Energy Research and Development Division

FINAL PROJECT REPORT

PLANNING ALTERNATIVE CORRIDORS FOR TRANSMISSION (PACT)

Validation Using Real Projects as Test Cases

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

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Planning Alternative Corridors for Transmission (PACT) – Validation Using Real Projects as Test Cases is the final report for the PACT project (Contract Number 500-08-030 The information from this project contributes to Energy Research and Development Division's Energy-Related Environmental Research Program.

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ABSTRACT

The Planning Alternative Corridors for Transmission (PACT) is a Web-based decision-support tool set for analyzing environmental, societal, and economic/financial impacts of potential electrical transmission corridors, transmission lines, and other energy infrastructure. This project thoroughly tested all aspects of the PACT software and its operation, identified any existing problems and weaknesses, and then corrected them. Beta tests were performed to test the model for two real-world projects at different spatial scales. The first beta test applied PACT to analyze the entire Desert Renewable Energy Conservation Plan region. The second beta test analyzed facility and transmission line siting at a project level using a dataset developed for the *Palmdale Hybrid Power Plant Staff Assessment.* Throughout the project, significant additions and improvements were made to the PACT tool set. PACT benefits California by supporting better decisions about energy infrastructure. Several operational applications of the PACT tool are underway as a direct result of the demonstration of the capabilities of PACT in this project's beta tests.

Keywords: California Energy Commission, Planning Alternative Corridors for Transmission, PACT, spatial model, GIS, transmission line analysis, transparent decision making,, transmission technology, public process, renewable energy, public utility planning, infrastructure planning, green energy project, Desert Renewable Energy Conservation Plan, DRECP, environmental decision factors

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EXECUTIVE SUMMARY

Decisions about where to locate new energy infrastructure are extremely challenging, involving large investments and long-term commitments of land. These choices also affect energy costs, reliability of energy supply, and ultimately economic growth. Huge uncertainties about the potential success of new generation and transmission technologies, economic trends, and the long-term effects of climate change add to the challenge. Energy infrastructure choices must also balance immediate and localized impacts caused by renewable energy generation facilities against the global and long-term benefits of reducing carbon emissions.

California has taken a lead in addressing these issues. The California Environmental Quality Act review process mandates a comprehensive analysis of both a project's environmental impacts and the criteria used to measure the anticipated impacts. This approach integrates economics, ecology, and society into the project impact analysis process and requires a multidisciplinary, multiple-objective approach in comparing alternatives sites for projects.

The Planning Alternative Corridors for Transmission (PACT) is a set of Web-based tools that support a robust, efficient, and comprehensive process for both site and project selection of electrical facilities, transmission lines, and corridors. Building on more than 15 years of research and project experience by Facet Decision Systems and Southern California Edison, PACT was designed to support rapidly evolving decision-making processes where:

- A large number of stakeholders participate.
- A transparent, multiple-objective decision-making process is required.
- Information comes from a variety of sources.
- New data are constantly becoming available even as decisions are made.
- Speed is essential.
- Subject-matter experts to support decision-making are uncommon.

PACT-supported decision processes are applicable to several stages of energy infrastructure planning:

- Choosing the best renewable energy generation sites taking into account conservation priorities, technical feasibility, and economic factors
- Identifying the best transmission corridors for bringing energy to market
- Choosing the best option for aligning transmission within a corridor
- Choosing the best transmission technology
- Choosing the best sites for facilities, such as substations.

Whenever possible, data, analysis results, and decision criteria are shown on maps and analyzed spatially. This integrates location into the entire decision making process.

This project tested PACT by applying it to a set of real decision processes to make sure that the tools could achieve the same range of analyses, level of expert judgment, and presentation of results as conventional methods. The intention was to thoroughly test all aspects of the PACT software and its operation, identify any existing problems and weaknesses, and then correct them. The researchers tested PACT using actual data and support from subject-matter experts on the Desert Renewable Energy Conservation Plan (DRECP) and Palmdale Hybrid Power Plant projects. DRECP is a regional planning effort to provide effective protection of desert ecosystems while allowing for the appropriate development of renewable energy. Project personnel (Facet Decision Systems) focused on issues of data handling, modeling, user interface, user workflow, data presentation and visualization, overall PACT performance, reliability, training, and documentation.

During early testing, problems were identified with data handling, visualization, user interfaces, and ease of use. Project personnel fixed these problems using an iterative software development method (that is, requirements and solutions evolve through team collaborations) and retested the resulting enhancements. Throughout the project, significant additions and improvements were made to the capability of the PACT tool set. The result of this effort was to both improve and validate the outcomes produced by the PACT tool set.

Presenting complex information effectively is a challenge for any decision support tool. Energy supply decisions that impact California will be made with wide-ranging stakeholder groups.

PACT benefits California by supporting better decisions about energy infrastructure. Many of the lessons learned in the PACT beta tests will inform the design of future tools and output products intended for stakeholders and decision makers throughout the state. PACT will help stakeholder processes reach balanced conclusions about California's economic, social, and environmental well-being. Several operational applications of the tool are underway as a direct result of the capabilities PACT demonstrated in this project. Southern California Edison is using a variant of PACT to evaluate transmission substation and transmission line siting alternatives. It has integrated PACT into its ongoing, operational decision-making processes for siting in California. The Western Electricity Coordinating Council is using PACT to support long-range (20-year) planning for the Western Interconnect, one of the two major alternating current power grids in North America. This large planning effort will use PACT to assist with making energy generation choices that will help California meet its renewable energy targets, while ensuring a reliable energy supply at the lowest possible cost and environmental impact. PACT's economic analysis functions can also help reduce transmission costs and ensure competitively priced energy, which is needed for economic development. PACT will be a key component in developing an ideal configuration for the Western Interconnect.

CHAPTER 1:
Project Background

1.1 How PACT Works

The Planning Alternative Corridors for Transmission (PACT) is a web based tool set used to evaluate, rate, and ultimately rank different alternatives according to a set of evaluation criteria or factors. Factors are multi-disciplinary data that may come from existing maps and databases, field studies, model results, or expert judgment. The factors are combined into a common decision framework that ensures that alternatives are compared fairly, and decision criteria are clearly documented. PACT structures decisions by ranking alternatives using weighted scoring schemes to evaluate sets of decision factors that describe the differences between alternatives.

There are several sources for decision factors:

- Expert judgment (for example, subjective data based field site visits, or the expert interpretation of non-Geographic Information Systems (GIS) data.
- External data sources (for example, projected energy generated by a project);
- External models (for example, power flow analysis or species habitat model);
- Spatial Geographic Information System measurements (for example, length of a transmission line segment or area of a project);
- Spatial (GIS) layers (for example, areas of natural communities affected by a proposed project);
- Calculations done by PACT models based on other decision factors and parametric assumptions (for example, benefit or cost per acre of remediation/mitigation).

Using a PACT website, decision factors are grouped and then combined using weighted grading systems similar to those used for calculating grade point averages (GPA) for academic grades. PACT adds one important extension to this GPA-like grading concept: each stakeholder can use different grading approaches and weights. This means that each alternative can be graded according to different stakeholder viewpoints. For example, a utility focused primarily on efficient energy delivery to ratepayers can use a different grading system than an environmental protection agency.

For each alternative being evaluated (for example, transmission corridor), this GPA-like approach develops an aggregate grade. This is similar to how individual student grades get calculated for a school course or set of courses. For example, a biological score might combine several species and land cover decision factors, each based on different data but graded against a common grading scheme and weighted against each other. This biological grade could be evaluated by itself, or it could be combined with other environmental aggregate grades based on air quality, and water quality factors to define an overall environmental grade.

PACT organizes factors into a hierarchy that looks like the file folders on a computer desktop. Contents of a folder can be weighted relative to each other to change the contribution of each factor to the composite grade for a folder. In some cases, like the environmental example above, a higher-level folder can combine grades from different subject area folders. This makes the most sense and is easiest to understand when the subject areas are related in some way. If the folders contain wildly different factors, cross-folder aggregation becomes more difficult. For example, it is easier to combine biology with environmental factors than it is to combine biology with engineering and economic factors. The PACT folder hierarchy allows aggregation of folder grades where this makes sense, but there is no requirement to use grades aggregated across folders. This flexibility allows PACT websites to capture the widest possible cross-section of stakeholder viewpoints.

1.2 Why a Tool like PACT Is Needed

Decisions that involve land use and natural resources are often difficult to make because so many different factors come into play. An objective like increasing the amount of renewable energy generated in California becomes complicated because many sites that are ideal for solar or wind generation are in sensitive environmental areas that contain important habitats for endangered or other listed species. These areas may also be far from the markets that require the energy, so new transmission lines are required to bring the energy to where it is needed. The transmission lines may have to traverse environmentally sensitive areas or areas with high agricultural value. Ultimately, transmission lines might even have to cross developed areas to deliver energy to the electrical transmission grid.

Tradeoffs between renewable energy generation and habitat protection objectives are only part of the overall decision-making framework needed. Electricity generation and transmission facilities last for decades and may cost billions of dollars. Engineering design, operational efficiency, economics, system reliability, aesthetics, compatible land uses, and other societal objectives must also be considered in decisions of this type. PACT was designed to integrate many of these different considerations into a single web-accessible evaluation framework.

1.3 Project Objectives

This project tested PACT by applying it to a set of real decision processes. These decision processes were real, in that actual project and survey data were used, project subject-matter experts were part of the process and used PACT tools, and results were to make sure that PACT could represent the same spectrum of analytical results, expert judgment, and presentation of study team conclusions that were found in the Final Staff Assessment (FSA) document. The results of this review are found in Chapter 2 under the descriptions of subtests 1 through 9 in this report.

It was crucial that PACT testing did not interfere with mission-critical decision processes underway, so the decision analyses were real, but not employed for ongoing or past decision processes. The PACT work trailed processes that were already underway so that there was no chance of this project having an adverse effect on other projects.

The tests were designed to push the limits of the PACT tools by testing extremes. The following is a list of the issues that PACT encountered in this validation:

- PACT was applied to the entire Desert Renewable Energy Conservation Plan (DRECP) region and to individual transmission line segments only a few hundred yards in length. This tested PACT's ability to operate across a broad range of spatial resolutions.
- Large datasets were used that covered the entire desert region at a coarse scale, coupled with other much more precise data.
- Diverse users were supported from casual users with no PACT experience to experienced modellers and analysts. Each user brought different objectives, a different background, and a different set of tasks that needed to be supported by PACT.
- Decisions were presented at an extremely high level with full audit drill-down to technical and data details.

CHAPTER 2:
Tests Made and Strategies Adopted

The following pages discuss the major tests done during this project and the approaches taken to mitigate risks that were encountered. This section of the document illustrates the challenges that were overcome when applying PACT to the Beta test cases performed in this project.

2.1 Testing the Breadth of Potential PACT Applications

PACT was originally developed for siting transmission lines and electrical substations. The DRECP-related applications for this project seemed similar enough to other generalized siting problems, but there was a risk that PACT would not be able to accommodate the differences. This challenge was chosen because it would test PACT's potential adaptability and ability to support other spatial decision support challenges that might emerge in future.

2.1.1 Potential Uses of PACT Evaluated as Possible Beta Tests:

- *Analyze decisions inside the DRECP study area that involved siting***.** This was the easiest approach because it used PACT for its original design purpose. The only challenge was integrating data generated by the DRECP process into PACT decision frameworks. This was a minor challenge because PACT was designed to use almost any type of spatial data into its factor calculations and analysis.

- *Apply siting-style analysis to the entire DRECP landscape***.** California Department of Fish and Game (DFG) had developed two hexagonal grid overlays for California that were being used to support DRECP data analysis. This approach treated each grid cell as if it was a potential site for a facility, calculating factor values based on GIS data available, and grading the results according to different grading regimens of evaluation. The risks in this approach came from the size of the study area, and the inconsistencies in data quality and coverage. The large area might make data processing too slow for interactive performance over the Internet, and the inconsistencies in data might make the results difficult to interpret or use for decision support.

- *Combine both uses above.* This approach created an opportunity to test how well PACT concepts could transfer between regional analysis and project-specific analysis. The breadth and general decision support capabilities of PACT would be clearly demonstrated if the same PACT facilities would support analysis, presentation, and user interaction facilities for region-wide and project-specific decisions.

The third approach, which combines the first two approaches, was chosen. Separate subtests were created for the DRECP study area as a whole and for the analysis of transmission, facility, and other infrastructure siting processes related to the Palmdale hybrid solar generation facility and transmission lines. Wherever possible the datasets, decision factors, and web presentation of the results were aligned.

The Palmdale Beta test attempted to match and extend the analyses and data interpretation done by Energy Commission staff for the Palmdale FSA. Analysis of the FSA document showed that different analytical approaches were used depending on the subject areas. For this beta test, a series of subtests were developed that matched PACT functionality to the analytical and documentation used in the FSA. While the subtests did not duplicate the entire FSA, they did cover all the major topic areas and datasets used.

2.2 Subtests Based on Analysis of Siting Decisions Inside the Desert Renewable Energy Conservation Plan Study Area

Nine subtests were performed using a dataset developed for the FSA for the Palmdale Hybrid Power Project. This proposed project is inside the DRECP study area. Other datasets used included California Natural Diversity Database (CNDDB), which inventories the status and locations of special-status plants and animals in California, and the California Wildlife Habitat Relationships (CWHR) database, which provides species range maps. CNDDB data included state and federal threatened and endangered species and candidates for listing, as well as Natureserve global and state ranks of rarity and California rare plant lists. Mitigation Area Potential and Surface Water Area datasets collected as part of the DRECP effort were not included in these nine subtests but were included in the subtests covering the entire DRECP study area. This allowed comprehensive testing of PACT against real datasets and also tested shifting data and models from one target use to another.

The FSA document [1]provided many insights into how staff evaluations are performed. Each subtest reviewed part of the FSA to identify the types of analysis performed and the data used. An equivalent analytical process was then performed using PACT tools. The intention was to replicate what was documented in the FSA as a minimum, and to expand the analysis and presentation of results where possible with PACT.

2.2.1 Subtest 1: Special-Status Species

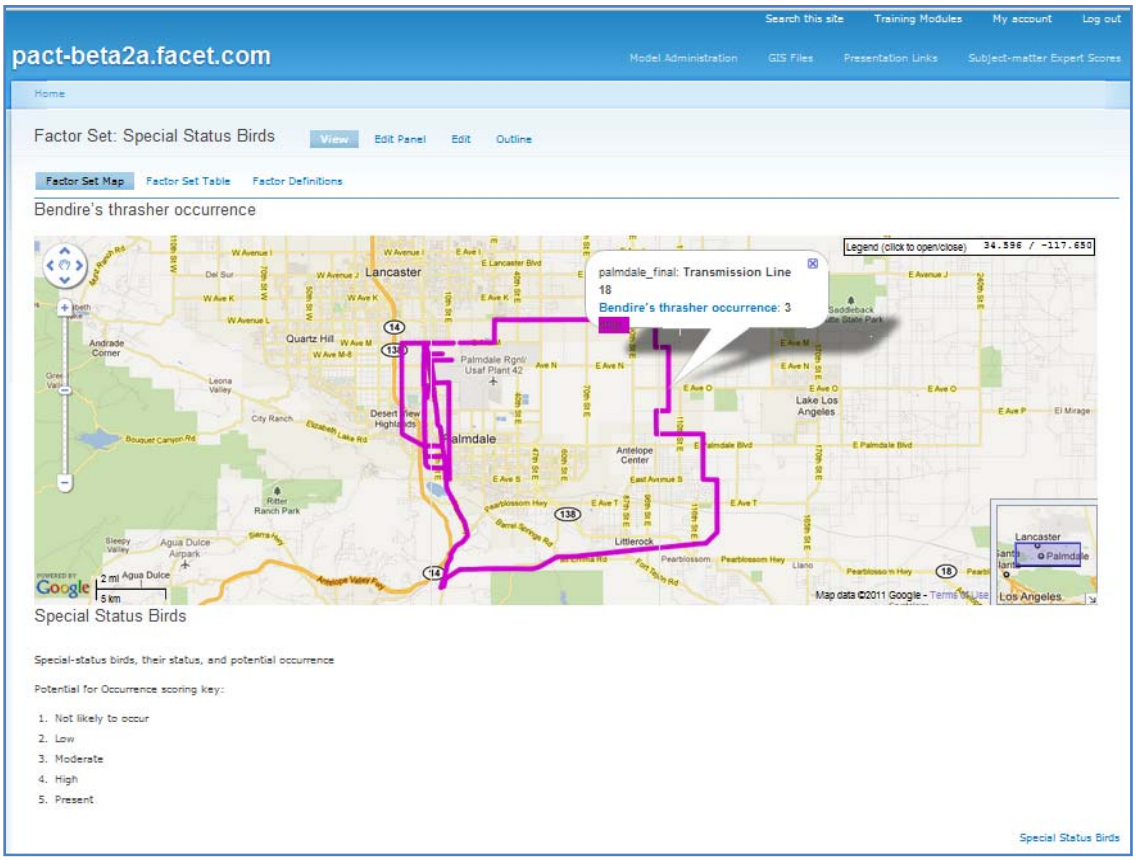
The FSA described potential project impacts on special-status species using a species-by-species narrative that pulled together field survey results with other information known about the likelihood a species would occur in the area.

To replicate this in PACT, two approaches were tested. The first approach included a narrative description for each species similar to that in the FSA. This pure text approach used in the FSA was then extended by adding an interactive map. Selecting an element on the map showed a numeric code that was interpreted according to the key below the map.

In the example shown below, the map shows the likelihood of occurrence for Bendire's thrasher in the study area. Note that all the lines have the same color because they are all treated identically. The balloon contains the code 3, which is interpreted using the key below the map as meaning there would be a moderate chance of the species occurring within the project boundary, Figure 1.

1 http://www.energy.ca.gov/2010publications/CEC-700-2010-001/CEC-700-2010-001-FSA.PDF

Figure 1: Special-Status Species Subtest 1



This map shows the likelihood of occurrence for Bendire's thrasher in the study area. Note: the data shown in the figures
are for test and example purposes only and are not necessarily current or accurate.
Image Credit: Facet Decision Systems, Inc.

Table 1 shows the project-wide scoring scheme and the results found in the website. Note that the scores in this case apply to the entire project and are not broken out by transmission line segment. This approach mimics the approach used in the FSA document. The Scoring is in a range of 1 to 5 where 1 indicates that the species is unlikely to occur.

Table 1: Example of Projectwide Scoring Scheme From PACT Website

Factor	**Potential for Occurrence**[2]
Special Status Amphibians	
Arroyo toad occurrence	Score 1

2 Potential for Occurrence scoring key: 1. Not likely to occur, 2. Low, 3. Moderate, 4. High, 5. Present

Factor	Potential for Occurrence[2]
Mountain yellow-legged frog occurrence	Score 2
Western spadefoot occurrence	Score 2
Special Status Birds	
Bald eagle occurrence	Score 4
Bendire's thrasher occurrence	Score 3
California condor occurrence	Score 1
California horned lark occurrence	Score 5
Cooper's hawk occurrence	Score 5
Ferruginous hawk occurrence	Score 5
Golden eagle occurrence	Score 3 along transmission line corridor, Score 2 on power plant site
Least Bell's vireo occurrence	Score 1
LeConte's thrasher occurrence	Score 5
Loggerhead shrike occurrence	Score 5
Long-billed curlew occurrence	Score 4
Long-eared owl occurrence	Score 3
Merlin occurrence	Score 4
Mountain plover occurrence	Score 4
Northern harrier occurrence	Score 1
Prairie falcon occurrence	Score 5
Southwestern willow flycatcher occurrence	Score 1
Summer tanager occurrence	Score 1
Swainson's hawk occurrence	Score 5
Tricolored blackbird occurrence	Score 1
Vaux's swift occurrence	Score 5
Vermilion flycatcher occurrence	Score 1
Western burrowing owl occurrence	Score 5
White-tailed kite occurrence	Score 1
Yellow-billed cuckoo occurrence	Score 1
Yellow-breasted chat occurrence	Score 1
Special Status Fish	

Factor	Potential for Occurrence[2]
Arroyo chub occurrence	Score 1
Santa Ana speckled dace occurrence	Score 1
Santa Ana sucker occurrence	Score 1
Unarmored threespine stickleback occurrence	Score 1
Special Status Mammals	
American badger occurrence	Score 4
Los Angeles pocket mouse occurrence	Score 1
Mohave ground squirrel occurrence	Score 5
Pallid bat occurrence	Score 3
Pallid San Diego pocket mouse occurrence	Score 3
Southern grasshopper mouse occurrence	Score 3
Spotted bat occurrence	Score 2
Townsend's big-eared bat occurrence	Score 2
Western mastiff bat occurrence	Score 2
Western red bat occurrence	Score 3

Source: Facet Decision Systems, Inc.

2.2.2 Subtest 2: Special-Status Species Details

Adding maps to the narrative created the opportunity to integrate other available information, such as the California Wildlife Habitat Relationships (CWHR) Range data used in the DRECP process into the special-status species narratives. California Wildlife Habitat Relationships (CWHR) is a state-of-the-art information system for California's wildlife. CWHR contains life history, geographic range, habitat relationships, and management information on 694 species of amphibians, reptiles, birds, and mammals known to occur in the state. Having spatially explicit information also allowed PACT to characterize impacts on project elements instead of looking at the entire project.

In this subtest, details were added that supported the special-status species narratives in the FSA. This was done in two ways: firstly by applying the narrative to individual project elements (for example, each possible transmission line segment); and secondly by providing more maps to give background information showing how the assessment was developed. The FSA's assessment of moderate potential was likely based on the same information, but the supporting information used was not always referenced in the FSA document.

This display now shows the likelihood assessment along with the CWHR range data. Transmission Line 18, shown on the map, indicates a likelihood of arroyo toad occurrence of

Score 3 (Moderate). The light-brown polygon on the map shows the CWHR range polygon for the same species. Notes can be added for each element, providing additional details. Figure 2 below shows this.

Figure 2: Special-Status Species Details Subtest 2

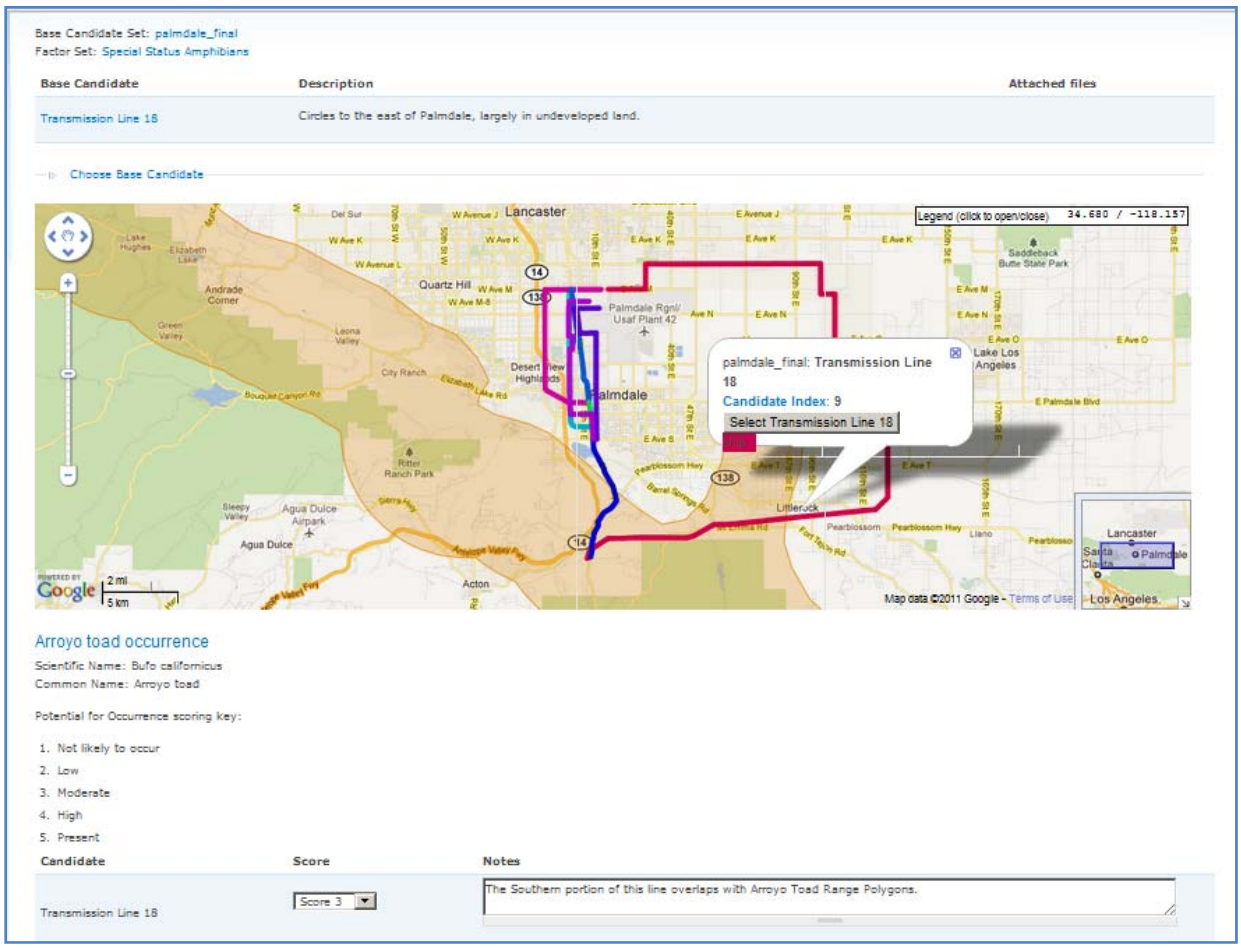


Image Credit: Facet Decision Systems, Inc.

Parts of the FSA narrative described the characteristics of transmission line alternatives that were evaluated. This narrative included a description of the route the transmission line would take, calling attention to any characteristics that would limit the utility of an alternative, or make it attractive. Several subtests were done with PACT to see how it could emulate or expand on this part of the FSA. PACT reported which species ranges overlapped with proposed transmission line segments.

2.2.3 Subtest 3: Route Descriptions

In PACT, a transmission route is built up from individual transmission segments. This allows a segment to be shared by multiple routes, and captures any overlaps explicitly. In the FSA the

text describing the assessment rationale is usually linked either to the entire project, or to a specific alternative route. PACT is able to do exactly same thing, linking assessment text to either the entire project, or to alternative routes, but PACT also offers the potential for useful extensions. The table below shows five routes, three of which share transmission line segment 3A2, and four of which share transmission line segment Overhead. Figure 3 below shows this.

Figure 3: PACT Route Descriptions

Candidate Analysis | Comparison Maps | Candidate Descriptions

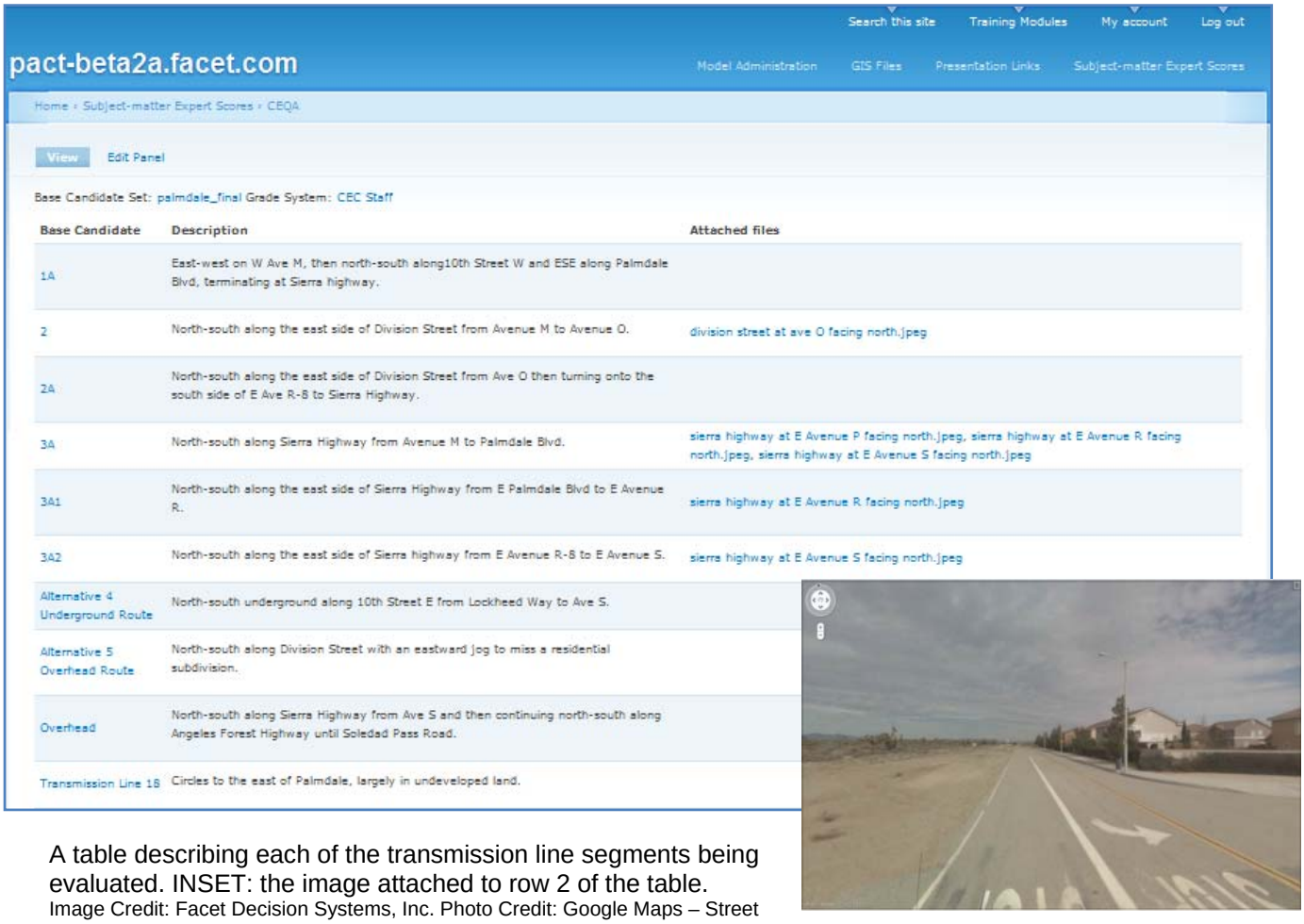
	Description	Base Candidate(s)
A) Applicant Preferred Route	The proposed generator tie-line would be owned, operated and maintained by the City of Palmdale and would consist of a 35.6-mile long overhead generator tie-line with two segments. The proposed segment 1 would be 23.7 miles long and located within new and existing rights-of-way (ROW) as it extends from the on-site substation through the northeast corner of the site, along 10th St E and E Ave L. The line would then continue over industrial and agricultural areas, over open spaces, and along new and existing road rights-of-way, until it connects at the California Department of Water Resources (DWR) Pearblossom substation. The generator tie-line along segment 1 would be a single circuit 230 kV line supported on steel poles spaced approximately 750 feet apart, and between 100 feet and 135 feet in height. The majority of segment 1, approximately 18.2 miles, would be located within the city of Palmdale, while the remaining 5.5 miles would be within unincorporated Los Angeles County. Segment 2 is 11.9 miles long, proposed to be built along the existing Southern California Edison's (SCE) ROW, and would proceed from north of the Department of Water Resources Pearblossom Pumping Station southwest to the SCE's Vincent Substation. Segment 2 would be constructed for double-circuit transmission with conductors on both sides of the support poles. One set of conductors would be the new 230 kV interconnection between Pearblossom and Vincent substations, the other would be the replacement for the 230 kV line currently providing power to DWR's water pumping station via the Vincent Substation. The Segment 2 line would be designed, built, operated, and maintained by SCE, as the line is located within an existing SCE ROW. The proposed segment 2 is located in unincorporated Los Angeles County within an existing SCE ROW.	Transmission Line 18
B) Route 1: 10th Street W. Route	The 10th Street W. Route would shorten the length of the initially-proposed transmission interconnection by 20.6 miles. The route would avoid potential impacts associated with airspace for U.S. Air Force Plant 42, but would travel through a busy commercial district, creating a temporary increase in traffic impacts due to construction and visual impacts. In addition, the existing SCE easement would not be wide enough to support a 230 kV line and sufficient land is not available to widen the easement.	3A2 3A1 Overhead 1A
C) Route 2: Division Street Route	Alternative Route 2, the Division Street Route would be located in an undeveloped corridor with existing low-voltage transmission lines as well as a developed area, and would require several crossings of Division Street to avoid a housing subdivision and other homes in the area. However, even with the crossings, the route would potentially create conflicts with existing residences south of East Avenue O where a 60-foot ROW would not be feasible without the take of several residences. The route would be located more than 150 feet from the Palmdale Learning Plaza, which is permitted under the "School Site Selection and Approval Guide" by the School Facilities Planning Division of the California Department of Education.	3A2 2 2A Overhead
D) Route 3: Underground Along Sierra Highway	Alternative Route 3, the Underground Route, would run along Sierra Highway, and would also be considerably shorter than the proposed route. This route would reduce impacts to biological resources because it would be located primarily in a developed area, and would eliminate visual impacts for the 5.5-mile underground segment. Costs for maintenance would be higher and maintenance response times would increase, but maintenance for this underground route would be less frequent than an overhead route exposed to severe weather conditions, such as lightening, wind and freezing, in the high desert around Palmdale. Assuming the route described in the AFC would not be substantially altered, the Underground Along Sierra Highway alternative is considered to be feasible compared to the applicant's proposed route in the AFC and it would reduce some environmental impacts as well.	3A2 3A1 3A Overhead
E) Route 4: Partial Underground Transmission Line	Alternative Route 4, the Partial Underground/Overhead Transmission Route would run along the proposed gas pipeline and proposed water line and would be considerably shorter than the proposed route. This route would reduce direct and indirect impacts to biological resources because it would be located primarily in a developed area, and it would eliminate visual impacts and air safety concerns at U.S. Air Force Plant 42 for the 6.75-mile underground segment.	Overhead Alternative 4 Underground Route

Narrative descriptions in PACT are similar in content and detail to those in the FSA. Note that some transmission line segments are shared by different routes.
Image Credit: Facet Decision Systems, Inc.

2.2.3.1 Subtest 3A: Addition of Images to Segment Descriptions

This subtest added other documents related to the transmission line segments to the website. This allows the website to act as a repository of information about alternatives. For the text, images of the landscape from key viewpoints were attached to the segment descriptions.

Figure 3 A: Segment Descriptions with Image



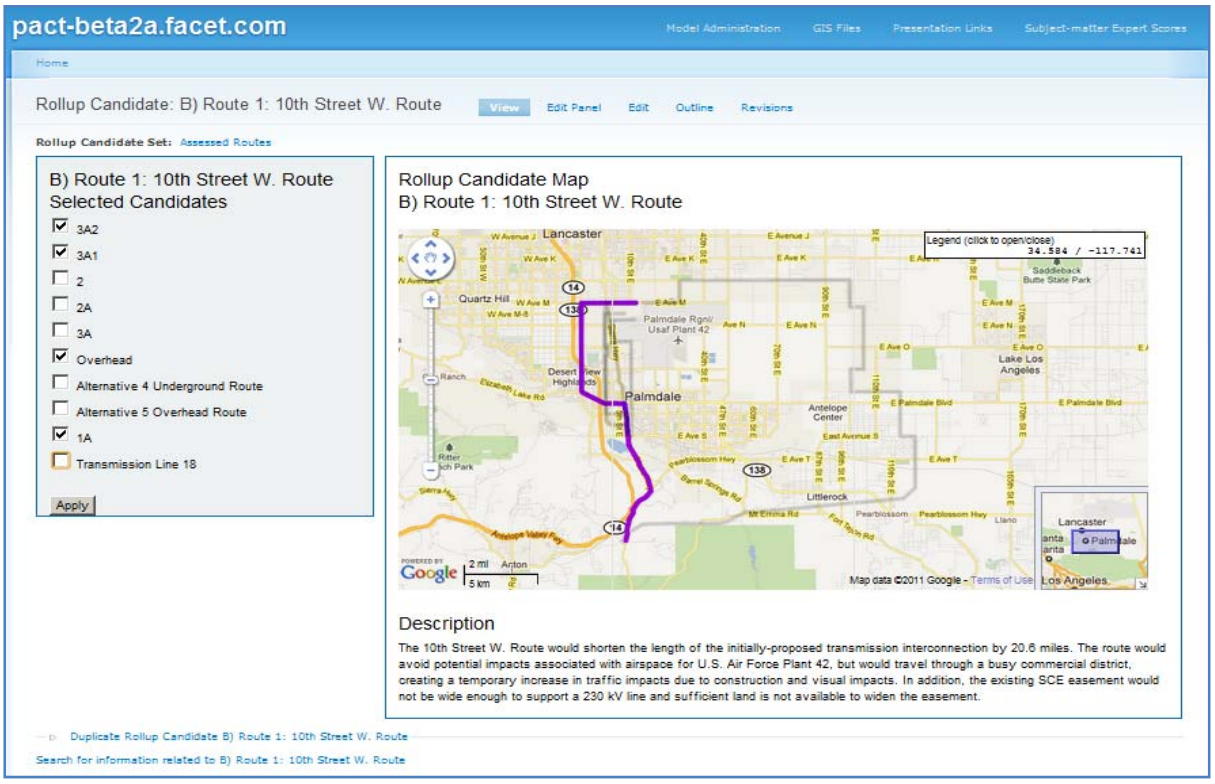
Base Candidate	Description	Attached files
1A	East-west on W Ave M, then north-south along10th Street W and ESE along Palmdale Blvd, terminating at Sierra highway.	
2	North-south along the east side of Division Street from Avenue M to Avenue O.	division street at ave O facing north.jpeg
2A	North-south along the east side of Division Street from Ave O then turning onto the south side of E Ave R-8 to Sierra Highway.	
3A	North-south along Sierra Highway from Avenue M to Palmdale Blvd.	sierra highway at E Avenue P facing north.jpeg, sierra highway at E Avenue R facing north.jpeg, sierra highway at E Avenue S facing north.jpeg
3A1	North-south along the east side of Sierra Highway from E Palmdale Blvd to E Avenue R.	sierra highway at E Avenue R facing north.jpeg
3A2	North-south along the east side of Sierra highway from E Avenue R-8 to E Avenue S.	sierra highway at E Avenue S facing north.jpeg
Alternative 4 Underground Route	North-south underground along 10th Street E from Lockheed Way to Ave S.	
Alternative 5 Overhead Route	North-south along Division Street with an eastward jog to miss a residential subdivision.	
Overhead	North-south along Sierra Highway from Ave S and then continuing north-south along Angeles Forest Highway until Soledad Pass Road.	
Transmission Line 18	Circles to the east of Palmdale, largely in undeveloped land.	

A table describing each of the transmission line segments being evaluated. INSET: the image attached to row 2 of the table.
Image Credit: Facet Decision Systems, Inc. Photo Credit: Google Maps – Street View

2.2.4 Subtest 4: Route Description Details

PACT allows users to visualize maps along with the text-based narrative from the FSA. Easy-to-use tick-boxes show which transmission line segments have been included in the route evaluation.

Figure 4: Route Map and Detailed Description



The map shows the connected segments that make Route 1. The light gray lines overlaying the map how other segments that are part of the analysis, but not part of this route.
Image Credit: Facet Decision Systems, Inc.

2.2.5 Subtest 5: Incorporation of Google Street View

Adding interactive maps based on Google tools opened the opportunity to use Street View, Google's map facility that displays interactive street images at a location. This allows the user to see a 360-degree view along most roads. This is invaluable to project teams and stakeholders who want to see what the landscape and streetscape look like as they evaluate alternatives.

Figure 5: Google Street View Example for Route 1

This interactive Street View from Google allows a 360-degree view at any location along the road. The center location used as the starting place for the navigation map is linked from the PACT map, so it is tied to the PACT route descriptions.
Image Credit: Facet Decision Systems, Inc.

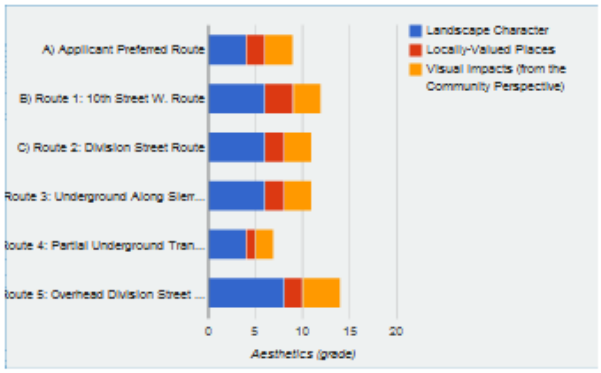
2.2.6 Subtest 6: Analytical Comparison of Alternative Routes

The FSA captures the expertise of the study team in the analysis, data, and tables that are included in the document. In PACT, this analysis can easily be displayed, and then combined with other elements for use in interactive presentations. This subtest used the PACT factor hierarchy to graphically show composite grades for each of the alternatives based on subject-matter expert input. Presentations like this help explain the overall conclusions reached by the FSA evaluation team by showing the background analysis in each technical area.

Figure 6: Analytical Route Comparison in PACT

Comparison Table

Factor Category	Kind	A) Applicant Preferred Route	B) Route 1: 10th Street W. Route	C) Route 2: Division Street Route	D) Route 3: Underground Along Sierra Highway	E) Route 4: Partial Underground Transmission Line	F) Route 5: Overhead Division Street Route (Staff's Alternative)
⊟ td_fse_grade_table updated	composite	94.0	80.0	82.0	78.0	70.0	99.0
⊞ GIS-based Factors	composite	9.0	13.0	13.0	13.0	13.0	13.0
⊟ Subject-matter Expert Scores	composite	85.0	67.0	69.0	65.0	57.0	86.0
⊟ CEQA	composite	45.0	49.0	47.0	47.0	43.0	50.0
⊟ Aesthetics	composite	9.0	12.0	11.0	11.0	7.0	14.0
Landscape Character	weighted grade	4.0	6.0	6.0	6.0	4.0	8.0
Locally-Valued Places	weighted grade	2.0	3.0	2.0	2.0	1.0	2.0
Visual Impacts (from the Community Perspective)	weighted grade	3.0	3.0	3.0	3.0	2.0	4.0
⊞ Biology	composite	5.0	5.0	5.0	5.0	5.0	5.0
⊞ Community	composite	5.0	5.0	5.0	5.0	5.0	5.0
⊞ Cultural Resources	composite	4.0	4.0	4.0	4.0	4.0	4.0
⊞ EMF	composite	1.0	2.0	1.0	1.0	1.0	1.0
⊞ Engineering	composite	9.0	9.0	9.0	9.0	9.0	9.0
⊞ Geology	composite	7.0	7.0	7.0	7.0	7.0	7.0
⊞ Land Acquisition	composite	1.0	1.0	1.0	1.0	1.0	1.0
⊞ Land Use	composite	4.0	4.0	4.0	4.0	4.0	4.0
⊞ Stakeholder	composite	40.0	18.0	22.0	18.0	14.0	36.0

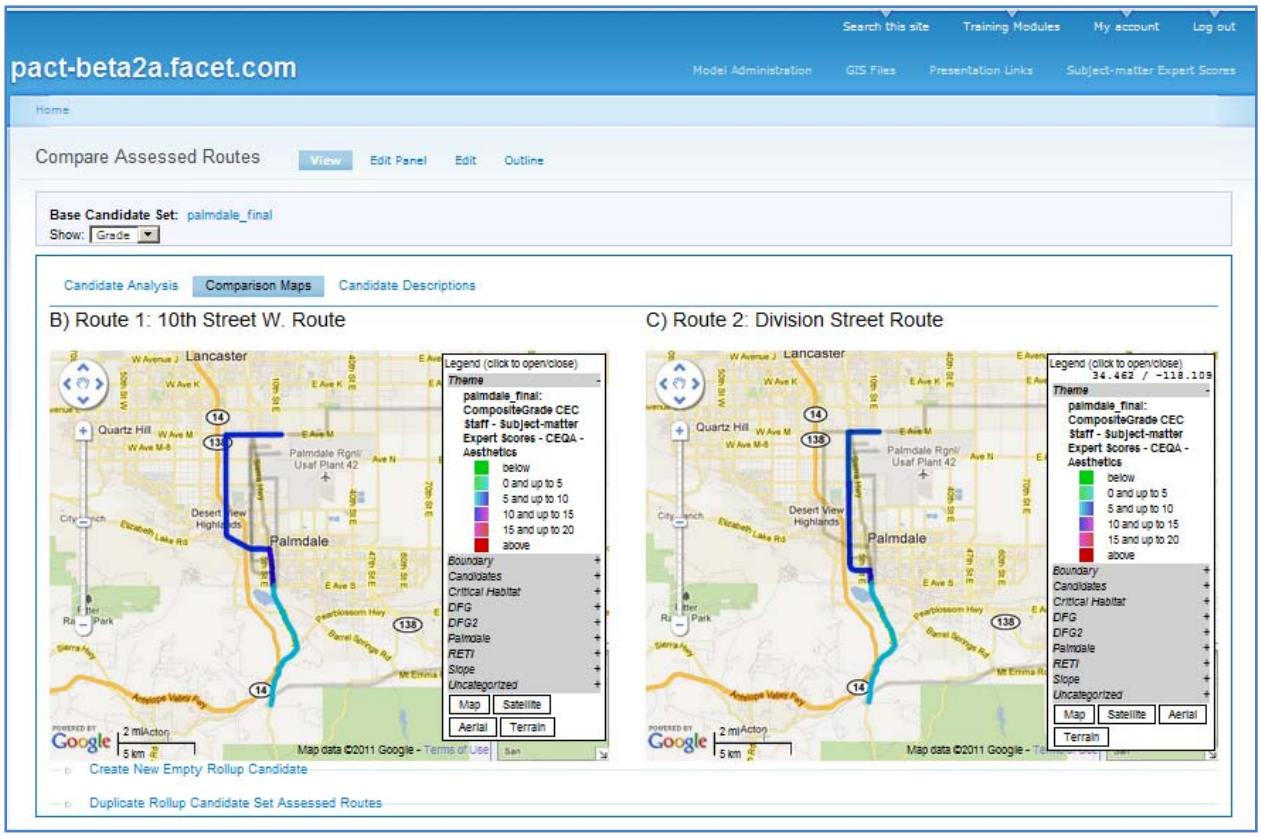


This comparison table shows the factor hierarchy being used to compare six routes.
The chart bars show the results for the selected row. In the case of Aesthetics as shown, there are three factors defined, each of which is assigned a different color in the bar. Wider bars indicate higher impact, and therefore, those routes are less desirable.
Image Credit: Facet Decision Systems, Inc.

2.2.7 Subtest 7: Map Comparison of Routes

One way to understand the differences between alternatives is to compare maps showing the differences. PACT's side-by-side map comparison display was configured to show pairs of routes against each other. This is easier to interpret than a single map containing multiple routes that might overlap.

Figure 7: Side-by-Side Route Comparison

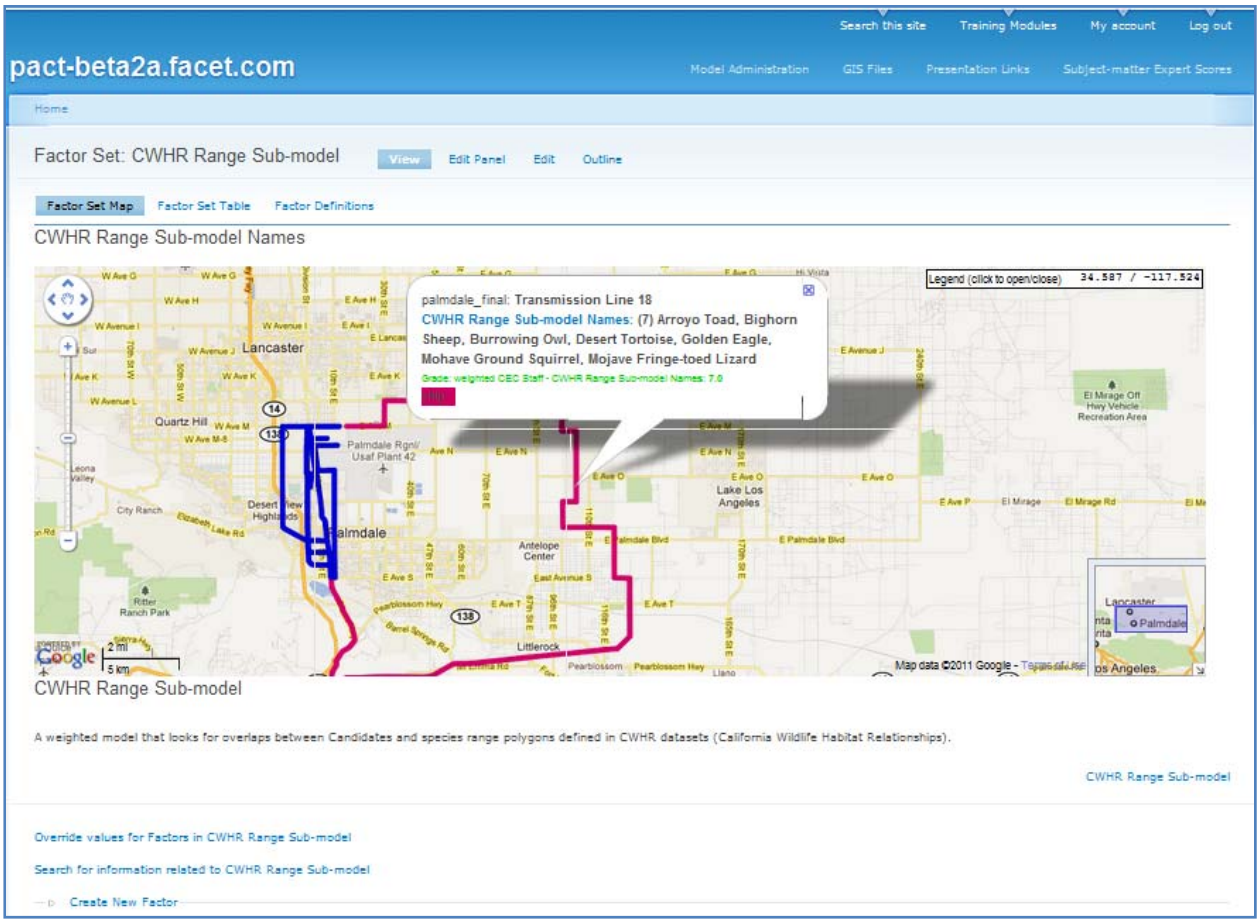


Route 1 shares some of the same elements as Route 2. The side-by-side comparison makes it easy to identify where routes are identical and where they are different.
MAP COLORS: The map colors show the Aesthetics composite grades for each of the segments. Segment with a green/turquoise color have lower impact than those that are blue.
Image Credit: Facet Decision Systems, Inc.

2.2.8 Subtest 8: Including Geographic Information Systems Data Analysis Factors

As well as using the CWHR data, the Palmdale FSA team interpreted field study data, and GIS data from the CNDDB. While maps are included in the FSA text, those generated using PACT to combine CWHR and CNDDB are not. This subtest extended the approach used in the FSA to include PACT analysis of CWHR and CNDDB GIS datasets.

Figure 8: Geographic Information Systems Analysis

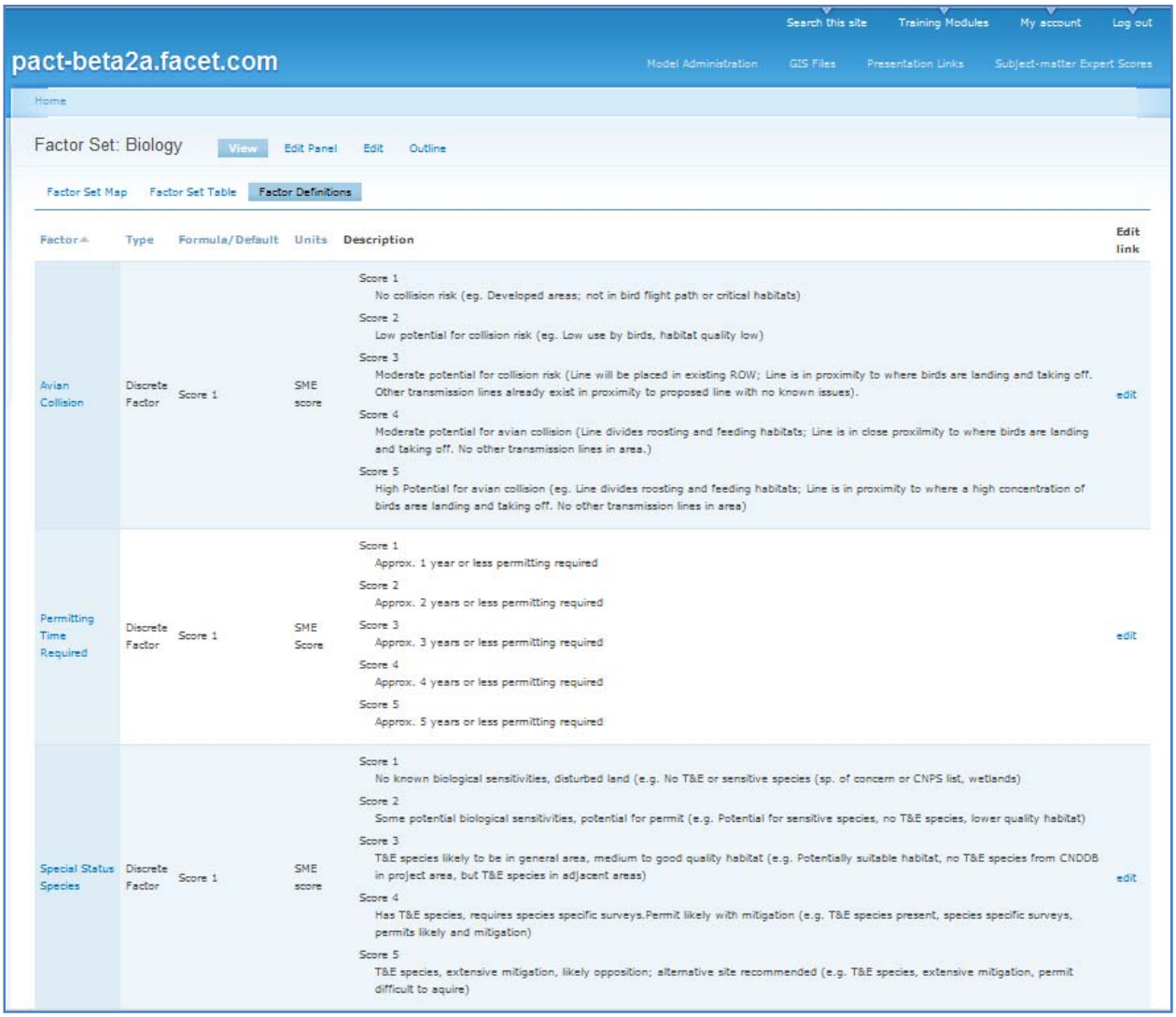


The balloon lists the CWHR species ranges that overlap with Transmission Line 18. This data is displayed with CNDDB data. The text in the balloon is generated by PACT spatial data intersection tools. The analysis is automatically applied whenever new data are loaded onto the website.
Image Credit: Facet Decision Systems, Inc.

2.2.9 Subtest 9: Application of Standard Evaluation Framework

Establishing a consistent evaluation approach for cross-disciplinary assessment of project alternatives is extremely difficult. It is important to make sure that the same criteria are applied consistently to an alternative, whether it is conceived early in the project or evolves in later iterations. Maintaining consistency becomes more problematic when team members change or when the same criteria are applied in an entirely different project context. PACT addresses this in two ways. The first approach uses a six-point grading system that ranges from score 1 (minimal or no impact) through score 5 (very high impact) to F (fails to comply with a project requirement). Each subject area is characterized with a set of factors that use the same scoring scheme but define explicit scoring criteria. The factor subject areas in this table were based on a California Environmental Quality Act (CEQA) framework enhanced with transmission engineering factors.

Figure 9: Example Scoring Keys for the Six-Point System



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Home

Factor Set: Biology — View | Edit Panel | Edit | Outline

Factor Set Map | Factor Set Table | Factor Definitions

Factor	Type	Formula/Default	Units	Description	Edit link
Avian Collision	Discrete Factor	Score 1	SME score	Score 1 No collision risk (eg. Developed areas; not in bird flight path or critical habitats) Score 2 Low potential for collision risk (eg. Low use by birds, habitat quality low) Score 3 Moderate potential for collision risk (Line will be placed in existing ROW; Line is in proximity to where birds are landing and taking off. Other transmission lines already exist in proximity to proposed line with no known issues). Score 4 Moderate potential for avian collision (Line divides roosting and feeding habitats; Line is in close proxilmity to where birds are landing and taking off. No other transmission lines in area.) Score 5 High Potential for avian collision (eg. Line divides roosting and feeding habitats; Line is in proximity to where a high concentration of birds aree landing and taking off. No other transmission lines in area)	edit
Permitting Time Required	Discrete Factor	Score 1	SME Score	Score 1 Approx. 1 year or less permitting required Score 2 Approx. 2 years or less permitting required Score 3 Approx. 3 years or less permitting required Score 4 Approx. 4 years or less permitting required Score 5 Approx. 5 years or less permitting required	edit
Special Status Species	Discrete Factor	Score 1	SME score	Score 1 No known biological sensitivities, disturbed land (e.g. No T&E or sensitive species (sp. of concern or CNPS list, wetlands) Score 2 Some potential biological sensitivities, potential for permit (e.g. Potential for sensitive species, no T&E species, lower quality habitat) Score 3 T&E species likely to be in general area, medium to good quality habitat (e.g. Potentially suitable habitat, no T&E species from CNDDB in project area, but T&E species in adjacent areas) Score 4 Has T&E species, requires species specific surveys.Permit likely with mitigation (e.g. T&E species present, species specific surveys, permits likely and mitigation) Score 5 T&E species, extensive mitigation, likely opposition; alternative site recommended (e.g. T&E species, extensive mitigation, permit difficult to aquire)	edit

A standard scoring key was used for biological factors in a CEQA-based framework. Note that all use the range from Score 1 to Score 5. A score of F is also an option in this scoring regimen. Factors are weighted against each other in a separate step.
Image Credit: Facet Decision Systems, Inc.

This scoring approach organizes the evaluation of alternatives against a consistent multi-disciplinary framework that can be maintained across different projects and as project team members change. This makes scoring easier for evaluation teams and helps them be consistent as they integrate new information over the duration of an evaluation.

2.2.9.1 Results for the Palmdale Test

PACT provides GIS processing and modeling that can automatically generate results such as those shown in Subtests 2, 7, and 8. These automated analyses provide information to the study team in a consistent, well-organized structure that helps to support their analyses. PACT automated processing flagged CWHR range overlaps that were not shown in FSA figures.

However, it missed several species that were described in the FSA. If the data were not found in CNDDB or CWHR databases, the automated tools could not find them. PACT addresses this issue by also including tools for collecting, organizing and using expert judgment in the decision support process. This means that any information generated by fieldwork, or provided by subject-matter experts, is easily captured and incorporated into the tools. This is demonstrated in subtests 1, 3, 4, 6, and 9, which used PACT tools to capture and organize subject-matter expert information and incorporate it in a structured analysis. The subtests show that PACT can capture the same information that is found in the FSA narrative and tables.

In testing PACT, the project demonstrated that PACT can do the following:

- Capture the same types of information that are found in the FSA.
- Mimic the level of detail found in the FSA tables.
- Augment the FSA with a richer set of graphics and maps to support the conclusions of a study team.
- Augment the expert knowledge-driven decision making with automated processes that present preliminary results. Results of PACT automated analysis were tested for accuracy against the contents of CNDDB and CWHR. PACT accurately shows what is found in these databases. By themselves, these databases are not sufficient for decision-making and must be augmented with field visits and expert judgment.
- Incorporate both automated and expert-driven data and results into an integrated framework for transmission decision-making. Frameworks help with evaluation because they structure the process, integrating checklists of what needs to be assessed into the decision process (as illustrated in subtests 1, 2, 8 and 9, which use the framework to structure information). The PACT framework acts as a suggested list of evaluation criteria, which can be modified and augmented by the study team. Subject matter experts are best suited to identifying what parts of the framework pertain to an individual study area. The tests showed that the framework can accommodate many of the types of information found in the FSA.

2.3 Subtests Based on Analysis of the Entire DRECP Study Area

A second series of subtests was done looking at the entire DRECP study area. These subtests developed models based on data provided by DFG. Data comprised datasets such as CNDDB and CWHR data, and other information (that is, Mitigation Area Potential, Digital Elevation

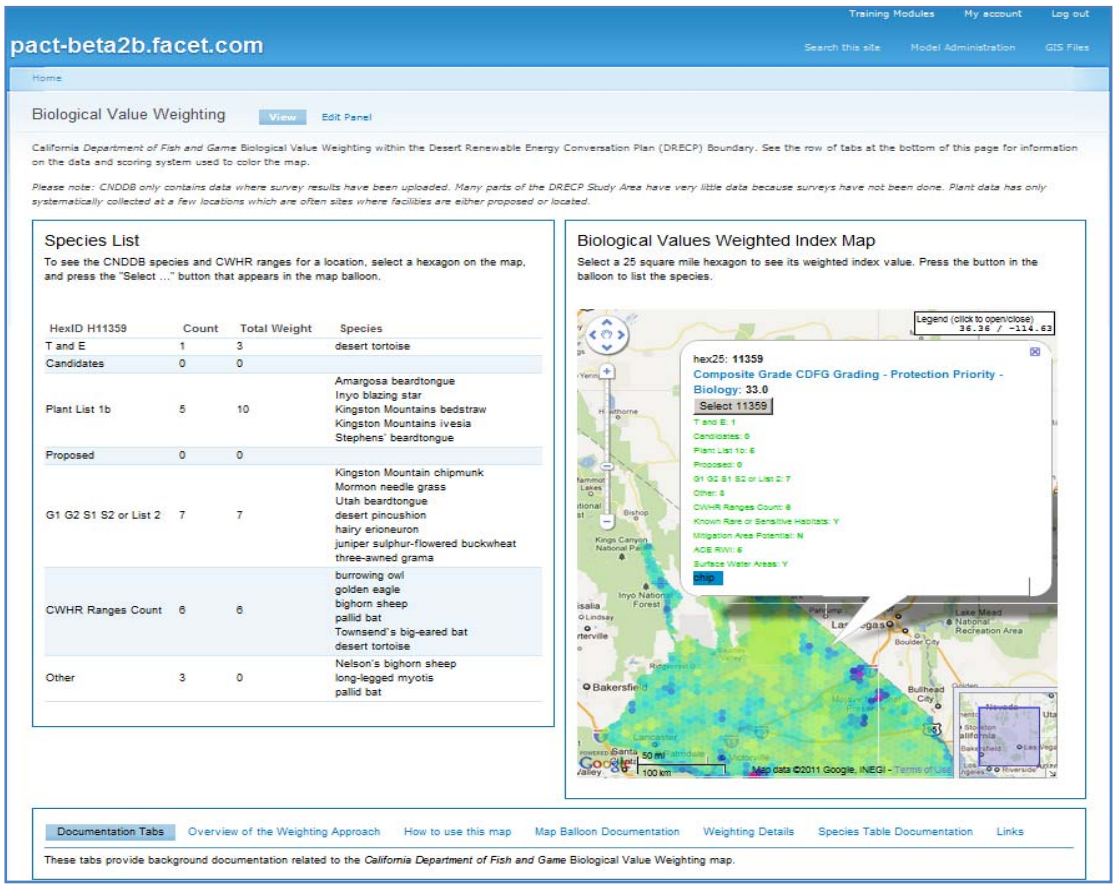
Model Data with derived slopes, and Surface Water Area datasets) assembled for DRECP analyses.

Most of the subtests were initially developed based on a 25 square mile hexagonal grid used by DFG for state-wide and large region analysis of spatial data. The models developed were then transferred to a higher resolution grid and then to a set of polygons showing the footprint of solar energy projects.

2.3.1 Subtest 10: Reporting on Species

This subtest integrated data from CNDDB and CWHR into a single dataset that was used to drive an interactive map. Selecting on the map triggered a balloon that listed counts of special-status species. A button in the balloon updated a report beside the map that listed the species for each set of lists.

Figure 10: Species Report Map Query



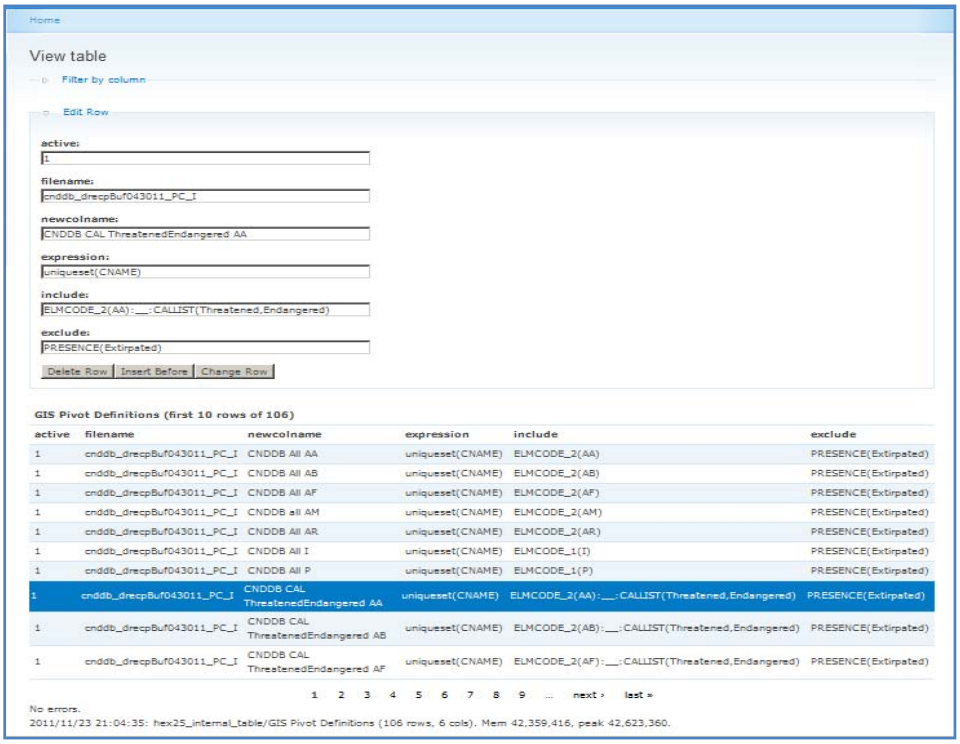
Selecting on the map opens a balloon that summarizes information available for the hexagon selected. Each hexagon contains a summary of CNDDB and CWHR data that were found inside it or intersected with it. The balloon summarizes the species count. The Species List Table shows the species details. The Total Weight Column calculates a weighted importance for the species in each list.
Image Credit: Facet Decision Systems, Inc.

This subtest highlighted an important issue with the technical datasets in general and CNDDB in particular. There were several apparent hot spots on the map that showed much higher species counts than the rest of the regions. Examination of these hot spots showed that they are all near solar installations or other facilities where extensive field surveys were required as part of the environmental review process. The DRECP area is so large that it has not been practical or economically feasible to survey all of it to the same level of detail. A naïve interpretation of this data could easily lead a stakeholder or member of the public to a wrong conclusion. Expert interpretation is needed for these datasets.

2.3.2 Subtest 11: Accessing CNDDB Data

CNDDB is a repository of biological data from many sources, developed using many different survey methods and acquired over many years. It is important that any model or tool using the dataset be configured to access the data properly so the results are meaningful. This subtest verified that PACT could access CNDDB data properly, skipping records that were not useful for a particular task and summarizing the data properly. PACT was able to access CNDDB and summarize it as needed for the modeling.

Figure 11: CNDDB Access Queries – Edit Row Form

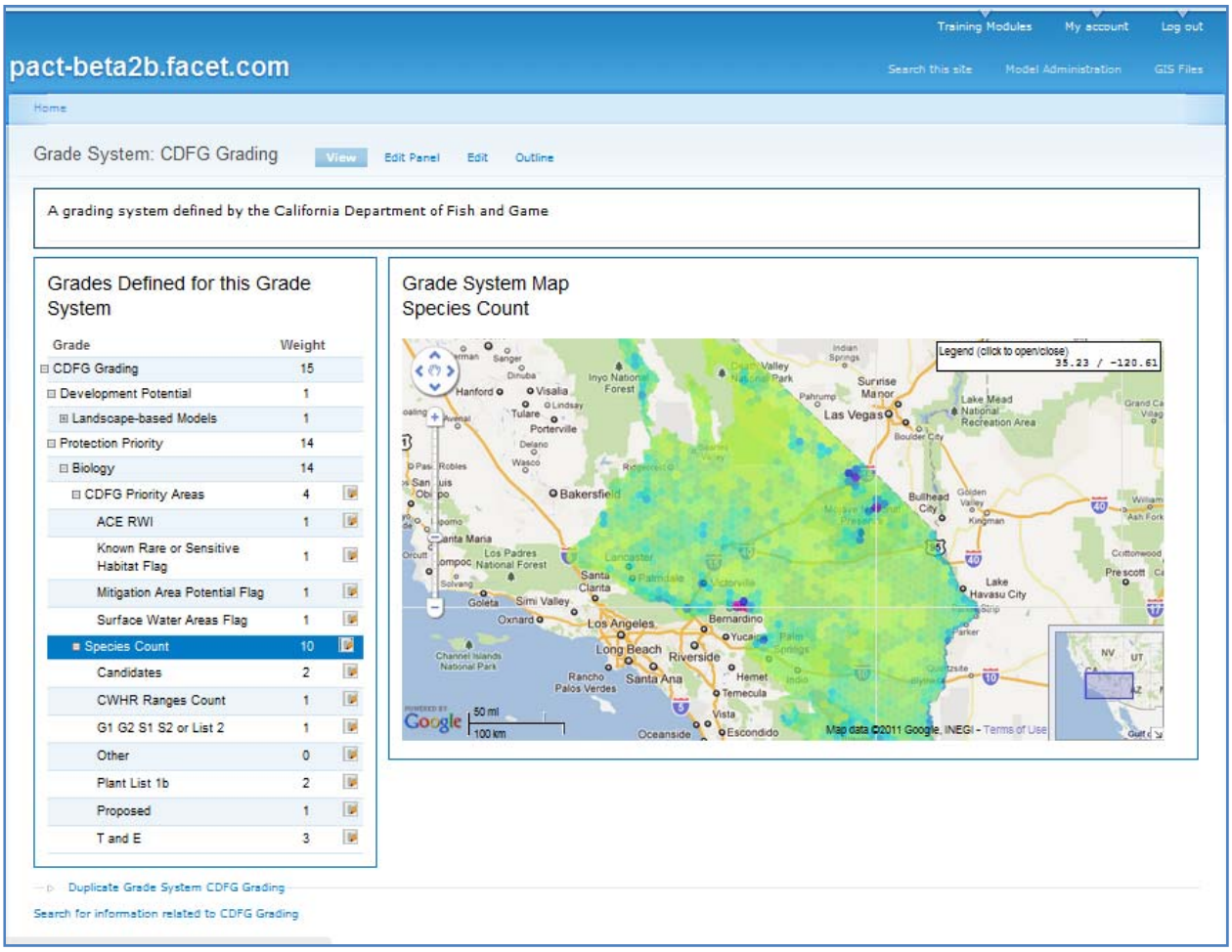


This set of input fields defines the query used to extract CNDDB data records for Amphibian Species. Note that records flagged extirpated are excluded from the results. The unique set in the Expression field builds a list of the species encountered. Other summaries count the number of CNDDB records encountered or even generate species-by-species summaries.
Image Credit: Facet Decision Systems, Inc.

2.3.3 Subtest 12: Replicating a Weighted Model for Special-Status Species

CNDDB identifies the federal and state list status for each species. Some lists indicate that the species has a higher protection priority compared to species on other lists. DFG has developed a series of weighted models based on the different lists. Several versions of weighted models were tested against CNDDB data and CWHR data combined. PACT was able to replicate the weighted models specified by DFG.

Figure 12: Model Weights



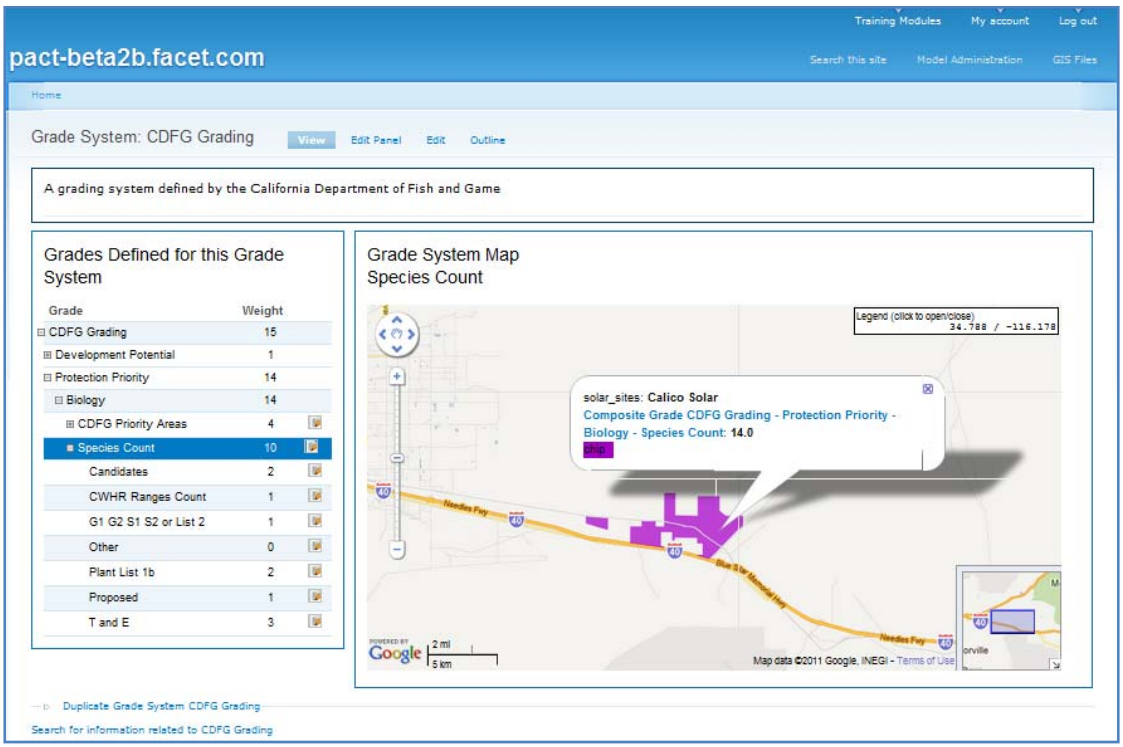
The weight column shows the relative weights assigned to different species lists. This weighted model was later extended to include species range information from CWHR and other datasets related to land use.
Photo Credit: Facet Decision Systems, Inc.

2.3.4 Subtest 13: Transferring Models between Datasets

One of the advantages of PACT's modeling approach is its ability to transfer the model logic developed for one geographic region or dataset onto another region or dataset. This allows the

subject domain expertise in a model to be reused easily. This subtest transferred the model developed for the 25 square mile hexagonal grid to a smaller grid and to a set of polygons. This subtest demonstrated that the model transferred successfully. Figure 13 below shows this.

Figure 13: Hexagonal Grid Model Logic Applied to Solar Polygons



The evaluation framework defined for the hexagonal grid in developed for subtest 13 was applied to a set of solar site polygons. Loading the polygons triggered the entire calculation and created this interactive map automatically.
Photo Credit: Facet Decision Systems, Inc.

2.4 Large Heterogeneous Datasets and Geographic Regions

The DRECP study area covers a large region of California, many parts of which lack detailed biological survey data. A few scattered areas of the DRECP study area, namely proposed renewable energy sites, have been surveyed intensively. For such areas, the CNDDB contains large data sets compared to other desert areas that have not been systematically surveyed and therefore have little to no available biological data and no consistent reporting of negative findings. Building web-based tools capable of presenting this amount of data and achieving reasonable performance is difficult.

2.4.1 Problems Encountered in the Previous Version (MapGuide Toolset)

The previous version of PACT had poor web performance on much smaller data sets than were encountered in the DRECP datasets. Performance problems included:

- Frequent crashes or freezing of the web browser.
- Occasional failure to paint maps that were loaded.
- Lock-up of mouse interactions.
- Inability to display large datasets.
- Large numbers of software bugs in the open source toolkit for preparing and displaying maps.
- Problems loading and processing data.
- Slow map rendering, which interfered with effective use of the tool.
- Poor handling of aerial photography and satellite images.
- Lack of good map background material.

2.4.2 Performance Optimization Alternatives Adopted

A multi-pronged approach was adopted to optimize the performance in applications such as this:

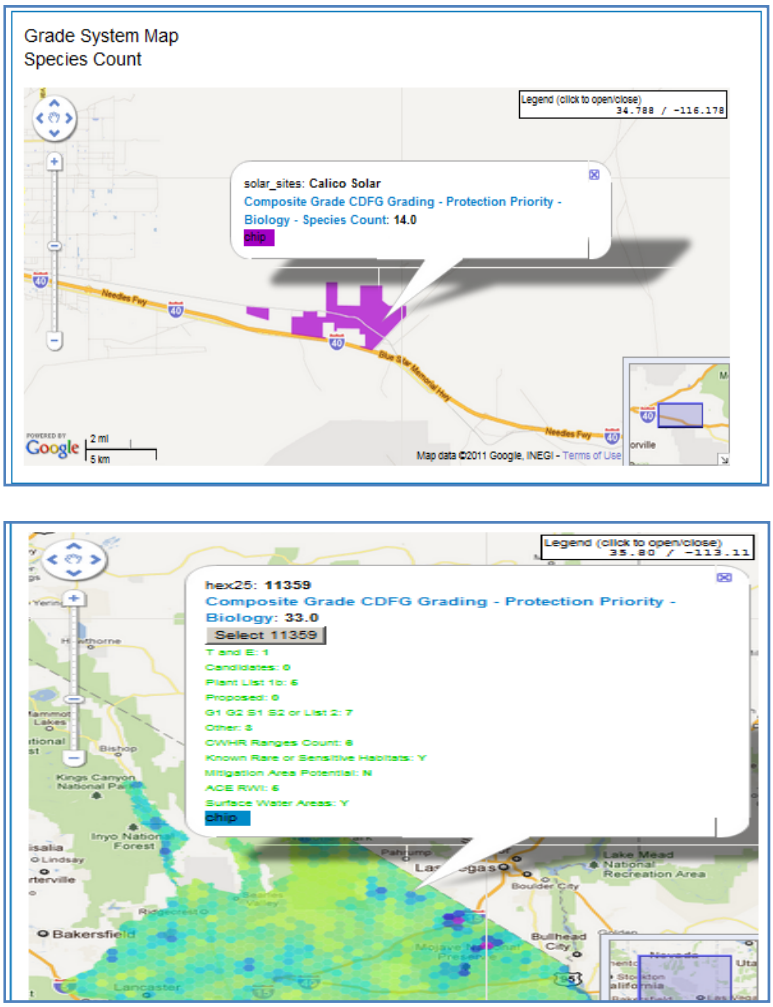
- The web-based toolset for rendering GIS data on the web must be extremely fast.
- Data sets must be tuned to be as small as possible to avoid transmission delays and reduce the amount of memory needed in the web browser.
- Multi-level caching strategies must be used to eliminate unnecessary reloads and retrieval of information.
- Processing must be optimized to achieve the right balance between work done on the server and work done on the PC where the browser is running.

2.4.3 Choices and Subtest Results

The project team replaced the open source MapGuide toolset used in the original version of PACT with Google Maps. This resulted in significant performance enhancements and much higher reliability.

Tuning the data sets to make them smaller was more problematic. The Google Maps data structures are efficient, but they are also more feature rich. The research team found it desirable to add much more text to the balloon content for the map features. This improved interaction and user utility but boosted the amount of data. The project team resolved this issue by setting the system up to be as flexible as possible, so that this trade-off between user interaction and data size could be made based on each unique user's set of requirements.

Figure 14: Comparison of Large and Small Map Balloon Help



Small balloon text on a small number of polygons uses fewer system resources than large balloon text for the entire hexagonal grid.

Image Credits: Facet Decision Systems, Inc.

One aspect of modern Internet applications is that they cache data that is likely to be asked for again in local memory or on local disk drives. This means that there is no need for the data to be retrieved over the Internet when it is asked for again. This approach is called multi-level caching. This concept seemed so promising that it was extended beyond just the Internet delivery of information to the browser; caching stages were defined throughout the entire process from loading GIS data initially, through the various transformation steps used to convert it into results, and finally to its presentation on the maps, in charts, and as tables on the website. Multi-level caching strategies worked extremely well in the new version of PACT.

The research team was able to do some optimization of the process and workflows to achieve a better balance between the server and client machines. This is an active area of research in the

industry as a whole, so more work would have to be done to achieve truly optimal performance. The website is able to deliver information significantly faster than the previous version and can support a much larger number of users.

2.4.3.1 Expanded User Roles and User Interface Requirements

The previous version of PACT was developed in a modeling environment called Cause & Effect. Cause & Effect is a powerful modeling environment specifically designed for building decision support tools that use maps and other spatial data.

The previous version of PACT supported three types of users:

Model Builder. A Cause & Effect user who constructed model logic and built interactive websites. This role was primarily played by Facet staff in the first project. Southern California Edison staff members were trained to do this and did create models in some cases. Technical Advisory Group members did not build models but were actively involved in the detailed design of all the model logic.

GIS Expert. A person who is deeply familiar with GIS concepts and could prepare data for use in the model and website. This role was played by Facet and Southern California Edison staff in the first project.

Stakeholder. A stakeholder or decision maker who used the website to compare alternatives and make choices. This role was played by all the other users in the first project.

2.4.3.2 New User Roles Identified for This Project

Working with the second team for this PACT validation project, we found that the above roles did not match the expertise or expectations of the new PACT users. This project's version of PACT was enhanced to support the following user types:

GIS Model Builder. DFG staff had deep GIS knowledge and an understanding of the GIS data standards and data used by their agency and other agencies in California. They became the primary source for all spatial data; however, they did not have time to learn Cause & Effect's GIS data loading and data conditioning tools, so Facet staff performed this function. This divided the GIS-related tasks between two user roles. DFG provided the data, and the Facet team did the loading and data conditioning. DFG, Aspen, and Energy Commission staff collaborated with Facet on data quality checks.

Casual User. A casual user is allowed to do simple exploration of prepared data sets on the website. Exploration involves simple queries or selecting areas or features on a map. This user is presented with a single webpage upon logging in and is restricted from seeing most of the website.

GIS Expert. The GIS expert's sole function is to find and load GIS data that matches website requirements. This is a much more restricted role than was found in the first project, but it better matches DFG's focus.

Presenter. A presenter acts as a mediator or facilitator, using the PACT website to explain data and alternatives to stakeholders and collect stakeholder input. This may be done in public meetings or workshops. This role is often played by Energy Commission staff members, who are familiar with the types of questions stakeholders will ask.

Site Administrator. A site administrator handles user access permissions and the overall administration of the site. This role was designed so it could be played by Aspen or Energy Commission staff. Facet staff members currently perform this role.

Subject Matter Expert. This is a domain expert who is tasked with providing expert judgment on alternatives. These users are expected to be experts in their subject area but not necessarily expert computer users. This role was played by Energy Commission and Aspen staff.

Subject Matter Expert Manager. This user is tasked with ensuring that a team of subject matter experts provides input on alternatives. This role requires access to reports showing the progress each subject matter expert is making in reviewing and scoring alternatives.

Trusted PHP Master. (Note: PHP is an acronym for Hypertext Preprocessor which is an HTML-embedded scripting language used for implementing websites). The PHP master is tasked with configuring the website's pages to support workflows for each role. Facet currently performs the PHP master role.

Model Builder. This user creates the underlying logic used to present data and represent alternatives in the website. Facet currently performs this role but has configured PACT so that Energy Commission staff can perform it in the future. The model builder is responsible for conditioning GIS data loaded by the GIS expert.

2.4.4 Approach Taken and Results

The research team implemented all these roles for both the DRECP and Palmdale PACT websites. User testing showed that where it was possible to match a user to an appropriate user role, PACT achieved good results. User responses were less positive when the user's experience and orientation did not match the role they were testing.

Facet's experience on other projects has shown that is best to use an iterative approach to refine user interfaces, especially for roles that have a limited scope. More sophisticated users want analysis power; less sophisticated users want ease of use. The only way to meet both these objectives is to separate user roles and provide custom interfaces for each role. The strategy was successful once the project team understood which roles were needed, but there is still room to refine the user interfaces for some of the roles.

2.5 Elimination of Solaris UNIX and Adoption of Open Source Tool Set

2.5.1 Issues

Solaris UNIX was the base platform for the original Cause & Effect tools used in PACT. At the time, this provided the most robust and powerful environment for developing spatial decision support tools. Since then, Solaris has lost its dominant position and other tools have improved

to the point where they are more cost-effective, more widely available, and easier to use and deploy.

Staying with Solaris UNIX would have limited functionality and long-term potential for PACT. Performance of some of the Solaris tools, especially the web-based mapping had become too restrictive and would not have met the performance requirements driven by the larger datasets used in the DRECP project. This would have severely limited the utility of the resulting tools, and limited the testing to impractically small datasets which violated the testing objectives of this project.

2.5.2 Approach Taken and Results

The research team chose to port existing PACT algorithms and model structure from Solaris to the new environment. The effort required was less than originally anticipated.

The advances in map handling, better support for multiple user roles, improved content management, and large data set processing would not have been feasible with the Solaris platform. The choice was well justified by the result.

2.6 Port to New Technology Base to Support Larger Data Sets

2.6.1 Issues

The original PACT project used MySQL as an underlying database to support the website. The Cause & Effect models were supported with a custom database design built on Solaris tools. This mix of technologies had performance problems when working with large data sets. The technical mix also made it difficult to enhance user interfaces on the websites.

The port from Solaris opened up an opportunity to use Drupal as a platform for managing both the modeling content and the website. Drupal is an extremely powerful open source web content management toolset and environment. Drupal is layered on MySQL which is a robust database which the project technical team knew would provide more than adequate performance.

2.6.2 Approach Taken and Results

Analysis showed that using Drupal would lower project risk and provide similar, if not better, performance to other approaches. The project results matched expectations. Larger numbers of users are being supported on much smaller server configurations than were needed in the first project. Drupal database tools are more than adequate to support data sets much larger than the ones used in the current project.

2.7 Training Approach

2.7.1 Issues

Many users of tools like PACT do not access the websites on a regular basis. They may use the tools intensely in short bursts to complete a project. After the short burst, they may not use the tools for months. This makes it very difficult for users because they tend to forget how to use the tools in the intervals.

2.7.2 Approach Taken and Results

The first PACT project in 2008 (Mary Beard Deming, 2008[3]) developed training manuals and training courses, which were given in person in California. Large classes of 20 people or more were brought together for one- or two-day workshops. Trainees left the workshops able to perform the basic tasks they were taught, such as defining factors or loading GIS data. However, they were unable to use the tools months later.

A review of alternate approaches found that most online software packages are using a combination of training exercises and video course modules. This combination of approaches has the advantage that people can review training before they have to use the systems. Training is always available and modules can be reviewed at any time. Many web tools augment training with extensive search capabilities, online help, and how-to descriptions.

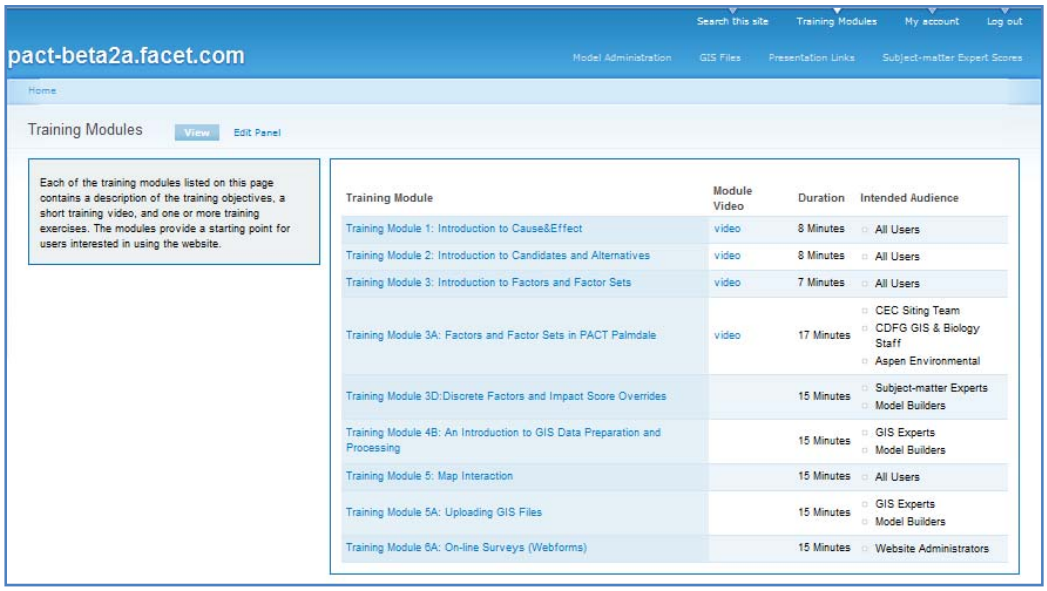
The research team chose to develop the following online resources instead of providing conventional training:

- Videos that explained the concepts behind the tool and demonstrated how the tool was used.
- A comprehensive search capability that can be used to find videos, training modules, how-tos and other documentation.
- Training exercises that provide step-by-step instructions on how to perform operations based around special training examples.
- How-to explanations that explain step-by-step processes using a general example.

Response to the online resources was very good. It is definitely better to integrate training into the online tools.

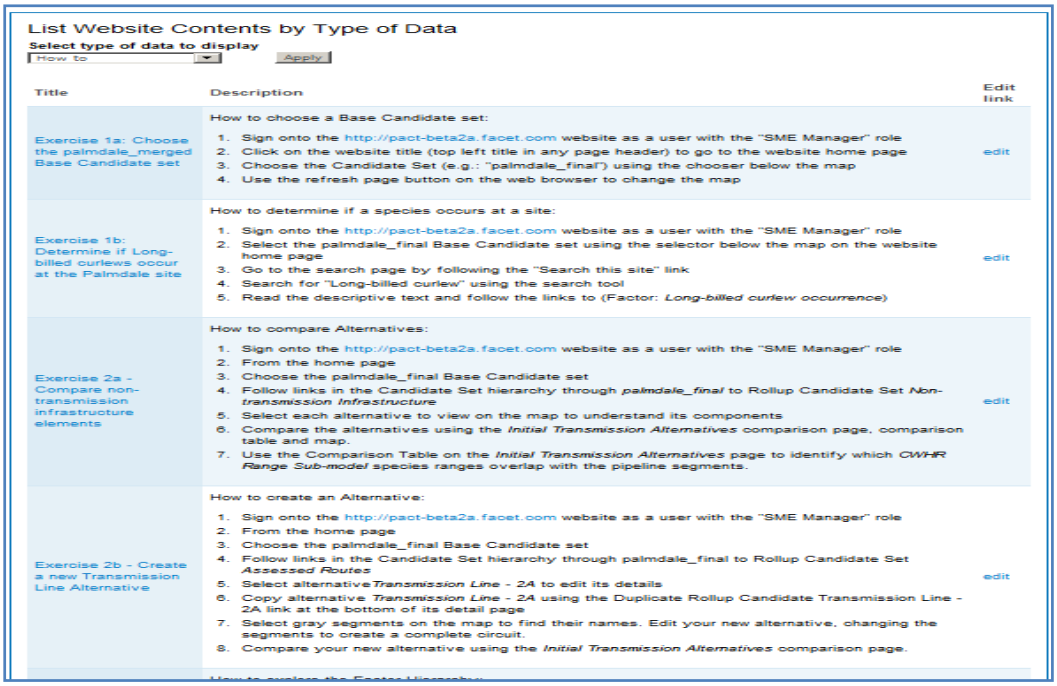
3 http://www.energy.ca.gov/2009publications/CEC-500-2009-079/CEC-500-2009-079.PDF

Figure 15: Website Training Modules



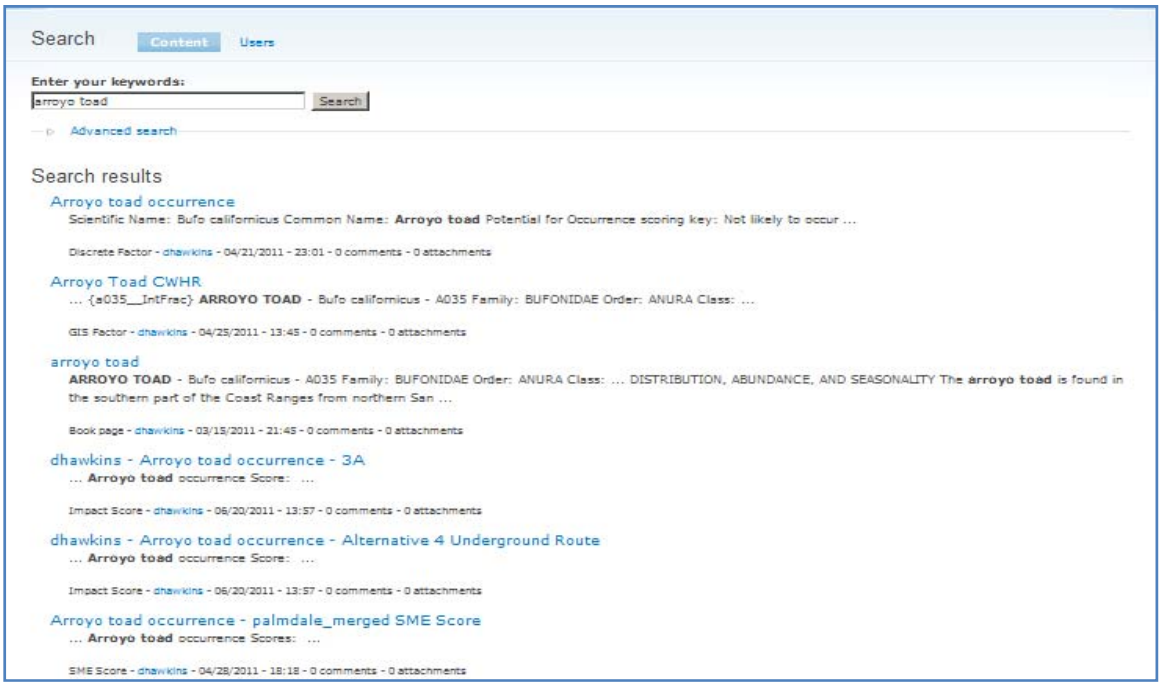
This page on the website shows a list of the training modules created for PACT, with a description of the intended audience and duration of video portions of the course.
Photo Credit: Facet Decision Systems, Inc.

Figure 16: PACT How-To Example



Four examples of How to descriptions of common tasks performed using PACT. These descriptions are quick recipe-like step-by-step instructions. The How-tos are accessed through links in other website content and by using the search facility on the websites.
Image Credit: Facet Decision Systems, Inc.

Figure 17: Example PACT Website Search



A powerful search facility lists website content, making it easy to find content related to specific topics.
Image Credit: Facet Decision Systems, Inc.

2.8 Testing Against California Department of Fish and Game Data While Meeting Siting Requirements

2.8.1 Issues

DFG staff members were very concerned that the tools built should properly represent CNDDB and other biological data correctly. As custodians of biological data for the state of California, the DFG is rightly concerned about proper data usage. This meant that every data load was scrutinized for interpretation errors in the Facet models.

This inverted Facet's normal approach to constructing decision support systems. The Facet team has found in other projects that it is best to work from the decision towards the data. Once a decision has been structured properly, the data can be fitted in place and tested for accuracy. However, accurate data are not required when developing the decision structure in the first place.

2.8.2 Approach Taken and Results

Facet started the project using its standard approach, but DFG staff members were uncomfortable with the way the data were being represented. They did not feel they could review any of the modeling until these issues were resolved. This inhibited Facet's ability to define roles and user interfaces.

The research team switched the project emphasis towards a sharp focus on DFG data sets. The research team was able to demonstrate that the tools used could properly represent DFG and other biological data. This was done by mimicking models that DFG had developed in support of DRECP and other initiatives.

While this testing was taking place, Facet developed and maintained a parallel test environment focused on transmission and substation siting while DFG data set subtests were being performed. This parallel test environment was used to ensure that Energy Commission siting requirements would be satisfied.

Once the project team had demonstrated that DFG data were loaded and interpreted properly, the parallel test environments were merged into a single website. The website was demonstrated to Energy Commission, DFG, and Aspen staff. Comments from that review were used to develop the refined set of user roles and use cases which guided the design for the final two Beta test sites.

Facet believes that the original approach would have achieved project objectives more quickly and at lower cost. The four months spent refine the data processing and integrating technical expert input made it challenging to make all the desired improvements to user interfaces for the two Beta tests.

CHAPTER 3:
Key Project Accomplishments

The port of PACT from UNIX was entirely successful and done at lower cost, faster, with lower effort than the original estimate. This is important to the future of PACT because supporting UNIX is expensive and wasteful of technical resources. The new PACT hosting environment is compatible with cloud hosting facilities that offer low-cost, highly scalable web hosting services.

Google Maps was found to be a significant enhancement over MapGuide. It is more robust, faster, easier to use, and has a much better applications programming interface. The simple link from Google Maps to Street view, which allows streetscape viewing, is one example of the type of benefits that accrued from the switch. The Google environment also comes with a large amount of extremely high quality map and image data that provides an ideal background for other map data as it is loaded. This provides context that makes the other data more meaningful.

PACT training materials are now fully integrated into the websites. This makes it easier for new users to learn how to use the tools and allows sporadic users to brush up on the tools before they use them after a hiatus. This is very important given the often sporadic use of tools, typical of many users. Project participants concluded that additional training materials may be needed.

Using Drupal has allowed PACT tools to implement a much richer suite of user interfaces than was possible in the previous version. This has made it possible for PACT to support different user roles with user interfaces that better match specific workflows. In the new version of PACT multiple user roles were documented, implemented, and refined. This was a step forward, because it allows PACT to support broader number of users, including people who have limited technical skills and people who are only sporadic users of the tools. Defining different user interfaces and workflows is crucial to the success of Internet-based decision support tools like PACT.

The switch to Drupal also enhanced PACT's ability to handle large and complex data sets. This is important in decision support systems that are used for important and complex decisions and comparisons.

The original project called for two Beta tests. In actuality, Facet developed five significant models with matching websites for testing the tools. Each of these test models was equivalent to plan scope of the original two. More Beta testing allowed Facet to develop a much more robust and powerful set of tools.

Given the breadth of tests and the ambitious objectives, the testing was remarkably successful. Issues that PACT encountered were resolved once the tool was configured properly. This demonstrates the tool's power and flexibility. The same PACT facilities support analysis, presentation, and user interaction facilities for region-wide and project-specific decisions.

The Palmdale portion of the test demonstrated that PACT has potential for use as a tool by Energy Commission staff and by electrical utilities developing transmission line and electrical infrastructure siting projects. The websites manage multi-disciplinary data and organize it into a structure that could aid analysis and increase consistency across evaluation teams, over extended timelines, and between projects.

3.1 Web-Delivered Results

Facet has delivered three Beta tests as websites accessible to Energy Commission staff:

- The first website, called http://PACT-beta1.facet.com, demonstrates the new modeling tools, Google Maps, model organization, Drupal, and the use of wizards as a mechanism for documenting how the tools are used.
- The second website, calledhttp://PACT-beta2a.facet.com, demonstrates PACT's use in transmission siting. This test mimics parts of the FSA for the Palmdale generation facility.
- The third website, called http://PACT-beta2b.facet.com, demonstrates PACT processing of CNDDB and CWHR data supplied by DFG.

Each of these sites includes a rich set of maps and documentation, training, search facilities, and user interfaces.

CHAPTER 4: Conclusion

The available choices of land for infrastructure development are diminishing, stakeholders (both internal and external) are engaged and concerned, and the cost of errors continues to escalate. News headlines are full of controversy about land use and infrastructure. The choices that are being made are subject to increased scrutiny by the general public, special interest groups, political forces, and corporate shareholders. Making good geographic use decisions, defending them, and getting stakeholders' buy-in have never been so important or more difficult.

Recent advances in Internet mapping and the increasing ubiquity of low-cost geographic data will continue to cut the costs of acquiring, managing and delivering data. Powerful graphics on computers, tablets and mobile phones now show interactive maps to wide audiences. These changes will revolutionize the way people, companies, and government agencies make land use and infrastructure decisions in several key ways:

- Data delivery used to require specialists who designed and created paper maps, each one a custom-built object designed for a specific use. Map design is now easier due to better tools, and delivery is now almost trivial for tool developers. Most mobile devices, and all Internet enabled computers can now show maps that only specialists could see only a decade ago.
- Data acquisition continues to be a major cost for most geographic decision processes; however, this is changing rapidly. Much of the cost comes from applying cartographic tools to make precise data where the precision either isn't needed, or provides a false sense of accuracy. This was highlighted in the Palmdale FSA where the likelihood of a species being present was applied to the entire project. Data acquired by the team in field visits had to be integrated in subject-matter expert's heads, because much of it was not represented digitally, or if it was, the digital version of the data was not incorporated into the FSA document. A smart phone with Geographic Positioning System (GPS) coordinates and a digital camera is an ideal tool for acquiring, digitizing and documenting much of the information that now has to go through a costly cycle of map making. The beta test showed this by using StreetView images to document transmission line segments. StreetView is another example of how these tools can drastically cut survey costs in many cases.
- People are now used to finding information online. This opens up new ways to communicate with stakeholders and decision makers by creating highly interactive tools for presenting and exploring data, information, and analytical results. This provides opportunities to educate people bit-by-bit as they need it. This PACT project demonstrated this approach with the user training videos and how to instructions.
- Moving the tools from the back room onto the Internet is a fundamental shift that is empowering stakeholders and non-technical decision makers. Historically, GIS work

happened on desktop computers using proprietary software that actively inhibits sharing of results. The tools are so hard to use they require months (or years) of specialized training. This is now changing. Map-making tools are now available for anyone with a web browser. The PACT Beta tests demonstrated this. Users can create their own maps, linking transmission line segments into complete circuits with a simple interactive tool. The simple act of linking the segments triggers an automatic analytical process that rates the segment against a set of criteria defined by experts. This coupling of naïve user interaction with expert judgement is a strong example of how tools will work in the future.

Most infrastructure and land use decisions boil down to choosing from a relatively small list of alternatives constrained by location, cost, and a broad set of multi-disciplinary factors. PACT takes full advantage of the new Internet infrastructure and data, allowing users to create and manipulate decision factors, do analysis, visualize data, present results to stakeholders, and support land use decisions. Tools like PACT can now interact with any part of a decision process. Everything from field data collection, analysis, visualization, interaction, presentation, stakeholder engagement, and ultimately decision making can be done wherever the Internet is accessible.

Due to the success of this project, PACT is now being used to design new energy infrastructure for the State of California and the Western Interconnect. This has potential for far-reaching benefits to the state's environment and its economy. This will ultimately help to improve economic opportunities and personal well-being for California residents.

GLOSSARY

CEQA	California Environmental Quality Act
CNDDB	California Natural Diversity Database
CWHR	California Wildlife Habitat Relationships
DFG	California Department of Fish and Game
DRECP	Desert Renewable Energy Conservation Plan
FACET	Facet Decision Systems
GPA	Grade Point Average
GPS	Geographic Positioning System
PACT	Planning Alternative Corridors for Transmission
Palmdale	Palmdale Hybrid Power Plant
PHP	Hypertext Preprocessor