (after project approval) does not, in my view, constitute the "taking into account" that the law requires. One might as well say that one will minimize the potential for damage from offshore oil spills by cleaning up after them.

There are other problems with the PA, notably the narrow focus on archaeological sites that is explicit in some sections and implicit in others (for instance, in the use of terms like "100 percent survey" and "avoidance"). Although occasional bows are made toward Indian tribal concerns -- which may relate to project impacts on extensive landscapes, viewscapes, plant and animal resources, etc. -- there is no real provision for addressing such concerns, and any similar concerns that non-tribal parties may have are not considered at all. The provisions for future consultation with outside parties -- such as they are -- are so narrowly structured as to be meaningless; typically, BLM will inform people of things, give them a restricted period in which to comment, and then decide what to do, without any required regard for what people have said. This is not consultation; it is a formula for high-handed disregard of public interests.

Again -- a PA may very well be appropriate in this case, but not the sort of pig-in-a-poke PA you have drafted. BLM should sit down with the consulting parties and seek to get a realistic handle on what the effects of the various project alternatives may be, then craft creative mechanisms

for addressing them. This may or may not require more study of the alternatives and their specific effects; that is for the consulting parties to decide. Going forward with this PA as drafted, however, would be offensive to any fair reading of the requirements of Section 106 (to say nothing of NEPA, CEQA, AIRFA, RFRA, and perhaps other legal authorities), as well as insulting to the intelligence of the consulting parties.

Thank you for the opportunity to comment.

Tom King

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Recently published by Dog Ear Publishing: Thirteen Bones. See www.tomfking.com. Recently published by Left Coast Press: Unprotected Heritage: Whitewashing Destruction of Our Natural and Cultural Environment. February 2009
Also recently published: Cultural Resource Laws and Practice (3rd Edition)
Altamira Press 2008. Saving Places That Matter: a Citizens' Guide to the National Historic Preservation Act. Left Coast Press 2007; Cultural resource management classes See
http://www.swca.com/jsps/training/training.htm

PROGRAMMATIC AGREEMENT
AMONG THE
BUREAU OF LAND MANAGEMENT-CALIFORNIA,
THE CALIFORNIA STATE HISTORIC PRESERVATION OFFICER,
THE ADVISORY COUNCIL ON HISTORIC PRESERVATION
THE UNITED STATES ARMY CORPS OF ENGINEERS,
THE NATIONAL PARK SERVICE,
THE CALIFORNIA ENERGY COMMISSION,
AND THE TESSERA SOLAR COMPANY,
REGARDING THE TESSERA SOLAR - IMPERIAL VALLEY SOLAR PROJECT, IMPERIAL COUNTY, CALIFORNIA

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DRAFT

INTRODUCTION

The intent of this Programmatic Agreement (Agreement) is to provide processes whereby the Bureau of Land Management (BLM) and the California Energy Commission (Energy Commission), in consultation with the California State Historic Preservation Officer, the Advisory Council on Historic Preservation, Indian Tribes and other consulting parties, shall determine the steps the agencies shall follow to take into account effects on historic properties as required by section 106 of the National Historic Preservation Act and satisfy the requirements of the California Environmental Quality Act.

Comment [MSOffice1]: But Section 106 of NHPA requires that effects be taken into account PRIOR TO a federal decision. It doesn't allow an agency simply to figure out how it's going to take such effects into account AFTER the decision. So this PA seems to be an agreement to violate the law.

The Energy Commission and the BLM, in consultation with the consulting parties to this Agreement, will consider and incorporate within the section 106 consultation process the mitigation measures and performance standards of the *Staff Assessment and Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project, Application for Certification (08-AFC-5) Imperial County (2010)* as adopted by the Energy Commission and the BLM in any decision to permit the Imperial Valley Solar Project. The BLM and the Energy Commission will endeavor to make the historic properties management provisions of this Agreement as consistent as possible with the objectives and terms of the Supplemental Staff Assessment/Final Environmental Impact Statement.

Comment [MSOffice2]: Do the consulting parties concur in the adequacy of this document?

Government agencies, consulting parties, and the public identified in the scoping and public notification process for Staff Assessment/Environmental Impact Statement will be advised in the *Supplemental Staff Assessment/Final Environmental Impact Statement that historic properties* associated with the undertaking would be treated consistent with the mitigation measures or performance standards identified in the final Supplemental Staff Assessment/Final Environmental Impact Statement and adopted by the agencies, and consistent with the stipulations of this Agreement. A proposed final draft of this Agreement will be circulated for public comment as an attachment to the Final Supplemental Staff Assessment/Final Environmental Impact Statement. The Signatories have consulted with the Invited Signatories and Concurring Parties to this Agreement, and have taken into consideration applicable public comments, if any, received regarding the draft Agreement in preparing this final Agreement. *Additionally, the BLM has made written requests to Indian Tribes to provide comments* regarding the proposed final draft Agreement and has consulted with the other Signatories and Invited Signatories to take into consideration applicable comments received from the Indian Tribes in making this final Agreement.

Comment [MSOffice3]: "If any?" You mean you don't know? Then how can you say you've considered them? Who decided which were "applicable?" "Applicable" to what?

Comment [MSOffice4]: As above.

PROJECT DESCRIPTION

a) The proposed undertaking includes the following components:

i) The Imperial Valley Solar Project would consist of a solar thermal power plant facility approximately 14 miles west of El Centro, California in Imperial County. The proposed project would be constructed in two phases utilizing SunCatcher (Sterling Engine) technology, and would include approximately 30,000 25 kilowatt (kW) solar power dishes with a generating capacity of approximately 750 megawatts (MW).

(1) The first phase would consist of up to 12,000 SunCatchers configured in arrays of 200 1.5 mW solar groups (60 SunCatchers/1.5 MW group) with a generating capacity of about 300 MW.

(2) The second phase would consist of approximately 18,000 SunCatchers configured in 500 1.5 MW groups (60 SunCatchers/1.5 MW group) with a net generating capacity of 450 MW.

ii) Each SunCatcher system consists of a 38x40 foot wide solar concentrator dish that supports an array of curved glass mirror facets designed to automatically track the sun and focus solar energy onto a Power Conversion Unit which generates electricity.

iii) Related structures include a main services complex, assembly buildings, a 230-kilovolts (kV) electrical substation, a ten (10) mile transmission line, access roads, supply water line, and a ten (10) mile 230 kV transmission line from the project site to the existing substation.

iv) The project would be located on approximately 6,500 acres of land, including approximately 6,180 acres of public land administered by the Bureau of Land Management and 320 acres of privately owned land.

v) An off-site 6-inch-diameter water supply pipeline will be constructed a distance of approximately 12 miles from the Seeley Water Treatment Plant to the project boundary.

vi) An off-site double-circuit generation interconnection transmission line will be constructed a distance of approximately 10 miles to connect the Imperial Valley Solar Project to the San Diego Gas and Electric Imperial Valley Substation.

vii) A site access road will be constructed from Dunaway Road to the eastern boundary of the project site and generally follow an existing road.

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THE UNITED STATES ARMY CORPS OF ENGINEERS,
THE NATIONAL PARK SERVICE,
THE CALIFORNIA ENERGY COMMISSION,
AND THE TESSERA SOLAR COMPANY,
REGARDING THE TESSERA SOLAR - IMPERIAL VALLEY SOLAR PROJECT,
IMPERIAL COUNTY, CALIFORNIA

WHEREAS, Tessera Solar (Applicant) has applied for a right of way (ROW) grant on public lands managed by the Bureau of Land Management (BLM) and proposes to construct, operate and maintain a solar energy electrical generating facility (hereinafter referred to as the Imperial Valley Solar Project, or "the undertaking") to generate power, including construction of associated transmission lines and other facilities and infrastructure in accordance with the Federal Land Policy and Management Act (FLPMA) (Public Law 940-579; 43 USC 1701) and the BLM pursuant to 36 CFR 800.2(a) has determined that the Imperial Valley Solar Project is an undertaking as defined at 36 CFR 800.16(y); and

WHEREAS, in August 2005, the United States Congress enacted the Energy Policy Act of 2005 (Public Law 109-58). In section 211 of this Act, Congress directed that the Secretary of the Interior (the "Secretary") should, before the end of the 10-year period beginning on the date of enactment of the Act, seek to have approved non-hydropower renewable energy projects located on the public lands with a generation capacity of at least 10,000 megawatts of electricity; and

WHEREAS, by Secretarial Order No. 3285 issued March 11, 2009, the Secretary stated as policy that encouraging the production, development, and delivery of renewable energy is one of the Department of Interior's (DOI) highest priorities and that agencies and bureaus within the DOI will work collaboratively with each other, and with other Federal agencies, departments, states, local communities, and private landowners to encourage the timely and responsible development of renewable energy and associated transmission while protecting and enhancing the Nation's water, wildlife, and other natural resources; and

WHEREAS, in February 2009, the United States Congress enacted the American Reinvestment and Recovery Act of 2009 (ARRA)(Public Law 111-5) for the purpose of expanding the use of clean and renewable energy. In section 1603 of this Act, Congress appropriated funds for payments to reimburse eligible applicants for a portion of expenses who place in service specified energy properties during 2009 or 2010, and the Applicant has notified BLM that it intends to apply for such funds; and

WHEREAS, BLM has consulted with the California State Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation (ACHP), pursuant to 36 CFR 800.14(b)(3) and following the procedures outlined at 36 CFR 800.6, and is in the process of considering different alternatives for the undertaking that may have the potential to adversely affect historic properties and may reach a decision regarding approval of the undertaking before the effects of the undertaking's implementation on historic properties have been fully determined, the BLM chooses to continue its assessment of the undertaking's potential adverse effect and resolve any such effect through the implementation of this Programmatic Agreement (Agreement); and

WHEREAS, the BLM, in consultation with the SHPO and the ACHP and pursuant to 36 CFR 800.4(b)(2), has determined that a phased (tiered) process for compliance with section 106 of the National Historic Preservation Act (NHPA) is appropriate for the undertaking, such that completion of the identification of historic properties, determinations of specific effects on historic properties, and consultation concerning measures to avoid, minimize, or mitigate any adverse effects will be carried out as part of planning for and prior to any Notice to Proceed and for any specific project implementation; and

WHEREAS, the Juan Bautista de Anza National Historic Trail and jurisdictional waters as defined by Section 404 of the Clean Water Act are located within the APE for this undertaking and the National Park Service (NPS) and the U.S. Army Corps of Engineers intend to use this Agreement to comply with section 106 of the NHPA and have agreed to participate in the section 106 consultation regarding the undertaking under the terms of this Agreement and are Invited Signatories to this Agreement; and

WHEREAS, the California Energy Commission (Energy Commission), may certify the Imperial Valley Solar Project located on both public and private lands pursuant to Section 25519, subsection (c) of the Warren-Alquist Act of 1974 and for the purposes of consistency proposes to manage all historical resources in accordance with the stipulations of this Agreement; and

WHEREAS, the BLM and the Energy Commission have prepared the *Staff Assessment and Draft Environmental Impact Statement and Draft California Desert Conservation Area Plan Amendment, SES Solar Two Project, Application for Certification (08-AFC-5) Imperial County (2010)* to identify the general alternatives for purposes of the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and have comparatively examined the relative effects of the alternatives on known historic properties; and

Comment [MSOffice5]: Known to whom? How have they become known? Are the consulting parties satisfied that BLM has a sufficient understanding of the area's historic properties to judge effects and assess alternatives?

WHEREAS, the Applicant, as grantee of the proposed ROW, has participated in consultation per 36 CFR 800.2(c)(4), and shall provide all cultural resources documentation required by the BLM in support of the stipulations to this agreement and is willing to carry out the stipulations of this Agreement under the oversight of BLM, and is an Invited Signatory to this Agreement; and

WHEREAS, pursuant to section 101(d)(6)(B) of the NHPA, 36 CFR 800.2(c)(2)(ii), the American Indian Religious Freedom Act (AIRFA), Executive Order 13175, and section 3(c) of the Native American Graves Protection and Repatriation Act (NAGPRA), the BLM is responsible for government-to-government consultation with Federally recognized Indian Tribes and is the lead agency for all Native American consultation and coordination, and has formally

notified and invited the Campo Kumeyaay Nation, the Cocopah Indian Tribe, the Quechan Indian Tribe, the Ewiiaapaayp Band of Kumeyaay Indians, the Jamul Indian Village, the Kwaaymii Laguna Band of Indians, the La Posta Band of Kumeyaay Indians, the Manzanita Band of Kumeyaay Indians, the San Pasqual Band of Diegueno Indians, and the Santa Ysabel Band of Diegueno Indians (Tribes), and the Ah-Mut Pipa Foundation and Kumeyaay Cultural Repatriation Committee (Tribal Organizations) to consult on this undertaking and participate in this Agreement as a Concurring Party, with the further understanding that, notwithstanding any decision by these Tribes or Tribal Organizations to not participate in this Agreement, BLM shall continue to consult with these Tribes and Tribal Organizations throughout the implementation of this Agreement regarding the potential effects on historic properties to which they attach religious and cultural significance. Through consultation, Tribes and Tribal Organizations have expressed their views and concerns about the importance and sensitivity of cultural resources within and near the project area and attach significance to the broader cultural landscape; and

Comment [MSOffice6]: What are "cultural resources?"

Comment [MSOffice7]: What does this mean? Broader than what?

WHEREAS, the National Trust for Historic Preservation, the Anza Society, the California Unions for Reliable Energy, and the Sacred Lands Institute, as organizations, and Edie Harmon and Greg Smestad as individuals, have been invited to consult on this undertaking and this Agreement, have been afforded consulting party status pursuant to 36 CFR 800.4, and have been invited to be Concurring Parties to this Agreement; and

NOW, THEREFORE, the BLM, the SHPO, and the ACHP (hereinafter "Signatories) and the NPS, the U.S. Army Corps of Engineers, the Energy Commission, and the Applicant (hereinafter "Invited Signatories"), agree that the Signatories and Invited Signatories, to the extent of their respective legal authorities, shall administer the undertaking in accordance with the following stipulations to satisfy the federal agencies' section 106 responsibilities for this undertaking.

STIPULATIONS

BLM shall ensure that the following stipulations are carried out:

I. DEFINITIONS

The definitions found at 36 CFR 800.16 apply throughout this agreement except where another definition is offered in this Agreement.

a) "Cultural resource" is an object or definite location of human activity, occupation, or use identifiable through field inventory, historical documentation, or oral evidence. Cultural resources are prehistoric, historic, archaeological, or architectural sites, structures, buildings, places, or objects and definite locations of traditional cultural or religious importance to specified social and/or culture groups. Cultural resources include the entire spectrum of resources, from artifacts to cultural landscapes, without regard to eligibility for listing on the National Register of Historic Places (NRHP) or California Register of Historical Resources (CRHR).

Comment [MSOffice8]: OK, there's your definition, but since it's not derived from any statute or regulation, what does it actually mean, as distinct from the statutorily defined term "historic property?"

b) "Day," singular or plural, refers to a calendar, rather than a business, day.

c) "Tribes" mean the federally recognized and non-federally recognized Indian Tribes that BLM has invited to consult on this undertaking and participate and concur in this Agreement.

II. AREA OF POTENTIAL EFFECTS

a) The area of potential effects (APE) for the proposed undertaking is defined as follows:

i) Prior to and during construction of the undertaking, the APE shall include all areas in which:

(1) Historic properties could sustain direct effects as a result of the undertaking and is defined to include:

(a) All areas subject to the BLM's ROW decision for the Phase I 300 mW and the Phase II 450 mW portions of the project area and the Imperial Valley substation.

(b) The APE for linear elements of the undertaking, such as the water supply line and the access road, is defined by a 50-foot buffer on either side of the center line of each linear facility (100 foot corridor).

(c) The APE for the transmission line alignment is defined as a 150-foot buffer on either side of the center of the transmission line (300 foot corridor).

Comment [MSOffice9]: It appears you're equating "direct" effects with physical effects, like bulldozing things. Is this true?

ii) Any area within which historic properties could sustain indirect effects as a result of the Undertaking.

Comment [MSOffice10]: What is your understanding of "indirect" effects, as opposed to "direct" effects?

b) The APE encompasses an area sufficient to accommodate all of the proposed and alternative project components under consideration as of the date of the execution of this Agreement. If BLM determines in the future that unforeseen changes to the undertaking may cause alterations in the character or use of historic properties, if any such properties exist, in a geographic area or areas beyond the extent of the original APE above, then the BLM, in consultation with the Signatories, and other Invited Signatories as appropriate, shall modify the size of the APE using the process set forth in stipulation below.

Comment [MSOffice11]: Says BLM. Is there a map by which the reviewer might judge whether this is true?

i) Any party to this agreement may propose that the APE established hereunder be modified. The BLM shall notify the Signatories and appropriate Invited Signatories of the proposal and consult for no more than 15 days to reach agreement on the proposal.

ii) If the Signatories agree to the proposal, then the BLM will prepare a description and a map of the modification to which the Signatories agree. The BLM will keep copies of the description and the map on file for its administrative record and distribute copies of each to the other Signatories and Invited signatories within 30 days of the day upon which agreement was reached.

iii) Upon agreement to a modification to the APE that adds a new geographic area, the BLM shall follow the processes set forth in Stipulation III to identify and evaluate

historic properties in the new APE, assess the effects of the undertaking on any historic properties in the APE, and provide for the resolution of any adverse effects to such properties, known or subsequently discovered.

iv) If the Signatories cannot agree to a proposal for the modification of the APE, then they will resolve the dispute in accordance with Stipulation XI.

III. IDENTIFICATION AND EVALUATION

a) The BLM and the Energy Commission shall ensure that cultural resources located within the APE are identified and evaluated for the NRHP and the CRHR pursuant to Appendix A of this Agreement.

Comment [MSOffice12]: So you haven't yet identified such resources, whatever they are.

b) Amendment of the identification and evaluation process as set forth hereunder will not require amendment of this Agreement if all Signatories do so agree.

IV. TREATMENT OF HISTORIC PROPERTIES

a) BLM shall ensure that a Historic Property Treatment Plan (HPTP), developed in accordance with Appendix B of this Agreement, is implemented and completed.

Comment [MSOffice13]: So you don't yet know how such resources, if identified, will be or even may be treated.

b) Amendment of the HPTP as set forth hereunder will not require amendment of this Agreement if all Signatories do so agree.

V. DISCOVERIES AND UNANTICIPATED EFFECTS

a) If the BLM determines during implementation of the HPTP that either the HPTP or the undertaking will affect a previously unidentified property that may be eligible for the NRHP, or affect a known historic property in an unanticipated manner, the BLM will address the discovery or unanticipated effect in accordance with those provisions of the HPTP that relate to the treatment of discoveries and unanticipated effects. BLM at its discretion may hereunder assume any discovered property to be eligible for inclusion in the National Register. BLM compliance with this stipulation shall satisfy the requirements of 36 CFR 800.13(a)(2).

Comment [MSOffice14]: What if somebody else determines such a thing?

VI. TREATMENT OF HUMAN REMAINS OF NATIVE AMERICAN ORIGIN

a) The parties to this Agreement agree that Native American burials and related items discovered during implementation of the terms of the Agreement will be treated in accordance with the requirements of the NAGPRA. The BLM will consult with concerned Indian Tribes, Tribal Organizations, or individuals in accordance with the requirements of §§ 3(c) and 3(d) of the NAGPRA and implementing regulations found at 43 CFR Part 10 to address the treatment of Native American burials and related cultural items that may be discovered during implementation of this Agreement.

Comment [MSOffice15]: Oh, you're going to follow the law? Jolly decent of you!

Comment [MSOffice16]: According to the NAGPRA regulations, if you anticipate the discovery of such remains, or cultural items ('related' or not), you consult with tribes and develop a plan of action BEFORE going forward with the project, not afterwards. I don't think the consulting parties can agree just to ignore a legal requirement.

VII. STANDARDS AND QUALIFICATIONS

a) PROFESSIONAL QUALIFICATIONS. All actions prescribed by this Agreement that involve the identification, evaluation, analysis, recordation, treatment, monitoring, and disposition of historic properties and that involve the reporting and documentation of such actions in the form of reports, forms or other records, shall be carried out by or under the direct supervision of a person or persons meeting, at a minimum, the Secretary of the Interior's Professional Qualifications Standards (PQS) for archaeology, history, or architectural history, as appropriate (48 FR. 44739). However, nothing in this stipulation may be interpreted to preclude any party qualified under the terms of this paragraph from using the services of properly supervised persons who do not meet the PQS.

b) DOCUMENTATION STANDARDS. Reporting on and documenting the actions cited in Stipulation III and IV of this stipulation shall conform to every reasonable extent with the Secretary of the Interior's Standards and Guidelines for Archeology and Historic Preservation (48 FR. 44716-44740), as well as, the BLM 8100 Manual, the California Office of Historic Preservation's Preservation Planning Bulletin Number 4(a) December 1989, Archaeological Resource Management Reports (ARMR): Recommended Contents and Format (ARMR Guidelines) for the Preparation and Review of Archaeological Reports, and any specific county or local requirements or report formats as necessary.

c) CURATION STANDARDS. To the extent permitted under §§ 5097.98 and 5097.991 of the California Public Resources Code, the materials and records resulting from the actions cited in Stipulation III and IV of this Agreement for non-federal lands shall be curated in accordance with 36 CFR Part 79. Where Federal lands are involved, all records and materials resulting from the actions cited in Stipulation III and IV of this Agreement shall be curated in accordance with 36 CFR Part 79 and the provisions of the NAGPRA, 43 CFR Part 10, as applicable. Curation and disposition of cultural materials obtained from state-owned lands and records pertaining to cultural resources on state-owned lands will be curated with materials obtained from federal lands. If cultural materials are recovered from private lands, the BLM will seek to have the materials donated through a written donation agreement to be curated with other cultural materials. The BLM will attempt to have all collections curated at one location unless otherwise agreed to by the consulting parties.

VIII. REPORTING REQUIREMENTS

a) Within eighteen (18) months after the BLM, in consultation with the Energy Commission, has determined that all fieldwork required by Stipulation III and IV has been completed, the BLM will ensure preparation, and concurrent distribution to the consulting parties as appropriate a written draft report that documents the results of implementing the requirements of Stipulation III or IV. The reviewing parties will be afforded 30 days following receipt of the draft report to submit any written comments to the BLM. Failure of these parties to respond within this time frame shall not preclude the BLM from authorizing revisions to the draft report as the BLM may deem appropriate. The BLM will provide the reviewing parties with written documentation indicating

whether and how the draft report will be modified in accordance with any reviewing party comments. Unless the reviewing parties object to this documentation in writing to the BLM within 14 days following receipt, the BLM may modify the draft report as the BLM may deem appropriate. All objections shall be resolved pursuant to Stipulation XI. Thereafter, the BLM may issue the report in final form and distribute this document in accordance with Stipulation VIII(b).

b) Copies of the final report documenting the results of implementing the requirements of Stipulation III or IV, will be distributed by the BLM to the other parties as appropriate and to the appropriate California Historical Resources Information Survey (CHRIS) Regional Information Center.

c) The BLM shall ensure that any draft document that communicates, in lay terms, the results of implementing the requirements of Stipulation III or IV, to members of the interested public, is distributed for review and comment concurrently with and in the same manner as that prescribed for the draft technical report prescribed by Stipulation VIII(a). If the draft document prescribed hereunder is a publication such as a report or brochure, publication shall upon completion be distributed by the BLM to the other consulting and concurring parties, and to any other entity that the consulting and concurring parties through consultation may deem appropriate.

IX. IMPLEMENTATION OF THE UNDERTAKING

a) The BLM may authorize project activities, including but not limited to those listed in Stipulation IX(a)(1-3), to proceed in specific geographic areas of the undertaking's APE where there are no historic properties, where there will be no effect to historic properties, and where a monitoring and inadvertent discovery plan has been executed according to Stipulation V. Such construction activities may include:

Comment [MSOffice17]: According to whom?

Comment [MSOffice18]: According to whom?

Comment [MSOffice19]: So even if there ARE historic properties that WILL BE affected, BLM can let the project go ahead if there's such a plan?

(1) the demarcation, set up, and use of staging areas for the project's construction,
(2) the conduct of geotechnical boring investigations or other geophysical and engineering activities, and
(3) construction activities such as grading, buildings, and installations of Sun Catchers

b) Initiation of these activities on federal lands would not occur until a ROW and Notices to Proceed have been issued by the BLM.

X. AMENDMENTS TO THE AGREEMENT

a) This Agreement may be amended only upon written agreement of the Signatories.

b) Any party to this Agreement may at any time propose amendments.

i) Upon receipt of a request to amend this Agreement, the BLM will immediately notify the other consulting parties and initiate a 30 day period to consult on the proposed amendment, whereupon all parties shall consult to consider such amendments.

ii) At the conclusion of the consultation period, or before if agreement on the amendment is reached, the Agreement may be amended. If agreement to the amendment cannot be reached within the 30 day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation XI.

c) Any party to this Agreement may at any time propose modifications to the Appendices.

i) Each Appendix to the Agreement may be individually modified without requiring amendment of the Agreement, unless the Signatories through such consultation decide otherwise.

ii) Upon receipt of a request to modify an Appendix, BLM will immediately notify the Signatories and determine the appropriate Invited Signatories and Concurring parties to consult on the proposed modifications and initiate a 30 day consultation period, whereupon all parties shall consult to consider such modification.

iii) At the conclusion of the consultation period, or before if agreement on the modification is reached, the Appendix may be modified. If agreement on the modification cannot be reached within the 30 day period, resolution of the issue may proceed by following the dispute resolution process in Stipulation XI(c).

iv) Modifications to an Appendix shall take effect on the date that they are executed by the Signatories.

d) Amendments to this Agreement shall take effect on the dates that they are fully executed by the Signatories.

e) If the Agreement is not amended through the above process, any Signatory to this Agreement may terminate the Agreement in accordance with Stipulation XII.

XI. DISPUTE RESOLUTION

a) Should the Signatories or Invited Signatories object at any time to the manner in which the terms of this Agreement are implemented, the BLM will immediately notify the other Signatories and Invited Signatories and initiate a 30 day period in which to resolve the objection.

b) If the objection can be resolved within the consultation period, the BLM may authorize the disputed action to proceed in accordance with the terms of such resolution.

c) If at the end of the 30 day consultation period, the objection cannot be resolved through such consultation, the BLM will forward all documentation relevant to the objection to

the ACHP per 36 CFR 800.2(b)(2). Any comments provided by the ACHP within 30 days after its receipt of all relevant documentation will be taken into account by the BLM in reaching a final decision regarding the objection. The BLM will notify the Signatories, Invited Signatories, and Concurring Parties in writing of its final decision within 14 days after it is rendered.

d) The BLM's responsibility to carry out all other actions under this Agreement that are not the subject of the objection will remain unchanged.

e) At any time during implementation of the terms of this Agreement, should an objection pertaining to the Agreement be raised by a Concurring party or a member of the interested public, the BLM shall immediately notify the Signatories, Invited Signatories, and other Concurring parties, consult with SHPO about the objection, and take the objection into account. The other consulting parties may comment on the objection to the BLM. The BLM shall consult with the objecting party(ies) for no more than 30 days. Within 14 days following closure of consultation, the BLM will render a decision regarding the objection and notify all parties of its decision in writing. In reaching its final decision, the BLM will take into account all comments from the parties regarding the objection. The BLM shall have the authority to make the final decision resolving the objection. Any dispute pertaining to the NRHP eligibility of historic properties or cultural resources covered by this agreement will be addressed by the BLM per 36 CFR 800.4(c)(2).

XII. TERMINATION

a) The Signatories have the sole authority to terminate this Agreement. If this Agreement is not amended as provided for in Stipulation X, or if a Signatory proposes termination of this Agreement for other reasons, the Signatory proposing termination shall notify the other Signatories in writing, explain the reasons for proposing termination, and consult for no more than 60 days to resolve the objection.

b) If an Invited Signatory or a Concurring party seeks termination of this Agreement, they shall notify the Signatories and Invited Signatories in writing, explain the reasons for proposing termination, and consult for no more than 60 days to resolve the objection.

c) Should consultation result in an agreement to resolve the objection, the Signatories shall proceed in accordance with that agreement.

d) Should such consultations fail, the BLM and the ACHP may terminate this Agreement by notifying the other parties in writing.

e) Should this Agreement be terminated, then the BLM shall either consult in accordance with 36 CFR 800.14(b) to develop a new agreement or request the comments of the Council pursuant to 36 CFR 800.4-800.6.

f) Beginning with the date of termination, the BLM shall ensure that until and unless a new agreement is executed for the actions covered by this Agreement, such undertakings shall be reviewed individually in accordance with 36 CFR 800.4-800.6.

XIII. WITHDRAWAL OR ADDITION OF PARTIES FROM/TO THE AGREEMENT

a) The BLM will respond to any written request for consulting party or Invited Signatory status pursuant to 36 CFR 800.2 and 36 CFR 800.3(f).

i) Should an Invited Signatory or Concurring party determine that its participation in the undertaking and this Agreement is no longer warranted, the party may withdraw from participation by informing the BLM of its intention to withdraw as soon as is practicable. The BLM shall inform the other consulting parties to this Agreement of the withdrawal.

ii) Should conditions of the undertaking change such that other state, federal, or tribal entities not already party to this agreement request to participate, the BLM will invite the new party to sign the Agreement and notify the other consulting parties.

XIV. DURATION OF THIS AGREEMENT

a) This Agreement will expire if the undertaking or the stipulations of this Agreement have not been implemented within five (5) years from the date of its execution. At such time, and prior to work continuing on the undertaking, the BLM shall either (a) execute a memorandum of agreement pursuant to 36 CFR 800.6, or (b) request, take into account, and respond to the comments of the ACHP under 36 C.F.R. 800.7. Prior to such time, the BLM may consult with the other consulting parties to reconsider the terms of the Agreement and amend it in accordance with Stipulation X. The BLM shall notify the Signatories as to the course of action it will pursue within 30 days.

b) The terms of this Agreement shall be reviewed by the parties to this Agreement not later than five (5) years following the date of execution by the Signatories to determine if the Agreement has been fully implemented or should be extended, modified, or terminated. In the event of termination, BLM will comply with Stipulation XII(e) if it determines that the undertaking will proceed notwithstanding termination of this Agreement.

c) This Agreement is in effect for the life of the ROW grant unless extended by written agreement of the Signatories. The Signatories and Invited Signatories shall consult every 10 years to review this Agreement. Additionally, the Signatories and Invited Signatories shall consult not less than one year prior to the expiration date to reconsider the terms of this Agreement and, if acceptable, have the Signatories extend the term of this Agreement. Reconsideration may include continuation of the Agreement as originally executed or amended, or termination. Extensions are treated as amendments to the Agreement under Stipulation X.

XV. EFFECTIVE DATE

a) This Agreement shall take effect on the date that it has been fully executed by the Signatories. Attachments to this Agreement shall take effect on the dates they are fully executed by the Signatories, or such other self-executing dates as may be described in those attachments.

b) EXECUTION AND IMPLEMENTATION OF THIS Agreement is evidence that BLM has afforded the ACHP a reasonable opportunity to comment on the undertaking and its effects on historic properties. The Signatories to this agreement represent that they have the authority to sign for and bind the entities on behalf of whom they sign.

DRAFT

SIGNATORY PARTIES:

U.S. BUREAU OF LAND MANAGEMENT

BY:_____ DATE_____
James Wesley Abbot
State Director

CALIFORNIA STATE HISTORIC PRESERVATION OFFICER

BY:_____ DATE_____
Milford Wayne Donaldson, FAIA
State Historic Preservation Officer

ADVISORY COUNCIL ON HISTORIC PRESERVATION

BY: _____ DATE _____
John Fowler
Executive Director

DRAFT

INVITED SIGNATORIES:

CALIFORNIA ENERGY COMMISSION

BY: _____ DATE _____
TITLE: _____

NATIONAL PARK SERVICE

BY: _____ DATE _____
TITLE: _____

U.S. ARMY CORPS OF ENGINEERS

BY: _____ DATE _____
TITLE: _____

TESSERA SOLAR L.L.C.

BY: _____ DATE _____
TITLE: _____

DRAFT

CONCURRING PARTIES:

(This is a potential list only)
CALIFORNIA UNIONS FOR RELIABLE ENERGY
NATIONAL TRUST FOR HISTORIC PRESERVATION
ANZA SOCIETY
EDIE HARMON
SACRED LANDS INSTITUTE
GREG SMESTAD

DRAFT

CALIFORNIA UNIONS FOR RELIABLE ENERGY

BY: _____ DATE _____
TITLE: _____

NATIONAL TRUST FOR HISTORIC PRESERVATION

BY: _____ DATE _____
TITLE: _____

ANZA SOCIETY

BY: _____ DATE _____
TITLE: _____

EDIE HARMON

BY: _____ DATE _____
TITLE: _____

DRAFT

APPENDIX A: IDENTIFICATION AND EVALUATION

I. IDENTIFICATION

a) The BLM, in consultation with the Energy Commission, has authorized the proponent to carry out specific identification efforts for this undertaking including a literature search, a BLM Class III inventory, ethnographic studies, or any other studies necessary to identify historic properties that might be located within the APE. The BLM, in consultation with the Energy Commission, may require additional field investigations to ensure the accuracy of site recordation and to provide additional information to support site evaluations and the assessment of effects. The BLM and the Energy Commission, separately or together, have the right and the discretion, under this agreement, to request additional field studies.

Comment [MSOffice20]: According to whom?

Comment [MSOffice21]: Which appears to be defined solely with reference to direct physical effects.

Comment [MSOffice22]: Additional to what? If BLM is going to do everything "necessary," is this a commitment to do unnecessary studies?

Comment [MSOffice23]: Request of whom?

b) An inventory report (URS December 2009) has been submitted that includes 100 percent survey of the APE to the BLM and the Energy Commission and is currently under review. The agencies will assess whether the report conforms with the field methodology and site description template required under BLM Fieldwork Authorization CA-670-06-07FA09 and Fieldwork Authorization CA-670-06-07FA10 and Energy Commission transaction number Data Requests Set 2, Part 2 #142, Docket number 08-AFC-5. Based upon the outcome of that review additional fieldwork may be required.

Comment [MSOffice24]: What does this mean? Identification of 100 percent of the historic properties? 100 percent of the "cultural resources?" The archaeological sites? Or does it just mean that archaeologists have walked over 100 percent of the APE (however the APE is defined)?

Comment [MSOffice25]: By whom? Will consulting parties have anything to say about it? And note that all this happens AFTER the federal decision is made.

c) The BLM will ensure that all cultural resources identified during Class III inventories are recorded on new or updated California Department of Parks and Recreation Form DPR 523 (Series 1/95), using the "Instructions for Recording Historical Resources" (Office of Historic Preservation, March 1995). The cultural resources contractor will obtain permanent site numbers from California Historical Resources Information System (CHRIS) regional information center. The BLM, in consultation with the Energy Commission and the SHPO, shall review all site records for accuracy, adequacy of information, and completeness and determine whether they are sufficient to support agency determinations and findings. Final approved site records shall be submitted to the CHRIS. Permanent site numbers shall then be used in all final reports and other documents prepared pursuant to the requirements of this Agreement.

d) The BLM shall consult with Tribes, Tribal organizations or tribal individuals to identify traditional cultural places that may exist in the APE.

Comment [MSOffice26]: So these obviously cultural sorts of resources have not yet been identified in this "100 percent" survey?

e) Previously unknown traditional cultural properties identified during Class III inventories and/or through consultations with Tribes may be recorded on the DPR Form 523 for resources in California, unless a Tribe or an individual from a Tribe objects. If such objection arises, the properties may be recorded on a form and in a manner that is in accordance with the recommendations of the Tribe or of the individual. If the traditional cultural property is also a historic or archaeological site, those components of site will be recorded on the appropriate DPR form and filed with CHRIS.

f) The BLM in consultation with the Energy Commission will ensure that the Class III inventory report is responsive to Data Requests.

Comment [MSOffice27]: Jargon. What do these terms mean?

II. EVALUATION

a) Subsequent to the approval of the complete complement of Class III Reports for the present undertaking and prior to the initiation of fieldwork to evaluate the historical significance of the cultural resources in the APE, the Applicant shall submit an analysis of the cultural resources that the Undertaking appears likely to affect, as defined at 36 CFR Part 800.16(i). The analysis shall detail which cultural resources that the undertaking appears to have no potential to affect, which cultural resources the Applicant commits to avoiding through the implementation of formal avoidance measures, and which cultural resources the Applicant believes will be subject to undertaking effects. Subsequent to the final approval of the analysis, the Applicant shall be responsible to formally notify the BLM and the Energy Commission of any changes in the design or implementation of the Undertaking that would alter the original results of that analysis.

Comment [MSOffice28]: This exhibits an exclusive focus on physically impactable archaeological sites; it makes no sense at all with respect to types of places on which the project may have visual, auditory, esthetic, and other less physical effects.

b) The Applicant, subject to the approval of the BLM and the Energy Commission, may prepare the analysis referenced here in phases that represent discrete geographic portions of the APE, provided that analyses are ultimately prepared for 100 percent of the APE and provided that the Applicant does not initiate field investigations under this stipulation for geographic portions of the APE for which no such analysis has been prepared.

Comment [MSOffice29]: But BLM IS permitted to approve the project before any such evaluations are done, yes?

c) The BLM shall, evidencing consideration of the results of the analysis or analyses prepared under section 1 of this stipulation, authorize field investigations that the Applicant shall prepare and conduct in accordance with the evaluation protocols developed by the BLM and the Energy Commission in consideration of the site types (but not limited to) listed below for the purpose of evaluating the historical significance of the cultural resources in the Undertaking's APE.

Comment [MSOffice30]: So BLM binds itself to authorizing these investigations regardless of the quality of their proposals?

Prehistoric Archaeological Resources
Potential Lake Cahuilla Shoreline District
Chipped Stone Deposits
Sparse Lithic Scatters
Chipped and Ground Stone Deposits
Ceramic Deposits
Archaeological Deposits that Include FAR Concentrations
Trail Segments

Historical Archaeological Resources
Potential Early Twentieth Century Sand and Gravel Mining Landscape
Surveying Monuments
Historic Refuse Deposits
Pebble and Cobble Concentrations

Unique Archaeological Resources

Ethnographic Resources

d) Properties formally determined eligible for inclusion in the NRHP will be treated as eligible for the CRHR.

e) The parties to this agreement agree that isolated artifacts shall be considered not eligible for inclusion in the NRHP or the CRHR.
   i) Isolated artifacts are defined in accordance with OHP -----as three or less artifacts that do not constitute a feature.

f) Where avoidance of cultural resources within the APE can be achieved through project design, the cultural resources will remain unevaluated and BLM may treat the cultural resource as eligible for the NRHP for purpose of project management. If a cultural resource cannot be avoided it must be evaluated.

g) Prior to consultation with the SHPO on the eligibility of any cultural resource in the APE for inclusion in the NRHP, the BLM shall seek the views and comments as appropriate from the consulting parties on any such determination that the BLM may propose.

h) The BLM shall consult with Indian Tribes and seek the views and comments of Tribal Organizations and individual tribal members regarding places to which they attach religious or cultural significance in order to ascertain the status of these places relative to NRHP and CRHR eligibility criteria.

i) Where the undertaking may affect a cultural resource, the BLM shall apply the criteria of the NRHP and make a determination of eligibility pursuant to 36 CFR 800.4(c)(1). The BLM will submit to the SHPO its determinations of eligibility and the SHPO will have 30 days in which to review and comment. Absent comments within this time frame, The BLM may assume, and formally document for the record, that the SHPO has elected not to comment and concurs with BLM's determinations. The determinations will serve as the basis for the development of the HPTP to resolve the effects of the undertaking.

j) The BLM shall notify all consulting parties of the agency's determinations and make those available for public inspection.

k) If cultural resources are determined not included or eligible for inclusion on the NRHP but are eligible for the CRHR, the BLM will, at the direction of the Energy Commission, provide all relevant information to and consult with the Energy Commission. The Energy Commission will coordinate its review of all submittals with the Signatories, Invited Signatories, and the Applicant. The Energy Commission has the authority to make a final determination regarding a cultural resource's eligibility to the CRHR. The consulting federal agencies may decline to participate in this review by written notification to the Energy Commission.

Comment [MSOffice31]: So numbers of artifacts are the sine qua non of "cultural resource"-ness?

Comment [MSOffice32]: Again, relates only to archaeological sites.

Comment [MSOffice33]: Who determines "appropriateness?" How? What does BLM do with such views and comments?

Comment [MSOffice34]: How is BLM going to know they do or don't?

Comment [MSOffice35]: What gives BLM the right to decide on this status? Do tribes have any recourse in the event of an inapt or inept BLM ascertainment?

Comment [MSOffice36]: According to whom? How?

Comment [MSOffice37]: And nobody else? Tribes? Other consulting parties?

Comment [MSOffice38]: And if someone in the public thinks they stink?????

APPENDIX B: HISTORIC PROPERTIES TREATMENT PLAN AND HISTORIC PROPERTIES MANAGEMENT PLAN

I. HISTORIC PROPERTIES TREATMENT PLAN

a) Prior to the issuance of a Notice to Proceed related to the implementation of the undertaking, with the exception of the process set out in Stipulation IX of the Agreement, the Applicant shall develop, in consultation with the BLM and other signatories, a HPTP that shall include but is not limited to:

Comment [MSOffice39]: But after the overall approval of the project, yes?

i) A list of the Historic Properties, determined or treated as eligible for project management purposes, in the undertaking's APE that the construction of the Project will unconditionally avoid.

Comment [MSOffice40]: Sic: works with archaeological sites (as valued by archaeologists) only.

ii) individually specify how the Applicant will avoid, minimize, or resolve the adverse effects on particular Historic Properties.

Comment [MSOffice41]: Embraces a whole universe of possibilities.

iii) Provide a plan for monitoring during construction, which would include the treatment of inadvertent discoveries and the participation of tribal cultural specialists. The following should be considered during development of these plans:

(a) qualifications archaeological monitors
(b) participation of tribal cultural specialists in monitoring
(c) areas in the APE requiring monitoring
(d) authority of monitors to halt work
(e) protective measures for historic properties
(f) communication protocols
(g) safety and resource training
(h) procedures upon discovery
(i) evaluation of the inadvertent discoveries
(j) implementation of standard treatment measures
(k) field protocol upon discovery of human remains

iv) The proposed disposition of recovered materials and records which shall include a discussion of curation per 36 CFR Part 79.

v) The procedures for treatment and disposition of any human remains, funerary objects, sacred objects, and objects of cultural patrimony in accordance with NAGPRA and the California Health and Safety Code 7050.5 as appropriate.

vi) A research design which addresses significant themes and questions for the types of historic properties to receive treatment.

Comment [MSOffice42]: Relevant only to archaeological interests.

vii) A schedule for completing treatment measures, including analysis, reporting and disposition of materials and records, as well as a schedule for completing the draft and final data recovery report(s).

viii) In consultation with the NPS and BLM's National Trail Office, provide a plan for treating effects to the Juan Bautista de Anza National Historic Trail corridor.

ix) A description of alternative treatments for adverse effects that are not data recovery and that may include (but is not limited to):

(1) Placement of construction within portions of historic properties that do not contribute to the qualities that make the resource eligible
(2) Deeding cemetery areas into open-space in perpetuity and providing the necessary long-term protection measures
(3) Public interpretation including the preparation of a public version of the cultural resources studies and/or education materials for local schools
(4) Access by tribes to traditional areas in property after the project has been constructed
(5) Support by Applicant to cultural centers in the preparation of interpretive displays
(6) Consideration of other off-site mitigation

b) The HPTP will be implemented prior to the issuance of a Notice to Proceed for construction in those portions of the Project addressed by the HPTP.

c) The BLM may authorize the phased implementation of the HPTP or if appropriate the development of individual cultural resources, issue oriented, or geographically focused HPTP consistent with the stipulations in this section.

d) Any treatment plan tiered from this Agreement or the HPTP shall reflect the guidance provided in the *Council's Treatment of Archaeological Properties (1980)*, *Council's Recommended Approach for Consultation on Recovery of Significant Information from Archeological Sites* (1999), the BLM 8100 Manual, and the Secretary of the Interior's Standards for the Treatment of Historic Properties and will be focused on the treatment of the Project effects.

e) BLM shall submit the HPTP to all parties to this Agreement for a 30 day review period. Absent comments within this time frame, the BLM may finalize the HPTP. BLM will provide the parties with written documentation indicating whether and how the draft HPTP will be modified in response to any timely comments received. If the HPTP is revised in response to comments, the BLM shall submit the revised HPTP to all parties for a 15 day review period. Absent comments within this time frame, the BLM will finalize the HPTP. The BLM will provide the parties a copy of the final HPTP.

II. COORDINATION WITH CEQA

a) Guidelines for implementation codified in the California Code of Regulations (CCR), Title 14, Chapter 3, Sections 15000 et seq., requires state and local public agencies to

Comment [MSOffice43]: Suggests that none of those measures to avoid, minimize, or resolve adverse effects could involve anything but data recovery.

Comment [MSOffice44]: All very well, but under what circumstances would the applicant be motivated to adopt such measures? And what about adverse effects that aren't site-specific? Are (5) and (6) supposed to take care of these?

Comment [MSOffice45]: But after project approval, yes?

Comment [MSOffice46]: So, after BLM approves the project, the parties get 30 days to comment on specific treatment measures, and if they don't like them BLM decides whether it's going to do anything about their objections and they get another 15 days to comment on BLM's decision, but BLM need do nothing with their comments. Am I understanding this correctly?

identify the environmental impacts of proposed discretionary activities or projects, determine if the impacts will be significant, and identify alternatives and mitigation measures that will substantially reduce or eliminate significant impacts to the environment. Pursuant to section 15126.4(a)(1), feasible measures which could minimize adverse impacts must be described in the environmental assessment.

i) Section 15221(b) provides that because NEPA does not require separate discussion of mitigation measures, these points of analysis will need to be added, supplemented, or identified before the EIS can be used as an EIR.

ii) Section 15126.4(a)(1)(B) states that formulation of mitigation measures should not be deferred until some future time, but that measures may specify performance standards which would mitigate the significant effect of the project and which may be accomplished in more than one specified way.

(1) Performance standards for professional qualifications, documentation, and curation and provided at Stipulation VII of the Agreement. Performance standards for inventory and documentation are also provided in Appendix A(I)(c) (Identification and Evaluation) and Appendix B(I)(e) (Historic Properties Treatment Plan and Appendix B(III) (b) (Management Plans).

b) CEQA cultural mitigation measures and performance standards considered within the section 106 consultation process include, but are not limited to:

i) Avoidance [Provided for in Appendix A(I)(a)(i and ii) above]

(1) For cultural resources, the preferred method of mitigation is avoidance of all cultural resources wherever possible. Mitigation measures are normally developed to reduce impacts to significant cultural resources.

ii) Archaeological Data Recovery [Provided for in Appendix A(I)(a-e) above]

(1) When data recovery through excavation is the only feasible mitigation, a data recovery plan, which makes provision for adequately recovering the scientifically consequential information from and about the historical resource, shall be prepared and adopted prior to any excavation being undertaken.

(2) Data recovery shall not be required for an historical resource if the lead agency determines that testing or studies already completed have adequately recovered the scientifically consequential information from and about the archaeological or historical resource.

iii) Built-Environment Resources

(1) HABS/HAER Documentation (need to develop proposed mitigation measures/performance standard)

iv) Properties of Sacred or Cultural Significance to Indian Tribes

(1) Need to develop proposed mitigation measures/performance standard.

Comment [MSOffice47]: So BLM figures that despite AIRFA, RFRA, the Free Exercise Clause of the 1st Amendment, and a considerable body of case law about tribal (and other) religious rights, it can approve a project that will (or may) have impacts on a tribe's practice of religion subject to a promise to adopt "mitigation measures" somehow or other after the fact?

v) Discoveries

(1) Following the discovery of significant resources, the Applicant shall ensure that the designated cultural resources specialist prepares a research design and a scope of work for any necessary data recovery or additional mitigation. The Applicant shall submit the proposed research design and scope of work to the BLM and the Compliance Project Manager (CPM) for review and approval.

(2) The proposed research design and scope of work shall include (but not be limited to): a discussion of the methods to be used to recover additional information and any needed analysis to be conducted on recovered materials; a discussion of the research questions that the materials may address or answer by the data recovered from the project, and; discussion of possible results and findings.

vi) Monitoring

(1) Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, the Applicant shall provide the designated cultural resources specialist and the CPM with maps and/or drawings showing the footprint of the power plant and all linear facilities. Maps provided will include USGS 7.5-minute topographic quadrangle maps. If the designated cultural resource specialist requests enlargements or strip maps for linear facility routes, the Applicant shall provide them. If the footprint of the power plant or linear facilities changes, the Applicant shall provide maps and drawings reflecting these changes, to the cultural resources specialist within five days. Maps shall show the location of all areas where surface disturbance may be associated with project-related access roads and any other project components.

(2) The designated cultural resource specialist shall be available at all times to respond within 24 hours after pre-construction or construction activities have been halted due to the discovery of a cultural resource(s). The specialist or representative of the Applicant shall have the authority to halt or redirect construction activities if previously undiscovered cultural resource materials are encountered during vegetation clearance or earth disturbing activities or project site preparation or construction. If such resources are discovered, the designated cultural resource specialist shall be notified and the Applicant or Applicant's representative shall halt construction in the immediate area in order to protect the discovery from further damage; project construction may continue elsewhere on the project.

vii) Qualifications

(1) Prior to the start of construction-related vegetation clearance, or earth-disturbing activities or project site preparation; or the movement or parking of heavy equipment onto or over the project surface, the Applicant shall provide the CPM with the name and statement of qualifications for its designated cultural resource specialist and alternate cultural resource specialist, if an alternate is proposed, who will be responsible for implementation of all cultural resources conditions of

certification. The statement of qualifications for the designated cultural resource specialist and alternate shall include all information needed to demonstrate that the specialist meets at least the minimum qualifications specified by the National Park Service, Heritage Preservation Services.

(2) Training

(a) Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, the designated cultural resource specialist shall prepare an employee training program. The Applicant shall submit the cultural resources training program for review and written approval. If a video is used as part of the training program, the owner shall submit the script review and written approval.

(b) Prior to the start of vegetation clearance or earth disturbing activities or project site preparation, and throughout the project construction period as needed for all new employees, the Applicant shall ensure that the designated cultural resource trainer(s) provide(s) approved cultural resources training to all project managers, construction supervisors, and workers. The Applicant shall ensure that the designated trainer provides the workers with the approved a set of procedures for reporting any sensitive resources that may be discovered during project-related ground disturbance. In addition, the Applicant shall communicate the work curtailment procedures that the workers are to follow if previously undiscovered cultural resources are encountered during construction.

III. HISTORIC PROPERTIES MANAGEMENT PLAN

a) A Historic Properties Management Plan (HPMP) will be developed to further manage or prescribe additional treatment to historic properties within the APE during the future operation, maintenance and decommissioning of the Imperial Valley Solar Project and consider effects to historic properties in relation to those actions.

b) The BLM shall submit the HPMP to the consulting parties to the Agreement for a 60 day review period. Absent comments within this time frame, the BLM may finalize the HPMP. The BLM will provide the parties with written documentation indicating whether and how the draft HPMP will be modified in response to any timely comments received. If the HPMP is revised in response to comments, the BLM shall submit the revised HPMP to all parties for a 30 day review period. Absent comments within this time frame, the BLM will finalize the HPMP. The BLM will provide the parties a copy of the final HPMP.

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Tom King's CRM Plus

Ruminations on "cultural resource management," environmental impact assessment, and related esoteric topics, by a curmudgeon who seldom has anything good to say about anything -- and occasional updates on the archaeological search for Amelia Earhart.

About Me

NAME: THOMAS KING **LOCATION:** SILVER SPRING, MARYLAND, UNITED STATES

PhD 1976 Univ. of Calif. Riverside, anthropology. Archaeological fieldwork in California and Pacific islands. Major work over last 45 years has been in cultural resource management, historic preservation, environmental impact assessment. For recreation, do archaeology with The International Group for Historic Aircraft Recovery (TIGHAR) in pursuit of Amelia Earhart on Nikumaroro Island in Kiribati. Author of eight textbooks and one tradebook (as of 2010) through Left Coast Press and Altamira Press. Last year's book from Left Coast Press -- "Unprotected Heritage" -- is a critique of U.S. environmental impact assessment and cultural resource management, with recommendations for improvement. Also published last year by Dog Ear Press: "Thirteen Bones," a novel about the 1940 discovery of Amelia Earhart's(?) bones. Currently teaching for SWCA Environmental Consultants, providing consultation assistance to the Department of Veterans Affairs, the Fort Mojave Indian Tribe, and other clients, and editing a textbook for Wiley-Blackwell.

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MONDAY, MAY 10, 2010

King, You're Full of Crap

Nobody else has asked this question – too polite, I suppose – so I will.

"OK, King, you've excoriated the Bureau of Land Management (BLM) for putting out a programmatic agreement (PA) on solar projects that turns on post-approval development of cultural resource management plans (CRMPs). You say BLM is violating Section 106 of the National Historic Preservation Act (NHPA). However, you conveniently ignore the fact that there are scores, hundreds, maybe thousands of PAs already in place all over the country that do exactly the same thing. For instance, there are military bases with integrated cultural resource management plans (ICRMPs), and there are reservoirs where the Federal Energy Regulatory Commission (FERC) has done PAs requiring CRMPs. There are interstate pipelines with PAs calling for CRMPs. If BLM's solar PA is contrary to law, how come all those others aren't? How come the people who drafted them – including you, King – aren't in jail? Huh? Huh?"

Fair question, I (naturally) think, and it may well be that those who drafted some of those PAs should be in jail, but I do think there's an important distinction between at least many of the CRMP (by whatever

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acronym)-based PAs now in existence and what BLM is trying to peddle to the solar power industry.

Consider, for instance, a FERC-regulated hydroelectric project – basically a reservoir – where FERC executes a PA requiring preparation of a CRMP. The undertaking subject to review here is not the construction of a new facility; the federal undertaking is FERC's decision -making about whether to extend the power company's license for another 20 or 30 or 50 years. So FERC causes the permitee to collect some basic information on what's happening to "cultural resources" (admittedly, usually too narrowly defined, but that's another issue) around the reservoir and then consults, for awhile at least, with the permitee, State Historic Preservation Officer (SHPO), tribes, and other interested parties and decides that, yup, there are ongoing effects (through erosion, public access, whatever), and a CRMP should be developed to deal with them. In this case FERC has taken effects into account, and it's simply decided that a CRMP is a good tool for addressing them. Never mind whether they're right or wrong in particular cases; they've played the game by the rules.

Or take the more difficult case of the interstate pipeline. The typical problem here is that the applicant for federal rights of way can't get on the land they want to traverse to do surveys and such until they get their financing, and they can't get their financing without their right-of-way, and they can't get their right-of-way without the federal agencies going through Section 106 review. So they can't possibly identify "all" the historic properties subject to effect (as if anyone ever could) before the federal action is taken. So what happens – in my experience, and admittedly it's been awhile since I've done a pipeline – is that the agencies, applicant, SHPOs, tribes, et al sit down and review what they DO know about the rights-of-way and alternatives, and say, for example, that since the thing is basically a ditch in the ground, the major effects are going to be on archaeological sites, but maybe there'll be visual effect issues when they go through the Green Ridge Mountains where the tribes carry out spirit quests on hilltops. Then they'll put together a CRMP that spells out how archaeological sites will be dealt with and how further consultation will be done to control visual effects in the Green Ridge – and maybe that alternative route X will be used because it's thought by the consulting parties to have the least potential for such effects. Again, they've taken effects into account, and used the CRMP as a mechanism for addressing those effects.

What BLM is proposing appears to be quite different. Apparently the applicant has had some archaeological surveys done, and maybe they've talked to some people about effects, but there's nothing in the PA that even purports to represent consideration of the results of these studies, this consultation. Instead, the PA proposes that BLM will carry out the whole standard process of Section 106 review – identifying historic properties, evaluating them, determining effects on them, resolving adverse effects – via the CRMP after a project is approved. In this case, BLM has not taken effects into account; it has just proposed to promise to do so sometime down the road, after the project is approved.

Now, it may be that there are lots of other PAs out there that reflect the same approach as BLM is proposing for the solar projects; if so, then I'd say they're contrary to the letter and spirit of the law. But those that use CRMPs (or ICRMPs, or HRMPs, HPMPs, HMPs or Freds) to address effects that have been recognized as occurring (as in a typical FERC hydro project) or reasonably predicted to occur (as in the pipeline example) seem to me to be in the clear. The more ethereal and abstract they get, however – the more they push everything off into the post-decisional future – the more likely they are to violate the straightforward language of the statute:

The head of any Federal agency having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking in any State and the head of any Federal department or independent agency having authority to license any undertaking shall, ***prior to the approval of the expenditure of any Federal funds on the undertaking or prior to the issuance of any license, as the case may be,*** *take into account the effect of the undertaking on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register.*
(NHPA Section 106 [16 USC 470f], emphasis added)

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posted by Tom King | 3:16 AM | 0 comments

SATURDAY, MAY 08, 2010

Responding to a Rumor, or, Post-Hoc Planning is an Oxmoron

I'm told it's being noised about in California that I've been retained to comment on programmatic agreements (PAs) being proposed by the Bureau of Land Management for solar projects in the California desert. This in fact is not (currently) the case; I was approached to perform such services, but the key dates fell during the time I'll be out of the country without email (on Nikumaroro, in Kiribati), so I had to decline. Without such retention, however, I did file a comment on a current proposed BLM solar PA; my comment email is shown below. Attached to it was a marked-up copy of the PA itself, which I'd be happy to provide to anyone who's interested (IF you contact me in the next few days before I head for Nikumaroro). In short, I think BLM is getting waaaay carried away in its infatuation with PAs and "cultural resource management plans," to the point at which it's simply ignoring the straightforward letter of the law. Guys, read the statute: gencies are supposed to consider the effects of their proposed actions BEFORE they make decisions, not sometime afterwards.

Text of 5-1-2010 Email:

The California Unions for Reliable Energy, a consulting party in the above-referenced matter, have asked my advice in preparing comments on the draft programmatic agreement (PA), and in the interests of

efficiency have suggested that I forward my initial comments directly to you. I trust that you will distribute them to the other consulting parties. I attach a precis of my qualifications for your reference; suffice to say that I have been involved in the development and implementation of many PAs over the last forty years, and in the development of regulatory and other guidance for their preparation and use.

I have appended comments on specific sections to the attached PDF copy of the draft. In summary, I think this PA represents a deliberate though probably unwitting effort on BLM's part to circumvent both the letter and the intent of Section 106 of the National Historic Preservation Act. That section directs federal agencies to take into account the effects of their actions on historic properties PRIOR TO the issuance of any license. The PA rather explicitly provides for such effects to be taken into account -- to the extent they will be -- AFTER issuance of a license for the Tessera Solar - Imperial Valley Solar Project. It is a sort of promissory note: the consulting parties are expected somehow to trust BLM to comply with the requirements of Section 106 at a later date, after it has deliberately NOT complied with them at the point in its planning process at which Congress directed it to comply.

I am aware, of course, of the allowance made at 36 CFR 800.1(c) for "conducting or authorizing nondestructive project planning activities before completing compliance with section 106," but note that this allowance is subject to the caveat that such actions must not "restrict the subsequent consideration of alternatives to avoid, minimize, or mitigate the undertaking's adverse effects on historic properties." This PA would permit BLM to authorize far more than "nondestructive project planning activities;" it would allow it to adopt an alternative and authorize its development, thus restricting the consideration of all other alternatives.

I am also aware of the provision at 36 CFR 800.14(b)(1)(ii) for a PA to be developed "when effects on historic properties cannot be fully determined prior to approval of an undertaking." This provision may well be relevant in this case, given the scale of the subject project and the dispatch with which BLM is expected to reach a decision about it. I do not believe, however, that this provision justifies entirely putting off all consideration of effects on historic properties until after BLM makes its decision. It may well be that BLM cannot identify every possibly affected historic property to the extent it thinks necessary to comply with Section 106, or to develop a detailed appreciation of every effect, before making its decision, but surely it can do SOMETHING to assess such effects. Simply adopting the applicant's "cultural resource" (sic: archaeological) survey reports and saying that further identification of historic properties, all effect determination, and all consideration of measures to avoid, minimize, or otherwise mitigate adverse effects will be done later (after project approval) does not, in my view, constitute the "taking into account" that the law requires. One might as well say that one will minimize the potential for damage from offshore oil spills by cleaning up after them.

There are other problems with the PA, notably the narrow focus on archaeological sites that is explicit in some sections and implicit in others (for instance, in the use of terms like "100 percent survey" and "avoidance"). Although occasional bows are made toward Indian tribal concerns -- which may relate to project impacts on extensive landscapes, viewscapes, plant and animal resources, etc. -- there is no real provision for addressing such concerns, and any similar concerns that non-tribal parties may have are not considered at all. The provisions for future consultation with outside parties -- such as they are -- are so narrowly structured as to be meaningless; typically, BLM will inform people of things, give them a restricted period in which to comment, and then decide what to do, without any required regard for what people have said. This is not consultation; it is a formula for high-handed disregard of public interests.

Again -- a PA may very well be appropriate in this case, but not the sort of pig-in-a-poke PA you have drafted. BLM should sit down with the consulting parties and seek to get a realistic handle on what the effects of the various project alternatives may be, then craft creative mechanisms for addressing them. This may or may not require more study of the alternatives and their specific effects; that is for the consulting parties to decide. Going forward with this PA as drafted, however, would be offensive to any fair reading of the requirements of Section 106 (to say nothing of NEPA, CEQA, AIRFA, RFRA, and perhaps other legal authorities), as well as insulting to the intelligence of the consulting parties.

Thank you for the opportunity to comment.

Tom King

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posted by Tom King | 3:53 AM | 0 comments

TUESDAY, APRIL 27, 2010

Blowing Wind on Capitol Hill

I know I'm in a minority, but my guess is that when he makes his decision this week or next on the Cape Wind project, the Secretary of the Interior will say no. If this happens, it will almost certainly generate a great flurry of snorting, trumpeting and braying on Capitol Hill, with proposals to:

• Exempt wind (and probably solar and nuclear) projects from the requirements of NHPA (and maybe NEPA);

• Rein in the renegade Advisory Council on Historic Preservation by somehow constraining the range of things it can say in comments;

• Resurrect the tired old notion of having Section 106 apply only to formally registered properties; and even

499-A

STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

REBUTTAL TESTIMONY OF DR. CHRISTOPHER BOWLES and CHRISTOPHER CAMPBELL ON BEHALF OF CALIFORNIA UNIONS FOR RELIABLE ENERGY ON SOIL AND WATER RESOURCES FOR THE IMPERIAL VALLEY SOLAR PROJECT

May 17, 2010

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2218-113a

1 INTRODUCTION

The following represents our rebuttal testimony to soil and water resource elements of the Applicant's opening and supplemental testimony. Given that a significant amount of new information was provided with the Applicant's supplemental testimony (e.g., Exhibit 32), we were unable to sufficiently review all the new information; the following represents our initial rebuttal testimony, especially with respect to groundwater issues pertaining to the newly identified water supply.

2 APPLICANT'S OPENING TESTIMONY

1. Exhibit 11 – Supplemental Cumulative Analysis

   a. In the Applicant's supplemental cumulative analysis, the soils cumulative analysis area is limited to the outward extent of the three primary State Soil Geographic (STATSGO) soil types that intersect at the project site (see figure in Attachment C to Exhibit 11).

      This interpretation of cumulative soil impacts is inadequate because the geographic scope is improperly limited by soil typing boundaries rather than the geographic scope defined by the Salton Sea.

      This interpretation of cumulative soil impacts also completely ignores the incremental downstream impacts of onsite soil erosion from the solar arrays, and other project features, to the degradation of onsite and offsite washes; Imperial Valley farmland; and water quality of the Imperial Valley canals and drains, the New River, and the Salton Sea.

      Finally, this interpretation of cumulative soil impacts completely ignores the previously mentioned downstream impacts in the broader geographic scope, which should take into account the effect that past, present, and future projects might have on the New River and the Salton Sea.

      Furthermore, it has also been demonstrated in our opening testimony that the soil loss calculations, lack of understanding of the environmental setting (which defines baseline conditions), and assumptions regarding Best Management Practices (BMP) effectiveness are inadequate, and as such, render the impact assessment and Drainage Erosion and Soil Control Plan (DESCP)/Storm Water Pollution Prevent Plan (SWPPP) inadequate.

   b. It is our understanding that specific elements and inferences in the water resources component of Exhibit 11 are superseded by more recent information and exhibits, namely, the U.S. Army Corps of Engineers' (USACE) preliminary determination of jurisdictional waters, the wash avoidance site plan (see Exhibit 34), and the interim (or potentially long-

term) use of local groundwater within the sole source Coyote Wells Valley Groundwater Basin (see Exhibit 32). Regardless, the water resources cumulative analysis area is limited to areas west of the Westside Main Canal that are tributary to and intersected by project infrastructure (see figure in Attachment C to Exhibit 11).

This interpretation of the cumulative water resource impact area is inadequate because:

a) The geographic scope is limited to the project infrastructure rather than the geographic scope of the Project area watershed that includes the Salton Sea.

b) It completely ignores the incremental downstream impacts of onsite increases in effective percent impervious cover (PIC) and subsequent increases in runoff peaks and volumes. The subsequent increases in runoff peaks and volumes are significant because they have the ability to increase flood hazards, impact the morphology of onsite and offsite washes, and convey runoff laden with sediments and soluble salts to the already impaired Imperial Valley Drains, the New River, and the Salton Sea.

c) It completely ignores the previously mentioned impacts in the broader geographic scope and any water resource impacts past, present, and future projects might have on the New River and the Salton Sea in aggregate. Furthermore, it has also been demonstrated in our opening testimony that the hydrology, hydraulic, and sediment transport modeling and calculations are inadequate, partially driven by the lack of understanding of the environmental setting (which defines baseline conditions) in the Staff Assessment/Draft Environmental Impact Statement (SA/DEIS) and Applicant's filings and oversimplification of underlying assumptions and techniques, rendering the impact assessment inadequate.

2. Matthew Moore (MM) – Water Resources

   a. According to Question #5, as likely supported by Exhibit 18, MM concluded that the Seeley Waste Water Treatment Plant (SWWTP) would not impact the water quality (and salinity) of the New River and Salton Sea because a) the decrease in freshwater flows at the New River and the Salton Sea would be negligible at 0.15% and 0.05%, respectively, under maximum project deliveries, and b) these negligible decreases would be offset by the improved water quality of the effluent.

   This analysis ignores the fact that the Salton Sea is significantly impaired regarding salinity, and any reductions in freshwater flows, incremental or cumulative, can have a significant impact on the salinity balance of the Salton Sea, which is presently more saline than the ocean. It is our understanding, based on the testimony and exhibits to date (i.e., Exhibit 18), that engineering calculations *have not been provided to substantiate this claim* that enhanced water quality and reduced salinity levels (or TDS content) in the SWWTP effluent (per the future upgrade) will successfully offset the reductions in freshwater (effluent) flows

to the Salton Sea. Until such calculations are provided, the Applicant's testimony provides *only unsupported assumptions that there will be no salinity impacts to the Salton Sea as a* result of the SWWTP diversion. Without evidence to the contrary, it appears that project diversions from the SWWTP pose a significant risk to the water quality of the Salton Sea.

b. According to Question #9, MM concluded that sedimentation and morphological impacts from the project would be mitigated such that the project would comply with all applicable LORS per implementation of the DESCP/SWPPP and compliance with relevant Conditions of Certification.

   Based on our opening testimony, we have previously demonstrated that the referenced hydrologic, sedimentation, hydraulic, and sediment transport studies are inadequate to fully assess the onsite, offsite, and cumulative impacts of the project and subsequent benefits of proposed mitigation measures, to soil and water resources. Until such time that corrective and supplemental measures are taken to improve the adequacy of these studies, the project poses a significant impact to onsite and offsite resources.

3 APPLICANT'S SUPPLEMENTAL AND REBUTTAL TESTIMONY

1. Robert Scott (RS) – Water Resources

   a. According to Question #3, RS concluded via Exhibit 32 that extraction of groundwater from the sole source aquifer "will have no significant impacts to the aquifer."

      As referenced by Exhibit 11 (see page 12), it was previously stated that the Coyote Wells Valley Groundwater Basin was in an overdraft deficient status:

      > *The proposed Project would obtain water from an off-site waterline and is not expected to use groundwater wells for construction, operation, and maintenance water supplies. This is because the Coyote Wells Valley Groundwater Basin is already in a water overdraft deficient status (CDWR 2004). However, in emergency situations, SES may use groundwater for operation and maintenance.*

      While we recognize that the SWWTP upgrades could take some time to come online or the SWWTP could even be prevented from providing deliveries to the project (given the potential to significantly impact the salinity of the Salton Sea), thus resulting in project delays if an alternative source of water is not made available, we are of the opinion that Exhibit 32 was inadequate in quantifying the cumulative and potentially long-term impacts of groundwater diversions from the aquifer.

According to CEQA Guidelines, as reiterated on page 2.5-3 of Exhibit 32, a project would have a significant impact on hydrology if the project depleted groundwater supplies such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table. Given that the aquifer was designated as a sole source aquifer by the EPA in 1996 and is currently in an overdraft deficient status with static water levels declining on average 1 foot every five years (see page 2.5-2), it is difficult to fathom how this project would not further contribute to the cumulative groundwater deficit and lowering of the water table, which is not even acknowledged as a cumulative impact.

2. Exhibit 32 – Supplement to the AFC

   a. According to page 2.5-3, the average water demand during construction was stated to be 45,000 gpd or 50 afy, with a peak demand of 90,000 gpd, which is reduced to 33 afy during operations.

      If water deliveries from the groundwater supply for construction are limited to 40 afy, the project will suffer a water supply deficit of 10 afy or 20% per year. If construction spans 40 months or 3.33 years, the total deficit will be approximately 33.3 af. Assuming the project intends to store water in the two (2) 1-acre evaporation ponds, perhaps through water deliveries in the first year, the evaporation ponds would need to be at least 15 feet deep. In addition, the groundwater stored in the evaporation ponds would be subject to evaporation into the atmosphere. Mean evaporation from the evaporation ponds could be 111.4 in/yr[1,2,3] or 9.28 ft/yr or 0.31 in/day. As such, 56% of the stored groundwater could be lost to the atmosphere, thereby increasing the project's demand on groundwater resources. In our opinion, these details (i.e., logistics, scheduling, and evaporative losses of stored water) have not been adequately addressed in the impact analysis.

   b. According to page 2.5-4, "a drawdown analysis performed for this well indicates that pumping of the well at the prescribed rates will have no significant impact on water levels and water quality in the area, as the ZOI is considerably less than the distance to the closest well, approximately 500 feet away."

      While this test may demonstrate that the Zone of Influence (ZOI) is relatively small and that there should be no short-term impacts of pumping on adjacent wells, it does not address the long-term cumulative impacts that pumping may lower the water table since it has already been acknowledged that the basin is an in overdraft deficient state.

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[1] Pan evaporation, used as a surrogate for evaporation from the project's evaporation ponds, was estimated by Grismer et al. (2002) as 111.2 in/day for El Centro and by the WRCC as 111.6 in/day for the Mojave Desert.

[2] *Grismer*, M.E., M. Orang, R. Snyder, and R. Matyac. 2002. Pan evaporation to reference evapotranspiration conversion methods. *Journal of Irrigation and Drainage Engineering* 128(3):180-184.

[3] Western Region Climate Center (WRCC) pan evaporation data was accessed on May 15, 2010 from the following website: http://www.wrcc.dri.edu/htmlfiles/westevap.final.html.

In our opinion, the Applicant has wholly omitted analysis of the cumulative long-term impacts to adjacent wells from long-term pumping.

c. Exhibit 32 includes Appendix C (United States Gypsum Draft EIR/EIS Hydrology and Water Quality Section) and Appendix D (Groundwater Evaluation Report).

We have not had sufficient time to thoroughly review these items and we reserve the right to submit testimony on these exhibits at a later date.

3. Mike Fitzgerald (MF) – Biology

a. According to Questions #4 and #5, the three mitigation measures proposed by Dr. Chang in Exhibit 30 (i.e., delete sediment basins, change culvert crossings to at-grade crossings, consider 5 foot scour in washes for solar dish structural design), with the exception of the at-grade road crossings, were implemented in the revised Plan of Development (POD) and the Clean Water Act 404B-1 Alternatives Analysis (which have not been made available for our review). The workaround to the at-grade road crossing at Wash G was a bottomless CON/SPAN or BEBO crossing.

While we are in agreement to delete the sediment basins from the project and to use a bottomless clear span crossing over Wash G, we are not in agreement with all of Dr. Chang's findings per our opening testimony, which identified shortcomings in the sediment transport analysis that render the analysis inadequate. As such, significant sedimentation and morphological impacts to onsite and offsite resources still exist. We also question the qualifications of Ecosphere staff, predominately biologists, to assess the geomorphic merits of a sediment transport analysis.

b. According to Questions #6 and #7, the California Rapid Assessment Method (CRAM) was applied at the project site at the suggestion of the USACE as an experimental test case in the application of CRAM to desert environments.

Based on these responses and our understanding of the geomorphic components of CRAM, and as MF suggests, application of the CRAM results will be "speculative" until a CRAM module for desert washes and alluvial fans is developed. Until such time that a relevant CRAM module has been developed and thoroughly tested, which would likely require a reapplication of CRAM to the project site per a newly designed module, the geomorphic data and results should not be relied upon without confirmation by quantitative analyses.

c. According to Questions #8 and #9, the proposed project was modified to avoid specific washes (see Exhibit 34), and per the Applicant's practicability analysis, was determined to be the Applicant's proposed LEDPA.

We would argue that the modified project is not the LEDPA. It is our understanding that Exhibit 34 is more-or-less a variation on the USACE's Drainage Avoidance #1 alternative, except that primary washes A, D, the lower end of E, F, and the lower end of G are no longer avoided. As such, per our opening testimony, the unmitigated hydrologic and geomorphic impacts we identified for Drainage Avoidance #1 alternative are transferable to the modified project. What is not clear, since we were not privy to the 404B-1 Alternatives Analysis or other published information, is if a detailed cost-logistics-technology analysis has even been performed. In order to understand the practicability of the modified project, this analysis and underlying assumptions need to be made available.

d. According to Question #10, Dr. Chang's analysis may be used to qualitatively assess the geomorphic impacts of the modified project per Exhibit 34.

   Per our opening testimony, which identified shortcomings and inadequacies in the sediment transport analysis (Exhibit 30), to which we can only assume will be used to make qualitative inferences about the impacts modified project and necessary mitigation measures, we are of the opinion that a quantitative sediment transport analysis must be performed, before any qualitative inferences can be made, per the corrective measures and suggestions we identified in order to provide a better understanding of project impacts to onsite and offsite resources.

We are sponsoring the following exhibit:

Exhibit 499-D	Coleman, MacRae and Stein, Effect of Increases in Peak Flows and Imperviousness on the Morphology of southern California Streams, April 2005.

499-B

Declaration of Christopher Bowles
Imperial Valley Solar Project

Docket 08-AFC-5

I, Christopher Bowles, declare as follows:

1. I have been a business partner in cbec, inc., eco engineering, a California Corporation, since its incorporation in July 2008. Prior to incorporation, I was a sole proprietor since December 2007. Prior to becoming a sole proprietor, I was a Principal at PWA, Ltd. I have consulted in water resources in the U.S.A. for over 11 years and have been working in the water resources internationally for over 17 years. I am very familiar with the hydrology and geomorphology of the western U.S.A.

2. I hold a Ph.D. in Civil Engineering (with a specialization in water resources) and a Bachelor of Engineering (First Class with Honors) in Civil Engineering. Both of these degrees were obtained in England, UK. My relevant professional qualifications and experience are set forth in the attached CV.

3. I jointly prepared the testimony and figures with Christopher Campbell, attached hereto and incorporated herein by reference, relating to the hydrologic and geomorphic impacts of the Imperial Valley Solar Project.

4. It is my professional opinion that the attached testimony and figures are true and accurate with respect to the information that they portray.

5. I am personally familiar with the facts and conclusions described within the attached testimony and figures, and if called as a witness, I could testify competently thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Dated: MAY 17, 2010 **Signed:** C. B. Bowles

Location: WEST SACRAMENTO, CA **Printed:** CHRISTOPHER B. BOWLES

Declaration of Chris Campbell
Imperial Valley Solar Project

Docket 08-AFC-5

I, Christopher Campbell, declare as follows:

1. I have been a business partner in cbec, inc., a California Corporation, since its incorporation in July 2008. Prior to starting the business, I was a Senior Associate at PWA, Ltd.

2. I hold a M.S. degree in Biological and Agricultural Engineering and I am currently pursuing a Ph.D. in Civil Engineering. My relevant professional qualifications and experience are set forth in the attached CV.

3. I jointly prepared the testimony and figures with Chris Bowles, attached hereto and incorporated herein by reference, relating to the hydrologic and geomorphic impacts of the Imperial Valley Solar Project.

4. It is my professional opinion that the attached testimony and figures are true and accurate with respect to the information that they portray.

5. I am personally familiar with the facts and conclusions described within the attached testimony and figures, and if called as a witness, I could testify competently thereto.

I declare under penalty of perjury that the foregoing is true and correct to the best of my knowledge and belief.

Dated: MAY 17, 2010 **Signed:** Christopher R. Campbell

Location: WEST SACRAMENTO, CA **Printed:** CHRISTOPHER R. CAMPBELL

499-C

Pan Evaporation to Reference Evapotranspiration Conversion Methods

M. E. Grismer[1]; M. Orang[2]; R. Snyder[3]; and R. Matyac[4]

Abstract: Reference evapotranspiration (ET_0) is often estimated from evaporation pan data as they are widely available and of longer duration than more recently available micrometeorologically based ET_0 estimates. Evaporation pan estimation of ET_0 ($=K_pE_{pan}$) relies on determination of the pan coefficient (K_p), which depends on upwind fetch distance, wind run, and relative humidity at the pan site. The K_p estimation equations have been developed using regression techniques applied either to the table presented in FAO-24 or to the original data upon which this table was based (from lysimeter studies in Davis, Calif.). Here, the relative performances of the FAO-24 table and six different K_p equations are evaluated with respect to reproducing the original data table using the FAO-24 table as a standard. Evaporation pan- and CIMIS-based estimates of ET_0 are also compared for stations having ranges of mean humidities (48–66%) and mean wind runs (156–193 km/day) located in the Sacramento and San Joaquin valleys, and for a coastal station (Point Heuneme) near Ventura, Calif., having a greater mean humidity (71%). In comparing the means, standard deviations, root-mean-square errors, and linear regression coefficients, five of the six equations reproduced the original data table with approximately the same accuracy as the FAO-24 table. Use of either K_p table slightly underestimated measured ET_0 at the coastal site, while the Cuenca, Allen-Pruitt, and Snyder K_p equations most closely approximated the average measured ET_0 at all seven sites.

DOI: 10.1061/(ASCE)0733-9437(2002)128:3(180)

CE Database keywords: Irrigation scheduling; Evaporation; Evapotranspiration; Hydrologic models.

Introduction

Accurate reference evapotranspiration (ET_0) data are essential to water resources project planning and farm irrigation scheduling. As direct (that is, lysimeter-based) field measurements of ET_0 are rarely available, ET_0 rates are generally estimated from theoretical predictive equations requiring meteorological data. About 50 methods are available for estimation of ET_0, often yielding inconsistent results as their assumptions and meteorological data requirements differ. In many areas, the necessary meteorological data are lacking, and simpler techniques are required. One of the most common and fairly reliable techniques for estimating ET_0 is using evaporation pan data when adjustments are made for the pan environment (Singh 1989). Evaporation rates from National Weather Service (NWS) Class A pans are widely available throughout the world and can be used to estimate ET_0. The ratio of ET_0 to Class A pan evaporation, E_{pan}, defines the pan coefficient, K_p, whose values range from 0.35 to 0.85; K_p is essentially a correction factor that depends on the prevailing upwind fetch distance, average daily wind speed, and relative humidity conditions associated with the sitting of the evaporation pan (Doorenbos and Pruitt 1977).

When developing their guideline K_p values in the United Nations Food and Agricultural Organization publication (FAO-24) from the Davis, Calif., lysimeter data, Doorenbos and Pruitt (1977) modified their original results by selecting ranges for the individual values of daily wind run and relative humidity while rounding all calculated K_p values up to the nearest 0.05 increment (Allen and Pruitt 1991). (Both the original table values and those published in FAO-24 are in Tables 1 and 2, respectively.) This modification represents their cumulative judgment of the accuracy of their data in terms of estimating ET_0 from evaporation pan data. As such, a quantitative comparison of the FAO-24 K_p table and the original K_p table results sets a criterion by which to judge the acceptability of different equations developed to determine K_p values.

Equations for K_p have been developed based on the FAO-24 table using linear, nonlinear, and indicator regression techniques or combinations thereof. We modify those equations here to estimate K_p values based on the original data table (rather than the FAO-24 table) and compare the statistics of the calculated K_p values with those obtained from the FAO-24 table and the original table to evaluate the relative merits of each equation. We also evaluate how evaporation pan estimates of ET_0 compare with California Irrigation Management and Information System (CIMIS)-based ET_0 estimates in relatively moderate- and high-humidity sites of California The CIMIS station estimates of ET_0 are based on the modified Penman, or equivalently, Penman-Monteith equations (Snyder and Pruitt 1992; Ventura et al. 1999), respectively.

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[2]Associate Land and Water Use Analyst, Div. of Planning, California Dept. of Water Resources, Sacramento, CA.

[3]Extension Specialist, Dept. of Land Air and Water Resources, Univ. of California at Davis, Davis, CA.

[4]Senior Land and Water Use Analyst, Div. of Planning, California Dept. of Water Resources, Sacramento, CA.

Note. Discussion open until November 1, 2002. Separate discussions must be submitted for individual papers. To extend the closing date by one month, a written request must be filed with the ASCE Managing Editor. The manuscript for this technical note was submitted for review and possible publication on December 6, 2000; approved on August 7, 2001. This technical note is part of the ***Journal of Irrigation and Drainage Engineering***, Vol. 128, No. 3, June 1, 2002. ©ASCE, ISSN 0733-9437/2002/3-180–184/$8.00+$.50 per page.

Table 1. Original Pan Coefficient Values for Calculating Reference Evapotranspiration using U.S. NWS Class A Pan Data with Green Fetch

Wind run (km/day)	Fetch (m)	Relative humidity (%)		
		30	57	84
84	1	0.55	0.64	0.73
84	10	0.66	0.75	0.82
84	100	0.74	0.81	0.85
84	1,000	0.77	0.83	0.87
260	1	0.5	0.58	0.65
260	10	0.6	0.68	0.75
260	100	0.66	0.73	0.78
260	1,000	0.7	0.77	0.81
465	1	0.45	0.52	0.59
465	10	0.52	0.6	0.67
465	100	0.58	0.66	0.71
465	1,000	0.62	0.7	0.75
700	1	0.4	0.45	0.52
700	10	0.45	0.53	0.61
700	100	0.5	0.59	0.65
700	1,000	0.55	0.63	0.68

Assessment of Pan Coefficient Equations

Several K_p equations have been developed in the past decade, including Cuenca (1989), Allen and Pruitt (1991), Snyder (1992), Orang (1998), and Raghuwanshi and Wallender (1998). The equations developed by Cuenca, Snyder, and Raghuwanshi and Wallender were based on the FAO-24 K_p table, while those of Allen and Pruitt and Orang were developed using the original data table. We follow Snyder's (1992) approach to develop another K_p equation, but base the equation on the original data table and refer to it here as the modified Snyder equation. Orang (1998) combines linear regression techniques similar to those used by Snyder (1992) with interpolation between fetch distances to develop a K_p equation, also based on the original K_p table. The indicator regression approach used by Raghuwanshi and Wallender (1998) is not affected by the differences between the FAO-24 and original table values as the approach depends on categories rather than average or particular values within a range.

Table 2. Estimated Pan Coefficient Values of FAO-24 Table for Calculating Reference Evapotranspiration using U.S. NWS Class A Pan Data with Green Fetch (Doorenbos and Pruitt 1977)

Wind run (km/day)	Fetch (m)	Relative humidity (%)		
		<40	40–70	>70
<175	1	0.55	0.65	0.75
<175	10	0.65	0.75	0.85
<175	100	0.7	0.8	0.85
<175	1,000	0.75	0.85	0.85
175–425	1	0.5	0.6	0.65
175–425	10	0.6	0.7	0.75
175–425	100	0.65	0.75	0.8
175–425	1,000	0.7	0.8	0.8
425–700	1	0.45	0.5	0.6
425–700	10	0.55	0.6	0.65
425–700	100	0.6	0.65	0.7
425–700	1,000	0.65	0.7	0.75
>700	1	0.4	0.45	0.5
>700	10	0.45	0.55	0.6
>700	100	0.5	0.6	0.65
>700	1,000	0.55	0.6	0.65

The K_p equations are summarized below in Eqs. (1)–(6). All are functions of daily mean relative humidity, H (%), daily mean wind run, U (km/day), and fetch distance, $F(m)$, as defined by Doorenbos and Pruitt (1977).

Cuenca (1989):

$$K_p = 0.475 - 2.4\times10^{-4}U + 5.16\times10^{-3}H + 1.18\times10^{-3}F - 1.6\times10^{-5}H^2 - 1.01\times10^{-6}F^2 - 8.0\times10^{-9}H^2U - 1.0\times10^{-8}H^2F \quad (1)$$

Allen and Pruitt (1991):

$$K_p = 0.108 - 0.000331U + 0.0422\ln(F) + 0.1434\ln(H) - 0.000631[\ln(F)]^2\ln(H) \quad (2)$$

Snyder (1992):

$$K_p = 0.482 - 0.000376U + 0.024\ln(F) + 0.0045H \quad (3)$$

Modified Snyder:

$$K_p = 0.5321 - 0.00030U + 0.0249\ln(F) + 0.0025H \quad (4)$$

Orang (1998):

$$K_p = 0.51206 - 0.000321U + 0.002889H + 0.031886\ln(F) - 0.000107H\ln(F) \quad (5)$$

Raghuwanshi and Wallender (1998):

$$K_p = 0.5944 + 0.0242X_1 - 0.0583X_2 - 0.1333X_3 - 0.2083X_4 + 0.0812X_5 + 0.1344X_6 \quad (6)$$

where $X_1 = \ln(F)$; $X_2, X_3, X_4 = 0$ (if category is not present) or 1 (if present), corresponding to wind run categories of 175–425, 425–700, and >700 km/day, respectively; and $X_5, X_6 = 0$ (if category is not present) or 1 (if present), corresponding to relative humidity categories of 40–70 and >70%, respectively.

We evaluate the relative performance of Eqs. (1)–(6) in comparison to the FAO-24 K_p table based on their ability to reproduce the values in the original K_p table as well as their ability to estimate ET_0 at six inland valley stations and a coastal station of California. The performance of each equation is based on

1. Proximity of the mean and standard deviation of predicted K_p values to those of the original table;
2. Comparison of linear coefficients of determination (R^2) and root-mean-square errors (RMSE) between predicted K_p and original table values; and
3. Comparison of linear coefficients of determination (R^2) and RMSE between E_{pan} predicted and CIMIS ET_0 values for valley and coastal stations in California.

Results and Discussion

We first compare the relative performance of the equations above in predicting the original table K_p values relative to the ability of the FAO-24 table and then consider their relative performance with respect to ET_0 estimation in California. Table 3 summarizes the statistics associated with the original table K_p values, followed by those obtained from the FAO-24 K_p table and Eqs.

Table 3. Summary of Statistical Parameters ($n=48$) Associated with Estimation of Pan Coefficients (K_p) Relative to Original Data Table used to Develop Coefficients

Method	Mean	Standard deviation	R^2 (%)[a]	RMSE
Original table	0.650	0.117	NA	NA
FAO-24 table	0.650	0.118	97.9	0.017
Cuenca (1989)	0.650	0.105	91.4	0.034
Allen and Pruitt (1991)	0.650	0.116	99.0	0.012
Snyder (1992)	0.649	0.115	96.8	0.021
Modified Snyder	0.647	0.110	97.1	0.020
Orang (1998)	0.645	0.115	97.5	0.019
Raghuwanshi and Wallender (1998)	0.650	0.115	97.4	0.019

[a]Linear coefficient of determination assuming zero intercept.

(1)–(6). Generally, all but the Cuenca (1989) equation reproduced the original table K_p values means, standard deviations, and linear coefficients of determination (R^2) values (assuming zero intercepts) approximately equal to that resulting from comparison of the FAO-24 table to the original table. With the exception of both the Cuenca (1989) and Snyder (1992) equations, the RMSE values associated with comparison of the predicted K_p values to those in the original table were similar to those between the FAO-24 table and the original table K_p values. Overall then, it appears that the Allen and Pruitt (1991), Modified Snyder, Orang (1998), and Raghuwanshi and Wallender (1998) equations accurately represent the original K_p table with the same precision as that given by the FAO-24 K_p table. However, the value of this distinction depends in part on the accuracy of ET_0 predictions resulting from use of the different K_p equations, as described in the analysis by Park et al. (2000).

The station environments considered by Park et al. (2000) are either in many ways similar to that at Davis, Calif., where the K_p tables were developed, or less humid (that is, Shafter, Bakersfield, and El Centro). To assess the performance of the K_p equations near the more humid portion of the K_p tables, we consider a relatively humid site on the south-central Calif. coast near Ventura (Point Heuneme). Before considering ET_0 prediction capability, we evaluate the K_p equations in terms of their ability to generate K_p values with the same consistency as the FAO-24 table for Point Hueneme, following the same procedures/comparisons used in developing Table 3 (Table 4).

In this relatively high-humidity range of the K_p table, only the Raghuwanshi and Wallender (1998) equation has a similar RMSE value and a slightly smaller mean value than that given by the FAO-24 table. RMSE values for the remaining K_p equations are nearly three to seven times greater than that given by the FAO-24 table, while all mean values are less, with the exception of the Modified Snyder equation, which is equivalent to that given by the FAO-24 table. However, the Modified Snyder equation results in the largest coefficient of variation (COV) value (56% greater than that given by the FAO-24 table), while the remaining K_p equations yield similar or smaller COV values. The R^2 values between the equation-predicted K_p values and those from the original table appear to be meaningless due to the narrow range of K_p values considered.

Park et al. (2000) compared ET_0 predictions from CIMIS station data with those from adjacent evaporation pan estimates using the Cuenca (1989), Allen and Pruitt (1991), Snyder (1992), and Orang (1998) K_p equations for six different interior valley regions of California. Two of the four K_p equations that is, Cuenca (1989) and Snyder (1992) they considered are based on the FAO-24 K_p table. While the RMSE values reported by Park et al. (2000) were correct, the ET_0/K_pE_{pan} slopes were in error and have been corrected by Snyder (personal communication, Feb. 15, 2001), who also included analysis of the Modified Snyder equation. The RMSE differences between equation predictions were similar and ranged from ~0.5 mm/day at Shafter to ~0.9 mm/day at El Centro. The evaporation pan environment characteristics of the six sites as well as the more humid Point Hueneme site are summarized in Table 5. The Nicolaus and Manteca valley stations are roughly equidistant north and south of the original Davis lysimeter site used to develop the K_p tables, respectively, while the remaining four stations are progressively south, three in the San Joaquin Valley and one in the Imperial Valley. The Point Hueneme coastal site is southwest of Bakersfield.

The Point Hueneme evaporation pan station had been operational for several years prior to installation of an adjacent CIMIS station in February 1991. Evaporation pan readings were continued on a somewhat irregular schedule from August 1993 through October 1999 following the CIMIS station installation, and the CIMIS station was finally decommissioned in March 2000. Similar to Park et al.'s (2000) analyses, evaporation pan water levels were measured at 2–10 day intervals and were converted to daily ET_0 rates (mm/day) for the intervening period. Concurrently, the CIMIS station provided direct daily precipitation, temperature, windspeed, relative humidity, and ET_0 measurements. The CIMIS daily ET_0 measurements were averaged for the same 2–10 day periods corresponding to evaporation pan measurements. We "filtered" the evaporation data set in three passes: first, removing obvious erroneous readings, second, removing erroneous readings often associated with excess rainfall, and third, removing a few

Table 4. Summary of Statistical Parameters Associated with Estimation of K_p for Point Heuneme Relative to those Developed from Original Table

Method	Minimum/maximum	Mean	CoV (%)	R^2 (%)[a]	RMSE
Original table	0.73/0.85	0.815	4.64	NA	NA
FAO-24 table	0.70/0.85	0.817	4.07	87.5	0.0118
Cuenca (1989)	0.66/0.86	0.791	3.92	17.6	0.0379
Allen and Pruitt (1991)	0.70/0.85	0.803	2.96	39.4	0.0310
Snyder (1992)	0.62/0.92	0.818	6.36	39.6	0.0405
Modified Snyder	0.63/0.82	0.749	4.12	24.2	0.0724
Orang (1998)	0.68/0.83	0.779	3.56	5.0	0.0466
Raghuwanshi-Wallender (1998)	0.65/0.84	0.803	4.67	91.6	0.0160

[a]Linear coefficient of determination assuming zero intercept.

Table 5. Summary of Climate and ET (mean ET_0 and E_{pan}) Characteristics of Weather Stations of Interior California (Arranged from North to South) Considered by Park et al. (2000) and Coastal Point Hueneme Station

Station	Analysis period	n	F (m)	ET_0 (mm/day)	E_{pan} (mm/day)	U (km/d) Mean	U (km/d) Minimum/Maximum	H (%) Mean	H (%) Minimum/Maximum
Nicolaus	1/85–4/97	551	100	3.74	4.70	193	84/571	65.5	24/99
Manteca	8/85–4/97	288	330	3.58	4.60	175	44/361	66.4	38/99
Fresno	10/88–12/96	385	152	3.78	4.96	174	84/320	63.2	28/96
Shafter	1/85–6/97	557	100	4.43	5.69	159	81/272	57.4	29/96
Bakersfield	1/85–12/96	622	133	4.11	4.54	156	76/272	59.5	29/99
El Centro	1/90–5/97	380	33	4.99	7.74	191	81/409	48.4	23/91
Point Hueneme	8/93–10/99	166	100	3.16	3.74	159	58/245	71.2	38/92

readings that were more than three times greater or 1/3 less than the associated average daily CIMIS ET_0. The filtering process reduced the overall data set by approximately 10%. Finally, we compared the statistics of the smaller evaporation pan data set ($n=166$) with that of the much larger CIMIS data set ($n=3{,}320$) and found that the smaller evaporation pan data set had mean values similar to that of the CIMIS data set, suggesting that the smaller set is a fair representation of the decade-long data set for purposes of ET_0 comparison.

Table 6 summarizes R^2 values and slopes (based on linear regressions assuming zero intercepts) between CIMIS and E_{pan}-based ET_0 estimates for all seven sites. Use of any K_p equation results in slight overestimation of ET_0 (by 5–9%) at the hot, dry El Centro (Imperial Valley) site; conversely, all the equations underestimate ET_0 (by 13–21%) at the Bakersfield site. We suspect that there is an error in the pan data from Bakersfield, potentially associated with use of a screen over the evaporation pan. Use of the Cuenca (1989) equation overestimates ET_0 (by ~13%) at the Manteca site, apparently as a result of the exceptionally large fetch distance at this site. Use of a 100 m fetch distance (rather than 330 m) in this equation results in much better ET_0 predictions than the Cuenca (1989) equation for Manteca. However, the Cuenca (1989) equation results in an average ET_0/K_pE_{pan} slope nearest to 1.00 for the seven sites considered. The Allen and Pruitt (1991) and Snyder (1992) equations result in ET_0/K_pE_{pan} slopes that are more consistently near unity for the seven sites, while the Modified Snyder and Orang (1998) equations result in ET_0/K_pE_{pan} slopes slightly greater than one.

Overall, it appears that evaporation pan-based estimates of ET_0 using both K_p tables and equations are generally within an error of approximately 10% for both humid and relatively dry regions of California. Of the K_p equations, the Allen and Pruitt (1991) and Raghuwanshi and Wallender (1998) equations appear to most consistently represent the original and FAO-24 K_p table values, as well as providing ET_0 estimates across the state that are similar to those obtained from micrometeorologically based methods.

Summary and Conclusions

We evaluate the relative performance of commonly used nonlinear and linear regression equations for prediction of evaporation pan coefficients, K_p, needed for estimation of ET_0 from evaporation pan data. Using the predictive capability of the FAO-24 K_p table as a standard of judgment by which to compare the K_p equations, means, standard deviations, coefficients of determination, and RMSEs were determined for each set of equation predictions as compared to the original K_p table values. With the exception of the Cuenca (1989) equation, the K_p equations predicted original table values with an accuracy similar to that of the FAO-24 table. We note that the relative sensitivity of the K_p equation coefficients is greatest for the cross-product terms and least for the fetch [$\ln(F)$] and wind run (U) terms.

In contrast, when applying the K_p tables and equations to estimation of ET_0 as compared to CIMIS ET_0 values, we found that their relative performance varied slightly, depending on site location, and was not related to the relative ability of each equation to reproduce the original K_p table. For example, the Cuenca (1989) equation yielded ET_0 values nearer the measured CIMIS values than any other equation on average for all sites, though it performed more poorly with respect to reproducing original K_p table values. On average, the Allen and Pruitt (1991) K_p equation yielded K_p values with an accuracy equivalent to or exceeding

Table 6. Linear Coefficients of Determination (Zero Intercepts) and Slopes between CIMIS ET_0 and E_{pan}-Based ET_0 Estimates for Park et al. (2000) Dataset and Point Hueneme Data

Station	Slope ET_0/K_pE_{pan} (mm/mm) Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)	Coefficients of determination (%) Eq. (1)	Eq. (2)	Eq. (3)	Eq. (4)	Eq. (5)
Nicolaus	1.032	1.051	1.027	1.094	1.091	94.0	94.7	92.9	94.4	94.5
Manteca	0.837	1.005	0.969	1.031	1.027	93.5	93.5	92.1	93.3	93.4
Fresno	0.956	1.015	1.006	0.929	1.050	92.7	92.9	91.3	91.3	92.8
Shafter	1.030	1.035	1.032	1.078	1.072	96.0	95.6	96.1	96.1	96.1
Bakersfield	1.128	1.170	1.165	1.218	1.211	91.9	92.3	90.9	92.3	92.3
El Centro	0.963	0.909	0.922	0.952	0.951	89.0	89.8	87.7	89.8	90.0
Point Hueneme	1.050	1.034	1.012	1.109	1.064	62.6	63.2	60.6	62.2	63.0
Average slope	0.999	1.031	1.019	1.059	1.067	—	—	—	—	—

that of the FAO-24 table, and when used to estimate ET_0, was consistently nearer the measured (CIMIS) values than that estimated using any other equation.

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499-D

Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams

Technical Report 450
April 2005

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EFFECT OF INCREASES IN PEAK FLOWS AND IMPERVIOUSNESS ON THE MORPHOLOGY OF SOUTHERN CALIFORNIA STREAMS

A report from the Stormwater Monitoring Coalition

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EXECUTIVE SUMMARY

Urbanization in southern California has resulted in direct and indirect effects on natural stream courses that have altered their physical and biological character. Development typically increases impervious surfaces on formerly undeveloped (or less developed) landscapes and reduces the capacity of remaining pervious surfaces to capture and infiltrate rainfall. The result is that as a watershed develops, a larger percentage of rainfall becomes runoff during any given storm. In addition, runoff reaches the stream channel much more efficiently, so that the peak discharge rates for floods are higher for an equivalent rainfall than they were prior to development. This process has been termed *hydromodification*.

Although the effects of increased impervious cover on stream flow have been well documented (Bledsoe, 2001; Booth, 1990; 1991; MacRae, 1992; 1993; 1996), the majority of past studies have focused on perennial streams. Until recently, few comparable studies have evaluated the impacts of urbanization on ephemeral or intermittent streams of arid or semi-arid climates. This had made it difficult to effectively manage stormwater impacts on southern California's natural streams. In response, the Stormwater Monitoring Coalition (SMC) conducted this study to assess the relationship between stream erosion and urbanization. It is anticipated that the results of this study will be useful in developing peak flow criteria for Los Angeles County as well as future stormwater regulations or management strategies.

The goal of this study is to assess relationships between stream channel type and resistance that will allow prediction of channel response under changed conditions associated with increased impervious cover. The specific study objectives are to:

- Establish a stream channel classification system for southern California streams;
- Assess stream channel response to watershed change, and attempt to develop deterministic or predictive relationships between changes in impervious cover and stream channel enlargement; and
- Provide a conceptual model of stream channel behavior that will form the basis for future development of a numeric model.

The intent of this study was to use multiple watersheds (each containing a single site) studied in broad scope rather than a single watershed (with many sites) studied in great detail. Consequently a total of 11 separate sites were selected in 8 distinct watersheds (Table ES-1).

Table ES-1 Study Site List

Site No.	Site Name	CDA (mi^2)	Major Watershed	Type of Site	County
1	Topanga Creek	18.07	Santa Monica Bay	Control Site	Los Angeles
3u	Hasley Canyon	1.55	Santa Clara River	Control Site	Los Angeles
3d	Hasley Canyon	1.66	Santa Clara River	Developed Site	Los Angeles
4u	Plum Canyon	2.23	Santa Clara River	Developed Site	Los Angeles
4d	Plum Canyon	2.40	Santa Clara River	Developed Site	Los Angeles
7u	Borrego Canyon	2.27	San Diego Creek	Developed Site	Orange
7d	Borrego Canyon	3.06	San Diego Creek	Developed Site	Orange
9	Serrano Creek	2.64	San Diego Creek	Developed Site	Orange
10	Santiago Creek	12.36	Santa Ana River	Control Site	Orange
23	Dry Canyon	1.22	Calleguas Creek	Control Site	Ventura
27	Hicks Canyon	1.33	San Diego Creek	Control Site	Orange

CDA = catchment drainage area

The study approach was to evaluate the changes in stream channel configuration over time and compare them to the changes in total basin impervious cover (TIMP) over the same time period. Data collection occurred in two phases. In the first phase background and historic information was gathered on each site and its contributing drainage area. In the second phase detailed field data was collected on the geomorphic condition of each study reach. The combinations of historic and contemporary data were used to develop predictive relationships between changes in impervious cover and channel form.

This study resulted in the following general conclusions regarding the relationship between impervious cover and stream channel form for ephemeral streams in southern California:

1. **Southern California streams exhibit deterministic relationships between bankfull discharge (Q_{bfl}), and measures of channel geometry such as cross section area (A_{bfl}).** Of the field measures calculated, the greatest consistency in relationship to the discharge rate at the bankfull stage, also termed the *Dominant Discharge* (Q_{bfl}), was with the channel cross-sectional area (A_{bfl}). Dominant Discharge exhibited a clear, predictable (or deterministic) relationship with features of channel geometry, such as channel width and cross-section area, i.e. as discharge increases, predictable increases in channel size are observed. An example of this deterministic relationship is shown in Figure ES-1, which indicates that the initial channel response to increases in discharge is to widen; however, with increasing discharge, the rate of channel widening decreases and downcutting is the predominant response.

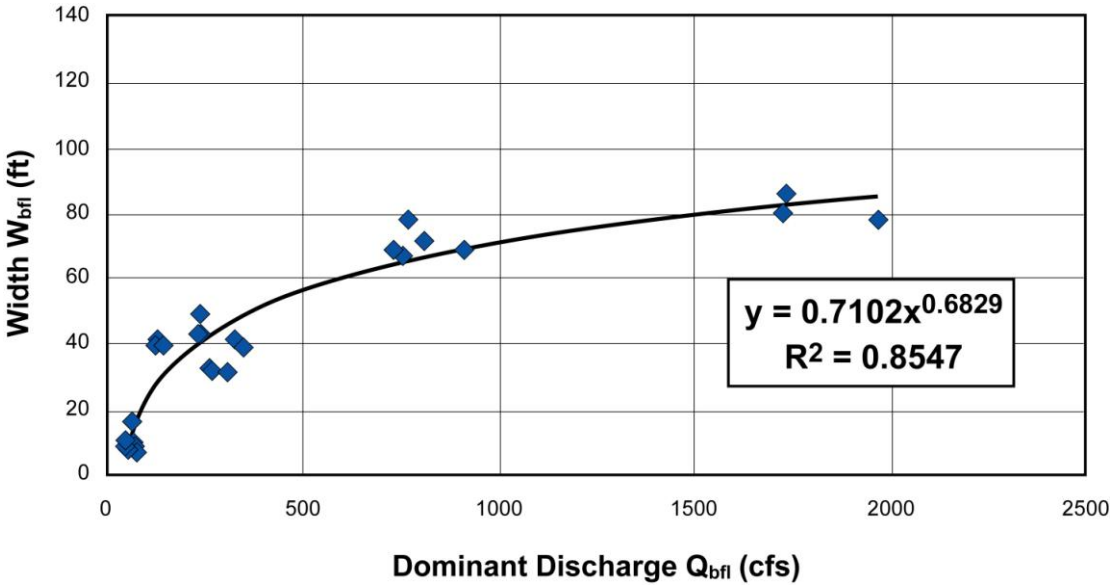

Figure ES-1: Relationship of Dominant Discharge to Channel Width

2. **The ephemeral/intermittent streams in southern California appear to be more sensitive to changes in TIMP than streams in other areas**. Stream channel response can be represented using an *enlargement curve*, which relates the percent of impervious cover (TIMP) to a change in cross-sectional area (Figure ES-2). The data for southern California streams forms a relationship very similar in shape to the enlargement curves developed for other North American streams. However, the curve for southern California streams is above the general curve for streams in other climates. This suggests that a specific enlargement ratio is produced at a lower value of impervious surface area in southern California than in other parts of North America. Specifically, the estimated threshold of response is approximately 2-3% TIMP, as compared to 7-10% for other portions of the U.S. It is important to note that this conclusion applies specifically to streams with a catchment drainage area less than $5mi^2$.

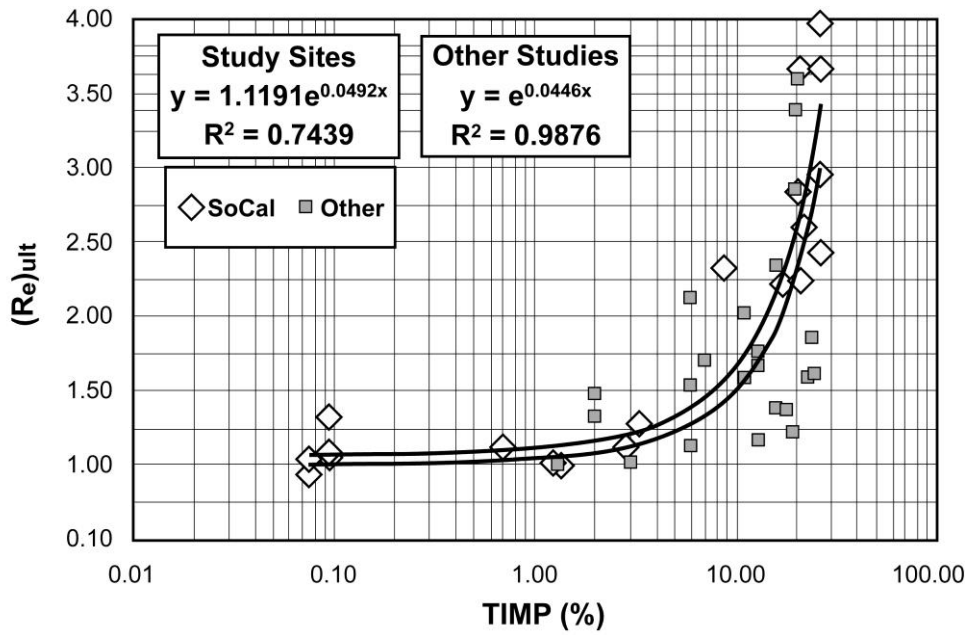

Figure ES-2. Enlargement Curve for Southern California.

Upper curve and data points are for southern California channels in the current study. Lower curve is based on data from other locations in North America.

3. **There is a natural background level of channel degradation that is occurring in all stream channels studied, even in the absence of development within the drainage area.** A minimal rate of change in channel bottom elevation was observed in all sites, regardless of whether the watershed has experienced an increase in impervious cover. Control sites exhibited a state of dynamic equilibrium where downcutting was observed, but channel morphology did not change appreciably over time. In contrast, the developed sites exhibited instability, where one or more measures of channel morphology changed over time. In addition, the rate of change in downcutting was greater in the developed sites than in the control sites. For example, at the Dry Canyon control site downcutting was estimated to be 0.7 ft/yr, while the rate at the developing Plum Canyon site was estimated to be 1.7 ft/yr. These results demonstrate poor channel resistance to increased flow in all stream channels except those subject to bedrock control, such as Topanga Creek.

4. **Streams are sensitive to both peak discharge and duration of discharge.** The ephemeral and intermittent streams investigated in this study appear to be highly sensitive to changes in flow rates associated with increased impervious cover. Additionally, they appear to have a low resistance to erosion, which results in increased susceptibility to channel enlargement in response to increases in the duration of high flows.

The predictive relationships established in this study can be used to evaluate potential effects of proposed development on the stability of natural streams. There are ranges of strategies that can be used to help reduce the potential effects of increased TIMP. However, the selection of a management strategy is dependent upon the extent to which a stream channel has been impacted by development within the watershed, the nature of the stream channel reach under consideration, and the anticipated future watershed conditions (i.e. expected increases in TIMP). Three general strategies should be considered when attempting to manage increases in peak flow:

1. **Limit Impervious Area.** Although the focus of this study was necessarily on TIMP, disconnecting impervious areas from the drainage network and adjacent impervious areas is a key approach to protecting channel stability. Utilizing this strategy can make it practical to keep the effective impervious cover (i.e. the amount hydrologically connected to the stream) equal to or less than the identified threshold of 2-3%.

2. **Control Runoff.** Hydrograph matching is not recommended for a single "design" storm with a specific return period, but rather for a range of return periods from 1 year to 10 years. Accomplishing such hydrograph matching will be challenging, and undoubtedly require a combination of techniques to prevent (retain), as well as to delay or attenuate (detain) runoff and/or stream flow.

3. **Stream Channel Movement.** Allow the greatest freedom possible for "natural stream channel" activity. This includes establishing buffer zones and maintaining setbacks to allow for channel movement and adjustment to changes in energy (associated with runoff). However, where in-stream controls are required consider all potential management options.

It is important to keep in mind that the choice of a management approach or approaches should be dictated by the strategies that are appropriate given the conditions of each stream reach and its contributing watershed. Consequently a suite of management approaches may need to be applied to provide a comprehensive solution to managing potential increases in runoff due to land use change.

Stream channels respond to changes in basin imperviousness in complex ways, and specific responses will vary based on the characteristics of the stream and watershed. An exhaustive analysis of these issues was beyond the scope of this study; nevertheless, the present study represents an important first step in understanding the response of ephemeral streams to increases in impervious cover.

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1.0 INTRODUCTION

The southern California region is expected to experience significant urbanization over the next several decades that has the potential to have significant impact on the many ephemeral or intermittent streams of this arid to semi-arid region. In response to this concern, the 2001 Los Angeles County Municipal Stormwater Permit calls for a study to help develop numeric criteria to prevent or minimize erosion of natural stream channels and banks associated with urbanization.

Working through the Stormwater Monitoring Coalition (SMC), the Southern California Coastal Water Research Project (SCCWRP) has been designated as the facilitator for studies to assess the relationship between stream erosion and urbanization. It is anticipated that the results of this study will be useful in developing peak flow criteria for Los Angeles County as well as future stormwater regulations. Earth Tech, Inc. has been retained to conduct this study to relate measurable urban/suburban development within a watershed to observable changes in stream-channel morphology (including width, depth, cross-sectional area, and plan-form shape) in the southern California region.

1.1 Project Background

The process of urbanization alters many aspects of a landscape and often results in the emplacement of structures and infrastructure. One of the primary changes that has the potential to affect stream courses is alteration of watershed hydrology. Development increases impervious surfaces on formerly undeveloped (or less developed) landscapes and reduces the capacity of remaining pervious surfaces to capture and infiltrate rainfall. The result is that as a watershed develops, a larger percentage of rainfall becomes runoff during any given storm. In addition, runoff reaches the stream channel much more efficiently, so that the peak discharge rates for floods are higher for an equivalent rainfall than they were prior to development. This has been well documented since the early research by Hammer (1972) and Hollis (1975), through the recent efforts of Bledsoe (2001), Booth (1990, 1991), and MacRae (1992, 1993, 1996). Changes in runoff and flow have also been shown to result in impacts on aquatic habitat and species (Benke, et al. 1981, Booth and Jackson 1997, Garie and McIntosh 1986, Jones and Clark 1987, and Pedersen and Perkins 1986).

Although the effects of increased impervious cover on stream flow have been well documented, the majority of past studies have focused on perennial streams. Few comparable studies have evaluated the impacts of urbanization on streams of arid or semi-arid climates where most of the smaller streams are ephemeral or intermittent. Ephemeral streams are defined as those that flow only in direct response to a rainfall event, and (particularly in southern California) are otherwise dry for most of the year. Intermittent streams will have base flow for some of the period between rainfall events, but will also have dry periods throughout the year. Perennial streams will flow throughout the year, having enough base flow to maintain water in the stream channel even during the long months of the dry season.

Two recent projects in California have begun to investigate effects of increased peak flow on arid streams that were either formerly ephemeral (Thompson Creek in Santa Clara County) or presently and historically ephemeral (Arroyo Simi in Ventura County). In each case, reports prepared for these projects summarized the relevant literature and noted the sparseness of work on streams in arid or semi-arid climates. GeoSyntec (2002) provides a substantial review of the literature on this topic, and AQUA TERRA (2004) contributes additional references not covered in the more extensive GeoSyntec (2002) literature review. Of the 123 papers, reports, or books reviewed between these two references, only one citation was noted specifically for considering and evaluating ephemeral streams (Caraco 2000). This emphasizes the lack of reference material available for assessing ephemeral or intermittent streams in dry climates.

There are additional classic (Graf 1987) and recent (Tooth 2000, and Bull and Kirkby 2002) works on stream processes in arid areas not cited by the recent California projects. However, these additional publications do not focus on impacts from increased imperviousness. Therefore, the limited nature of applicable research is particularly problematic for the relatively steep arid and semi-arid streams typically found in southern California, which may have different bed and bank properties than streams in other regions. The lack of research into the impacts of urbanization on ephemeral and intermittent streams also makes it difficult to manage stormwater impacts on natural streams effectively in southern California or other parts of the southwest. Furthermore, the current, rapid pace of urbanization in foothill areas of the study region emphasizes the importance of understanding the relationship between changes in the hydrologic and hydraulic processes of these systems and the resultant change in stability of the streams in arid watersheds. Such an understanding is urgently needed to help managers make informed decisions regarding strategies to protect these streams.

The present study is another step toward understanding the responsiveness of ephemeral stream channels to changes in hydrology (i.e. evaluating their resistance to expected changes in the flow peaks and duration). The approach adopted here differs from the two recent efforts in California to evaluate the impacts of urbanization. AQUA TERRA (2004) used a modeling approach with field verification to evaluate a single watershed using data from six stream channel monitoring points. GeoSyntec (2003), also used multiple stream channel data collection points within a single watershed to evaluate stream channel response to development. The present study evaluated stream channel study sites in multiple, small watersheds from a larger geographic area that includes Los Angeles, Orange and Ventura counties in order to begin developing a regional understanding of the relationship between increased impervious cover and stream channel stability.

1.2 Study Objectives

The primary objective of this study was to find relationships between stream channel type and resistance that would allow prediction of channel response under changed conditions associated with increased impervious cover. Ultimately this effort will contribute to the establishment of stormwater management criteria to help minimize the impacts to stream channels from the conversion of undeveloped (or less developed) areas to residential, commercial, or other intensive land uses.

The study was structured to address specific problems expressed in terms of urbanizing systems (Table 1-1). Although solutions to these problems may not be attainable through this study, they are presented as a desirable outcome of this type of research. More tenable study goals are provided as reasonable expected results of this project. Finally, several viable approaches applied by this project are presented to indicate how the study addressed the stated problems in order to reach the stated study goals.

Table 1-1. Project Structure

Problems	Approaches	Study Goals
1. Understand stream channel response to urbanization in southern California streams. 2. Isolate the effects of urbanization on stream channel response. 3. Identify geomorphic thresholds for southern California streams. 4. Understand the effectiveness of mitigation strategies. 5. Establish a model or procedure to extrapolate relationships based on case studies.	1. Use data obtained from the study sites to establish a stream channel classification system for southern California. 2. Use stream channel type to discriminate among the quantifiable impacts to stream channel morphology. 3. Establish a procedure to assess significance of morphological impacts.	1. Evaluate the impact of urbanization on stream morphology in natural ephemeral stream-channel systems in southern California. 2. Develop cause and effect relations between stream channel morphology change and urbanization. 3. Review potential BMP implementation. 4. Recommend possible applications of this study's findings to other streams and watersheds in southern California.

Since this was an empirical study, it required several stream channel sites that were selected from within a six-county region in southern California. The investigation looked at historical changes in stream channel configuration relative to historical changes in land use. The intent, therefore, was to use multiple watersheds (each containing a single site) studied in broad scope rather than a single watershed (with many sites) studied in great detail. Consequently a total of 11 separate sites were selected in 8 distinct watersheds. The locations of these watersheds are regional, and range from northwestern Los Angeles County through southern Ventura County, and down to central Orange County. The evaluations performed should allow a greater range of site conditions to be evaluated than they would for a single watershed, and ultimately provide results with broader applicability in the southern California region. There is a great need for additional research in this geographic area on the impacts from urbanization, and this need is for both focused (single watershed) and regional (multiple watersheds) investigations. The two recent California studies (AQUA TERRA 2004 and GeoSyntec 2004) were focused studies. The present study is the first regional investigation of ephemeral stream channel response to urbanization.

The objectives of this study, which were needed in establishing the relationship sought by the primary study goal, include the following:

- Create a classification system to generalize responses of different types of stream channels,
- Evaluate stream channel response to watershed change, and
- Attempt to provide a conceptual model of stream channel behavior.

While the results of the current study are only directly applicable to the sites included in this study, the use of a classification system similar to the one proposed here (see Section 3) holds promise for eventually broadening this applicability and allowing extrapolation of results to other similar stream types. Understanding such relationships could be an important part of future watershed and stormwater management by identifying stream channel reaches that are most susceptible to change. Toward this end, Section 4 of this report provides some recommendations for additional research needs to provide a broader scientific basis for the classification of stream channels in all six counties of the study region and their applicability to different development scenarios.

2. DATA COLLECTION METHODS

This study employed a stepwise stream evaluation protocol previously applied at a number of sites throughout North America, and developed partly from research conducted worldwide (Table 2-1). This project evaluated the applicability of this protocol to the semi-arid southern California region. Specifically, the study tested the comparability of relationships derived from southern California streams to data collected in other areas encompassing more diverse hydrologic settings. If the two data sets are comparable, the larger data set can be used to augment the relatively modest data expected from this study; thereby strengthening the reliability of the analysis based on local conditions.

2.1 Evaluation Process

The overall protocol includes eleven steps, but only steps 1 through 5, 7, and 8 have been employed in this study, as this study has been broadly applied to sites in southern California rather than being applied to a single watershed with multiple stream or river channel sites. Each step of the process and a brief summary of its application to this study are provided below. The remaining sections of this report provide background information on the study sites and evaluations performed for the application of this protocol. Detailed field and analytical data are contained in the appendices to this report.

Table 2-1. Eleven-Step Protocol
The Protocol, as applied in this study pertains to the geomorphic component of stream channel investigations.

ID	Name	Question
STEP 1	Study Objectives	What is the nature and degree of the perceived problem?
STEP 2	Past Stream channel	What was the form of the historic stream channel?
STEP 3	Expected Disturbances	What future disturbance is likely to occur?
STEP 4	Present Stream channel	What is the stream channel like today?
STEP 5	Future Stream channel	What will the stream channel look like in the future?
STEP 6	Accept/Reject Future	Is the future stream channel form desirable, acceptable or unacceptable?
STEP 7	Disturbance Control	Can the perturbations be controlled through watershed planning?
STEP 8	Channel Works	Are instream works required, desirable, feasible and practical?
STEP 9	River Management	What is the preferred river corridor management plan?
STEP 10	Engineering Design	What does the detailed design look like?
STEP 11	Implementation	How will the plan be implemented?

Study Objectives. The first step of the protocol is to establish study objectives by defining the problems to be solved, establishing goals for solving these problems, and defining an assessment approach for determining when the goals are reached. For this study, the objectives have been articulated previously in Section 1.2, Study Objectives.

Past Stream Channel. Previously surveyed cross sections were available for each of the study sites, including at least one at every stream channel reach. These cross sections are an important key to evaluating how stream channel morphology differed in the past from its present-day form. The differences in stream channel geometry between past sections and present sections were evaluated for

every site. The results of this evaluation are used as a basis for both the stream channel classification system and the stream channel response evaluation discussed in Section 3 of this Technical Report.

Expected Disturbances. This study is focused entirely on expected disturbances related to land use changes within the watersheds of these sites. Therefore, evaluation of expected disturbances is centered on changes in energy and erosion potential at these stream reaches.

Present Stream Channel. The present stream channel configurations are very clearly understood at all of the sites through the diagnostic surveys performed in May 2004. Each stream channel reach had from three to six cross sections surveyed, with characterizations made of the topography and the composition of bed and bank materials. In addition, a longitudinal profile was also surveyed that tied all of the cross sections together spatially and geometrically.

Future Stream Channel. Evaluation of the historical changes in stream channel morphology, combined with the data on bed and bank material composition, and bank cohesion, allowed an assessment of the potential for additional adjustment in stream channel morphology at each of the study reaches.

Accept/Reject Expected Future. If the purpose of this study had been stormwater management for a specific watershed, then the intent of this step would be applicable to the current discussion. However, because this effort is attempting to characterize a broad range of stream channels and assess their thresholds for stream channel change (most specifically enlargement), accepting or rejecting change is not required.

Disturbance Control. This study attempts to provide a generic assessment of the effectiveness of different classes of stormwater management measures, and when they can be appropriate to use in controlling the expected stream channel change resulting from urbanization.

Channel Works (BMPs). This project also considers the need for, and appropriate use of, in-channel management practices and under what conditions they might be appropriate.

2.2 Site Selection

The general goals in site selection were to find stream channels that would be representative of stream channel types across the region. In addition, candidate sites needed to have available historic information on the stream channel and the watershed. Finally, the selected watersheds must have been subject to some degree of development over the period for which information is available.

A detailed discussion of the logic behind the site selection process, and the guidelines applied while selecting the sites used in the study, can be found in the Work Plan prepared for this effort (Earth Tech, 2004). However, a brief summary of each guideline is presented below. A brief description of the sites selected and key background information on each site is presented in Sections 3.

- **Selection Guideline 1. Small Watershed Size.** The target drainage area for selected study sites/reaches was between 1 and 5 square miles, depending upon the degree of impervious cover.
- **Selection Guideline 2. Shear Stress Dominated.** The selected stream channel sites needed to have well-formed morphological characteristics that could be readily distinguished and surveyed using traditional geomorphic and engineering study techniques. Ideally, the stream channel system would be approaching a metastable position and shear stress processes are the dominant channel-forming mechanism.
- **Selection Guideline 3. Natural Channel.** The stream channels were to be primarily undisturbed by direct human activity (as well as could be determined) during the surveyed period. This included such activity as channel straightening, channel enlargement, bank protection or stabilization, upstream or downstream hydraulic control devices, and sediment trapping or containment structures. The length of the undisturbed stream channel needed to be greater than the minimum survey length of 1 to 2 meander wavelengths or the equivalent of 10 to 20 bankfull stream channel widths.

- **Selection Guideline 4. Development.** The watershed areas of the sites had to contain some level of urban (or suburban) development. Preferably at least 5 to 10 percent of the land area within the watershed should be in urban, suburban, commercial, or industrial land use categories.
- **Selection Guideline 5. Historic Cross Sections.** It was absolutely critical that each of the sites has previous stream channel cross-section surveys available for comparison. Ideally, these cross sections would be for one or more time periods prior to, and during the development period. Preferably the surveys would be from a time when a smaller percentage of the watershed was developed than it is currently.
- **Selection Guideline 6. Streamflow Data.** Sites were sought with stream flow data available in or near the study reach. Acceptable data was from actual flow measurements, modeled flow values, estimated peak discharges for specific recurrence intervals, or regional relationships. In the absence of such data, some idea of the number of days in a year that the stream channel contains flowing water was sought.
- **Selection Guideline 7. Aerial Photos.** Although not required, paired, stereographic aerial photographs at a useable scale (e.g., 1:10,000 or better) were sought for one or more historic periods.
- **Selection Guideline 8. Topographic Maps.** A study reach needed maps with a useable scale and contour interval (ideally 1 inch = 50 feet, to 1 inch = 100 feet, and a contour interval of 1 foot).
- **Selection Guideline 9. Geotechnical Data.** The availability of the results of geotechnical investigations that characterized materials similar to the stream channel bank and bed materials for a reach was considered very helpful in the site selection process.

The site selection process was a two-phase effort of (1) identifying potential (or "candidate") sites and (2) picking a subset of these sites for inclusion in the investigation. The process included contacting federal, state, county, and local government agency personnel, faculty members at local universities, and staff at local non-profit organizations to seek recommendations for candidate sites that generally appeared to meet the selection guidelines. The identified candidate sites are shown in Figure 2-1, as well as the final selected sites for the study. Details on the selected sites are given in Section 3.0, including location, topography, local geology, and other salient information.

2.3 Data Collection

Two phases of data collection were conducted for each of the eleven selected study sites. The first phase consisted of collecting background and historic information on each site and its contributing drainage area. The second phase consisted of collecting intensive field data on the geomorphic condition of each study reach. These two phases are described in detail in sections 2.3.1 and 2.3.2 below.

The historic data gathered for this study included the following types:

- Land use maps and/or digital files marking a specific land use coverage at a specific point in time.
- Surveyed cross sections (of distance and elevation) previously measured at each of the study sites.
- Precipitation records for rain gauges close to the watershed areas of the study sites; primarily annual amounts for the period of record.
- Stream flow measurements at local USGS (or other) stream gages; mostly annual peak flows for the period of record.
- Aerial photographs covering a range of times over the watershed area.

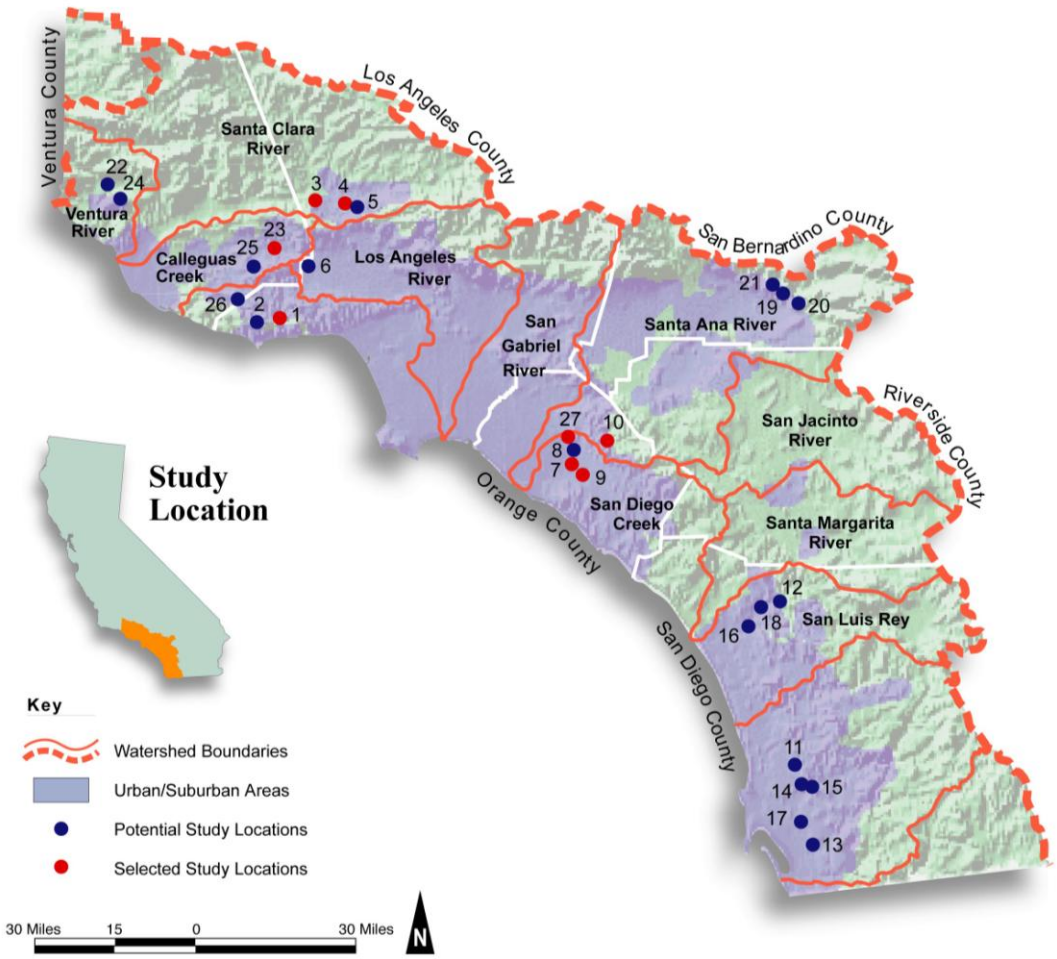


Figure 2-1. Study Sites

Map of study area showing the locations of potential study sites. See Table 1-1 for identification of, and additional information about, the selected study sites.

(Includes all candidates sites.)

- Evaporation (or evapotranspiration) records or approximate amounts for the watershed of the modeled reach.
- Satellite imagery and interpretation for impervious areas in the Hasley Canyon and Plum Canyon watersheds.

The current data was collected during two weeks of field work in May 2004. The specific types of field data collected at each of the stream channel reaches selected for this study include:

- Total-station surveys of the entire study reach that included stream channel cross sections (especially at locations of the previously surveyed cross sections), longitudinal profiles of the stream channel, and other points of interest tied to the geomorphic mapping.
- Geomorphic mapping of the stream channel reach, including up to, and slightly beyond the perceived "bankfull" channel configuration.
- Pebble counts and/or sieve analyses at multiple points across the stream channel to characterize bed materials.
- Sieve analyses and Torvane® shear stress meter readings to characterize bank material sizes and cohesion of both right and left banks.
- Rapid geomorphic assessment of each study reach.

2.3.1 Historic Data

Sources for the historic data are summarized below. These data generally required some amount of processing to make them consistent with the other data sources, and useable with the field-generated data from the current study.

Land Use. Land use data were used as a surrogate for impervious surface area within the watersheds. Land use/impervious cover data came from three primary sources (Table 2-2). The basic land use data came from detailed maps prepared for the Southern California Association of Governments (SCAG) for the years 1990, 1993, and 2001. Older land use data came from aerial photos and interpreted land use maps for the Serrano Creek and Borrego Canyon sites made available by Felicia Federico of UCLA. Data from DigitalGlobe was used to supplement the land use mapping for Hasley and Plum canyons. It consisted of digital orthoimagery collected with the QuickBird® satellite, which was used to supplement the SCAG land use maps. The DigitalGlobe imagery of Hasley Canyon was taken on 23-July-2002, while the imagery for Plum Canyon was taken on 22-March-2003.

Cross Sections. Previously surveyed cross sections came from six primary sources (Table 2-3). Most data were for multiple sections surveyed one or more years apart. The exceptions were Topanga Creek (one section, one survey time), Borrego Canyon (one section for each site, multiple survey times), and Santiago Creek (four sections, one survey time). Monuments used in the original survey, or other recoverable "surrogate" monuments were used to tie the current surveys to their historic cross section counterparts.

Precipitation Records. Rainfall records were sought for each watershed area to provide background information on relative hydrologic conditions for the period of land use change and the related adjustment in stream channel morphology (Table 2-4). Rainfall records were obtained for multiple weather stations near the watershed areas of the sites. The relative locations of the weather stations to the watersheds are shown in Figures 2-2 and 2-3.

Table 2-2. Land Use/Impervious Cover Data

Site		Source	Information
Site 1.	Topanga Creek	SCAG (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data.
Site 3.	Hasley Canyon	SCAG (2004), DigitalGlobe (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data; satellite imagery for 23-July-2002.
Site 4u.	Plum Canyon (upstream)	SCAG (2004), DigitalGlobe (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data; satellite imagery for 22-March-2003.
Site 4d.	Plum Canyon (downstream)	SCAG (2004), DigitalGlobe (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data; satellite imagery for 22-March-2003.
Site 7u.	Borrego Canyon (upstream)	SCAG (2004), Aerial Photos.	Land use mapping with GIS layers for 1990, 1993, and 2001 data; aerial photos for 1952, 1967, 1972, 1983
Site 7d.	Borrego Canyon (downstream)	SCAG (2004) Aerial Photos.	Land use mapping with GIS layers for 1990, 1993, and 2001 data; aerial photos for 1952, 1967, 1972, 1983
Site 9.	Serrano Creek	SCAG (2004) Aerial Photos and Interpretation (Federico 2003).	Land use mapping with GIS layers for 1990, 1993, and 2001 data; land use mapping for 1949, 1968, 1978, 1982, and 1997
Site 10.	Santiago Creek	SCAG (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data
Site 23.	Dry Canyon	SCAG (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data
Site 27.	Hicks Canyon	SCAG (2004).	Land use mapping with GIS layers for 1990, 1993, and 2001 data

Stream Gage Records. Although only two of the sites (Topanga Creek and Santiago Creek) have stream gages near the study reach, we have collected stream flow records from local gages for as many of the reaches as possible (Table 2-5). These gage records have been used to establish flow frequency relationships that are essential for estimating the recurrence interval (RI) of discharge values calculated for the study sites. The process involves prorating the calculated discharge values, by watershed area, to an equivalent discharge at a gage. The gage discharge is then used to estimate a RI with the established flow frequency relationship. Verification of these return period values made with the regional flood frequency relationships developed by the U. S. Geological Survey (Waananen and Crippen 1977).

Table 2-3. Historic Cross Section Data

Site		Source	Information
Site 1.	Topanga Creek	Rosi Dagit, Santa Monica Mountains Resource Conservation District.	Copy of field notes for original survey of cross section TS-1 performed in November 2000 by Orme, et al. (2002).
Site 3.	Hasley Canyon	Matt Yeager, Ph.D. candidate, University of California, Los Angeles.	Electronic file copies of surveys for cross sections HC-1, HC-2, HC-2.5, HC-3, HC-4, and HC-5 taken from October 2001 to April 2003.
Site 4u.	Plum Canyon (upstream)	Matt Yeager, Ph.D. candidate, University of California, Los Angeles.	Electronic file copies of surveys for cross sections PC-2, PC-2.75, PC-3, and PC-4 taken from October 2001 to April 2003.
Site 4d.	Plum Canyon (downstream)	Matt Yeager, Ph.D. candidate, University of California, Los Angeles.	Electronic file copies of surveys for cross sections PC-1, PC-2, and PC-2.5 taken from October 2001 to April 2003.
Site 7u.	Borrego Canyon (upstream)	Professor Stanley Trimble, Department of Geography, University of California, Los Angeles.	Copy of field notes for surveys of cross section (Range) 4A taken in September 1992, April 1993, December 1998, and February 2003.
Site 7d.	Borrego Canyon (downstream)	Professor Stanley Trimble, Department of Geography, University of California, Los Angeles.	Copy of field notes for surveys of cross section (Range) 4D taken in September 1992, April 1993, and February 2003.
Site 9.	Serrano Creek	Felicia Federico, Ph.D. candidate, University of California, Los Angeles.	Copy of field notes for surveys of cross section (Range) C taken in October 1997, and cross sections (Ranges) A2 and A4 taken in September 1991, and May 1993.
Site 10.	Santiago Creek	Jeff Agajanian, U. S. Geological Survey	Copy of field notes for surveys of cross sections XS-1, XS-2, XS-3, and XS-4 taken in April 1995.
Site 23.	Dry Canyon	Darla Wise, Ventura County Watershed Protection District	Electronic file copies of AutoCAD cross sections North, Middle, and South taken in October 2001, January 2002, and March 2003.
Site 27.	Hicks Canyon	Professor Stanley Trimble, Department of Geography, University of California, Los Angeles.	Copy of field notes for surveys of and cross sections (Ranges) A2 and A4 taken in September 1986, April 1992, and April 1993.

Table 2-4. Precipitation Data

Site		Source	Information
Site 1.	Topanga Creek	Los Angeles County Department of Public Works (LA DPW)	LA Co. Stations 6 and 1194
Site 3.	Hasley Canyon	LA DPW	LA Co. Stations 372, 801B, 1012B, 1262, and 1263
Site 4u.	Plum Canyon (upstream)	LA DPW	LA Co. Stations 372, 801B, and 1262
Site 4d.	Plum Canyon (downstream)	LA DPW	LA Co. Stations 372, 801B, and 1262
Site 7u.	Borrego Canyon (upstream)	Orange County Resources and Development Management Department, Watershed and Coastal Resources Division (RDMD); California Irrigation Management Information System (CIMIS)	OC Stations 121, 165, 169, 173, 176 (annual and hourly), and 216; CIMIS Station #75 (hourly)
Site 7d.	Borrego Canyon (downstream)	RDMD and CIMIS.	OC Stations 121, 165, 169, 173, 176 (annual and hourly), and 216; CIMIS Station #75 (annual and hourly)
Site 9.	Serrano Creek	RDMD and CIMIS.	OC Stations 121, 165, 169, 173, 176, and 216
Site 10.	Santiago Creek	RDMD and CIMIS.	OC Stations 121, 165, 169, 173, 176, and 216
Site 23.	Dry Canyon	Ventura County Watershed Protection District (VC WPD)	Ventura Co. Stations 154, 193, and 196
Site 27.	Hicks Canyon	RDMD and CIMIS.	OC Stations 121, 165, 169, 173, 176, and 216

Table 2-5. Stream Gage Records

Agency	Site ID Number	Site Name	Elevation of Gage (ft.)	CDA (mi^2)	Years of Record
LA DPW	F54C-R	Topanga Creek above Mouth of Canyon	265.6	16.0	63
USGS	11104000	Topanga Creek near Topanga Beach, CA	255.0	18.0	49
USGS	11047500	Aliso Creek at El Toro	440.0	7.9	50
USGS	11075800	Santiago Creek at Modjeska	1,210.0	13.0	42
USGS	11096500	Little Tujunga Creek near San Fernando, CA	1,068.4	21.1	46
USGS	11105850	Arroyo Simi near Simi	720.0	70.6	42

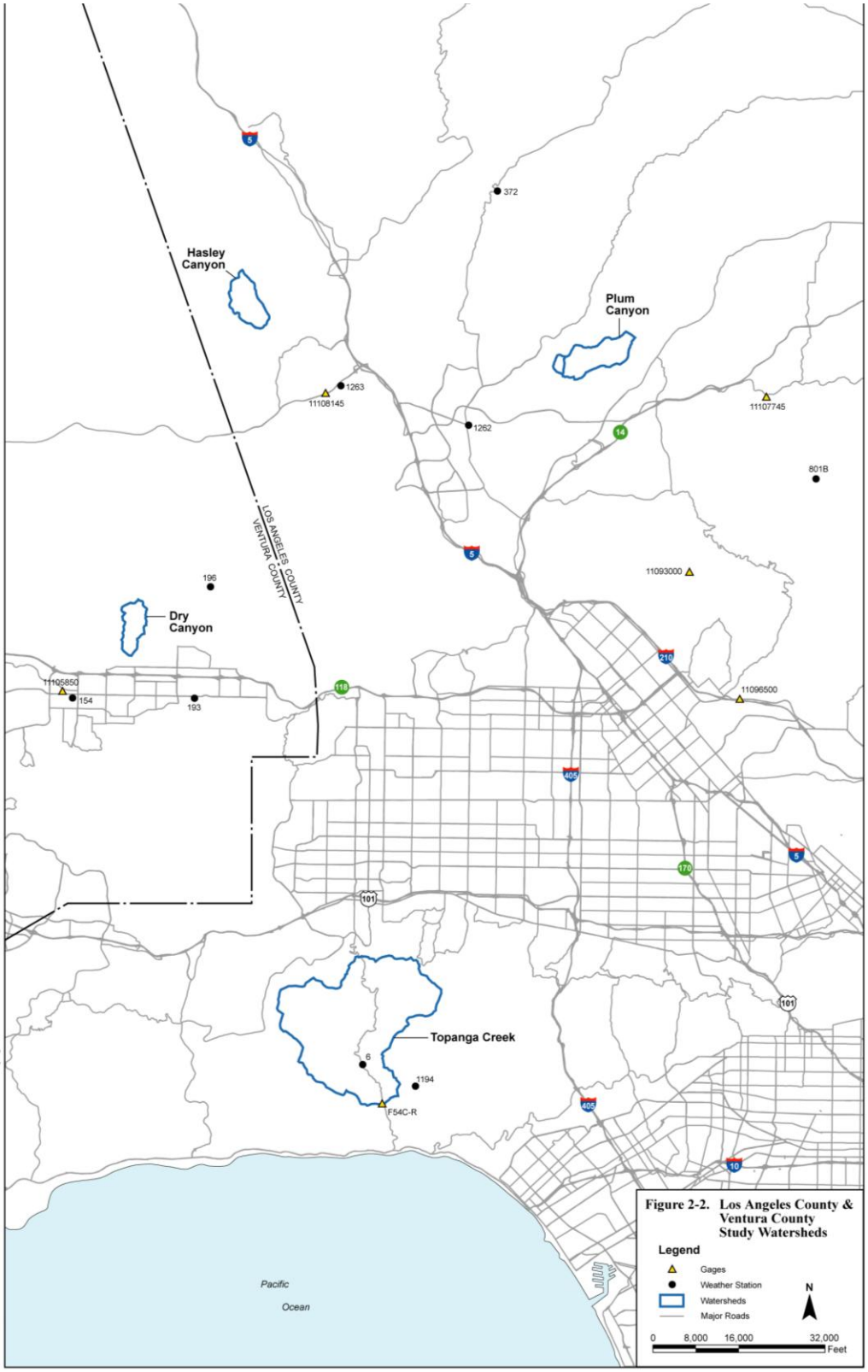


Figure 2-2. Los Angeles County and Ventura County Study Watersheds

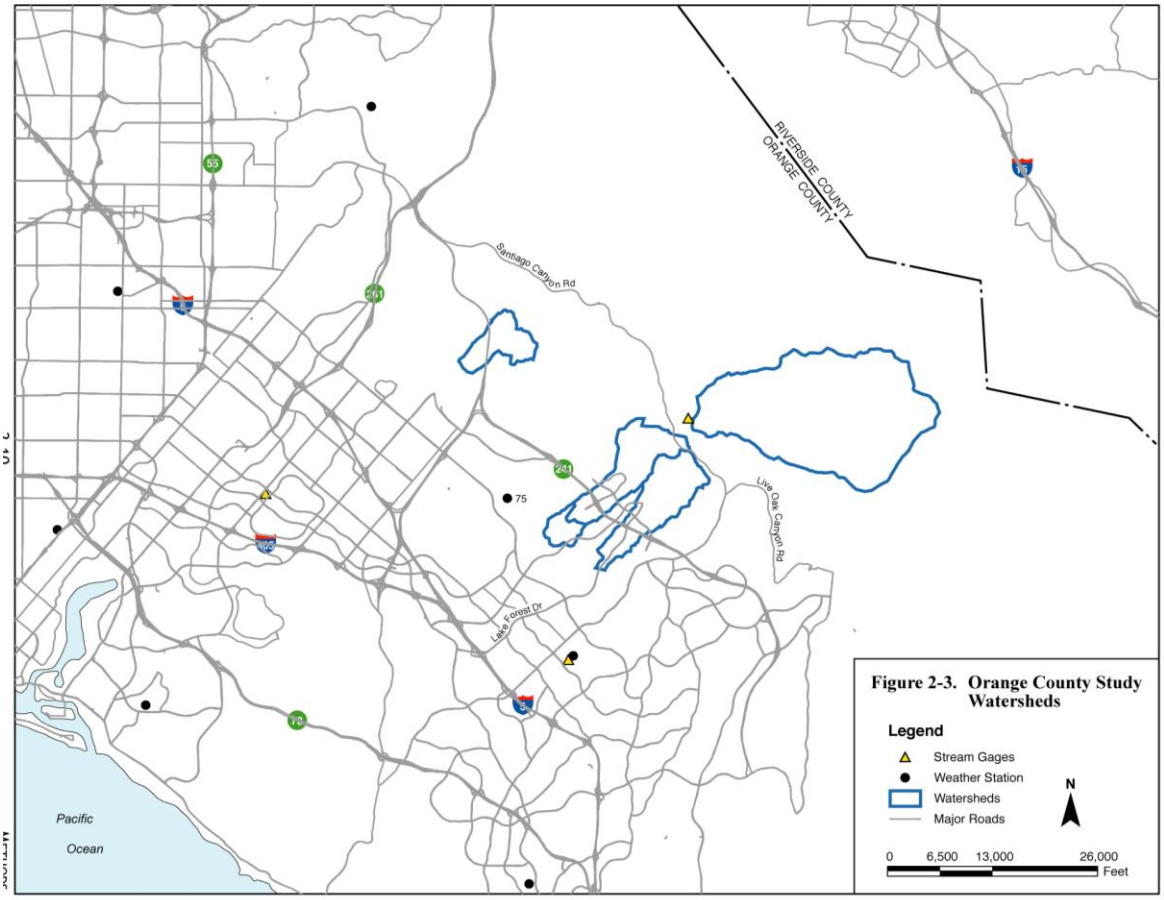


Figure 2-3. Orange County Study Watersheds

2.3.2 Field Data

Current conditions at each study site were evaluated through measurements and observations made during a two-week field program conducted from 3-May-2004 through 13-May-2004. A five- to seven-person field crew collected the data. The field procedures and data collection techniques are briefly described below. Data collected during this field program are provided in Appendix B.

Topographic Surveys. Distance and elevation readings were made using a Leica TPS700 Total Station surveying instrument. This instrument was capable of measuring distance, elevation difference, and declination from the instrument to a survey target, or prism. Readings were taken for specific stream channel features along the reach (thalweg, cut banks, bars chutes, etc.) as well as for the individual cross sections of interest. At least one cross section per site was termed the Master Section, and it coincided with the historic cross section, thus allowing comparison with the historic section(s) for that specific study reach. Generally the Master Section was the middle cross section in a series of three to five sections, and often had more detailed bed sediment data gathered, in addition to being the section used for evaluating historic changes at the site. Spacing of the cross sections were at distances approximately equal to 5 bankfull channel widths apart, for each of the 5 cross sections. Stream channel feature interpretations were also based on the geomorphic mapping prepared for the reach. Cross section surveys provide key data on stream channel morphology and capacity, which can be compared to historic values. Table 2-6 provides the details of which current cross sections match to the historic cross section(s) for each site. Longitudinal profile data, which also were measured during these topographic surveys, are important for deciphering current hydraulic conditions at these reaches, as well as estimating past or future conditions.

Geomorphic Mapping. Detailed mapping of geomorphic features was prepared for the reach at each study site using tape measure readings from a survey centerline that was established for the site during the survey. The centerline tape was turned and extended as needed to complete the full reach. Centerline points were included in the topographic surveys to help align and combine them with the synoptic geomorphic mapping, once both were completed. Specific geomorphic features were mapped that would aid in interpreting the current conditions in the study reach and help define what morphological changes had occurred.

Bed Material. Composition of bed material was characterized through a combination of pebble counts (Wolman 1954) and sieve analyses at a selected number of points across the bed at each surveyed cross section for all study sites.

Bank Material. Composition of the material in the stream channel banks was characterized through a combination of sieve analyses, detailed soil descriptions including standard field assessment of silt and clay fractions.

Rapid Geomorphic Assessment. In addition to the detailed synoptic mapping that was conducted, a quick assessment of the condition of each reach was made with a tool called the rapid geomorphic assessment (RGA; see Section 5.7 for additional details on the RGA).

Table 2-6. Matching Cross Section Surveys

		Historic Cross Section ID[1]					
Site	**Current Section[2]:**	**1**	**2**	**3**	**4**	**5**	**6[3]**
Site 1.	Topanga Creek	--	TS-1	--	ns	ns	ns
Site 3u.	Hasley Canyon (upstream)	--	--	--	HC-2	ns	ns
Site 3d.	Hasley Canyon (downstream)	--	HC-2.5	--	--	ns	ns
Site 4u.	Plum Canyon (upstream)	--	--	--	PC-3	PC-4	ns
Site 4d.	Plum Canyon (downstream)	--	PC-1	--	--	--	ns
Site 7u.	Borrego Canyon (upstream)	--	--	Range 4A	--	--	ns
Site 7d.	Borrego Canyon (downstream)	--	--	Range 4D	--	--	ns
Site 9.	Serrano Creek	--	--	Range D	Range C	Range B2	ns
Site 10.	Santiago Creek	XS-4	XS-3	XS-2	XS-1	--	ns
Site 23.	Dry Canyon	--	South	Middle	North	--	na
Site 27.	Hicks Canyon	--	Range A2	--	Range A4	--	Range A3

(1) Historic sections as identified by the source.

(2) Current section numbering starts at the downstream end of the reach. Unique section identification numbers have been given to each current section for the discussion and data presentation in Appendix C.

(3) Section 6 was surveyed only for Hicks Canyon, and that section was on a tributary, not the main stream channel.

ns Not a surveyed cross section in the current program.

3. STREAM CHANNEL STUDY SITES

The site selection effort covered a six-county region, including Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura counties. There were two general phases in the site selection process. Phase I was a screening process to identify candidate sites that generally appeared to meet the selection guidelines established for the project. Contacts were made either by networking referrals or targeting local agencies in the study region. The final candidate site list included a total of 27 stream channel locations in five of the six counties in the study region. No candidate sites were identified for Riverside County. Locations of all 27 candidate sites are shown in Figure 2-1. Phase II was a closer evaluation of the candidate sites to see how much data was available for each, and how well they met the specific selection guidelines. A total of 8 streams were selected for the study, after it was established that sufficient data was available for each. Two of these streams had multiple sections that proved distinct enough to be treated as separate sites. Therefore, sites 4 and 7 were divided into an upstream (4u and 7u) and a downstream (4d and 7d) site prior to field data collection. The selected sites are identified and key information provided on each in Table 3-1. After field data gathering was completed, it was concluded that Site 3 should also be treated as two separate sites. See the site description for Hasley Canyon in Section 3.1 for a discussion of this adjustment. Therefore, the final list of sites with data used in the evaluation presented in this report, included 11 sites in 8 different watersheds.

Table 3-1. Study Site List

Site No.	Site Name	CDA (mi^2)	Major Watershed	Type of Site	County	Thomas Brother's Map Sheet No.
1	Topanga Creek	18.07	Santa Monica Bay	Control Site	Los Angeles	630
3u	Hasley Canyon	1.55	Santa Clara River	Control Site	Los Angeles	4459
3d	Hasley Canyon	1.66	Santa Clara River	Developed Site	Los Angeles	4459
4u	Plum Canyon	2.23	Santa Clara River	Developed Site	Los Angeles	4461
4d	Plum Canyon	2.40	Santa Clara River	Developed Site	Los Angeles	4461
7u	Borrego Canyon	2.27	San Diego Creek	Developed Site	Orange	861
7d	Borrego Canyon	3.06	San Diego Creek	Developed Site	Orange	861
9	Serrano Creek	2.64	San Diego Creek	Developed Site	Orange	862
10	Santiago Creek	12.36	Santa Ana River	Control Site	Orange	832
23	Dry Canyon	1.22	Calleguas Creek	Control Site	Ventura	478
27	Hicks Canyon	1.33	San Diego Creek	Control Site	Orange	831

CDA = catchment drainage area

3.1 Study Site Streams

The stream channel study sites used in this investigation, with two exceptions, were formed in medium to coarse alluvial materials (sands and gravels). Topanga Creek and Serrano Creek were the exceptions, both being influenced by bedrock. The larger channels formed in alluvial materials have similar wide, shallow shapes (width to depth ratios greater than 20). The smaller watersheds, bedrock channels, and the control sites all have narrower and deeper channels (width to depth ratios smaller than 20).

Topanga Creek. Topanga Creek is located in western Los Angeles County between Highway 101 and the Pacific Ocean. The creek empties directly into Santa Monica Bay between Pacific Palisades and Malibu. The long axis of its watershed is oriented in a north-south direction and much of the watershed is in the Santa Monica Mountains. The watershed has some development in the northernmost part in the Glenview area and also in the central part of the watershed in Fernwood. The study site is located along Highway 27 (Topanga Canyon Boulevard), approximately halfway between Highway 101 and the Pacific Coast Highway. Gage records for this watershed show that it should be considered a perennial stream. Only 6 years in a 68-year record showed a minimum flow of zero.
Topanga Creek has outcrops of resistant volcanic bedrock in or near the channel in the study reach. There are also deposits of very coarse alluvial material, ranging from sand and silt to boulder sizes, in the valley bottom. The alluvium forms a flood plain with an atypical alluvial surface and rugged channel banks.

Hasley Canyon. Hasley Canyon is situated in northwest Los Angeles County west of Interstate 5, north of State Route 126, and between Lake Piru and Castaic Lake. The watershed trends from the northwest to the southeast. Development is occurring in the watershed adjacent to and upstream from the study site. Hasley Canyon is a tributary to Castaic Creek and is situated about 1.4 miles upstream from Castaic Creek's confluence with the Santa Clara River. The stream channel at this site is considered ephemeral, although there is a tributary entering from the west that had a small flow coming from the new large-lot residential development across Hasley Canyon Road. Evaluation of the data for Hasley Canyon demonstrated distinctly different changes at the upstream cross section (#4) compared to the other sections (#1, #2, and #3). It was concluded that a tributary to the main channel joining between section #3 and #4 affected only the lower sections (#1, #2, and #3). Furthermore, the watershed of this tributary includes all of the recently developed land (i.e. all of the increased total impervious surface area (TIMP)). As a result, the Hasley Canyon site has been divided into two sites; an upstream site (section #4) and a downstream site (sections #1, #2, and #3).

The Hasley Canyon channel is formed in a finer grained alluvium in the channel and has a more cohesive channel bank than most of these sites. In addition, there is an obvious enlargement and slight incision of the channel downstream from the tributary channel that drains the adjacent housing development.

Plum Canyon. Plum Canyon is located northeast of Santa Clarita in the Canyon Country of northern Los Angeles County. The watershed is a tributary of Bouquet Canyon, which empties into the Santa Clara River near the town of Saugus. The watershed is a northeast to southwest trending basin that is moderately developed in the lower portion and undergoing development in the upper portions. Two study reaches were used on Plum Canyon as sites, separated by a distance of more than 500 feet. Both sites are considered ephemeral stream channels, and both were dry in May 2004 during field data collection.
Plum Canyon, the stream channels of both the upstream and downstream sites, are formed in coarse materials (sands and gravels) and have wide, shallow channel shapes. These are among the steeper sites, both averaging more than a 2% gradient. Upstream from both sites is a major valley fill that has accounted for most of the new development within the watershed, extending up to the crossing of the Plum Canyon/Whites Canyon Road. In the early to mid 1990s a box culvert (twin 8' x 8' cells approximately 200' long) was installed to carry stream flow from Plum Canyon under the road. An extension of that conveyance (in the form of a single, 10-foot diameter, round concrete pipe) was installed

within the past five years to allow the placement of the valley fill. The outlet of this concrete pipe lies at least 1,500 feet upstream (linear channel distance) from the most upstream channel. This is well beyond the selection guideline of 10-20 bankfull widths (approximately 580 feet to 1,160 feet based on an average bankfull width of 58 feet for the upstream Plum Canyon site).

Borrego Canyon Wash. Borrego Canyon Wash is located in Orange County northeast of Interstate 5 and drains across the new Foothill Transportation Corridor toll road (State Route 241). In its lower reaches (downstream from the study reaches) the wash is confined within a U-shaped concrete channel as it runs adjacent to the former El Toro Marine Corps Air Station. Borrego Canyon Wash empties into Agua Chinon Wash about 1 mile upstream from its confluence with San Diego Creek. The watershed trends from northeast to southwest. A good portion of the watershed from the former Marine Corps base upstream to the toll road is mostly undeveloped. The watershed above the toll road is fairly heavily developed, except in the Whiting Ranch Park, which occupies most of the headwaters area. The two Borrego Canyon Wash study sites are separated by a significant stream channel distance and represent distinct stream channel types. Both sites are considered to be ephemeral stream channels, and both were dry in May 2004 during field data collection.

The Borrego Canyon sites, both upstream and downstream, are formed in alluvial materials consisting of sands and gravels. While both sites have wide, shallow channels, the upstream site has the widest channel of all the study sites, averaging 95 feet.

Serrano Creek. Serrano Creek is located in Orange County. It is similar in size, shape, and alignment to Borrego Canyon Wash and shares a common watershed boundary to along the northwestern side. However, the Serrano Creek watershed is developed to a greater extent than Borrego Canyon wash. Much of the lower portion is occupied by residential development. The middle portion contains primarily commercial type development, although some open space is present. The upper portion has significant areas of residential development, but also contains the Whiting Ranch Wilderness Park. Serrano Creek is a tributary to San Diego Creek with a confluence just east of Interstate 5. The Serrano Creek study site is upstream from Dimension Drive. Although once this site was considered to be an ephemeral stream channel, because of the degree and proximity of development, this site appears to have a small amount of base flow most of the time.

Serrano Creek has a soft sedimentary bedrock that forms the channel bed and most of the channel banks. It is the most deeply entrenched study site, and has the smallest width to depth ratio (averaging less than 4).

Santiago Creek. Santiago Creek is located in Orange County. It is a tributary to the Santa Ana River and drains portions of the southern flank of the Santa Ana Mountains. The watershed is mostly undeveloped except for pockets of houses along Modjeska Canyon Road between Santiago Canyon Road and the Tucker Wildlife Sanctuary. The upper part of the watershed is in the Cleveland National Forest and is undeveloped. This site is considered to be an ephemeral stream channel, and it was dry in May 2004 during field data collection. Santiago Creek serves as a control site.

Santiago Creek is formed in alluvial material that appears to have been modified somewhat by earthmoving equipment to help maintain a flood protection berm adjacent to the channel. This was probably associated with the last major flood event in 1995, and natural hydrologic forces have been at work modifying and maintaining the channel configuration since.

Dry Canyon. Dry Canyon is located in Ventura County on the northern side of Simi Valley, less than a mile north of State Route 118. It is about halfway between the City of Moorpark and the Los Angeles County line. The watershed trends north to south and is a tributary to Arroyo Simi. Flow from Arroyo Simi empties into Arroyo Las Posas, which is a tributary to Calleguas Creek. The watershed is

undeveloped except for the Lost Canyon Golf Club. This site is considered to be an ephemeral stream channel, and it was dry in May 2004 during field data collection. Dry Canyon serves as a control site. The Dry Canyon channel is formed in alluvium, though the bed material is primarily sand and the banks are fairly cohesive. This has resulted in a width to depth ratio that is among the smallest of the study sites (averaging less than 6).

Hicks Canyon Wash. Hick's Canyon Wash is located in the foothills of the Santa Ana Mountains in Orange County. It is a tributary to Rattlesnake Wash, which empties into Peters Canyon Wash before it discharges into San Diego Creek. The site reach is north of Portola Parkway, south of the Foothill Transportation Corridor Toll Road, and just east of the Hicks Canyon Haul Road. Most of the watershed is undeveloped. This site is considered to be an ephemeral stream channel, and it was dry in May 2004 during field data collection. Hicks Canyon serves as a control site.

Hicks Canyon appears to be entrenched into a thick (greater than 10 to 20 feet) alluvial sequence. The channel bottom consists of sands with minor amounts of gravel. The banks are made of similar materials that are cohesive. Consequently, the channel has the smallest width to depth ratio of any of the alluvial channels (averaging just over 5).

3.2 Suitability of Selected Sites

One of the great difficulties in this project was locating suitable study sites, due to the specific requirements of the site selection guidelines. Thus it is reasonable to inquire about the satisfaction of selection guidelines by the final sites included in the study. A summary of how well these sites meet the selection guidelines is provided below. There is no specific order of importance of the selection guidelines, however, the first five are all equally important and critical for a successful outcome.

Small Watershed Size. The desired CDA size range for a selected study site was between 1 square mile and 5 square miles. As shown in Table 3-1, all of the study sites fell within this size range, except Topanga Creek and Santiago Creek, both of which are control sites. Thus, all of the watersheds that have experienced some level of development (i.e. the altered sites) are within the desired watershed size range.

Shear Stress Dominated. Streams that have movable beds and erodible banks under the normal range of stream flows (from frequent to infrequent) are considered to be "Shear Stress Dominated." In general this includes channels formed in alluvial materials, but not those formed in bedrock materials. The latter are generally considered to be "bedrock dominated" channels. By this definition, all of the channels included in this study would be considered as shear stress dominated, except Serrano Creek. However, the bedrock in the site reach of Serrano Creek is considered to be soft enough that normal stream flows can erode it.

On the other hand, Topanga Creek, although technically an "alluvial" channel is somewhat limited in its erodibility. The alluvial materials present are dominated by extremely large particle sizes, and are also underlain by resistant bedrock. Therefore, it is very difficult to move these alluvial materials with the frequent (smaller size) flows, and even more difficult to move or erode the bedrock even with rare flood events.

Natural Channel. The stream channel sites used by this study needed to be found in a more or less "natural" state, meaning that they are not controlled by engineering works. By this definition, all of the sites included in this study have natural channels with freedom to deposit or erode bed material or bank material, and alter their geometry by the action of their flows. Many of these channels have "unnatural" stretches either upstream or downstream, and sometimes both. The control sites had very limited amounts of unnatural channel reaches, while the developed watershed sites generally at least had downstream engineering works. One of the control sites, Santiago Creek, had evidence of anthropomorphic manipulation in that a berm had been constructed to limit the flooding extent on the valley bottom for very large flows. However, this berm was well away from the active channel and did not impact the

channel configuration of the bankfull (Dominant Discharge) stage. Therefore, the site is considered acceptable as a natural, or self-formed stream channel reach.

Watershed Development. Because this study evaluates the impacts from watershed development on natural stream channels, it was equally necessary to have study sites that included watershed development, except in the control sites. The desired level of development, in terms of impervious area, was a TIMP value of between 5% and 10%. As will be discussed in Section 5, the sites with developed watersheds had TIMP values that ranged from 3.3% to 26.7% (see Table 5-1 in Section 5). In contrast, the control sites had TIMP values that remained very constant throughout the time period that was evaluated, and these ranged from 0.2% to 2.8%. Additional details about the measurement of impervious cover and its change over time in the developed watersheds is provided in Appendix A1.

Historic Cross Sections. Historic cross section surveys provide the means by which channel change can be measured. Therefore, the availability of such surveys for each of the study sites was imperative. The number of historic cross section locations for each site varied, as did the number of times each was surveyed previously, and the total time span covered. Most of the sites had only one previously surveyed cross section (Topanga, Hasley u/s, Hasley d/s, Plum d/s, Borrego u/s, and Borrego d/s). However, all but the Topanga cross section were surveyed more than once. The remaining sites had multiple cross section locations surveyed (Plum u/s: 2, Serrano: 3, Santiago: 4, Dry: 3, and Hick's: 2). Table 2-3 provides background on the match-up between historic sections and sections resurveyed during field data gathering for this project. Appendix Table A4-1 gives details concerning the dates of the previously surveyed cross sections.

Stream Flow Data. Although important, stream flow data was not imperative since engineering practice has provided the means by which flows can be estimated. Certainly actual flow measurements are superior to use than estimated values, but the stream gaging network in southern California is limited. Therefore, a single and distinct stream gage for each of the sites providing accurate and substantive coverage of the stream flow history of each stream was not expected, nor was it realized. Two channels did have stream flow records of significant length at or near the site location, Topanga Creek and Santiago Creek. Other stream gages were located in general proximity to the remaining sites (see Figures 2-2 and 2-3 for the locations). Table 2-4 identifies the stream gage records used in this project, and Appendix A2 provides the annual peak flow record available for each of these gages.

Aerial Photos. Available aerial photos can be used for evaluating land use changes over time, and if they are of a large enough scale, can provide information on channel plan form at specific points in time. Photos obtained for this project were limited in coverage (Table 2-2) and not detailed enough to show channel plan form at any of the study sites.

Topographic Maps. Us of topographic maps for evaluating channel form changes requires that they be at a very detailed scale. The guideline established for this use in the current project was for amps with a scale of least 1 inch equals 100 feet (or better) and a contour interval of 1 foot. No contour maps meeting these guidelines were identified for any of the study sites.

Geotechnical Data. Geotechnical data (descriptions of the soil/sediment materials) were sought to provide historical comparisons with the current data collected at each site of bed and/or bank material. Unfortunately, no geotechnical data was located for any of the study sites.

In summary, the selected study sites meet the critical guidelines established for site selection in this project very well, with one exception. Topanga Creek is limited in that there is only one historic cross section, and it was surveyed relatively coarsely compared to the other historic cross sections surveyed for the other study sites. In addition, the specific location of the historic Topanga Creek section was not reoccupied with a high level of confidence. None-the-less, the data generated for this site is valuable as it provides information for a channel type and watershed size not included in the other sites. This allows

better definition of the results as it provides a broader spectrum of plotting positions in many of the deterministic relationships and channel adjustment relationships discussed in later sections of this report. The final sites selected are considered to provide a reasonably robust data set. The main limitations of these data are the relatively short period of time that is covered by the historic period and the similar channel types of all the sites except Topanga Creek and Serrano Creek. However, this is an unavoidable limitation of the study.

4.0 STREAM CHANNEL CLASSIFICATION SYSTEM

Different stream types respond to changes in peak flow in different ways. Therefore, it was necessary to develop a classification system to organize relationships between impervious cover and channel stability and guide management decisions for each stream type. The classification system proposed here focuses on the relevant physical attributes of the system starting with large-scale features (the watershed) and progressing toward detailed consideration of bed and bank properties for specific stream channel reaches.

The framework for the proposed classification system includes three primary factors, or levels that can be used to systematically separate sites into similar management units based on physical characteristics. Each level has a different focus with a specific set of considerations that are described in the subsections below. The levels can be summarized as follows. Details about selecting features of form and process used in classifying streams are provided in Appendix C1.

- **Level 1. Watershed Characteristics.** The first step in classification is to define the nature of the watershed. Watershed characteristics include the physical attributes of the basin including size, shape and topography that may affect runoff patterns in the stream of interest.
- **Level 2. Stream Channel Characteristics.** The next step in classifying stream reaches is to define the stream channel type. Stream channel characteristics involve the stream channel morphology, channel form (shape and slope), energy potential (flows in the stream channel), and degree of alteration
- **Level 3. Stream Channel Resistance.** The third step in classification is an assessment of the expected, or potential, responsiveness of the stream channel system to perturbations in the watershed system by such things as changing land uses. This level focuses on a characterization of the ability of the stream channel to resist erosion based on the inherent mechanical properties of the bed and banks.

4.1 Watershed Characteristics

The first factor for differentiating sites is the size and nature of the watershed, or catchment drainage area (CDA). Zielinski (2002) provides a useful classification of CDA size in urban streams (Table 4-1). An alternate size discriminator could be stream order, though assigning stream order is dependant on the map scale used and the mapping methodology. Because there currently is no consistent regional map that includes all ephemeral and intermittent streams, stream order is not recommended as an alternative for CDA.

The focus of the present study was on smaller drainage areas that generally are more responsive to changes in impervious surface area. Therefore, the proposed classification system focuses on small watershed management units that fall within the size range of the subwatershed- and catchment-size categories of Table 4-1.

While CDA is the most obvious differentiator among watersheds, it is by no means the only characteristic that can be used. Topographic relief, shape, and location within the study region can all affect rainfall-runoff response. However, CDA is likely to have the greatest effect on runoff, so it is the focus of Level 1 of the proposed classification system.

Watershed management units should be delineated in three size ranges, defined by their degree of sensitivity to land use change (Table 4-2). In general, priority should be given to the management of the smallest units first (2.5 square miles or less) as they provide the greatest sensitivity to change and are the most responsive to management actions. Zielinski (2002) offers several other considerations for delineating watershed management unit boundaries.

Table 4-1. Possible Watershed Management Units

Watershed Management Unit	Typical Area of Feature (mi^2)	Relative Influence of Impervious Cover	Sample Management Measure
Catchment	0.05 – 0.5	Very strong	Stormwater management and site design
Subwatershed	0.5 – 30	Strong	Stream classification and management
Watershed	30 – 100	Moderate	Watershed based zoning
Sub-Basin	100 – 1,000	Weak	Basin planning
Basin	1,000 – 10,000	Very Weak	Basin planning

From: Zielinski, 2002.

Table 4-2. Level 1 CDA Categories

Category	Designation	CDA (mi^2)	Explanation
Very sensitive	i	≤ 2.5	Basins of this size show the greatest rates of change in response to urbanization. It is easier for development to impact a larger portion of the CDA.
Mildly sensitive	ii	≤ 10.0	Between 2.5 and 10.0 square miles the rates of change in stream channel morphology in response to changes in impervious area fall significantly.
Least sensitive	iii	≤ 20.0	Basins larger than 10 square miles but less than 20 square miles show some sensitivity to changes in impervious area, but less than the smaller subwatershed areas.

- *Subwatershed size.* In addition to the guidelines in Table 4-2, start delineations downstream from tributary junctions (rather than upstream),
- *Jurisdictional boundaries.* Keep watershed management units entirely within a single jurisdiction(cities, counties, etc.) where possible,
- *Impoundments or stormwater management facilities.* Delineate from the outlet of ponds, lakes, or detention/retention basins,
- *Monitoring stations.* Include existing monitoring stations (stream gages, water quality sample points, etc.) within watershed management unit boundaries where possible,
- *Access points.* Delineate from existing roads or bridges to provide easier access for sample collection or field surveys.

4.2 Stream Channel Characteristics

Level 2 of the classification system focuses on the stability/state of a particular stream reach (Table 4-3). Stream channels are divided into stable or unstable based on the results of the RGA (see Section 5.7). The RGA is a semi-quantitative method for evaluating the stability of a site based on geomorphic indicators observed and recorded in the field. The RGA produces a stability index (SI) that can be used to categorize the geomorphic condition of the stream reach (SI scores range from 0 –1.0). A stability index (SI) score of 0.25 or less indicates that the stream channel is stable, while anything greater that 0.25 indicates that the stream channel is unstable. Alternatively, a qualitative assessment of geomorphic stability can be performed based on observable field evidence of channel instability, such as excessive deposition of sediment, stream channel widening, and/or stream channel scour that is noticeably divergent from upstream and downstream reaches. Unstable stream channels are already reacting to some hydrologic or sediment regime change within the watershed, and therefore have little to no tolerance for additional change to the hydrologic or sediment regime. Unstable stream channels receive no additional classification at this level and are only considered further at the final classification level (Level 3, Stream Channel Responsiveness). Stable stream channels do not show noticeable signs of either aggradation or degradation throughout the reach under consideration. Altered stream channels, i.e. those that have been modified through direct, engineered changes, such as stream channel lining, bed or bank protection, relocation or realignment, stabilization, are not considered further in this classification system, because they fall outside the scope of the present study.

Following the general assessment of stability, stream channels should be further classified according to their morphology (see Table 4-3). The data needed for this classification are the stream channel slope (as measured in the field over a distance of 10 times the stream channel width), and unit discharge (discharge divided by the width of the stream channel). The elevations used to calculate slopes should be a consistent stream channel feature such as the deepest point in the stream channel (thalweg) or the toe of a common bank for the length of the stream channel used. The distance measured for slope calculation should be the curvilinear distance along the flow-line of the stream channel, again using a common feature such as the thalweg (i.e. deepest portion of the channel) or the toe of a bank.

Because discharge data is often not readily available on any given stream, or at any specific point along a stream channel, we recommend using the USGS regional equations (Waananen and Crippen 1977) to calculate the 2-year recurrence interval storm discharge (Q_2), as indicated below. The 2-year equation is selected as the lowest value in recurrence interval for any of the regional equations and the closest to an assumed recurrence for the dominant discharge (1.5 to 2.0 years).

$$\mathbf{Q_2} = 0.14\ \mathbf{CDA}^{0.72}\mathbf{P}^{1.62} \qquad [4.1]$$

Where: **CDA** is catchment drainage area (mi^2)

P is average annual precipitation (in.)

The precipitation value should be selected for a weather monitoring station near the watershed being classified. Selected values of average annual precipitation for stations located in the vicinity of the sites in this investigation are given in Table 4-4. Stream channel widths should be measured in the field at the same time stream channel slopes are measured. Two to four width measurements should be made and averaged to provide the width used to define stream channel morphology with Figure 4-1. The width feature to measure is the top of the “bankfull” channel, which is defined as the top of the “active” channel, which should be discernable (the active channel) by a lack of permanent vegetation and/or the presence of obvious stream channel deposit features such as bar deposits.

Table 4-3. Level 2 Stream Channel Morphology

Condition	Current State	Category	Designation	Indications
Altered	Altered		X	Altered stream channels already have had permanent instream management actions applied; they are no longer considered to be natural
Natural	Unstable		Un	Unstable stream channels show signs of change to the stream channel morphology such as aggradation (excessive sediment deposition), stream channel widening (one or both channel banks have fresh, cut surfaces or undermined bank materials), or channel scour (loose material on the channel bed is scarce and adjacent bank height is significantly different from stable upstream or downstream reaches.
	Stable	Tranquil	St-t	Slope of the stream channel appears to be very shallow; when water is flowing the velocity is relatively slow. Sediment load is very low.
		Anastamosing	St-a	Anastamosing stream channels also have shallow slopes, but slightly steeper than tranquil stream channels. Sediment load is low. Stream channel pattern can be very sinuous, with multiple, inter-twining stream channel threads.
		Meander, Pool-Riffle	St-m	The meandering stream channel is a single conveyance with a slightly to moderately sinuous form that has periodically spaced shallow, rapid flowing water in “riffles” interspersed with deeper “pools.” Depending on sediment type and load riffles can be more transient (fine sediment) or more permanent (coarse sediment) under higher flows. Point bar deposits and cut banks alternate along opposite sides of the stream channel.
		Braided, Cascade-Pool	St-b	The braided stream channel is wide, shallow, and steep with multiple, inter-twining conveyances and an abundant sediment load. Shifting channel positions are common after, or during, periods of channel flow.
		Step-Pool, Canyon	St-s	Cascade-Pool channels are also steep, but have an abundance of very coarse sediment that is beyond the normal capacity of flood flows (except in very rare, high discharge rates). These materials tend to armor the channel and form very persistent, steep-flowing riffle features.

The flow and channel data described above can be used to calculate a unit stream power (2-year peak flow divided by channel width) (Q_2/w). The unit stream power can be plotted against the stream channel gradient for each site (Figure 4-1), This relationship will define the expected form of the stream channel based on measurements of its energy. Deviations from the expected form indicate that the stream reach is in the process of adjusting to a new form. This is discussed in more detail in the next section.

Table 4-4. Selected Annual Precipitation Averages

Station ID	Station Name	Latitude	Longitude	Elevation (feet)	Years of Record	Ave. Annual Precipitation (inches)
LA DPW # 6	Topanga Patrol	34.084167	118.599167	745	77	23.94
LA DPW # 372	San Fran. Pwr Hs	34.533889	118.524167	1,580	63	16.22
LA DPW # 801B	Magic Mountain	34.38833	118.324167	4,720	37	17.53
LA DPW # 1012B	Castaic Junction	34.738333	118.611944	1,005	35	12.40
LA DPW # 1194	Santa Ynez Res.	34.073056	118.566389	735	31	20.25
LA DPW # 1262	Saugus Reclam.	34.413333	118.539722	1,150	19	13.66
LA DPW # 1263	Valencia Reclam.	34.431944	118.620278	1,000	19	12.18
OC RDMD # 121	Santa Ana	33.751111	117.869722	170	96	12.98
OC RDMD # 165	Costa Mesa	33.668611	117.893056	53	48	12.14
OC RDMD # 169	Corona del Mar	33.609722	117.857500	300	44	12.46
OC RDMD # 173	Villa Park Dam	33.814722	117.766667	566	43	15.01
OC RDMD # 176	El Toro	33.627500	117.68333	445	39	14.96
OC RDMD # 216	Laguna Niguel	33.549722	117.70000	200	29	14.58
CIMIS # 75	Irvine	33.688611	117.720556	410	17	14.24
VC WPD # 154	Simi, Co Fire Sta	34.270000	118.781667	760	56	14.85
VC WPD # 193	Santa Susana	34,270833	118.706667	950	47	14.62
VC WPD # 196	Tapo Canyon	34.328333	118.698333	1,525	46	19.20

4.3 Stream Channel Resistance

Level 3 of the classification assesses the ability of the stream channel to tolerate changes in its hydrologic and/or sediment regimes. The hydrologic regime is defined by the quantity and timing of flow, while the sediment regime is defined by the texture (or size distribution) of the sediment load, the quantity of the load, and the timing of its delivery. The quickest and most direct way to evaluate a stream channel's resistance is by plotting its position on the gradient vs. stream power curve (Figure 4-1). If the plotting position of stream power vs. gradient is within the "stable energy" zone for the determined stream channel type, it can be considered as stable. Conversely, if the plotting position is close to the upper limit of the zone, it is an indication of relative instability, because it is approaching, or is within, a transition zone. For example, ω values for Site 23 (Dry Canyon) fall between the 25 and 87 Watts/ft^2 isoclines; therefore this site appears to be a relatively stable braided, cascade-pool system. In contrast, ω values for Site 9 (Serrano Creek) appear to be deviating from the 87 Watts/ft^2 isocline, indicating that the stream channel is shifting to a new morphological form.

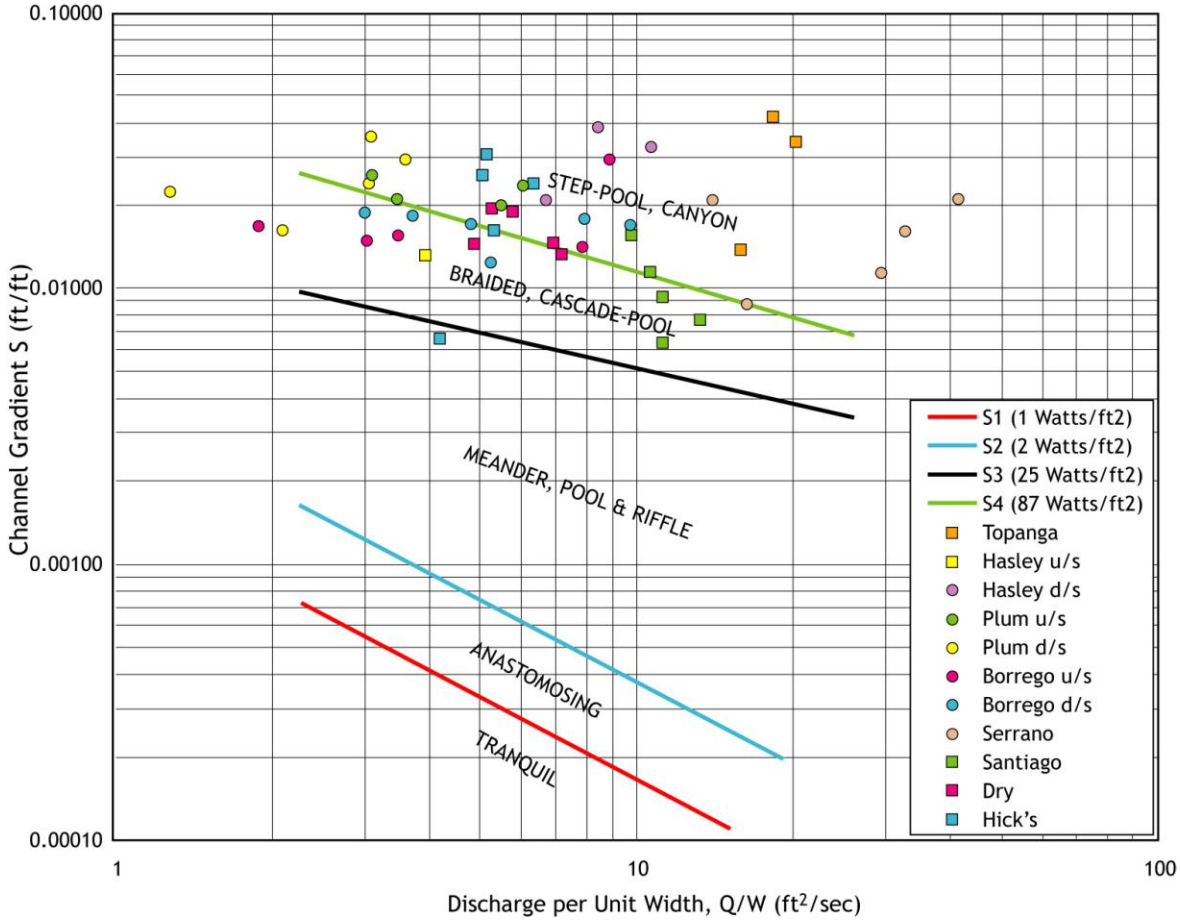


Figure 4-1. Stream Channel Morphology

Stream Power (Discharge/Unit Width) versus Gradient (Longitudinal Slope) for streams within the study area. Energy ranges are defined below:

	Energy Range (Watts/ft^2)	
Classification	*Minimum*	*Maximum*
Step-pool, Canyon	*87.0*	--
Braided, Cascade-pool	*25.0*	*87.0*
Meander-pool-riffle	*2.0*	*25.0*
Anastamosing	*1.0*	*2.0*
Non-shear stress dominated	--	*1.0*

Additional qualitative classification of channel resistance can be made based on field observations of the relative erodibility of the bed and bank materials (see Table 4-5). For stable stream channels, this evaluation should confirm the plotting position on the stream channel morphology chart (Figure 4-1). In contrast, if the plotting position of a site is within the "meander, pool-riffle" stream channel morphology zone, but the field observations suggest that this site looks more like a "braided, cascade-pool" site, this is an indication that the site is not stable and is about to change stream channel morphology in response to higher energy levels. See Figure 4-2 for an example of this type of assessment.

A more rigorous assessment of the resistance provided by either the bed or the bank is possible using equations for stream power [4.2] and specific stream power [4.3]. First they must be transformed into units of applied shear stress that can be compared to a critical shear stress value for either the bed material or the bank material.

$$\Omega = \rho g Q S \qquad [4.2]$$

where:

Ω = stream power applied to channel perimeter (watts/foot)
ρ = density of channel bed sediment (kilgrams/cubic foot)
g = gravity (feet/second^2)
Q = discharge (cfs) calculated for the channel configuration at which slope, width, and average depth are measured
S = slope of the channel as measured in the field (feet/foot)

Dividing Ω by the stream channel width (W) produces the specific stream power.

$$\omega = \Omega/W = \rho g Q S/W \qquad [4.3]$$

where:

ω = specific stream power (watts/square foot)
W = stream channel width (feet)

Specific stream power can be translated to an applied shear stress, as follows

$$\tau = \rho g d S \qquad [4.4]$$

where:

τ = average shear stress (newtons/square foot)
d = average depth (feet)

Knowing that discharge is a volume per time:

$$Q = AV = WdV \qquad [4.5]$$

where:

A = stream channel cross-sectional area (square feet)
V = average velocity of flow (feet/second)

We can combine equations [4.2], [4.4] and [4.5] to represent stream power in terms of applied shear stress:

$$\Omega = \rho g Q S = \tau V W \qquad [4.6]$$

Finally we can express this in terms of specific stream power:

$$\omega = \tau V \qquad [4.7]$$

Sample Calculation for Channel Form(Hasley Canyon Data)

Step 1 Estimate the drainage area of the watershed to the site and obtain a value of the average annual rainfall for the area.

CDA = 1.66 square miles (from Table 3-1)
P = 12.18 inches (from Table 4-4)

Step 2 Calculate discharge using equation [4.1]

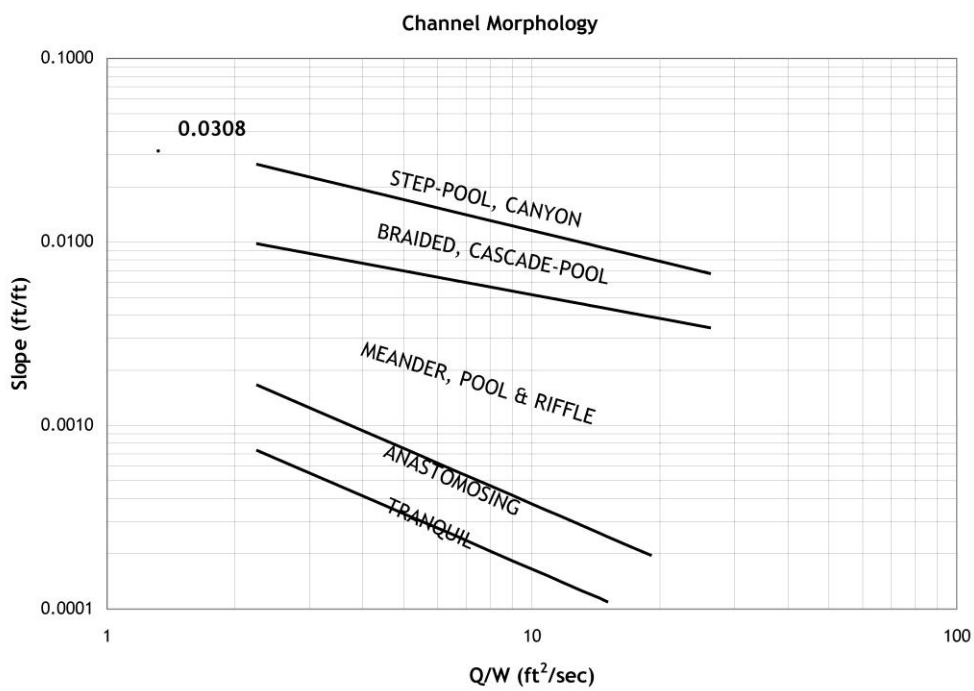
$Q_2 = 0.14 \times [(1.66)^{0.72} \times (12.18)^{1.62}]$
$= 0.14 \times [(1.44) \times (57.38)]$
$= 11.57$ cfs

Step 3 Measure bankfull channel width and bankfull channel slope in the field. In this case we are using averages for these values measured from several points in the site reach.

W_{bfl} = 8.71 feet
S_{bfl} = 0.0308 feet/feet

Step 4 Plot these values on the channel morphology classification chart (Figure 3-1).

Q_2/W_{bfl} = 1.33 square feet/second
S_{bfl} = 0.0308 feet/feet



Step 5 Assess channel form as braided based on plotting position. However, field observations suggest the form is actually a step pool form.

Figure 4-2. Example Calculation of Channel Form

Remembering that the length term is a unit value to keep the equation dimensionally correct, it is insignificant in calculations. Therefore, specific stream power can be expressed in terms of calculated shear stress and calculated average velocity. These calculations depend on actual field measurements of the stream channel dimensions and slope, and an estimate of the flow velocity and from there an estimate can be made of the flow rate. In order to apportion the calculated specific stream power to the bed and bank, two "geometric correction" factors are introduced that resolve the specific stream power for these two different parts of the stream channel. They are used in the specific stream power equation [4.7] as follows:

$$\omega = k_b \tau V \qquad [4.8]$$

$$\omega = k_s \tau V \qquad [4.9]$$

where:

k_b = geometric correction factor for the bed (dimensionless)
k_s = geometric correction factor for the bank (dimensionless)

Table 4-5. Level 3 Stream Channel Resistance

Bed Material	**Bank Material**	
	Resistant	Susceptible
Resistant	**Designation**: Bdr / Bkr Generally true for rock channels and rock bed channels with very cohesive to indurated bank materials. These stream channels have the most flexibility for management options as they are best at tolerating changes in hydrologic or sediment regimes	**Designation**: Bdr/ Bks Generally true for rock bed channels with alluvial material in the bank; can also be found in alluvial channels where stream power is not sufficient to carry the current sediment load (braided channel condition).
Susceptible	Designation: Bds / Bkr Unusual for arid streams, though Serrano Creek is an example; there the bed and bank material is a poorly cemented sandstone. Bank material has proven to be more resistant to erosive forces in the stream channel than has the bed material. Channel scour occurs resulting in a deepening of the stream channel. Width to depth ratio of the stream channel should decrease.	**Designation**: Bds / Bks Expect this to occur, if not be common, in ephemeral and intermittent stream channels. Lack of water, or even moisture, in and around the stream channel for much of the year Stream channel scour and widening occurs at the same time. Width to depth ratio should remain relatively constant, but stream channel area (in cross-section) will likely increase.

Using field-measured values to estimate flow (Q), the average velocity can be calculated, the length term is insignificant, and the stream power range has been read from Figure 4-2, so the applied shear stress on the bed can be calculated using equation [4.10] or the bank using equation [4.11].

$$k_b \tau = \omega / V \qquad [4.10]$$

$$k_s \tau = \omega / V \qquad [4.11]$$

In this case it is not necessary to know the value of the correction factors, because the whole term is used to compare to a critical shear stress value (τ_c) determined for either the bed or the banks. Details of the recommended procedure for determining the critical shear stress values are given in Appendix C. A comparison is made between the estimated applied shear stress and the estimated critical shear stress representing the resistance of the bed or bank. Under stable conditions, the following expressions would be true:

$$k_b\tau \leq \tau_{cb} \qquad [4.12]$$

$$k_s\tau \leq \tau_{cs} \qquad [4.13]$$

where:

τ_{cb} = critical shear stress for the bed (newtons/square foot)

τ_{cs} = critical shear stress for the bank (newtons/square foot)

If either expression is untrue, then an unstable condition is present. Depending on which feature is considered stable (or unstable), or if both bed and bank are the same, the classification of stream channel resistance follows from Table 4-6. See Figure 4-3 for an example of this evaluation.

4.4 Classification Summary

This classification is proposed as a starting point for the development of a system that could be applied throughout the southern California region. It does not restrict the classification to ephemeral or intermittent stream channels, but would apply to perennial streams as well. Although the creation of a complete and exhaustive classification system is beyond the scope of this project, a general framework for establishing such a classification system has been presented. This classification system could be used to define characteristics of the watershed-stream channel system that are important in selecting management strategies and approaches, which are discussed in Section 7.2 (Management/Regulatory Approach). A summary of the steps of the proposed stream classification process is provided below. In addition, Table 4-6 provides a summary of the designation of each of the study sites using this classification system.

STEP 1: Locate the CDA within its major watershed.

STEP 2: Identify the CDA category (based on size)

STEP 3: Collect local site information and calculate Q_2 using regional equation [4.1] to estimate stream channel slope and specific stream power

STEP 4: Define stream channel form using calculations from Step 3 and plotting position from Figure 4-1

STEP 5: Estimate stream channel resistance using field evaluations by experienced field personnel, and/or evaluate with measured field data to compare with calculated erosive forces.

Table 4-6. Study Site Classification

Study Site	Watershed Designation[1]	CDA Category[2]	Channel Form[3]	Channel Resistance[4]	Full Designation
1. Topanga Creek	SMB	iii	St-s	Bdr-Bkr	SMB/iii/St-s/Bdr-Bkr
3. Hasley Canyon	SCR	i	Un	Bds-Bks	SCR/i/Un/Bds-Bks
4u. Plum Canyon	SCR	i	Un	Bds-Bks	SCR/i/Un/Bds-Bks
4d. Plum Canyon	SCR	i	Un	Bds-Bks	SCR/i/Un/Bds-Bks
7u. Borrego Cyn.	SDC	ii	Un	Bds-Bks	SDC/ii/Un/Bds-Bks
7d. Borrego Cyn.	SDC	i	Un	Bds-Bks	SDC/i/Un/Bds-Bks
9. Serrano Creek	SDC	ii	Un	Bds-Bks	SDC/ii/Un/Bds-Bks
10. Santiago Ck.	SAR	iii	Un	Bds-Bks	SAR/iii/Un/Bds-Bks
23. Dry Canyon	CGC	i	St-s	Bdr-Bkr	CGC/i/St-s/Bdr-Bkr
27. Hicks Canyon	SDC	i	Un	Bds-Bks	SDC/i/Un/Bds-Bks

EXPLANATIONS

1 Watersheds

CGC Calleguas Creek
SAR Santa Ana River
SCR Santa Clara River
SDC San Diego Creek
SMB Santa Monica Bay

2 CDA Size Ranges (Table 3-3)

i $CDA \leq 2.5\ mi^2$
ii $2.5 < CDA \leq 20\ mi^2$
iii $20\ mi^2 < CDA$

3 Channel Forms (Table 3-4)

St-b Stable, braided
St-s Stable, step-pool
Un Unstable

4 Channel Resistance (Table 3-6)

Bdr Resistant bed
Bds Susceptible bed
Bkr Resistant bank
Bks Susceptible bank

Disregarding the major watershed location, this classification system could result in one of three size categories, one of seven different channel form types, and one of four distinct channel resistance categories. Therefore, there are potentially 84 distinct classifications (3 x 7 x 4 = 84) of stream channels. The 10 stream channel sites selected for this study represent only 5 distinct channel types in this classification system. Whether or not all 84 stream types are represented in the study region remains to be evaluated.

SAMPLE CALCULATION FOR CHANNEL RESISTANCE
(Hasley Canyon Data)

STEP 1 Establish values for variables of channel characteristics (using field measurements) and properties of water at standard conditions.

W_{bfl}	=	10.6 ft	(from Table 5-6)
S_{bfl}	=	0.0264 ft/ft	(from Table 5-6)
d_{bfl}	=	1.7 ft	(from Table 5-6)
ρ	=	62 lb/ft^3	(density at normal temperatures)
g	=	32 ft/sec^2	(acceleration due to gravity)

STEP 2 Calculate the expected shear stress from the measured channel values using equation [4.4]:

$$\tau = \rho g d_{bfl} S_{bfl} = 62 \times 32 \times 1.7 \times 0.0264 = 89 \text{ newtons/ft}^2$$

STEP 3 Resolve the expected shear stress from Step 2 into an applied shear force on the bed material using the geometric correction factor (k_b), and an applied shear force on the bank material using the geometric correction factor (k_s). The geometric correction factor for the bed shear stress (Lane 1955) is based on the width to depth ratio of the measured channel values established in Step 1 (10.6/1.7 = 6.2). The correction factor for the bank shear stress is also based on channel geometry (Lane 1955).

$k_b\tau$	=	0.95 x 89	=	84.6 newtons/ft^2	(Bed material)
$k_s\tau$	=	0.75 x 89	=	66.8 newtons/ft^2	(Bank material)

STEP 4 Compare the calculated shear forces on both the bed and bank to resistance values derived with the sediment characteristics measured in the field.

84.6 newtons/ft^2	≥	57.2 newtons/ft^2	(Bed material)
66.8 newtons/ft^2	≥	14.8 newtons/ft^2	(Bank material)

STEP 5 Assess channel resistance as Bds-Bks, or a susceptible bed and susceptible banks.

Figure 4-3. Example Calculation of Channel Resistance

5. SUMMARY OF FIELD DATA

For each of the 10 study sites, the following data was collected for both historic and current conditions: 1) characteristics of the catchment draining to the site; 2) rainfall and streamflow; and 3) physical condition of the stream channel.

Land use records and aerial photographs were used to estimate the total impervious surface area (TIMP) values in the study watersheds. Precipitation records were evaluated to gain an understanding of when the wet and dry periods occurred in the regions where the study watersheds are located, and whether or not the rainfall amounts were representative of normal conditions during both the period of land use change and the period of stream channel morphology change. The stream flow records provided data for statistical analyses of peak flow frequency for the different drainage areas and serve as a second piece of evidence to determine the representativeness of the climatic conditions during the period of urbanization. Data on bed and bank material were used to evaluate susceptibility to erosion (critical shear stress) and to help define roughness for hydraulic calculations. The results of these analyses are summarized in the sections below.

5.1 Impervious Surface Area (TIMP)

Data on land uses were either available in ArcGIS format (SCAG data) or were delineated on aerial photographs and imported into AcrGIS. The surface area covered by each land use type was calculated for the watershed (drainage area) of each study site. Each land use type was then assigned a specific percent impervious cover value. Total and percent impervious surface area for each watershed was then calculated based on the extent of land use types within the watershed (Table 5-1). A detailed discussion of the process, the percent impervious cover values used for each land use, and the tabulation of land uses and impervious areas by watershed is provided in Appendix A1.

A word of caution is necessary concerning the use of TIMP to represent the degree of development in a watershed and provide a quantitative value against which to relate observed channel changes. Better relationships would likely result from the use of a different representation of impervious area that accounts for the location of impervious surfaces relative to the stream channel and the connection between impervious surfaces and conveyance routes for surface runoff. Such a measurement is often called CIMP (Connected Impervious Cover) or FRIMP (the FRaction of IMPervious surface that is directly connected to another impervious surface and eventually a storm sewer or to the stream channel). However, FRIMP was not used in this study, for two reasons.

1. It is very difficult to calculate FRIMP because it requires field verification of impervious area connections based on air photo or map interpretation. Not only is it difficult and time-consuming to verify for current conditions, it is nearly impossible to verify estimates for historic conditions. Also, the cost for this level of effort is not reasonable for a regional study of this nature.

2. The bulk of the published literature on the effects of urbanization uses TIMP values, so comparisons of values for southern California would be more appropriate using TIMP values. Nevertheless, it would be useful to revisit the FRIMP values for the study watersheds and compare them to the calculated TIMP values; however, this is beyond the scope of the present study.

Table 5-1. Impervious Area Estimates from Land Use Data

SITE NO.	SITE NAME	PERCENT IMPERVIOUS (TIMP)														
		1949(1)	1952(1)	1967(1)	1968(1)	1972(1)	1978(1)	1982(1)	1983(1)	1990(3)	1993(3)	1997(1)	2001(3)	2002(2)	2003(2)	2004(2)
1	Topanga Creek									2.48%	2.62%		2.82%			
3u	Hasley Canyon (upstream)									1.19%	1.26%		1.34%	1.34%	1.34%	
3d	Hasley Canyon (downstream)									1.19%	1.26%		1.34%	1.34%	3.27%	
4u	Plum Canyon (upstream)									0.15%	0.15%		0.16%		1.73%	16.96%
4d	Plum Canyon (downstream)									0.20%	0.20%		1.64%		1.62%	17.52%
7u	Borrego Canyon (upstream)		1.00%	1.05%		1.03%			1.04%	1.46%	5.80%	13.19%	22.00%			
7d	Borrego Canyon (downstream)		1.23%	1.06%		1.06%			1.08%	1.87%	5.08%	11.47%	21.00%			
9	Serrano Creek	1.08%			1.14%		1.11%	3.74%		5.98%	11.18%	21.75%	26.66%			
10	Santiago Creek									0.23%	0.23%		0.24%			
23	Dry Canyon									0.06%	0.06%		0.70%			
27	Hicks Canyon									0.10%	0.10%		1.24%			

(1) Aerial Photo Interpretation
(2) DigitalGlobe® Satellite Imagery
(3) SCAG Land Use Maps

5.2 Precipitation

Rainfall records were obtained from various sources adjacent to each of the study areas (see Table 2-3). Rainfall data for each of the weather stations listed in Table 2-3, and plots of rainfall amounts over time are provided in Appendix A2. Precipitation data were used to help assess the relative importance of climatic factors on the observed changes in stream channel morphology for the period of land use change covered by this study. Comparisons were made between the rainfall during the post-urbanization period (i.e. the period of interest for this study) and the average annual precipitation to assess the representativeness of the time period being evaluated.(see Tables 5-2, 5-3, and 5-4). Because the empirical investigation methods employed in this study related changes in stream channel form to changes in runoff potential, no direct use of rainfall events, amounts, or intensities was made. The empirical methods attempt to look at cumulative effects rather than specific, event-related results.

Development in the Hasley Canyon and Plum Canyon watersheds has only recently begun; therefore, there is only a short period of record available since urbanization. According to the changes in impervious surface area (see Table 5-1) the limited development in Hasley Canyon began in approximately 2002, while the more extensive development in Plum Canyon began initially in 2002 and continued through 2003. Therefore, the average annual rainfall for the period from 2001 through 2003 was calculated and compared to the average for the period of record for four of the stations near these two watersheds (Table 5-2). For these watersheds, it appears that the rainfall was less than normal during the period of urbanization. Thus, climatic factors probably did not contribute to the impacts on these stream channels.More time has passed since the development in the Borrego Canyon and Serrano Creek watersheds occurred. Using the values of TIMP in Table 5-2 as a guide, the start of development for Serrano Creek was estimated to be around 1980, while in Borrego Canyon it was estimated to be around 1991. Therefore, there are enough records available to consider 3-year, 5-year and 10-year averages for annual precipitation after the start of urbanization (Tables 5-3 and 5-4). Results of these comparisons are much different than for the Los Angeles County streams, and suggest that above-average rainfalls could have played a role in the observed stream channel morphology changes in the Orange County sites. Further discussion concerning the implications of above average rainfall amounts on study results is included in Section 6.2 (Evaluating Changes in Stream Channel Condition).

Table 5-2. Hasley and Plum Canyons Rainfall Comparisons

Comparison of the average precipitation for the period of urbanization to the period of record for the station.

	Station 372(1)	Station 801B(1)	Station 1262	Station 1263
Ave. Ann. Precip. (inches)	16.22	17.53	13.66	12.18
Length of Record	63	37	19	19
3-Year Period	2001-2003	2001-2003	2001-2003	2001-2003
3-Year Average (inches)	11.64	14.88	13.66	5.86

(1) Only 2 years of record were available for the 2001-2003 period.

5.3 Stream Flow

Stream gage data for peak flows at recording stations at or near study sites were obtained from the USGS web site [http://waterdata.usgs.gov/ca/nwis/nwis] or from Los Angeles County. The data for each gaging station were prepared for plotting flow frequency curves using the Weibull formula (Haan 1977). Values were taken from these curves to prepare regional peak flow curves (CDA vs. peak discharge) for specific,

low value recurrence interval events (1.2-year, 2-year, 5 year, and 10-year). Data and curves are provided in Appendix A3.

Table 5-3. Borrego Canyon Wash Rainfall Comparisons

Comparison of the average precipitation for the period of urbanization to the period of record for the station.

	Station 121	Station 165	Station 169	Station 173	Station 167	Station 216
Ave. Ann. Precip. (inches)	12.98	12.14	12.46	15.01	14.96	14.58
Length of Record	96	48	44	43	39	29
3-Year Period	1991-1993	1991-1993	1991-1993	1991-1993	1991-1993	1991-1993
3-Year Average (inches)	17.25	15.03	15.27	20.06	18.97	16.00
5-Year Period	1991-1995	1991-1995	1991-1995	1991-1995	1991-1995	1991-1995
5-Year Average (inches)	17.57	15.00	15.78	19.79	18.89	17.31
10-Year Period	1991-2000	1991-2000	1991-2000	1991-2000	1991-2000	1991-2000
10-Year Average (inches)	16.24	14.36	15.03	18.11	17.84	17.13

Peak flow data were also reviewed as a second approach to consider the impact of climatic factors on the change in stream channel morphology for Borrego Canyon and Serrano Creek. The Santiago Creek gage at Modjeska has a continuous record from 1962 through the present. The entire record of annual peak flows for this gage is presented in Table 5-5. The return periods of the annual peaks from 1980 through 1989 (urbanization period for Serrano Creek) show two flows above an 8-year return period. These flows ranked as the third and fifth largest flows of the 42-year record at this gage. The return periods of the annual peaks from 1991 through 2000 (urbanization period for Borrego Canyon) show two flows above a 10-year return period (ranked as the second and fourth largest flows on record). This concentration of higher than normal flows during these two periods is consistent with the conclusion that climate could have contributed to the morphological changes in the Borrego Canyon and Serrano Creek stream channels.

5.4 Stream Channel Characteristics

Field data gathered in May 2004 consisted of a series of cross sections and a single, longitudinal profile for the entire reach at each site. Measurements of stream channel width, cross-sectional area, average depth, and longitudinal gradient (channel slope) were made for each surveyed cross section (Table 5-6). The common feature used to standardize the measurements among the sites was the bankfull stage (i.e., the elevation/depth of flow that fills the active channel), also referred to in this study as the Dominant Discharge (see Appendix C2 for a discussion of the logic for this determination). In addition, sediments in the stream channel bed and banks were characterized. Hydraulic calculations from the data in Table 5-6 provide an estimate of discharge at the bankfull stage (Q_{bfl}).

Table 5-4. Serrano Creek Rainfall Comparisons

Comparison of the average precipitation for the period of urbanization to the period of record for the station.

	Station 121	Station 165	Station 169	Station 173	Station 167	Station 216
Ave. Ann. Precip. (inches)	12.98	12.14	12.46	15.01	14.96	14.58
Length of Record	96	48	44	43	39	29
3-Year Period	1980-1982	1980-1982	1980-1982	1980-1982	1980-1982	1980-1982
3-Year Average (inches)	16.12	16.30	16.56	17.79	15.85	14.45
5-Year Period	1980-1984	1980-1984	1980-1984	1980-1984	1980-1984	1980-1984
5-Year Average (inches)	15.73	15.38	15.93	18.16	17.11	16.15
10-Year Period	1980-1989	1980-1989	1980-1989	1980-1989	1980-1989	1980-1989
10-Year Average (inches)	16.34	15.90	16.00	18.68	17.56	16.17

Nine of the eleven sites are channels formed in relatively erosive alluvial material. The remaining two sites are bedrock controlled (i.e. outcropping bedrock in the channel and banks within, or very near to, the study reach). Although not caused by geomorphic setting, the most obvious difference in these two sites from other sites is that Topanga Creek (the largest watershed) and Serrano Creek (the most developed watershed) are the only two non-ephemeral stream channels in the study. Both channels had flowing water at the time of the survey in May 2004. However, it was not documented whether flow persisted all year (i.e. whether either stream is perennial). Despite that fact that Topanga and Serrano creeks were both bedrock controlled, differences in the composition of the bedrock influenced their relative resistivity. The Topanga Creek site consists of resistant bedrock that provides the source of coarse sediment in the channel (cobble to boulder size). In contrast, the bedrock in Serrano Creek is a poorly-consolidated sandstone that has proven to have little resistance to erosion.

Differences in channel type help explain some of the variability in channel metrics between the sites. Nevertheless it is useful to consider this data set as a whole and make some general statements about the values obtained for the existing conditions at these sites. Judging by the values in Table 5-6, the calculated discharge rates for the bankfull stage show the greatest consistency among the sites. The standard deviation for the Dominant Discharge (Q_{bfl}) calculated for each site show the lowest values and smallest range of values of any parameter in the table. Figure 5-1 shows the relation between CDA and the Dominant Discharge. The developed sites show higher runoff rates for similar watershed areas. On the other hand, the measured widths and slopes have the highest values and largest range of values. This is logical in that discharge should be the most dependent on watershed size, and therefore vary the least in a short channel reach. The fact that this calculated value is consistent for all of the sites demonstrates that the bankfull stage is a reliable feature to identify in the field and use for comparison purposes. It is also important to point out that the downstream sites at Plum Canyon and Borrego Canyon Wash have smaller values for the Dominant Discharge than the upstream sites. Therefore, it is apparent that in each of these reaches there is loss of flow between the upstream and downstream sites. This can be explained as a loss to infiltration into the porous materials in the channel bottom.

Table 5-5. Stream Gage Record for Santiago Creek at Modjeska

Annual peak flows for the period of record (water years 1962 – 2003)

Rank	Peak Q (cfs)	Peak Date	Return Period (years)	Rank	Peak Q (cfs)	Peak Date	Return Period (years)
11	825.00	16-Mar-03	3.91	20	386.00	20-Jan-82	2.15
42	3.40	21-Dec-01	1.02	17	483.00	29-Jan-81	2.53
34	75.00	25-Feb-01	1.26	5	1,810.00	18-Feb-80	8.60
31	97.00	21-Feb-00	1.39	14	555.00	05-Jan-79	3.07
41	5.60	26-Jan-99	1.05	6	1,550.00	09-Feb-78	7.17
2	6,200.00	23-Feb-98	21.50	39	16.00	07-Jan-77	1.10
24	257.00	26-Jan-97	1.79	18	440.00	01-Mar-76	2.39
33	77.00	21-Feb-96	1.30	28	185.00	08-Mar-75	1.54
4	2,400.00	05-Mar-95	10.75	13	575.00	08-Jan-74	3.31
36	36.00	20-Feb-94	1.19	15	516.00	11-Feb-73	2.87
10	1,370.00	17-Jan-93	4.30	25	241.00	25-Dec-71	1.72
12	807.00	12-Feb-92	3.58	35	56.00	21-Dec-70	1.23
23	274.00	01-Mar-91	1.87	32	90.00	02-Mar-70	1.34
22	287.00	17-Feb-90	1.95	1	6,520.00	25-Feb-69	43.00
30	167.00	25-Dec-88	1.43	26	211.00	08-Mar-68	1.65
27	203.00	17-Jan-88	1.59	8	1,420.00	06-Dec-66	5.38
40	13.00	05-Jan-87	1.08	7	1,500.00	22-Nov-65	6.14
19	396.00	29-Nov-85	2.26	29	175.00	09-Apr-65	1.48
9	1,400.00	19-Dec-84	4.78	38	17.00	02-Apr-64	1.13
16	490.00	24-Nov-83	2.69	37	30.00	10-Feb-63	1.16
3	3,400.00	02-Mar-83	14.33	21	302.00	11-Feb-62	2.05

Given that the variability of channel depth and cross-sectional area are also relatively small, the high variability in the width and slope are quite logical. Since the flow in these sites is conservative (as the data in Table 5-6 suggest) flow is not changing much over time, nor is the depth of flow or channel area. Therefore, adjustment to changes in stream power to maintain channel competency (i.e. its ability to transport sediment load) is accomplished primarily through changes in width and slope of the channels. This is easily accomplished in alluvial channels with the abundance of loose sediment material available to move and be reshaped.

5.5 Dominant Discharge

The concept of using a single, discrete flow to represent the actions of a range of flows that a channel experiences, is very useful. This is the basis for the use of the term *Dominant Discharge*. The actual value of the Dominant Discharge has been defined in various ways, (a) related to channel form (as in meander wavelength), (b) the flow that does the most work, statistically, in carrying sediment, or (c) the flow which fills the channel to capacity (i.e. the

"bankfull stage"). Knighton (1984) asserts that there is enough evidence from previous studies to make a compelling case for a convergence of these methods of defining Dominant Discharge.

Table 5-6. Stream Channel Site Data
Average values for measurements and standard deviations taken in May 2004. Actual measurements by cross section are presented in Appendix B1.

Site No.	Name	Value	Q_{bfl} (cfs)	A_{bfl} (ft^2)	W_{bfl} (ft)	d_{bfl} (ft)	S_{bfl} (ft/ft)
1	Topanga	Average	1,427.4	191.1	75.7	6.0	0.0298
		Stnd. Dev.	3.4%	18.0%	9.7%	3.6%	48.3%
3	Hasley	Average	71.0	11.4	10.6	1.7	0.0264
		Stnd. Dev.	7.8%	21.5%	38.1%	12.8%	43.4%
4u	Plum	Average	267.7	49.1	53.7	2.2	0.0216
	Upstream	Stnd. Dev.	11.2%	20.0%	49.2%	23.1%	15.6%
4d	Plum	Average	127.8	32.6	54.8	1.1	0.0257
	Downstream	Stnd. Dev.	7.5%	19.5%	42.7%	22.7%	28.1%
7u	Borrego	Average	343.5	79.0	95.1	1.7	0.0183
	Upstream	Stnd. Dev.	4.2%	32.1%	59.9%	6.5%	34.6%
7d	Borrego	Average	248.1	54.2	54.7	1.9	0.0170
	Downstream	Stnd. Dev.	11.5%	16.7%	34.0%	18.1%	15.5%
9	Serrano	Average	346.1	43.2	17.0	5.2	0.0157
		Stnd. Dev.	3.3%	16.9%	34.7%	22.1%	35.4%
10	Santiago	Average	752.1	136.3	69.9	3.9	0.0101
		Stnd. Dev.	8.9%	16.4%	7.7%	14.6%	35.9%
23	Dry	Average	55.5	11.2	9.6	1.7	0.0163
		Stnd. Dev.	7.6%	9.6%	13.2%	10.6%	17.8%
27	Hicks	Average	48.3	9.1	8.7	1.7	0.0208
		Stnd. Dev.	11.9%	18.0%	13.0%	14.1%	45.9%

The single flow identified as Dominant Discharge is often thought of as a "channel forming" flow that is responsible for the present shape of a natural stream channel. However, the Dominant Discharge is actually just concept, and represents the variability in flows of each watershed. Nevertheless, because of the demonstrated tendency of the Dominant Discharge to be coincident with the current channel form, the bankfull stage can be used to estimate Dominant Discharge. This application is adopted for this study, and the Dominant Discharge is used as a surrogate for the range of geomorphic activities in the channel. Consequently, it provides an effective comparative value among channels.

The obvious concerns with using this feature are how well adjusted it is to the range of flows that are currently representative of watershed activity, and how accurately it can be measured for any given stream channel segment. Both of these sources of error can be significant, but this is an accepted level of uncertainty in geomorphic research when drawing deterministic conclusions about stream channel activity in natural systems. Perhaps the uncertainty is even greater than normal when dealing with bankfull features in semi-arid systems because the channel form can be unduly impacted by the most recent major storm to reach the watershed. Graf (1988) provides a strong argument for the importance of recent flows

in dryland watersheds. However, even with the complexities of the relationship between channel form and the range of flows within a watershed (and their timing), this use of the Dominant Discharge concept provided the best opportunity to draw meaningful conclusions about channel behavior in these semi-arid locations.

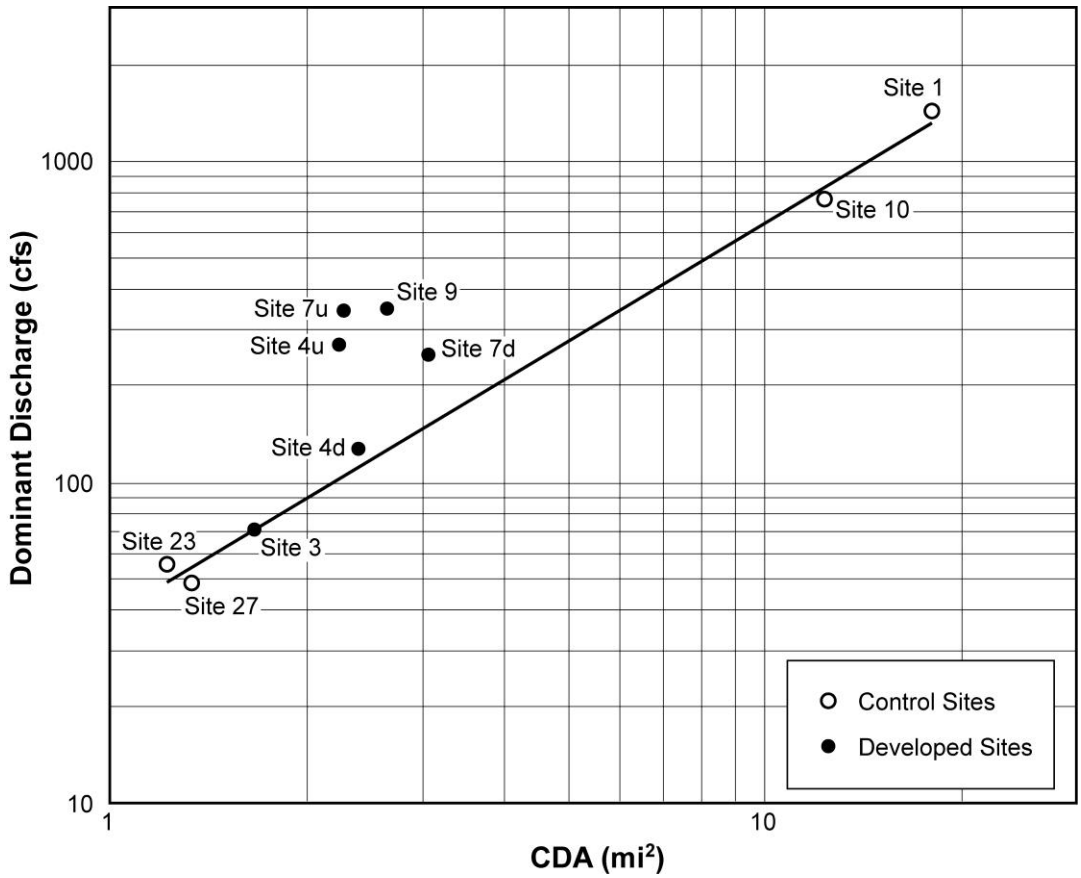


Figure 5-1. Discharge and Drainage Area

The reference line is a best fit for the control sites. Most of the sites with developed watersheds are well above the line, demonstrating greater runoff per unit area than the control sites.

Concerning the specific data for the study sites, the Dominant Discharge calculated for each cross section at every site is based on bio-geomorphic indicators (see Appendix C2). Of interest to this study, as well as urban stormwater managers, is the relative frequency of these discharges. It is well established in the literature that urbanizing watersheds (in the absence of stormwater management measures) have an increase in runoff associated with a storm of a similar frequency. Therefore the return period of the discharge associated with the bankfull stage, the Dominant Discharge, is significant for comparing these sites. Table 5-7 provides two estimates of the value of the return period for the calculated Dominant Discharges for a specific cross section at each of the sites.

Recurrence intervals are estimated with two distinct methods as a means of comparing and validating results. The first method employs the regional equations developed by the U.S. Geological Survey (Waananen and Crippen 1977) to estimate peak discharges for ungaged basins. These equations provide estimates of peak flow for specific recurrence intervals based on watershed size (CDA) and average annual rainfall amounts. Graphs were prepared for each site, plotting recurrence interval vs. discharge, using these equations and specific CDA values and rainfall amounts. The Dominant Discharge calculated

for a cross section can then be plotted on the graph to estimated recurrence interval A more detailed description of this process and the results are provided in Appendix C2.

Table 5-7. Recurrence Interval Estimates
Values estimated for current conditions at specified cross sections

Study Site		Section	Date of Survey	Dominant Discharge Q_{bfl} (cfs)	Recurrence Interval	
					USGS Estimate (yrs)	Prorate to Gage (yrs)
1	Topanga Creek	TOP-02	4-May-04	1,381.4	n/a	2.4
3u	Hasley Canyon	HAS-04	9-May-04	64.8	6.2	2.1
3d	Hasley Canyon	HAS-02	9-May-04	77.5	6.6	2.1
4u	Plum Canyon	PLU(u/s)-05	11-May-04	308.2	3.9	5.7
4d	Plum Canyon	PLU(d/s)-02	10-May-04	127.8	7.3	2.5
7u	Borrego Canyon	BOR(u/s)-03	6-May-04	327.7	10.5	6.7
7d	Borrego Canyon	BOR(d/s)-03	7-May-04	292.2	6.6	3.9
9	Serrano Creek	SER-03	7-May-04	353.6	2.8	5.6
10	Santiago Creek	SAN-01	13-May-04	754.4	1.5	4.1
23	Dry Canyon	All stations	11-May-04	55.6	6.4	2.3
27	Hick's Canyon	HIC-04	8-May-04	54.8	6.0	2.2

The second method uses gage records to develop flow frequency curves from which return periods can be read for a corresponding discharge. However, the flow frequency curve is specific for the CDA to the gage. Therefore, the Dominant Discharge calculated for a specific cross section at a study site must be prorated by CDA size to obtain the corresponding flow rate at the gage before its return period can be read from the flow frequency curve.

5.6 Bed and Bank Material

A summary of the particle-size distributions of the channel bed sediment evaluated during field assessment for the current study is given in Table 5-8. The material characterized represents the coarse fraction of bed sediment that is actually or potentially the sediments that result in natural channel armoring. The ϕ_{16}, ϕ_{50}, ϕ_{75}, and ϕ_{84}, values represent the sediment particle size diameter for which 16%, 50%, 75%, and 84% of the cumulative size distribution is smaller. These material size values have been used in the evaluation of channel bed resistance to erosion. In addition to the coarse sediment fraction, the finer sediments were characterized with sieve analyses in the field. The fact that all of these sites had bed sediment ϕ_{50} sizes ranging from sand size (0.01 in. to 0.08 in.) to boulder gravel (greater than 10 in.) indicates that they are poorly to very poorly sorted sediments. The ϕ_{50} size values in Table 5-8 classify most of the "armor fraction" of these sediments in the cobble gravel size range (2.5 in. to 10 in., Compton 1962). The only real distinction among these sites based on sediment size is the order of magnitude difference of the Topanga sediment from the other sites.

A Torvane® shear meter was used to measure the cohesion of the bank materials. The size distributions of bank materials as a description of cohesion (using units of applied shear force) are ultimately used in evaluating the susceptibility of the bed and bank materials to erosion based on the estimated applied shear forces of the Dominant Discharge. Results of the analysis of sediment data, including the size-fraction distribution, are provided in Appendix B2.

Table 5-8. Summary of Particle Size Data

Values presented in this table are from pebble counts, using the Wolman (1954) method, of the coarsest materials in the channel bed at each cross section.

Watershed	Cross-Section ID	Equivalent Diameter For Selected Particle Size Fractions			
		ϕ_{16} (in)	ϕ_{50} (in)	ϕ_{75} (in)	ϕ_{84} (in)
Topanga Canyon	TOP-01		29.95		44.98
	TOP-02		35.65		44.96
	TOP-03		17.49		22.13
Hasley Canyon Upstream	HAS-04	2.05	3.46	4.72	5.00
Hasley Canyon Downstream	HAS-01	2.95	5.04	5.71	5.94
	HAS-02	2.05	2.83	3.19	3.27
	HAS-03	2.13	2.91	3.15	3.23
Plum Canyon Upstream	PLU-01u/s	2.01	3.11	3.62	3.78
	PLU-02u/s	3.43	5.87	7.60	8.15
	PLU-03u/s	1.97	3.07	3.66	4.02
	PLU-04u/s	2.99	5.39	7.20	7.72
	PLU-05u/s	2.60	3.94	4.76	4.96
Plum Canyon Downstream	PLU-01d/s	4.09	8.15	9.13	9.21
	PLU-02d/s	2.40	3.15	3.35	3.43
	PLU-03d/s	2.17	3.35	3.82	4.06
	PLU-04d/s	1.93	3.62	5.67	5.79
Borrego Canyon Wash Upstream	BOR-01u/s	3.74	6.93	8.43	8.98
	BOR -02u/s	3.15	4.69	5.55	5.83
	BOR -03u/s	3.19	3.82	4.37	4.49
	BOR -04u/s	3.74	5.20	5.79	6.02
	BOR -05u/s	3.19	5.20	6.57	7.52
Borrego Canyon Wash Downstream	BOR-01d/s	2.56	3.43	3.98	4.25
	BOR –02d/s	4.80	8.11	9.53	9.92
	BOR –03d/s	2.60	4.41	5.35	5.63
	BOR –04d/s	2.32	4.13	5.59	5.91
	BOR –05d/s	3.94	7.09	7.48	7.56
Serrano Creek	SER-01	3.19	4.21	5.16	5.35
	SER-02	3.94	6.89	7.52	7.60
	SER-03	2.64	4.17	5.67	5.91
Santiago Canyon	SAN-01	1.81	3.35	4.17	4.41
	SAN-02	2.28	5.83	6.81	7.05
	SAN-03	7.13	8.90	9.37	9.84
	SAN-04	2.68	5.08	5.35	5.43
	SAN-05	2.36	3.74	4.72	5.24
Dry Creek	DRY-01	2.76	4.76	6.38	6.50
	DRY-02	3.39	5.59	6.06	6.22
	DRY-03	1.93	3.11	3.43	3.58
	DRY-04	2.44	3.39	3.98	4.45
Hick's Canyon Wash	HIC-01	4.06	7.64	8.98	9.41
	HIC-02	2.48	3.58	5.12	5.43
	HIC-03	0.87	1.22	1.30	1.46
	HIC-04	0.87	1.10	1.26	1.34
	HIC-05	1.97	3.70	4.13	4.13

5.7 Rapid Geomorphic Assessment

Channel stability at each site was evaluated using a Rapid Geomorphic Assessment (RGA). The RGA is a semi-quantitative method for evaluating the stability of a site based on geomorphic indicators observed and recorded in the field. The RGA produces a stability index (SI) that can be used to categorize the geomorphic condition of the stream reach. The calculated stability index values suggest that all of the study sites are either already unstable or are in transition to being unstable (Table 5-9). The two control sites, Hicks and Dry canyons, had the lowest SI scores while more developed watersheds, such as Plum and Serrano canyons had appreciably higher SI values. Nevertheless, the "undisturbed" watersheds still exhibited moderate channel instability. These results suggest that all channels are continually undergoing adjustment and that there is some level of naturally occurring background hydromodification within southern California watersheds, even in the absence of development.

Table 5-9. Rapid Geomorphic Assessment

Results of evaluation process designed to assess the stability of a stream site

	Site	Stream Type	AI	DI	WI	PI	M	SI	Stability Class
1	Topanga Canyon	AL(Ar)	0.33	0.40	1.00	-	3	0.43	A
3	Hasley Canyon	AL	-	0.89	0.83	0.43	4	0.54	A
4u	Plum Canyon u/s	AL	0.80	0.80	0.71	1.00	4	0.83	A
4d	Plum Canyon d/s	AL	0.83	0.60	0.71	1.00	4	0.79	A
7u	Borrego Creek u/s	AL	0.83	0.40	0.80	0.86	4	0.72	A
7d	Borrego Creek d/s	AL	0.83	0.83	0.71	0.67	4	0.76	A
9	Serrano Creek	RC	-	1.00	0.83	0.43	3	0.75	A
10	Santiago Creek	AL	0.60	0.80	0.60	0.57	4	0.64	A
23	Dry Creek	AL	-	0.57	0.83	0.43	4	0.46	A
27	Hick's Canyon	AL	-	0.71	0.75	0.14	4	0.40	T

Explanation:

AI Evidence of aggradation
DI Evidence of degradation
WI Evidence of widening
PI Evidence of plan form adjustment
SI Stability Index (see interpretation of SI value below)

SI Value	Interpretation	Comment
$0 \leq SI \leq 0.25$	S - Stable	The morphologic features do not show evidence of progressive alteration and type and variance in the dimensions of morphologic features is within acceptable levels.
$0.25 < SI \leq 0.4$	T - Transitional	The type and variance of observed morphologic features indicates that the stream channel is in or about to begin the initial stages of adjustment.
$0.4 < S \leq 1.0$	A - In Adjustment	The type of morphologic features suggests that the channel system has been de-stabilized and is in the middle of adjusting to new conditions.

5.8 Data Summary

The data collected for this study, both historical and field data, have been summarized and described in this section. More detailed presentations of this data are provided in Appendix A (land use, precipitation, stream flow, and historic surveys) and Appendix B (survey comparisons and channel materials). A basic assessment of the data including some general implications about the channel and watershed systems that they describe has also been provided. These serve more to describe the study sites and provide background and general findings based on the data collected.

6. CHANNEL RESPONSE

Results of the analysis of stream channel response to changes in watershed TIMP are presented in this section, followed by a discussion of the implications of these results for management purposes in Section 7. Analysis of channel response was based on an evaluation of the discernable changes in channel form and how they relate to measurable changes in watershed imperviousness (TIMP). Various channel metrics (measurements of channel form) are evaluated to establish these relationships. Summarized below are the results of channel-specific data evaluation and the connections between changes in channel morphology and the changes in watershed development (i.e. imperviousness). More detailed discussion and data on these evaluations are provided in Appendix C.

6.1 Stream Channel Morphology

Stream channel morphology was evaluated based on channel width (W_{bfl}), average channel depth (d_{bfl}), and cross sectional area (A_{bfl}, or the combination of width times average depth), and flow velocity (V_{bfl}). Width and cross sectional area are measured directly from the plotted cross sections derived through current and historic field surveys. Average depth was calculated from the measured data ($d_{bfl} = A_{bfl} / W_{bfl}$). Flow velocity was also calculated using channel slope (S_{bfl}) and estimates of roughness derived from sediment data collected during field surveys. These features were measured at the stage (water surface elevation) of the Dominant Discharge, also referred to as the "bankfull" stage (hence the various subscripts of "bfl"). Details of the selection of Dominant Discharge for use among the channels is given in Appendix C2.

The channel features for a specific stream type were plotted against the estimated Dominant Discharge ($Q_{bfl} = A_{bfl} * V_{bfl}$) to look for a correlation values that would indicate deterministic behavior. The following three relationships were established:

1. There is a logarithmic relationship between dominant discharge (Q_{bfl}) and channel width (W_{bfl}; Figure 6-1). The data used in this plot excluded the braided channel types (Sites 4d and 7d) and the canyon channel type (Site 9).
2. Dominant discharge (Q_{bfl}) is realated to cross sectional area (A_{bfl}) by a power function (Figure 6-2). The data set for this assessment included all of the sections for all of the study sites.
3. There is an inverse logarithmic relationship between the width to depth ratio (W_{bfl} / d_{bfl}) and the ratio of excess shear stress for the bed materials to the excess shear stress for the bank materials (Figure 6-3). The latter ratio expressed on the x-axis is a measure of the inherent ability of the channel bed and bank materials to resist the erosive forces associated with flowing water. The term "excess" in this case is the difference between actual calculated shear stress on the bed or bank and the critical shear stress required to move (or erode) particles. The full expression is provided in Appendix C3, along with an expanded discussion of the evaluation process. The correlation of these values is considerably lower than it is for the channel geometry components ($R^2 = 0.67$), but is surprisingly good considering the range of activities represented by this measure of channel shape.

The relationships between channel features and the Dominant Discharge (Figures 6-1 and 6-2) demonstrate a predictable or deterministic behavior in the channel geometry at these sites. As discharge increases, there is an expected increase in channel size. Comparing Figures 6-1 and 6-2 show that the initial channel response to increases in discharge is to widen; however, with increasing discharge, increased depth (i.e. downcutting) is the predominant response. The relationship of channel shape to excess shear stress (Figure 6-3) also establishes a good basis for the predictable nature channel form. The shear stress relationship also suggests threshold

behavior for the widening or deepening of the stream channel. After a minimal level or bed and bank resistivity has been exceeded, the width-to-depth quickly declines (i.e. channel incision). All of these relationships provide useful techniques to fill data gaps in time series assessments of channel changes.

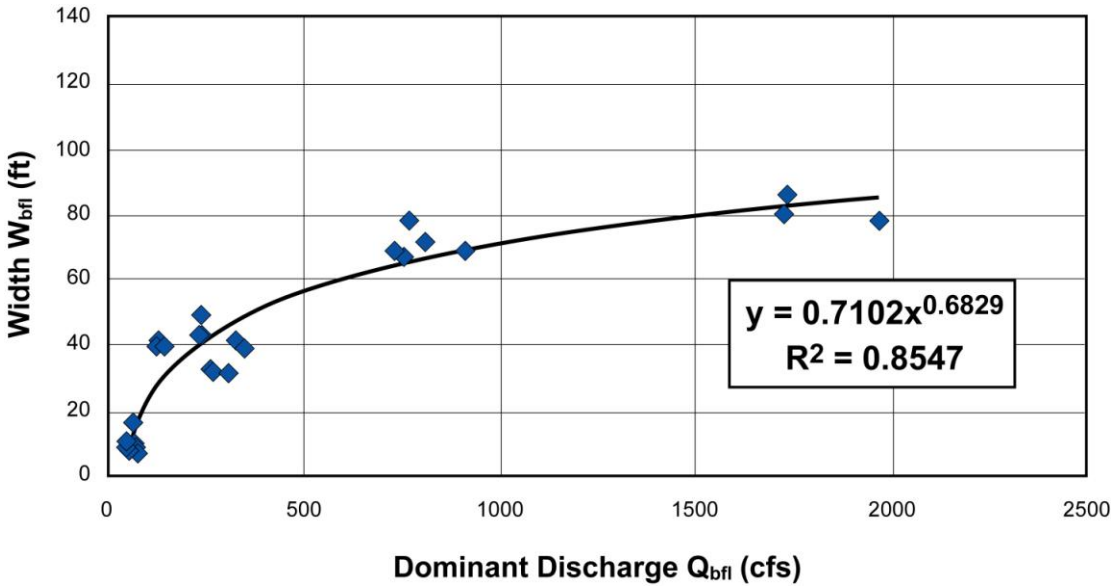


Figure 6-1. Channel Width and Dominant Discharge

6.2 Evaluating Changes in Stream Channel Condition

Natural stream channels exhibit changes over time in their geometry (width, depth, and slope) due to changes in environmental conditions. Various conceptual models exist that can be used to explain the state of a stream channel relative to an equilibrium condition, including steady state, dynamic equilibrium, and metastable equilibrium. The literature on this subject is quite large and the application of terminology has been somewhat inconsistent. Therefore, the terms and concepts discussed here in relation to conceptual models of channel adjustment are defined below.

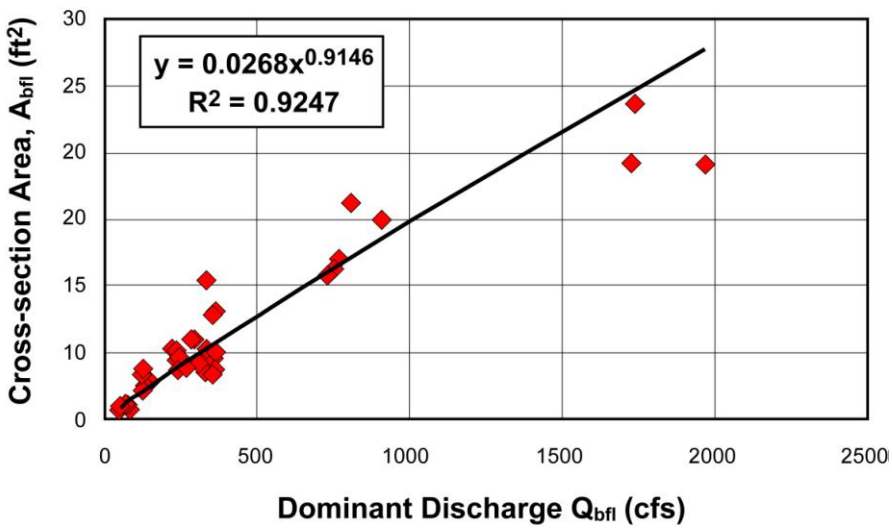


Figure 6-2. Cross Section and Discharge

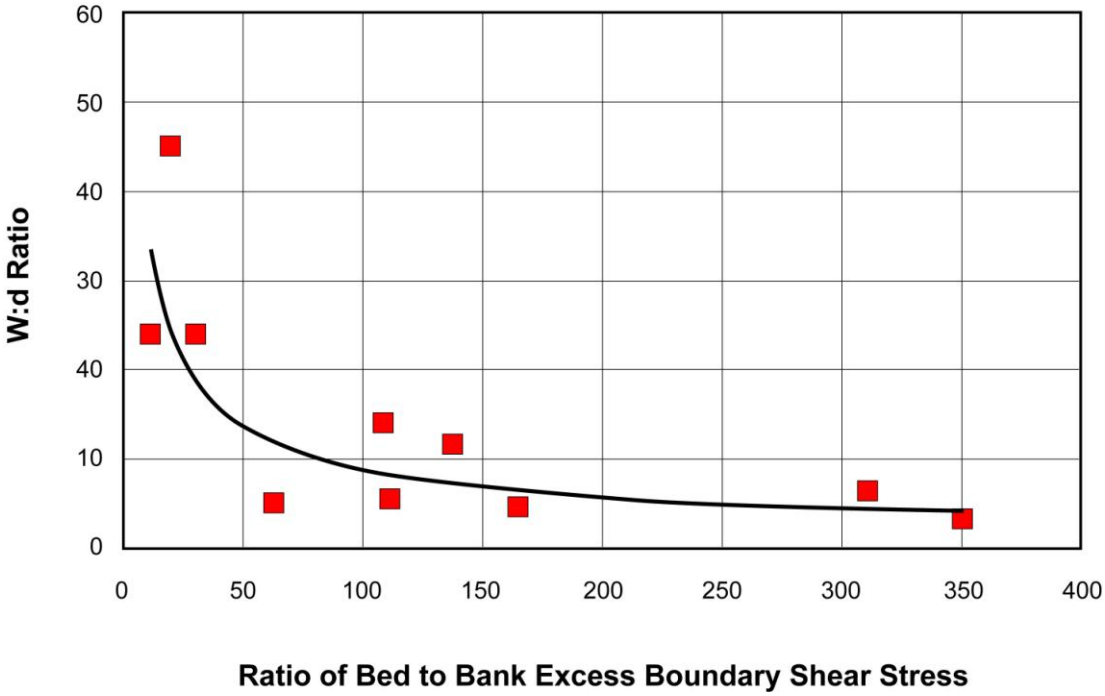


Figure 6-3. Channel Shape and Resistance

Width to depth ratio as a function of the product of specific stream power and the ratio of bed to bank excess boundary shear stress

- **Steady State.** Channel form components, including the width, depth, and slope, vary over time, but always within a definable range about a mean value that does not change over the period of time under consideration. Such a system is usually identified only for short time periods.

- **Dynamic Equilibrium.** Channel form components vary about a mean value that slowly changes over time. This type of condition usually can be identified for longer time periods than the Steady State condition.
- **Metastable Equilibrium.** Channel components also vary about a slowly changing mean value. However, this mean value can suffer rapid and dramatic change if a threshold is passed. Thus, the Metastable Equilibrium state is multiple periods of dynamic equilibrium separated by significant adjustment.
- **Statistical Stationarity.** Demonstration of a steady state condition through the application of statistical evaluation of one or more components of channel form.

In the present study the length of time represented by the data set is relatively short, which makes evaluating the system equilibrium a challenge. In addition, because this investigation is looking at artificially induced change in the equilibrium of these systems, it is important to be able to distinguish between internal (or natural) system change, and external (or artificial) change. The attempt to sort out the equilibrium status of these systems included the use of "control" sites where little to no development has occurred over the period of historic measurement of channel form.

Two of the control sites were Dry Canyon (Ventura County) and Hicks Canyon (Orange County). Each of these sites had multiple measurements at the same channel cross section over time periods of 3 years and 18 years respectively. Although both of these sites demonstrated periodic, or cyclical behavior in the adjustment of some channel geometry components (including W_{bfl} and A_{bfl}), they also exhibited an abrupt change in the thalweg elevation that to-date does not appear to be reversing. Neither change appears to have resulted from excessive storm events or other external causes. Therefore, it appears that the studied channel systems in southern California are not in a steady state condition, and the statistical stationarity of this system (at least in terms of the thalweg elevation) cannot be demonstrated. In other words, even in the absence of external forces, there is a natural rate of change of stream channel depth over time (see also Appendix C3, Section C3.4).

Both the control and the developed sites experienced channel degradation (i.e. negative change in the thalweg elevation) over the period studied. The average degradation rate over the longer period of records was 0.12 ft./yr. for the control sites and 0.31 ft./yr. for the developed sites. It appears that one of the effects of increased TIMP is an increase in the *rate* of channel degradation.

In addition, the precipitation averages during the periods of change for the stream channel sites adjacent to these control sites differed in each area (see Section 5.2). The Ventura County and LA County data suggest that changes occurring at Hasley Canyon and Plum Canyon occurred during a period of lower than average precipitation. The data for Orange County suggests the opposite situation, with higher than average precipitation amounts occurring during the periods of channel change. However, the actual impact of these higher than normal rainfall amounts and stream flows (see Section 5.3) on the Orange County sites, does not appear to alter the conclusion that changes in TIMP were the primary cause of channel change, and not higher than normal rainfall. The most important argument for this assertion is that the channel conditions at nearby Hick's Canyon remained stable during this same period, even though it was experiencing a decrease in thalweg elevation. Thus the same rainfall conditions that were causing significant channel erosion at Borrego Canyon Wash and Serrano Creek, were not significantly altering the channel conditions at Hick's Canyon other than the thalweg elevation.

The fact that deterministic relationships have been demonstrated for a number of channel geometry components and for channel boundary resistance (as described earlier in Section 5), argues for these systems being at least in a dynamic equilibrium. Since statistical stationarity cannot be demonstrated, dynamic equilibrium is still possible and steady state is not likely. Furthermore, because the developed watersheds are undergoing imposed changes, and the stream channels are responding to this perturbation, significant adjustments are occurring in the general

mean values of the system in its state of dynamic equilibrium. This suggests further refinement of the model to one of dynamic metastable equilibrium. More detailed discussion of this topic is provided in Appendix C3.

6.3 Stream Channel Response

Evaluation of channel enlargement requires multiple data points over a time sequence that includes the predevelopment condition (as the baseline or beginning point in time), the current condition (as the end-point), and one or more "historical" data points. The historical data points represent conditions that occurred along the time sequence between the baseline and the end point. In many cases the current conditions do not represent the ultimate end of the adjustment response (the ultimate end point). Therefore, the ultimate condition must be estimated, if possible, using specific and consistent techniques. A full description of the channel enlargement evaluation process is provided in Appendix C4. A brief summary of the procedure follows:

1. Collect available data and decide whether the data coverage is adequate.
2. Establish the baseline time marker (the actual date, or a time of t_0) and channel baseline condition (A_{pre}) for each site.
3. Evaluate all historical points between the baseline time marker (t_0) and the present time (t_{ext}) to understand their condition. Decide whether a single response or multiple responses are occurring at each site.
4. Predict the ultimate condition of the channel at each site upon completion of the adjustment (assuming the existing condition is not the ultimate condition). Appendix C4 provides a discussion of the techniques for completing Steps 3 and 4 if the data set is incomplete.
5. Use the data output from Steps 2, 3, and 4 to construct the *relaxation curve* for each site.
6. Since all of the sites have varying amounts of change in their watershed with regard to TIMP, and this causes varying amounts of channel adjustment, an enlargement curve (defined below) is developed to understand and compare data. To do create the enlargement curve we must assume or predict values of the time it will take to reach the ultimate condition, and the value of that ultimate condition (A_{ult}), for each adjusting site.

Two important aspects of channel change are compared over time, (a) the change in thalweg elevation and (b) the change in channel cross section area for the bankfull stage. The availability of all of this data for historic and/or baseline conditions is not always ideal, so adjustments must be made to complete the evaluation. However, all of the data mentioned above, except the channel slope, can be calculated from surveyed cross sections.

Comparison of the cross-section area of the channel at the bankfull or Dominant Discharge stage (Q_{bfl}) at different points in time produces a ratio of channel cross section area (A_{bfl}) from a later period to the earliest, or baseline period. This comparison is termed the enlargement ratio (R_e), and takes the form of Equation [6.1].

$$(R_e)_{his} = A_{his} / A_{pre} \qquad [6.1]$$

where:

A_{his} = Cross section area of the bankfull channel at an historical point in time (square feet).

A_{pre} = Cross section area of the bankfull channel for the baseline condition (square feet).

Similar comparisons are made for the existing condition (A_{ext}) and the projected, ultimate condition (A_{ult}). The ultimate condition requires an estimation of channel metrics at the end of the adjustment period. None of these sites has reached its ultimate condition in response to the development that has occurred, as this can take several decades (see Appendix C4). Therefore, the ultimate channel condition, and the time it will take to achieve it, must be estimated. The amount of time required for the full adjustment to be completed is called the *relaxation period*. The plot of the adjustment process over time is called the *relaxation curve*. Data from the current study are plotted in Figure 6-4 along with a reference relaxation curve developed using data from urban stream channels on Austin, Texas, which have similar geomorphic and hydraulic conditions, but somewhat different precipitation patterns.

The data plotted on Figure 6-4 are the results of the current investigation with the curve developed for the Austin data. It appears that the changes occurring at the current study sites are still within the initial stages of adjustment, and thus too close to the increase in TIMP to effectively predict the complete adjustment process. Therefore, it is still premature to prepare a relaxation curve developed only with the southern California data from the study sites. In addition, some of the study site data, particularly for the Plum Canyon and Borrego Canyon Wash sites, are not typical of the enlargement data in general.

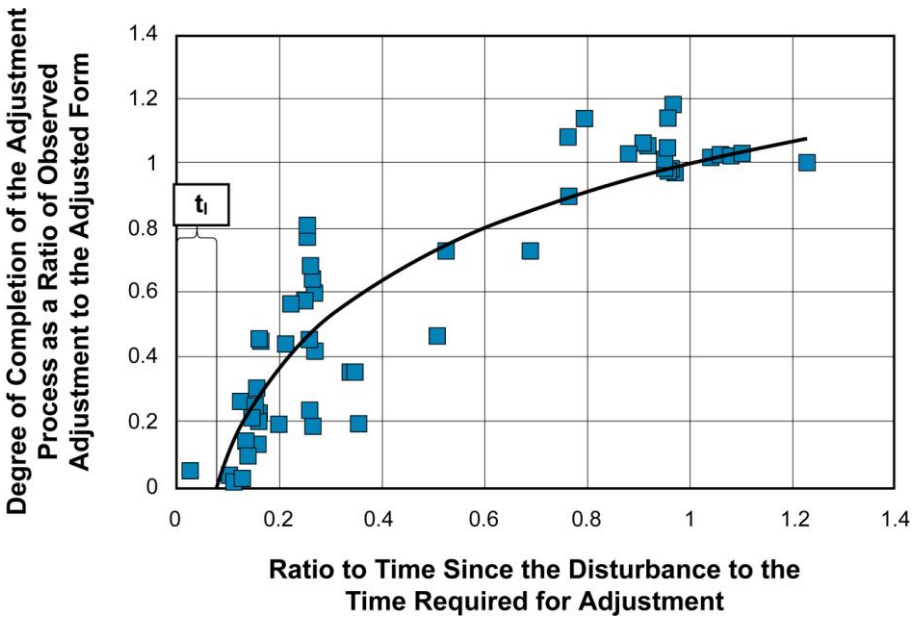


Figure 6-4. Relaxation Curve and Study Data.
Curve developed for urban channels in the Austin, Texas area formed in alluvium. Data points shown are for the study sites in southern California.

The Plum Canyon (LA County) and Borrego Canyon Wash (Orange County) sites are similar to each other and dissimilar to the other sites. Each of these stream channels had two sites, an upstream and a downstream site. On each stream the downstream site has a smaller channel and smaller Dominant Discharge than the upstream site, indicating a loss of flow downstream (i.e. a losing stream). In both cases the upstream sites showed a significant increase in channel size in response to the increase in TIMP, followed by a decrease in channel area. At Site 4u (Plum upstream) the channel cross section area initially increased more than 100% [$(R_e)_{his}$ = 2.22] and then decreased to a size only 43% greater than the baseline condition [$(R_e)_{ext}$ = 1.43] as recorded in the current survey data. At Site 7u (Borrego upstream) the enlargement ratio initially went to 1.37, declined to 1.25, increased to 1.47 and then decreased to 1.06 in the current survey. In neither case did the enlargement ratio continue to increase, albeit at a declining rate of increase, toward an expected ultimate value (as the curve in Figure 6-4 shows). In contrast, the

other sites with developed watersheds (Sites 3u, 3d, 4d, 7d and 9) did show consistent increases in enlargement ratios.

A possible explanation for the changes observed at the upstream Borrego Canyon and Plum Canyon sites is suggested in a conceptual model proposed by Andrews (1979). His model identifies three phases of channel adjustment.

- The **First Phase** of Andrews' Three-Phase response model predicts straightening of the channel thalweg and destruction of the bed forms leading to homogenization of the bed materials and fluvial features in the longitudinal sense. This increases the slope and decreases channel resistance thereby effectively increasing the energy available in the watercourse to perform work.
- In the **Second Phase** of the adjustment process, Andrews' model predicts one of three responses: downcutting, widening or both downcutting and widening. The actual response will depend on the absolute resistance of the boundary materials as well as the relative resistance of the bed and bank materials at the least resistant bank toe stratigraphic unit (MacRae, 1992). The net effect of channel widening would only be temporary, however, as eventually the channel becomes too wide to support continued growth.
- The **Third Phase** would result in a new channel forming (incising) into the newly formed, extra-wide channel. Channel change from this point would then follow the more common response to increased flow and reduced sediment load with the typical enlargement of the channel to a new equilibrium position.

The current observations at the upstream Borrego Canyon and Plum Canyon sites are likely at the transition between the second and third phases of Andrew's 3-Phase model; the channel has constricted after initially enlarging significantly. The bank materials in the upstream Borrego and Plum reaches are highly erodable (mostly unconsolidated sands) while the bed may have been armored with cobbles prior to urbanization. Consequently, the resistance of the bank materials is very low relative to the bed materials as is the absolute resistance of the bank materials to the applied stress. Consequently, while there may have been some downcutting it is likely that the initial response was widening. Furthermore, overbank flows would have easily reworked the loose sands in the overbank area creating chutes and scouring out the wide swath of channel that was observed at the upstream sites.

Although the data from the current study are not adequate by themselves to develop a specific relaxation curve for southern California streams, they were used in conjunction with the established curve (in Figure 6-4) to develop an enlargement curve (Figure 6-5). The data for southern California streams forms a relationship very similar in shape to the enlargement curves developed for the larger database of North American streams. However, the database for southern California streams plots above the general line for the other data, suggesting that a specific enlargement ratio is produced at a lower value of impervious surface area in southern California than in other parts of North America. It is important to emphasize that the data for southern California streams are from systems in the initial stages of adjustment, and therefore are less reliable than they would be if the data were from a more advanced stage of adjustment.

Nevertheless, there are some important conclusions that can be drawn from the data of the current study.

- The channel systems studied here are very sensitive to external changes in the impervious areas within their watersheds. Increases on the order of 2% to 3% in TIMP have initiated increases in channel cross sectional area. The threshold of response for channel enlargement in southern California appears to be substantially lower than in other parts of North America.

- On the short time frame considered in this investigation (10 to 20 years) these systems are considered to be in a state of dynamic equilibrium. The control sites exhibit signs of active downcutting (thalweg elevation decreases) over time while maintaining stable channel morphology. This indicates that all channels are undergoing change; however, the rate of change may be different between streams that are subject to increases in peak flow and those that are not. Longer time series of analysis is necessary to more clearly define these relationships.

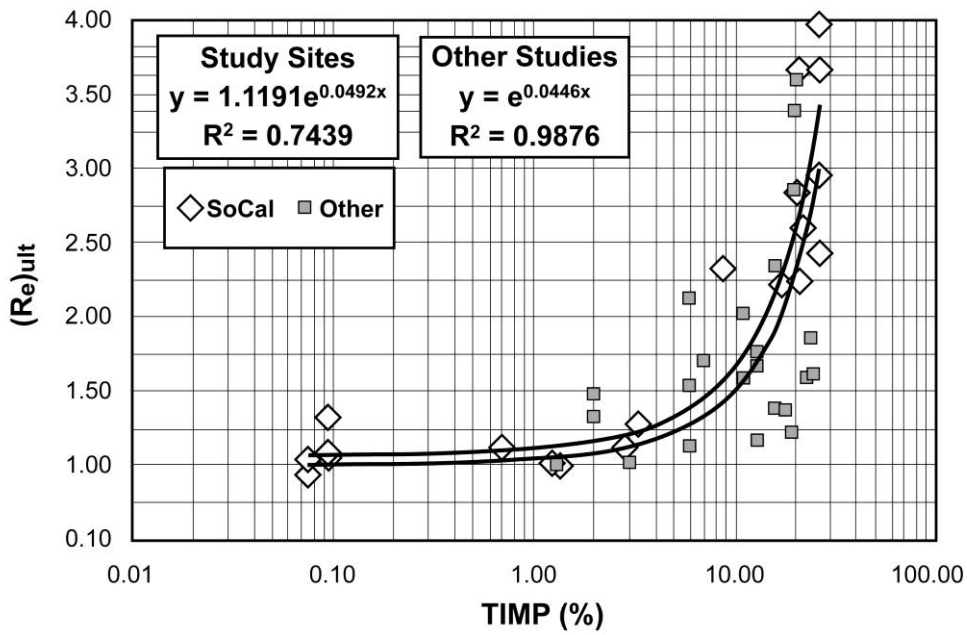


Figure 6-5. Enlargement Curve for Southern California.
Upper curve and data points are for southern California channels in the current study. Lower curve is based on data from other locations in North America.

- Because the measurement error is of the same order of magnitude as the sensitivity values, these systems should be considered to have zero tolerance for increases to TIMP values, and be managed accordingly. This includes adopting one or more of the following management strategies:

  1. Zero tolerance for runoff increases (if not actually reducing runoff to below pre-development levels); or
  2. Employ active management of stream channels to maintain or stabilize the stream channel condition and habitat; or
  3. Establish a "no build" or "no disturb" riparian corridor to accommodate the expected channel adjustment response to the expected change in watershed imperviousness.

7. CONCLUSIONS AND RECOMMENDATIONS

The affects of urbanization on stream channels have been well studied in perennial systems in the humid regions of the U.S. The results of these studies are widely accepted, and demonstrate that increases of urban (or developed) areas within a watershed lead to increases in stream channel size (depth and/or width) and a decline in the diversity of aquatic species and the quality of aquatic habitat. The present investigation attempted to expand this understanding into ephemeral and intermittent stream channels in semi-arid climates. However, because many of the smaller stream channels in arid to semi-arid areas are ephemeral and intermittent, the present study focused solely on changes in stream channel morphology and did not address impacts to aquatic habitat.

The primary concerns about the affects of urbanization on natural stream channels in southern California, from a regulatory/management perspective, can be summarized as follows

a) How do semi-arid stream channels differ from humid area stream channels in their response to increases in impervious area?
b) How can effective controls be selected for minimizing the impacts from increases in impervious area?
c) Which situations and what conditions are appropriate for use of the identified controls?

The following subsections provide answers to these questions to the extent that the data generated by, and analyzed under, this investigation will allow.

7.1 Conclusions

The focus of this study was to relate changes in watershed development to observed changes in the morphology of the stream channel draining the watershed. The study sites selected were intentionally small (i.e. all less than 20 mi^2 and most less than 5 mi^2) since stream channels draining smaller watershed areas are most sensitive to changes in impervious cover. Ephemeral stream channels can be found in all climates, the main difference between regions is the size at which the contributing watershed area becomes large enough to support perennial stream flow. This size is dependent on a number of variables, but climate is a significant variable. In general, stream channels in arid areas remain ephemeral with larger catchment drainage areas than stream channels in more humid regions. This difference contributes to their increased sensitivity to changes in TIMP.

Based on the results of the present investigation, several principles of urbanizing ephemeral stream channels are suggested. The first principle concerns watershed area.

Principle 1. CDA Size Focus. The drainage area contributing runoff to a stream channel is a key characteristic for determining stream channel size. Ephemeral/intermittent stream channels are no different than perennial streams in this regard.

- Hydromodification from changes in impervious area are most recognizable in watersheds smaller than about 20 square miles.
- Watersheds in the present study with CDA < 15 $mi.^2$ are ephemeral, with one exception (Serrano Creek appears to have a nuisance base flow from surrounding residential areas).
- Management of impervious area and connected impervious area is most critical in the smallest watershed management units (CDA ≤ 2.5 square miles).

The results of this investigation suggest that the threshold for TIMP (total impervious area) at which changes in stream channel morphology would be expected is lower in the semi-arid sites that are typical of southern California than for comparably-sized sites on perennial streams in more humid areas. Based on the current data set the apparent threshold in the value of TIMP for

initiating stream channel morphology change is between 2% and 3%. Similar threshold values for perennial streams generally are closer to 7% for the northeastern U. S. (Schueler 1998) and 10% for the northwestern U. S. (Booth 1997).

The sites in this investigation that experienced changes in their morphology all had relatively low resistance to bed and bank erosion. This leads to the second principle of urbanizing (and arid) ephemeral streams:

Principle 2. TIMP Sensitivity Ephemeral stream channels are also affected by change in total watershed imperviousness (TIMP). The ephemeral/intermittent stream channels of the arid to semi-arid study region in southern California appear to be more sensitive to such changes than are perennial streams in the literature.

- The threshold of ephemeral stream channels for exhibiting changes to stream channel morphology due to change in TIMP value, is between 2% and 3% change in the total impervious area for the watershed.
- The threshold of response will vary based on stream type. For example, ephemeral stream channels that are configured like Topanga Creek with highly resistant bed and bank materials are likely to have a higher TIMP threshold for stream channel change.

The form of a stream channel is a composite response (by its ability to resist erosion) to the cumulative applied forces of stream flow. The forces imposed on the stream channel result from its hydrologic and sediment regimes, the size and timing of flows and the stream channel form, particularly the slope of the stream channel, or energy grade. The resistance of the stream channel to the imposed erosive forces is dependent on the competence and cohesion of the materials forming the stream channel bed and banks. This relates both to characteristics of the stream channel form as well as the resistance of its bed and bank materials.

The stream channels studied in this project included control sites, where little or no watershed development had occurred, and developed (i.e. adjusting) sites, where changes in TIMP had occurred over a period of time. Some minimal rate of change in channel depth and area was observed in all sites (control and adjusting); however, the rate of change was greater in the developed sites than in the control sites. The control sites exhibited a state of dynamic equilibrium because downcutting was observed, but channel morphology did not change appreciably over time. The adjusting sites exhibited instability, as some significant change had occurred in one or more measure of channel morphology. These results demonstrate poor channel resistance to increased flow in all the adjusting channels except Topanga Creek. However, because this is a relatively small data set, generalizations made from the current data will have to be confirmed with a more extensive inventory of stream channel form, stream channel slope, and bed and bank material resistance for both ephemeral streams and perennial streams in the study area.

A key component of stream bank resistance, especially in smaller streams, is the vegetation present and the impact it has in providing resistance to erosion through root binding or energy dissipation. While the study sites had vegetation present to varying degrees, it did not appear to be a significant component of the stream channel stability, particularly at those sites experiencing changes in stream channel morphology. This probably has as much to do with climate, because the dry conditions in ephemeral stream channels in southern California persist for large blocks of time through the year, favoring a limited vegetative cover for banks, and hence less cohesive stream channel banks.

This leads to the third principle of urbanizing ephemeral streams:

Principle 3. Stream Channel Resiliency is Low. The small sample of ephemeral stream channels taken in this investigation whose morphology is changing, had relatively low resistance to erosion. However, further investigation is needed to verify and quantify any differences in stream channel resistance between ephemeral and perennial streams in southern California. The role of vegetation in stream channel resistance also needs to be better defined.

- It is suspected that ephemeral stream channels have a narrower range in resistance and resiliency than perennial streams, and that this is on the lower end of the resistance scale, however there is no conclusive proof of this in the results of the current investigation.
- The low impact of vegetation on stream channel resiliency appears to be a significant difference between ephemeral and perennial streams.

The management of increased stormwater runoff due to development must be concerned not only with the total volume of runoff but also with the flow peaks for individual flood events (both of which increase with increasing TIMP). If the results of the current study are representative of ephemeral stream channels in southern California, then it appears concern for both volume control and peak control should be exercised for control of hydromodification. Because these stream channels appear to be more sensitive to changes in TIMP (Principle 2) it follows that they would be very sensitive to increases in flow rates. Additionally, they appear to have a low resiliency, or resistance to erosion (Principle 3), so it would also follow that these stream channels are more susceptible to channel enlargement. Change in the flow rate would imply not only the peak flow rate but also the duration of time that erosive flows occur. Therefore, it would appear that maintaining the current regime (i.e. hydrograph matching) would be necessary to avoid stream channel enlargement.

This leads to the fourth principal of urbanizing ephemeral streams:

Principle 4. Management Considerations. As an extension of Principles 2 and 3, ephemeral stream channels are expected to be sensitive to both the larger flow peaks resulting from volume control, and the extended duration of erosive flows under peak control.

- In the absence of channel stabilization or other in-stream controls, retention methods are likely to be more effective than detention methods.

Management options and strategies to address these concerns are discussed further in Section 4.2 to explore the alternatives available to watershed managers.

Previous stormwater management investigations were primarily concerned with perennial stream channels. This investigation has looked at a small number of sites on ephemeral/intermittent stream channels in a very large region with significant diversity. In spite of a considerable effort to locate study sites with the broadest representation possible, the sites selected provide only a limited representation of that diversity. Still, these sites have provided some very useful results in characterizing ephemeral stream channels. Differences clearly exist between the ephemeral/intermittent stream channels of this study and the perennial stream channels in the literature in sensitivity to increases in TIMP and stream channel resiliency. Some of these differences have been better clarified by this study, while others have been identified for further investigation.

This investigation and its results should provide both the regulatory community and management personnel with insights into ephemeral/intermittent stream channel behavior and management options that were previously not available or elucidated.

7.2 Management/Regulatory Approach

Management of stormwater ultimately begins with a vision of how the drainage network and stream channel system should look and function. This will determine the opportunities and constraints possible for stormwater management. The vision must be realistic and flexible, and is not likely to be the same for all watersheds. The focus of this investigation has been on physical properties of the “natural” stream channel, its response to changes in watershed development, and management implications.

7.2.1 Management Objective

Once the vision has been established, stormwater management starts with the establishment of global goals and objectives for the watershed. From these goals and objectives will follow the specific objectives for local stream channel reaches and smaller subwatershed areas. If preservation (or re-establishment) of natural stream channel appearance and function is one of these specific, local objectives, the results of this study provide a modest start toward establishing some of the criteria needed to meet this objective. The classification system provided in Section 4 forms the basis for making informed decisions regarding the type and focus of stormwater management and stream channel maintenance applications. By focusing on maintaining a viable, "natural" stream channel (at least in form and function), management approaches include some form of runoff control (to lessen possible increases in the volume of water in the stream channel) and/or stream channel protection (to prevent stream channel erosion due to increased forces on the bed and bank materials). The relative effectiveness of these two types of management is represented in Figure 7-1.

7.2.2 General Approaches

Three general approaches for accomplishing the specified stormwater management objectives are described below. They involve a trade-off between runoff control, and stream channel protection.

Natural Channel Design (NCD). This management approach is concerned primarily with preserving the native (and stable) condition of the stream channel reach under consideration. Because the emphasis is on preserving existing functions, this approach precludes in-channel activities that are not created using materials that are not native to that location and emphasizes surface runoff controls as the primary management tool. Allowable development within the contributing watershed can only be tolerated to the threshold level before surface runoff control must be implemented. The threshold for a watershed will depend on the type of stream channel and the nature of the stream channel slope, soil characteristics and bedrock in the watershed. For example, a stream channel with highly resistant bed and banks (like Site 1, Topanga Creek) will be able to accommodate a significantly higher level of change without a meaningful adjustment in stream channel morphology. Other stream channels (like the remaining study sites) can only tolerate a change in TIMP of between 2% and 3% above the "natural" condition of the pre-disturbed watershed. Therefore, zoning and building density restrictions to encourage low-impact, or "smart" development will be very important with this approach, as well as runoff controls.

Geomorphologically-Referenced River Engineering (GRRE). The goal of this management approach is to preserve the appearance of natural stream channel function to the greatest extent possible while limiting instability in stream channel morphology. Geomorphic principals are used to design a stable stream channel given the expected hydrologic and sediment regimes (which will be different than the pre-disturbed state). The stream channel is re-shaped to this design using a minimum of hard, engineered structural elements within the stream channel so that the natural appearance is preserved while the new stream channel form can remain stable. However, both surface runoff and in-channel controls are required to maintain the hydrologic and sediment regimes for which the new stream channel is designed. Allowable development that can be tolerated under this approach has fewer restrictions than the NCD approach in that the new stream channel is designed to accommodate flows that are larger than the flows that shaped the stream channel under the natural conditions of the watershed prior to development. None-the-less, surface runoff controls eventually become just as critical to the stability of the new stream channel design,

as it maintains semi-autonomous behavior. In-stream controls are employed to the extent they are needed, and are not necessarily created with native materials.

Traditional River Engineering (TRE). The goal of this management approach, also referred to as "hard-lining," is to create the most efficient conveyance system possible for stormwater, and provide the greatest degree of protection for the bed and banks of the stream channel that provides stormwater conveyance. The stream channel system is engineered to accommodate flows up to the design storm level, whatever that may be, and is protected by hard-lining the bed and banks. Surface runoff controls are much less important under this approach than they are under the NCD or GRRE approaches.

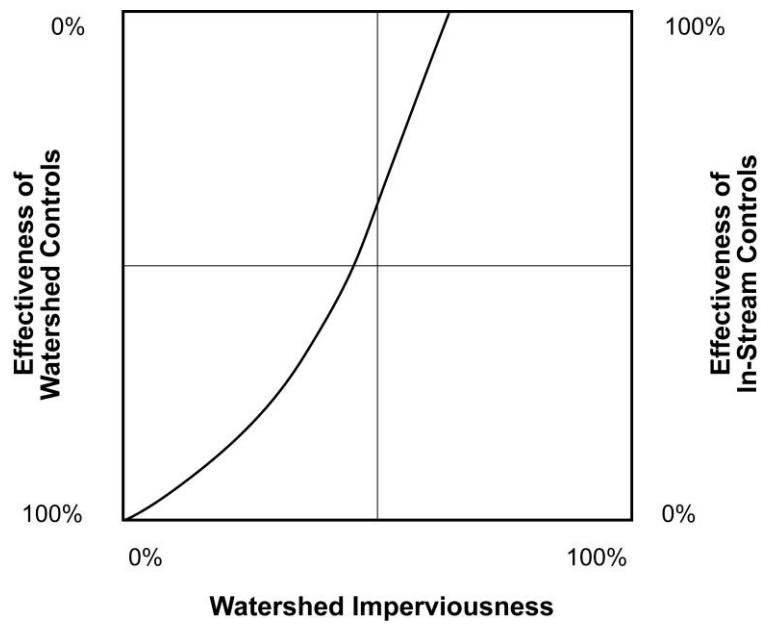


Figure 7-1. Effectiveness of Stormwater Management Control Strategies

Management approaches are selected so that they match the general goals and objectives for the watershed, as well as the specific objectives established for the stream channel reach in question. Because this investigation is concerned primarily with natural stream channel form and function, it focuses only on stormwater quantity and sediment load as it relates to stream channel activity, and is not directly concerned with water quality. There are a variety of best management practices (BMPs) available for controlling stormwater quantity, and a number of sources for obtaining information about these practices (EPA 1999, 2002, Mays 2001, WEF 1992). Controlling runoff can be organized into three general areas of control (source control, conveyance system control, and centralized control). Specific practices that illustrate these areas are listed in Table 7-1a. In-stream management practices also fall into multiple areas (grade control, sediment regime control, and bank stabilization). Some specific practices are listed in Table 7-1b. These tables list representative stormwater management options, but are not intended to be exhaustive lists.

7.2.3 Management Strategies

A general framework for assessing stormwater management strategies is presented in Table 7-2, which describes the applicability of four management strategies. The strategies are based on the

current amount of development (i.e. TIMP) in a watershed and the expected stream channel stability. Functional relationships between these strategies, the management approaches discussed previously in this section, and the stream channel type classification system presented in Section 4 of this Technical Report are explored further in the discussions of these strategies presented below.

Preservation. The strategy for watersheds that have relatively little development and therefore a low percentage of impervious area is to take advantage of the opportunity to maintain or preserve a stable stream channel system. The recommended management for these watersheds is to first to consider NCD, as this is likely to be one of those rare occasions where NCD can be effective. The stream channel in its existing form is considered desirable and worth retaining. The stream channel is also considered to be a metastable system where change in stream channel form under natural conditions is considered acceptable over the planning horizon of 100 years. Management efforts are based almost entirely on surface runoff control with limited in-stream actions.

Table 7-1a. Stormwater Management Practices

Focus	Objective	
	Retention	**Detention**
Source Control	• Dry well • French drain • Cistern • Rain barrel • Bioretention	• Detached downspouts • Vegetated areas
Conveyance System Control	4. Porous pavement 5. Channel diversions	6. Rural drainage profile 7. Grassed swales 8. Stream Corridor Buffer zones 9. In-line detention 10. Reconnecting channel to the floodplain
Centralized Control	• Infiltration basin • Retention basin	• Constructed wetlands • Detention basin

Table 7-1b. In-Stream Management Practices

Focus	Practices	
	Soft Engineering	**Hard Engineering**
Grade Control	• Riffle • Boulder clusters	• Drop structures • Channel lining
Sediment Regime Control	• Pool • Sediment introduction	11. In-line detention 12. In-line sediment trap
Bank Stabilization	• Grading and vegetation of stream banks • Vegetated gabions	• Riprap • Rock gabions • Pavers • Channel lining

Restoration. Watersheds with greater amounts of impervious area require management focused on bringing an unstable stream channel system back into a stable situation. Part of the management effort, ultimately, is to decide on an acceptable level of development for the watershed. Although the stream channel is destabilized, it can be restored to pre-disturbance form through control of the sediment-flow regime and in-stream works strategically located for grade control. Once provided with the right balance of control, the stream channel is able to restore itself through its own means. Erosion control is still primarily managed with surface runoff controls, although the emphasis on in-stream measures has increased to include localized sites and unstable and incised stream channel reaches.

Rehabilitation. Watersheds with significant impervious areas that are still manageable in total amount can have seriously degraded stream channels that are highly unstable and require significant effort to bring the stream channel back into a new, and stable, condition. The stream channel cannot be restored to its pre-disturbance form due to irrevocable changes to its form. However, the stream channel can be modified through a combination of surface runoff and in-stream works in accordance with the vision for the stream channel-valley system. Erosion control is based on matching the morphology of the stream channel with the new sediment-flow regime established for the stream channel based on implementation of a preferred SWM Alternative. SWM measures a required for new development and retrofit of existing developments. The emphasis on in-stream measures has increased to include localized sites and all unstable stream channel reaches.

Table 7-2. Stormwater Management Strategies

Strategy Name	Applicability	Description
Preservation	Stable Channel TIMP ≤ 6%	Stream channel is expected to be stable; Effort will be to keep it stable.
Restoration	Unstable Channel 6% < TIMP ≤ 10%	Stream channel is likely to be experiencing some instability (increase in capacity, change in hydraulic geometry values, etc.); effort will be correct changing inputs and nudge stream channel back to normal conditions
Rehabilitation	10% < TIMP ≤ 20%	Stream channel probably has experienced irreparable changes (not able to restore "normal" conditions); effort will be to create a new (and maintainable) "natural" stream channel configuration.
Stabilization	20% < TIMP	Stream channel has become extremely unstable and is on the verge (or in the middle) of significant morphological changes; effort will be to stabilize conditions with any means necessary and prevent excessive change.

Stabilization. The worst case is in a watershed with levels of impervious area that are so high the focus of stream channel management must be on stabilizing a situation that will only get worse if nothing is done to address the stream channel erosion. The stream channel has become entrenched and the valley is confined by development, floodplain fill, and/or infrastructure

encroachment. Instability is systemic to the majority of the main stream channel and erosion threatens property and infrastructure. Further adjustment of the stream channel is anticipated and will exacerbate the problem. Surface runoff controls for new developments and retrofit options for existing developments can achieve significant reductions in erosion potential. However, surface runoff management is not sufficient to stabilize the stream channel that is undergoing valley formation and susceptible to catastrophic failure during rare flood flow events. In-stream works are required to reconnect the stream channel to its floodplain, arrest the down-cutting process and stabilize the stream channel. Due to encroachment of development into the floodplain and infrastructure located within the valley, lateral migration of the stream channel may not be desirable. In this case GRRE at TRE approaches may be required, and these approaches may have no alternative except to hard-line the stream channel. In this situation surface runoff controls become redundant from an erosion control perspective. However, surface runoff control measures may be necessary for water quality or flood hazard issues. Surface runoff controls may also be required to meet the long-term vision for the watershed as the urban landscape reshapes itself through in filling and redevelopment.

7.2.4 Implementation of Management Strategies

Selection of a management strategy is dependent upon the extent to which a stream channel has been impacted by development within the watershed. The first step in implementing a management plan requires local communities to inventory and characterize each channel segment. This may result in a single stream having one or more stream segments with each of the four management goals. Therefore, land use controls and in-stream practices would vary based upon the established strategy for that particular stream segment. Table 7-3 summarizes the criteria and methods that could be used by communities to manage their stream networks.

Table 7-4 summarizes the various management approaches discussed earlier and shows linkages with implementation strategies that are appropriate for a given channel type and degree of TIMP. This table is based on practical, nationwide experience in stormwater management implementation that has been tailored for consideration in the southern California setting. In addition to this table, there are a three general strategies which should be considered when attempting to manage increases in peak flow:

1. **Limit Impervious Area.** Although the focus of this study was necessarily on TIMP, disconnecting impervious areas from the drainage network and adjacent impervious areas is a key approach to protecting channel stability. Utilizing this strategy can make it practical to keep the effective impervious cover (i.e. the amount hydrologically connected to the stream) equal to or less than the identified threshold of 2-3%.
2. **Control Runoff.** Hydrograph matching is not recommended for a single “design” storm with a specific return period, but rather for a range of return periods from 1 year to 10 years. Accomplishing such hydrograph matching will be challenging, and undoubtedly require a combination of techniques to prevent (retain), as well as to delay or attenuate (detain) runoff and/or stream flow.
3. **Stream Channel Movement.** Allow the greatest freedom possible for “natural stream channel” activity. This includes establishing buffer zones and maintaining setbacks to allow for channel movement and adjustment to changes in energy (associated with runoff). However, where in-stream controls are required consider all potential management options.

It is important to keep in mind that the choice of a management approach or approaches should be dictated by the strategies that are appropriate given the conditions of each stream reach and its contributing watershed. Consequently a suite of management approaches may need to be applied to provide a comprehensive solution to managing increases in peak runoff.

7.3 Applicability

Impacts to stream channels resulting from changes within the contributing watershed area, such as development and increased impervious area, are generally viewed as negative. Although no positive impacts were identified at any of the study sites, positive results are possible. The best example of this would be a stream reach that has an excess sediment load prior to development (i.e. an aggrading reach). Increased runoff and stream flow resulting from development could increase the carrying capacity of the stream enough to accommodate the excessive sediment load, thus producing a stable reach.

In order to relate the measurable changes in stream channels to changes in development, a measurable variable for development must be identified. The most commonly used value to represent development changes has been the areal extent of impervious area. This can be measured, laboriously, from maps and aerial photographs, or it can be estimated from existing land use maps with accepted conversion values. The latter method provides an estimate of the total impervious area (TIMP) in a watershed. A more accurate assessment of the actual impacts from development would come from the use of "connected impervious" area, or "CIMP" (also termed FRIMP). However, CIMP cannot be estimated as easily or effectively from land use data as can TIMP. CIMP must be carefully measured or delineated using detailed aerial photographs and (if available) detailed maps such as development plot plans or municipal parcel maps combined with extensive ground-truth checks. This is possible, though difficult, for current conditions, but it becomes much more difficult (if not virtually impossible) for historical conditions where ground-truthing is not possible. The degree of difficulty in calculating CIMP values and the scarcity of CIMP values in previous studies led to the decision to use TIMP values in the current investigation rather than CIMP values.

Table 7-3. Implementation of Recommendations

Management Goal	Management Strategy	Role of Local Government	Funding	Implementation Approach
NCD – Preservation Stable Channel 0% ≤ TIMP ≤ 6%	Minimize Impervious Area Maximize Infiltration Preserve Environmentally Sensitive Areas	Land use planning Zoning restrictions Develop design standards for "smart growth"	Private developers	Inventory stream characteristics Complete assessments of individual watersheds Complete land use planning Preserve environmentally sensitive areas Establish stream channel/valley buffer zone Develop "smart growth" design standards that • Maintain "natural" shear stresses and hydroperiod of watershed. • Post-development runoff volumes to closely equal pre-development runoff volumes • Post-development peak rate of runoff < pre-development peak rate of runoff Implement riparian vegetation planting/ management program Monitor field conditions
NCD – Restoration Unstable channel 6% ≤ TIMP ≤ 10%	Minimize addition of new Impervious Area Maximize infiltration Preserve strategic environmentally sensitive Areas Restore "natural" hydroperiod Restore natural characteristics of stream channels	Land use planning Zoning restrictions Develop design standards for "smart growth" Restore natural characteristics of stream channels	Private developers Public capital improvements	Inventory stream characteristics Complete watershed assessments Complete land use planning Preserve environmentally sensitive areas Establish stream channel/valley buffer zones Develop "smart growth" design standards • Maintain "natural" shear stresses and hydroperiod of watershed. • Post-development runoff volumes to closely equal pre-development runoff volumes • Require post-development peak rate of runoff to be less than pre-development peak rate of runoff Implement riparian vegetation planting/ management program Develop design criteria to retrofit existing development to mitigate increases in runoff volume and peak discharge rates Plan, design and implement projects to retrofit existing development. Limit in-stream works (localized erosion problems) Monitor field conditions

Table 7-3 (continued)

Management Goal	Management Strategy	Role of Local Government	Funding	Implementation Approach
GRRE – Rehabilitation Unstable channel 10% ≤ TIMP ≤ 20%	Preserve existing hydroperiod Stablize stream channels	Development of design standards for runoff peak and volume controls Stablize stream channels	Private developers Public capital improvements	Inventory stream characteristics Develop design criteria for a new development to maintain existing runoff volume and peak discharge rates • Post-development peak rate of runoff = or < pre-development peak rate of runoff Plan, design and implement BMPs to retrofit existing development. Preserve vegetative cover of stream channel and buffer strips along stream channel Substantial In-stream works to stabilize stream channel • Establish grade controls • Use bioengineering techniques to stabilize stream channels
TRE – Stablization Unstable channel 20% ≤ TIMP	Stablize stream channels	Stablize stream channels	Public Capital Improvements	Inventory stream characteristics Maximize storage of stormwater runoff to reduce in-stream peak discharges Channel hardening & grade controls • Maximize use bioengineering techniques to stabilize stream channels • Maximize use of "natural" materials to harden Stream channels • Preserve vegetative buffer strips along stream channel Flow Diversions

In addition to concern over physical changes to stream channels (hydromodification) that result from increased impervious areas, impacts to habitat can also be significant. Natural stream channels offer some of the best opportunities in the southern California region for threatened and endangered bird species to avoid the pressures of development. Stable riparian zones can also support native plant species effectively. Such habitat is predicated on conditions remaining stable within the stream channel. Adjustment of plant and animal species to unstable conditions within the stream channel would require a separate, study. A study of this type should focus on the expected adjustments to various types of stream channel changes (widening, deepening, loss of soil, etc.) by a variety of biotic communities. The current study had to necessarily focus on understanding the physical system while attempting to understand the relationships of change within it.

Although stream flow records were available for only 2 of the 10 study sites, all of the stream gage records obtained were used primarily for establishing generic flow frequency relationships and return periods. This can be effectively accomplished (and was in this study) using nearby gage data. Therefore, the lack of specific gage data for each site is more a concern for

convenience rather than reliability of results. Also, measuring stream flows for specific storms before and after development and relating that to changes in impervious area would be very helpful data for this investigation. However, in watershed studies as in much of scientific endeavor, there is always a gap between the ideal data set and the actual data set. The relation that was possible to measure compared stream channel changes (that resulted from changes in discharge) directly to the changes in impervious area. This did not provide the ideal comparison (impervious area to stream flow, stream flow to stream channel change) but it does provide a quantifiable relationship between stream channel change and impervious area change.

7.4 Study Limitations

The charge of this study, the defined objectives, and the adopted approaches were all very ambitious. However, the need for data on these types of systems in this environmental setting is great, and aim was therefore to maximize results for the available resources. Thus, the results should be recognized as preliminary.

This study attempted to define several complex relationships involving stream channel response to watershed change using a modest data set that covers a relatively short period of time. Because there are many variables that affect the complex relationships between TIMP, runoff, and geomorphic response in stream channels, the study design attempted to limit the potential influences of certain variables to better evaluate the response of others. However, in reality it is difficult to achieve the desired control of variables that is required for definitive results in a study of this type. Consequently, it is important to be aware of the following points while assessing the results of this study.

- The data gathering and assessment requirements of this project included three major efforts that each could have been addressed as stand-alone investigations. Stream channel classification, evaluation of Dominant Discharge, and assessment of form and process of streams located in urbanizing watersheds of a semi-arid region could each have been a significant investigative effort on their own. Therefore, the analytical effort was great relative to the data set generated.
- The scale of the study region is very large compared to the actual area included in the study. The size of the study region, excluding the interior drainage areas, is nearly 6,300 square miles. The total watershed area covered by the sites used in this study is less than 33 square miles.
- The nature and response of watersheds in drylands is generally different than watersheds in humid areas. Dryland streams have fewer stream flow events and the importance of the flows from the last storm event is greater (Graf 1988). Knowing the magnitude of the latest flood event is important for interpreting the channel features measured after that event. However, in all cases, the field measurements of channel features did not follow a wet season with significant storm events, and thus are considered representative of the lower range of more normal events in these systems.
- Although a sizeable effort went into gathering data for this study, a relatively small data set was generated and used to evaluate channel response. Therefore, compelling as the results of this study may be, they must be considered preliminary.

7.5 Additional Research Needs

There is a large body of research into the effects of urbanization on increases in peak flow from regions of the county with wetter climates. However, this information is nearly absent for semi-arid regions, like southern California. This investigation is one of the first to assess the response of ephemeral/intermittent stream channels in an arid region with changing hydrology due to urbanization of the watershed. This is a common condition throughout the six counties of the study area that grew at a rate of more than 12% between the last two censuses. Communities are increasingly concerned about the damage to the environment and to property but are uncertain as to how to make sound management decisions to control the situation. This investigation has identified a number of principles that appear to characterize the

relationship between urbanization and the stability, or lack of stability, of ephemeral/intermittent stream channels. However, the investigation included a very limited number of streams. Therefore, it is recommended that future investigations be conducted to confirm and expand the understating of the unique processes involved.

(A) Survey stream channels in the study area with reconnaissance or remote sensing techniques to identify and classify the critical "natural" stream channel reaches that still remain in this region, and help focus management efforts and prioritize future research.

(B) Measure stream channel form, stream channel slope, and bed and bank material resistance for both ephemeral streams and perennial streams in the study area that fall into the category of critical "natural" stream channel reaches. This could include streams and rivers in the study region with watersheds greater than the size limits recommended for the classification system here.

(C) Study USGS and county stream gage data that span the period of urbanization in various locations throughout the study region to establish quantitative values for increased flows. Tie back to percent change in impervious area for this time period. Quantitatively assess whether relationships exist that could predict "effective rainfall" levels (the minimum precipitation needed to produce an "effective" flow in the stream channel) based on watershed size and TIMP

(D) Investigate in greater detail the measurement or estimation of impervious area through various methods and establish a correlation between them. This will create a common set of assessment values that would allow the use of older photographs and newer digital imagery remote sensing techniques to overlap TIMP calculations for longer time periods.

(E) Identify more candidate sites for future studies. Establish a permanent set of sites that will be less likely to be affected by future development or stream channel "improvements." Use the long-term monitoring of these sites to quantify natural rates of change over various climatic cycles.

(F) Develop and test conceptual and/or predictive models for use in evaluating management strategies and specific management options in different watersheds and stream channel types.

(G) Broaden understanding of ephemeral stream channels in the six county region with additional characterization and study; perhaps extending into the truly arid (interior drainage) parts of this region.

(H) Resurvey the study sites within the current water year to capture the impacts on these stream channels from an excessively wet rainfall season.

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499-E

Declaration

I, Janet M. Laurain, declare as follows:

1. I am a paralegal at Adams Broadwell Joseph & Cardozo. I make this declaration from my personal knowledge. If called as a witness, I could testify competently to facts stated in this declaration.

2. Exhibit 499-E is a true and correct copy of the Comment letter from Center for Biological Diversity to the U.S. Army Corps of Engineers, dated May 11, 2010. I downloaded and printed this document on May 17, 2010 from an email sent to me by Loulena Miles. The email originated from Elizabeth Goldmann at the Environmental Protection Agency.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct. Executed this 17th day of May, 2010, at South San Francisco, California.

Janet M. Laurain

Janet M. Laurain

CENTER *for* BIOLOGICAL DIVERSITY

VIA ELECTRONIC MAIL AND U.S. MAIL

U.S. Army Corps of Engineers, Los Angeles District
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May 11, 2010

Re: Public Notice/Application No.: SPL-2008-01244-MLM

Dear Army Corps of Engineers:

On behalf of the Center for Biological Diversity's 240,000 staff, members and on-line activists in California and throughout the western states, we submit these comments on the Public Notice/Application No.: SPL-2008-01244-MLM ("Notice") re-issued on April 28. 2010.

Introduction

The development of renewable energy is a critical component of efforts to reduce greenhouse gas emissions, avoid the worst consequences of global warming, and to assist California in meeting emission reductions set by AB 32 and Executive Orders S-03-05 and S-21-09. The Center for Biological Diversity (the "Center") strongly supports the development of renewable energy production, and the generation of electricity from solar power, in particular. However, like any project, proposed solar power projects should be thoughtfully planned to minimize impacts to the environment. In particular, renewable energy projects should avoid impacts to sensitive species and habitat, and should be sited in proximity to the areas of electricity end-use in order to reduce the need for extensive new transmission corridors and the efficiency loss associated with extended energy transmission. Only by maintaining the highest environmental standards with regard to local impacts, and effects on species and habitat, can renewable energy production be truly sustainable.

Unfortunately, the Notice for the 404 permitting and the DEIS for the proposed plan amendment and right-of-way application on which the Corps relies fail to provide adequate identification and analysis of the significant impacts to water resources, water quality, ephemeral streams and washes, Peninsular bighorn sheep, flat-tailed horned lizard, rare plants, other biological resources, cumulative and growth inducing impacts of the project, and lacks consideration of a reasonable range of alternatives. In addition, the agencies have failed to fully examine in impact of the proposed plan amendment (and other similar proposed plan amendments) that would result in industrial sites sprawling across the California Desert within habitat that should be protected to achieve the goals of the bioregional plan as a whole.

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The Project is Not Water Dependent and Therefore Should Avoid Impacts to All Desert Washes, Ephemeral Streams, and Riparian Areas

As the Corps Notice correctly states (Notice at 8), the proposed project is not water dependent. Therefore, all desert washes, ephemeral streams and riparian areas should be avoided. As the Corps is well aware desert riparian areas are fragile and disturbance of the soils in these areas can significantly increase erosion and sedimentation. Although water is scarce and flooding infrequent in desert regions, ephemeral and intermittent streams are a significant ecosystem component and washes are critical to the survival of many native plants and animals. *See, e.g.,* Levick, et al. (2008). "Ephemeral and intermittent streams make up approximately 59% of all streams in the United States (excluding Alaska), and over 81% in the arid and semi-arid Southwest (Arizona, New Mexico, Nevada, Utah, Colorado and California)." *Id.* at iii.

> Ephemeral and intermittent streams provide the same ecological and hydrological functions as perennial streams by moving water, nutrients, and sediment throughout the watershed. When functioning properly, these streams provide landscape hydrologic connections; stream energy dissipation during high-water flows to reduce erosion and improve water quality; surface and subsurface water storage and exchange; ground-water recharge and discharge; sediment transport, storage, and deposition to aid in floodplain maintenance and development; nutrient storage and cycling; wildlife habitat and migration corridors; support for vegetation communities to help stabilize stream banks and provide wildlife services; and water supply and water-quality filtering. They provide a wide array of ecological functions including forage, cover, nesting, and movement corridors for wildlife. Because of the relatively higher moisture content in arid and semi-arid region streams, vegetation and wildlife abundance and diversity in and near them is proportionally higher than in the surrounding uplands.

Id. The use of washes for any of the project solar collectors should be prohibited as well as destruction of vegetation. In addition, creation of a network of new roads in the washes to access solar collectors outside of the washes should be avoided because such roads would destroy vegetation and habitat, increase siltation, and destroy soil integrity.

Alternatives Analysis is Inadequate

The alternatives analysis is inadequate even with the inclusion of an alternative that would avoid all "primary" streams (Drainage Avoidance #1) and a smaller 300 MW project for which there is existing transmission capacity (Drainage Avoidance #2). At least one alternative should be considered that both avoids all primary streams and is limited to the 300 MW for which there is existing transmission capacity. Moreover, other alternatives should be considered which would avoid both "primary" and "secondary" streams including, for example, alternative siting on previously degraded lands such as nearby farmlands. In addition, the Notice and the DEIS should have considered distributed solar alternatives and others that could avoid impacts of the proposed project as well as impacts of the associated transmission lines and substations.

The Corps in the Notice and the BLM in the DEIS failed to adequately address such an

off-site alternative that would significantly reduce the impacts to water resources and water quality, as well as biological resources including the flat-tailed horned lizard and it its occupied habitat, and other special status species including rare plants and Peninsular bighorn sheep. The Center urges Corps not to rely on the BLM's flawed DEIS and to work with the BLM to revise the DEIS to adequately address these and other issues detailed below and then to re-circulate both a revised Notice and a supplemental DEIS for public comment.

Peninsular Bighorn Sheep

The federally endangered and state listed threatened Peninsular bighorn sheep were documented to occur on the project site. In fact, the five animals in a ewe-group, were documented foraging in one of the washes in 2009 by consultants. Actually, no evidence exists that this ewe-group's occurrence on site was a transient occurrence, despite the Notice's allegation (at pg. 6). In fact, Peninsular bighorn sheep use desert washes to forage in especially when good forage is available, as was the case with the animals documented on the project site. Furthermore, despite the speculation in the DEIS that the ewe-group "could have been flushed by OHV activity and possibly became disoriented and wandered onto the project site" (DEIS at pg. C.2-24) is just that – speculation. The facts document the use of the project site, and in particular, the desert washes as foraging areas for the Peninsular bighorn. Furthermore the DEIS states that "The presence of Peninsular bighorn sheep on the project site was confirmed this year" (DEIS at pg. C.2-24), which presumably means 2010, the year the DEIS was published, however no additional information is provided.

The Corps needs to fully consider the impacts to Peninsular bighorn sheep and the elimination of essential foraging areas for this endangered species as a result of the proposed project.

Rare Plants and Plant Communities

The rare plant surveys were deemed inadequate in the DEIS (at pg. C.2-20). Because the surveys were inadequate, the impacts can not be adequately analyzed. Therefore the Corps cannot rely on the information in the DEIS or the DEIS itself as an adequate document on which to base permitting decisions. We again, urge you to work with the BLM to revise the DEIS so that adequate data is included, so that a meaningful impact analysis can be performed.

Flat-Tailed Horned Lizard

The scant information provided in the Notice is insufficient to show that the Corps has the information to adequately assess the impacts to the flat-tailed horned lizard which is found in the ephemeral streams and washes on the property as well as in upland areas. In the more than 15 years since listing this species was first proposed in 1993, the threats to the flat-tailed horned lizard have only increased. Clearly the lizard is still in decline and should be protected under the Endangered Species Act. Unfortunately, the Flat-tailed Horned Lizard Management Areas, the voluntary conservation agreement that has been in place since 1997 and the Rangewide Management Strategy (2003) are not sufficient to protect the survival of the species or contribute to its recovery. Essential habitat for the lizard continues to be lost and fragmented throughout

the lizard's range even within the flat-tailed horned lizard management areas.

The proposed project is one among many new projects are increasing the already severe threats facing the flat-tailed horned lizard in California and Arizona. Several renewable energy projects are proposed within flat-tailed horned lizard habitat including the SES Solar Two project and the Ocotillo Express wind project proposal which would cover over 6,000 acres, including many acres of flat-tailed horned lizard habitat. The Solar Two project could also further fragment the remaining habitat for the species and could block gene flow between the West Mesa and Yuha Desert area populations. In addition, there are at least another five pending right of way applications for both solar and wind projects covering more than 20,000 acres in areas that may include significant lizard habitat some of them adjacent to the management areas. Each of these proposed energy projects will require a new gen-tie power lines that will likely impact lizard habitat and many may also require new substations and other infrastructure that may directly affect lizard habitat. Moreover, these large-scale, single-use projects will displace other multiple uses on public lands and increase the pressure on the flat-tailed horned lizard management areas and other flat-tailed horned lizard habitat from ORV use in particular. These projects will also fragment habitat and may provide subsidies and perches for predators. The impacts of these and other activities in the area, including ORV use, border patrol activities, and new large-scale transmission lines on the flat-tailed horned lizard must be adequately identified and analyzed in the Corps' and the BLM's cumulative impacts analysis for the lizard and other resources both as part of its NEPA analysis and as part of the conference with Fish and Wildlife Service for this species.

Water Resources and Sole Source Aquifer

The Notice fails to explain that after the DEIS was published by BLM several issues arose regarding the proposed water source for the project from the Seeley Waste Water Treatment Facility including a delay in approval of the needed facility expansion. As a result, the DEIS is inaccurate. It is now unclear whether or when reclaimed water will be available for the project from the Seeley facility. In response, the project proponent has stated that it will likely use groundwater either from wells on site or from nearby wells for the construction phase and until the Seeley water is available (assuming that it is in the future). This is a major change in the project description and this issue needs to be fully evaluated by the Corps in a revised Notice and by BLM in a supplemental DEIS. The environmental review must consider the water source for the proposed project for the life of the project and must fully analyze the impacts of that water use.

As the Corps should be aware, the Ocotillo-Coyote Wells Aquifer was designated as a sole source aquifer by the EPA on September 10, 1996. 61 Fed. Reg. 47752-53. The EPA determined that the aquifer "serves as the 'sole source' of drinking water for the residents of Ocotillo, Coyote Wells, Yuha Estates and Nomirage." *Id.* at 47753. Further, the EPA determined that the aquifer should be protected because "[t]here is no economically feasible alternative drinking water source near the designated area." *Id.* As the EPA noted the boundary of the sole source aquifer area at the Elsinore Fault "separates the sole source aquifer area, which contains high quality, potable water, from high saline, non-potable water to the east of the fault." *Id.* This designation protects this aquifer from contamination by all activities whether by actively

polluting the water source or by degradation of water quality due to excessive pumping and overdraft.

The newly-proposed use of groundwater for both construction and operation of the proposed project for some length of time could impact existing uses by local communities for drinking water and domestic use and at the expense of other environmental resources as well. Cumulative impacts of this use along with other proposed uses (including those by the neighboring Plaster City plant) must be identified and analyzed as well. Impacts of the over-draft of this aquifer and use of groundwater by the proposed project must be fully analyzed including impacts such as drawdown of springs and creeks in the area and the impacts to the fragile biological resources of the region that could result including resources in the and San Sebastian Marsh/San Felipe Creek Areas of Critical Environmental Concern (ACECs). Any drawdown of the aquifer would have substantial effects on water supply for other existing users. Moreover, issues regarding use of the water in this aquifer by the Plaster City plant have been in litigation for several years, including issues regarding the possibly catastrophic impacts loss of reliable well water would have on existing communities.

Conclusion

The Notice and the BLM's DEIS on which the Corps relies, are inadequate both because they omit important information and fail to consider a range of alternatives that will avoid the impacts to water resources and water quality from dredge and fill activities, and impacts to other resources. The Center urges the Corps to work with the BLM and other responsible agencies to revise the environmental review documents and to issue a revised Notice for public review in the future.

Sincerely,

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STATE OF CALIFORNIA
California Energy Commission

In the Matter of: The Application for Certification for the IMPERIAL VALLEY SOLAR PROJECT	Docket No. 08-AFC-5

DECLARATION OF SERVICE

I, Bonnie Heeley declare that on May 17, 2010, I served and filed copies of the attached Partial Rebuttal Testimony on Behalf of the California Unions for Reliable Energy for the Imperial Valley Solar Project dated May 17, 2010. The original document, filed with the Docket Office, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: http://www.energy.ca.gov/sitingcases/solartwo.

The document has been sent to both the other parties in this proceeding (as shown on the Proof of Service list) and to the Commission's Docket Office via email and overnight mail.

I declare under penalty of perjury that the foregoing is true and correct. Executed at South San Francisco, California on May 17, 2010.

/s/
Bonnie Heeley

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