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DOCKET
09-AFC-4
DATE SEP 28 2010
RECD. SEP 28 2010

September 28, 2010

Mr. Pierre Martinez
Siting Project Manager
California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Subject: Oakley Generating Station Project (09-AFC-4)
Supplemental Information Item #4: Revised Stormwater Drainage Design

Dear Mr. Martinez:

Attached please find three (3) hardcopies of the Supplemental Information Item #4: Revised Stormwater Drainage Design for the Oakley Generating Station (09-AFC-4). A revised Drainage, Erosion, and Sedimentation Control Plan reflecting these design changes will be filed at the Commission shortly.

If you have any questions about this matter, please contact me at (916) 286-0278.

Sincerely,

CH2M HILL

Douglas M. Davy, Ph.D.
AFC Project Manager

cc: POS List
Project File

Supplemental Filing

OGS Supplemental Information Item #4
Revised Stormwater Drainage Design

In support of the

Application for Certification

for

Oakley Generating Station Project

Oakley, California
(09-AFC-04)

Submitted to the:
California Energy Commission

Submitted by:

RADBACK ENERGY

With Technical Assistance by:

CH2MHILL
Sacramento, California

September 2010

BLACK & VEATCH

MEMORANDUM

Radback Energy
Oakley Generating Station (Tenaska)
Summary of Stormwater Modifications

B&V Project 163994
B&V File 14.0100
22 September 2010

To: Jim McLucas

From: Paul Nelson & Craig Kantola
PLN CAK

Philip Williams & Associates (PWA), consultant for the California Energy Commission (CEC), provided comments related to the proposed stormwater management system for the Oakley Generating Station project. The stormwater management system reviewed by PWA consisted of a network of bioswales designed in accordance with the recommendations and procedures outlined in the Contra Costa Clean Water Program's (CCCWP) Stormwater C.3 Guidebook.. Flood control is proposed within the existing wetland area and a proposed detention basin in the northwest corner of the site. This memo summarizes the overall proposed stormwater management concept and also documents adjustments to the stormwater model in response to PWA comments.

Flood Control for the project will still be provided within the existing wetland area and the proposed detention basin, which was expanded per PWA comments. The volume provided within these areas is sufficient to store the combined 100-year and 10-year runoff volumes without discharging stormwater off-site. PWA requested that the hydrologic modeling be updated to more clearly demonstrate the impact of directly connected impervious areas (DCIA) on the project site.

Wetland Hydrology is of importance to ensure that the existing wetland will be provided with a consistent source of stormwater runoff. The revised design includes the use of low-flow orifices placed within the bioswale and detention basin outlet structures to allow runoff from small storm events to reach the wetland area. The sizing of these orifices is discussed in the response to the PWA comments listed below.

Water Quality Treatment will be provided to stormwater runoff within the proposed bioswales and detention basin prior to discharging into the existing wetland area. Bioswale 1-2 was determined to be sufficiently sized in the previous PWA review and has not been revised. Bioswale 3 has been removed to allow expansion of the detention basin. Bioswales 4 and 5 were determined by PWA to be improperly sized. The stormwater plan for the site has been revised to result in two facilities for water quality treatment – Bioswale 1-2 (which has not been revised) and the detention basin (which provides treatment for the areas previously included within Bioswales 3, 4 and 5). Bioswale and basin sizing are based on CCCWP C.3 Guidebook. Calculations for each are included in B&V calculation 52.5406.1008 and are discussed in greater detail below.

Response to PWA Comments

<u>Wetland Hydrology – #1</u>
The proposed design has been revised to include low-flow orifices within the bioswale and pond outlet structures to allow passage of water through the system during smaller, frequent storm events. This change was made to address the concern that the wetland quality could suffer from a lack of runoff during smaller rain events where runoff was retained and infiltrated within the bioswales in the prior design approach. A result of adding the low-flow orifices is that in most rainfall events generating runoff, there will be more water directed into the wetland system than if the runoff was retained in the bioswales to infiltrate into the ground.

The bioswale low-flow orifice sizing is based on passing the water quality flow rate (defined as the flow generated by a rainfall intensity of 0.2 inches per hour) with one foot of head above the orifices. The pond orifice sizing is based on draining the water quality volume (WQV) from the

pond in approximately 24 hours. This approach allows stormwater runoff to be treated within the bioswale and pond areas without diminishing the wetland hydrology. See pages 24 to 27 of B&V calculation 52.5406.1007 for further details on the bioswale orifice sizing and pages 9a to 9b of B&V calculation 52.5406.1008 for further details on the pond orifice sizing.

Wetland Hydrology – #2
This comment was an observation, no changes to the analysis were requested in Comment #2. However the pond configuration was modified based on other PWA comments and the 0.33 ac-ft volume noted has been reduced. See response to PWA Water Quality Treatment Comment #5.

Wetland Hydrology – #3
The existing and proposed runoff models have been updated to reflect additional impervious areas within the PG&E yard as requested. As noted, this results in additional runoff from the PG&E site that crosses the project site and enters the wetland area. See pages 5 and 11 of B&V calculation 52.5406.1003 and pages 5a and 15a of B&V calculation 52.5406.1006 for further details.

Wetland Hydrology – #4
The existing and proposed runoff models have been updated to account for impervious areas that could be considered 'directly connected'. Previously all impervious areas were factored into the runoff curve number (CN) for each drainage area. The updated models have separated out a portion of the impervious area to reflect 'directly connected' conditions. It was estimated that generally 25 percent of the impervious areas within the power block site will be located near enough to the storm sewer system inlets to be considered directly connected. The result of this change was a slight increase in the runoff volume produced for each storm event, when compared to the previously submitted model and calculations. See pages 11 to 17 of B&V calculation 52.5406.1006 for further details.

Note that all of the storm sewers in the power block area are routed through bioswales and/or the detention pond prior to discharge into the wetland and are not directly connected to the wetland area. This offers an opportunity for runoff from all impervious surfaces to infiltrate into the ground before reaching the wetland.

Water Quality Treatment – #1 & #2
PWA suggested that the bioswale cross-sections be revised to a greater width in order to meet a 1-foot maximum treatment depth criterion. Due to space limitations and the desire to preserve existing woodlands, widening the bioswales is not preferred. As noted in the PWA letter, Bioswale 1-2 is sufficiently sized for its drainage area. The detention basin has been expanded to provide water quality treatment for the remaining areas. See response to Comment #5 below.

Water Quality Treatment – #2
The low-flow orifice design limits the capture and infiltration of runoff in the bioswales by allowing the water quality flow rate (the flow rate generated by a rainfall intensity of 0.2 in/hr) to pass with one foot of hydraulic head. See pages 24 to 27 of B&V Calculation 52.5406.1007 for further details.

Water Quality Treatment – #3
Gravel check dams will be installed within the bioswales to limit erosion and transport of soil mix within the bioswales during higher flow rates.

Water Quality Treatment – #4
B&V Calculation 52.5406.1008 has been revised to reflect the changes proposed for meeting water quality treatment criteria. Bioswale 1-2 sufficiently sized for its drainage area and did not require revision. Bioswale 3 has been removed and the detention pond expanded to capture runoff in that area. Bioswale 4 has not been revised. However, since the treatment depth is greater than one foot, the detention basin was designed to provide treatment for this area prior to discharge to the wetland. Bioswale 5 has been shortened and the detention pond expanded to capture and treat runoff from that area prior to discharge into the wetland. Bioswales 4 and 5 will provide additional treatment, particularly during construction, to limit sedimentation from construction activities from reaching the wetland.

Water Quality Treatment – #5
PWA suggested the pond berm be lowered by two feet, down to elevation 13.0, which is one foot above the computed high water level in the pond. In addition, PWA suggested the pond footprint be expanded to provide additional volume and treatment capacity for the WQV captured by undersized Bioswales 4 and 5.

The C.3 Guidebook offers a method to determine basin sizing required for 80% capture within the basin. The C.3 chart 'Unit Basin Storage Size for 80% Capture' is used and is based on the annual precipitation depth and directly connected impervious area within the drainage area.

B&V Calculation 52.5406.1008 pages 9a to 9c provide detailed calculations for the water quality treatment storage volume for the pond using the C.3 chart. The mean annual precipitation for the site is estimated at 12.5 inches, per Contra Costa County Department of Public Works Drawing B-166. The directly connected impervious area (DCIA) coverage is estimated at 50%, which includes paved and roof surfaces (accounted at 100% DCIA) and gravel surfaces (accounted at 50%). These values correspond to a 'Unit Basin Storage Size for 80% Capture' value of 0.025 feet from the chart. When multiplied by the area draining to the pond (12.02 acres), the resulting WQV = 0.30 ac-ft. This volume is detained in the pond at elevation 9.34 which is below the pond overflow elevation of 12.0. The water is released to the wetland via low flow orifices as noted below.

Water Quality Treatment – #6
As discussed in the telephone conversation with PWA on September 2, 2010, the WQV should drain from the pond within 24-48 hours. It was suggested that the pond should drain closer to 24 hours to maintain hydration of the existing wetland area. Low-flow orifices within the pond are provided to meet this criterion. B&V Calculation 52.5406.1008 page 9b demonstrates the time to dewater the WQV from the pond.

Given the high permeability of the Delhi Sand soils found in the area, any water below the low-flow orifices is expected to infiltrate in a short period of time. With three inches of depth below the orifices and permeability rate of 5.95 to 19.98 in/hr for Delhi Sand, any water below the orifices would infiltrate swiftly, minimizing the potential for mosquito production.

Stormwater Analysis for Wetland

BLACK & VEATCH

Calculation Record

Client Name: Radback Energy Page 1 of 53

Project Name: Tenaska Project No.: 163994

Calculation Title: Stormwater Analysis for Wetland

Calculation No./File No.: 52. 5406. 1003

Calculation Is: (check all that apply) ☐ Preliminary ☒ Final ☐ Nuclear Safety-Related

Objective To determine if the existing wetland at the Tenaska project site can retain the runoff of a 100-yr 24-hr storm without overflowing to other properties. The analysis is performed for pre-construction ground conditions at the site.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

See Page 2 of this calculation for additional assumptions.

This Section Used for Computer Generated Calculations

Program Name/Number: HEC-HMS Version: 3.3

Evidence of or reference to computer program verification, if applicable:

Bases or reference thereto supporting application of the computer program to the physical problem:

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	J Zhong Jimmy Zhong	March 5, 2009	PLNelson	6 MAR 09	PLNelson	6 MAR 09
1	J Zhong Jimmy Zhong	21 APR 09	PLNelson	21 APR 09	PLNelson	21 APR 09
2	C Kantola	8 Jun 10	PLNelson	10 JUN 10	PLNelson	10 JUN 10
3	C Kantola	9 Sept 10	PLNelson	16 Sept 10	PLNelson	16 Sept 10

Purpose

To determine if the existing wetland at the Tenaska project site can retain the runoff of a 100-year 24-hour storm without overflowing to other properties. The analysis is performed for pre-construction ground conditions at the project site. The existing wetland has no outlet structure.

References

1. Black & Veatch Drawings:
   - 163994-SS-3001, Rev. A, "Grading & Drainage - Site"
   - 163994-SS-3002, Rev. A, "Grading & Drainage - Site"
2. US Department of Agriculture; Urban Hydrology for Small Watersheds, 2nd Edition; Technical Release 55 (TR-55); June 1986.
3. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, User's Manual, Version 3.3; September 2008.
4. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, Technical Reference Manual; March 2000.
5. US Department of Commerce; Technical Paper No. 40; Rainfall Frequency Atlas of the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years; May 1961.
6. US Department of Agriculture, Natural Resources Conservation Service; Web Soil Survey; http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
7. Mays, L. W.; Stormwater Collection Systems Design Handbook, McGraw-Hill; 2001.
8. Black & Veatch Calculation, "IMP Sizing for Plant Area", File No. 52.5406.1002 Rev 0, Same project, March 2009 (Rev 1)
9. Contra Costa County Public Works Department; Mean Seasonal Isohyets (Dwg B-166) Precipitation Duration-Frequency-Depth Curves (100-YR) (Dwg B-159); 1977 (Rev 2)

Definition of Units and Constants

English units will be used.

Example of Common Unit Designations:

Rainfall amount in inches (in)
Drainage area in acres (ac)

Attachments

1. HEC-HMS Input
2. HEC-HMS Output
3. Reference 2 – Select Pages
4. Reference 6 – Select Pages

Summary

Based on the HEC-HMS analysis, the maximum water elevation in the wetland is determined to be EL ~~8.9~~ 8.9 (Rev 2) PLN 6/10/10 feet. The lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.5 feet. Based on the HEC-HMS analysis with current ground cover conditions, the stormwater runoff to the wetland will not overflow to other properties for a 100-year 24-hour storm. ~~Since the project site will be developed based on Contra Costa County's Stormwater C.3 Guidebook, the post development runoff will be no greater than pre-development runoff.~~ Rev 1

VOID Rev 2 PLN 6/10/10
See Calculations 52.5406.1006 & .1007 for further information on post development.

SUPERSEDED 9/7/10 CAK
SEE PAGE 3a

Summary

Based on the HEC-HMS analysis, the maximum water elevation in the wetland is determined to be EL 9.0 feet. The lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.5 feet. Based on the HEC-HMS analysis with current ground cover conditions, the stormwater runoff to the wetland will not overflow to other properties for a 100-year 24-hour storm.

See calculations 52.5406.1006 and .1007 for further information on post-development.

Hydrology Modeling – HEC-HMS

There is one drainage area that will drain to the wetland. See Page 5 for the boundary delineation of this area. This drainage area generally has four types of ground cover: (1) Vineyard, 19.85 acres; (2) Gravel Pavement, 3.96 acres; (3) Railroad Yard, 0.94 acres; and (4) Wetland, 0.40 acres. The total area of this drainage area is 25.15 acres (0.0393 mile^2). The measurements of the above areas were made by using AutoCAD.

The stormwater runoff to the wetland for a 100-year 24-hour storm event was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).

Section 1.0 Determine the Time of Concentration

Time of concentration (T_c) can be calculated as:

$$T_c = T_{sheet} + T_{shallow} + T_{channel} \qquad \text{(Ref. 4, Eq. 6-11)}$$

Where:

T_{sheet} = travel time in sheet flow;
$T_{shallow}$ = travel time in shallow concentrated flow;
$T_{channel}$ = travel time in open channels.

There is no open channel flow on this site. Thus $T_{channel} = 0$.

The flow path from the hydraulically most distant point of this drainage area to the wetland is identified as shown on Page 5.

The total flow length is measured to 1490 feet.

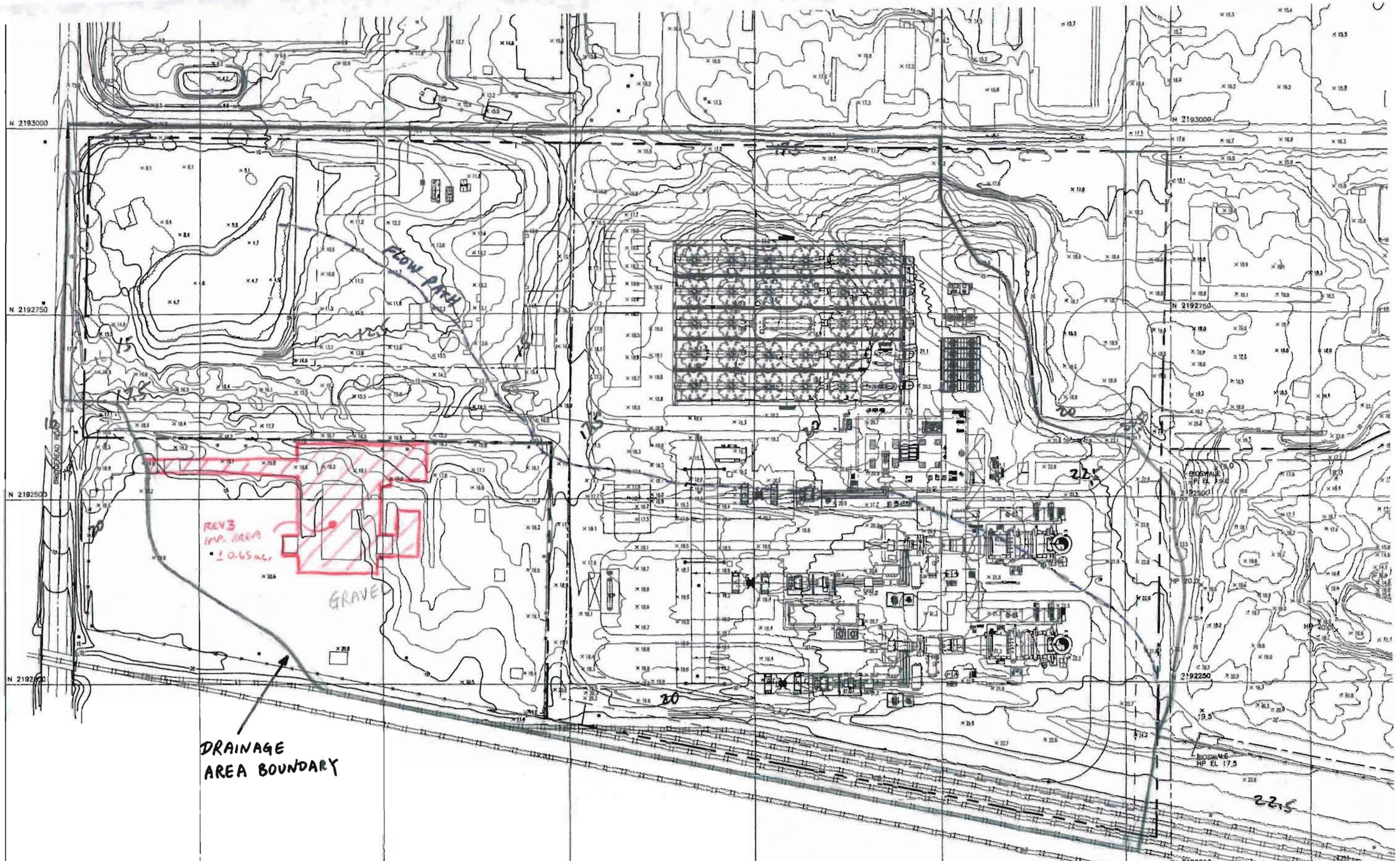
(1) Sheet Flow

Sheet flow travel time can be calculated as:

$$T_{sheet} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{(Ref. 2, Eq. 3-3)}$$

Where:

n = roughness coefficient;
L = flow length (ft);
P_2 = 2-year, 24-hour rainfall (in);
s = land slope (ft/ft).



Radback Tenaska project
project # 163994
52 5466.1003

stormwater Analysis
page 5 of 53

prepared by: J zhong
Date 3/4/09
checked by: PLW
Date: 3/6/09

REV 3 CAK
DATE 9/7/10
CK BY: PLW
DATE: 9/16/10

NOTE: THIS PAGE IS A PORTION OF B&V Drawing 163994-SS-300 Rev A.

AC4D 16.1s (LMS Tech)
1=1
29.17:10

0.06 (Rev. 2) PLN 6/10/10 < (Rev 2)

Roughness coefficient n = 0.~~17~~ for "cultivated soils, residue cover ~~≤~~ 20%". (Ref. 2, Table 3-1)

Existing conditions have sparse ground coverage based on aerial photos | Rev 2

Per Ref. 2, "After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow". Use sheet flow length L = 300 feet.

1.6 (Rev 2) PLN 6/10/10 9 (Rev 2)

2-year, 24-hour rainfall P_2 = ~~2~~ inch for this site per Ref. ~~5~~ (see Page 8).

The land slope for the first 300 feet = (24.2-21.5)/300 = 0.009 ft/ft. (Refer to Page 5)

0.06 (Rev 2) 0.37 (Rev 2)

Thus, $T_{sheet} = \dfrac{0.007 \times (0.\cancel{17} \times 300)^{0.8}}{\cancel{2}^{0.5} \times 0.009^{0.4}}$ = 0.~~76~~ hour.

1.6 (Rev 2) PLN 6/10/10

(2) Shallow Concentrated Flow

The flow length for shallow concentrated flow L = 1490-300 = 1190 feet.

The average watercourse slope = (21.5-5) / 1190 = 0.014 ft/ft. (Refer to Page 5)

Based on a slope of 0.014 ft/ft, from Ref. 2, Figure 3-1, the average velocity (V) for "unpaved" surface is found to be:

V = 1.9 ft/sec.

Thus the travel time for shallow concentrated flow is calculated to be:

$$T_{shallow} = \frac{L}{3600 \times V} = \frac{1190}{3600 \times 1.9} = 0.17 \text{ hour.}$$

In summary, the time of concentration is calculated to be:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$

= ~~0.76~~ + 0.17 + 0

(Rev 2) 0.37

= ~~0.93~~ hour.

0.54 hr (Rev. 2) PLN 6/10/10

Per Ref. 4, "For ungaged watersheds, the SCS suggests that the UH (unit hydrograph) lag time may be related to the time of concentration, T_c, as: $T_{lag} = 0.6\ T_c$". See Page 7.

The SCS UH lag time (T_{lag}) is an input parameter into the HEC-HMS computer program. Thus

T_{lag} = 0.6 x ~~0.93~~ = ~~0.56~~ hour = ~~33.6~~ minutes.

0.54 = 0.324 hr = 19.4 min (Rev. 2)

PLN 6/10/10

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UH can be found from the dimensionless form, which is included in HEC-HMS, by multiplication.

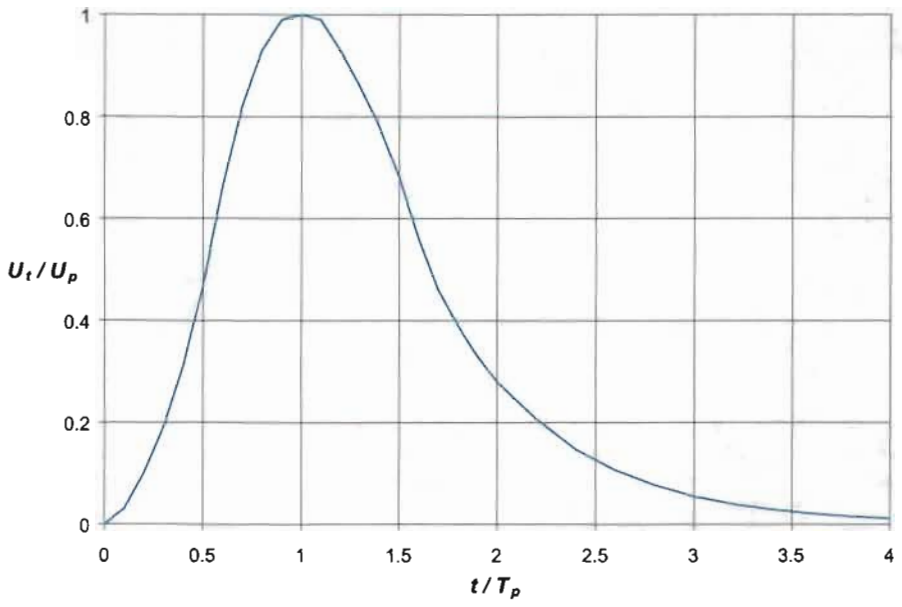

Figure 6-2. SCS unit hydrograph

Estimating the SCS UH Model Parameters

The SCS UH lag can be estimated via calibration, using procedures described in Chapter 9, for gaged headwater subwatersheds.

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$$t_{lag} = 0.6\, t_c \tag{6-10}$$

Time of concentration is a quasi-physically based parameter that can be estimated as

$$t_c = t_{sheet} + t_{shallow} + t_{channel} \tag{6-11}$$

where t_{sheet} = sum of travel time in sheet flow segments over the watershed land surface; $t_{shallow}$ = sum of travel time in shallow flow segments, down streets, in gutters, or in shallow rills and rivulets; and $t_{channel}$ = sum of travel time in channel segments.

NOTE: THIS PAGE IS FROM REF. 4.

Identify open channels where cross section information is available. Obtain cross sections from field surveys, maps, or aerial photographs. For these channels, estimate velocity by Manning's equation:

$$V = \frac{CR^{2/3}S^{1/2}}{n} \tag{6-12}$$

where V = average velocity; R = the hydraulic radius (defined as the ratio of channel cross-section area to wetted perimeter); S = slope of the energy grade

Figure 26

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

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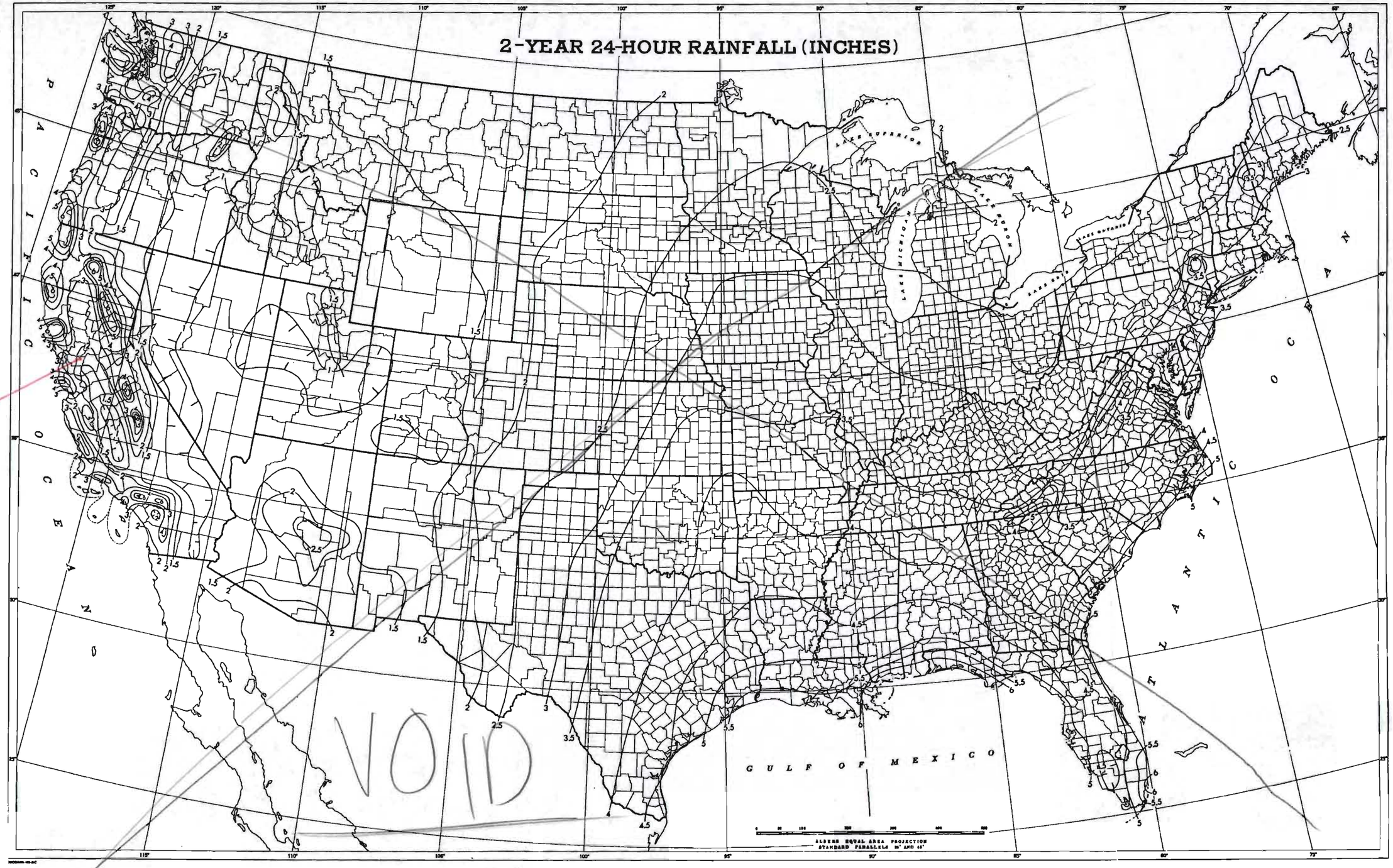
Note:
This page is from Ref. 9



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NOTE: THIS PAGE IS FROM REF. 5.

SUPERSEDED BY REV 2

Section 2.0 Rainfall Distribution

From Ref. 2, Figure B-2, the rainfall distribution for the site in Contra Costa County, California should be Type I distribution.

From Ref. 5, the 100-year 24-hour rainfall amount for the site is ~~4~~ 3.9 (Rev. 2) PLN 6/10/10 inches. (See Page 10) + 10A

Section 3.0 Determine the Composite SCS Curve Number

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area.

The drainage area generally has four types of ground cover: (1) Vineyard, 19.85 acres; (2) Gravel Pavement, 3.96 acres; (3) Railroad Yard, 0.94 acres; and (4) Wetland, 0.40 acres. The total area of this drainage area is 25.15 acres (0.0393 mile^2). The measurements of the above areas were made by using AutoCAD.

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". See Attachment 4. Per Ref. 2, this type of soil can be classified as Hydrologic Soil Group A soil.

Per Ref. 2, Table 2-2b, the curve number (CN) for "Row Crops, straight row (SR) with crop residue cover (CR)" for Group A soil is between 64 (good condition) and 71 (poor condition). Use the average curve number 68 for the vineyard area.

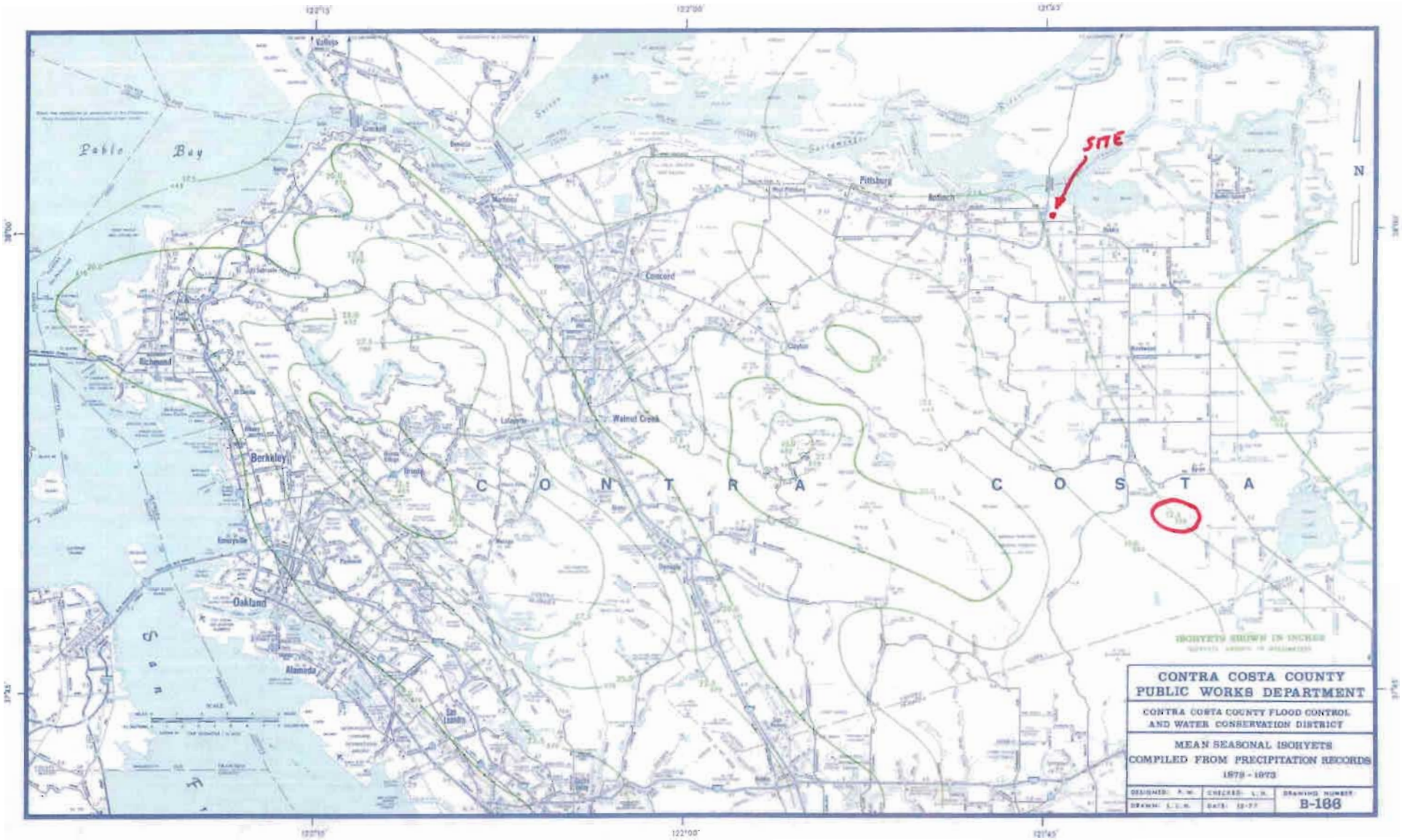
Per Ref. 2, Table 2-2a, the curve number for gravel area for Group A soil is 76. The ground cover in railroad yard is similar to the gravel area. Use the same curve number (76) for the railroad yard.

Treat the wetland as an impervious area since it may have standing water in it. Per Ref. 2, Table 2-2a, a curve number of 98 can be used for this area.

Thus the composite curve number (CN) for the drainage area is calculated as:

$$CN = (19.85 \times 68 + 3.96 \times 76 + 0.94 \times 76 + 0.40 \times 98) / 25.15 = 70.$$

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It



Rev 2

Radback Teraska Project
Stormwater Analysis

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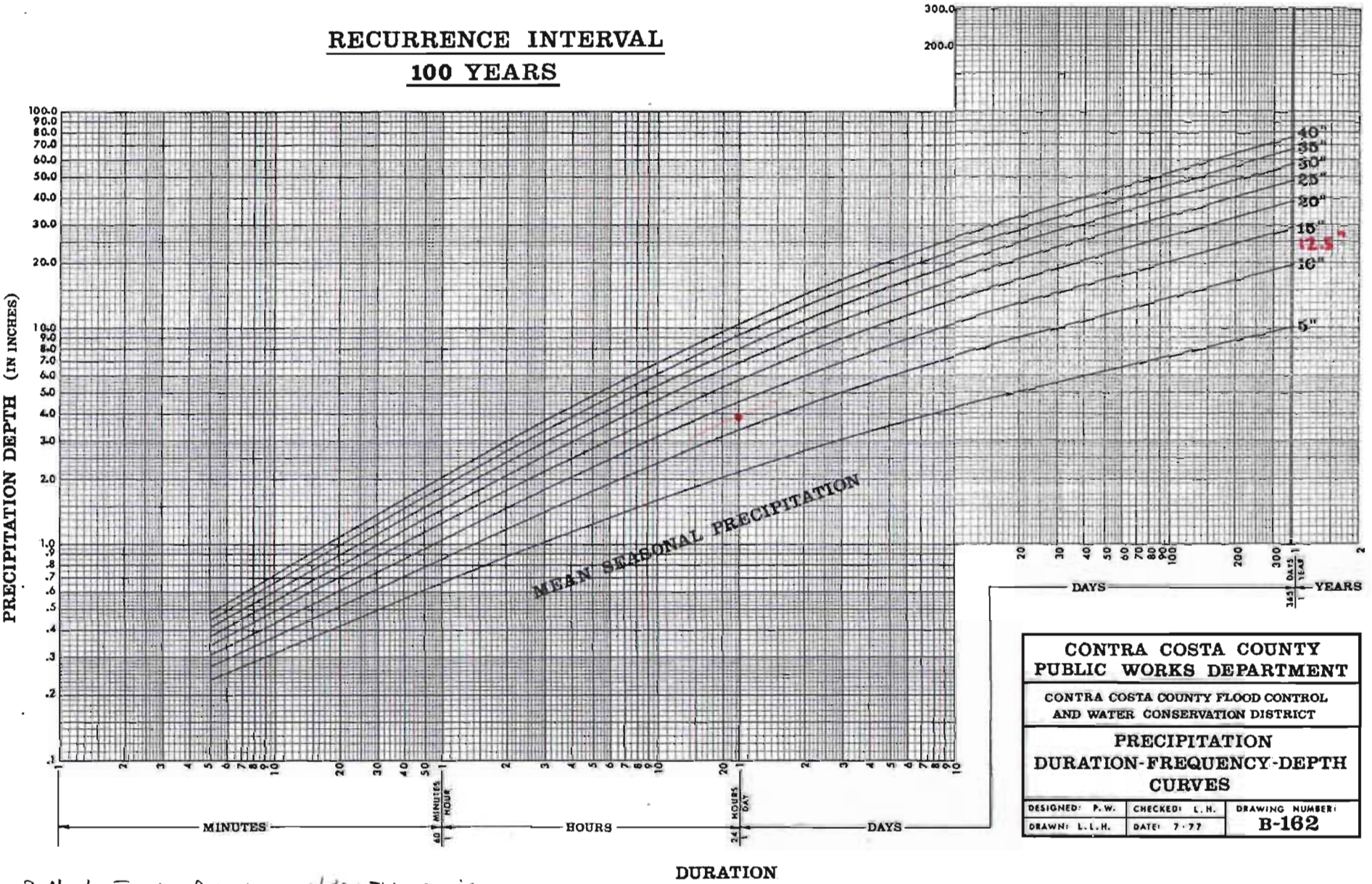
Note: this page is from Ref. 9

MSP = 12.5"



REV 2

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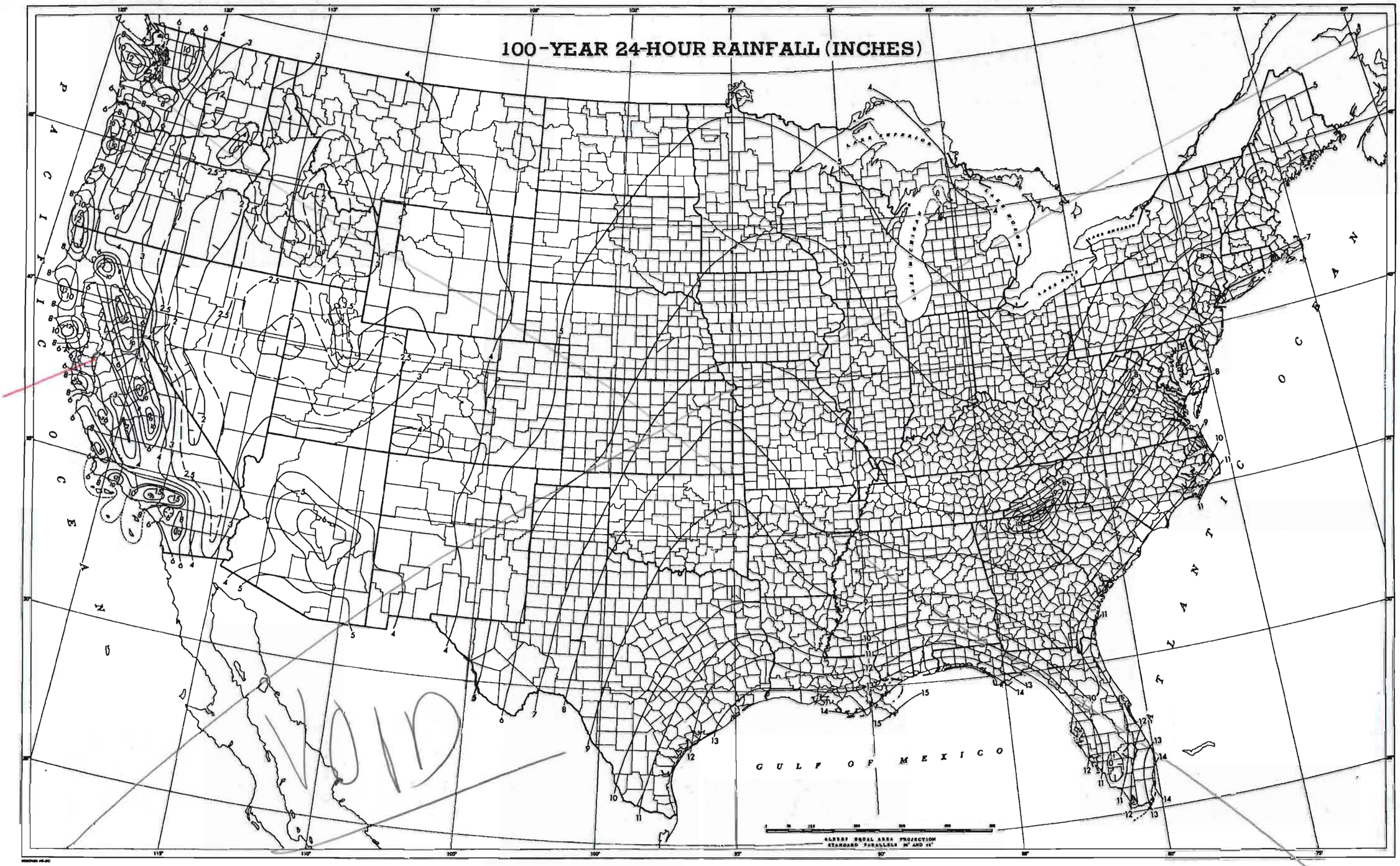
Note: This pg. is from Ref 9

MSP = 12.5" (DWG B-166)

24-HR = 3.9" (ABOVE)



Radback Tenaska project
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SUPERSEDED BY REV. 2

NOTE: THIS PAGE IS FROM REF. 5.

includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2)

Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 70, the initial abstraction is calculated to be:

$$I_a = 0.2 \times (1000/70 - 10) = 0.857 \text{ inch.}$$

and pavement

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. The impervious area consists of the roofs of a few small buildings in the southwest portion of the drainage area. By using AutoCAD, the total roof area is measured to be ~~0.17~~ acre. Thus,

% impervious = ~~0.17~~ / 25.15 = ~~0.68~~%, say ~~1~~%.

REV 3 0.65 / Pw 9/16/10

0.65/25.15 = 2.58% 2.6%

Section 4.0 Wetland Area versus Elevation

The bottom of the wetland is at an approximate elevation of 5 feet. See B&V Drawing SS-3001 (Page 5). The relationship of Area versus Elevation for the wetland area was presented in the table below. The wetland area was measured by using AutoCAD. It should be noted that a small portion of the wetland at the east side within the project property will be filled at a later time. This area will be graded at a 4 (H) to 1 (V) slope towards the wetland. The area in the table below at Elevation 10 (1.44 acres) has already had the future fill area been deducted to accurately model the wetland storage capacity.

Elevation (ft)	Wetland Area (acre)
5.0	0.40
7.5	0.62
10.0	1.44

Section 5.0 HEC-HMS Output

The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The initial water elevation in the wetland is specified to be at

EL 5 assuming that standing water in the wetland is not higher than EL 5 before the 100-year 24-hour storm begins.

The maximum water elevation in the wetland was calculated by running the HEC-HMS program.

The output results are included in Attachment 2 and are summarized below.

			(Rev 2)	(Rev 3)
Peak Inflow:	~~9.0~~ 11.8 ft^3/sec.	12.3		
~~Peak Storage~~ Total Runoff:	~~2.8~~ acre-feet	2.10 2.79	Pkw 6/10/10	
Peak Elevation:	~~9.1~~ 8.9 feet.	9.0		

Rev 1 ~~Reference 8 demonstrates that the developed project meets the requirements of Contra Costa County's Stormwater C.3 Guidebook. The basis of the C.3 guidebook is flow control and treatment of stormwater runoff. Hence, the post development runoff will be no greater than pre-development runoff.~~ VOID Rev 2 Pkw 6/10/10

Conclusion:

Based on the HEC-HMS analysis, the existing wetland will be able to contain all the runoff from its drainage area at current ground cover conditions for a 100-year 24-hour storm.

From B&V Drawing SS-3001, the lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.5 feet. Based on the HEC-HMS analysis, the stormwater runoff to the wetland will not overflow to other properties for a 100-year 24-hour storm. Rev 1 ~~Since the project site will be developed based on Contra Costa County's Stormwater C.3 Guidebook, the post development runoff will be no greater than pre-development runoff~~ VOID Rev 2 Pkw 6/10/10

SUPERSEDED 9/7/10 CAK

SEE PG 12a

EL 5 assuming that standing water in the wetland is not higher than EL 5 before the 100-year 24-hour storm begins.

The maximum water elevation in the wetland was calculated by running the HEC-HMS program.

The output results are included in Attachment 2 and are summarized below.

Peak Inflow:	12.3 ft^3/sec.
Total Runoff:	2.79 acre-feet
Peak Elevation:	9.0 feet

Conclusion:

Based on the HEC-HMS analysis, the existing wetland will be able to contain all the runoff from its drainage area at current ground cover conditions for a 100-year 24-hour storm.

From B&V Drawing SS-3001, the lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.5 feet. Based on the HEC-HMS analysis, the stormwater runoff to the wetland will not overflow to other properties for a 100-year 24-hour storm.

Radback Tenaska project
project # 163994

Stormwater Analysis

JZ 3/4/09

# of pages: 12
52.5406.1003

Including this page.

Attachment 1

HEC-HMS Input

Rev 3 all pages
PKW 16 Sept 10

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
      - Wetland
  - Meteorologic Models
    - Met 1
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

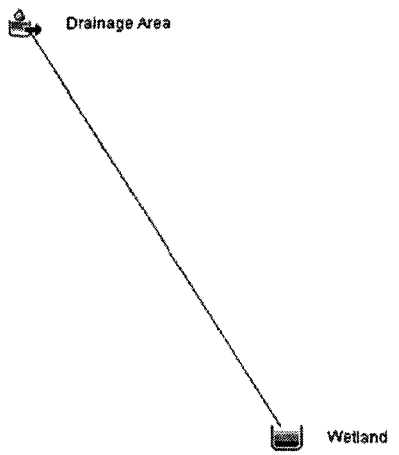
Components | Compute | Results

Subbasin | Loss | Transform | Options

Basin Name: Basin 1
Element Name: Drainage Area

Description:	Tenaska Site
Downstream:	Wetland
Area (MI2)	0.0393
Loss Method:	SCS Curve Number
Transform Method:	SCS Unit Hydrograph
Baseflow Method:	--None--

Basin Model [Basin 1] Current Run [Run 1]




```
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
NOTE 10184: Began computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
  - Control Specifications
  - Time-Series Data
  - Paired Data

Components | Compute | Results

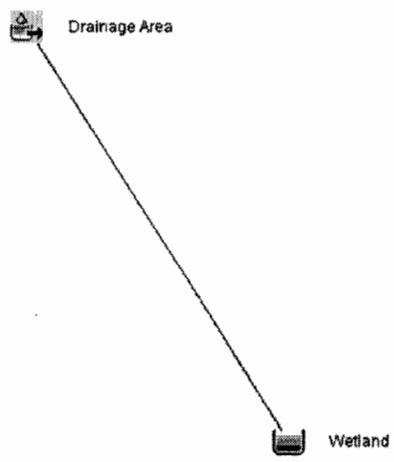
Subbasin | Loss | Transform | Options

Basin Name: Basin 1
Element Name: Drainage Area

Initial Abstraction (IN)	0.857
Curve Number:	70
Impervious (%)	2.6

REV3

Basin Model [Basin 1] Current Run [Run 1]



NOTE 10179: Opened basin model "Basin 1" at time 11Mar2009, 13:42:37.
NOTE 10181: Opened control specifications "Control 1" at time 11Mar2009, 13:42:56.
NOTE 10180: Opened meteorologic model "Met 1" at time 11Mar2009, 13:42:56.
NOTE 10184: Began computing simulation run "Run 1" at time 11Mar2009, 13:42:58.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 11Mar2009, 13:42:58.

start | Inbox - Microsoft Out... | HEC-HMS 3.3 [C:\hms... | 1:45 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
      - Wetland
  - Meteorologic Models
    - Met 1
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

Components | Compute | Results

Subbasin | Loss | Transform | Options

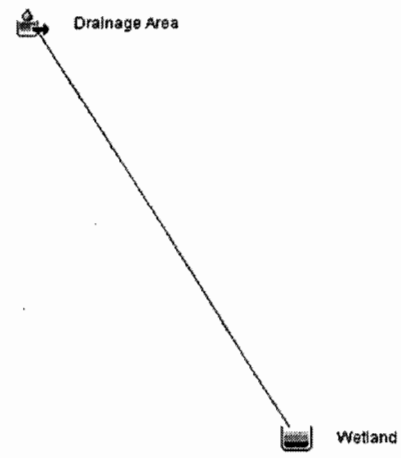
Basin Name: Basin 1
Element Name: Drainage Area

Graph Type: Standard

Lag Time (MIN) 33.000000

19.4 (Rev 2)

Basin Model [Basin 1] Current Run [Run 1]




```
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 2:22 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
      - Wetland
  - Meteorologic Models
    - Met 1
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

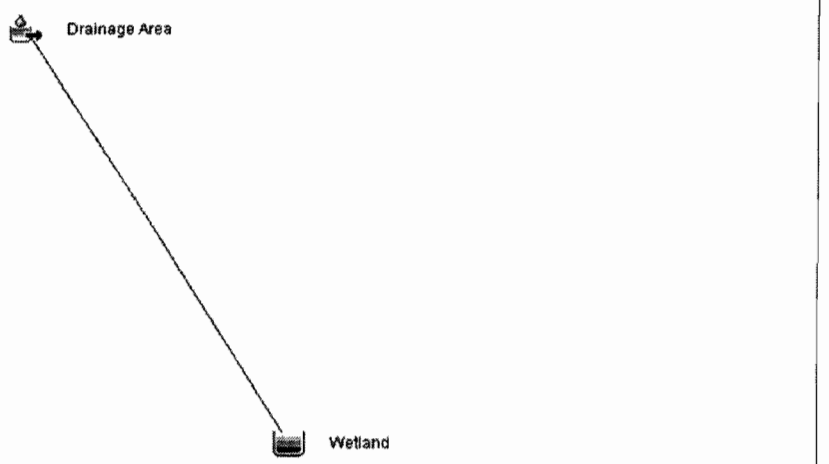
Components | Compute | Results

Subbasin | Loss | Transform | Options

Basin Name: Basin 1
Element Name: Drainage Area

Observed Flow: --None--
Observed Stage: --None--
Observed SWE: --None--
Elev-Discharge: --None--
Ref Flow (CFS)
Ref Label:

Basin Model [Basin 1] Current Run [Run 1]




```
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
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NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 2:22 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

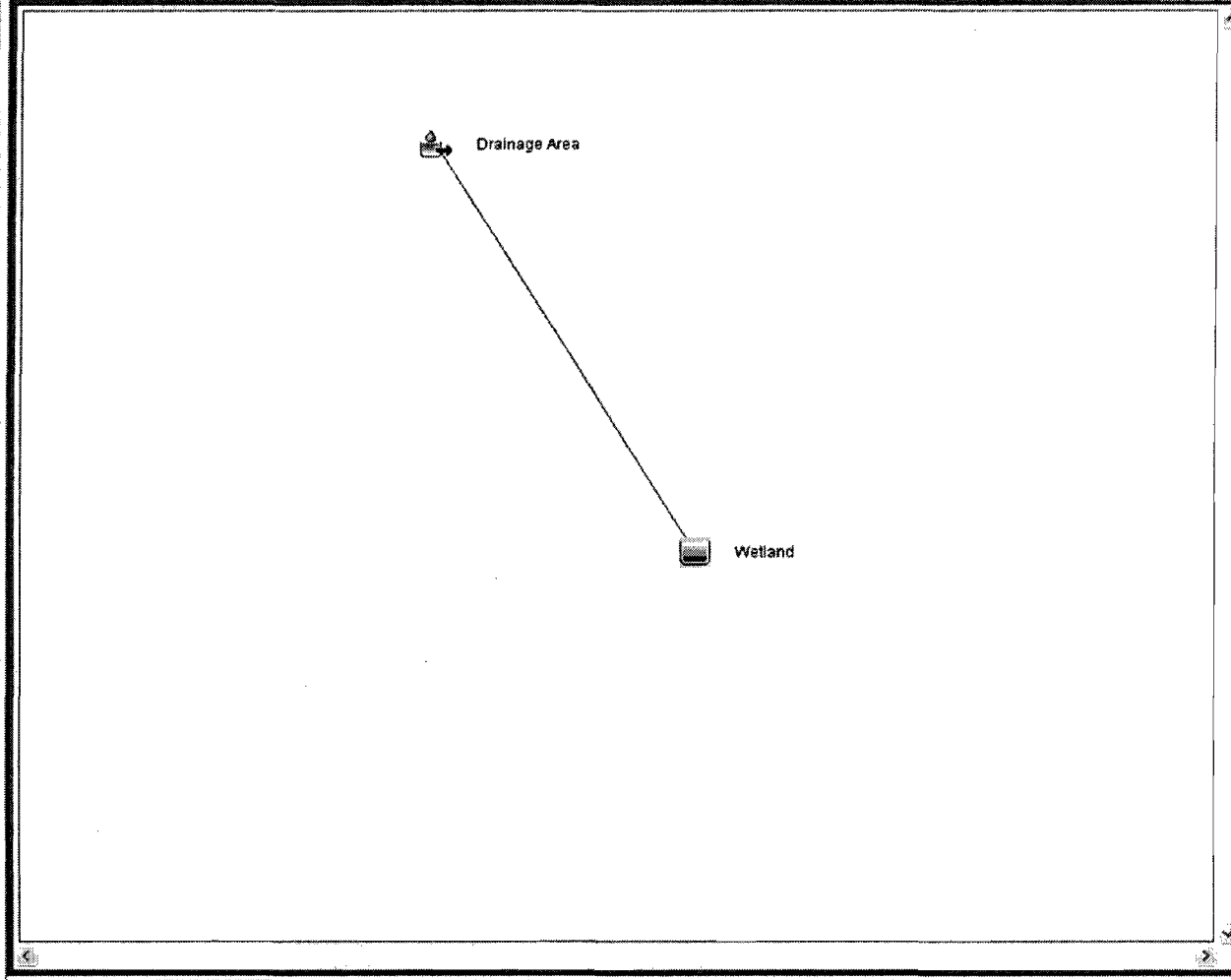
Components | Compute | Results

Reservoir | Options

Basin Name: Basin 1
Element Name: Wetland

Description:	Wetland Storage
Downstream:	<None>
Method:	Specified Release
Storage Method:	Elevation-Area
Elev-Area Function:	Reservoir-1(Basin 1)
Initial Condition:	Elevation
Initial Elevation (FT)	5.0
Discharge Gage:	Gage 1
Max Release (CFS)	
Max Capacity (AC-FT)	

Basin Model [Basin 1] Current Run [Run 1]

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NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

Start | HEC-HMS 3.3 [C:\hms... | Untitled - Paint | 2:24 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

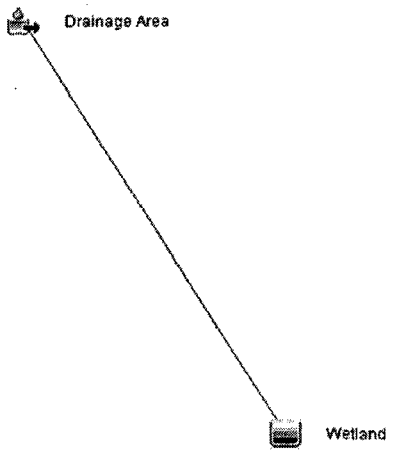
Components | Compute | Results

Reservoir | Options

Basin Name: Basin 1
Element Name: Wetland

Observed Flow: --None--
Observed Stage:
Observed Pool Elevation:
Elev-Discharge:
Ref Flow (CFS)
Ref Label:

Basin Model [Basin 1] Current Run [Run 1]




```
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 2:25 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
      - SCS Storm
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

Components | Compute | Results

Meteorology Model | Basins

Name: Met 1

Description: Antioch, CA (100-yr 24-hr storm)

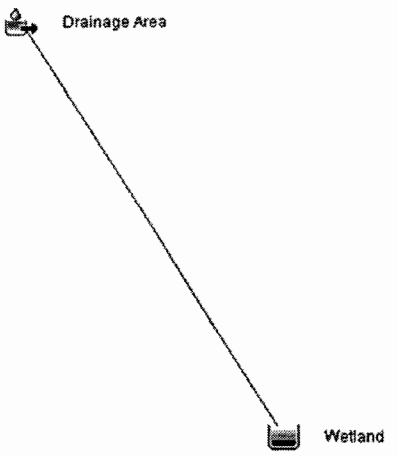
Precipitation: SCS Storm

Evapotranspiration: --None--

Snowmelt: --None--

Unit System: U.S. Customary

Basin Model [Basin 1] Current Run [Run 1]




```
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NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
      - SCS Storm
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

Components | Compute | Results

Precipitation

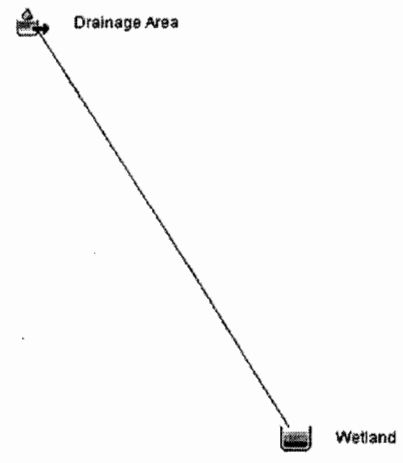
Name: Met 1

Method: Type 1

Depth (IN) 4.9

3.9 (Rev 2)

Basin Model [Basin 1] Current Run [Run 1]

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NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 2:27 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

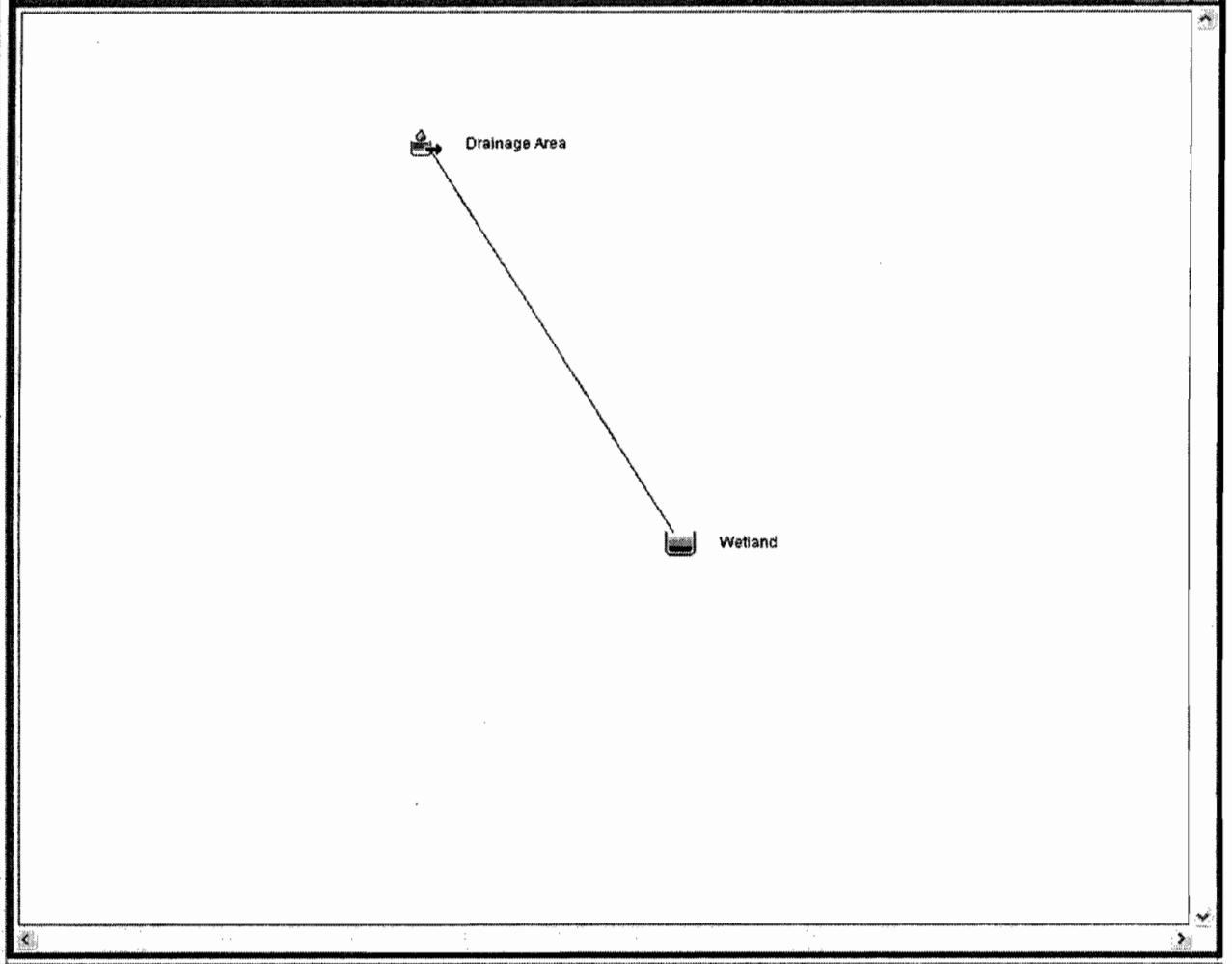
- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
      - SCS Storm
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
      - Gage 1
  - Paired Data
    - Elevation-Area Functions
      - Reservoir-1(Basin 1)

Components | Compute | Results

Paired Data | Table | Graph

Elevation (FT)	Area (AC)
5.0	0.40
7.5	0.62
10.0	1.44

Basin Model [Basin 1] Current Run [Run 1]




```
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
NOTE 10184: Began computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 2:29 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

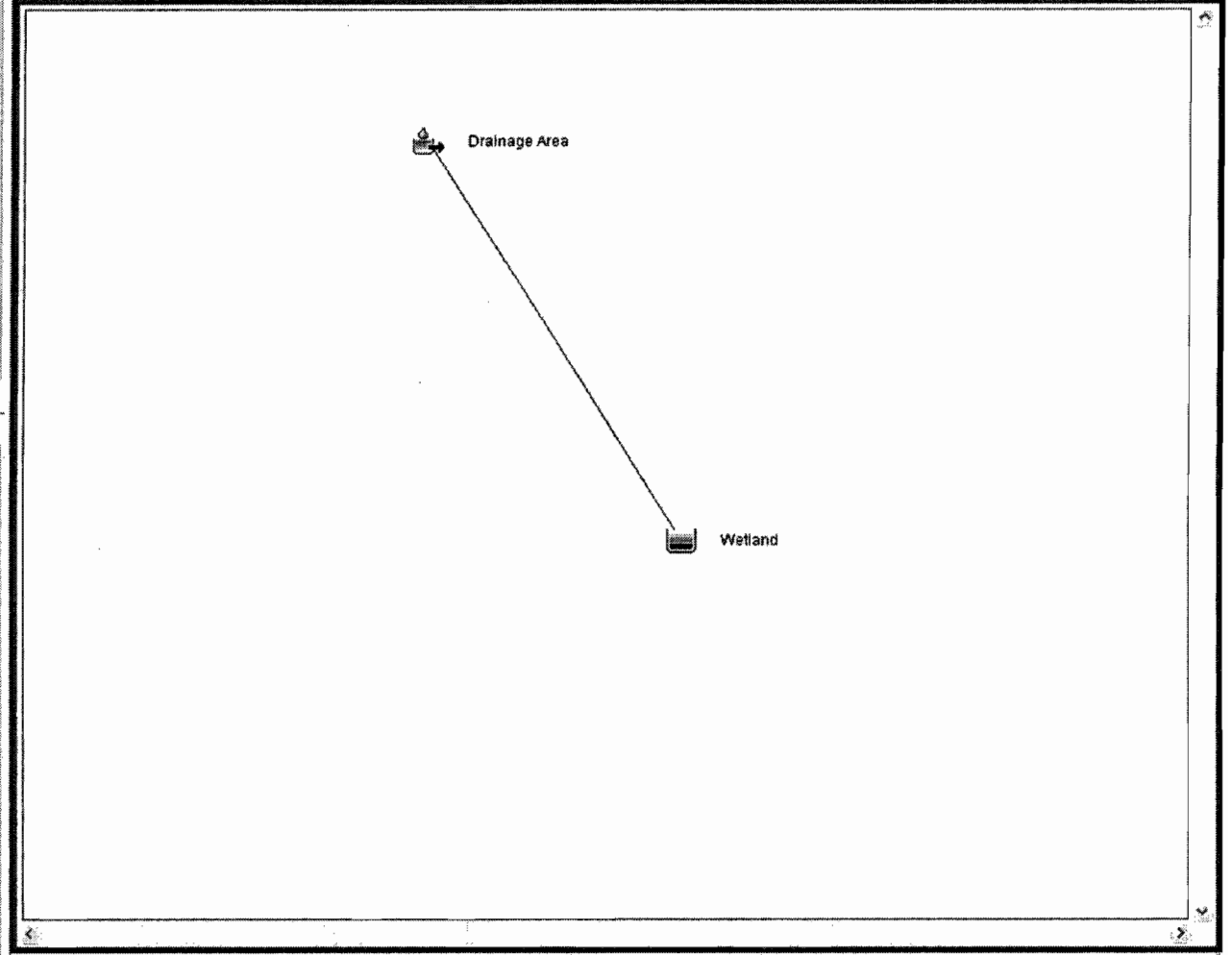
- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
      - SCS Storm
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
      - Gage 1
        - 10Jan2020, 06:00 - 12Jan2020, 06:00
  - Paired Data
    - Elevation-Area Functions
      - Reservoir-1(Basin 1)

Components | Compute | Results

Time-Series Gage | Time Window | Table | Graph

Time (ddMMMYYYY, HH:mm)	Discharge (CFS)
10Jan2020, 06:00	0.0
10Jan2020, 07:00	0.0
10Jan2020, 08:00	0.0
10Jan2020, 09:00	0.0
10Jan2020, 10:00	0.0
10Jan2020, 11:00	0.0
10Jan2020, 12:00	0.0
10Jan2020, 13:00	0.0
10Jan2020, 14:00	0.0
10Jan2020, 15:00	0.0
10Jan2020, 16:00	0.0
10Jan2020, 17:00	0.0
10Jan2020, 18:00	0.0
10Jan2020, 19:00	0.0
10Jan2020, 20:00	0.0
10Jan2020, 21:00	0.0
10Jan2020, 22:00	0.0
10Jan2020, 23:00	0.0
11Jan2020, 00:00	0.0
11Jan2020, 01:00	0.0
11Jan2020, 02:00	0.0
11Jan2020, 03:00	0.0
11Jan2020, 04:00	0.0
11Jan2020, 05:00	0.0
11Jan2020, 06:00	0.0

Basin Model [Basin 1], Current Run [Run 1]



NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
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NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 3:31 PM

HEC-HMS 3.3 [C:\hmsproj\Radback\Radback.hms]

File Edit View Components Parameters Compute Results Tools Help

- Radback
  - Basin Models
    - Basin 1
      - Drainage Area
        - SCS Curve Number
        - SCS Unit Hydrograph
        - No Baseflow
      - Wetland
  - Meteorologic Models
    - Met 1
      - SCS Storm
  - Control Specifications
    - Control 1
  - Time-Series Data
    - Discharge Gages
  - Paired Data
    - Elevation-Area Functions

Components | Compute | Results

Control Specifications

Name: Control 1

Description: Duration

Start Date (ddMMMYYYY): 10Jan2020

Start Time (HH:mm): 06:00

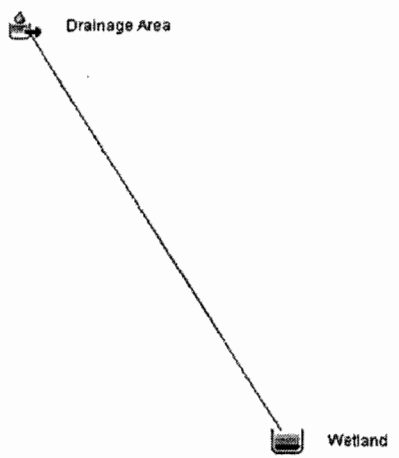
End Date (ddMMMYYYY): 12Jan2020

End Time (HH:mm): 06:00

Time Interval: 6 Minutes

3 (Rev 2)

Basin Model [Basin 1] Current Run [Run 1]




```
NOTE 10181: Opened control specifications "Control 1" at time 05Mar2009, 14:14:46.
NOTE 10179: Opened basin model "Basin 1" at time 05Mar2009, 14:14:46.
NOTE 10180: Opened meteorologic model "Met 1" at time 05Mar2009, 14:14:47.
NOTE 10184: Began computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
NOTE 20364: Found no parameter problems in meteorologic model "Met 1".
NOTE 40049: Found no parameter problems in basin model "Basin 1".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Run 1" at time 05Mar2009, 14:14:48.
```

start | HEC-HMS 3.3 [C:\hm... | untitled - Paint | 2:28 PM

Radback Tenaska Project stormwater Analysis JZ 3/4/09

project # 163994

# of pages: ~~15~~ 18

52.5406.1003

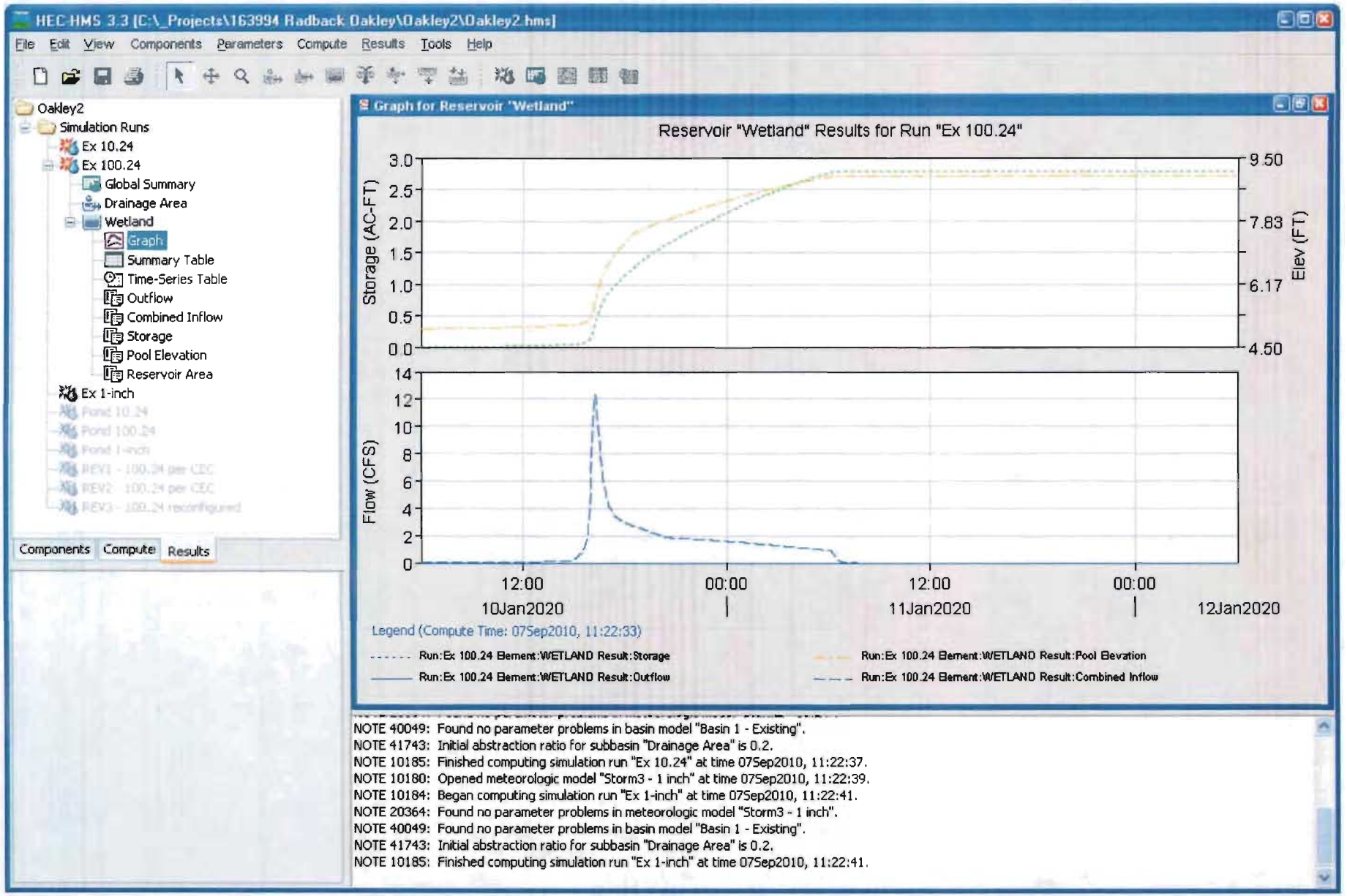
Rev 3 9/7/10

All Pages

CAK

Attachment 2

HEC-HMS Output


HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Oakley2
Simulation Runs
Ex 10.24
Ex 100.24
Global Summary
Drainage Area
Wetland
Graph
Summary Table
Time-Series Table
Outflow
Combined Inflow
Storage
Pool Elevation
Reservoir Area
Ex 1-inch
Components Compute Results
Graph for Reservoir "Wetland"
Reservoir "Wetland" Results for Run "Ex 100.24"
Storage (AC-FT)
Elev (FT)
Flow (CFS)
12:00
00:00
10Jan2020
11Jan2020
12Jan2020
Legend (Compute Time: 07Sep2010, 11:22:33)
Run:Ex 100.24 Element:WETLAND Result:Storage
Run:Ex 100.24 Element:WETLAND Result:Pool Elevation
Run:Ex 100.24 Element:WETLAND Result:Outflow
Run:Ex 100.24 Element:WETLAND Result:Combined Inflow
NOTE 40049: Found no parameter problems in basin model "Basin 1 - Existing".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Ex 10.24" at time 07Sep2010, 11:22:37.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 07Sep2010, 11:22:39.
NOTE 10184: Began computing simulation run "Ex 1-inch" at time 07Sep2010, 11:22:41.
NOTE 20364: Found no parameter problems in meteorologic model "Storm3 - 1 inch".
NOTE 40049: Found no parameter problems in basin model "Basin 1 - Existing".
NOTE 41743: Initial abstraction ratio for subbasin "Drainage Area" is 0.2.
NOTE 10185: Finished computing simulation run "Ex 1-inch" at time 07Sep2010, 11:22:41.

REV 3

Project: Oakley2
Simulation Run: Ex 100.24 Reservoir: Wetland

Start of Run: 10Jan2020, 06:00 Basin Model: Basin 1 - Existing
End of Run: 12Jan2020, 06:00 Meteorologic Model: Storm1 - 100.24
Compute Time: 07Sep2010, 11:22:33 Control Specifications: Control 1

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	06:00	0.0000	0.000	5.00	0.0000
10Jan2020	06:03	0.0003	0.000	5.00	0.0000
10Jan2020	06:06	0.0011	0.000	5.00	0.0000
10Jan2020	06:09	0.0028	0.000	5.00	0.0000
10Jan2020	06:12	0.0057	0.000	5.00	0.0000
10Jan2020	06:15	0.0097	0.000	5.00	0.0000
10Jan2020	06:18	0.0144	0.000	5.00	0.0000
10Jan2020	06:21	0.0193	0.000	5.00	0.0000
10Jan2020	06:24	0.0240	0.000	5.00	0.0000
10Jan2020	06:27	0.0282	0.000	5.00	0.0000
10Jan2020	06:30	0.0318	0.001	5.00	0.0000
10Jan2020	06:33	0.0347	0.001	5.00	0.0000
10Jan2020	06:36	0.0368	0.001	5.00	0.0000
10Jan2020	06:39	0.0385	0.001	5.00	0.0000
10Jan2020	06:42	0.0398	0.001	5.00	0.0000
10Jan2020	06:45	0.0409	0.001	5.00	0.0000
10Jan2020	06:48	0.0418	0.001	5.00	0.0000
10Jan2020	06:51	0.0424	0.002	5.00	0.0000
10Jan2020	06:54	0.0428	0.002	5.00	0.0000
10Jan2020	06:57	0.0432	0.002	5.00	0.0000
10Jan2020	07:00	0.0435	0.002	5.00	0.0000
10Jan2020	07:03	0.0438	0.002	5.00	0.0000
10Jan2020	07:06	0.0440	0.003	5.00	0.0000
10Jan2020	07:09	0.0442	0.003	5.01	0.0000
10Jan2020	07:12	0.0444	0.003	5.01	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	07:15	0.0447	0.003	5.01	0.0000
10Jan2020	07:18	0.0449	0.003	5.01	0.0000
10Jan2020	07:21	0.0450	0.003	5.01	0.0000
10Jan2020	07:24	0.0451	0.004	5.01	0.0000
10Jan2020	07:27	0.0451	0.004	5.01	0.0000
10Jan2020	07:30	0.0452	0.004	5.01	0.0000
10Jan2020	07:33	0.0452	0.004	5.01	0.0000
10Jan2020	07:36	0.0452	0.004	5.01	0.0000
10Jan2020	07:39	0.0451	0.005	5.01	0.0000
10Jan2020	07:42	0.0451	0.005	5.01	0.0000
10Jan2020	07:45	0.0451	0.005	5.01	0.0000
10Jan2020	07:48	0.0451	0.005	5.01	0.0000
10Jan2020	07:51	0.0451	0.005	5.01	0.0000
10Jan2020	07:54	0.0450	0.005	5.01	0.0000
10Jan2020	07:57	0.0450	0.006	5.01	0.0000
10Jan2020	08:00	0.0450	0.006	5.01	0.0000
10Jan2020	08:03	0.0450	0.006	5.01	0.0000
10Jan2020	08:06	0.0451	0.006	5.01	0.0000
10Jan2020	08:09	0.0451	0.006	5.01	0.0000
10Jan2020	08:12	0.0453	0.007	5.01	0.0000
10Jan2020	08:15	0.0454	0.007	5.01	0.0000
10Jan2020	08:18	0.0456	0.007	5.01	0.0000
10Jan2020	08:21	0.0457	0.007	5.01	0.0000
10Jan2020	08:24	0.0459	0.007	5.01	0.0000
10Jan2020	08:27	0.0461	0.008	5.01	0.0000
10Jan2020	08:30	0.0463	0.008	5.02	0.0000
10Jan2020	08:33	0.0466	0.008	5.02	0.0000
10Jan2020	08:36	0.0469	0.008	5.02	0.0000
10Jan2020	08:39	0.0473	0.008	5.02	0.0000
10Jan2020	08:42	0.0476	0.009	5.02	0.0000
10Jan2020	08:45	0.0478	0.009	5.02	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	08:48	0.0481	0.009	5.02	0.0000
10Jan2020	08:51	0.0484	0.009	5.02	0.0000
10Jan2020	08:54	0.0487	0.009	5.02	0.0000
10Jan2020	08:57	0.0490	0.010	5.02	0.0000
10Jan2020	09:00	0.0494	0.010	5.02	0.0000
10Jan2020	09:03	0.0497	0.010	5.02	0.0000
10Jan2020	09:06	0.0501	0.010	5.02	0.0000
10Jan2020	09:09	0.0505	0.010	5.02	0.0000
10Jan2020	09:12	0.0509	0.011	5.02	0.0000
10Jan2020	09:15	0.0513	0.011	5.02	0.0000
10Jan2020	09:18	0.0517	0.011	5.02	0.0000
10Jan2020	09:21	0.0521	0.011	5.02	0.0000
10Jan2020	09:24	0.0525	0.011	5.02	0.0000
10Jan2020	09:27	0.0529	0.012	5.02	0.0000
10Jan2020	09:30	0.0534	0.012	5.02	0.0000
10Jan2020	09:33	0.0538	0.012	5.02	0.0000
10Jan2020	09:36	0.0543	0.012	5.02	0.0000
10Jan2020	09:39	0.0547	0.012	5.02	0.0000
10Jan2020	09:42	0.0550	0.013	5.03	0.0000
10Jan2020	09:45	0.0554	0.013	5.03	0.0000
10Jan2020	09:48	0.0557	0.013	5.03	0.0000
10Jan2020	09:51	0.0560	0.013	5.03	0.0000
10Jan2020	09:54	0.0563	0.014	5.03	0.0000
10Jan2020	09:57	0.0567	0.014	5.03	0.0000
10Jan2020	10:00	0.0570	0.014	5.03	0.0000
10Jan2020	10:03	0.0574	0.014	5.03	0.0000
10Jan2020	10:06	0.0578	0.015	5.03	0.0000
10Jan2020	10:09	0.0582	0.015	5.03	0.0000
10Jan2020	10:12	0.0585	0.015	5.03	0.0000
10Jan2020	10:15	0.0589	0.015	5.03	0.0000
10Jan2020	10:18	0.0592	0.016	5.03	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	10:21	0.0594	0.016	5.03	0.0000
10Jan2020	10:24	0.0597	0.016	5.03	0.0000
10Jan2020	10:27	0.0599	0.016	5.03	0.0000
10Jan2020	10:30	0.0602	0.017	5.03	0.0000
10Jan2020	10:33	0.0603	0.017	5.03	0.0000
10Jan2020	10:36	0.0604	0.017	5.03	0.0000
10Jan2020	10:39	0.0605	0.017	5.03	0.0000
10Jan2020	10:42	0.0606	0.018	5.03	0.0000
10Jan2020	10:45	0.0607	0.018	5.04	0.0000
10Jan2020	10:48	0.0608	0.018	5.04	0.0000
10Jan2020	10:51	0.0610	0.018	5.04	0.0000
10Jan2020	10:54	0.0613	0.019	5.04	0.0000
10Jan2020	10:57	0.0616	0.019	5.04	0.0000
10Jan2020	11:00	0.0619	0.019	5.04	0.0000
10Jan2020	11:03	0.0621	0.019	5.04	0.0000
10Jan2020	11:06	0.0623	0.020	5.04	0.0000
10Jan2020	11:09	0.0624	0.020	5.04	0.0000
10Jan2020	11:12	0.0625	0.020	5.04	0.0000
10Jan2020	11:15	0.0626	0.020	5.04	0.0000
10Jan2020	11:18	0.0626	0.021	5.04	0.0000
10Jan2020	11:21	0.0627	0.021	5.04	0.0000
10Jan2020	11:24	0.0628	0.021	5.04	0.0000
10Jan2020	11:27	0.0628	0.021	5.04	0.0000
10Jan2020	11:30	0.0629	0.022	5.04	0.0000
10Jan2020	11:33	0.0631	0.022	5.04	0.0000
10Jan2020	11:36	0.0633	0.022	5.04	0.0000
10Jan2020	11:39	0.0634	0.022	5.04	0.0000
10Jan2020	11:42	0.0636	0.023	5.04	0.0000
10Jan2020	11:45	0.0638	0.023	5.05	0.0000
10Jan2020	11:48	0.0640	0.023	5.05	0.0000
10Jan2020	11:51	0.0643	0.023	5.05	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	11:54	0.0645	0.024	5.05	0.0000
10Jan2020	11:57	0.0647	0.024	5.05	0.0000
10Jan2020	12:00	0.0649	0.024	5.05	0.0000
10Jan2020	12:03	0.0651	0.025	5.05	0.0000
10Jan2020	12:06	0.0653	0.025	5.05	0.0000
10Jan2020	12:09	0.0654	0.025	5.05	0.0000
10Jan2020	12:12	0.0655	0.025	5.05	0.0000
10Jan2020	12:15	0.0657	0.026	5.05	0.0000
10Jan2020	12:18	0.0661	0.026	5.05	0.0000
10Jan2020	12:21	0.0667	0.026	5.05	0.0000
10Jan2020	12:24	0.0674	0.026	5.05	0.0000
10Jan2020	12:27	0.0683	0.027	5.05	0.0000
10Jan2020	12:30	0.0693	0.027	5.05	0.0000
10Jan2020	12:33	0.0704	0.027	5.05	0.0000
10Jan2020	12:36	0.0716	0.028	5.05	0.0000
10Jan2020	12:39	0.0728	0.028	5.06	0.0000
10Jan2020	12:42	0.0740	0.028	5.06	0.0000
10Jan2020	12:45	0.0753	0.029	5.06	0.0000
10Jan2020	12:48	0.0766	0.029	5.06	0.0000
10Jan2020	12:51	0.0779	0.029	5.06	0.0000
10Jan2020	12:54	0.0792	0.029	5.06	0.0000
10Jan2020	12:57	0.0805	0.030	5.06	0.0000
10Jan2020	13:00	0.0819	0.030	5.06	0.0000
10Jan2020	13:03	0.0833	0.030	5.06	0.0000
10Jan2020	13:06	0.0847	0.031	5.06	0.0000
10Jan2020	13:09	0.0861	0.031	5.06	0.0000
10Jan2020	13:12	0.0875	0.032	5.06	0.0000
10Jan2020	13:15	0.0887	0.032	5.06	0.0000
10Jan2020	13:18	0.0898	0.032	5.06	0.0000
10Jan2020	13:21	0.0907	0.033	5.06	0.0000
10Jan2020	13:24	0.0916	0.033	5.07	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	13:27	0.0924	0.033	5.07	0.0000
10Jan2020	13:30	0.0931	0.034	5.07	0.0000
10Jan2020	13:33	0.0937	0.034	5.07	0.0000
10Jan2020	13:36	0.0943	0.035	5.07	0.0000
10Jan2020	13:39	0.0949	0.035	5.07	0.0000
10Jan2020	13:42	0.0954	0.035	5.07	0.0000
10Jan2020	13:45	0.0959	0.036	5.07	0.0000
10Jan2020	13:48	0.0964	0.036	5.07	0.0000
10Jan2020	13:51	0.0969	0.037	5.07	0.0000
10Jan2020	13:54	0.0974	0.037	5.07	0.0000
10Jan2020	13:57	0.0978	0.037	5.07	0.0000
10Jan2020	14:00	0.0982	0.038	5.07	0.0000
10Jan2020	14:03	0.0987	0.038	5.08	0.0000
10Jan2020	14:06	0.0992	0.039	5.08	0.0000
10Jan2020	14:09	0.0999	0.039	5.08	0.0000
10Jan2020	14:12	0.1008	0.039	5.08	0.0000
10Jan2020	14:15	0.1020	0.040	5.08	0.0000
10Jan2020	14:18	0.1037	0.040	5.08	0.0000
10Jan2020	14:21	0.1059	0.041	5.08	0.0000
10Jan2020	14:24	0.1086	0.041	5.08	0.0000
10Jan2020	14:27	0.1119	0.042	5.08	0.0000
10Jan2020	14:30	0.1157	0.042	5.08	0.0000
10Jan2020	14:33	0.1199	0.043	5.08	0.0000
10Jan2020	14:36	0.1248	0.043	5.09	0.0000
10Jan2020	14:39	0.1306	0.044	5.09	0.0000
10Jan2020	14:42	0.1381	0.044	5.09	0.0000
10Jan2020	14:45	0.1483	0.045	5.09	0.0000
10Jan2020	14:48	0.1622	0.045	5.09	0.0000
10Jan2020	14:51	0.1804	0.046	5.09	0.0000
10Jan2020	14:54	0.2032	0.047	5.09	0.0000
10Jan2020	14:57	0.2309	0.048	5.09	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	15:00	0.2634	0.049	5.10	0.0000
10Jan2020	15:03	0.3005	0.050	5.10	0.0000
10Jan2020	15:06	0.3419	0.051	5.10	0.0000
10Jan2020	15:09	0.3879	0.053	5.10	0.0000
10Jan2020	15:12	0.4386	0.054	5.11	0.0000
10Jan2020	15:15	0.4945	0.056	5.11	0.0000
10Jan2020	15:18	0.5560	0.059	5.12	0.0000
10Jan2020	15:21	0.6237	0.061	5.12	0.0000
10Jan2020	15:24	0.6977	0.064	5.13	0.0000
10Jan2020	15:27	0.7782	0.067	5.13	0.0000
10Jan2020	15:30	0.8656	0.070	5.14	0.0000
10Jan2020	15:33	0.9627	0.074	5.15	0.0000
10Jan2020	15:36	1.0769	0.078	5.15	0.0000
10Jan2020	15:39	1.2229	0.083	5.16	0.0000
10Jan2020	15:42	1.4229	0.088	5.17	0.0000
10Jan2020	15:45	1.7068	0.095	5.19	0.0000
10Jan2020	15:48	2.1253	0.103	5.20	0.0000
10Jan2020	15:51	2.7659	0.113	5.22	0.0000
10Jan2020	15:54	3.7253	0.126	5.25	0.0000
10Jan2020	15:57	5.0629	0.144	5.29	0.0000
10Jan2020	16:00	6.7488	0.169	5.33	0.0000
10Jan2020	16:03	8.5962	0.201	5.40	0.0000
10Jan2020	16:06	10.2955	0.240	5.47	0.0000
10Jan2020	16:09	11.5563	0.285	5.56	0.0000
10Jan2020	16:12	12.2183	0.334	5.66	0.0000
10Jan2020	16:15	12.2873	0.384	5.76	0.0000
10Jan2020	16:18	11.8892	0.434	5.86	0.0000
10Jan2020	16:21	11.1762	0.482	5.95	0.0000
10Jan2020	16:24	10.2956	0.526	6.04	0.0000
10Jan2020	16:27	9.3922	0.567	6.12	0.0000
10Jan2020	16:30	8.5708	0.604	6.19	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	16:33	7.8738	0.638	6.26	0.0000
10Jan2020	16:36	7.2858	0.670	6.32	0.0000
10Jan2020	16:39	6.7646	0.699	6.38	0.0000
10Jan2020	16:42	6.2888	0.726	6.43	0.0000
10Jan2020	16:45	5.8612	0.751	6.48	0.0000
10Jan2020	16:48	5.4863	0.774	6.53	0.0000
10Jan2020	16:51	5.1620	0.796	6.57	0.0000
10Jan2020	16:54	4.8829	0.817	6.61	0.0000
10Jan2020	16:57	4.6441	0.837	6.65	0.0000
10Jan2020	17:00	4.4396	0.855	6.69	0.0000
10Jan2020	17:03	4.2622	0.873	6.73	0.0000
10Jan2020	17:06	4.1052	0.891	6.76	0.0000
10Jan2020	17:09	3.9649	0.907	6.79	0.0000
10Jan2020	17:12	3.8404	0.923	6.82	0.0000
10Jan2020	17:15	3.7314	0.939	6.86	0.0000
10Jan2020	17:18	3.6359	0.954	6.89	0.0000
10Jan2020	17:21	3.5516	0.969	6.92	0.0000
10Jan2020	17:24	3.4766	0.984	6.94	0.0000
10Jan2020	17:27	3.4094	0.998	6.97	0.0000
10Jan2020	17:30	3.3488	1.012	7.00	0.0000
10Jan2020	17:33	3.2942	1.026	7.03	0.0000
10Jan2020	17:36	3.2459	1.039	7.05	0.0000
10Jan2020	17:39	3.2039	1.052	7.08	0.0000
10Jan2020	17:42	3.1670	1.066	7.11	0.0000
10Jan2020	17:45	3.1339	1.079	7.13	0.0000
10Jan2020	17:48	3.1030	1.091	7.16	0.0000
10Jan2020	17:51	3.0731	1.104	7.18	0.0000
10Jan2020	17:54	3.0430	1.117	7.21	0.0000
10Jan2020	17:57	3.0125	1.129	7.23	0.0000
10Jan2020	18:00	2.9811	1.142	7.26	0.0000
10Jan2020	18:03	2.9491	1.154	7.28	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	18:06	2.9171	1.166	7.30	0.0000
10Jan2020	18:09	2.8855	1.178	7.33	0.0000
10Jan2020	18:12	2.8552	1.190	7.35	0.0000
10Jan2020	18:15	2.8268	1.202	7.37	0.0000
10Jan2020	18:18	2.8010	1.213	7.40	0.0000
10Jan2020	18:21	2.7779	1.225	7.42	0.0000
10Jan2020	18:24	2.7563	1.236	7.44	0.0000
10Jan2020	18:27	2.7348	1.248	7.47	0.0000
10Jan2020	18:30	2.7122	1.259	7.49	0.0000
10Jan2020	18:33	2.6890	1.270	7.51	0.0000
10Jan2020	18:36	2.6656	1.281	7.52	0.0000
10Jan2020	18:39	2.6427	1.292	7.53	0.0000
10Jan2020	18:42	2.6206	1.303	7.54	0.0000
10Jan2020	18:45	2.5995	1.314	7.55	0.0000
10Jan2020	18:48	2.5792	1.324	7.56	0.0000
10Jan2020	18:51	2.5593	1.335	7.57	0.0000
10Jan2020	18:54	2.5400	1.346	7.58	0.0000
10Jan2020	18:57	2.5210	1.356	7.59	0.0000
10Jan2020	19:00	2.5015	1.366	7.60	0.0000
10Jan2020	19:03	2.4813	1.377	7.61	0.0000
10Jan2020	19:06	2.4607	1.387	7.62	0.0000
10Jan2020	19:09	2.4404	1.397	7.63	0.0000
10Jan2020	19:12	2.4199	1.407	7.64	0.0000
10Jan2020	19:15	2.3987	1.417	7.65	0.0000
10Jan2020	19:18	2.3773	1.427	7.66	0.0000
10Jan2020	19:21	2.3560	1.437	7.67	0.0000
10Jan2020	19:24	2.3346	1.446	7.68	0.0000
10Jan2020	19:27	2.3133	1.456	7.69	0.0000
10Jan2020	19:30	2.2925	1.465	7.70	0.0000
10Jan2020	19:33	2.2726	1.475	7.71	0.0000
10Jan2020	19:36	2.2527	1.484	7.72	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	19:39	2.2312	1.494	7.73	0.0000
10Jan2020	19:42	2.2075	1.503	7.74	0.0000
10Jan2020	19:45	2.1821	1.512	7.75	0.0000
10Jan2020	19:48	2.1560	1.521	7.76	0.0000
10Jan2020	19:51	2.1306	1.530	7.76	0.0000
10Jan2020	19:54	2.1064	1.538	7.77	0.0000
10Jan2020	19:57	2.0836	1.547	7.78	0.0000
10Jan2020	20:00	2.0618	1.556	7.79	0.0000
10Jan2020	20:03	2.0392	1.564	7.80	0.0000
10Jan2020	20:06	2.0160	1.572	7.81	0.0000
10Jan2020	20:09	1.9924	1.581	7.82	0.0000
10Jan2020	20:12	1.9691	1.589	7.82	0.0000
10Jan2020	20:15	1.9480	1.597	7.83	0.0000
10Jan2020	20:18	1.9294	1.605	7.84	0.0000
10Jan2020	20:21	1.9122	1.613	7.85	0.0000
10Jan2020	20:24	1.8965	1.621	7.86	0.0000
10Jan2020	20:27	1.8825	1.629	7.86	0.0000
10Jan2020	20:30	1.8705	1.636	7.87	0.0000
10Jan2020	20:33	1.8605	1.644	7.88	0.0000
10Jan2020	20:36	1.8517	1.652	7.89	0.0000
10Jan2020	20:39	1.8444	1.659	7.89	0.0000
10Jan2020	20:42	1.8391	1.667	7.90	0.0000
10Jan2020	20:45	1.8357	1.675	7.91	0.0000
10Jan2020	20:48	1.8336	1.682	7.92	0.0000
10Jan2020	20:51	1.8325	1.690	7.92	0.0000
10Jan2020	20:54	1.8314	1.697	7.93	0.0000
10Jan2020	20:57	1.8294	1.705	7.94	0.0000
10Jan2020	21:00	1.8264	1.712	7.95	0.0000
10Jan2020	21:03	1.8214	1.720	7.95	0.0000
10Jan2020	21:06	1.8154	1.727	7.96	0.0000
10Jan2020	21:09	1.8103	1.735	7.97	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	21:12	1.8063	1.742	7.98	0.0000
10Jan2020	21:15	1.8032	1.750	7.98	0.0000
10Jan2020	21:18	1.8009	1.757	7.99	0.0000
10Jan2020	21:21	1.7976	1.765	8.00	0.0000
10Jan2020	21:24	1.7933	1.772	8.01	0.0000
10Jan2020	21:27	1.7891	1.780	8.01	0.0000
10Jan2020	21:30	1.7847	1.787	8.02	0.0000
10Jan2020	21:33	1.7813	1.794	8.03	0.0000
10Jan2020	21:36	1.7784	1.802	8.04	0.0000
10Jan2020	21:39	1.7751	1.809	8.04	0.0000
10Jan2020	21:42	1.7714	1.816	8.05	0.0000
10Jan2020	21:45	1.7667	1.824	8.06	0.0000
10Jan2020	21:48	1.7624	1.831	8.07	0.0000
10Jan2020	21:51	1.7593	1.838	8.07	0.0000
10Jan2020	21:54	1.7568	1.846	8.08	0.0000
10Jan2020	21:57	1.7535	1.853	8.09	0.0000
10Jan2020	22:00	1.7501	1.860	8.09	0.0000
10Jan2020	22:03	1.7453	1.867	8.10	0.0000
10Jan2020	22:06	1.7401	1.874	8.11	0.0000
10Jan2020	22:09	1.7359	1.882	8.12	0.0000
10Jan2020	22:12	1.7321	1.889	8.12	0.0000
10Jan2020	22:15	1.7291	1.896	8.13	0.0000
10Jan2020	22:18	1.7266	1.903	8.14	0.0000
10Jan2020	22:21	1.7232	1.910	8.14	0.0000
10Jan2020	22:24	1.7186	1.917	8.15	0.0000
10Jan2020	22:27	1.7133	1.924	8.16	0.0000
10Jan2020	22:30	1.7071	1.931	8.17	0.0000
10Jan2020	22:33	1.7009	1.939	8.17	0.0000
10Jan2020	22:36	1.6952	1.946	8.18	0.0000
10Jan2020	22:39	1.6900	1.953	8.19	0.0000
10Jan2020	22:42	1.6865	1.959	8.19	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	22:45	1.6842	1.966	8.20	0.0000
10Jan2020	22:48	1.6828	1.973	8.21	0.0000
10Jan2020	22:51	1.6821	1.980	8.21	0.0000
10Jan2020	22:54	1.6811	1.987	8.22	0.0000
10Jan2020	22:57	1.6789	1.994	8.23	0.0000
10Jan2020	23:00	1.6755	2.001	8.23	0.0000
10Jan2020	23:03	1.6699	2.008	8.24	0.0000
10Jan2020	23:06	1.6630	2.015	8.25	0.0000
10Jan2020	23:09	1.6572	2.022	8.26	0.0000
10Jan2020	23:12	1.6523	2.029	8.26	0.0000
10Jan2020	23:15	1.6484	2.036	8.27	0.0000
10Jan2020	23:18	1.6452	2.042	8.28	0.0000
10Jan2020	23:21	1.6410	2.049	8.28	0.0000
10Jan2020	23:24	1.6357	2.056	8.29	0.0000
10Jan2020	23:27	1.6305	2.063	8.30	0.0000
10Jan2020	23:30	1.6252	2.069	8.30	0.0000
10Jan2020	23:33	1.6208	2.076	8.31	0.0000
10Jan2020	23:36	1.6170	2.083	8.32	0.0000
10Jan2020	23:39	1.6127	2.089	8.32	0.0000
10Jan2020	23:42	1.6079	2.096	8.33	0.0000
10Jan2020	23:45	1.6023	2.103	8.34	0.0000
10Jan2020	23:48	1.5970	2.109	8.34	0.0000
10Jan2020	23:51	1.5930	2.116	8.35	0.0000
10Jan2020	23:54	1.5895	2.122	8.36	0.0000
10Jan2020	23:57	1.5854	2.129	8.36	0.0000
11Jan2020	00:00	1.5810	2.136	8.37	0.0000
11Jan2020	00:03	1.5752	2.142	8.38	0.0000
11Jan2020	00:06	1.5690	2.149	8.38	0.0000
11Jan2020	00:09	1.5639	2.155	8.39	0.0000
11Jan2020	00:12	1.5592	2.162	8.40	0.0000
11Jan2020	00:15	1.5553	2.168	8.40	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	00:18	1.5520	2.174	8.41	0.0000
11Jan2020	00:21	1.5478	2.181	8.41	0.0000
11Jan2020	00:24	1.5423	2.187	8.42	0.0000
11Jan2020	00:27	1.5360	2.194	8.43	0.0000
11Jan2020	00:30	1.5289	2.200	8.43	0.0000
11Jan2020	00:33	1.5218	2.206	8.44	0.0000
11Jan2020	00:36	1.5152	2.212	8.45	0.0000
11Jan2020	00:39	1.5091	2.219	8.45	0.0000
11Jan2020	00:42	1.5047	2.225	8.46	0.0000
11Jan2020	00:45	1.5016	2.231	8.46	0.0000
11Jan2020	00:48	1.4995	2.237	8.47	0.0000
11Jan2020	00:51	1.4981	2.244	8.48	0.0000
11Jan2020	00:54	1.4964	2.250	8.48	0.0000
11Jan2020	00:57	1.4935	2.256	8.49	0.0000
11Jan2020	01:00	1.4894	2.262	8.50	0.0000
11Jan2020	01:03	1.4829	2.268	8.50	0.0000
11Jan2020	01:06	1.4752	2.274	8.51	0.0000
11Jan2020	01:09	1.4685	2.280	8.51	0.0000
11Jan2020	01:12	1.4628	2.286	8.52	0.0000
11Jan2020	01:15	1.4581	2.292	8.53	0.0000
11Jan2020	01:18	1.4542	2.298	8.53	0.0000
11Jan2020	01:21	1.4493	2.304	8.54	0.0000
11Jan2020	01:24	1.4432	2.310	8.54	0.0000
11Jan2020	01:27	1.4364	2.316	8.55	0.0000
11Jan2020	01:30	1.4287	2.322	8.56	0.0000
11Jan2020	01:33	1.4211	2.328	8.56	0.0000
11Jan2020	01:36	1.4140	2.334	8.57	0.0000
11Jan2020	01:39	1.4075	2.340	8.57	0.0000
11Jan2020	01:42	1.4027	2.346	8.58	0.0000
11Jan2020	01:45	1.3993	2.351	8.58	0.0000
11Jan2020	01:48	1.3968	2.357	8.59	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	01:51	1.3952	2.363	8.60	0.0000
11Jan2020	01:54	1.3931	2.369	8.60	0.0000
11Jan2020	01:57	1.3899	2.375	8.61	0.0000
11Jan2020	02:00	1.3855	2.380	8.61	0.0000
11Jan2020	02:03	1.3787	2.386	8.62	0.0000
11Jan2020	02:06	1.3706	2.392	8.62	0.0000
11Jan2020	02:09	1.3635	2.397	8.63	0.0000
11Jan2020	02:12	1.3575	2.403	8.64	0.0000
11Jan2020	02:15	1.3525	2.409	8.64	0.0000
11Jan2020	02:18	1.3483	2.414	8.65	0.0000
11Jan2020	02:21	1.3431	2.420	8.65	0.0000
11Jan2020	02:24	1.3367	2.425	8.66	0.0000
11Jan2020	02:27	1.3304	2.431	8.66	0.0000
11Jan2020	02:30	1.3239	2.436	8.67	0.0000
11Jan2020	02:33	1.3185	2.442	8.67	0.0000
11Jan2020	02:36	1.3137	2.447	8.68	0.0000
11Jan2020	02:39	1.3085	2.453	8.69	0.0000
11Jan2020	02:42	1.3027	2.458	8.69	0.0000
11Jan2020	02:45	1.2960	2.463	8.70	0.0000
11Jan2020	02:48	1.2896	2.469	8.70	0.0000
11Jan2020	02:51	1.2846	2.474	8.71	0.0000
11Jan2020	02:54	1.2803	2.479	8.71	0.0000
11Jan2020	02:57	1.2752	2.485	8.72	0.0000
11Jan2020	03:00	1.2698	2.490	8.72	0.0000
11Jan2020	03:03	1.2631	2.495	8.73	0.0000
11Jan2020	03:06	1.2559	2.500	8.73	0.0000
11Jan2020	03:09	1.2498	2.505	8.74	0.0000
11Jan2020	03:12	1.2441	2.511	8.74	0.0000
11Jan2020	03:15	1.2394	2.516	8.75	0.0000
11Jan2020	03:18	1.2352	2.521	8.75	0.0000
11Jan2020	03:21	1.2300	2.526	8.76	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	03:24	1.2236	2.531	8.76	0.0000
11Jan2020	03:27	1.2173	2.536	8.77	0.0000
11Jan2020	03:30	1.2107	2.541	8.77	0.0000
11Jan2020	03:33	1.2052	2.546	8.78	0.0000
11Jan2020	03:36	1.2003	2.551	8.78	0.0000
11Jan2020	03:39	1.1948	2.556	8.79	0.0000
11Jan2020	03:42	1.1888	2.561	8.79	0.0000
11Jan2020	03:45	1.1819	2.566	8.80	0.0000
11Jan2020	03:48	1.1754	2.571	8.80	0.0000
11Jan2020	03:51	1.1702	2.575	8.81	0.0000
11Jan2020	03:54	1.1656	2.580	8.81	0.0000
11Jan2020	03:57	1.1603	2.585	8.82	0.0000
11Jan2020	04:00	1.1547	2.590	8.82	0.0000
11Jan2020	04:03	1.1477	2.595	8.83	0.0000
11Jan2020	04:06	1.1403	2.599	8.83	0.0000
11Jan2020	04:09	1.1339	2.604	8.84	0.0000
11Jan2020	04:12	1.1281	2.609	8.84	0.0000
11Jan2020	04:15	1.1231	2.613	8.85	0.0000
11Jan2020	04:18	1.1188	2.618	8.85	0.0000
11Jan2020	04:21	1.1134	2.623	8.86	0.0000
11Jan2020	04:24	1.1068	2.627	8.86	0.0000
11Jan2020	04:27	1.1002	2.632	8.86	0.0000
11Jan2020	04:30	1.0934	2.636	8.87	0.0000
11Jan2020	04:33	1.0876	2.641	8.87	0.0000
11Jan2020	04:36	1.0825	2.645	8.88	0.0000
11Jan2020	04:39	1.0769	2.650	8.88	0.0000
11Jan2020	04:42	1.0707	2.654	8.89	0.0000
11Jan2020	04:45	1.0636	2.659	8.89	0.0000
11Jan2020	04:48	1.0568	2.663	8.90	0.0000
11Jan2020	04:51	1.0514	2.667	8.90	0.0000
11Jan2020	04:54	1.0466	2.672	8.90	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	04:57	1.0411	2.676	8.91	0.0000
11Jan2020	05:00	1.0353	2.680	8.91	0.0000
11Jan2020	05:03	1.0281	2.685	8.92	0.0000
11Jan2020	05:06	1.0205	2.689	8.92	0.0000
11Jan2020	05:09	1.0139	2.693	8.93	0.0000
11Jan2020	05:12	1.0079	2.697	8.93	0.0000
11Jan2020	05:15	1.0027	2.701	8.93	0.0000
11Jan2020	05:18	0.9982	2.705	8.94	0.0000
11Jan2020	05:21	0.9927	2.710	8.94	0.0000
11Jan2020	05:24	0.9858	2.714	8.95	0.0000
11Jan2020	05:27	0.9790	2.718	8.95	0.0000
11Jan2020	05:30	0.9721	2.722	8.95	0.0000
11Jan2020	05:33	0.9661	2.726	8.96	0.0000
11Jan2020	05:36	0.9608	2.730	8.96	0.0000
11Jan2020	05:39	0.9550	2.734	8.97	0.0000
11Jan2020	05:42	0.9486	2.738	8.97	0.0000
11Jan2020	05:45	0.9413	2.742	8.97	0.0000
11Jan2020	05:48	0.9344	2.745	8.98	0.0000
11Jan2020	05:51	0.9288	2.749	8.98	0.0000
11Jan2020	05:54	0.9239	2.753	8.99	0.0000
11Jan2020	05:57	0.9182	2.757	8.99	0.0000
11Jan2020	06:00	0.9123	2.761	8.99	0.0000
11Jan2020	06:03	0.8997	2.764	9.00	0.0000
11Jan2020	06:06	0.8759	2.768	9.00	0.0000
11Jan2020	06:09	0.8360	2.772	9.00	0.0000
11Jan2020	06:12	0.7736	2.775	9.01	0.0000
11Jan2020	06:15	0.6907	2.778	9.01	0.0000
11Jan2020	06:18	0.5968	2.781	9.01	0.0000
11Jan2020	06:21	0.5009	2.783	9.02	0.0000
11Jan2020	06:24	0.4097	2.785	9.02	0.0000
11Jan2020	06:27	0.3282	2.786	9.02	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	06:30	0.2577	2.788	9.02	0.0000
11Jan2020	06:33	0.2022	2.788	9.02	0.0000
11Jan2020	06:36	0.1600	2.789	9.02	0.0000
11Jan2020	06:39	0.1266	2.790	9.02	0.0000
11Jan2020	06:42	0.1004	2.790	9.02	0.0000
11Jan2020	06:45	0.0792	2.791	9.02	0.0000
11Jan2020	06:48	0.0623	2.791	9.02	0.0000
11Jan2020	06:51	0.0491	2.791	9.02	0.0000
11Jan2020	06:54	0.0387	2.791	9.02	0.0000
11Jan2020	06:57	0.0303	2.792	9.02	0.0000
11Jan2020	07:00	0.0237	2.792	9.02	0.0000
11Jan2020	07:03	0.0186	2.792	9.02	0.0000
11Jan2020	07:06	0.0145	2.792	9.02	0.0000
11Jan2020	07:09	0.0113	2.792	9.02	0.0000
11Jan2020	07:12	0.0087	2.792	9.02	0.0000
11Jan2020	07:15	0.0067	2.792	9.02	0.0000
11Jan2020	07:18	0.0051	2.792	9.02	0.0000
11Jan2020	07:21	0.0038	2.792	9.02	0.0000
11Jan2020	07:24	0.0028	2.792	9.02	0.0000
11Jan2020	07:27	0.0019	2.792	9.02	0.0000
11Jan2020	07:30	0.0012	2.792	9.02	0.0000
11Jan2020	07:33	0.0007	2.792	9.02	0.0000
11Jan2020	07:36	0.0004	2.792	9.02	0.0000
11Jan2020	07:39	0.0001	2.792	9.02	0.0000
11Jan2020	07:42	0.0000	2.792	9.02	0.0000
11Jan2020	07:45	0.0000	2.792	9.02	0.0000
11Jan2020	07:48	0.0000	2.792	9.02	0.0000
11Jan2020	07:51	0.0000	2.792	9.02	0.0000
11Jan2020	07:54	0.0000	2.792	9.02	0.0000
11Jan2020	07:57	0.0000	2.792	9.02	0.0000
11Jan2020	08:00	0.0000	2.792	9.02	0.0000

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Attachment 3

Reference 2

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Chapter 2 Estimating Runoff

SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in appendix A for determining the HSG classification for disturbed soils.

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and $I_a=0.2S$

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Rev 2

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Chapter 3 Time of Concentration and Travel Time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow

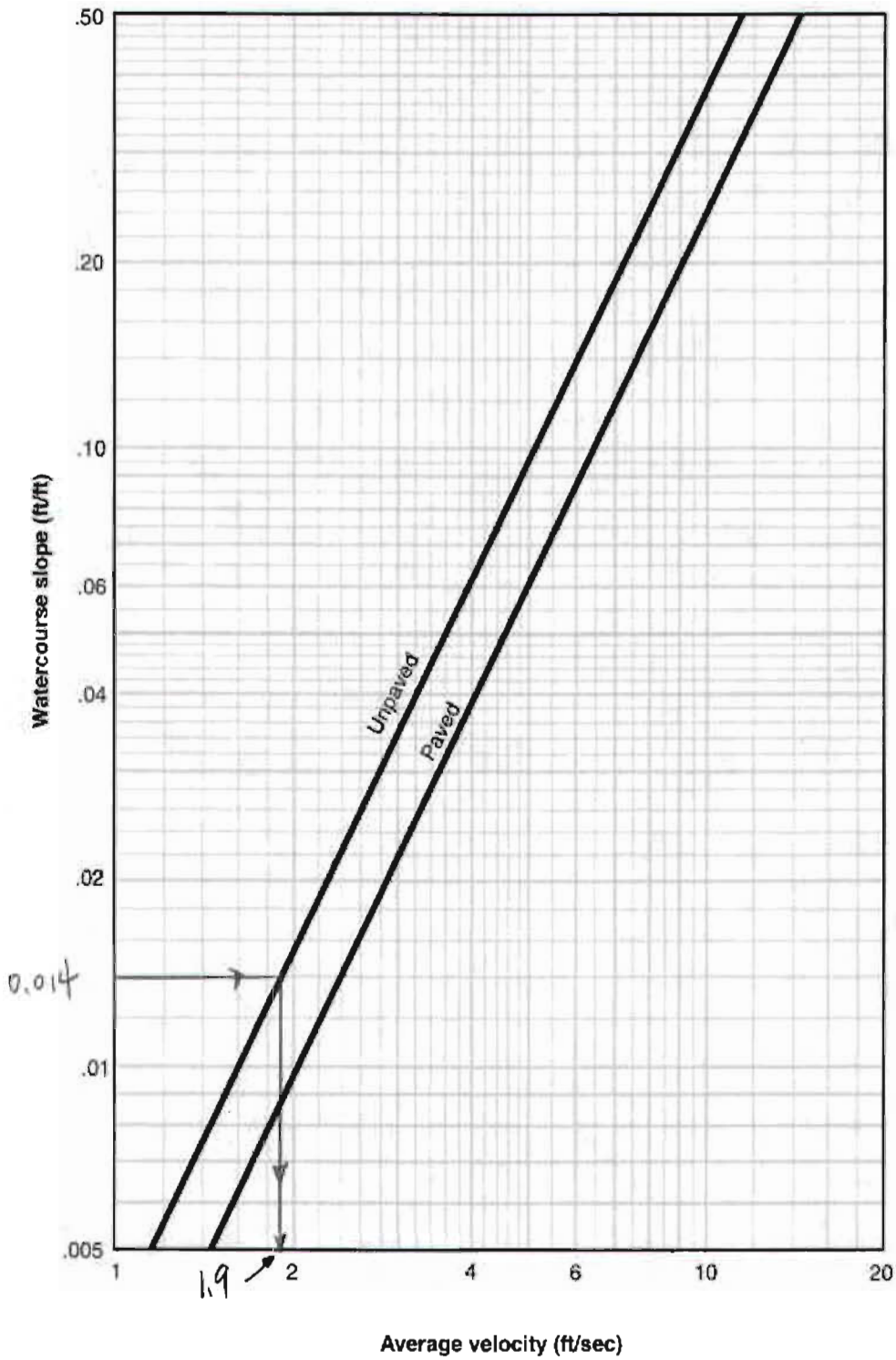
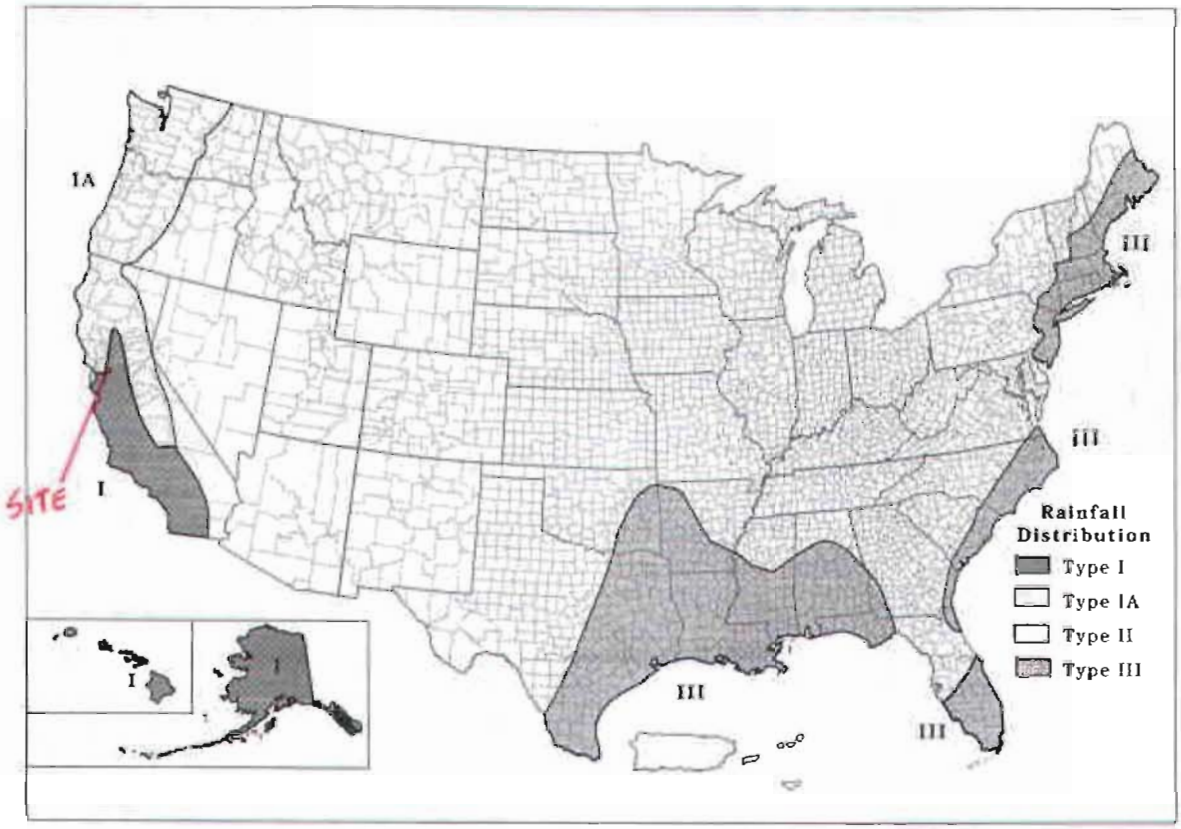


Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

Appendix A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

Radback Tenaska project Stormwater Analysis JT 3/4/09

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52.5406.1003

Attachment 4

Reference 6

Select pages

(printed out from the Online Web Soil Survey)

Project site

Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Contra Costa County, California

DaC—DELHI SAND, 2 TO 9 PERCENT SLOPES

Map Unit Setting

Elevation: 10 to 150 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Delhi and similar soils: 85 percent
Minor components: 15 percent

Description of Delhi

Setting

Landform: Flood plains, terraces, alluvial fans
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from igneous and sedimentary rock

Properties and qualities

Slope: 2 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability (nonirrigated): 6e

Typical profile

0 to 5 inches: Sand
5 to 60 inches: Sand

Minor Components

Unnamed

Percent of map unit: 12 percent

Laugenour

Percent of map unit: 3 percent

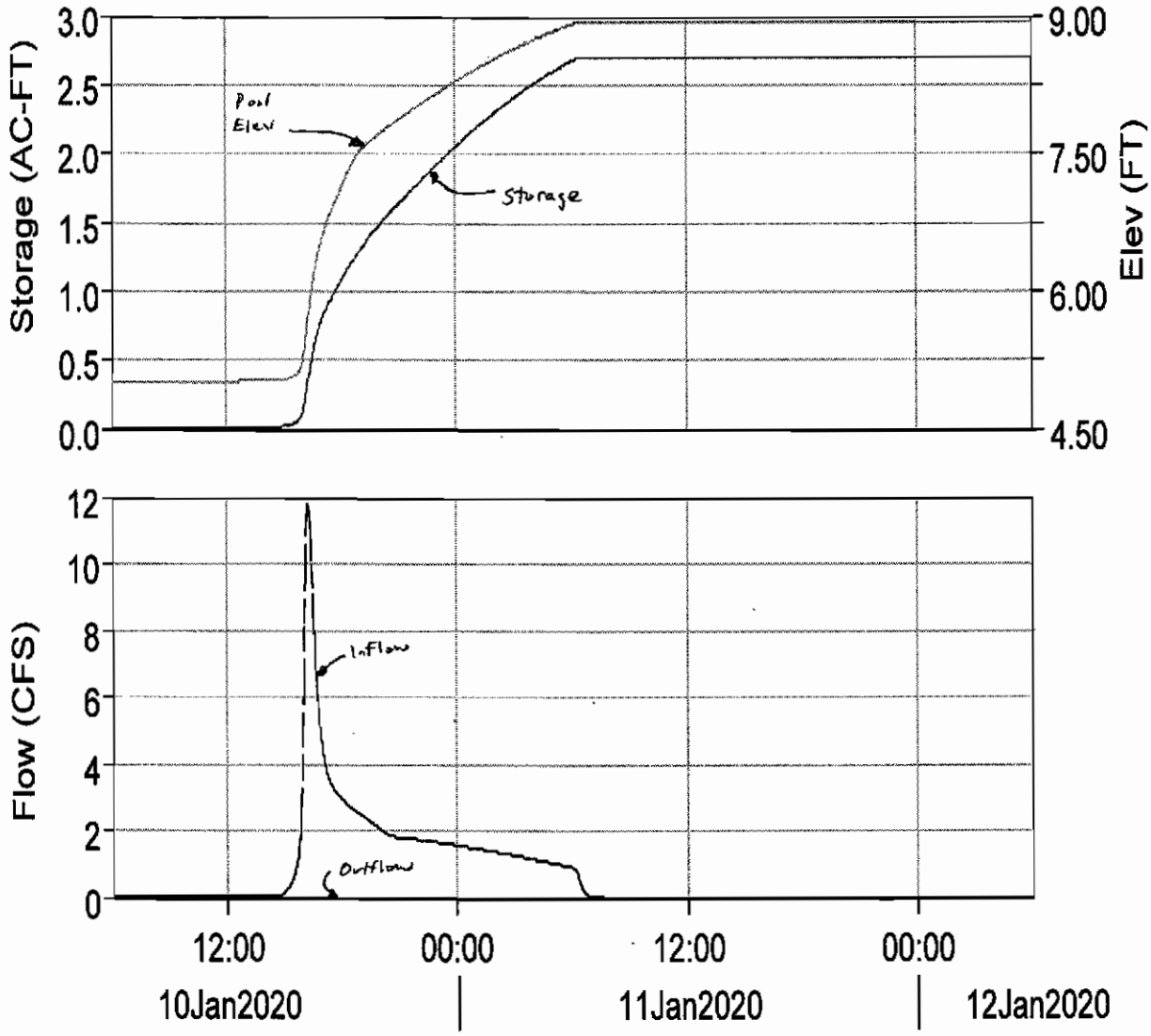
Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

VOID ATT #2

.1003 CALC (REV 2)

Reservoir "Wetland" Results for Run "Run1 - Ex 100.24"



Run:Run1 - Ex 100.24 Element:WETLAND Result:Storage

Run:Run1 - Ex 100.24 Element:WETLAND Result:Pool Elevation

Run:Run1 - Ex 100.24 Element:WETLAND Result:Outflow

Run:Run1 - Ex 100.24 Element:WETLAND Result:Combined Inflow

REV 2

Superseded by Rev 3

Project: Oakley
Simulation Run: Run1 - Ex 100.24 Reservoir: Wetland

Start of Run: 10Jan2020, 06:00 Basin Model: Basin 1 - Existin
End of Run: 12Jan2020, 06:00 Meteorologic Model: Storm1 - 10
Compute Time: 22Jun2010, 08:13:54 Control Specifications: Control

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	06:00	0.0000	0.000	5.00	0.0000
10Jan2020	06:03	0.0001	0.000	5.00	0.0000
10Jan2020	06:06	0.0004	0.000	5.00	0.0000
10Jan2020	06:09	0.0011	0.000	5.00	0.0000
10Jan2020	06:12	0.0022	0.000	5.00	0.0000
10Jan2020	06:15	0.0037	0.000	5.00	0.0000
10Jan2020	06:18	0.0055	0.000	5.00	0.0000
10Jan2020	06:21	0.0074	0.000	5.00	0.0000
10Jan2020	06:24	0.0092	0.000	5.00	0.0000
10Jan2020	06:27	0.0108	0.000	5.00	0.0000
10Jan2020	06:30	0.0122	0.000	5.00	0.0000
10Jan2020	06:33	0.0133	0.000	5.00	0.0000
10Jan2020	06:36	0.0142	0.000	5.00	0.0000
10Jan2020	06:39	0.0148	0.000	5.00	0.0000
10Jan2020	06:42	0.0153	0.000	5.00	0.0000
10Jan2020	06:45	0.0157	0.000	5.00	0.0000
10Jan2020	06:48	0.0161	0.001	5.00	0.0000
10Jan2020	06:51	0.0163	0.001	5.00	0.0000
10Jan2020	06:54	0.0165	0.001	5.00	0.0000
10Jan2020	06:57	0.0166	0.001	5.00	0.0000
10Jan2020	07:00	0.0167	0.001	5.00	0.0000
10Jan2020	07:03	0.0168	0.001	5.00	0.0000
10Jan2020	07:06	0.0169	0.001	5.00	0.0000
10Jan2020	07:09	0.0170	0.001	5.00	0.0000
10Jan2020	07:12	0.0171	0.001	5.00	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	07:15	0.0172	0.001	5.00	0.0000
10Jan2020	07:18	0.0173	0.001	5.00	0.0000
10Jan2020	07:21	0.0173	0.001	5.00	0.0000
10Jan2020	07:24	0.0173	0.001	5.00	0.0000
10Jan2020	07:27	0.0174	0.001	5.00	0.0000
10Jan2020	07:30	0.0174	0.002	5.00	0.0000
10Jan2020	07:33	0.0174	0.002	5.00	0.0000
10Jan2020	07:36	0.0174	0.002	5.00	0.0000
10Jan2020	07:39	0.0174	0.002	5.00	0.0000
10Jan2020	07:42	0.0173	0.002	5.00	0.0000
10Jan2020	07:45	0.0173	0.002	5.00	0.0000
10Jan2020	07:48	0.0173	0.002	5.00	0.0000
10Jan2020	07:51	0.0173	0.002	5.00	0.0000
10Jan2020	07:54	0.0173	0.002	5.00	0.0000
10Jan2020	07:57	0.0173	0.002	5.00	0.0000
10Jan2020	08:00	0.0173	0.002	5.00	0.0000
10Jan2020	08:03	0.0173	0.002	5.00	0.0000
10Jan2020	08:06	0.0173	0.002	5.00	0.0000
10Jan2020	08:09	0.0174	0.002	5.00	0.0000
10Jan2020	08:12	0.0174	0.003	5.01	0.0000
10Jan2020	08:15	0.0175	0.003	5.01	0.0000
10Jan2020	08:18	0.0175	0.003	5.01	0.0000
10Jan2020	08:21	0.0176	0.003	5.01	0.0000
10Jan2020	08:24	0.0176	0.003	5.01	0.0000
10Jan2020	08:27	0.0177	0.003	5.01	0.0000
10Jan2020	08:30	0.0178	0.003	5.01	0.0000
10Jan2020	08:33	0.0179	0.003	5.01	0.0000
10Jan2020	08:36	0.0181	0.003	5.01	0.0000
10Jan2020	08:39	0.0182	0.003	5.01	0.0000
10Jan2020	08:42	0.0183	0.003	5.01	0.0000
10Jan2020	08:45	0.0184	0.003	5.01	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
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10Jan2020	08:57	0.0189	0.004	5.01	0.0000
10Jan2020	09:00	0.0190	0.004	5.01	0.0000
10Jan2020	09:03	0.0191	0.004	5.01	0.0000
10Jan2020	09:06	0.0193	0.004	5.01	0.0000
10Jan2020	09:09	0.0194	0.004	5.01	0.0000
10Jan2020	09:12	0.0196	0.004	5.01	0.0000
10Jan2020	09:15	0.0197	0.004	5.01	0.0000
10Jan2020	09:18	0.0199	0.004	5.01	0.0000
10Jan2020	09:21	0.0201	0.004	5.01	0.0000
10Jan2020	09:24	0.0202	0.004	5.01	0.0000
10Jan2020	09:27	0.0204	0.004	5.01	0.0000
10Jan2020	09:30	0.0205	0.005	5.01	0.0000
10Jan2020	09:33	0.0207	0.005	5.01	0.0000
10Jan2020	09:36	0.0209	0.005	5.01	0.0000
10Jan2020	09:39	0.0210	0.005	5.01	0.0000
10Jan2020	09:42	0.0212	0.005	5.01	0.0000
10Jan2020	09:45	0.0213	0.005	5.01	0.0000
10Jan2020	09:48	0.0214	0.005	5.01	0.0000
10Jan2020	09:51	0.0215	0.005	5.01	0.0000
10Jan2020	09:54	0.0217	0.005	5.01	0.0000
10Jan2020	09:57	0.0218	0.005	5.01	0.0000
10Jan2020	10:00	0.0219	0.005	5.01	0.0000
10Jan2020	10:03	0.0221	0.006	5.01	0.0000
10Jan2020	10:06	0.0222	0.006	5.01	0.0000
10Jan2020	10:09	0.0224	0.006	5.01	0.0000
10Jan2020	10:12	0.0225	0.006	5.01	0.0000
10Jan2020	10:15	0.0226	0.006	5.01	0.0000
10Jan2020	10:18	0.0228	0.006	5.01	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
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10Jan2020	10:24	0.0230	0.006	5.01	0.0000
10Jan2020	10:27	0.0231	0.006	5.01	0.0000
10Jan2020	10:30	0.0231	0.006	5.01	0.0000
10Jan2020	10:33	0.0232	0.006	5.01	0.0000
10Jan2020	10:36	0.0232	0.007	5.01	0.0000
10Jan2020	10:39	0.0233	0.007	5.01	0.0000
10Jan2020	10:42	0.0233	0.007	5.01	0.0000
10Jan2020	10:45	0.0233	0.007	5.01	0.0000
10Jan2020	10:48	0.0234	0.007	5.01	0.0000
10Jan2020	10:51	0.0235	0.007	5.01	0.0000
10Jan2020	10:54	0.0236	0.007	5.01	0.0000
10Jan2020	10:57	0.0237	0.007	5.01	0.0000
10Jan2020	11:00	0.0238	0.007	5.01	0.0000
10Jan2020	11:03	0.0239	0.007	5.01	0.0000
10Jan2020	11:06	0.0240	0.008	5.01	0.0000
10Jan2020	11:09	0.0240	0.008	5.02	0.0000
10Jan2020	11:12	0.0241	0.008	5.02	0.0000
10Jan2020	11:15	0.0241	0.008	5.02	0.0000
10Jan2020	11:18	0.0241	0.008	5.02	0.0000
10Jan2020	11:21	0.0241	0.008	5.02	0.0000
10Jan2020	11:24	0.0241	0.008	5.02	0.0000
10Jan2020	11:27	0.0242	0.008	5.02	0.0000
10Jan2020	11:30	0.0242	0.008	5.02	0.0000
10Jan2020	11:33	0.0243	0.008	5.02	0.0000
10Jan2020	11:36	0.0243	0.009	5.02	0.0000
10Jan2020	11:39	0.0244	0.009	5.02	0.0000
10Jan2020	11:42	0.0245	0.009	5.02	0.0000
10Jan2020	11:45	0.0245	0.009	5.02	0.0000
10Jan2020	11:48	0.0246	0.009	5.02	0.0000
10Jan2020	11:51	0.0247	0.009	5.02	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	11:54	0.0248	0.009	5.02	0.0000
10Jan2020	11:57	0.0249	0.009	5.02	0.0000
10Jan2020	12:00	0.0250	0.009	5.02	0.0000
10Jan2020	12:03	0.0251	0.009	5.02	0.0000
10Jan2020	12:06	0.0251	0.010	5.02	0.0000
10Jan2020	12:09	0.0252	0.010	5.02	0.0000
10Jan2020	12:12	0.0252	0.010	5.02	0.0000
10Jan2020	12:15	0.0253	0.010	5.02	0.0000
10Jan2020	12:18	0.0254	0.010	5.02	0.0000
10Jan2020	12:21	0.0256	0.010	5.02	0.0000
10Jan2020	12:24	0.0259	0.010	5.02	0.0000
10Jan2020	12:27	0.0263	0.010	5.02	0.0000
10Jan2020	12:30	0.0267	0.010	5.02	0.0000
10Jan2020	12:33	0.0271	0.011	5.02	0.0000
10Jan2020	12:36	0.0275	0.011	5.02	0.0000
10Jan2020	12:39	0.0280	0.011	5.02	0.0000
10Jan2020	12:42	0.0285	0.011	5.02	0.0000
10Jan2020	12:45	0.0290	0.011	5.02	0.0000
10Jan2020	12:48	0.0295	0.011	5.02	0.0000
10Jan2020	12:51	0.0300	0.011	5.02	0.0000
10Jan2020	12:54	0.0305	0.011	5.02	0.0000
10Jan2020	12:57	0.0310	0.011	5.02	0.0000
10Jan2020	13:00	0.0315	0.012	5.02	0.0000
10Jan2020	13:03	0.0320	0.012	5.02	0.0000
10Jan2020	13:06	0.0326	0.012	5.02	0.0000
10Jan2020	13:09	0.0331	0.012	5.02	0.0000
10Jan2020	13:12	0.0336	0.012	5.02	0.0000
10Jan2020	13:15	0.0341	0.012	5.02	0.0000
10Jan2020	13:18	0.0345	0.012	5.02	0.0000
10Jan2020	13:21	0.0349	0.013	5.02	0.0000
10Jan2020	13:24	0.0352	0.013	5.03	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	13:27	0.0355	0.013	5.03	0.0000
10Jan2020	13:30	0.0358	0.013	5.03	0.0000
10Jan2020	13:33	0.0360	0.013	5.03	0.0000
10Jan2020	13:36	0.0363	0.013	5.03	0.0000
10Jan2020	13:39	0.0365	0.013	5.03	0.0000
10Jan2020	13:42	0.0367	0.014	5.03	0.0000
10Jan2020	13:45	0.0369	0.014	5.03	0.0000
10Jan2020	13:48	0.0371	0.014	5.03	0.0000
10Jan2020	13:51	0.0373	0.014	5.03	0.0000
10Jan2020	13:54	0.0374	0.014	5.03	0.0000
10Jan2020	13:57	0.0376	0.014	5.03	0.0000
10Jan2020	14:00	0.0378	0.015	5.03	0.0000
10Jan2020	14:03	0.0380	0.015	5.03	0.0000
10Jan2020	14:06	0.0382	0.015	5.03	0.0000
10Jan2020	14:09	0.0384	0.015	5.03	0.0000
10Jan2020	14:12	0.0388	0.015	5.03	0.0000
10Jan2020	14:15	0.0392	0.015	5.03	0.0000
10Jan2020	14:18	0.0399	0.015	5.03	0.0000
10Jan2020	14:21	0.0407	0.016	5.03	0.0000
10Jan2020	14:24	0.0418	0.016	5.03	0.0000
10Jan2020	14:27	0.0430	0.016	5.03	0.0000
10Jan2020	14:30	0.0445	0.016	5.03	0.0000
10Jan2020	14:33	0.0462	0.016	5.03	0.0000
10Jan2020	14:36	0.0483	0.017	5.03	0.0000
10Jan2020	14:39	0.0513	0.017	5.03	0.0000
10Jan2020	14:42	0.0560	0.017	5.03	0.0000
10Jan2020	14:45	0.0634	0.017	5.03	0.0000
10Jan2020	14:48	0.0745	0.018	5.03	0.0000
10Jan2020	14:51	0.0900	0.018	5.04	0.0000
10Jan2020	14:54	0.1101	0.018	5.04	0.0000
10Jan2020	14:57	0.1351	0.019	5.04	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	15:00	0.1650	0.019	5.04	0.0000
10Jan2020	15:03	0.1996	0.020	5.04	0.0000
10Jan2020	15:06	0.2385	0.021	5.04	0.0000
10Jan2020	15:09	0.2819	0.022	5.04	0.0000
10Jan2020	15:12	0.3300	0.023	5.05	0.0000
10Jan2020	15:15	0.3831	0.025	5.05	0.0000
10Jan2020	15:18	0.4418	0.027	5.05	0.0000
10Jan2020	15:21	0.5063	0.029	5.06	0.0000
10Jan2020	15:24	0.5771	0.031	5.06	0.0000
10Jan2020	15:27	0.6542	0.033	5.07	0.0000
10Jan2020	15:30	0.7381	0.036	5.07	0.0000
10Jan2020	15:33	0.8313	0.039	5.08	0.0000
10Jan2020	15:36	0.9409	0.043	5.09	0.0000
10Jan2020	15:39	1.0805	0.047	5.09	0.0000
10Jan2020	15:42	1.2711	0.052	5.10	0.0000
10Jan2020	15:45	1.5412	0.058	5.11	0.0000
10Jan2020	15:48	1.9399	0.065	5.13	0.0000
10Jan2020	15:51	2.5519	0.074	5.15	0.0000
10Jan2020	15:54	3.4727	0.087	5.17	0.0000
10Jan2020	15:57	4.7619	0.104	5.21	0.0000
10Jan2020	16:00	6.3932	0.127	5.25	0.0000
10Jan2020	16:03	8.1882	0.157	5.31	0.0000
10Jan2020	16:06	9.8475	0.194	5.38	0.0000
10Jan2020	16:09	11.0883	0.238	5.47	0.0000
10Jan2020	16:12	11.7521	0.285	5.56	0.0000
10Jan2020	16:15	11.8419	0.333	5.66	0.0000
10Jan2020	16:18	11.4779	0.382	5.75	0.0000
10Jan2020	16:21	10.8064	0.428	5.85	0.0000
10Jan2020	16:24	9.9691	0.471	5.93	0.0000
10Jan2020	16:27	9.1061	0.510	6.01	0.0000
10Jan2020	16:30	8.3194	0.546	6.08	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	16:33	7.6513	0.579	6.14	0.0000
10Jan2020	16:36	7.0873	0.610	6.20	0.0000
10Jan2020	16:39	6.5866	0.638	6.26	0.0000
10Jan2020	16:42	6.1289	0.664	6.31	0.0000
10Jan2020	16:45	5.7169	0.689	6.36	0.0000
10Jan2020	16:48	5.3553	0.711	6.41	0.0000
10Jan2020	16:51	5.0424	0.733	6.45	0.0000
10Jan2020	16:54	4.7729	0.753	6.49	0.0000
10Jan2020	16:57	4.5421	0.772	6.53	0.0000
10Jan2020	17:00	4.3445	0.791	6.56	0.0000
10Jan2020	17:03	4.1730	0.808	6.60	0.0000
10Jan2020	17:06	4.0212	0.825	6.63	0.0000
10Jan2020	17:09	3.8854	0.842	6.66	0.0000
10Jan2020	17:12	3.7648	0.857	6.69	0.0000
10Jan2020	17:15	3.6592	0.873	6.72	0.0000
10Jan2020	17:18	3.5667	0.888	6.75	0.0000
10Jan2020	17:21	3.4851	0.902	6.78	0.0000
10Jan2020	17:24	3.4126	0.917	6.81	0.0000
10Jan2020	17:27	3.3475	0.930	6.84	0.0000
10Jan2020	17:30	3.2888	0.944	6.87	0.0000
10Jan2020	17:33	3.2360	0.958	6.89	0.0000
10Jan2020	17:36	3.1892	0.971	6.92	0.0000
10Jan2020	17:39	3.1484	0.984	6.94	0.0000
10Jan2020	17:42	3.1128	0.997	6.97	0.0000
10Jan2020	17:45	3.0807	1.010	7.00	0.0000
10Jan2020	17:48	3.0508	1.022	7.02	0.0000
10Jan2020	17:51	3.0218	1.035	7.05	0.0000
10Jan2020	17:54	2.9927	1.047	7.07	0.0000
10Jan2020	17:57	2.9631	1.060	7.09	0.0000
10Jan2020	18:00	2.9326	1.072	7.12	0.0000
10Jan2020	18:03	2.9015	1.084	7.14	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	18:06	2.8703	1.096	7.17	0.0000
10Jan2020	18:09	2.8396	1.108	7.19	0.0000
10Jan2020	18:12	2.8102	1.119	7.21	0.0000
10Jan2020	18:15	2.7825	1.131	7.23	0.0000
10Jan2020	18:18	2.7574	1.142	7.26	0.0000
10Jan2020	18:21	2.7349	1.154	7.28	0.0000
10Jan2020	18:24	2.7140	1.165	7.30	0.0000
10Jan2020	18:27	2.6931	1.176	7.32	0.0000
10Jan2020	18:30	2.6711	1.187	7.35	0.0000
10Jan2020	18:33	2.6485	1.198	7.37	0.0000
10Jan2020	18:36	2.6258	1.209	7.39	0.0000
10Jan2020	18:39	2.6034	1.220	7.41	0.0000
10Jan2020	18:42	2.5819	1.231	7.43	0.0000
10Jan2020	18:45	2.5613	1.241	7.45	0.0000
10Jan2020	18:48	2.5416	1.252	7.47	0.0000
10Jan2020	18:51	2.5222	1.262	7.49	0.0000
10Jan2020	18:54	2.5034	1.273	7.51	0.0000
10Jan2020	18:57	2.4849	1.283	7.52	0.0000
10Jan2020	19:00	2.4658	1.293	7.53	0.0000
10Jan2020	19:03	2.4461	1.303	7.54	0.0000
10Jan2020	19:06	2.4260	1.313	7.55	0.0000
10Jan2020	19:09	2.4061	1.323	7.56	0.0000
10Jan2020	19:12	2.3861	1.333	7.57	0.0000
10Jan2020	19:15	2.3654	1.343	7.58	0.0000
10Jan2020	19:18	2.3444	1.353	7.59	0.0000
10Jan2020	19:21	2.3237	1.362	7.60	0.0000
10Jan2020	19:24	2.3027	1.372	7.61	0.0000
10Jan2020	19:27	2.2819	1.381	7.62	0.0000
10Jan2020	19:30	2.2614	1.391	7.63	0.0000
10Jan2020	19:33	2.2420	1.400	7.63	0.0000
10Jan2020	19:36	2.2225	1.409	7.64	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	19:39	2.2014	1.419	7.65	0.0000
10Jan2020	19:42	2.1782	1.428	7.66	0.0000
10Jan2020	19:45	2.1533	1.437	7.67	0.0000
10Jan2020	19:48	2.1276	1.445	7.68	0.0000
10Jan2020	19:51	2.1026	1.454	7.69	0.0000
10Jan2020	19:54	2.0789	1.463	7.70	0.0000
10Jan2020	19:57	2.0565	1.471	7.71	0.0000
10Jan2020	20:00	2.0351	1.480	7.71	0.0000
10Jan2020	20:03	2.0129	1.488	7.72	0.0000
10Jan2020	20:06	1.9900	1.496	7.73	0.0000
10Jan2020	20:09	1.9669	1.505	7.74	0.0000
10Jan2020	20:12	1.9440	1.513	7.75	0.0000
10Jan2020	20:15	1.9233	1.521	7.76	0.0000
10Jan2020	20:18	1.9050	1.529	7.76	0.0000
10Jan2020	20:21	1.8881	1.536	7.77	0.0000
10Jan2020	20:24	1.8727	1.544	7.78	0.0000
10Jan2020	20:27	1.8590	1.552	7.79	0.0000
10Jan2020	20:30	1.8472	1.560	7.79	0.0000
10Jan2020	20:33	1.8374	1.567	7.80	0.0000
10Jan2020	20:36	1.8288	1.575	7.81	0.0000
10Jan2020	20:39	1.8216	1.582	7.82	0.0000
10Jan2020	20:42	1.8165	1.590	7.82	0.0000
10Jan2020	20:45	1.8132	1.597	7.83	0.0000
10Jan2020	20:48	1.8112	1.605	7.84	0.0000
10Jan2020	20:51	1.8102	1.612	7.85	0.0000
10Jan2020	20:54	1.8092	1.620	7.85	0.0000
10Jan2020	20:57	1.8073	1.627	7.86	0.0000
10Jan2020	21:00	1.8044	1.635	7.87	0.0000
10Jan2020	21:03	1.7995	1.642	7.88	0.0000
10Jan2020	21:06	1.7936	1.650	7.88	0.0000
10Jan2020	21:09	1.7887	1.657	7.89	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	21:12	1.7848	1.664	7.90	0.0000
10Jan2020	21:15	1.7819	1.672	7.91	0.0000
10Jan2020	21:18	1.7796	1.679	7.91	0.0000
10Jan2020	21:21	1.7765	1.686	7.92	0.0000
10Jan2020	21:24	1.7722	1.694	7.93	0.0000
10Jan2020	21:27	1.7681	1.701	7.94	0.0000
10Jan2020	21:30	1.7639	1.708	7.94	0.0000
10Jan2020	21:33	1.7606	1.716	7.95	0.0000
10Jan2020	21:36	1.7578	1.723	7.96	0.0000
10Jan2020	21:39	1.7546	1.730	7.96	0.0000
10Jan2020	21:42	1.7510	1.737	7.97	0.0000
10Jan2020	21:45	1.7465	1.745	7.98	0.0000
10Jan2020	21:48	1.7422	1.752	7.99	0.0000
10Jan2020	21:51	1.7392	1.759	7.99	0.0000
10Jan2020	21:54	1.7368	1.766	8.00	0.0000
10Jan2020	21:57	1.7337	1.773	8.01	0.0000
10Jan2020	22:00	1.7303	1.781	8.01	0.0000
10Jan2020	22:03	1.7256	1.788	8.02	0.0000
10Jan2020	22:06	1.7205	1.795	8.03	0.0000
10Jan2020	22:09	1.7164	1.802	8.04	0.0000
10Jan2020	22:12	1.7127	1.809	8.04	0.0000
10Jan2020	22:15	1.7098	1.816	8.05	0.0000
10Jan2020	22:18	1.7074	1.823	8.06	0.0000
10Jan2020	22:21	1.7041	1.830	8.06	0.0000
10Jan2020	22:24	1.6996	1.837	8.07	0.0000
10Jan2020	22:27	1.6944	1.844	8.08	0.0000
10Jan2020	22:30	1.6883	1.851	8.09	0.0000
10Jan2020	22:33	1.6823	1.858	8.09	0.0000
10Jan2020	22:36	1.6767	1.865	8.10	0.0000
10Jan2020	22:39	1.6716	1.872	8.11	0.0000
10Jan2020	22:42	1.6681	1.879	8.11	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	22:45	1.6659	1.886	8.12	0.0000
10Jan2020	22:48	1.6646	1.893	8.13	0.0000
10Jan2020	22:51	1.6639	1.900	8.13	0.0000
10Jan2020	22:54	1.6630	1.906	8.14	0.0000
10Jan2020	22:57	1.6609	1.913	8.15	0.0000
10Jan2020	23:00	1.6576	1.920	8.15	0.0000
10Jan2020	23:03	1.6521	1.927	8.16	0.0000
10Jan2020	23:06	1.6454	1.934	8.17	0.0000
10Jan2020	23:09	1.6396	1.941	8.17	0.0000
10Jan2020	23:12	1.6348	1.947	8.18	0.0000
10Jan2020	23:15	1.6310	1.954	8.19	0.0000
10Jan2020	23:18	1.6279	1.961	8.19	0.0000
10Jan2020	23:21	1.6238	1.968	8.20	0.0000
10Jan2020	23:24	1.6186	1.974	8.21	0.0000
10Jan2020	23:27	1.6135	1.981	8.21	0.0000
10Jan2020	23:30	1.6082	1.988	8.22	0.0000
10Jan2020	23:33	1.6039	1.994	8.23	0.0000
10Jan2020	23:36	1.6002	2.001	8.23	0.0000
10Jan2020	23:39	1.5960	2.007	8.24	0.0000
10Jan2020	23:42	1.5913	2.014	8.25	0.0000
10Jan2020	23:45	1.5858	2.021	8.25	0.0000
10Jan2020	23:48	1.5806	2.027	8.26	0.0000
10Jan2020	23:51	1.5767	2.034	8.27	0.0000
10Jan2020	23:54	1.5733	2.040	8.27	0.0000
10Jan2020	23:57	1.5692	2.047	8.28	0.0000
11Jan2020	00:00	1.5649	2.053	8.29	0.0000
11Jan2020	00:03	1.5593	2.060	8.29	0.0000
11Jan2020	00:06	1.5532	2.066	8.30	0.0000
11Jan2020	00:09	1.5481	2.072	8.31	0.0000
11Jan2020	00:12	1.5435	2.079	8.31	0.0000
11Jan2020	00:15	1.5397	2.085	8.32	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	00:18	1.5365	2.092	8.33	0.0000
11Jan2020	00:21	1.5323	2.098	8.33	0.0000
11Jan2020	00:24	1.5269	2.104	8.34	0.0000
11Jan2020	00:27	1.5208	2.111	8.34	0.0000
11Jan2020	00:30	1.5137	2.117	8.35	0.0000
11Jan2020	00:33	1.5067	2.123	8.36	0.0000
11Jan2020	00:36	1.5002	2.129	8.36	0.0000
11Jan2020	00:39	1.4942	2.135	8.37	0.0000
11Jan2020	00:42	1.4899	2.142	8.38	0.0000
11Jan2020	00:45	1.4869	2.148	8.38	0.0000
11Jan2020	00:48	1.4848	2.154	8.39	0.0000
11Jan2020	00:51	1.4835	2.160	8.39	0.0000
11Jan2020	00:54	1.4818	2.166	8.40	0.0000
11Jan2020	00:57	1.4790	2.172	8.41	0.0000
11Jan2020	01:00	1.4749	2.178	8.41	0.0000
11Jan2020	01:03	1.4685	2.184	8.42	0.0000
11Jan2020	01:06	1.4609	2.190	8.42	0.0000
11Jan2020	01:09	1.4543	2.197	8.43	0.0000
11Jan2020	01:12	1.4487	2.203	8.44	0.0000
11Jan2020	01:15	1.4441	2.208	8.44	0.0000
11Jan2020	01:18	1.4402	2.214	8.45	0.0000
11Jan2020	01:21	1.4354	2.220	8.45	0.0000
11Jan2020	01:24	1.4294	2.226	8.46	0.0000
11Jan2020	01:27	1.4227	2.232	8.47	0.0000
11Jan2020	01:30	1.4151	2.238	8.47	0.0000
11Jan2020	01:33	1.4076	2.244	8.48	0.0000
11Jan2020	01:36	1.4006	2.250	8.48	0.0000
11Jan2020	01:39	1.3942	2.255	8.49	0.0000
11Jan2020	01:42	1.3895	2.261	8.49	0.0000
11Jan2020	01:45	1.3861	2.267	8.50	0.0000
11Jan2020	01:48	1.3837	2.273	8.51	0.0000

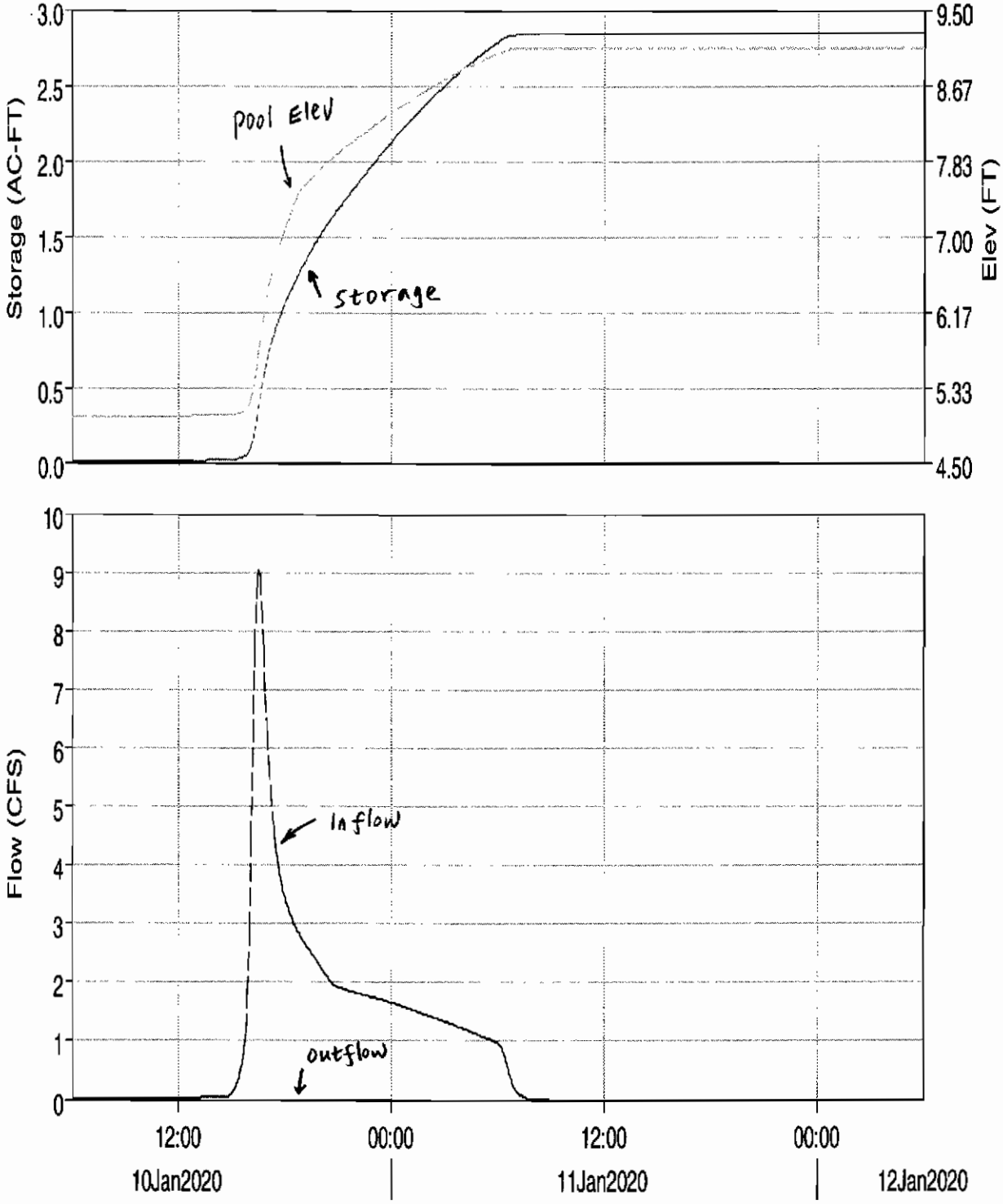
Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	01:51	1.3821	2.278	8.51	0.0000
11Jan2020	01:54	1.3801	2.284	8.52	0.0000
11Jan2020	01:57	1.3769	2.290	8.52	0.0000
11Jan2020	02:00	1.3726	2.295	8.53	0.0000
11Jan2020	02:03	1.3658	2.301	8.53	0.0000
11Jan2020	02:06	1.3578	2.307	8.54	0.0000
11Jan2020	02:09	1.3509	2.312	8.55	0.0000
11Jan2020	02:12	1.3449	2.318	8.55	0.0000
11Jan2020	02:15	1.3400	2.323	8.56	0.0000
11Jan2020	02:18	1.3359	2.329	8.56	0.0000
11Jan2020	02:21	1.3307	2.335	8.57	0.0000
11Jan2020	02:24	1.3244	2.340	8.57	0.0000
11Jan2020	02:27	1.3182	2.345	8.58	0.0000
11Jan2020	02:30	1.3118	2.351	8.58	0.0000
11Jan2020	02:33	1.3065	2.356	8.59	0.0000
11Jan2020	02:36	1.3017	2.362	8.59	0.0000
11Jan2020	02:39	1.2965	2.367	8.60	0.0000
11Jan2020	02:42	1.2908	2.372	8.61	0.0000
11Jan2020	02:45	1.2842	2.378	8.61	0.0000
11Jan2020	02:48	1.2779	2.383	8.62	0.0000
11Jan2020	02:51	1.2730	2.388	8.62	0.0000
11Jan2020	02:54	1.2687	2.394	8.63	0.0000
11Jan2020	02:57	1.2637	2.399	8.63	0.0000
11Jan2020	03:00	1.2584	2.404	8.64	0.0000
11Jan2020	03:03	1.2517	2.409	8.64	0.0000
11Jan2020	03:06	1.2446	2.414	8.65	0.0000
11Jan2020	03:09	1.2386	2.419	8.65	0.0000
11Jan2020	03:12	1.2330	2.425	8.66	0.0000
11Jan2020	03:15	1.2283	2.430	8.66	0.0000
11Jan2020	03:18	1.2242	2.435	8.67	0.0000
11Jan2020	03:21	1.2191	2.440	8.67	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	03:24	1.2127	2.445	8.68	0.0000
11Jan2020	03:27	1.2065	2.450	8.68	0.0000
11Jan2020	03:30	1.2000	2.455	8.69	0.0000
11Jan2020	03:33	1.1945	2.460	8.69	0.0000
11Jan2020	03:36	1.1897	2.465	8.70	0.0000
11Jan2020	03:39	1.1843	2.470	8.70	0.0000
11Jan2020	03:42	1.1784	2.474	8.71	0.0000
11Jan2020	03:45	1.1715	2.479	8.71	0.0000
11Jan2020	03:48	1.1650	2.484	8.72	0.0000
11Jan2020	03:51	1.1599	2.489	8.72	0.0000
11Jan2020	03:54	1.1554	2.494	8.73	0.0000
11Jan2020	03:57	1.1502	2.498	8.73	0.0000
11Jan2020	04:00	1.1446	2.503	8.74	0.0000
11Jan2020	04:03	1.1377	2.508	8.74	0.0000
11Jan2020	04:06	1.1304	2.513	8.75	0.0000
11Jan2020	04:09	1.1241	2.517	8.75	0.0000
11Jan2020	04:12	1.1183	2.522	8.75	0.0000
11Jan2020	04:15	1.1134	2.526	8.76	0.0000
11Jan2020	04:18	1.1091	2.531	8.76	0.0000
11Jan2020	04:21	1.1038	2.536	8.77	0.0000
11Jan2020	04:24	1.0972	2.540	8.77	0.0000
11Jan2020	04:27	1.0907	2.545	8.78	0.0000
11Jan2020	04:30	1.0840	2.549	8.78	0.0000
11Jan2020	04:33	1.0783	2.554	8.79	0.0000
11Jan2020	04:36	1.0732	2.558	8.79	0.0000
11Jan2020	04:39	1.0676	2.563	8.80	0.0000
11Jan2020	04:42	1.0615	2.567	8.80	0.0000
11Jan2020	04:45	1.0545	2.571	8.80	0.0000
11Jan2020	04:48	1.0477	2.576	8.81	0.0000
11Jan2020	04:51	1.0424	2.580	8.81	0.0000
11Jan2020	04:54	1.0377	2.584	8.82	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	04:57	1.0323	2.589	8.82	0.0000
11Jan2020	05:00	1.0265	2.593	8.83	0.0000
11Jan2020	05:03	1.0194	2.597	8.83	0.0000
11Jan2020	05:06	1.0118	2.601	8.83	0.0000
11Jan2020	05:09	1.0054	2.605	8.84	0.0000
11Jan2020	05:12	0.9994	2.610	8.84	0.0000
11Jan2020	05:15	0.9943	2.614	8.85	0.0000
11Jan2020	05:18	0.9898	2.618	8.85	0.0000
11Jan2020	05:21	0.9843	2.622	8.85	0.0000
11Jan2020	05:24	0.9775	2.626	8.86	0.0000
11Jan2020	05:27	0.9708	2.630	8.86	0.0000
11Jan2020	05:30	0.9639	2.634	8.87	0.0000
11Jan2020	05:33	0.9581	2.638	8.87	0.0000
11Jan2020	05:36	0.9528	2.642	8.87	0.0000
11Jan2020	05:39	0.9470	2.646	8.88	0.0000
11Jan2020	05:42	0.9407	2.650	8.88	0.0000
11Jan2020	05:45	0.9335	2.654	8.89	0.0000
11Jan2020	05:48	0.9266	2.657	8.89	0.0000
11Jan2020	05:51	0.9211	2.661	8.89	0.0000
11Jan2020	05:54	0.9162	2.665	8.90	0.0000
11Jan2020	05:57	0.9106	2.669	8.90	0.0000
11Jan2020	06:00	0.9047	2.673	8.91	0.0000
11Jan2020	06:03	0.8923	2.676	8.91	0.0000
11Jan2020	06:06	0.8686	2.680	8.91	0.0000
11Jan2020	06:09	0.8291	2.683	8.92	0.0000
11Jan2020	06:12	0.7672	2.687	8.92	0.0000
11Jan2020	06:15	0.6850	2.690	8.92	0.0000
11Jan2020	06:18	0.5919	2.692	8.93	0.0000
11Jan2020	06:21	0.4968	2.695	8.93	0.0000
11Jan2020	06:24	0.4063	2.696	8.93	0.0000
11Jan2020	06:27	0.3255	2.698	8.93	0.0000

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	06:30	0.2556	2.699	8.93	0.0000
11Jan2020	06:33	0.2005	2.700	8.93	0.0000
11Jan2020	06:36	0.1586	2.701	8.93	0.0000
11Jan2020	06:39	0.1256	2.701	8.93	0.0000
11Jan2020	06:42	0.0996	2.702	8.93	0.0000
11Jan2020	06:45	0.0785	2.702	8.93	0.0000
11Jan2020	06:48	0.0617	2.703	8.94	0.0000
11Jan2020	06:51	0.0487	2.703	8.94	0.0000
11Jan2020	06:54	0.0383	2.703	8.94	0.0000
11Jan2020	06:57	0.0301	2.703	8.94	0.0000
11Jan2020	07:00	0.0236	2.703	8.94	0.0000
11Jan2020	07:03	0.0185	2.703	8.94	0.0000
11Jan2020	07:06	0.0144	2.703	8.94	0.0000
11Jan2020	07:09	0.0112	2.703	8.94	0.0000
11Jan2020	07:12	0.0086	2.703	8.94	0.0000
11Jan2020	07:15	0.0066	2.703	8.94	0.0000
11Jan2020	07:18	0.0050	2.704	8.94	0.0000
11Jan2020	07:21	0.0038	2.704	8.94	0.0000
11Jan2020	07:24	0.0028	2.704	8.94	0.0000
11Jan2020	07:27	0.0019	2.704	8.94	0.0000
11Jan2020	07:30	0.0012	2.704	8.94	0.0000
11Jan2020	07:33	0.0007	2.704	8.94	0.0000
11Jan2020	07:36	0.0004	2.704	8.94	0.0000
11Jan2020	07:39	0.0001	2.704	8.94	0.0000
11Jan2020	07:42	0.0000	2.704	8.94	0.0000
11Jan2020	07:45	0.0000	2.704	8.94	0.0000
11Jan2020	07:48	0.0000	2.704	8.94	0.0000
11Jan2020	07:51	0.0000	2.704	8.94	0.0000
11Jan2020	07:54	0.0000	2.704	8.94	0.0000
11Jan2020	07:57	0.0000	2.704	8.94	0.0000
11Jan2020	08:00	0.0000	2.704	8.94	0.0000

Reservoir "Wetland" Results for Run "Run 1"



Run:Run 1 Element:WETLAND Result:Storage

Run:Run 1 Element:WETLAND Result:Pool Elevation

Run:Run 1 Element:WETLAND Result:Outflow

Run:Run 1 Element:WETLAND Result:Combined Inflow

Superseded by Rev 2

Project: Radback
Simulation Run: Run 1 Reservo

Start of Run: 10Jan2020, 06:00 Basin
End of Run: 12Jan2020, 06:00 M
Compute Time: 11Mar2009, 13:42:58

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	06:00	0.0	0.0	5.0	0.0
10Jan2020	06:06	0.0	0.0	5.0	0.0
10Jan2020	06:12	0.0	0.0	5.0	0.0
10Jan2020	06:18	0.0	0.0	5.0	0.0
10Jan2020	06:24	0.0	0.0	5.0	0.0
10Jan2020	06:30	0.0	0.0	5.0	0.0
10Jan2020	06:36	0.0	0.0	5.0	0.0
10Jan2020	06:42	0.0	0.0	5.0	0.0
10Jan2020	06:48	0.0	0.0	5.0	0.0
10Jan2020	06:54	0.0	0.0	5.0	0.0
10Jan2020	07:00	0.0	0.0	5.0	0.0
10Jan2020	07:06	0.0	0.0	5.0	0.0
10Jan2020	07:12	0.0	0.0	5.0	0.0
10Jan2020	07:18	0.0	0.0	5.0	0.0
10Jan2020	07:24	0.0	0.0	5.0	0.0
10Jan2020	07:30	0.0	0.0	5.0	0.0
10Jan2020	07:36	0.0	0.0	5.0	0.0
10Jan2020	07:42	0.0	0.0	5.0	0.0
10Jan2020	07:48	0.0	0.0	5.0	0.0
10Jan2020	07:54	0.0	0.0	5.0	0.0
10Jan2020	08:00	0.0	0.0	5.0	0.0
10Jan2020	08:06	0.0	0.0	5.0	0.0
10Jan2020	08:12	0.0	0.0	5.0	0.0
10Jan2020	08:18	0.0	0.0	5.0	0.0
10Jan2020	08:24	0.0	0.0	5.0	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	08:30	0.0	0.0	5.0	0.0
10Jan2020	08:36	0.0	0.0	5.0	0.0
10Jan2020	08:42	0.0	0.0	5.0	0.0
10Jan2020	08:48	0.0	0.0	5.0	0.0
10Jan2020	08:54	0.0	0.0	5.0	0.0
10Jan2020	09:00	0.0	0.0	5.0	0.0
10Jan2020	09:06	0.0	0.0	5.0	0.0
10Jan2020	09:12	0.0	0.0	5.0	0.0
10Jan2020	09:18	0.0	0.0	5.0	0.0
10Jan2020	09:24	0.0	0.0	5.0	0.0
10Jan2020	09:30	0.0	0.0	5.0	0.0
10Jan2020	09:36	0.0	0.0	5.0	0.0
10Jan2020	09:42	0.0	0.0	5.0	0.0
10Jan2020	09:48	0.0	0.0	5.0	0.0
10Jan2020	09:54	0.0	0.0	5.0	0.0
10Jan2020	10:00	0.0	0.0	5.0	0.0
10Jan2020	10:06	0.0	0.0	5.0	0.0
10Jan2020	10:12	0.0	0.0	5.0	0.0
10Jan2020	10:18	0.0	0.0	5.0	0.0
10Jan2020	10:24	0.0	0.0	5.0	0.0
10Jan2020	10:30	0.0	0.0	5.0	0.0
10Jan2020	10:36	0.0	0.0	5.0	0.0
10Jan2020	10:42	0.0	0.0	5.0	0.0
10Jan2020	10:48	0.0	0.0	5.0	0.0
10Jan2020	10:54	0.0	0.0	5.0	0.0
10Jan2020	11:00	0.0	0.0	5.0	0.0
10Jan2020	11:06	0.0	0.0	5.0	0.0
10Jan2020	11:12	0.0	0.0	5.0	0.0
10Jan2020	11:18	0.0	0.0	5.0	0.0
10Jan2020	11:24	0.0	0.0	5.0	0.0
10Jan2020	11:30	0.0	0.0	5.0	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	11:36	0.0	0.0	5.0	0.0
10Jan2020	11:42	0.0	0.0	5.0	0.0
10Jan2020	11:48	0.0	0.0	5.0	0.0
10Jan2020	11:54	0.0	0.0	5.0	0.0
10Jan2020	12:00	0.0	0.0	5.0	0.0
10Jan2020	12:06	0.0	0.0	5.0	0.0
10Jan2020	12:12	0.0	0.0	5.0	0.0
10Jan2020	12:18	0.0	0.0	5.0	0.0
10Jan2020	12:24	0.0	0.0	5.0	0.0
10Jan2020	12:30	0.0	0.0	5.0	0.0
10Jan2020	12:36	0.0	0.0	5.0	0.0
10Jan2020	12:42	0.0	0.0	5.0	0.0
10Jan2020	12:48	0.0	0.0	5.0	0.0
10Jan2020	12:54	0.0	0.0	5.0	0.0
10Jan2020	13:00	0.0	0.0	5.0	0.0
10Jan2020	13:06	0.0	0.0	5.0	0.0
10Jan2020	13:12	0.0	0.0	5.0	0.0
10Jan2020	13:18	0.0	0.0	5.0	0.0
10Jan2020	13:24	0.0	0.0	5.0	0.0
10Jan2020	13:30	0.0	0.0	5.0	0.0
10Jan2020	13:36	0.0	0.0	5.0	0.0
10Jan2020	13:42	0.0	0.0	5.0	0.0
10Jan2020	13:48	0.0	0.0	5.0	0.0
10Jan2020	13:54	0.0	0.0	5.0	0.0
10Jan2020	14:00	0.0	0.0	5.0	0.0
10Jan2020	14:06	0.0	0.0	5.0	0.0
10Jan2020	14:12	0.0	0.0	5.0	0.0
10Jan2020	14:18	0.0	0.0	5.0	0.0
10Jan2020	14:24	0.0	0.0	5.0	0.0
10Jan2020	14:30	0.0	0.0	5.0	0.0
10Jan2020	14:36	0.0	0.0	5.0	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	14:42	0.1	0.0	5.0	0.0
10Jan2020	14:48	0.1	0.0	5.0	0.0
10Jan2020	14:54	0.1	0.0	5.0	0.0
10Jan2020	15:00	0.1	0.0	5.0	0.0
10Jan2020	15:06	0.2	0.0	5.0	0.0
10Jan2020	15:12	0.2	0.0	5.0	0.0
10Jan2020	15:18	0.3	0.0	5.0	0.0
10Jan2020	15:24	0.4	0.0	5.1	0.0
10Jan2020	15:30	0.5	0.0	5.1	0.0
10Jan2020	15:36	0.6	0.0	5.1	0.0
10Jan2020	15:42	0.8	0.0	5.1	0.0
10Jan2020	15:48	1.1	0.0	5.1	0.0
10Jan2020	15:54	1.8	0.1	5.1	0.0
10Jan2020	16:00	2.9	0.1	5.2	0.0
10Jan2020	16:06	4.4	0.1	5.2	0.0
10Jan2020	16:12	6.2	0.2	5.3	0.0
10Jan2020	16:18	7.7	0.2	5.4	0.0
10Jan2020	16:24	8.7	0.3	5.6	0.0
10Jan2020	16:30	9.0	0.4	5.7	0.0
10Jan2020	16:36	8.9	0.4	5.8	0.0
10Jan2020	16:42	8.4	0.5	6.0	0.0
10Jan2020	16:48	7.7	0.6	6.1	0.0
10Jan2020	16:54	6.9	0.6	6.2	0.0
10Jan2020	17:00	6.3	0.7	6.3	0.0
10Jan2020	17:06	5.8	0.7	6.4	0.0
10Jan2020	17:12	5.3	0.8	6.5	0.0
10Jan2020	17:18	4.9	0.8	6.6	0.0
10Jan2020	17:24	4.6	0.9	6.7	0.0
10Jan2020	17:30	4.3	0.9	6.8	0.0
10Jan2020	17:36	4.1	0.9	6.8	0.0
10Jan2020	17:42	3.9	1.0	6.9	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	17:48	3.7	1.0	7.0	0.0
10Jan2020	17:54	3.6	1.0	7.0	0.0
10Jan2020	18:00	3.5	1.1	7.1	0.0
10Jan2020	18:06	3.3	1.1	7.1	0.0
10Jan2020	18:12	3.3	1.1	7.2	0.0
10Jan2020	18:18	3.2	1.1	7.2	0.0
10Jan2020	18:24	3.1	1.2	7.3	0.0
10Jan2020	18:30	3.0	1.2	7.3	0.0
10Jan2020	18:36	3.0	1.2	7.4	0.0
10Jan2020	18:42	2.9	1.2	7.4	0.0
10Jan2020	18:48	2.8	1.3	7.5	0.0
10Jan2020	18:54	2.8	1.3	7.5	0.0
10Jan2020	19:00	2.7	1.3	7.5	0.0
10Jan2020	19:06	2.7	1.3	7.6	0.0
10Jan2020	19:12	2.6	1.3	7.6	0.0
10Jan2020	19:18	2.6	1.4	7.6	0.0
10Jan2020	19:24	2.5	1.4	7.6	0.0
10Jan2020	19:30	2.5	1.4	7.6	0.0
10Jan2020	19:36	2.5	1.4	7.7	0.0
10Jan2020	19:42	2.4	1.5	7.7	0.0
10Jan2020	19:48	2.4	1.5	7.7	0.0
10Jan2020	19:54	2.3	1.5	7.7	0.0
10Jan2020	20:00	2.3	1.5	7.7	0.0
10Jan2020	20:06	2.2	1.5	7.8	0.0
10Jan2020	20:12	2.2	1.5	7.8	0.0
10Jan2020	20:18	2.1	1.6	7.8	0.0
10Jan2020	20:24	2.1	1.6	7.8	0.0
10Jan2020	20:30	2.1	1.6	7.8	0.0
10Jan2020	20:36	2.0	1.6	7.8	0.0
10Jan2020	20:42	2.0	1.6	7.9	0.0
10Jan2020	20:48	2.0	1.6	7.9	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
10Jan2020	20:54	1.9	1.7	7.9	0.0
10Jan2020	21:00	1.9	1.7	7.9	0.0
10Jan2020	21:06	1.9	1.7	7.9	0.0
10Jan2020	21:12	1.9	1.7	7.9	0.0
10Jan2020	21:18	1.9	1.7	8.0	0.0
10Jan2020	21:24	1.9	1.7	8.0	0.0
10Jan2020	21:30	1.9	1.8	8.0	0.0
10Jan2020	21:36	1.9	1.8	8.0	0.0
10Jan2020	21:42	1.9	1.8	8.0	0.0
10Jan2020	21:48	1.8	1.8	8.0	0.0
10Jan2020	21:54	1.8	1.8	8.1	0.0
10Jan2020	22:00	1.8	1.8	8.1	0.0
10Jan2020	22:06	1.8	1.8	8.1	0.0
10Jan2020	22:12	1.8	1.9	8.1	0.0
10Jan2020	22:18	1.8	1.9	8.1	0.0
10Jan2020	22:24	1.8	1.9	8.1	0.0
10Jan2020	22:30	1.8	1.9	8.1	0.0
10Jan2020	22:36	1.8	1.9	8.2	0.0
10Jan2020	22:42	1.8	1.9	8.2	0.0
10Jan2020	22:48	1.8	2.0	8.2	0.0
10Jan2020	22:54	1.8	2.0	8.2	0.0
10Jan2020	23:00	1.7	2.0	8.2	0.0
10Jan2020	23:06	1.7	2.0	8.2	0.0
10Jan2020	23:12	1.7	2.0	8.2	0.0
10Jan2020	23:18	1.7	2.0	8.3	0.0
10Jan2020	23:24	1.7	2.0	8.3	0.0
10Jan2020	23:30	1.7	2.1	8.3	0.0
10Jan2020	23:36	1.7	2.1	8.3	0.0
10Jan2020	23:42	1.7	2.1	8.3	0.0
10Jan2020	23:48	1.7	2.1	8.3	0.0
10Jan2020	23:54	1.7	2.1	8.3	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	00:00	1.7	2.1	8.4	0.0
11Jan2020	00:06	1.6	2.1	8.4	0.0
11Jan2020	00:12	1.6	2.2	8.4	0.0
11Jan2020	00:18	1.6	2.2	8.4	0.0
11Jan2020	00:24	1.6	2.2	8.4	0.0
11Jan2020	00:30	1.6	2.2	8.4	0.0
11Jan2020	00:36	1.6	2.2	8.4	0.0
11Jan2020	00:42	1.6	2.2	8.5	0.0
11Jan2020	00:48	1.6	2.2	8.5	0.0
11Jan2020	00:54	1.6	2.2	8.5	0.0
11Jan2020	01:00	1.6	2.3	8.5	0.0
11Jan2020	01:06	1.6	2.3	8.5	0.0
11Jan2020	01:12	1.5	2.3	8.5	0.0
11Jan2020	01:18	1.5	2.3	8.5	0.0
11Jan2020	01:24	1.5	2.3	8.5	0.0
11Jan2020	01:30	1.5	2.3	8.6	0.0
11Jan2020	01:36	1.5	2.3	8.6	0.0
11Jan2020	01:42	1.5	2.3	8.6	0.0
11Jan2020	01:48	1.5	2.4	8.6	0.0
11Jan2020	01:54	1.5	2.4	8.6	0.0
11Jan2020	02:00	1.5	2.4	8.6	0.0
11Jan2020	02:06	1.4	2.4	8.6	0.0
11Jan2020	02:12	1.4	2.4	8.6	0.0
11Jan2020	02:18	1.4	2.4	8.6	0.0
11Jan2020	02:24	1.4	2.4	8.7	0.0
11Jan2020	02:30	1.4	2.4	8.7	0.0
11Jan2020	02:36	1.4	2.5	8.7	0.0
11Jan2020	02:42	1.4	2.5	8.7	0.0
11Jan2020	02:48	1.4	2.5	8.7	0.0
11Jan2020	02:54	1.4	2.5	8.7	0.0
11Jan2020	03:00	1.3	2.5	8.7	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	03:06	1.3	2.5	8.7	0.0
11Jan2020	03:12	1.3	2.5	8.8	0.0
11Jan2020	03:18	1.3	2.5	8.8	0.0
11Jan2020	03:24	1.3	2.5	8.8	0.0
11Jan2020	03:30	1.3	2.6	8.8	0.0
11Jan2020	03:36	1.3	2.6	8.8	0.0
11Jan2020	03:42	1.3	2.6	8.8	0.0
11Jan2020	03:48	1.2	2.6	8.8	0.0
11Jan2020	03:54	1.2	2.6	8.8	0.0
11Jan2020	04:00	1.2	2.6	8.8	0.0
11Jan2020	04:06	1.2	2.6	8.8	0.0
11Jan2020	04:12	1.2	2.6	8.9	0.0
11Jan2020	04:18	1.2	2.6	8.9	0.0
11Jan2020	04:24	1.2	2.6	8.9	0.0
11Jan2020	04:30	1.2	2.7	8.9	0.0
11Jan2020	04:36	1.2	2.7	8.9	0.0
11Jan2020	04:42	1.1	2.7	8.9	0.0
11Jan2020	04:48	1.1	2.7	8.9	0.0
11Jan2020	04:54	1.1	2.7	8.9	0.0
11Jan2020	05:00	1.1	2.7	8.9	0.0
11Jan2020	05:06	1.1	2.7	8.9	0.0
11Jan2020	05:12	1.1	2.7	8.9	0.0
11Jan2020	05:18	1.1	2.7	9.0	0.0
11Jan2020	05:24	1.1	2.7	9.0	0.0
11Jan2020	05:30	1.0	2.7	9.0	0.0
11Jan2020	05:36	1.0	2.8	9.0	0.0
11Jan2020	05:42	1.0	2.8	9.0	0.0
11Jan2020	05:48	1.0	2.8	9.0	0.0
11Jan2020	05:54	1.0	2.8	9.0	0.0
11Jan2020	06:00	1.0	2.8	9.0	0.0
11Jan2020	06:06	1.0	2.8	9.0	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	06:12	0.9	2.8	9.0	0.0
11Jan2020	06:18	0.9	2.8	9.0	0.0
11Jan2020	06:24	0.8	2.8	9.0	0.0
11Jan2020	06:30	0.7	2.8	9.1	0.0
11Jan2020	06:36	0.5	2.8	9.1	0.0
11Jan2020	06:42	0.4	2.8	9.1	0.0
11Jan2020	06:48	0.3	2.8	9.1	0.0
11Jan2020	06:54	0.2	2.8	9.1	0.0
11Jan2020	07:00	0.2	2.8	9.1	0.0
11Jan2020	07:06	0.1	2.8	9.1	0.0
11Jan2020	07:12	0.1	2.8	9.1	0.0
11Jan2020	07:18	0.1	2.8	9.1	0.0
11Jan2020	07:24	0.1	2.8	9.1	0.0
11Jan2020	07:30	0.0	2.8	9.1	0.0
11Jan2020	07:36	0.0	2.8	9.1	0.0
11Jan2020	07:42	0.0	2.8	9.1	0.0
11Jan2020	07:48	0.0	2.8	9.1	0.0
11Jan2020	07:54	0.0	2.8	9.1	0.0
11Jan2020	08:00	0.0	2.8	9.1	0.0
11Jan2020	08:06	0.0	2.8	9.1	0.0
11Jan2020	08:12	0.0	2.8	9.1	0.0
11Jan2020	08:18	0.0	2.8	9.1	0.0
11Jan2020	08:24	0.0	2.8	9.1	0.0
11Jan2020	08:30	0.0	2.8	9.1	0.0
11Jan2020	08:36	0.0	2.8	9.1	0.0
11Jan2020	08:42	0.0	2.8	9.1	0.0
11Jan2020	08:48	0.0	2.8	9.1	0.0
11Jan2020	08:54	0.0	2.8	9.1	0.0
11Jan2020	09:00	0.0	2.8	9.1	0.0
11Jan2020	09:06	0.0	2.8	9.1	0.0
11Jan2020	09:12	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	09:18	0.0	2.8	9.1	0.0
11Jan2020	09:24	0.0	2.8	9.1	0.0
11Jan2020	09:30	0.0	2.8	9.1	0.0
11Jan2020	09:36	0.0	2.8	9.1	0.0
11Jan2020	09:42	0.0	2.8	9.1	0.0
11Jan2020	09:48	0.0	2.8	9.1	0.0
11Jan2020	09:54	0.0	2.8	9.1	0.0
11Jan2020	10:00	0.0	2.8	9.1	0.0
11Jan2020	10:06	0.0	2.8	9.1	0.0
11Jan2020	10:12	0.0	2.8	9.1	0.0
11Jan2020	10:18	0.0	2.8	9.1	0.0
11Jan2020	10:24	0.0	2.8	9.1	0.0
11Jan2020	10:30	0.0	2.8	9.1	0.0
11Jan2020	10:36	0.0	2.8	9.1	0.0
11Jan2020	10:42	0.0	2.8	9.1	0.0
11Jan2020	10:48	0.0	2.8	9.1	0.0
11Jan2020	10:54	0.0	2.8	9.1	0.0
11Jan2020	11:00	0.0	2.8	9.1	0.0
11Jan2020	11:06	0.0	2.8	9.1	0.0
11Jan2020	11:12	0.0	2.8	9.1	0.0
11Jan2020	11:18	0.0	2.8	9.1	0.0
11Jan2020	11:24	0.0	2.8	9.1	0.0
11Jan2020	11:30	0.0	2.8	9.1	0.0
11Jan2020	11:36	0.0	2.8	9.1	0.0
11Jan2020	11:42	0.0	2.8	9.1	0.0
11Jan2020	11:48	0.0	2.8	9.1	0.0
11Jan2020	11:54	0.0	2.8	9.1	0.0
11Jan2020	12:00	0.0	2.8	9.1	0.0
11Jan2020	12:06	0.0	2.8	9.1	0.0
11Jan2020	12:12	0.0	2.8	9.1	0.0
11Jan2020	12:18	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	12:24	0.0	2.8	9.1	0.0
11Jan2020	12:30	0.0	2.8	9.1	0.0
11Jan2020	12:36	0.0	2.8	9.1	0.0
11Jan2020	12:42	0.0	2.8	9.1	0.0
11Jan2020	12:48	0.0	2.8	9.1	0.0
11Jan2020	12:54	0.0	2.8	9.1	0.0
11Jan2020	13:00	0.0	2.8	9.1	0.0
11Jan2020	13:06	0.0	2.8	9.1	0.0
11Jan2020	13:12	0.0	2.8	9.1	0.0
11Jan2020	13:18	0.0	2.8	9.1	0.0
11Jan2020	13:24	0.0	2.8	9.1	0.0
11Jan2020	13:30	0.0	2.8	9.1	0.0
11Jan2020	13:36	0.0	2.8	9.1	0.0
11Jan2020	13:42	0.0	2.8	9.1	0.0
11Jan2020	13:48	0.0	2.8	9.1	0.0
11Jan2020	13:54	0.0	2.8	9.1	0.0
11Jan2020	14:00	0.0	2.8	9.1	0.0
11Jan2020	14:06	0.0	2.8	9.1	0.0
11Jan2020	14:12	0.0	2.8	9.1	0.0
11Jan2020	14:18	0.0	2.8	9.1	0.0
11Jan2020	14:24	0.0	2.8	9.1	0.0
11Jan2020	14:30	0.0	2.8	9.1	0.0
11Jan2020	14:36	0.0	2.8	9.1	0.0
11Jan2020	14:42	0.0	2.8	9.1	0.0
11Jan2020	14:48	0.0	2.8	9.1	0.0
11Jan2020	14:54	0.0	2.8	9.1	0.0
11Jan2020	15:00	0.0	2.8	9.1	0.0
11Jan2020	15:06	0.0	2.8	9.1	0.0
11Jan2020	15:12	0.0	2.8	9.1	0.0
11Jan2020	15:18	0.0	2.8	9.1	0.0
11Jan2020	15:24	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	15:30	0.0	2.8	9.1	0.0
11Jan2020	15:36	0.0	2.8	9.1	0.0
11Jan2020	15:42	0.0	2.8	9.1	0.0
11Jan2020	15:48	0.0	2.8	9.1	0.0
11Jan2020	15:54	0.0	2.8	9.1	0.0
11Jan2020	16:00	0.0	2.8	9.1	0.0
11Jan2020	16:06	0.0	2.8	9.1	0.0
11Jan2020	16:12	0.0	2.8	9.1	0.0
11Jan2020	16:18	0.0	2.8	9.1	0.0
11Jan2020	16:24	0.0	2.8	9.1	0.0
11Jan2020	16:30	0.0	2.8	9.1	0.0
11Jan2020	16:36	0.0	2.8	9.1	0.0
11Jan2020	16:42	0.0	2.8	9.1	0.0
11Jan2020	16:48	0.0	2.8	9.1	0.0
11Jan2020	16:54	0.0	2.8	9.1	0.0
11Jan2020	17:00	0.0	2.8	9.1	0.0
11Jan2020	17:06	0.0	2.8	9.1	0.0
11Jan2020	17:12	0.0	2.8	9.1	0.0
11Jan2020	17:18	0.0	2.8	9.1	0.0
11Jan2020	17:24	0.0	2.8	9.1	0.0
11Jan2020	17:30	0.0	2.8	9.1	0.0
11Jan2020	17:36	0.0	2.8	9.1	0.0
11Jan2020	17:42	0.0	2.8	9.1	0.0
11Jan2020	17:48	0.0	2.8	9.1	0.0
11Jan2020	17:54	0.0	2.8	9.1	0.0
11Jan2020	18:00	0.0	2.8	9.1	0.0
11Jan2020	18:06	0.0	2.8	9.1	0.0
11Jan2020	18:12	0.0	2.8	9.1	0.0
11Jan2020	18:18	0.0	2.8	9.1	0.0
11Jan2020	18:24	0.0	2.8	9.1	0.0
11Jan2020	18:30	0.0	2.8	9.1	0.0

Date	Time	Inflow (CFS)	Storage (AC-FT)	Elevation (FT)	Outflow (CFS)
11Jan2020	18:36	0.0	2.8	9.1	0.0
11Jan2020	18:42	0.0	2.8	9.1	0.0
11Jan2020	18:48	0.0	2.8	9.1	0.0
11Jan2020	18:54	0.0	2.8	9.1	0.0
11Jan2020	19:00	0.0	2.8	9.1	0.0
11Jan2020	19:06	0.0	2.8	9.1	0.0
11Jan2020	19:12	0.0	2.8	9.1	0.0
11Jan2020	19:18	0.0	2.8	9.1	0.0
11Jan2020	19:24	0.0	2.8	9.1	0.0
11Jan2020	19:30	0.0	2.8	9.1	0.0
11Jan2020	19:36	0.0	2.8	9.1	0.0
11Jan2020	19:42	0.0	2.8	9.1	0.0
11Jan2020	19:48	0.0	2.8	9.1	0.0
11Jan2020	19:54	0.0	2.8	9.1	0.0
11Jan2020	20:00	0.0	2.8	9.1	0.0
11Jan2020	20:06	0.0	2.8	9.1	0.0
11Jan2020	20:12	0.0	2.8	9.1	0.0
11Jan2020	20:18	0.0	2.8	9.1	0.0
11Jan2020	20:24	0.0	2.8	9.1	0.0
11Jan2020	20:30	0.0	2.8	9.1	0.0
11Jan2020	20:36	0.0	2.8	9.1	0.0
11Jan2020	20:42	0.0	2.8	9.1	0.0
11Jan2020	20:48	0.0	2.8	9.1	0.0
11Jan2020	20:54	0.0	2.8	9.1	0.0
11Jan2020	21:00	0.0	2.8	9.1	0.0
11Jan2020	21:06	0.0	2.8	9.1	0.0
11Jan2020	21:12	0.0	2.8	9.1	0.0
11Jan2020	21:18	0.0	2.8	9.1	0.0
11Jan2020	21:24	0.0	2.8	9.1	0.0
11Jan2020	21:30	0.0	2.8	9.1	0.0
11Jan2020	21:36	0.0	2.8	9.1	0.0

Post-Construction Wetland Volume and Water Surface Elevation

BLACK & VEATCH
Building a world of difference.

CALCULATION RECORD

Client Name: Radback Energy Page 1 of 21

Project Name: Oakley Generating Station Project No.: 163994

Calculation Title: Post-Construction Wetland Volume and Water Surface Elevation

Calculation No./File No.: 52.5406.1006

Verification Method: ☒ Check and Review ☐ Alternate Calculations

Objective To determine if the existing wetland at the project site can retain the runoff from various storm events without overflowing to other properties.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

Refer to Page _____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number: HEC-HMS Version: 3.3

Standard B&V Application Used? ☒ Yes ☐ No
If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	C Kantola SKK	11 June 2010	PLNelson	18 JUNE 2010	PLNelson	18 June 2010
1	C Kantola SKK	13 Sept 2010	PLNelson	16 Sept 10	PLNelson	16 Sept 10

Purpose

To determine the stormwater storage volume and water surface elevation for the existing wetland and the proposed pond at the Oakley project site for storm events including the 1-inch rainfall, 10-year/24-hour storm, and combined 100-year/24-hour plus 10-year/24-hour storm (100+10) events. The analyses are performed for pre-construction and post-construction ground conditions at the project site.

References

1. Black & Veatch Drawings:
   - 163994-SS-3001, Rev. A, "Grading & Drainage - Site"
   - 163994-SS-3001, Rev. 0, "Grading & Drainage - Site"
2. US Department of Agriculture; Urban Hydrology for Small Watersheds, 2nd Edition; Technical Release 55 (TR-55); June 1986.
3. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, User's Manual, Version 3.3; September 2008.
4. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, Technical Reference Manual; March 2000.
5. Contra Costa County Dept. of Public Works Maps; Mean Seasonal Isohyets Compiled from Precipitation Records 1879-1973; Drawing No. B-166; December 1977; Precipitation Duration-Frequency-Depth Curves (100-yr and 10-yr); Drawing Nos. B-159 and B-162; July 1977
6. US Department of Agriculture, Natural Resources Conservation Service; Web Soil Survey; http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
7. Mays, L. W.; Stormwater Collection Systems Design Handbook, McGraw-Hill; 2001.
8. Black & Veatch Calculation, "IMP Sizing for Plant Area", File No. 52.5406.1008 Rev 0, Same project, June 2010
9. Black & Veatch Calculation, "Stormwater Analysis", File No. 52.5406.1003 Rev 2, Same project, June 2010
10. Email Correspondence with Contra Costa County Flood Control, May 2010

Definition of Units and Constants

English units will be used.

Example of Common Unit Designations:

Rainfall amount in inches (in)

Drainage area in acres (ac)

Attachments

1. HEC-HMS Input
2. HEC-HMS Output
3. Reference 2 – Select Pages
4. Reference 6 – Select Pages
5. Reference 8 – Select Pages
6. Reference 9 – Select Pages
7. Reference 10

Summary

Based on the HEC-HMS analyses with current and proposed design conditions, the stormwater runoff to the wetland will not overflow to other properties for any of the analyzed storm events including the 100-year 24-hour storm followed by a 10-year 24-hour storm (100+10 event). This combined event was requested to be analyzed by Contra Costa County for the wetland area since there is no outlet within the wetland area. See Reference 10 – Attachment 7.

The maximum water surface elevation (WSEL) in the wetland is EL 10.7, produced by the combined 100+10 events. This is below the overflow elevation at the adjacent roadway of EL 11.7. The comparison between the existing and proposed site conditions for other storm events are summarized in the table below.

Summary of Runoff Volume & Wetland WSEL

Rainfall Event	Pre-Construction		Post-Construction	
	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)
1-inch	0.03	5.1	0.05	5.1
10-year	1.10	7.2	1.51	7.7
100-year	2.70	8.9	3.58	9.7
100-year + 10-year	3.80	10.0	5.42	10.7

superseded 9/13/10
See page 4A

Summary

Based on the HEC-HMS analyses with current and proposed design conditions, the stormwater runoff to the wetland will not overflow to other properties for any of the analyzed storm events including the 100-year 24-hour storm followed by a 10-year 24-hour storm (100+10 event). This combined event was requested to be analyzed by Contra Costa County for the wetland area since there is no outlet within the wetland area. See Reference 10 – Attachment 7.

The maximum water surface elevation (WSEL) in the wetland is produced by the combined 100+10 events which is below the overflow elevation at the adjacent roadway of EL 11.7. The comparison between the existing and proposed site conditions for other storm events are summarized in the table below.

Summary of Runoff Volume & Wetland WSEL

Rainfall Event	Pre-Construction		Post-Construction	
	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)
1-inch	0.06	5.1	0.15	5.3
10-year	1.17	7.3	1.90	8.1
100-year	2.79	9.0	3.58	9.8
100-year + 10-year	3.96	10.1	5.11	10.8

Hydrology Modeling – HEC-HMS

For the runoff volume and storage analysis, the entire site was modeled as one drainage area for the pre-construction (existing) condition (Reference 9) and separated into distinct drainage areas for the post-construction (proposed) condition (bioswales, and direct runoff to pond and wetland areas). See Page 6a7 for the boundary delineation of these areas. The drainage areas are summarized in the table below, with measurements taken from References 8 & 9 and also using AutoCAD.

VOID

Summary of Drainage Areas (in acres & square miles)

Ground Cover Type	Existing Site Acreage*	Post-Construction Site Acreage					
		Bioswale **				Direct to Pond	Direct to Wetland
		1+2	3	4	5		
Vineyard / Undisturbed	19.85	-	-	-	-	-	1.93
Gravel	3.96	2.30	-	2.51	3.35	-	-
Railroad Yard	0.94	-	-	-	0.94	-	-
Wetland	0.40	-	-	-	-	-	0.40
Lawn (Poor Coverage <50%)	-	4.55	0.45	0.54	1.50	0.85	-
Impervious Surface ***	-	2.75	0.14	1.21	0.88	0.13	0.27 (ex. roads)
Transformer Contain ****	-	0.10	-	0.12	-	-	-
Open Graded Aggregate	-	1.57	-	-	-	-	-
Total Acres:	25.15	11.17	0.59	4.26	6.67	0.98	2.60
Total (Sq. Mi.):	**0.0393**	**0.0175**	**0.0009**	**0.0067**	**0.0104**	**0.0015**	**0.0041**
		0.0411 sq. mi. (Total Post-Construction)					

* Existing site acreage as determined in BV Calc 52.5406.1003 (Ref 9)
** Post-construction areas as determined in BV Calc 52.5406.1008 (Ref 8)
*** Impervious surface computed as sum of Equipment/Roofs + Pavement (from Calc 52.5406.1002)
**** Transformer Containment area does not drain to Bioswales and is not included in total areas listed.

The stormwater runoff to the wetland for various storms was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).

Superseded 9/13/10 See Pg 5A

Hydrology Modeling – HEC-HMS

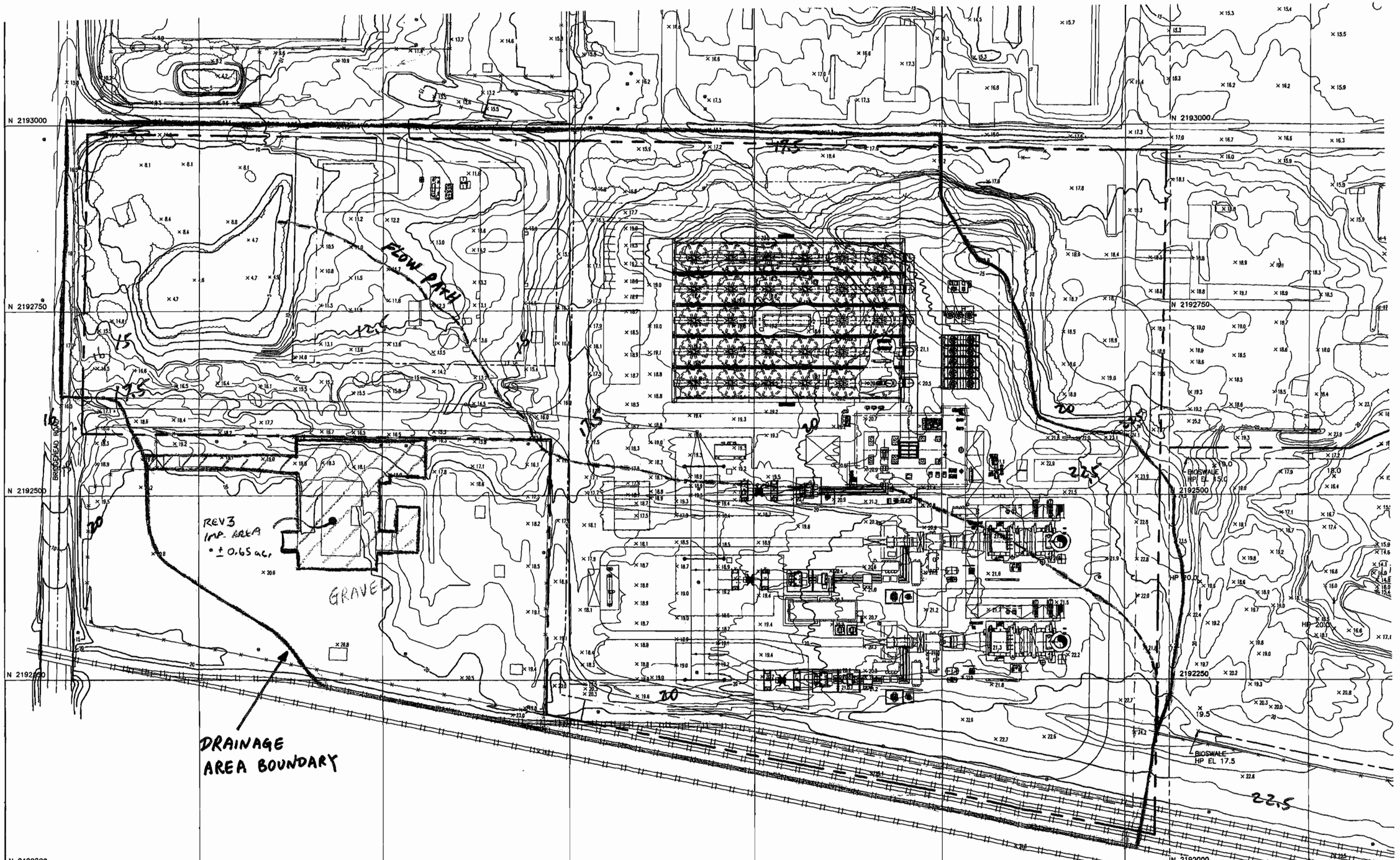
For the runoff volume and storage analysis, the entire site was modeled as one drainage area for the pre-construction (existing) condition (Reference 9) and separated into distinct drainage areas for the post-construction (proposed) condition (bioswales, and direct runoff to pond and wetland areas). See Page 6 & 7 for the boundary delineation of these areas. The drainage areas are summarized in the table below, with measurements taken from References 8 & 9 and also using AutoCAD.

Summary of Drainage Areas (in acres & square miles)

Ground Cover Type	Existing Site Acreage*	Post-Construction Site Acreage					
		Bioswale **				Direct to Pond	Direct to Wetland
		1+2	3	4	5		
Vineyard / Undisturbed	19.85	-	REMOVED IN REVISION 1	-	-	-	1.93
Gravel	3.96	2.30		2.51	2.87	0.1	-
Railroad Yard	0.94	-		-	0.94	-	-
Wetland	0.40	-		-	-	-	0.40
Lawn (Poor Coverage <50%)	-	4.55		0.54	0.95	1.28	0.47
Impervious Surface ***	-	2.75		1.21	1.32	0.30	0.28 (ex. roads)
Transformer Contain ****	-	0.10		0.12	-	-	-
Open Graded Aggregate	-	1.57		-	-	-	-
Total Acres:	25.15	11.17		4.26	6.08	1.68	3.08
Total (Sq. Mi.):	**0.0393**	**0.0175**	**0.0000**	**0.0067**	**0.0095**	**0.0026**	**0.0048**
		0.0411 sq. mi. (Total Post-Construction)					

* Existing site acreage as determined in BV Calc 52.5406.1003 (Ref 9)
** Post-construction areas as determined in BV Calc 52.5406.1008 (Ref 8)
*** Impervious surface computed as sum of Equipment/Roofs + Pavement (from Calc 52.5406.1002)
**** Transformer Containment area does not drain to Bioswales and is not included in total areas listed.

The stormwater runoff to the wetland for various storms was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).



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stormwater Analysis
page ~~8~~ of ~~53~~
6 of 21

prepared by: J zhong
Date: 3/4/09
checked by: PLN
Date: 3/6/09

REV 3 CAK
DATE 9/9/10
CK BY: PLN
DATE: 9/16/10

NOTE: THIS PAGE IS A PORTION OF B&V
Drawing 163994-SS-3001 Rev A.

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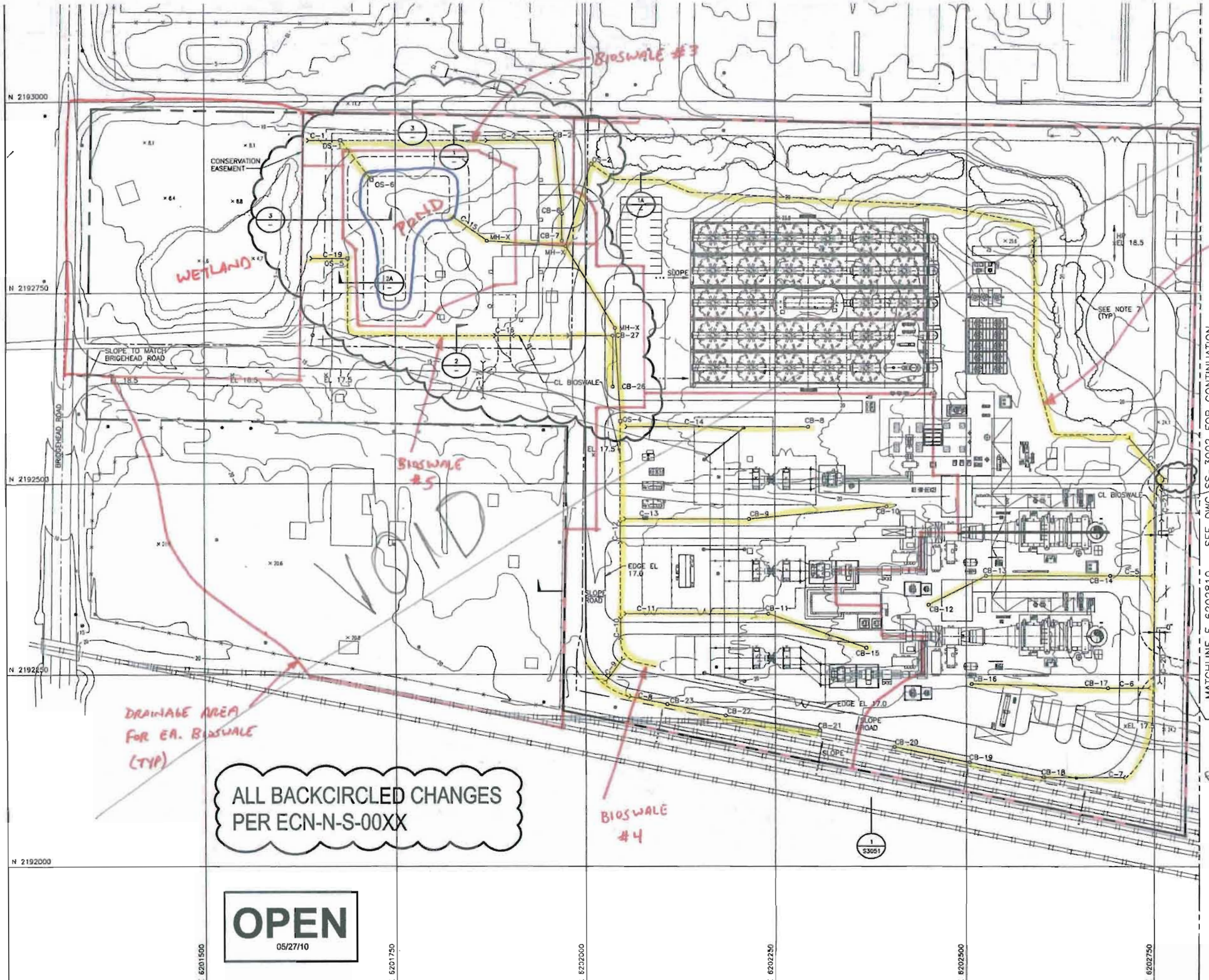

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Radiant Oakley Project # 163994 Stormwater Analysis 52.5426 ~~1007~~ 1006 page ~~6 of 57~~ 7 of 21

BY CK
Date 6/17/10
Ver: PW
Date: 6/18/10

B+W Dwg 163994-SS-3001 Rev 1

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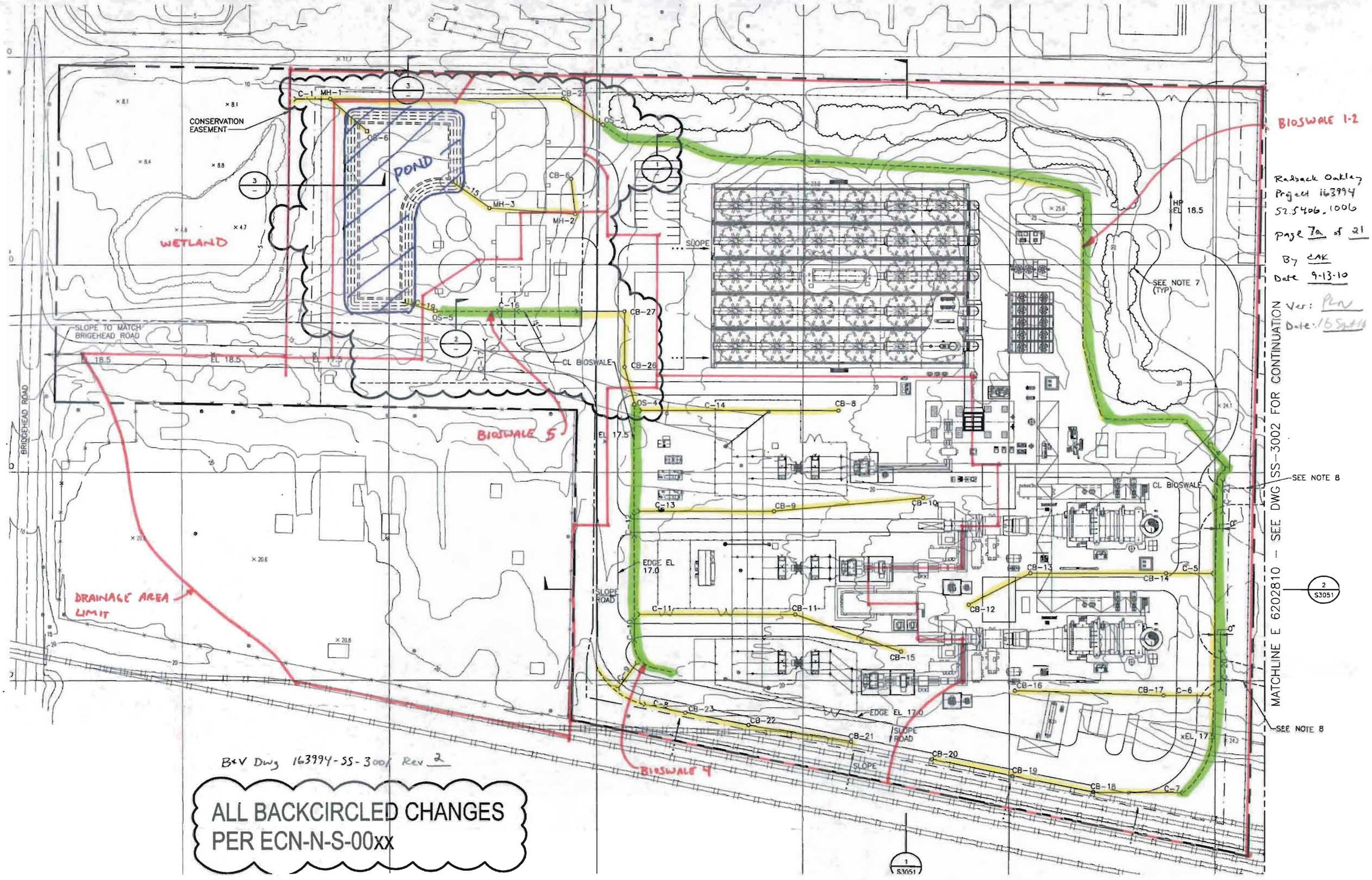
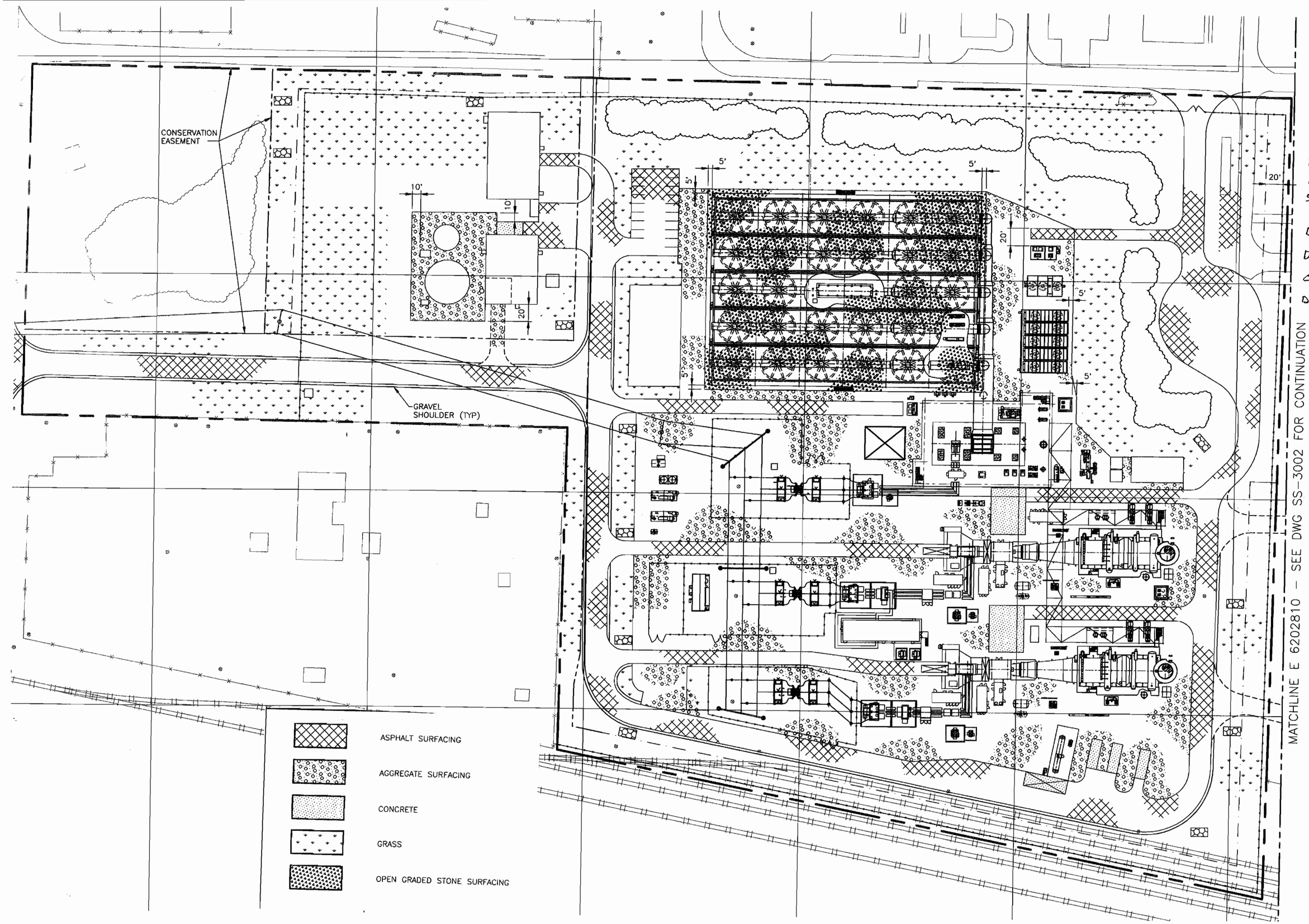


Radback Oakley
Project 163994
52.5406.1006
Page 7a of 21
By CAK
Date 9-13-10
Ver: PLN
Date: 16 Sept 10



Page 7b of 21

Radback Oakley
Project 163994
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By: C. Kantola
Date: 9-13-10
Chk: PW
Date: 9/16/10

Note: This page is a portion of B&V Drawing 163994-SS-3201 REV. 0

Section 1.0 – Determine the Time of Concentration (Tc) and Lag Time

This calculation is a volumetric analysis only. Lag time (which is a function of the time of concentration) is used by HEC-HMS to compute peak flow rates only and does not affect the runoff volume computations. Therefore for simplicity, lag times of 6.0 min and 3.6 min were used for the post-construction condition. These values do not impact the volume of runoff computed within HEC-HMS. Refer to BV Calculation 52.5406.1007.

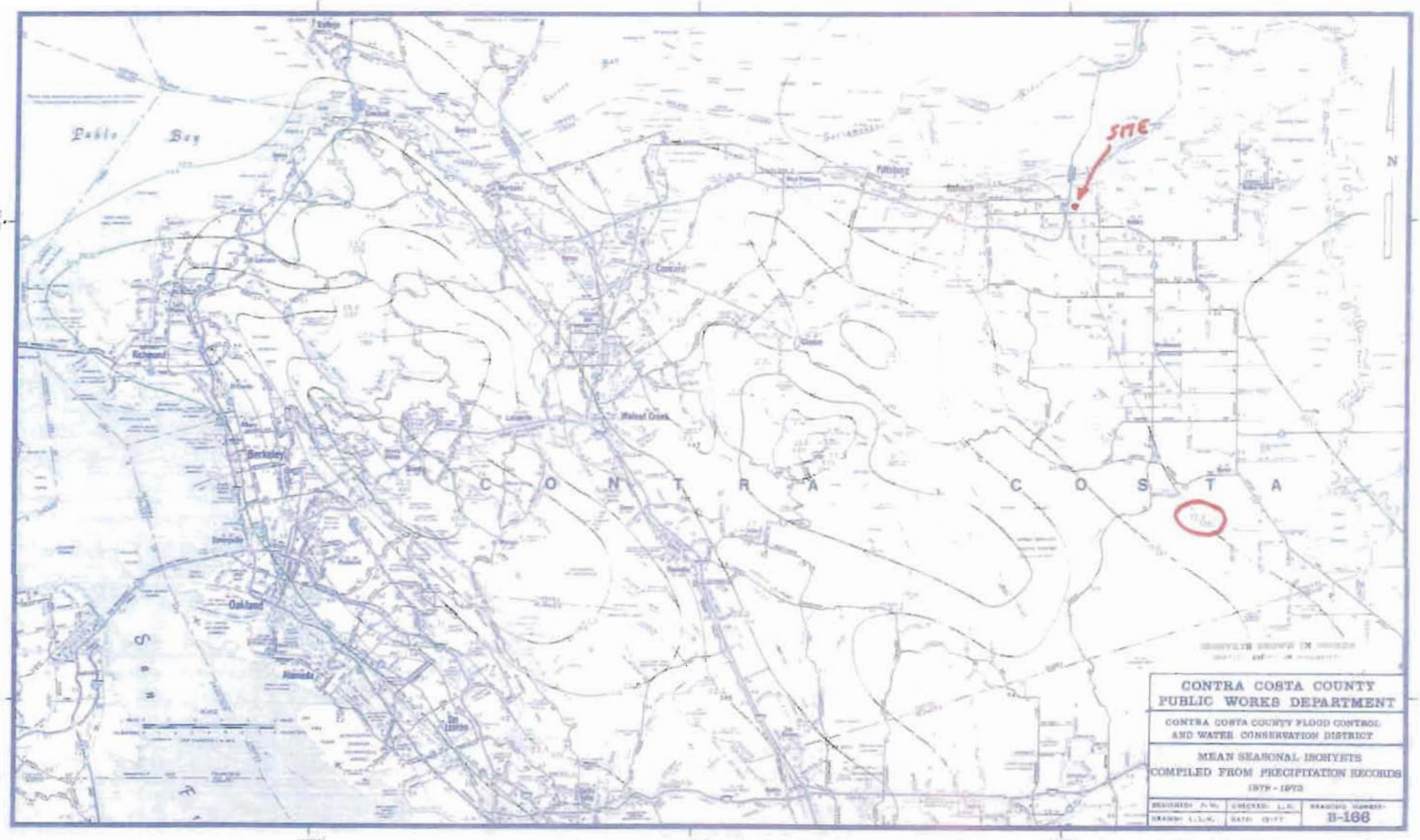
Section 2.0 – Rainfall Distribution

From Ref. 2, Figure B-2, the rainfall distribution for the site in Contra Costa County, California should be Type I distribution.

From Ref. 5, the 24-hour rainfall amounts for the site are: (See Pages 9+10)

Storm Event	100-year	10-year	Small event*
Rainfall	3.9 in.	2.6 in.	1.0 in.

* A smaller "typical" rain event of 0.75-1.0 inch was requested to be modeled by CEC



Radback Oakley Project #163994 (FROM REF. ~~14~~ 5)

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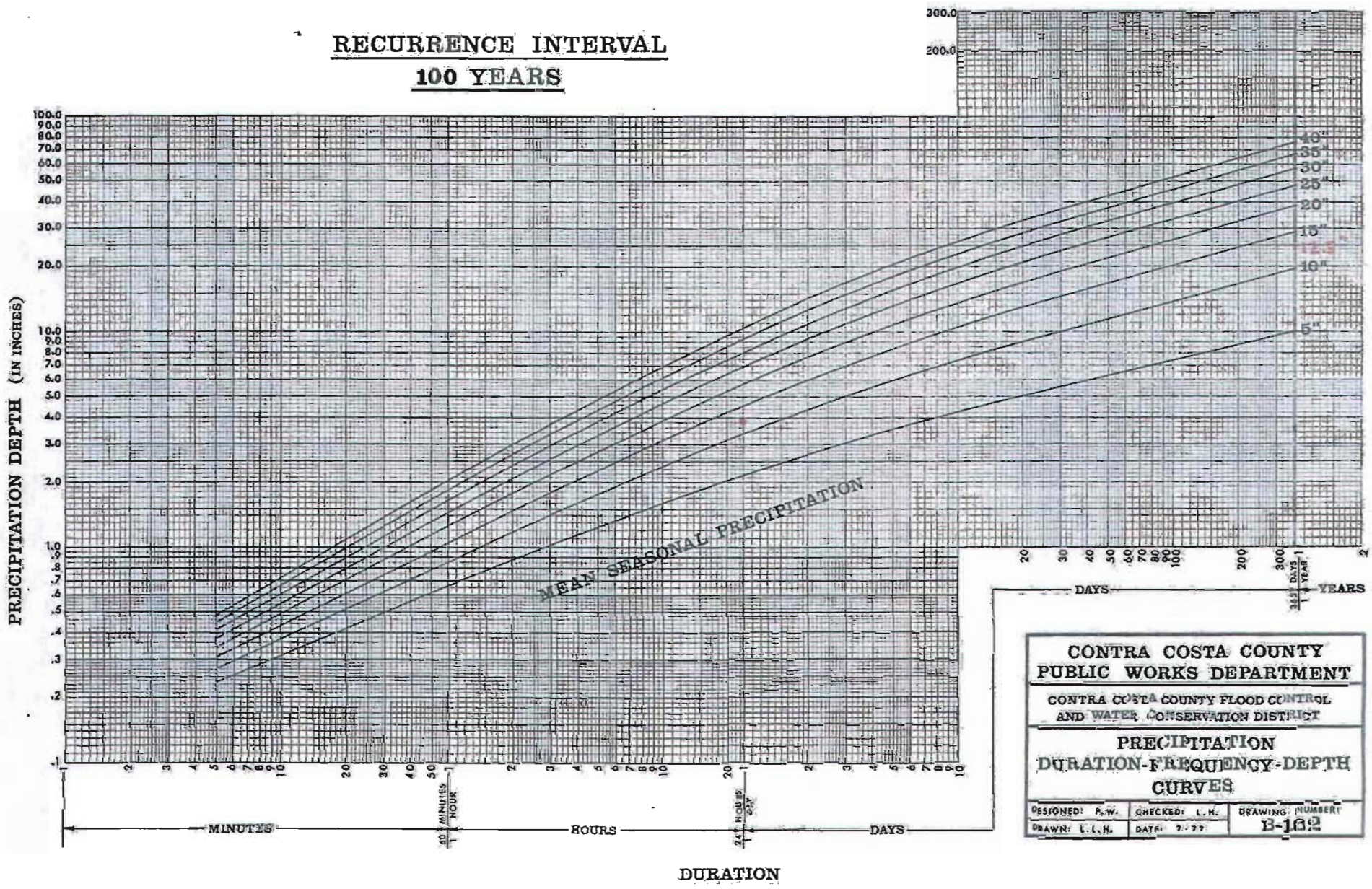
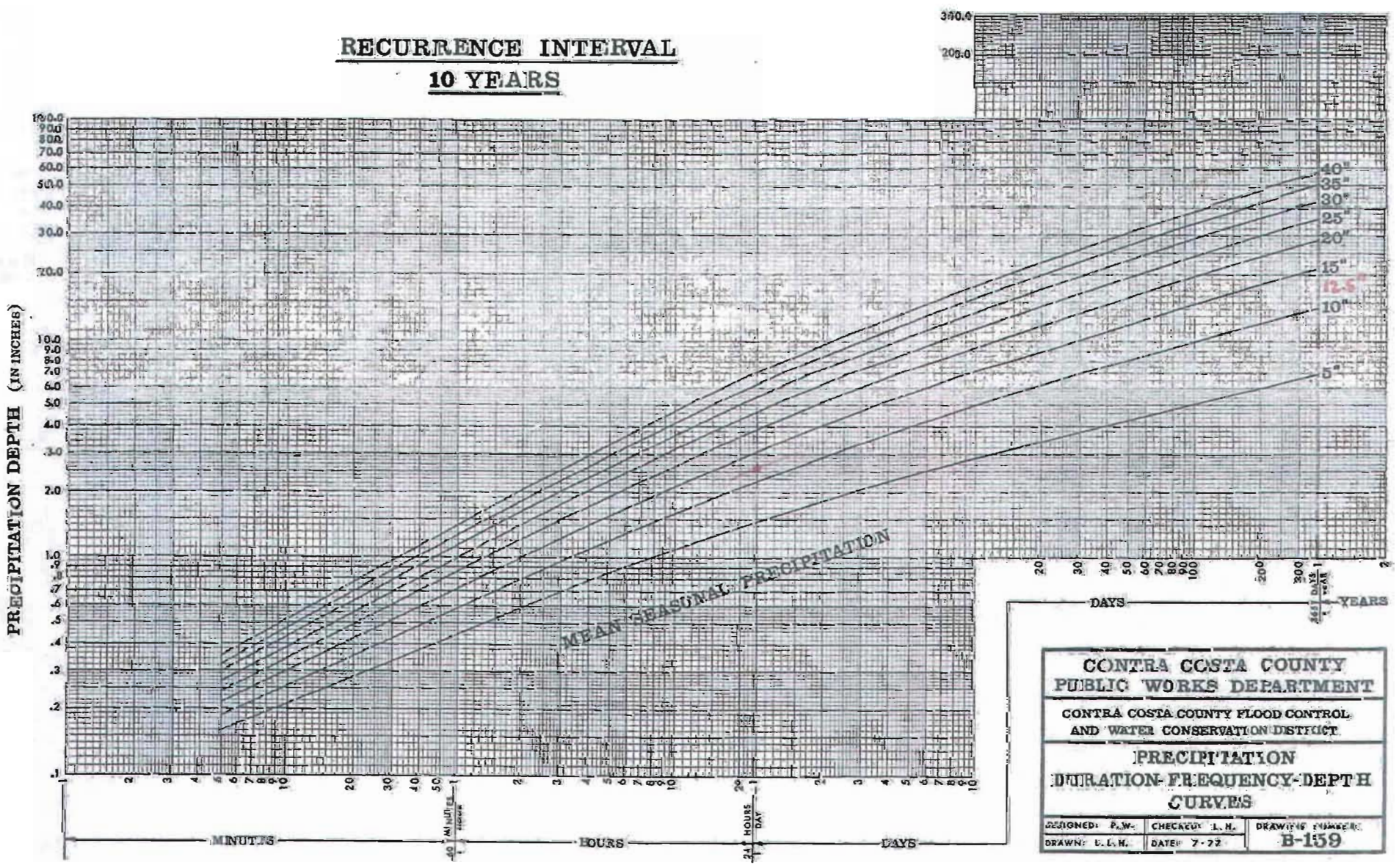
MSP = 12.5"



MSP = 12.5" (DWG B-166)

24-HR = 3.9" (ABOVE)



RADBACK OAKLEY PROJECT # 163994

52.5406 ~~.1007~~ .1006 Page ~~16 of 37~~ 10 of 21

(FROM REF. ~~4~~ 5)

MSP = 12.5" (DWG B-166)

24-HR = 2.6" (ABOVE)

Section 3.0 – Determine Composite SCS Curve Number, Initial Abstraction & Impervious %

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area. The SCS Curve Number (CN), Initial Abstraction (Ia) and Impervious % for the pre-construction site were determined in Reference 9 – see attachment 6.

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". See Attachment 4. Per Ref. 2, this type of soil can be classified as Hydrologic Soil Group A soil.

The proposed site drainage areas as determined earlier are summarized below, with individual CN values assigned to each type of ground cover (for Group A soils). CN values are based on Reference 2, Tables 2-2a and 2-2b.

For the pre-construction condition, the SCS Curve Number (CN = 70), Initial Abstraction (Ia = 0.857) and Impervious (% = 1) were determined in Reference 9 – see Attachment 6.

A summary of the pre- and post-construction basin parameter values determined in the following pages, and input into the HEC-HMS model are included in the table below:

Condition	Area (sq. mi.)	Composite CN	Initial Abstraction (in)	Impervious %	Lag Time (min)
Pre-Construction					
Entire Site	0.0393	70	0.857	1	19.4
Post-Construction					
Bioswale 1-2	0.0175	77	0.597	1	6.0
Bioswale 3	0.0009	75	0.667	1	6.0
Bioswale 4	0.0067	81	0.469	1	6.0
Bioswale 5	0.0104	77	0.597	1	6.0
Direct to Pond	0.0015	72	0.778	1	3.6
Direct to Wetland	0.0041	76	0.632	1	3.6

SUPERSEDED 9/13/10
See Pg 11A

Section 3.0 – Determine Composite SCS Curve Number, Initial Abstraction & Impervious %

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area. The SCS Curve Number (CN), Initial Abstraction (Ia) and Impervious % for the pre-construction site were determined in Reference 9 – see attachment 6.

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". See Attachment 4. Per Ref. 2, this type of soil can be classified as Hydrologic Soil Group A soil.

The proposed site drainage areas as determined earlier are summarized below, with individual CN values assigned to each type of ground cover (for Group A soils). CN values are based on Reference 2, Tables 2-2a and 2-2b.

For the pre-construction condition, the SCS Curve Number (CN = 70), Initial Abstraction (Ia = 0.857) and Impervious (% = 2.6) were determined in Reference 9 – see Attachment 6.

A summary of the pre- and post-construction basin parameter values determined in the following pages, and input into the HEC-HMS model are included in the table below:

Condition	Area (sq. mi.)	Composite CN	Initial Abstraction (in)	Impervious %	Lag Time (min)
Pre-Construction					
Entire Site	0.0393	70	0.857	2.6	19.4
Post-Construction					
Bioswale 1+2 CN	0.0164	76	0.632	0	6.0
Bioswale 1+2 Imp	0.0011	98	0.041	100	6.0
Bioswale 4 CN	0.0062	80	0.500	0	6.0
Bioswale 4 Imp	0.0005	98	0.041	100	6.0
Bioswale 5 CN	0.0085	77	0.597	0	6.0
Bioswale 5 Imp	0.0010	98	0.041	100	6.0
Direct to Pond CN	0.0025	73	0.740	0	3.6
Direct to Pond Imp	0.0001	98	0.041	100	3.6
Direct to Wetland	0.0048	75	0.667	0	3.6

Bioswale 1+2 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.30 ac.	174.8
Lawn (Poor Coverage <50%)	68	4.55 ac.	309.4
Impervious Surface	98	2.75 ac.	269.5
Open Graded Aggregate	68	1.57 ac.	106.76
Total		11.17 ac.	860.46
Composite CN = 860.46 / 11.17 = 77			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

SUPERSEDED 9/13/10

See Pg 12A

Bioswale 1+2 (Post-Construction): Curve Number (CN) and Impervious Area

HMS Subbasin: _*1+2 CN* Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Gravel	76	2.30 ac.	174.8
Lawn (Poor Coverage <50%)	68	4.55 ac.	309.4
Impervious Surface not directly connected (75% x 2.75 ac. Total)	98	2.06 ac.	202.1
Open Graded Aggregate	68	1.57 ac.	106.76
Total		10.48 ac.	793.1
Composite CN = 793.1 / 10.48 = 76			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/76 - 10)$ = <u>0.632 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 25% of the impervious areas contributing to Bioswale 1+2 are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_1+2 Imp**".

2.75 acres impervious x 0.25 directly connected = 0.69 ac = 0.0011 sq. mi.

Impervious % = 100%

Bioswale 3 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.45 ac.	30.6
Impervious Surface	98	0.14 ac.	13.7
Total		0.59 ac.	44.3
Composite CN = 44.3 / 0.59 = 75			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

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The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/75 - 10)$ = 0.667 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Rev 1 9/13/10 CAK
Bioswale 3 removed from design

Bioswale 4 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.51 ac.	190.8
Lawn (Poor Coverage <50%)	68	0.54 ac.	36.7
Impervious Surface	98	1.21 ac. 28.4%	118.6
Total		4.26 ac.	346.1
Composite CN = 346.1 / 4.26 = 81			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/81 - 10)$ = <u>0.469 inch</u>.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

SUPERSEDED 9/13/10
See pg 14A

Bioswale 4 (Post-Construction): Curve Number (CN) and Impervious Area

HMS Subbasin: _4 CN Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Gravel	76	2.51 ac.	190.8
Lawn (Poor Coverage <50%)	68	0.54 ac.	36.7
Impervious Surface not directly connected (75% x 1.21 ac. Total)	98	0.91 ac.	88.9
Total		3.96 ac.	316.4
Composite CN = 316.4 / 3.96 = 80			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/80 - 10)$ = <u>0.500 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 25% of the impervious areas contributing to Bioswale 4 are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_4 Imp**".

1.21 acres impervious x 0.25 directly connected = 0.30 ac = 0.0005 sq. mi.

Impervious % = 100%

Bioswale 5 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	3.35 ac.	254.6
Railroad Yard (similar to gravel)	76	0.94 ac.	71.4
Lawn (Poor Coverage <50%)	68	1.50 ac.	102
Impervious Surface	98	0.88 ac.	86.2
Total		6.67 ac.	514.2
Composite CN = 514.2 / 6.67 = 77			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

SUPERSEDED 8/13/10
See pg 15A

Bioswale 5 (Post-Construction): Curve Number (CN) and Impervious Area

HMS Subbasin: _5 CN Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Gravel	76	2.87 ac.	218.1
Railroad Yard (similar to gravel)	76	0.94 ac.	71.4
Lawn (Poor Coverage <50%)	68	0.95 ac.	64.6
Impervious Surface not directly connected (50% x 1.32 ac. Total)	98	0.66 ac.	64.7
Total		5.42 ac.	418.8
Composite CN = 418.8 / 5.42 = 77			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = <u>0.597 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 50% of the impervious areas contributing to Bioswale 5 are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_5 Imp**".

1.32 acres impervious x 0.50 directly connected = 0.66 ac = 0.0010 sq. mi.

Impervious % = 100%

Direct to Pond (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.85 ac.	57.8
Impervious Surface	98	0.13 ac.	12.74
Total		0.98 ac.	70.54
Composite CN = 514.2 / 6.67 = 72			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/72 - 10)$ = 0.778 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

SUPERSEDES 9/13/10

See pg 16A

Direct to Pond (Post-Construction): Curve Number (CN) and Impervious Area

HMS Subbasin: _*Pond CN* Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Lawn (Poor Coverage <50%)	68	1.28 ac.	87.0
Gravel	76	0.1 ac.	7.6
Impervious Surface not directly connected (75% x 0.30 ac. Total)	98	0.23 ac.	22.5
Total		1.61 ac.	116.7
Composite CN = 116.7 / 1.61 = 73			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/73 - 10)$ = <u>0.740 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 25% of the impervious areas contributing directly to the Pond are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_Pond Imp**".

0.30 acres impervious x 0.25 directly connected = 0.08 ac = 0.0001 sq. mi.

Impervious % = 100%

Direct to Wetland (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Wetland	98	0.4 ac.	39.2
Impervious Surface	98	0.27 ac.	26.5
Vineyard / Undisturbed Area	68	1.93 ac.	131.2
Total		2.6 ac.	196.9
Composite CN = 196.9 / 2.6 = 76			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/76 - 10)$ = 0.632 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

SUPERSEDED 9/13/10

See Pg 17 A

Direct to Wetland (Post-Construction): Curve Number (CN) and Impervious Area

HMS Subbasin: _*Wetland CN* Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Wetland	98	0.4 ac.	39.2
Impervious Surface	98	0.28 ac.	27.4
Vineyard / Undisturbed Area	68	1.93 ac.	131.2
Lawn (Poor Coverage <50%)	68	0.47 ac.	32.0
Total		3.08 ac.	229.8
Composite CN = 229.8 / 3.08 = 75			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/75 - 10)$ = <u>0.667 inch</u>.

Impervious % = 0 (all impervious area not directly connected, factored in CN above)

Section 4.0 – Storage Capacity versus Elevation for Wetland Area and Pond

The bottom of the wetland is at an approximate elevation of 5 feet (It is actually slightly lower than EL 5). See B&V Drawing SS-3001 (Page 6). The relationship of Area versus Elevation for the wetland area is presented in the table below. The wetland area was measured by using AutoCAD. It should be noted that a small portion of the wetland at the east side within the project property will be filled at a later time. This area will be graded at a 4 (H) to 1 (V) slope towards the wetland. The area in the table below at Elevation 10 (1.44 acres) has the future fill area deducted to accurately model the wetland storage capacity.

Incremental storage at each water surface elevation is calculated using the average end-area method below:

Incremental Storage Volume = $\left(\frac{AreaHi + AreaLo}{2} \times (ElevHi - ElevLo)\right)$

For the volume between elevations 5.0 and 7.5:

Incremental Storage Volume = $\left(\frac{0.62 + 0.40}{2} \times (7.5 - 5.0)\right)$ = 1.28 ac-ft

Wetland Elevation – Area – Storage Summary (See Ref. 9, Pg 11)

Elevation (ft)	Wetland Area (acre)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-
7.5	0.62	1.28	1.28
10.0	1.44	2.57	3.85
11.5	1.6	2.28	6.13

There is an outlet control structure proposed between the pond and wetland that will allow water to flow from the pond into the wetland when the water level in the pond is above elevation 10.0. The volume retained in the pond below elevation 10.0 prior to allowing discharge into the wetland is determined by calculating the total incremental storage provided below elevation 10.0 as shown in the table on the following page.

Retained Volume to Elevation 10.0 = 0.10 ac-ft + 0.23 ac-ft = 0.33 ac-ft

This storage volume reduces the runoff that reaches the wetland. The wetland water-surface elevation in the post-construction site condition takes this into account.

SUPERSEDED 9/13/10
See pg 18A

Section 4.0 – Storage Capacity versus Elevation for Wetland Area and Pond

The bottom of the wetland is at an approximate elevation of 5 feet (It is actually slightly lower than EL 5). See B&V Drawing SS-3001 (Page __). The relationship of Area versus Elevation for the wetland area is presented in the table below. The wetland area was measured by using AutoCAD. It should be noted that a small portion of the wetland at the east side within the project property will be filled at a later time. This area will be graded at a 4 (H) to 1 (V) slope towards the wetland. The area in the table below at Elevation 10 (1.44 acres) has the future fill area deducted to accurately model the wetland storage capacity.

Incremental storage at each water surface elevation is calculated using the average end-area method below:

$$\text{Incremental Storage Volume} = \left(\frac{AreaHi + AreaLo}{2} \times (ElevHi - ElevLo)\right)$$

For the volume between elevations 5.0 and 7.5:

$$\text{Incremental Storage Volume} = \left(\frac{0.62 + 0.40}{2} \times (7.5 - 5.0)\right) = 1.28 \text{ ac-ft}$$

Wetland Elevation – Area – Storage Summary (See Ref. 9, Pg 11)

Elevation (ft)	Wetland Area (acre)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-
7.5	0.62	1.28	1.28
10.0	1.44	2.57	3.85
11.5	1.6	2.28	6.13

There is an outlet control structure proposed between the pond and wetland that will allow water to flow from the pond into the wetland when the water level in the pond is above EL 8.75. The volume retained in the pond below EL 8.75 prior to allowing discharge into the wetland is determined by calculating the total incremental storage provided below EL 8.75 as shown in the table on the following page.

Retained Volume to EL 8.75 = 0.085 ac-ft (halfway between EL 8.5 and 9.0)

This storage reduces the volume that reaches the wetland from the pond. The wetland water-surface elevation (WSEL) in the post-construction site condition takes this into account for smaller storm events. For larger storm events, the WSEL becomes equalized between the pond and wetland and flow no longer occurs from the pond to wetland. Thus the volume of runoff to the wetland does not include the volume stored in the pond.

The proposed pond will provide additional storage capacity for the stormwater runoff from the post-construction site conditions. Below is a table summarizing the relationship of Area versus Elevation for the proposed pond (areas measured using AutoCAD). Also included are columns summarizing the incremental and cumulative storage volumes provided in the pond at each elevation interval.

Pond Elevation – Area – Storage Summary

Elevation (ft)	Pond Area (acres)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
8.5	0.18	-	-
9.0	0.21	0.10	0.10
10.0	0.26	0.23	0.33
11.0	0.31	0.29	0.62
12.0	0.37	0.34	0.96
13.0	0.43	0.40	1.36
14.0	0.50	0.46	1.82
15.0	0.56	0.53	2.35

For larger storm events, the water surface elevation in the wetland will exceed the outlet control elevation in the pond, resulting in an equalized water surface elevation between the wetland and pond. Below is a table summarizing the elevation and storage volume within the wetland and pond system for larger runoff volumes.

Equalized Wetland + Pond Elevation – Area – Storage Summary

Elevation (ft)	Wetland Area (acres)	Pond Area (acres)	Incremental Wetland Storage (ac-ft)	Incremental Pond Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-	-	-
7.5	0.62	-	1.28	-	1.28
8.5	0.95 *	0.18	0.78	-	2.06
9.0	1.11 *	0.21	0.52	0.10	2.68
10.0	1.44	0.26	1.28	0.23	4.19
11.0	1.55	0.31	1.50	0.29	5.98
11.5	1.6	0.34 *	0.79	0.16	6.93

* Denotes interpolated value

SUPERSEDED 9/13/10
See Pg 19A

The proposed pond will provide additional storage capacity for the stormwater runoff from the post-construction site conditions. Below is a table summarizing the relationship of Area versus Elevation for the proposed pond (areas measured using AutoCAD). Also included are columns summarizing the incremental and cumulative storage volumes provided in the pond at each elevation interval.

Pond Elevation – Area – Storage Summary

Elevation (ft)	Pond Area (acres)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
8.5	0.33	-	-
9.0	0.35	0.17	0.17
10.0	0.41	0.38	0.55
11.0	0.48	0.44	0.99
12.0	0.54	0.51	1.50
13.0	0.61	0.57	2.08

For larger storm events, the water surface elevation in the wetland will exceed the outlet control elevation in the pond, resulting in an equalized water surface elevation between the wetland and pond. Below is a table summarizing the elevation and storage volume within the wetland and pond system for larger runoff volumes.

Equalized Wetland + Pond Elevation – Area – Storage Summary

Elevation (ft)	Wetland Area (acres)	Pond Area (acres)	Incremental Wetland Storage (ac-ft)	Incremental Pond Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-	-	-
7.5	0.62	-	1.28	-	1.28
8.5	0.95 *	0.33	0.78	-	2.06
9.0	1.11 *	0.35	0.52	0.17	2.75
10.0	1.44	0.41	1.28	0.38	4.41
11.0	1.55	0.48	1.50	0.44	6.35
11.5	1.6	0.51 *	0.79	0.25	7.39

* Denotes interpolated value

Section 5.0 HEC-HMS Output

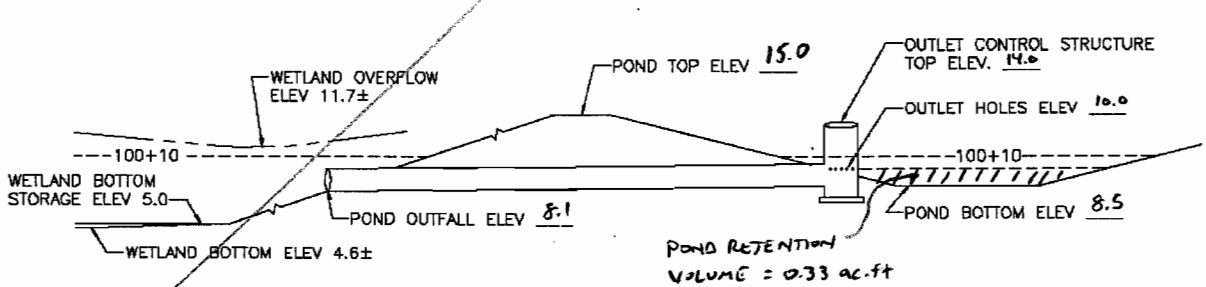
The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The initial water elevation in the wetland is specified to be at EL 5 assuming that standing water in the wetland is not higher than EL 5 when the modeled rainfall events begin. Normal water level is approximately EL 4.6 as shown on Page 6.

The total runoff volume for each storm event was calculated by running the HEC-HMS program. The table below summarizes the runoff volume produced in the pre-construction and post-construction site conditions for each storm event. The output results are included in Attachment 2.

Rainfall Event	Pre-Construction Runoff Volume	Post-Construction Runoff Volume
1-inch	0.03 ac-ft	0.14 ac-ft
10-year	1.10 ac-ft	1.84 ac-ft
100-year	2.70 ac-ft	3.91 ac-ft
100-year + 10-year	3.80 ac-ft	5.75 ac-ft

Section 6.0 – Determine WSEL within Wetland Area

The results from Sections 4.0 and 5.0 were used to determine the resulting WSEL within the wetland area for each storm event. The WSEL in the wetland is determined based on the amount of runoff that is conveyed to the wetland area. As calculated in Section 4.0, the proposed pond retains a volume of 0.33 ac-ft, therefore the amount of runoff that reaches the wetland in the post-construction condition can be reduced by 0.33 ac-ft to determine the resulting wetland WSEL. Below is a general diagram of the pond and wetland configuration, showing the retained volume in the pond below elevation 10.0.



By comparing the proposed runoff volumes discharged to the wetland against the interpolated storage capacity volumes by elevation (summarized in Section 4.0), the WSEL in the wetland is determined.

SUPERSEDED 9/13/10 See pg 20 A

Section 5.0 HEC-HMS Output

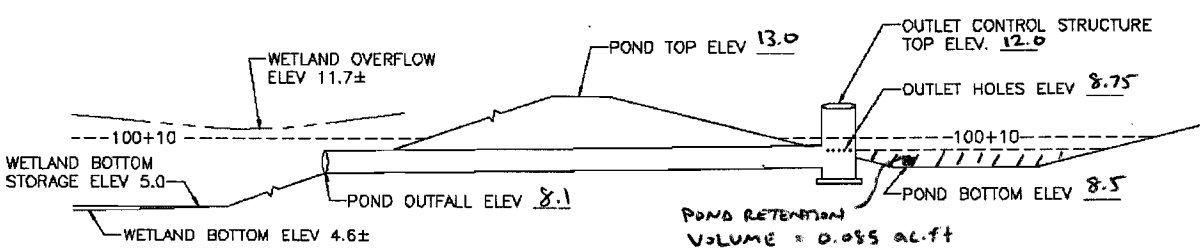
The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The initial water elevation in the wetland is specified to be at EL 5 assuming that standing water in the wetland is not higher than EL 5 when the modeled rainfall events begin. Normal water level is approximately EL 4.6 as shown on Page 6.

The total runoff volume for each storm event was calculated by running the HEC-HMS program. The table below summarizes the runoff volume produced in the pre-construction and post-construction site conditions for each storm event. The output results are included in Attachment 2.

Rainfall Event	Pre-Construction Runoff Volume	Post-Construction Runoff Volume
1-inch	0.06 ac-ft	0.24 ac-ft
10-year	1.17 ac-ft	1.98 ac-ft
100-year	2.79 ac-ft	4.05 ac-ft
100-year + 10-year	3.96 ac-ft	6.03 ac-ft

Section 6.0 – Determine WSEL within Wetland Area

The results from Sections 4.0 and 5.0 were used to determine the resulting WSEL within the wetland area for each storm event, based on the amount of runoff that is conveyed to the wetland area. Per Section 4.0, the pond retains a volume of 0.085 ac-ft for small storm events and provides greater storage when equalized with the wetland. Below is a general diagram of the pond and wetland configuration, showing the retained volume in the pond below the outlet hole elevation and the wetland / pond equalized WSEL.



By comparing the proposed runoff volumes reaching the wetland against the interpolated storage capacity volumes by elevation (per Section 4.0), the wetland WSEL is determined. For a 10-year event,

1.98 ac-ft site runoff – 0.085 ac-ft retained in pond = 1.895 ac-ft to wetland (use 1.90 ac-ft)

Determine WSEL10 (Wetland WSEL for 10-year/24-hr storm for post-construction site)

Wetland Elevation / Volume Data (from Section 4.0)

Wetland Elevation (ft)	Cumulative Wetland Storage (ac-ft)
7.5	1.28
Interpolate WSEL10	*1.51 (10-yr post- runoff to wetland)*
10.0	3.85

Interpolating for WSEL10 = $\frac{(1.51-1.28)(10.0-7.5)}{(3.85-1.28)}+7.5$ = 7.7 ft.

Using the above method for the other storm events, the resulting post-construction WSELs in the wetland are summarized in the table below. Since the pond provides 0.33 ac-ft of retention storage, up to 0.33 ac-ft of runoff volume to the pond is deducted from the total runoff volume to wetland. For example, in the 1-inch storm, a total of 0.09 ac-ft flows to the pond – see Attachment 2. Since this is less than the 0.33 ac-ft pond retention volume, this 0.09 ac-ft is retained in the pond and deducted from total runoff (0.14 ac-ft) to yield the post-construction runoff volume of 0.05 ac-ft to the wetland.

Summary of Runoff Volume & Wetland WSEL

Rainfall Event	Pre-Construction		Post-Construction	
	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)
1-inch	0.03	5.1	0.05	5.1
10-year	1.10	7.2	1.51	7.7
100-year	2.70	8.9	3.58	9.7
100-year + 10-year	3.80	10.0	5.42	10.7

Conclusion:

Based on the HEC-HMS analysis and the storage analysis of the existing wetland and proposed pond, the varying runoff volumes for each storm event will be contained on site without overflowing to adjacent properties. From B&V Drawing SS-3001, the lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.7 feet, while the maximum elevation for the 100+10 storm events is EL 10.7. This analysis does not account for storage within the bioswale system, nor infiltration that would be expected to occur which would reduce the volume of runoff that would be expected to actually reach the wetland area. Therefore this analysis can be considered conservative, relating to the overall flood storage capacity for the site.

SUPERSEDED 9/13/10
See pg 21A

Determine WSEL10 (Wetland WSEL for 10-year/24-hr storm for post-construction site)

Wetland Elevation / Volume Data (from Section 4.0)

Wetland Elevation (ft)	Cumulative Wetland Storage (ac-ft)
7.5	1.28
Interpolate WSEL10	*1.90 (10-yr post- runoff to wetland)*
10.0	3.85

Interpolating for WSEL10 = $\frac{(1.90-1.28)(10.0-7.5)}{(3.85-1.28)}+7.5$ = 8.1 ft.

Using the above method for the other storm events, the resulting post-construction WSELs in the wetland are summarized in the table below, taking into consideration the volume stored within the pond for each event. For the larger events (100-year and 100+10 events), the runoff volume results in an equalized WSEL in the wetland and pond. The runoff volume reaching the wetland is the total site runoff minus the volume provided within the pond at the equalized WSEL. For example, the 100-year site runoff is 4.05 ac-ft, with 0.47 ac-ft stored in the pond at EL 9.8. Therefore the runoff to wetland volume = 4.05 – 0.47 = 3.58 ac-ft.

Summary of Runoff Volume & Wetland WSEL

Rainfall Event	Pre-Construction		Post-Construction	
	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)	Runoff to Wetland (ac-ft)	WSEL in Wetland (ft)
1-inch	0.06	5.1	0.15	5.3
10-year	1.17	7.3	1.90	8.1
100-year	2.79	9.0	3.58	9.8
100-year + 10-year	3.96	10.1	5.11	10.8

Conclusion:

Based on the HEC-HMS analysis and the storage analysis of the existing wetland and proposed pond, the varying runoff volumes for each storm event will be contained on site without overflowing to adjacent properties. From B&V Drawing SS-3001, the lowest elevation where the stormwater in the wetland can overflow to other properties is EL 11.7 feet, while the maximum elevation for the 100+10 storm events is EL 10.8. This analysis does not account for storage within the bioswale system, nor infiltration that would be expected to occur which would reduce the volume of runoff that would be expected to actually reach the wetland area. Therefore this analysis can be considered conservative, relating to the overall flood storage capacity for the site.

Radback Tenaska Project

Project # 163994

Stormwater Analysis

CK 6/11/10

# of pages ~~12~~ 19

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Rev 1 (all pages)
9/13/10
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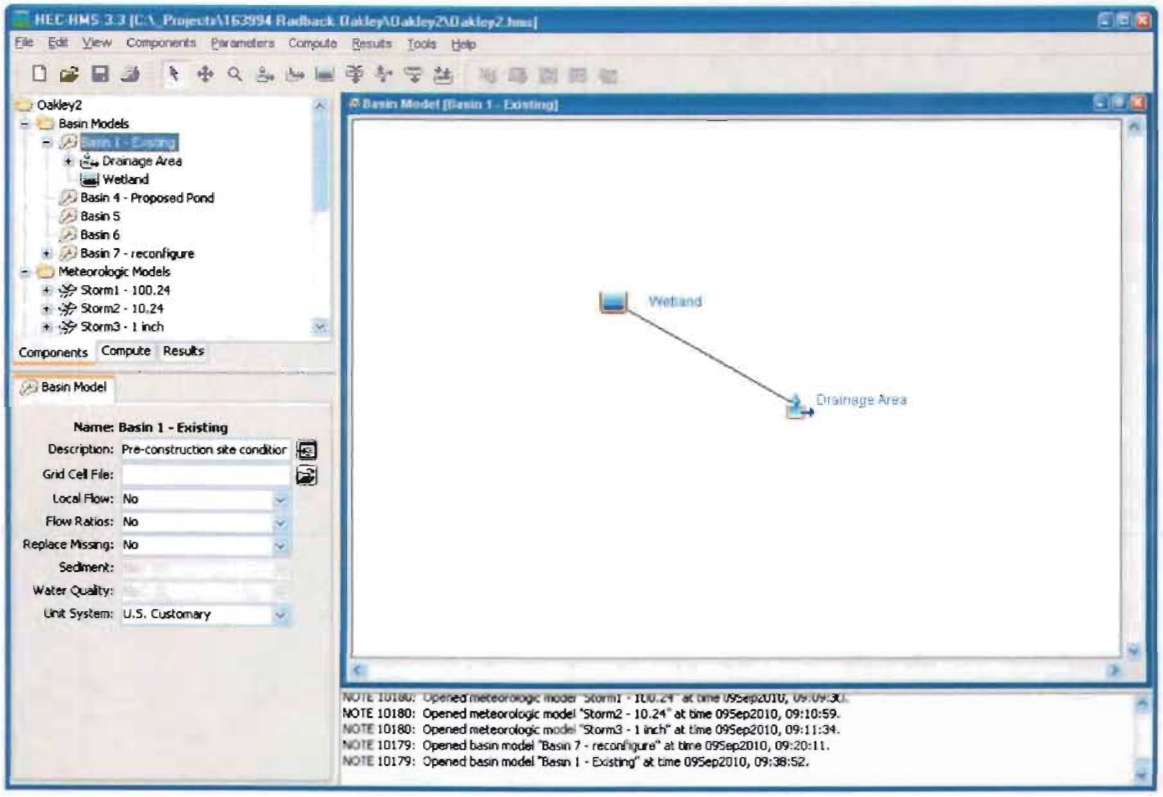
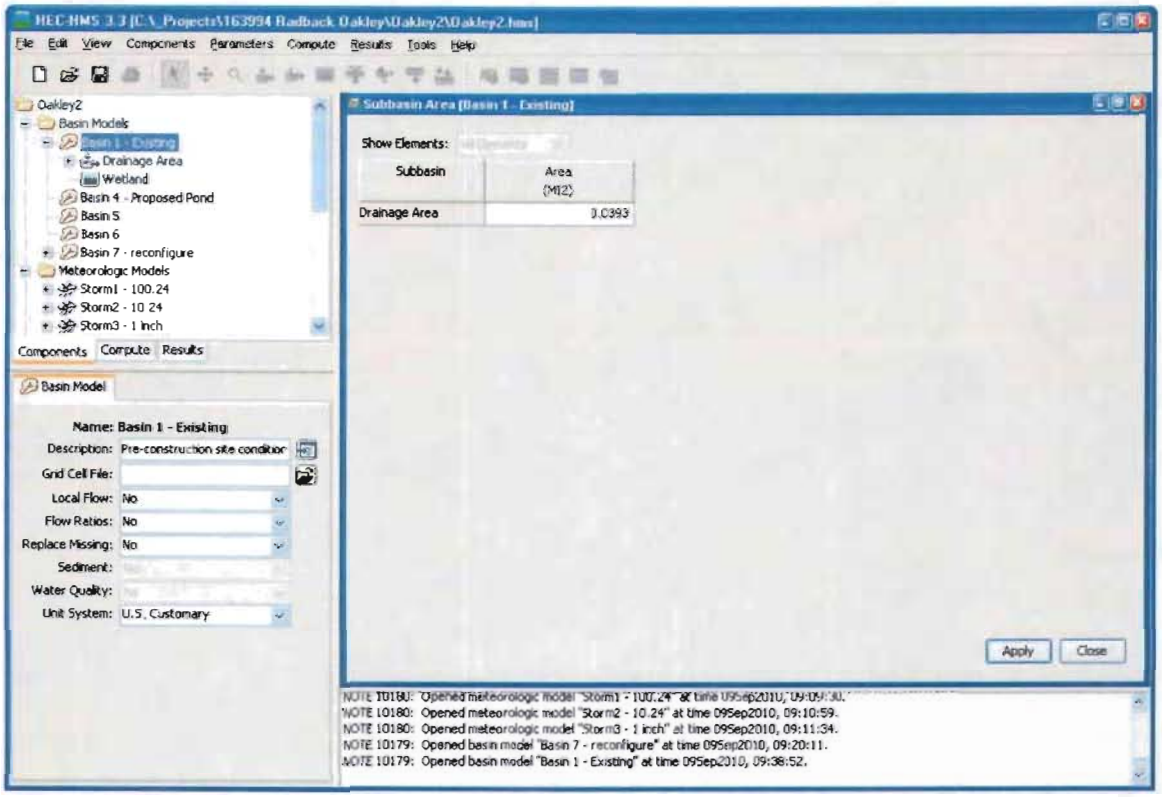
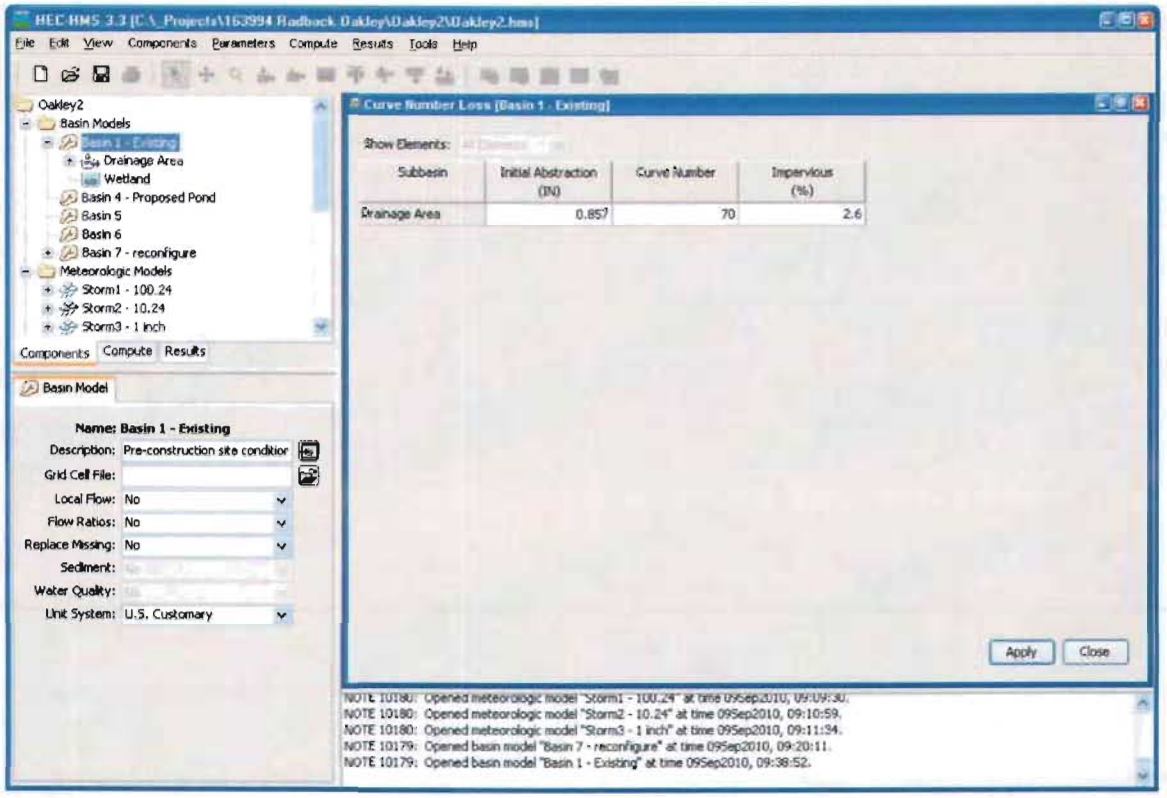
Attachment 1

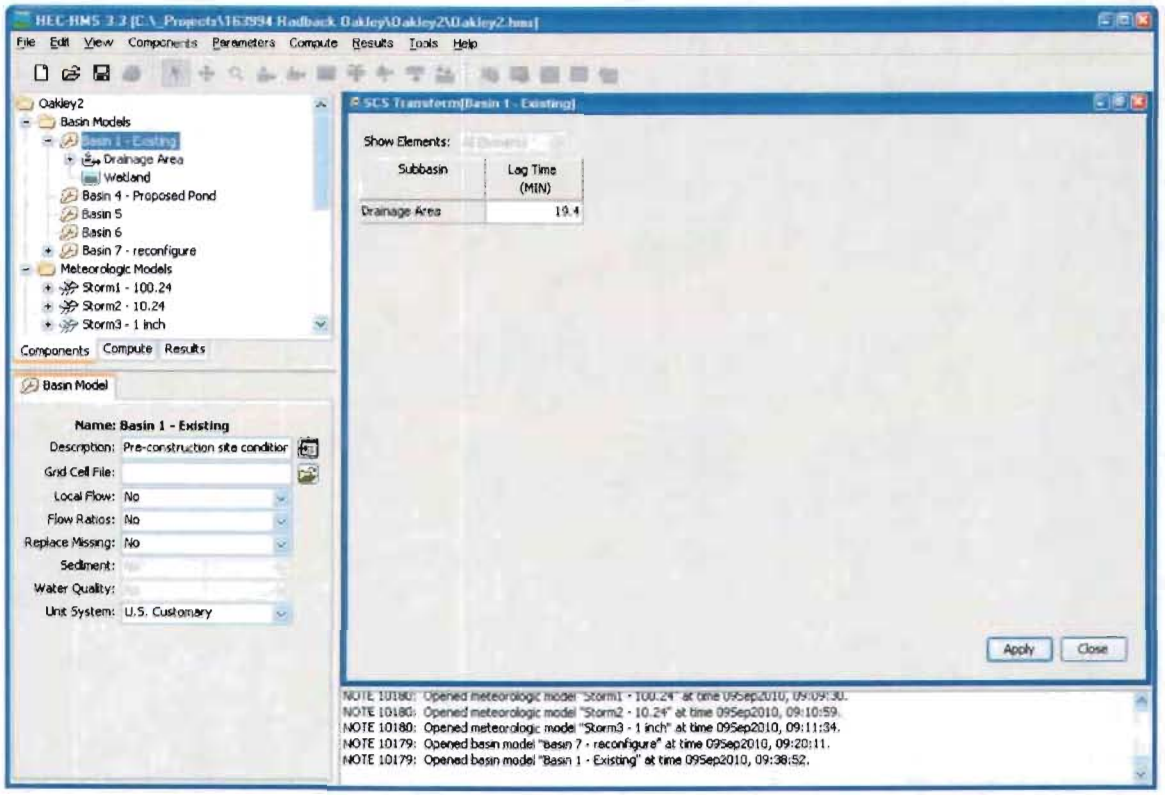
HEC-HMS Input

HEC-HMS Input – Basin Model 1 (Existing Condition)

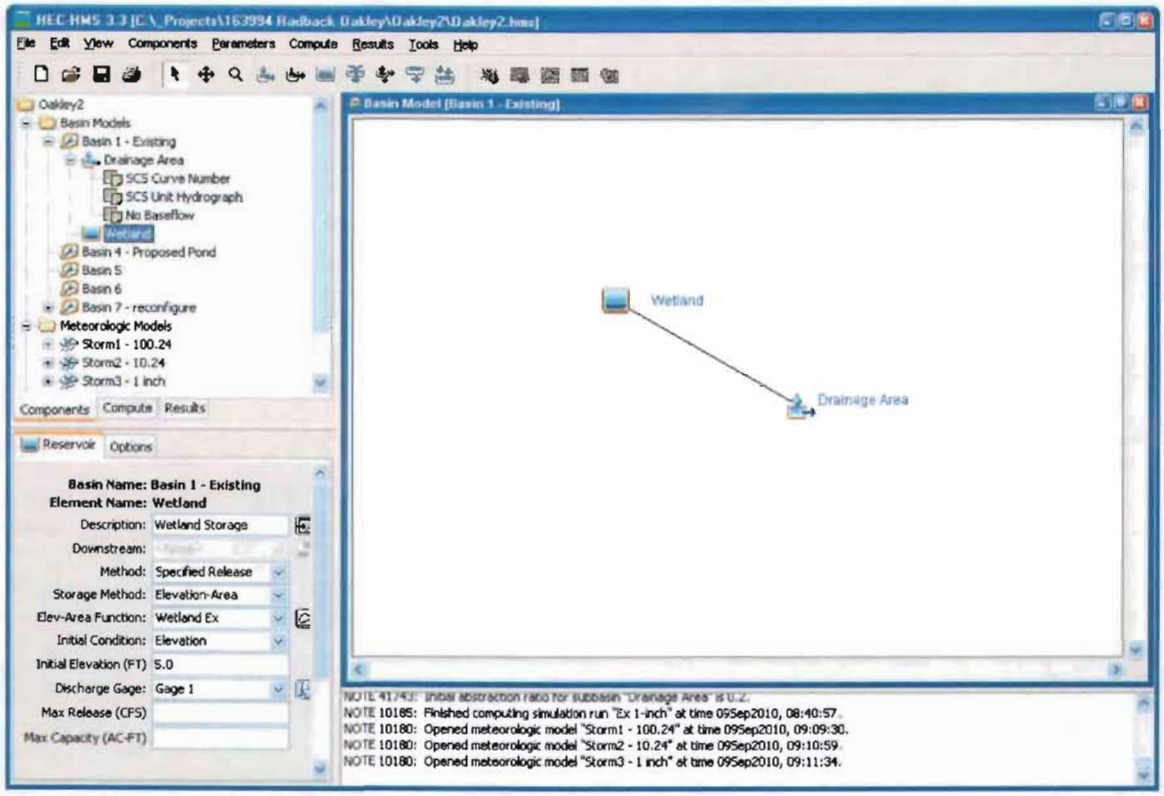


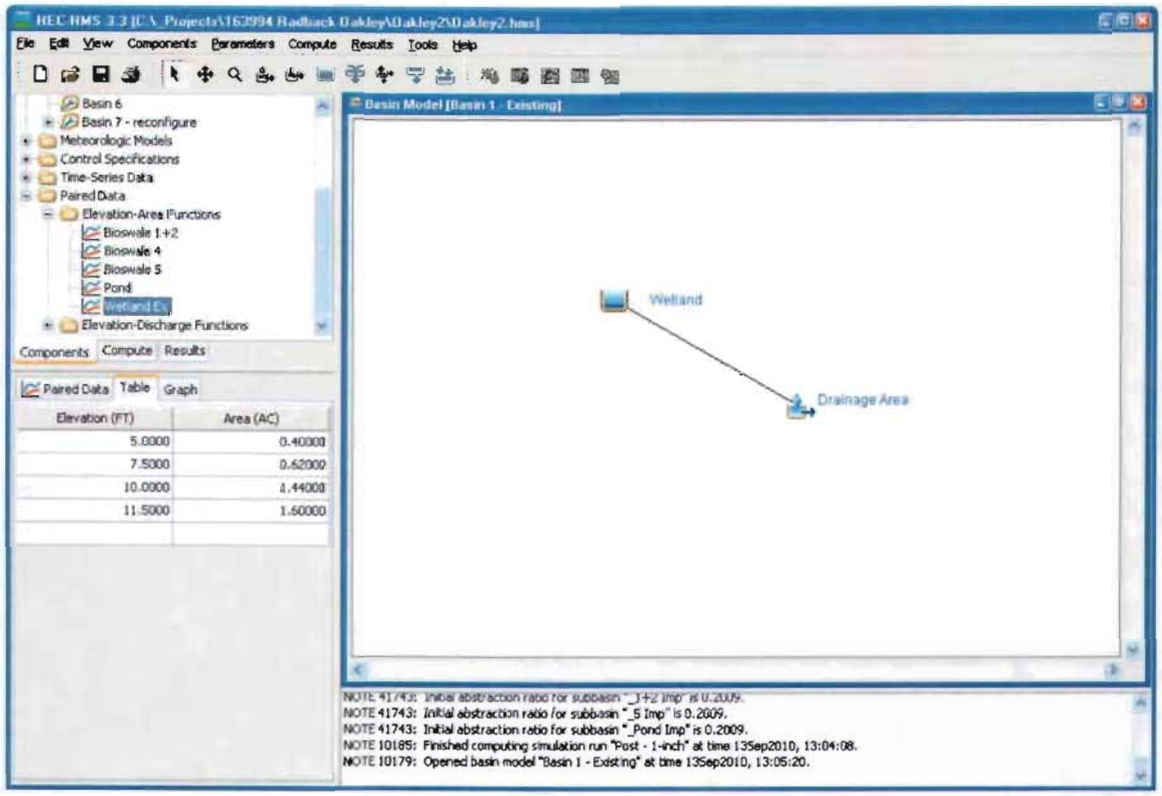



HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Oakley2
Basin Models
Basin 1 - Existing
Drainage Area
Wetland
Basin 4 - Proposed Pond
Basin 5
Basin 6
Basin 7 - reconfigure
Meteorologic Models
Storm1 - 100.24
Storm2 - 10.24
Storm3 - 1 inch
Components Compute Results
Basin Model
Name: Basin 1 - Existing
Description: Pre-construction site conditior
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
Curve Number Loss [Basin 1 - Existing]
Show Elements:
Subbasin
Initial Abstraction (IN)
Curve Number
Impervious (%)
Drainage Area
0.857
70
2.6
Apply
Close
NOTE 10180: Opened meteorologic model "Storm2 - 10.24" at time 09Sep2010, 09:10:59.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.


HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Oakley2
Basin Models
Basin 1 - Existing
Drainage Area
Wetland
Basin 4 - Proposed Pond
Basin 5
Basin 6
Basin 7 - reconfigure
Meteorologic Models
Storm1 - 100.24
Storm2 - 10.24
Storm3 - 1 inch
Components Compute Results
Basin Model
Name: Basin 1 - Existing
Description: Pre-construction site conditior
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
SCS Transform [Basin 1 - Existing]
Show Elements:
Subbasin
Lag Time (MIN)
Drainage Area
19.4
Apply
Close
NOTE 10180: Opened meteorologic model "Storm2 - 10.24" at time 09Sep2010, 09:10:59.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.

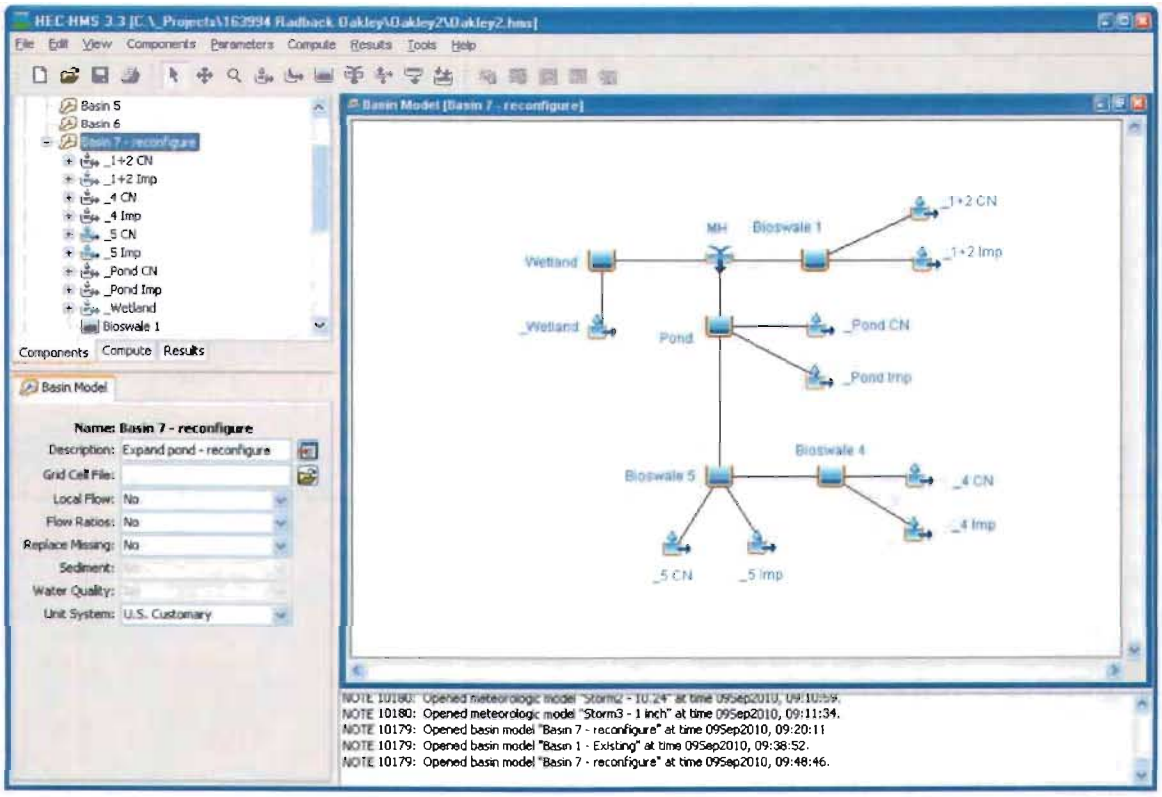
Wetland Storage Capacity Data

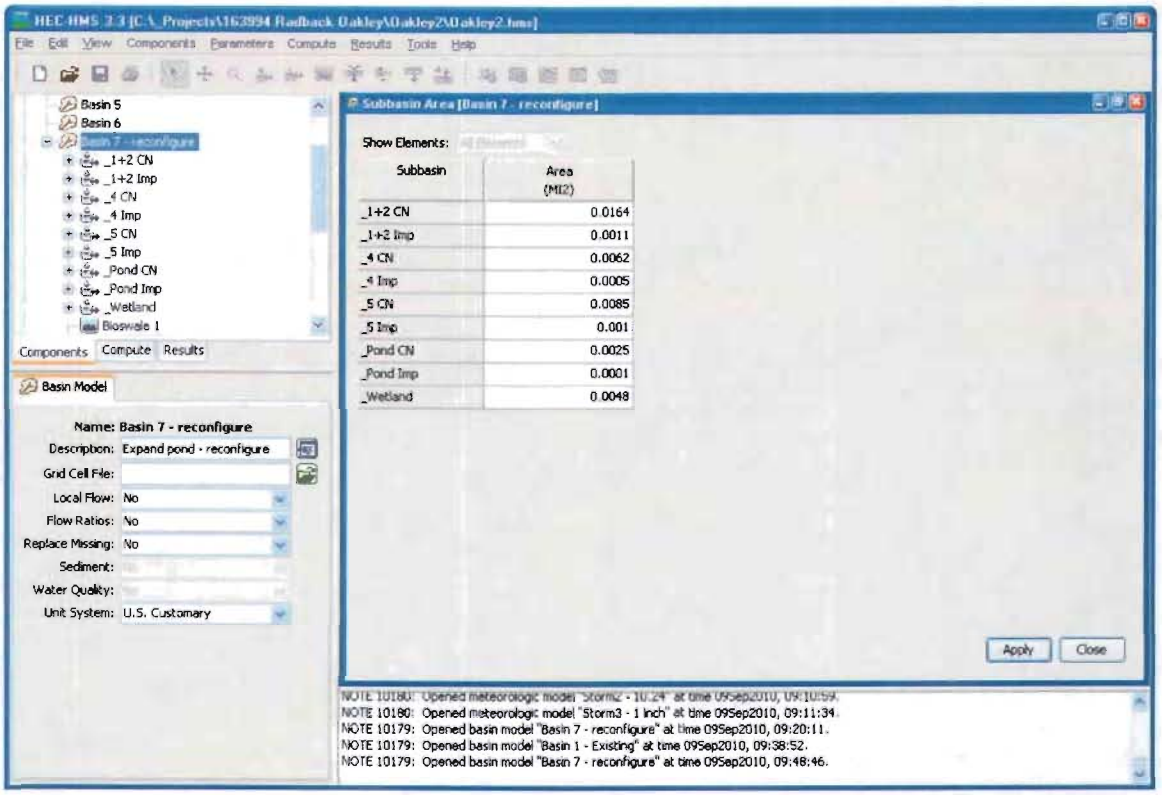




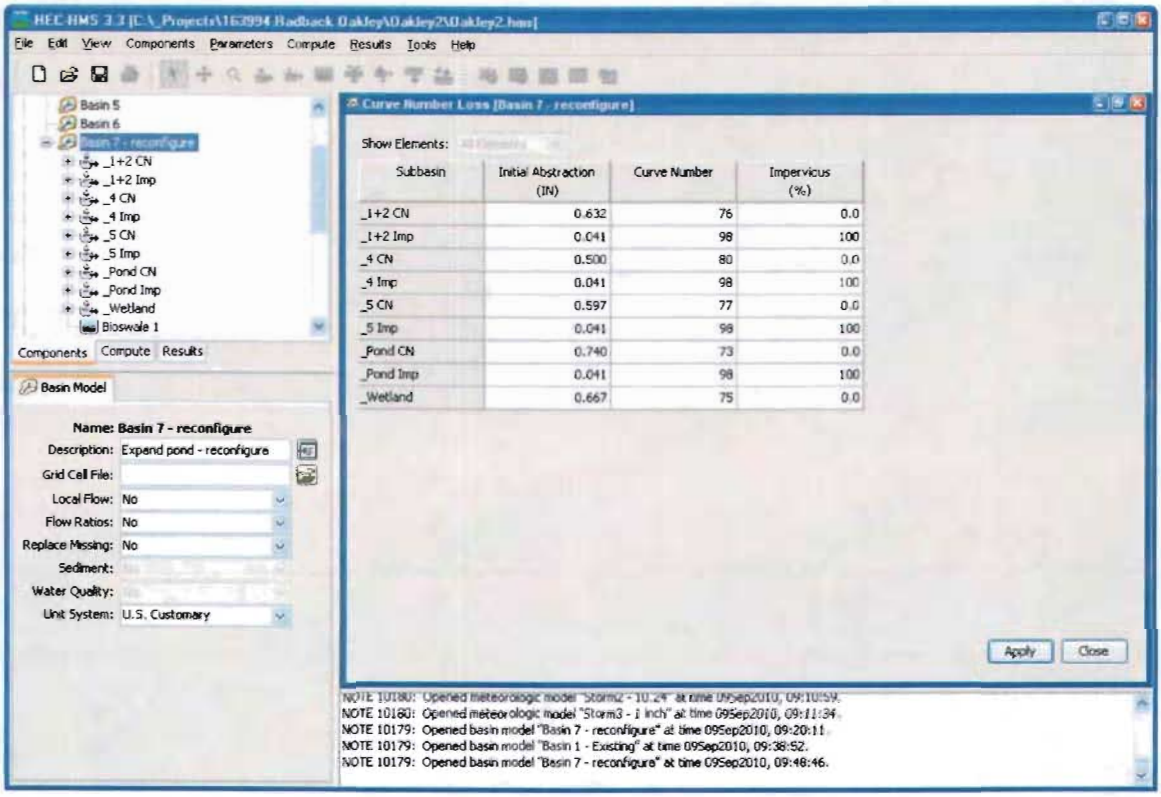
HEC-HMS Input – Basin Model 7 (Post-Construction Condition)

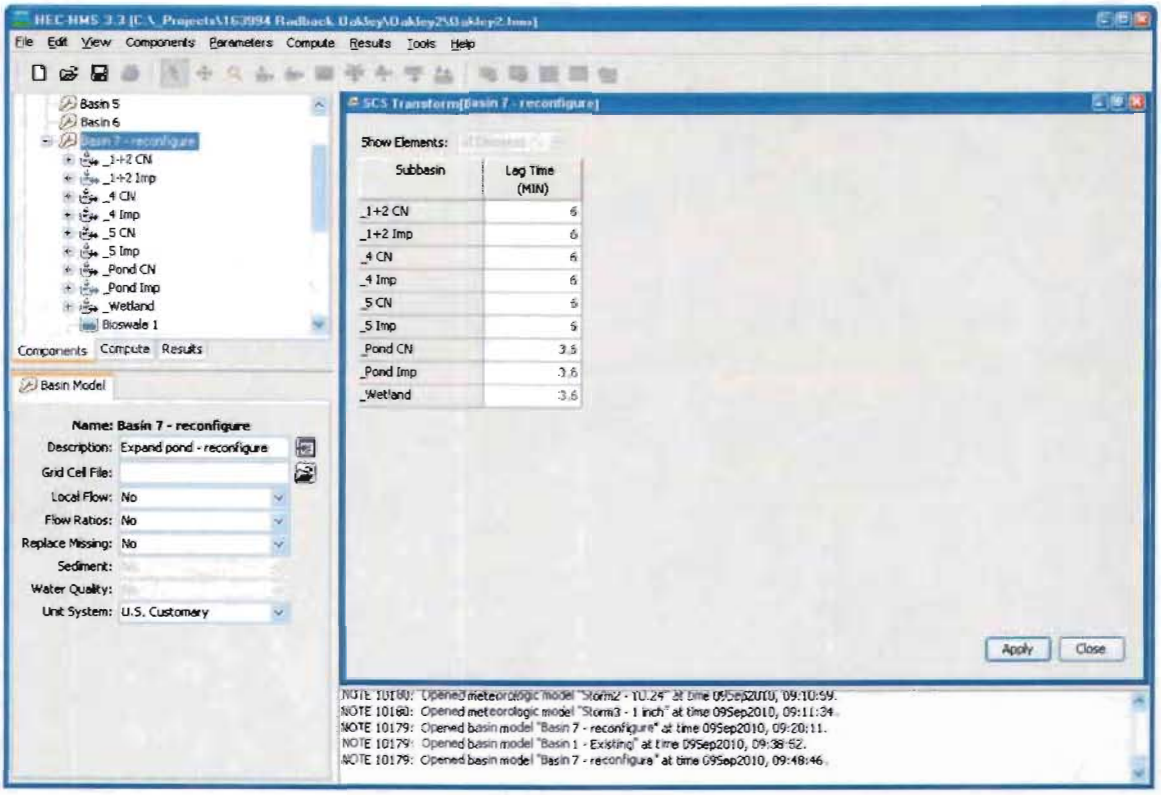
Subbasin Data



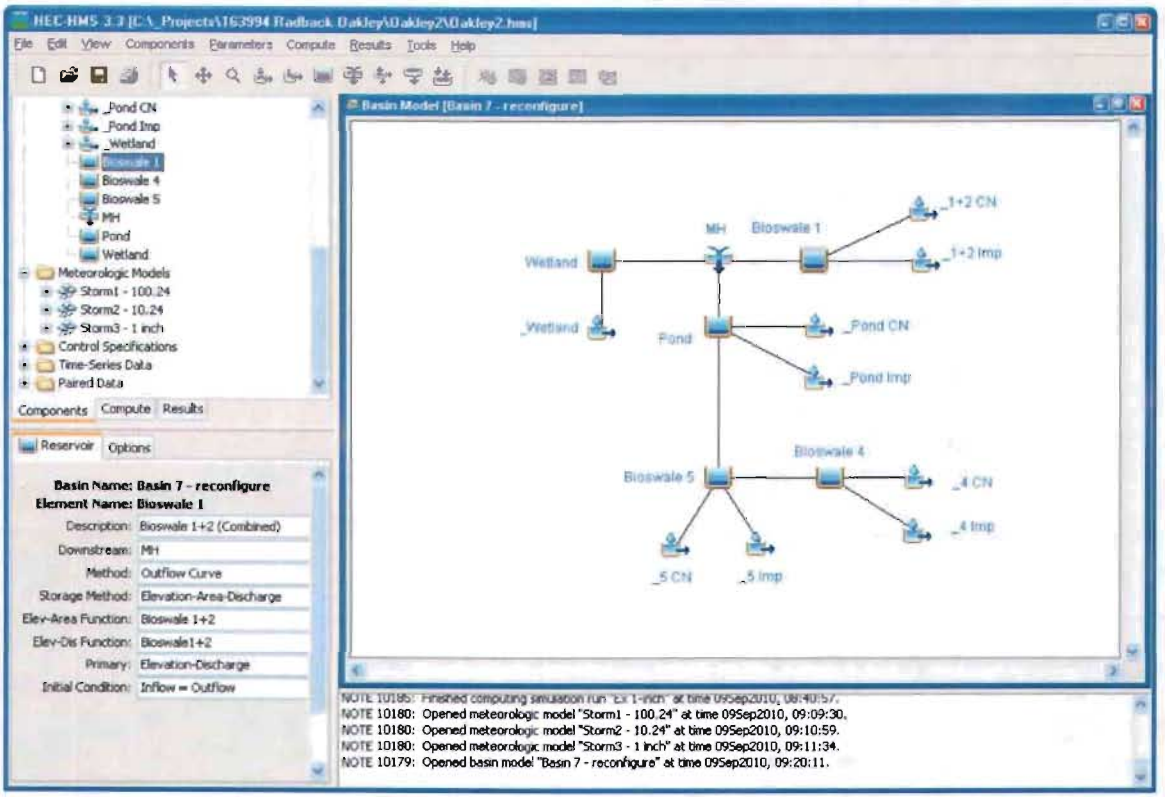


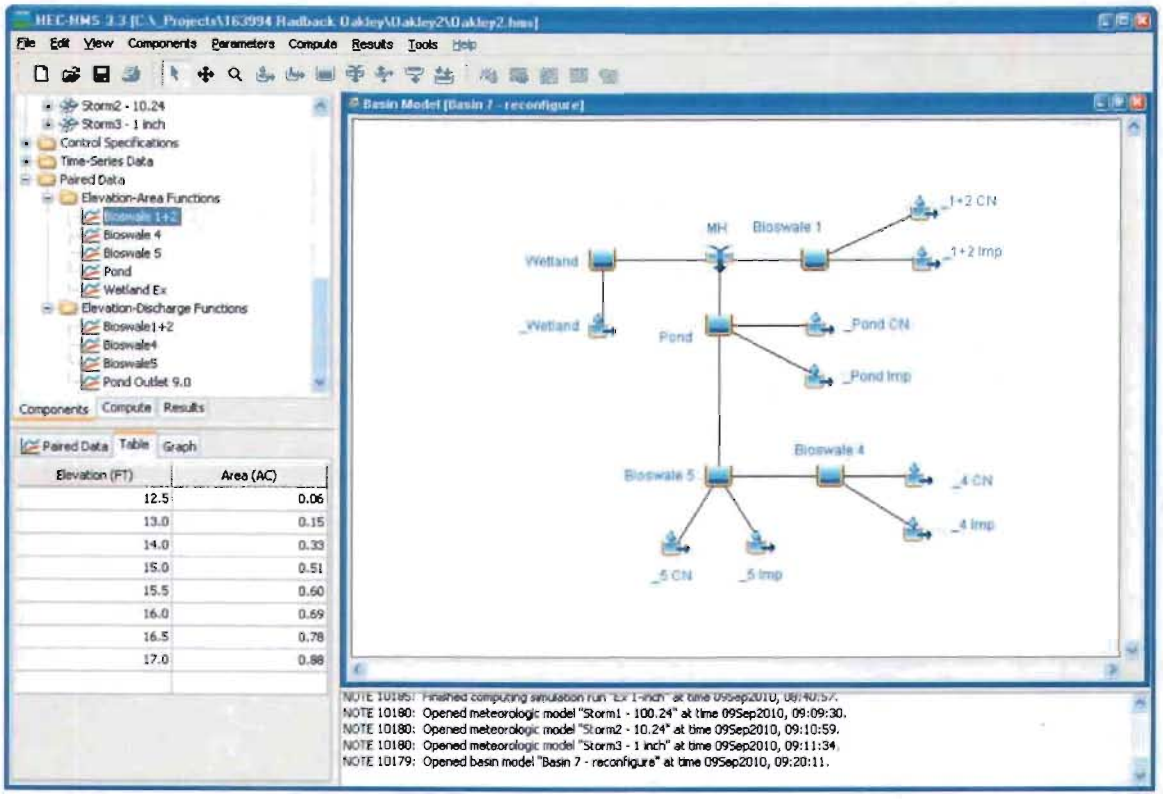
Subbasin	Area (MI2)
_1+2 CN	0.0164
_1+2 Imp	0.0011
_4 CN	0.0062
_4 Imp	0.0005
_5 CN	0.0085
_5 Imp	0.001
_Pond CN	0.0025
_Pond Imp	0.0001
_Wetland	0.0048

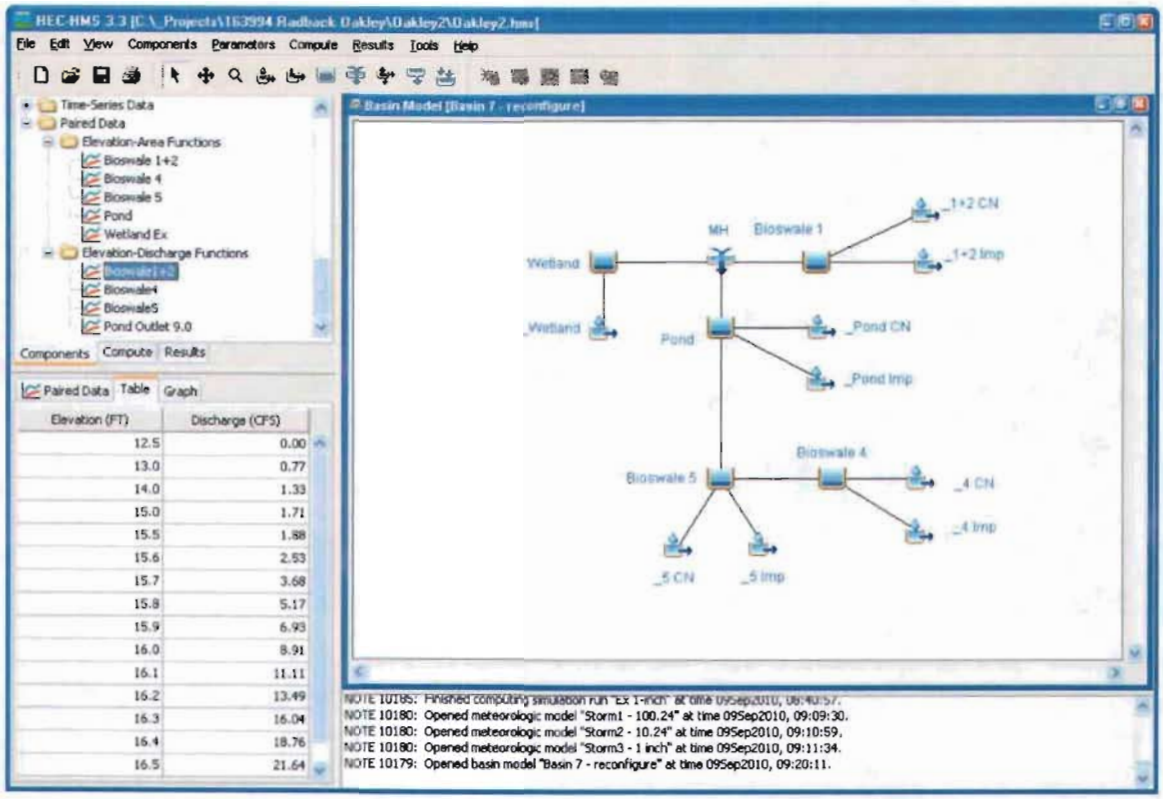

HEC-HMS 3.3 [C:_Projects\163994 Redback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Basin 5
Basin 6
Basin 7 - reconfigure
_1+2 CN
_1+2 Imp
_4 CN
_4 Imp
_5 CN
_5 Imp
_Pond CN
_Pond Imp
_Wetland
Bioswale 1
Components Compute Results
Basin Model
Name: Basin 7 - reconfigure
Description: Expand pond - reconfigure
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
Curve Number Loss [Basin 7 - reconfigure]
Show Elements:
Subbasin | Initial Abstraction (IN) | Curve Number | Impervious (%)
_1+2 CN | 0.632 | 76 | 0.0
_1+2 Imp | 0.041 | 98 | 100
_4 CN | 0.500 | 80 | 0.0
_4 Imp | 0.041 | 98 | 100
_5 CN | 0.597 | 77 | 0.0
_5 Imp | 0.041 | 98 | 100
_Pond CN | 0.740 | 73 | 0.0
_Pond Imp | 0.041 | 98 | 100
_Wetland | 0.667 | 75 | 0.0
Apply
Close
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.


HEC-HMS 3.3 [C:_Projects\163994 Redback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Basin 5
Basin 6
Basin 7 - reconfigure
_1+2 CN
_1+2 Imp
_4 CN
_4 Imp
_5 CN
_5 Imp
_Pond CN
_Pond Imp
_Wetland
Bioswale 1
Components Compute Results
Basin Model
Name: Basin 7 - reconfigure
Description: Expand pond - reconfigure
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
SCS Transform [Basin 7 - reconfigure]
Show Elements:
Subbasin | Lag Time (MIN)
_1+2 CN | 6
_1+2 Imp | 6
_4 CN | 6
_4 Imp | 6
_5 CN | 6
_5 Imp | 6
_Pond CN | 3.6
_Pond Imp | 3.6
_Wetland | 3.6
Apply
Close
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.

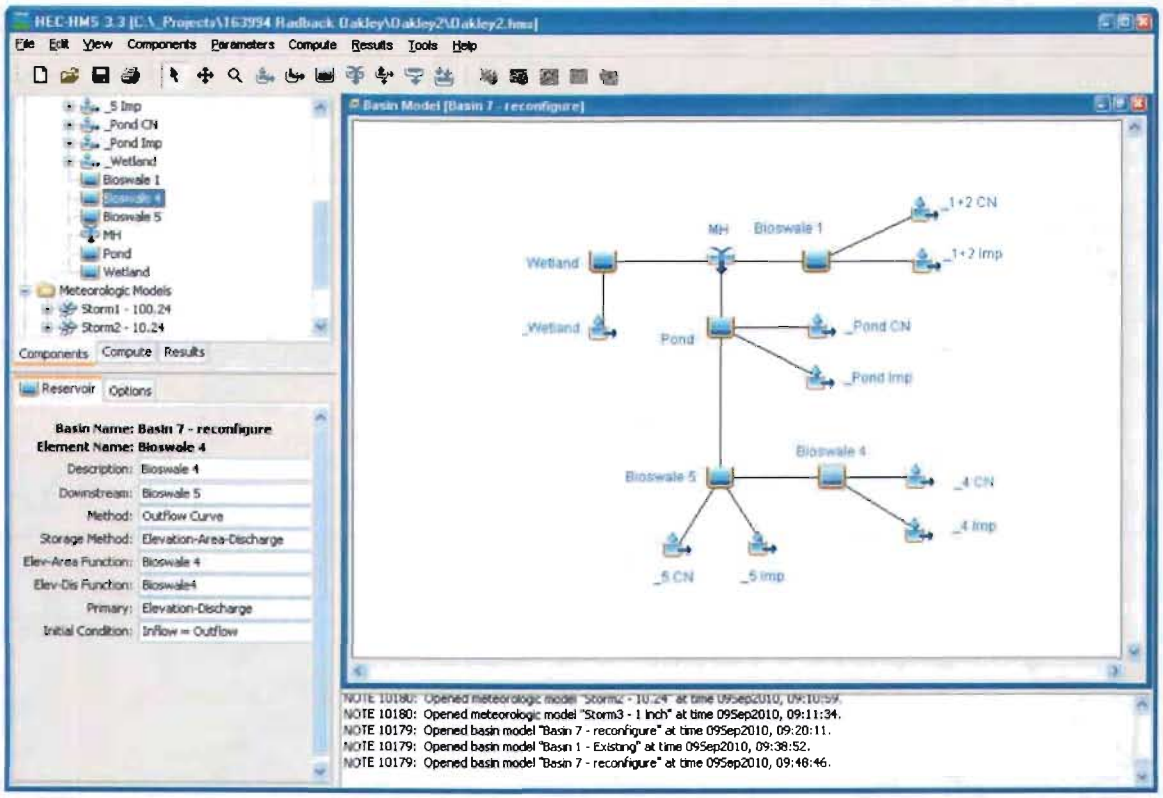
Bioswale 1 Storage Capacity & Discharge Data

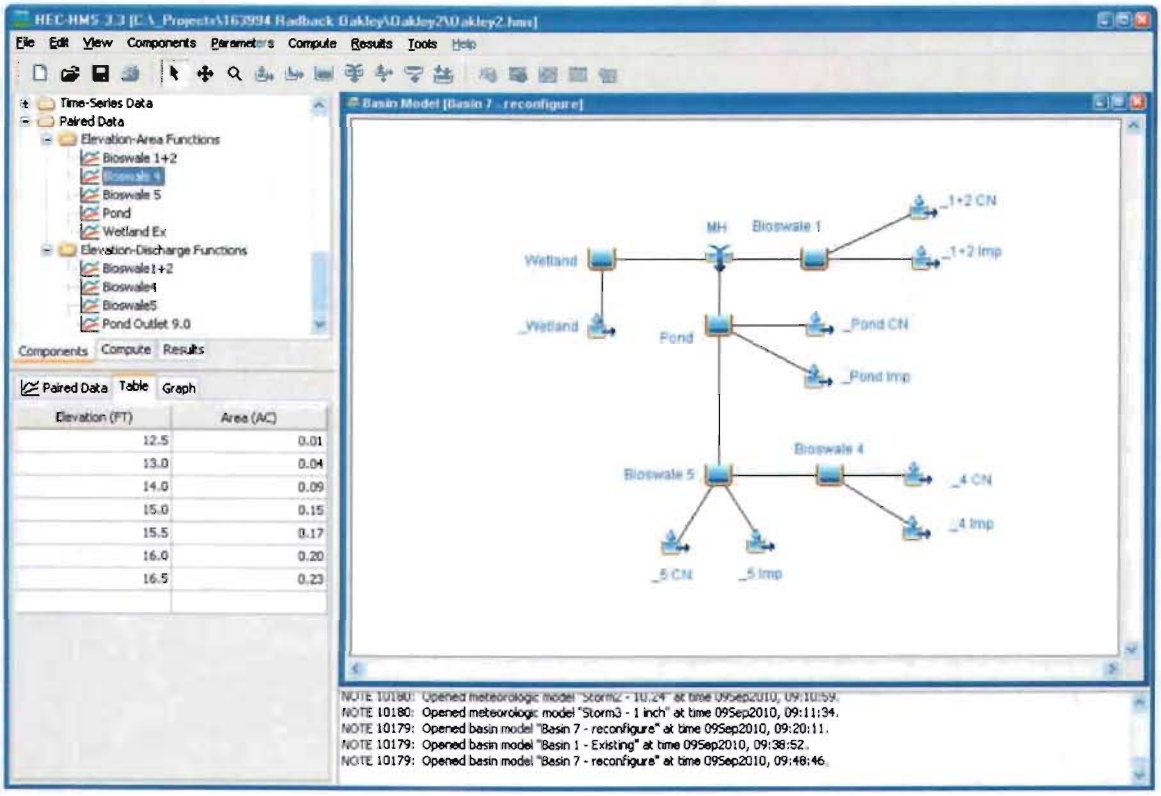


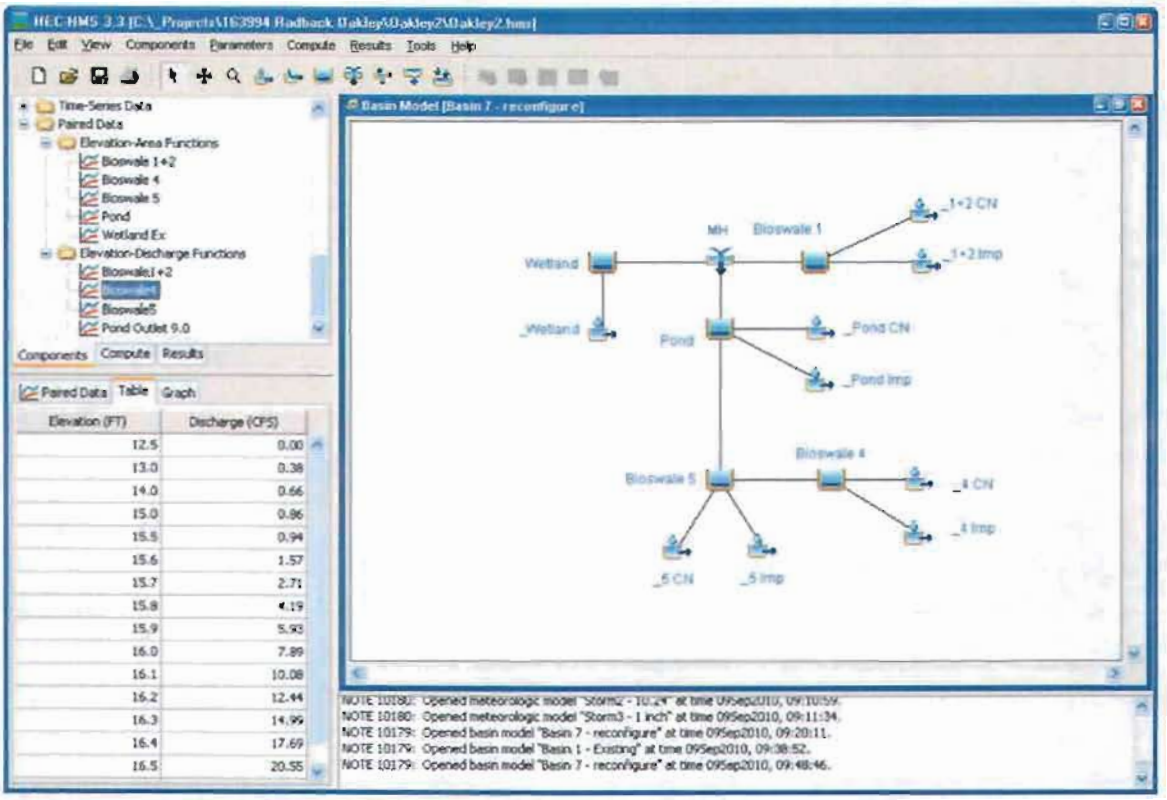



HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Bioswale5
Pond Outlet 9.0
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
12.5 0.00
13.0 0.77
14.0 1.33
15.0 1.71
15.5 1.88
15.6 2.53
15.7 3.68
15.8 5.17
15.9 6.93
16.0 8.91
16.1 11.11
16.2 13.49
16.3 16.04
16.4 18.76
16.5 21.64
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 10180: Opened meteorologic model "Storm1 - 100.24" at time 09Sep2010, 09:09:30.
NOTE 10180: Opened meteorologic model "Storm2 - 10.24" at time 09Sep2010, 09:10:59.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.

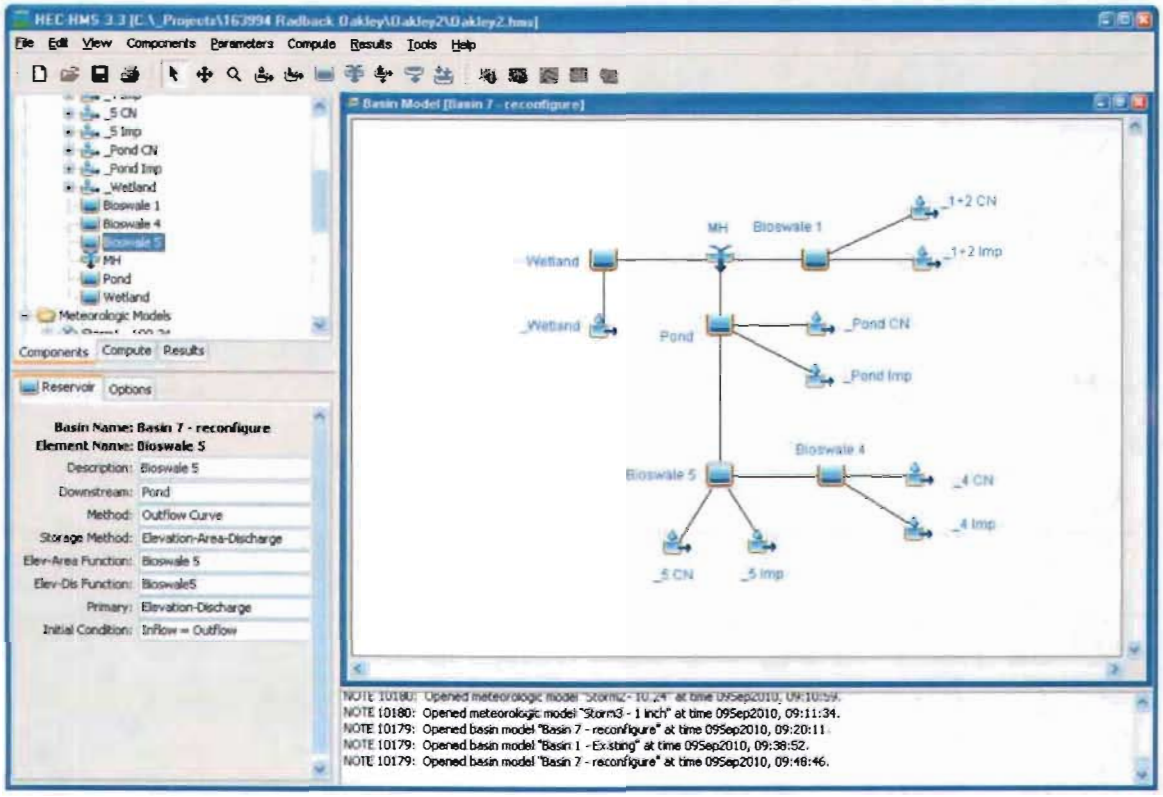
Bioswale 4 Storage Capacity & Discharge Data

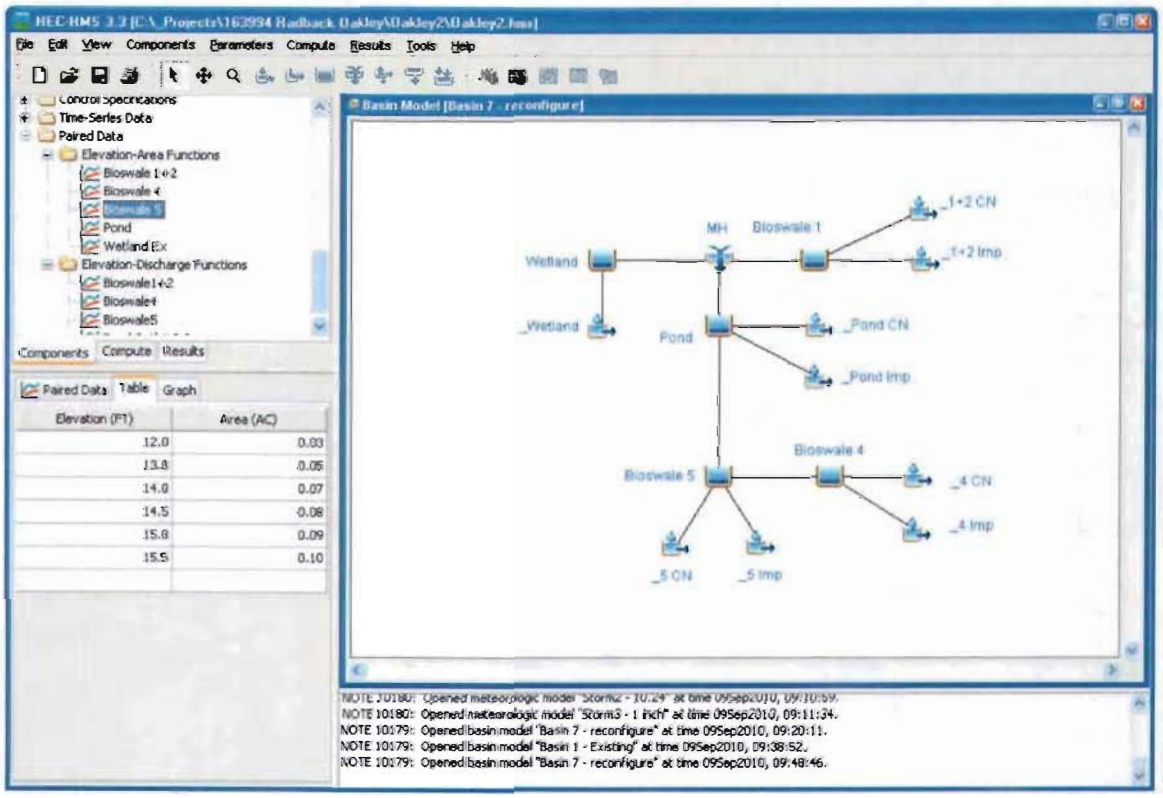


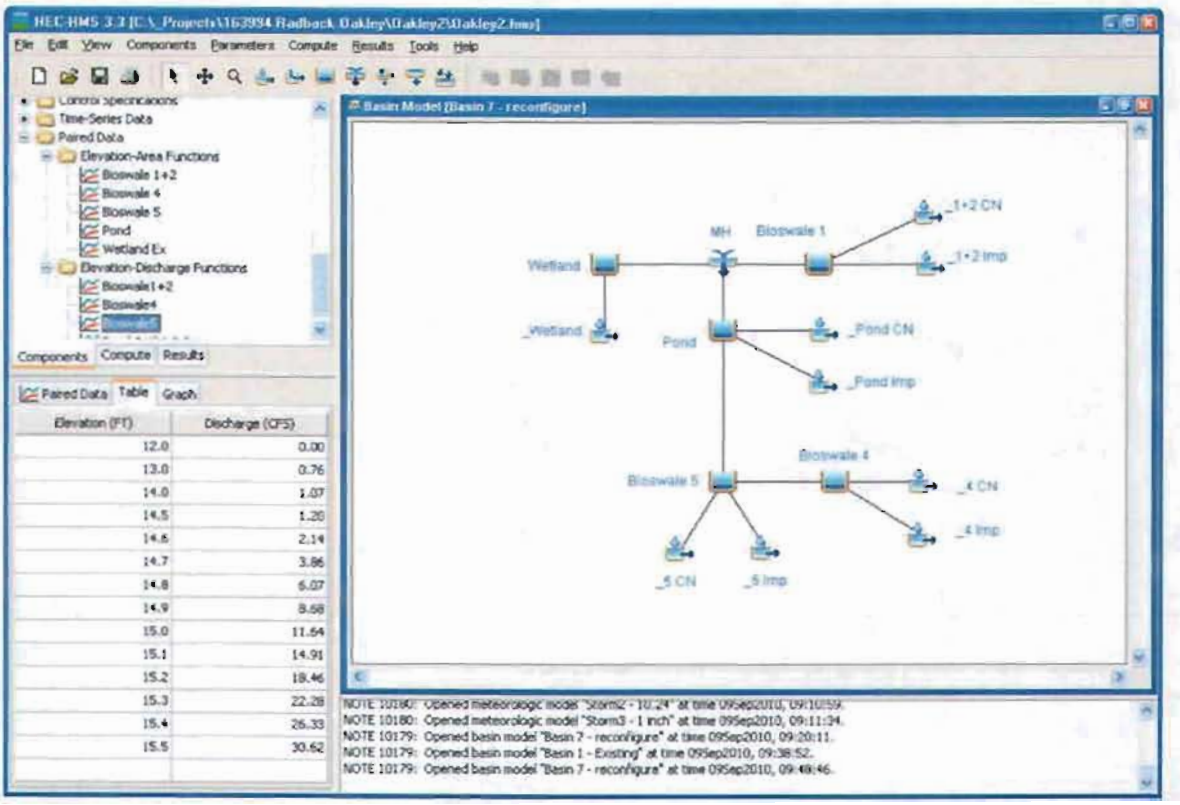



HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Bioswale5
Pond Outlet 9.0
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
12.5 0.00
13.0 0.38
14.0 0.66
15.0 0.86
15.5 0.94
15.6 1.57
15.7 2.71
15.8 4.19
15.9 5.93
16.0 7.89
16.1 10.08
16.2 12.44
16.3 14.99
16.4 17.69
16.5 20.55
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.

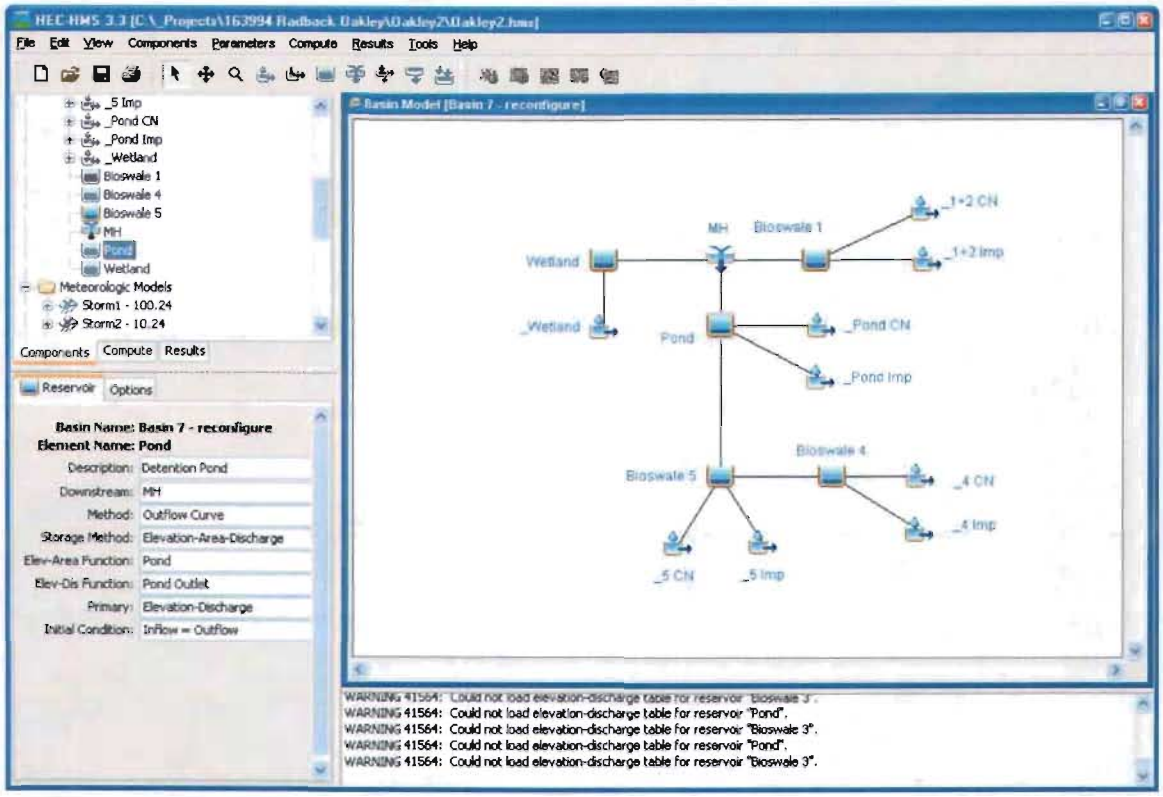
Bioswale 5 Storage Capacity & Discharge Data

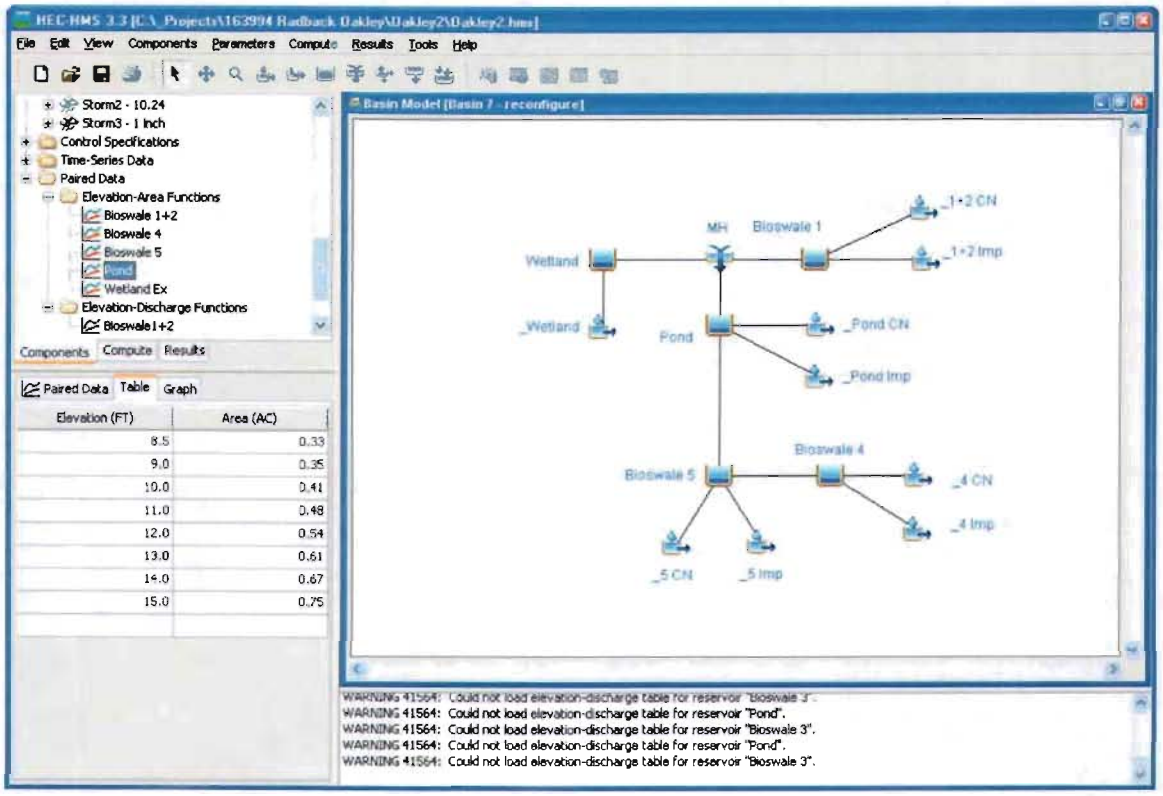


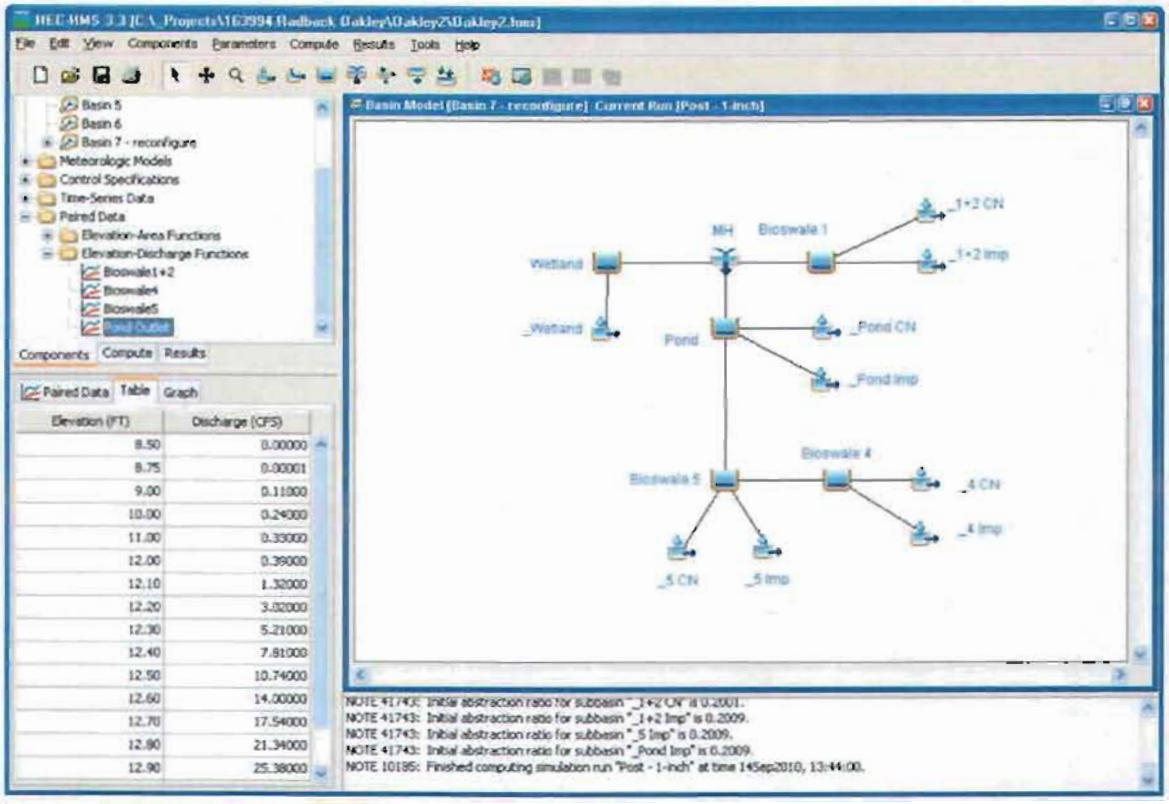



HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
12.0 0.00
13.0 0.76
14.0 1.07
14.5 1.20
14.6 2.14
14.7 3.86
14.8 6.07
14.9 8.68
15.0 11.64
15.1 14.91
15.2 18.46
15.3 22.28
15.4 26.33
15.5 30.62
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:24.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:49:46.

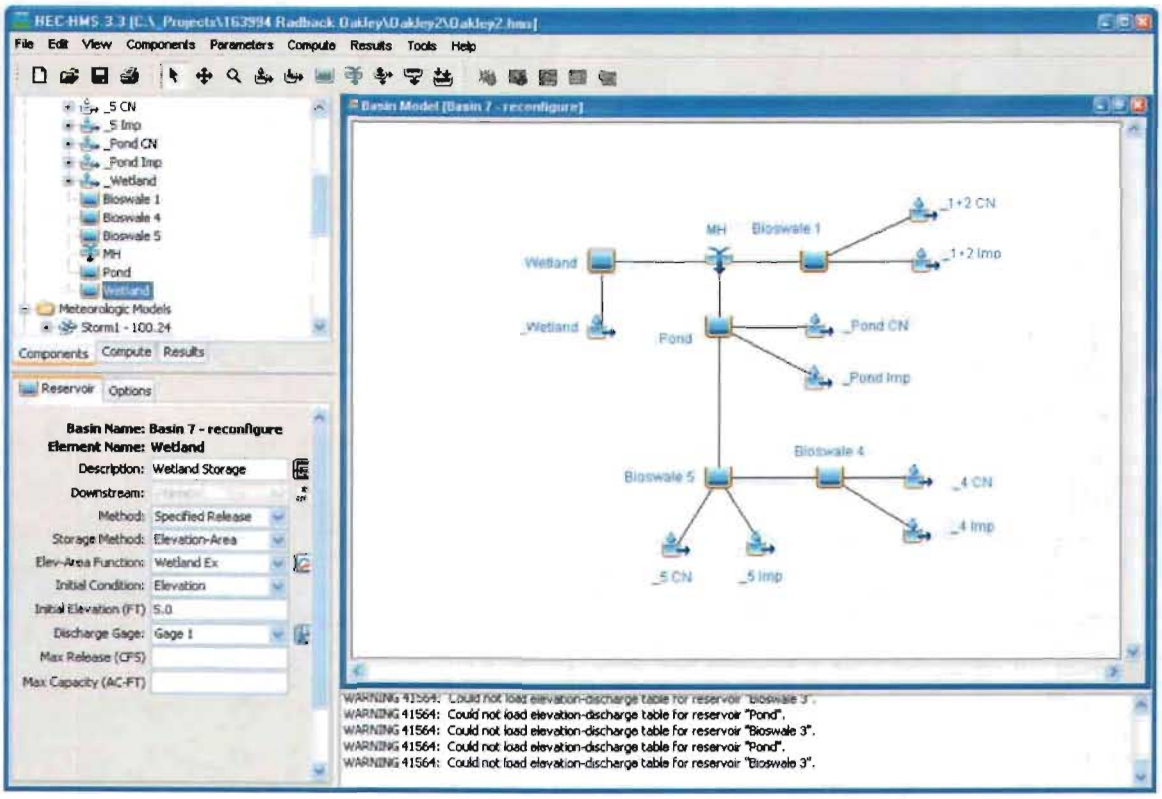
Pond Storage Capacity & Discharge Data

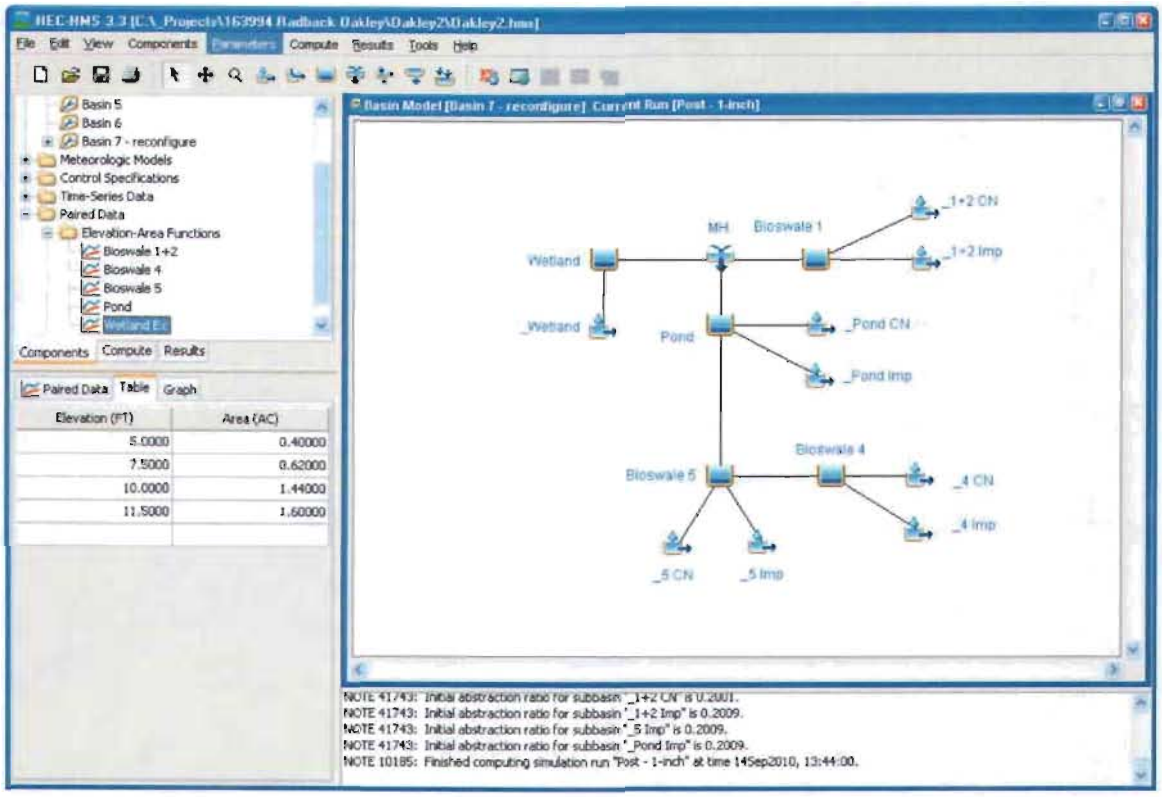


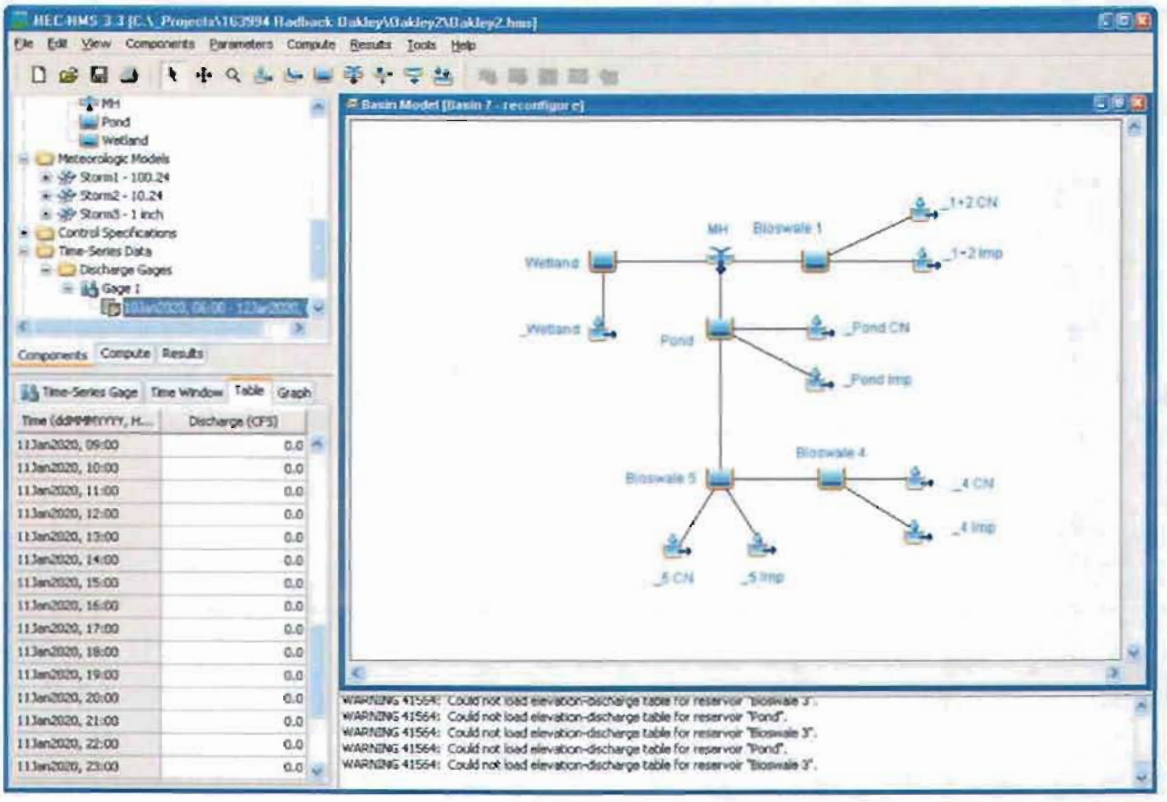



HEC-HMS 3.3 [C:_Projects\163994 Radbuck Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Basin 5
Basin 6
Basin 7 - reconfigure
Meteorologic Models
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Bioswale5
Pond Outlet
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
8.50 0.00000
8.75 0.00001
9.00 0.11000
10.00 0.24000
11.00 0.33000
12.00 0.39000
12.10 1.32000
12.20 3.02000
12.30 5.21000
12.40 7.81000
12.50 10.74000
12.60 14.00000
12.70 17.54000
12.80 21.34000
12.90 25.38000
Basin Model [Basin 7 - reconfigure] Current Run [Post - 1-inch]
Wetland
MH
Bioswale 1
_1+2 CN
_1+2 Imp
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 41743: Initial abstraction ratio for subbasin "_1+2 CN" is 0.2001.
NOTE 41743: Initial abstraction ratio for subbasin "_1+2 Imp" is 0.2009.
NOTE 41743: Initial abstraction ratio for subbasin "_5 Imp" is 0.2009.
NOTE 41743: Initial abstraction ratio for subbasin "_Pond Imp" is 0.2009.
NOTE 10185: Finished computing simulation run "Post - 1-inch" at time 14Sep2010, 13:44:00.

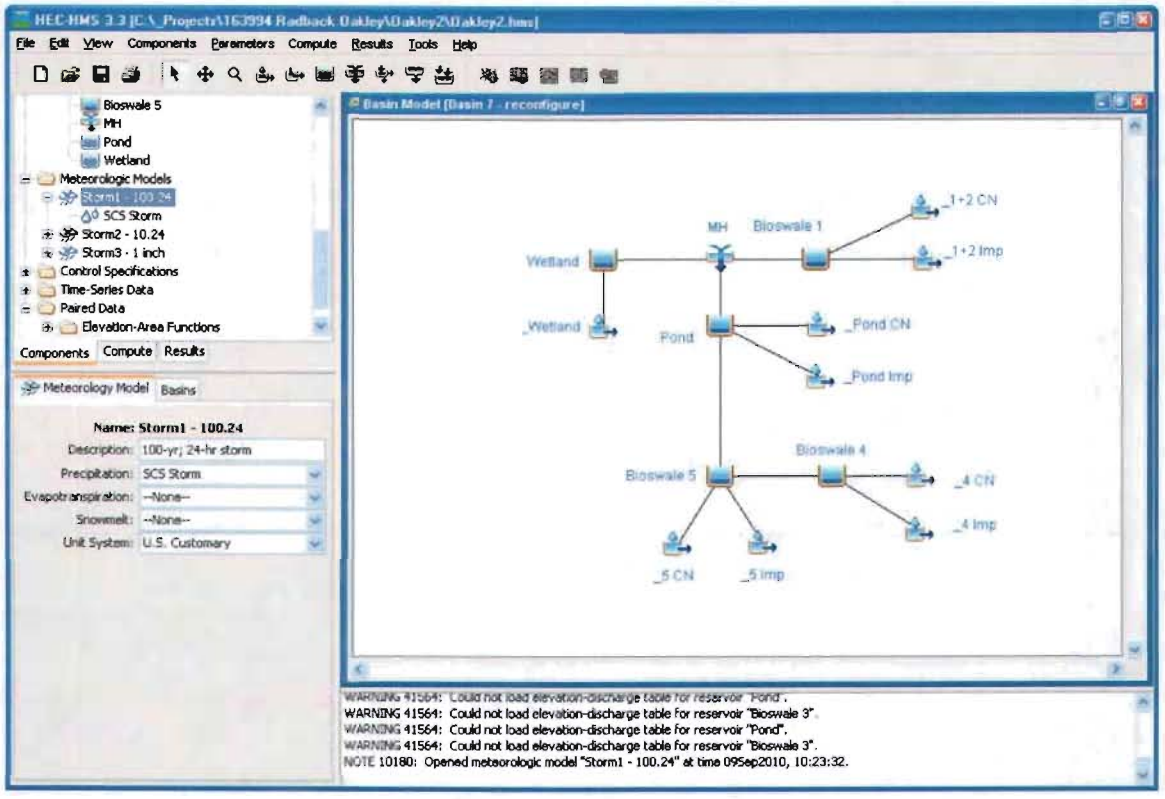
Wetland Storage Capacity Data

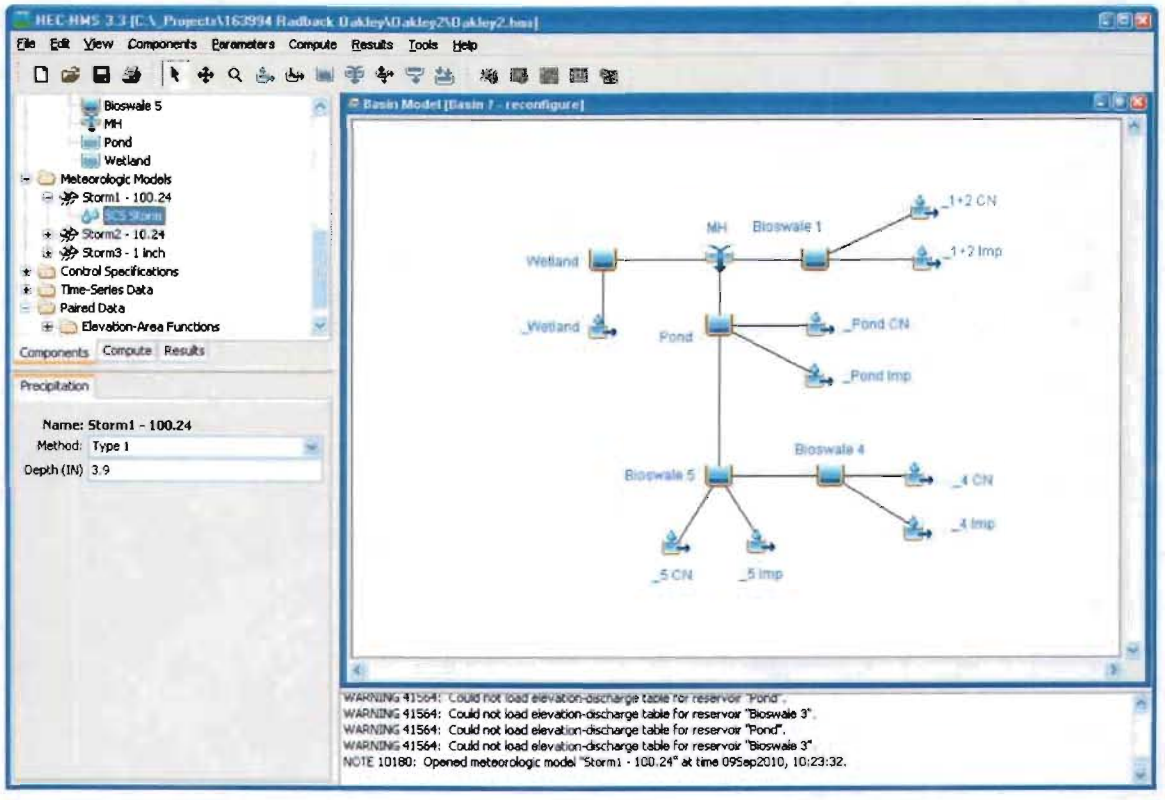




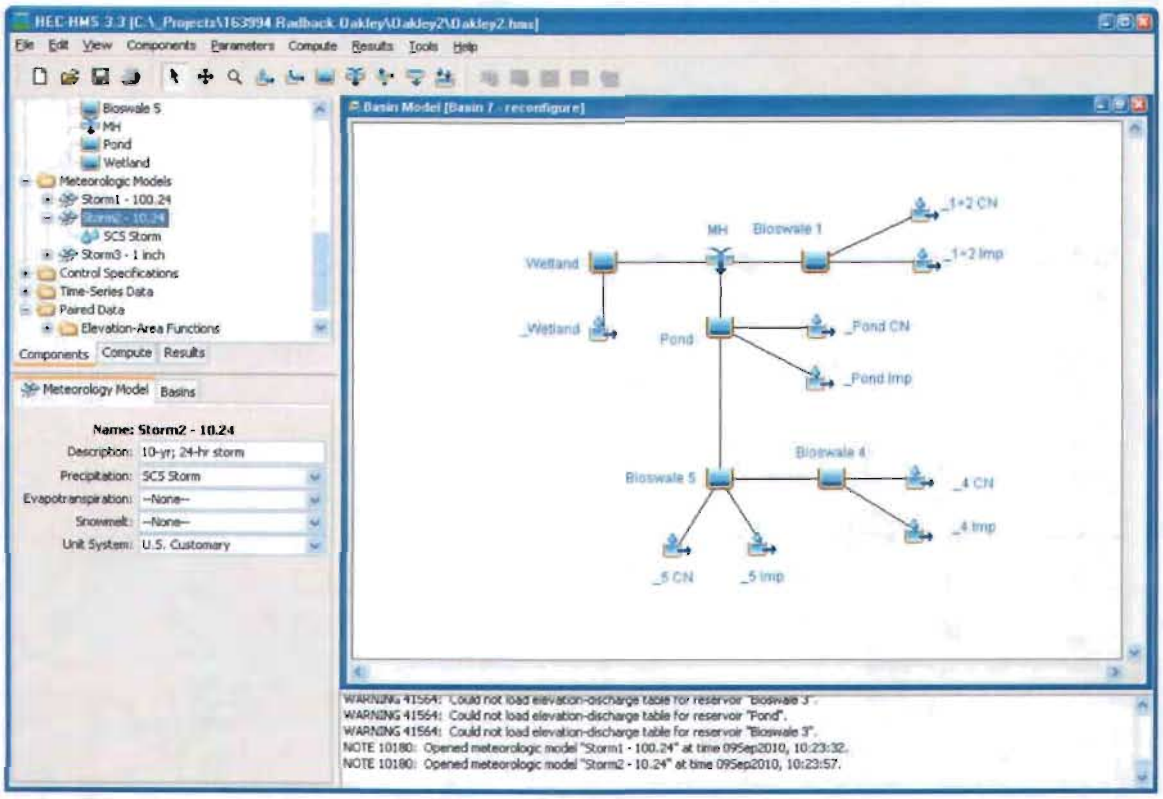

HEC-HMS 3.3 [C:_Projects\1U3994 Hadback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
MH
Pond
Wetland
Meteorologic Models
Storm1 - 100.24
Storm2 - 10.24
Storm3 - 1 inch
Control Specifications
Time-Series Data
Discharge Gages
Gage 1
Components Compute Results
Time-Series Gage Time Window Table Graph
Time (ddMMMYYYY, H... Discharge (CFS)
11Jan2020, 09:00 0.0
11Jan2020, 10:00 0.0
11Jan2020, 11:00 0.0
11Jan2020, 12:00 0.0
11Jan2020, 13:00 0.0
11Jan2020, 14:00 0.0
11Jan2020, 15:00 0.0
11Jan2020, 16:00 0.0
11Jan2020, 17:00 0.0
11Jan2020, 18:00 0.0
11Jan2020, 19:00 0.0
11Jan2020, 20:00 0.0
11Jan2020, 21:00 0.0
11Jan2020, 22:00 0.0
11Jan2020, 23:00 0.0
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
WARNING 41564: Could not load elevation-discharge table for reservoir "Bioswale 3".
WARNING 41564: Could not load elevation-discharge table for reservoir "Pond".
WARNING 41564: Could not load elevation-discharge table for reservoir "Bioswale 3".
WARNING 41564: Could not load elevation-discharge table for reservoir "Pond".
WARNING 41564: Could not load elevation-discharge table for reservoir "Bioswale 3".

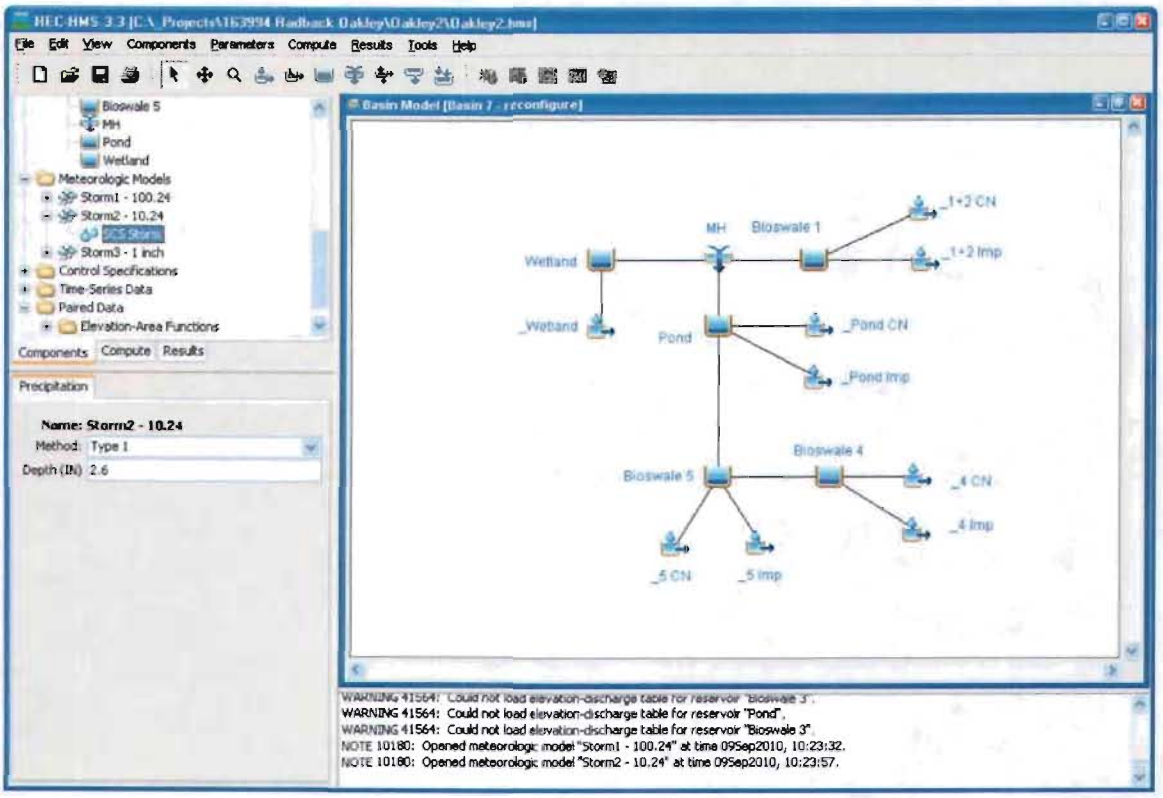
HEC-HMS Input – Meteorologic Model Storm1 – 100-year, 24-hour storm



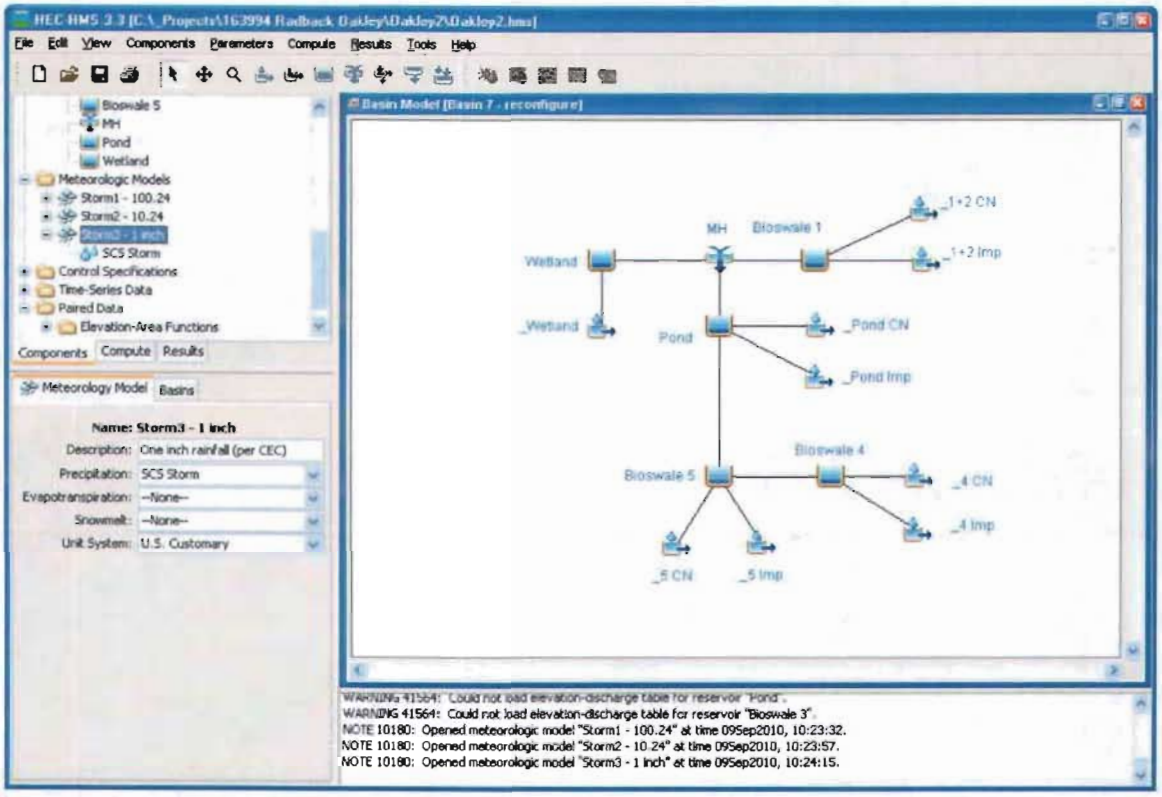


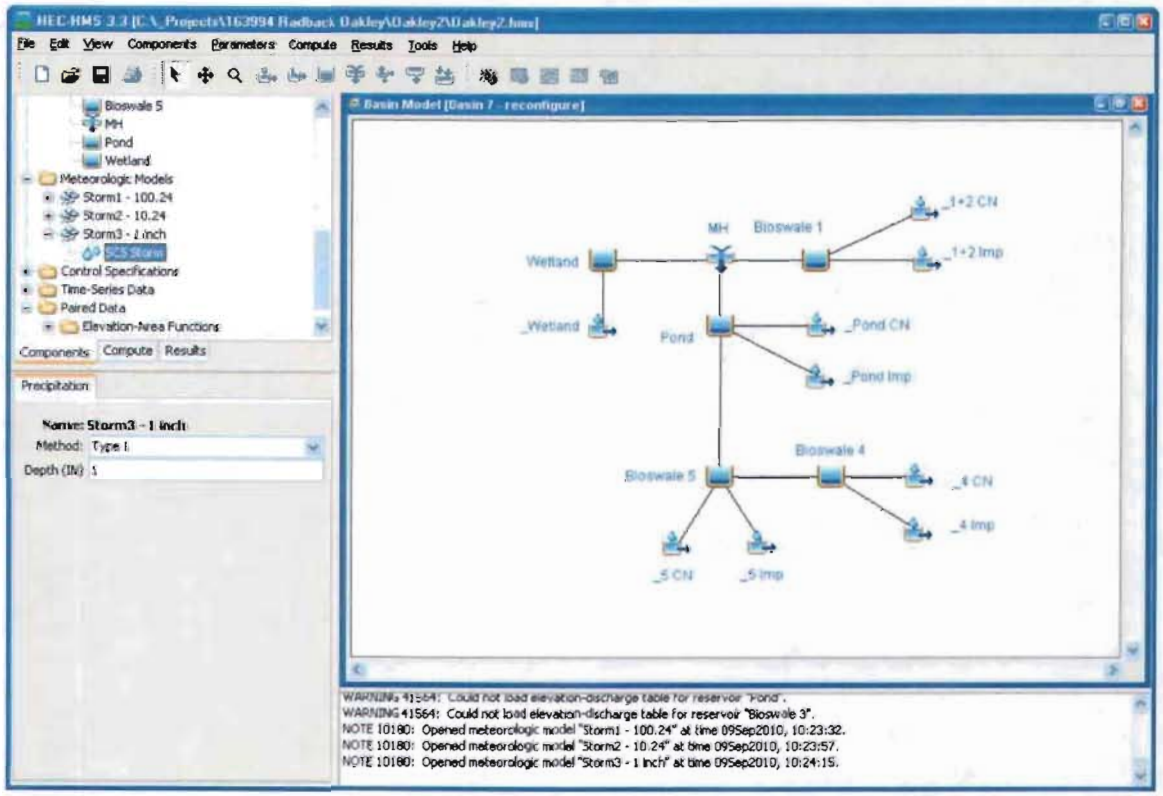
HEC-HMS Input – Meteorologic Model Storm2 – 10-year, 24-hour storm



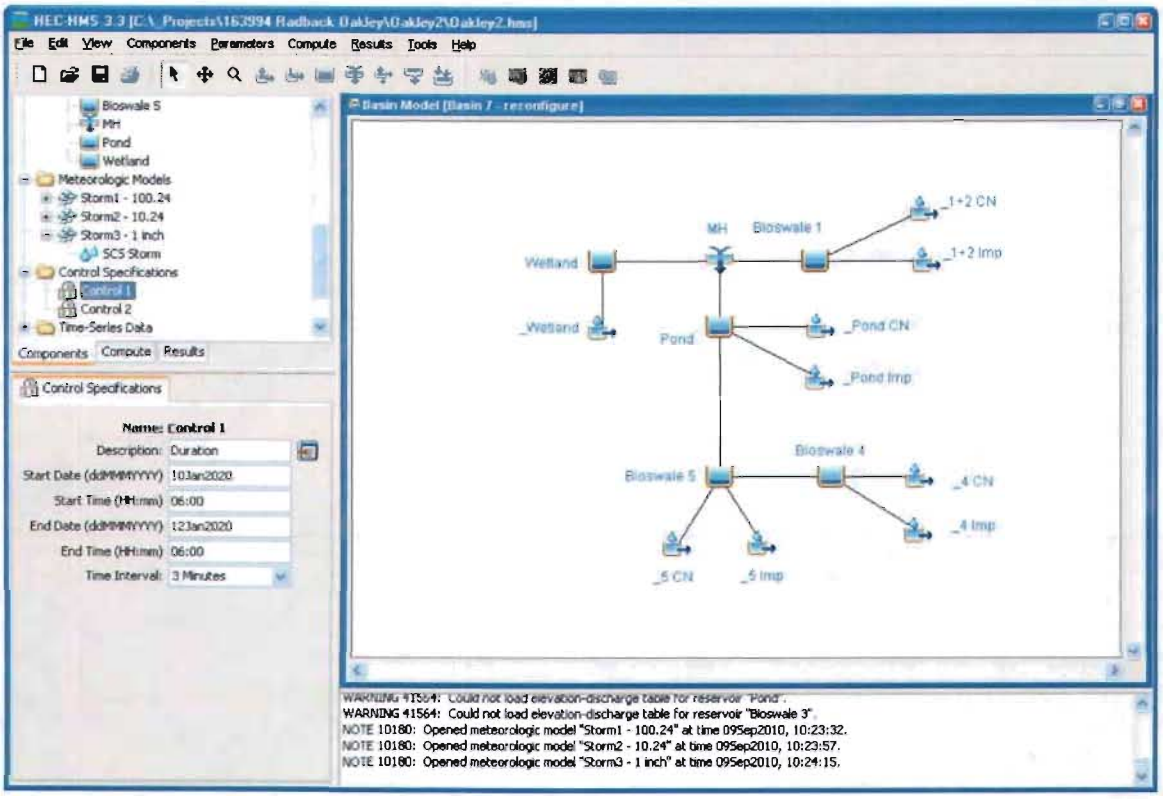


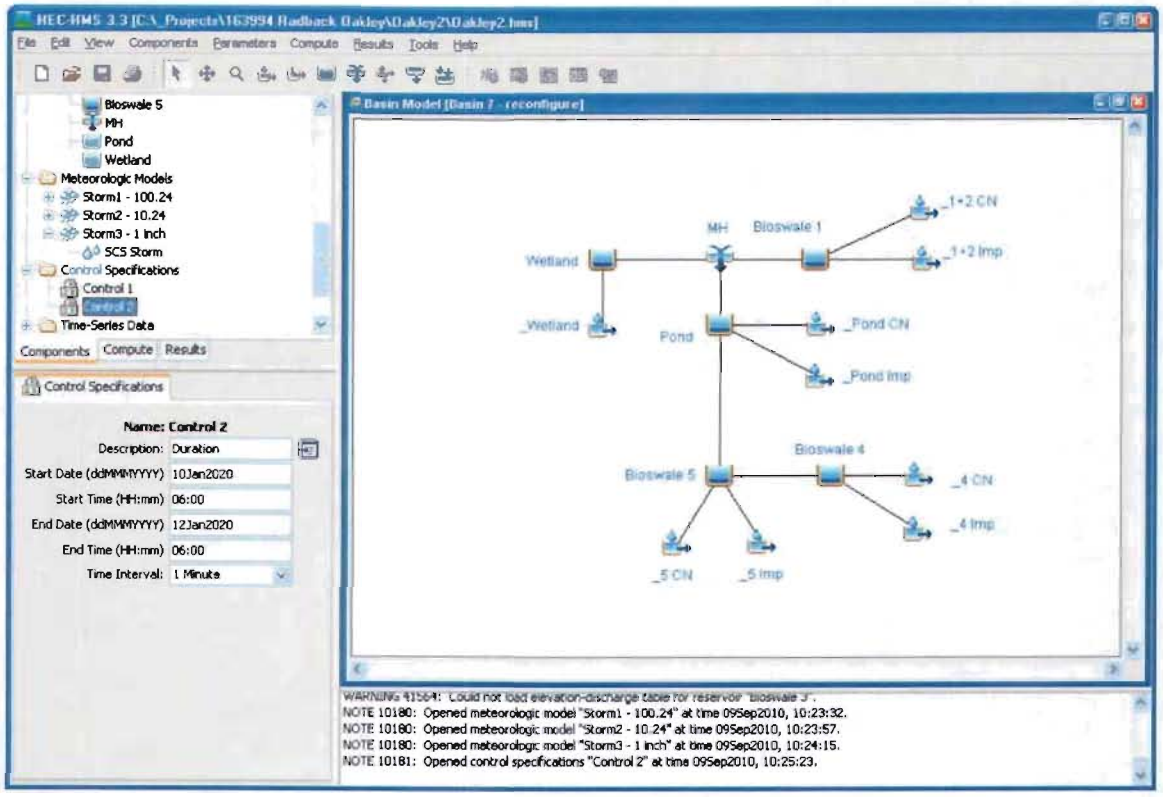
HEC-HMS Input – Meteorologic Model Storm3 – 1-inch rainfall





HEC-HMS Input – Control Data





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9/13/10
CAK

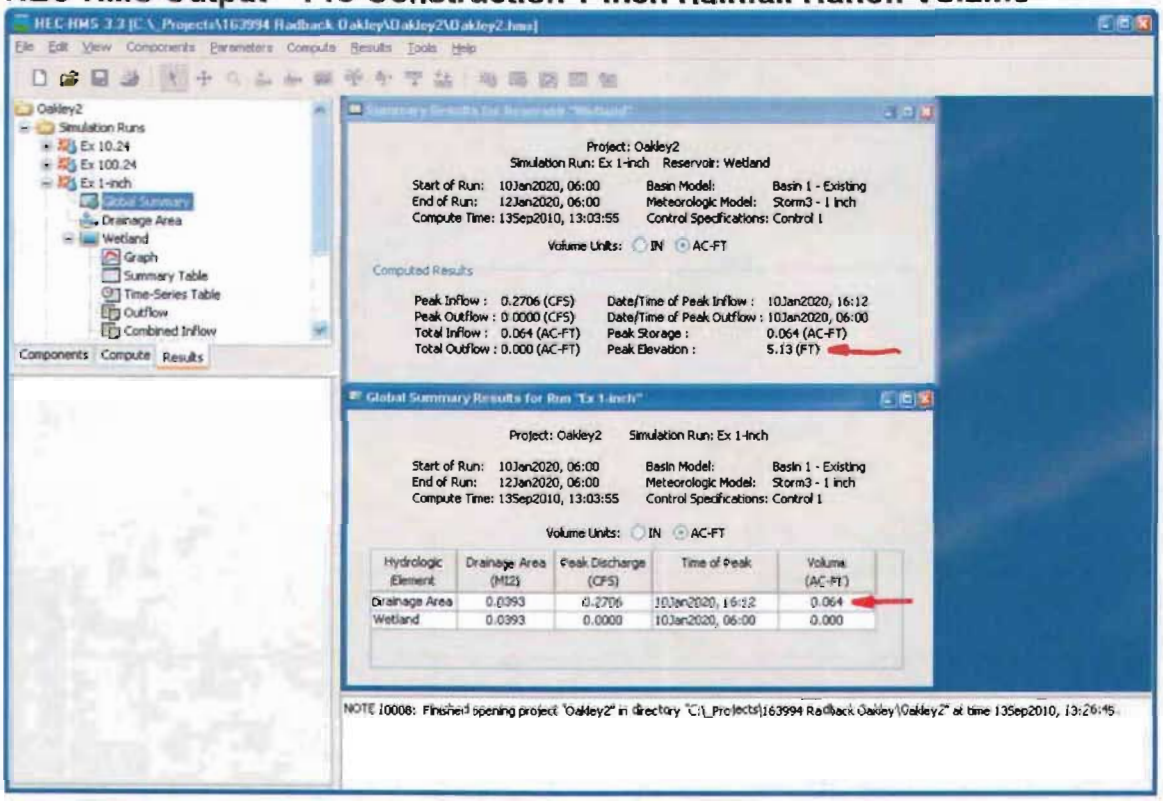
Attachment 2

HEC-HMS Output

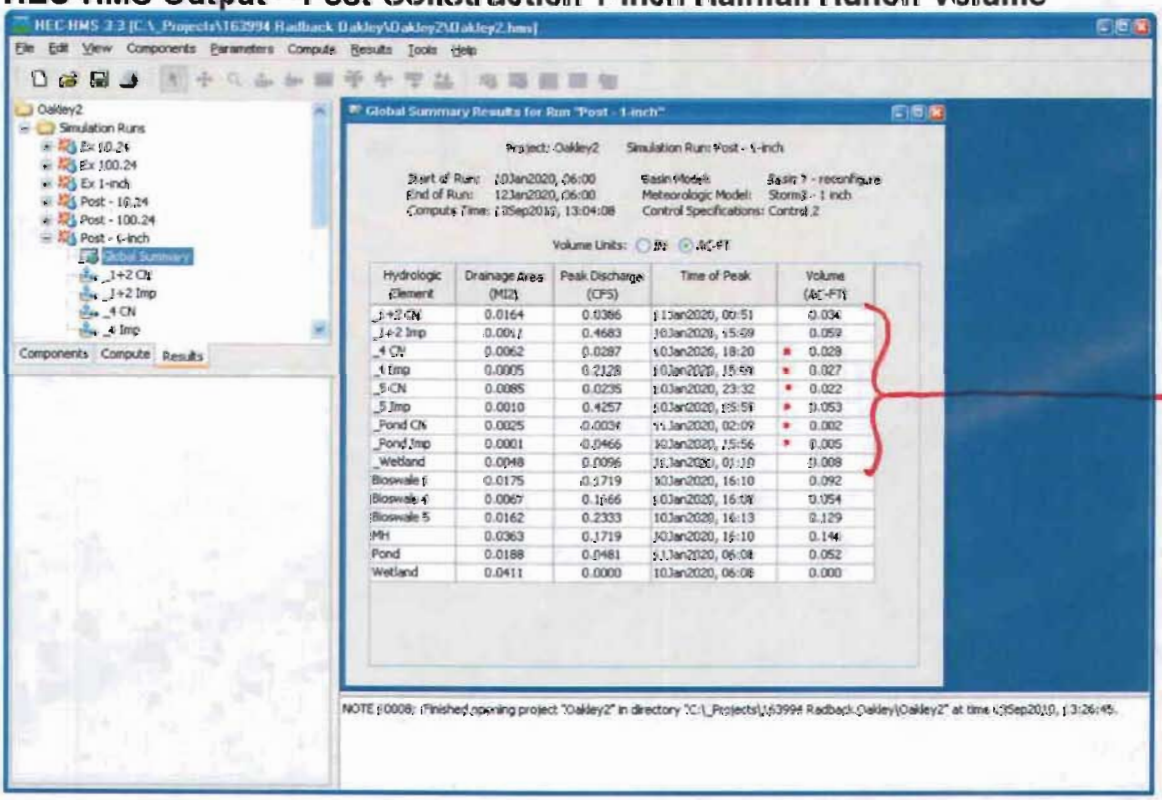
Description Key for HEC-HMS Input/Output Data

Hydrologic Element	Description
_1+2	Drainage area flowing to Bioswale 1+2
~~_3~~	~~Drainage area flowing to Bioswale 3~~
_4	Drainage area flowing to Bioswale 4
_5	Drainage area flowing to Bioswale 5
_Pond	Drainage area flowing directly to Pond
_Wetland	Drainage area flowing directly to Wetland
Bioswale 1+2	Flow from Bioswale 1+2 outlet (to MH1)
Bioswale 3	Flow from Bioswale 3 outlet (to MH2)
Bioswale 4	Flow from Bioswale 4 outlet (to MH1)
Bioswale 5	Flow from Bioswale 5 outlet (to Wetland)
MH1	Flow from Bioswales 1+2 and 4 (to Pond)
MH2	Flow from Pond and Bioswale 3 (to Wetland)
Pond	Flow from Pond Outlet (to MH2)
Wetland	Flow from Wetland (set to 0.0)

HEC-HMS Output – Pre-Construction 1-Inch Rainfall Runoff Volume



HEC-HMS Output – Post-Construction 1-Inch Rainfall Runoff Volume



0.24 ac·ft total runoff

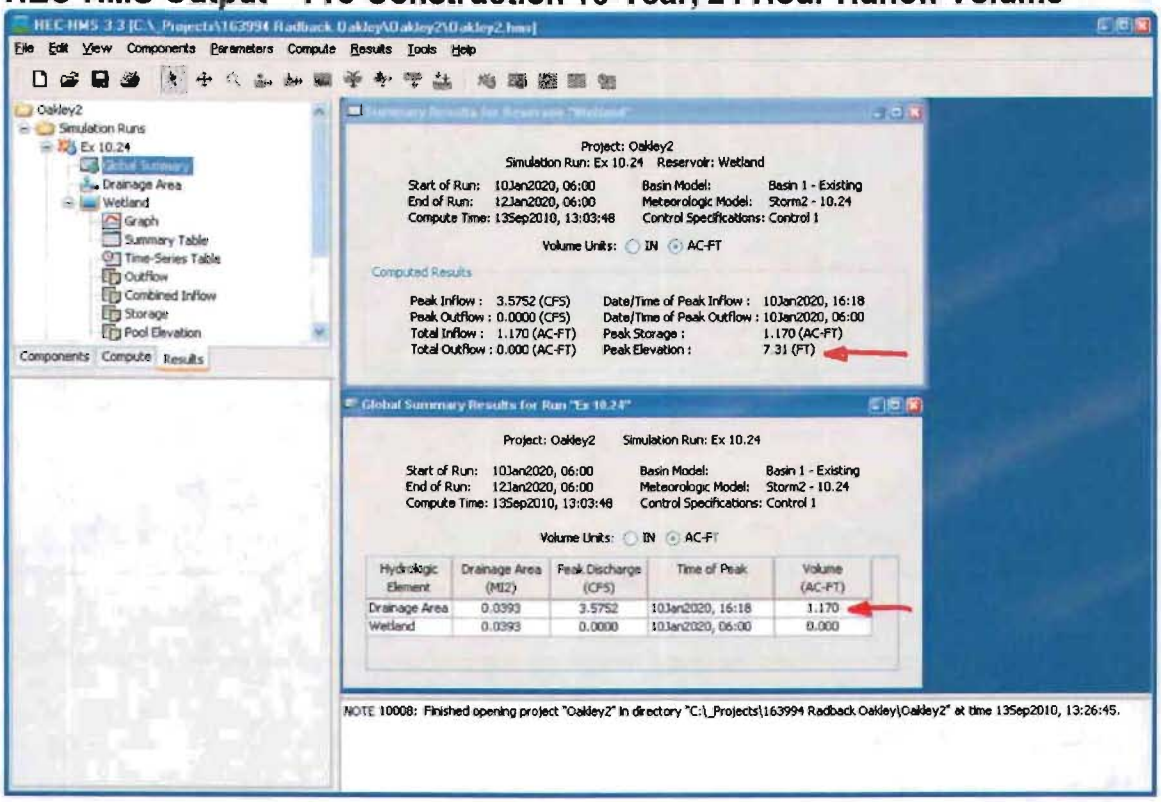
• 0.14 ac·ft to pond

0.14 > 0.085 ac·ft pond retention

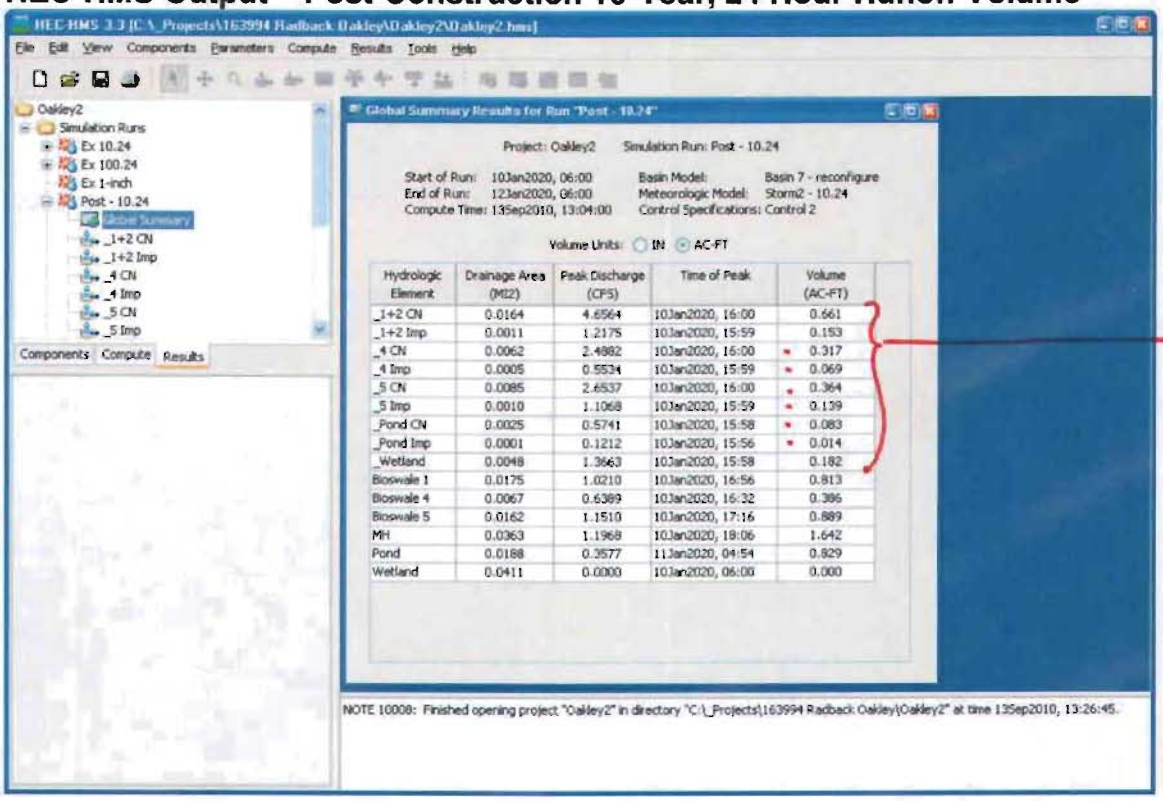
∴ total to wetland =

0.24
−0.085
0.155 ac·ft to WL

HEC-HMS Output – Pre-Construction 10-Year, 24 Hour Runoff Volume



HEC-HMS Output – Post-Construction 10-Year, 24 Hour Runoff Volume

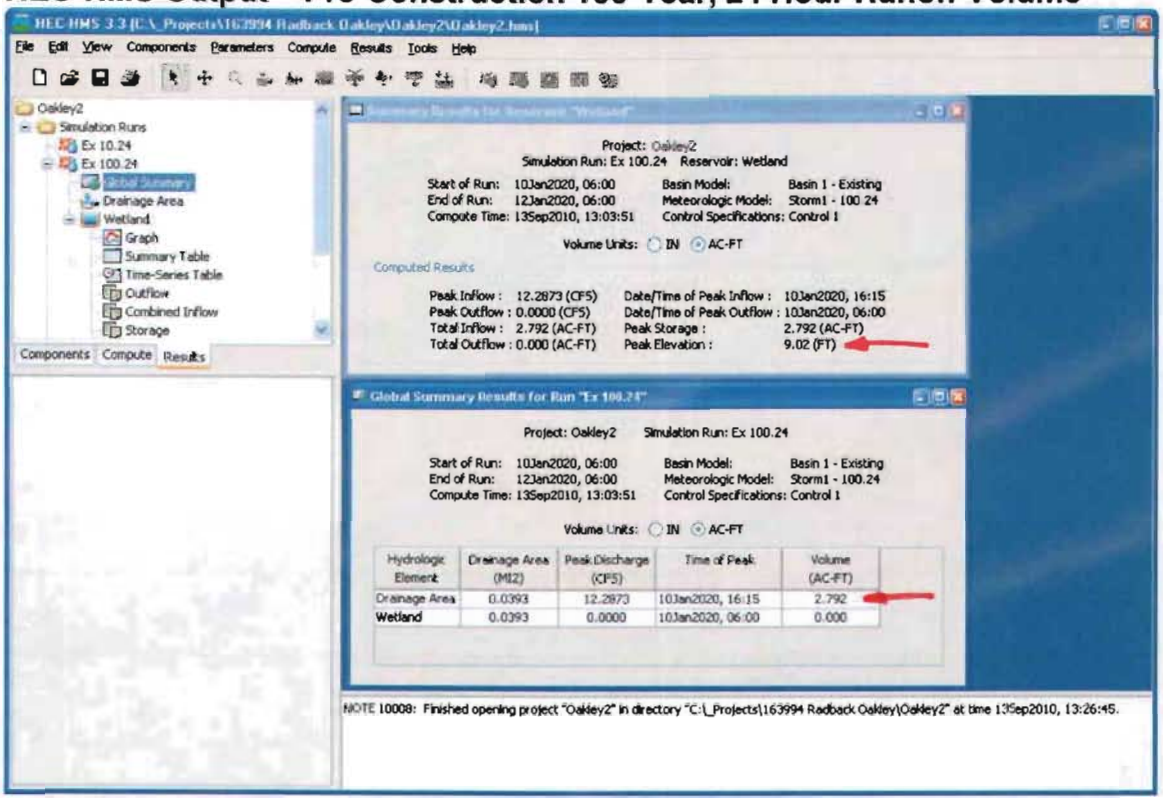


1.98 ac-ft total runoff

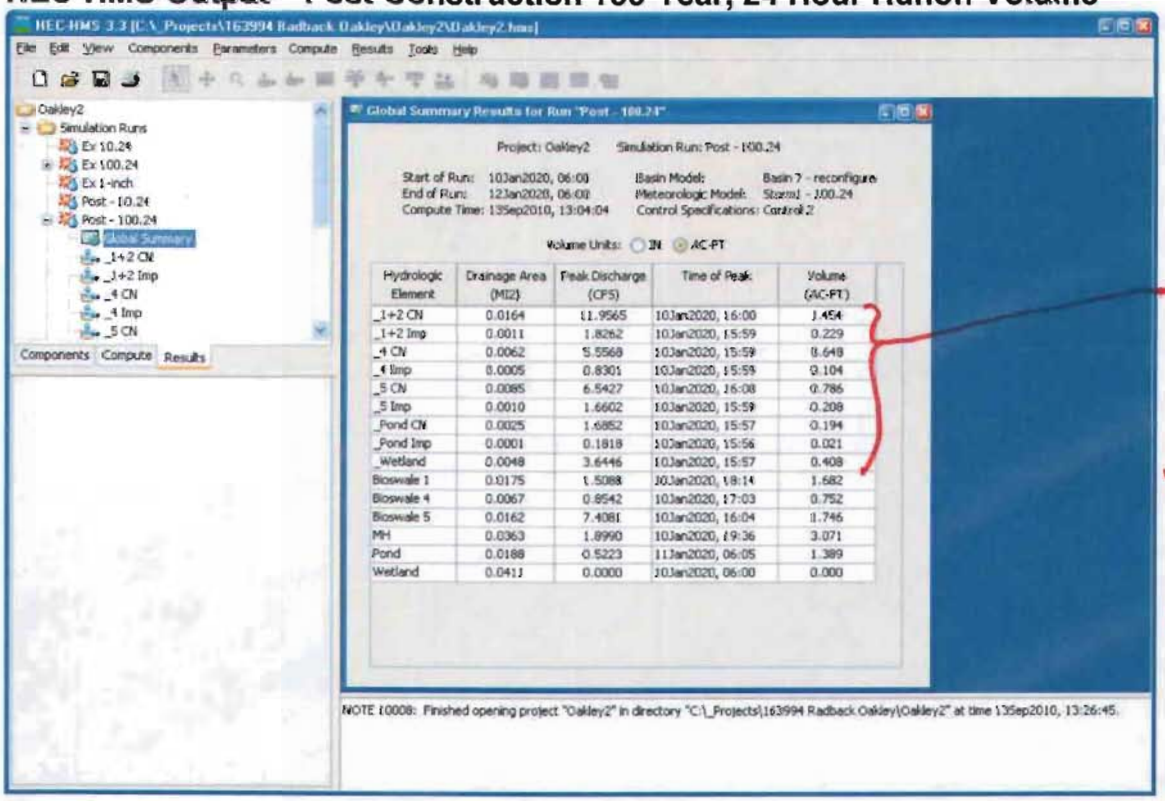
0.08 ac-ft pond retention

1.90 ac-ft to wetland (pond outlet above 10-yr WSEL in wetland)

HEC-HMS Output – Pre-Construction 100-Year, 24 Hour Runoff Volume



HEC-HMS Output – Post-Construction 100-Year, 24 Hour Runoff Volume



4.05 ac-ft total runoff

at equalized WSEL 9.8 wetland ~~pond~~ storage = 3.58 ac-ft

pond storage = 0.47 ac-ft

3.58
+0.47
4.05 ac-ft ✓

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Attachment 3

Reference 2

Select Pages

Chapter 2 Estimating Runoff

SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in appendix A for determining the HSG classification for disturbed soils.

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

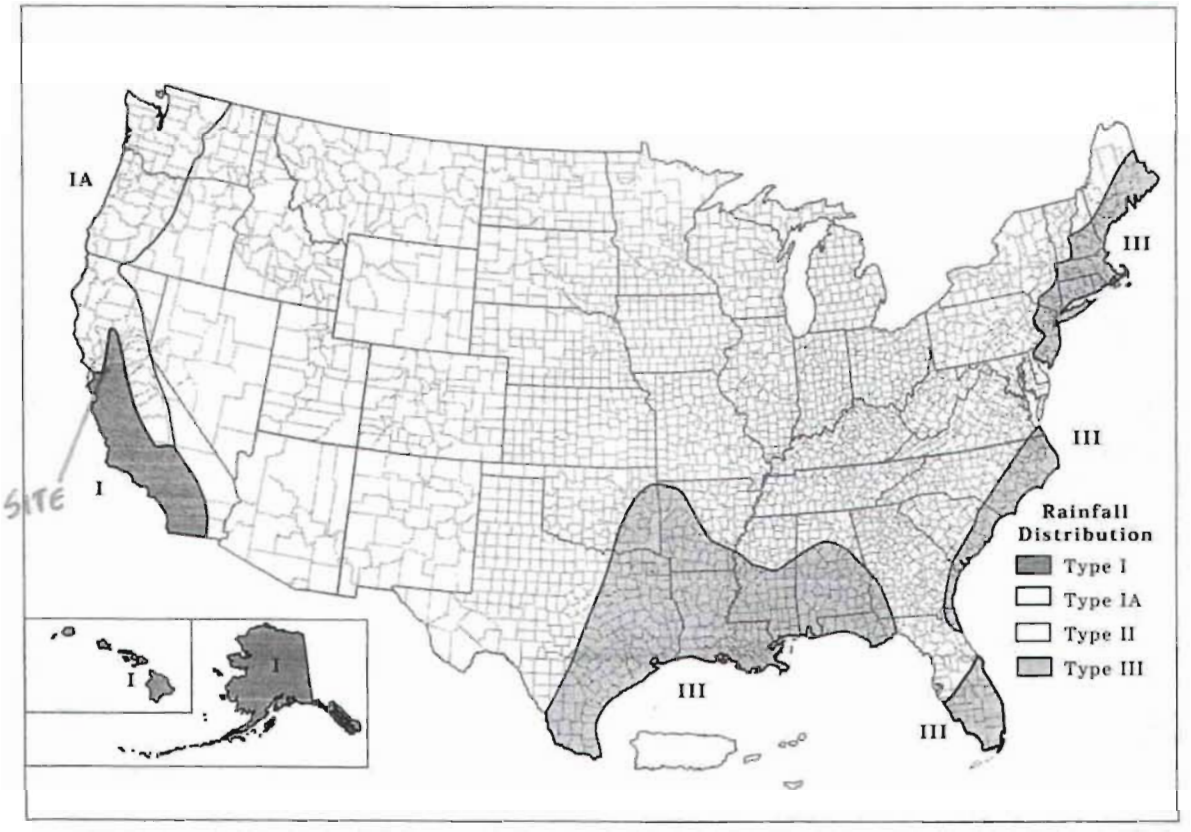
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

Appendix A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

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Attachment 4

Reference 6

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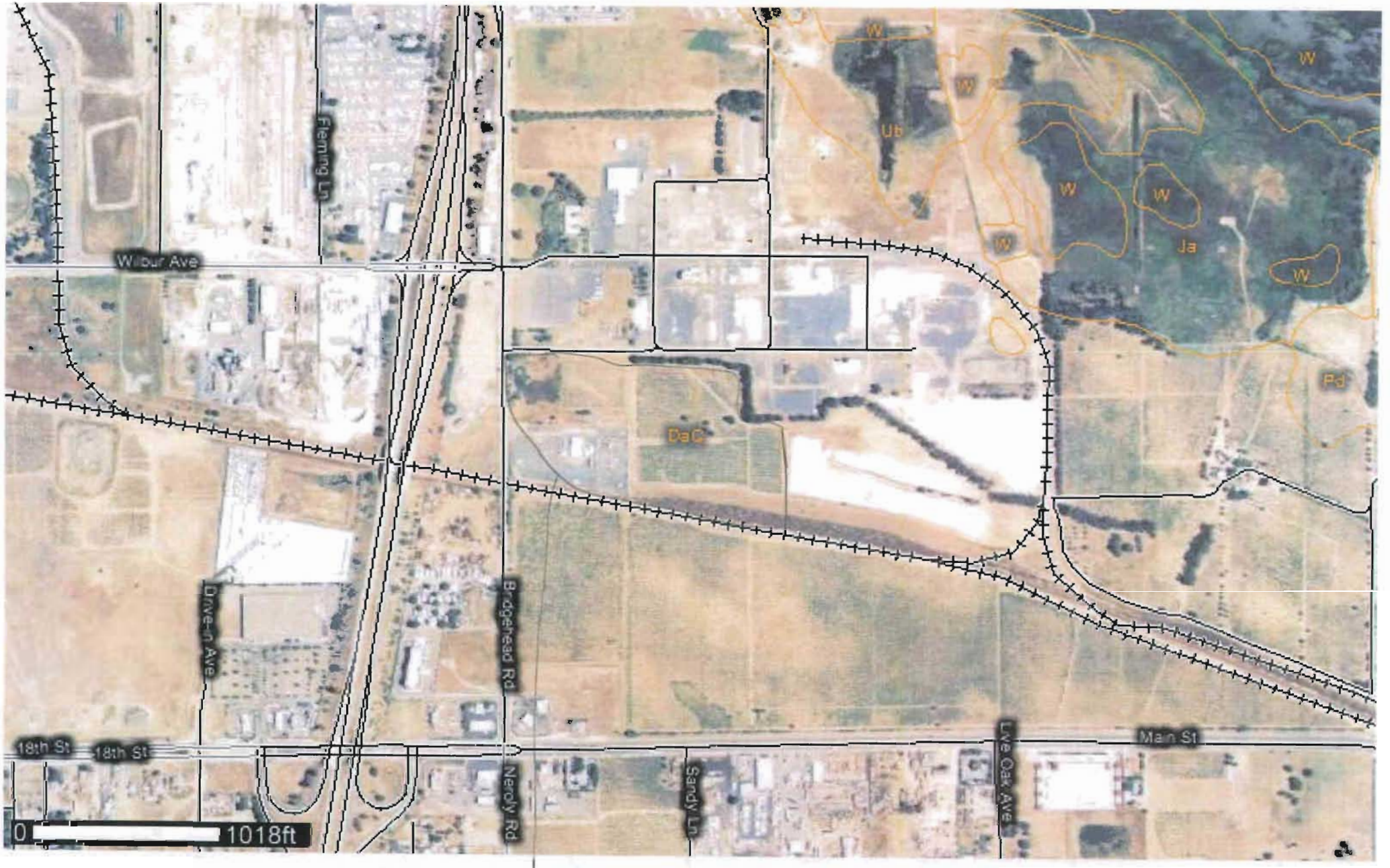
(printed out from the Online Web Soil Survey)



Project site

Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Contra Costa County, California

DaC—DELHI SAND, 2 TO 9 PERCENT SLOPES

Map Unit Setting

Elevation: 10 to 150 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Delhi and similar soils: 85 percent
Minor components: 15 percent

Description of Delhi

Setting

Landform: Flood plains, terraces, alluvial fans
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from igneous and sedimentary rock

Properties and qualities

Slope: 2 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability (nonirrigated): 6e

Typical profile

0 to 5 inches: Sand
5 to 60 inches: Sand

Minor Components

Unnamed

Percent of map unit: 12 percent

Laugenour

Percent of map unit: 3 percent

Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

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Attachment 5

Reference 8

Select Pages

IMP Sizing for Bioswale #1-2

Refer to Page 5, the total drainage area for bioswale #1-2 is measured to be: 491,168 ft^2 (11.28 ac). The bioswale is measured to be 1,323 feet long.

Six drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; (5) Transformer Containment; and (6) Open-Graded Aggregates (ACC Area).

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	54,900
DMA-2	Asphalt Pavement	65,113
DMA-3	Gravel Surfacing	100,200
DMA-4	Grass/Landscape	198,264
DMA-5	Transformer Containment	4,491
DMA-6	Open-Graded Aggregates	68,200

Runoff Coefficients

Dense-graded aggregate (Caltran Class 2 aggregate) will be utilized as the materials for aggregate surfacing. After being compacted, the dense-graded aggregate is estimated to have a runoff coefficient of 0.5 to 0.7. See communications with Contra Costa County Clean Water Program (Attachment 6). Use 0.6 in this calculation.

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Open Graded Aggregates" will have a runoff coefficient of 0.1. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (54{,}900x1+65{,}113x1+100{,}200x0.6+198{,}264x0.1+4{,}491x0+68{,}200x0.1)$$

$$= 206{,}779\ ft^2.$$

IMP Sizing for Bioswale #3

Refer to Page 5, the total drainage area for bioswale #3 is measured to be: 25,711 ft^2 (0.59 ac). The bioswale #3 is measured to be 187 feet long.

Three drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; and (3) Grass/Landscape.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	3,873
DMA-2	Asphalt Pavement	2,086
DMA-3	Grass/Landscape	19,752

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (3{,}873\text{x}1.0+2{,}086\text{x}1.0+19{,}752\text{x}0.1)$$

$$= 7{,}934\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

IMP Sizing for Bioswale #4

Refer to Page 5, the total drainage area for bioswale #4 is measured to be: 190,955 ft^2 (4.38 ac). The bioswale #4 is measured to be 391 feet long.

Five drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; and (5) Transformer Containment.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	19,314
DMA-2	Asphalt Pavement	33,262
DMA-3	Gravel Surfacing	109,208
DMA-4	Grass/Landscape	23,692
DMA-5	Transformer Containment	5,479

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (19{,}314\text{x}1.0+33{,}262\text{x}1.0+109{,}208\text{x}0.6+23{,}692\text{x}0.1+5{,}479\text{x}0)$$

$$= 120{,}470\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

IMP Sizing for Bioswale #5

Refer to Page 5, the total drainage area for bioswale #5 is measured to be: 290,529 ft^2 (6.67 ac) (natural gas facility included). The bioswale #5 is measured to be 385 feet long total.

Four drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; and (4) Grass/Landscape.

Including Railroad yard
PW 6/17/10

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	12,670
DMA-2	Asphalt Pavement	25,905
DMA-3	Gravel Surfacing	186,725
DMA-4	Grass/Landscape	65,229

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (12{,}670\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 157{,}133\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

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Attachment 6

Reference 9

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0.06 (Rev. 2) PZW 6/10/10 < (Rev 2)

Roughness coefficient n = 0.~~17~~ for "cultivated soils, residue cover ~~≤~~ 20%". (Ref. 2, Table 3-1)

Existing conditions have sparse ground coverage based on aerial photos | Rev 2

Per Ref. 2, "After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow". Use sheet flow length L = 300 feet.

1.6 (Rev 2) PZW 6/10/10 9 (Rev 2)

2-year, 24-hour rainfall P_2 = ~~2~~ inch for this site per Ref. ~~5~~ (see Page 8).

The land slope for the first 300 feet = (24.2-21.5)/300 = 0.009 ft/ft. (Refer to Page 5)

0.06 (Rev 2) 0.37 (Rev 2)

Thus, $T_{sheet} = \dfrac{0.007 \times (0.\cancel{17} \times 300)^{0.8}}{\cancel{2}^{0.5} \times 0.009^{0.4}}$ = 0.~~76~~ hour.

1.6 (Rev 2) PZW 6/10/10

(2) Shallow Concentrated Flow

The flow length for shallow concentrated flow L = 1490-300 = 1190 feet.

The average watercourse slope = (21.5-5) / 1190 = 0.014 ft/ft. (Refer to Page 5)

Based on a slope of 0.014 ft/ft, from Ref. 2, Figure 3-1, the average velocity (V) for "unpaved" surface is found to be:

V = 1.9 ft/sec.

Thus the travel time for shallow concentrated flow is calculated to be:

$$T_{shallow} = \frac{L}{3600 \times V} = \frac{1190}{3600 \times 1.9} = 0.17 \text{ hour.}$$

In summary, the time of concentration is calculated to be:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$

(Rev 2) 0.37 = ~~0.76~~ + 0.17 + 0

= 0.~~93~~ hour.

0.54 hr (Rev 2) PZW 6/10/10

Per Ref. 4, "For ungaged watersheds, the SCS suggests that the UH (unit hydrograph) lag time may be related to the time of concentration, T_c, as: $T_{lag} = 0.6\ T_c$". See Page 7.

The SCS UH lag time (T_{lag}) is an input parameter into the HEC-HMS computer program. Thus

T_{lag} = 0.6 x 0.~~93~~ = 0.~~56~~ hour = 3~~3.6~~ minutes.

0.54 = 0.324 hr = 19.4 min (Rev. 2)

PZW 6/10/10

Section 2.0 Rainfall Distribution

From Ref. 2, Figure B-2, the rainfall distribution for the site in Contra Costa County, California should be Type I distribution.

3.5 (Rev. 2) PLN 6/10/10

From Ref. 5, the 100-year 24-hour rainfall amount for the site is ~~4~~ inches. (See Page 10)

Section 3.0 Determine the Composite SCS Curve Number

"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area.

The drainage area generally has four types of ground cover: (1) Vineyard, 19.85 acres; (2) Gravel Pavement, 3.96 acres; (3) Railroad Yard, 0.94 acres; and (4) Wetland, 0.40 acres. The total area of this drainage area is 25.15 acres (0.0393 mile^2). The measurements of the above areas were made by using AutoCAD.

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". See Attachment 4. Per Ref. 2, this type of soil can be classified as Hydrologic Soil Group A soil.

Per Ref. 2, Table 2-2b, the curve number (CN) for "Row Crops, straight row (SR) with crop residue cover (CR)" for Group A soil is between 64 (good condition) and 71 (poor condition). Use the average curve number 68 for the vineyard area.

Per Ref. 2, Table 2-2a, the curve number for gravel area for Group A soil is 76. The ground cover in railroad yard is similar to the gravel area. Use the same curve number (76) for the railroad yard.

Treat the wetland as an impervious area since it may have standing water in it. Per Ref. 2, Table 2-2a, a curve number of 98 can be used for this area.

Thus the composite curve number (CN) for the drainage area is calculated as:

$$CN = (19.85 \times 68 + 3.96 \times 76 + 0.94 \times 76 + 0.40 \times 98) / 25.15 = 70.$$

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It

includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2)

Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 70, the initial abstraction is calculated to be:

$$I_a = 0.2 \times (1000/70 - 10) = 0.857 \text{ inch.}$$

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. The impervious area consists of the roofs of a few small buildings in the southwest portion of the drainage area. By using AutoCAD, the total roof area is measured to be 0.17 acre. Thus,

% impervious = 0.17 / 25.15 = 0.68%, say 1%.

Section 4.0 Wetland Area versus Elevation

The bottom of the wetland is at an approximate elevation of 5 feet. See B&V Drawing SS-3001 (Page 5). The relationship of Area versus Elevation for the wetland area was presented in the table below. The wetland area was measured by using AutoCAD. It should be noted that a small portion of the wetland at the east side within the project property will be filled at a later time. This area will be graded at a 4 (H) to 1 (V) slope towards the wetland. The area in the table below at Elevation 10 (1.44 acres) has already had the future fill area been deducted to accurately model the wetland storage capacity.

Elevation (ft)	Wetland Area (acre)
5.0	0.40
7.5	0.62
10.0	1.44

Section 5.0 HEC-HMS Output

The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The initial water elevation in the wetland is specified to be at

Radback Tenaska Project Stormwater Analysis CK 6/11/10

Project # 163994 # of pages 2

52.5406.1006

Attachment 7

Kantola, Craig

From: Jorge Hernandez [jhern@pw.cccounty.us]
Sent: Tuesday, May 18, 2010 8:37 PM
To: Kantola, Craig
Cc: Teri Rie; Tim Jensen
Subject: RE: Flood Control Standards - Oakley, CA
Attachments: CCCo Isohyet Map-Low Color.pdf; 025yr-Low.pdf; 050yr-Low.pdf; 100yr-Low.pdf; 005yr-Low.pdf; 010yr-Low.pdf; Supplemental Detention Basin Design Guidelines.doc

Mr. Kantola,

1. Per your request we are emailing a copy of our standard Isohyet map to determine the standard storm event.
2. For offsite conveyance of storm water runoff for an area less than 1-sqaure mile, the design storm event should be a 10-year event, however a detention/retention system should be able to store at the very least the 100-year design storm event.
3. See attached supplemental for suggested design of on-site facilities. Ultimately, the City will approve onsite facilities.
4. For the initial 100-year event, the assumption of an empty basin is acceptable, however a 10-year event after a recent 100-year occurrence should be analyzed. Additionally, the overland release of the basin should be directed north, per the current drainage pattern and not allowed to drain south to the existing inlet under the railroad crossing (bridge), which currently is outside of your parcel's drainage area and does not have the capacity to convey additional storm runoff.

If you have any additional question, you may contact me by either phone or email.

Thank you,

Jorge Hernandez
Staff Engineer

Contra Costa County
Flood Control
& Water Conservation District
255 Glacier Drive
Martinez, CA 94553-4897
Phone: (925) 313-2304
Fax: (925) 229-7955
A Division of the Public Works Department

From: Kantola, Craig [mailto:KantolaCA@bv.com]
Sent: Friday, May 14, 2010 10:21 AM
To: Jorge Hernandez
Subject: FW: Flood Control Standards - Oakley, CA

Jorge,
Good afternoon, I have left you a voice mail responding to your call from Wednesday. Any information you may be able to provide would be greatly appreciated. Please forward any design requirements for flood control in Contra Costa County

Stormwater Analysis for Wetland – Peak Flows

BLACK & VEATCH Building a world of difference.

CALCULATION RECORD

Client Name: Radback Energy Page 1 of 31

Project Name: Oakley Generating Station Project No.: 163994

Calculation Title: Stormwater Analysis for Wetland - Peak Flows

Calculation No./File No.: 52.5406.1007

Verification Method: ☒ Check and Review ☐ Alternate Calculations

Objective To determine the peak flow rates to the wetland area for the pre-construction and post-construction site conditions. The analysis compares pre-construction and anticipated post-construction ground conditions at the site.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

Refer to Page _____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number: HEC-HMS Version: 3.3

Standard B&V Application Used? ☒ Yes ☐ No

If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	C Kantola SKK	17 June 2010	PLNelson	18 JUNE 2010	PLNelson	18 JUNE 2010
1	C Kantola SKK	9/14/10	PLNelson	9/20/10	PLNelson	9/20/10

Purpose

To determine the stormwater runoff peak flows entering the existing wetland at the Oakley project site for storm events including the 1-inch rainfall, 10-year/24-hour storm, and 100-year/24-hour storm events. The analyses are performed for pre-construction and post-construction ground conditions at the project site.

References

1. Black & Veatch Drawing 163994-SS-3001, Rev. 1, "Grading & Drainage - Site"
2. US Department of Agriculture; Urban Hydrology for Small Watersheds, 2nd Edition; Technical Release 55 (TR-55); June 1986.
3. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, User's Manual, Version 3.3; September 2008.
4. US Army Corps of Engineers; Hydrologic Modeling System HEC-HMS, Technical Reference Manual; March 2000.
5. US Department of Commerce; NOAA Atlas 2, Precipitation-Frequency Atlas of the Western United States, Volume XI - California; 1973.
6. US Department of Agriculture, Natural Resources Conservation Service; Web Soil Survey; http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
7. Mays, L. W.; Stormwater Collection Systems Design Handbook, McGraw-Hill; 2001.
8. Black & Veatch Calculation, "IMP Sizing for Plant Area", File No. 52.5406.1008 Rev 0, Same project, June, 2010
9. Black & Veatch Calculation, "Stormwater Analysis", File No. 52.5406.1003 Rev 2, Same project, June 2010
10. Black & Veatch Calculation, "Storm Sewer Pipe Design", File No. 52.5406.1005 Rev 0, Same project, April 2009
11. Black & Veatch Calculation, "Post-Construction Wetland – Volume and Water Surface Elevation", File No. 52.5406.1006 Rev 0, Same project, June 2010
12. Ferguson, Bruce K., "Introduction to Stormwater", John Wiley & Sons, 1998
13. McCuen, Richard H., "Hydrologic Analysis and Design"; Prentice Hall, 1998
14. Contra Costa County Dept. of Public Works Maps; Mean Seasonal Isohyets Compiled from Precipitation Records 1879-1973; Drawing No. B-166; December 1977; Precipitation Duration-Frequency-Depth Curves (100-yr and 10-yr); Drawing Nos. B-159 and B-162; July 1977

Definition of Units and Constants

English units will be used.

Example of Common Unit Designations:

Rainfall amount in inches (in)

Drainage area in acres (ac)

Attachments

1. HEC-HMS Input
2. HEC-HMS Output
3. Reference 2 – Select Pages
4. Reference 6 – Select Pages
5. Reference 8 – Select Pages
6. Reference 9 – Select Pages
7. Reference 11 – Select Pages
8. Reference 12 – Select Page
9. Reference 7 – Select Page
10. Reference 13 – Select Page

Summary

Based on the HEC-HMS analyses with current and proposed ground cover conditions, the stormwater runoff flow rates to the wetland will change due to the proposed site construction. The pre-construction (existing) models determine flows to the wetland area under undeveloped conditions. The post-construction models determine flows to the wetland area for developed conditions, considering the effects of the bioswales and detention pond for peak flow attenuation. Below is a summary table showing the pre-construction and post-construction peak flow rates determined by the HEC-HMS models.

Summary of Runoff Peak Flow Rates to Wetland

Rainfall Event	Pre-Construction Peak Flow Rate to Existing Wetland	Post-Construction Peak Flow Rate to Existing Wetland
1-inch	0.1 cfs	0.1 cfs
10-year	3.2 cfs	3.1 cfs
100-year	11.8 cfs	9.1 cfs

SUPERSEDED 9/14/10
See pg 4A

Summary

Based on the HEC-HMS analyses with current and proposed ground cover conditions, the stormwater runoff flow rates to the wetland will change due to the proposed site construction. The pre-construction (existing) models determine flows to the wetland area under undeveloped conditions. The post-construction models determine flows to the wetland area for developed conditions, considering the effects of the bioswales and detention pond for peak flow attenuation. Below is a summary table showing the pre-construction and post-construction peak flow rates determined by the HEC-HMS models.

Summary of Runoff Peak Flow Rates to Wetland

Rainfall Event	Pre-Construction Peak Flow Rate to Existing Wetland	Post-Construction Peak Flow Rate to Existing Wetland
1-inch	0.3 cfs	0.2 cfs
10-year	3.6 cfs	2.2 cfs
100-year	12.3 cfs	4.8 cfs

The peak flow rates to the wetland are reduced due to the installation of flow control devices provided within the bioswales and detention basin, for stormwater treatment. Low-flow orifices are provided to maintain hydration of the existing wetland during smaller storm events.

Hydrology Modeling – HEC-HMS

For the runoff peak flow rate analysis, the entire site was modeled as one drainage area for the pre-construction (existing) condition (Reference 9) and separated into distinct drainage areas for the post-construction (proposed) condition (bioswales, and direct runoff to pond and wetland areas). See Page 6 for the boundary delineation of these areas. The drainage areas are summarized in the table below, with measurements taken from References 8 & 9 and also using AutoCAD.

Summary of Drainage Areas (in acres & square miles)

Ground Cover Type	Existing Site Acreage*	Post-Construction Site Acreage					
		Bioswale **				Direct to Pond	Direct to Wetland
		1+2	3	4	5		
Vineyard / Undisturbed	19.85	-	-	-	-	-	1.93
Gravel	3.96	2.30	-	2.51	3.35	-	-
Railroad Yard	0.94	-	-	-	0.94	-	-
Wetland	0.40	-	-	-	-	-	0.40
Lawn (Poor Coverage <50%)	-	4.55	0.45	0.54	1.50	0.85	-
Impervious Surface ***	-	2.75	0.14	1.21	0.88	0.13	0.27 (ex. roads)
Transformer Contain ****	-	0.10	-	0.12	-	-	-
Open Graded Aggregate	-	1.57	-	-	-	-	-
Total Acres:	25.15	11.17	0.59	4.26	6.67	0.98	2.60
Total (Sq. Mi.):	**0.0393**	**0.0175**	**0.0009**	**0.0067**	**0.0104**	**0.0015**	**0.0041**
		0.0411 sq. mi. (Total Post-Construction)					

* Existing site acreage as determined in BV Calc 52.5406.1003 (Ref 9)
** Post-construction areas as determined in BV Calc 52.5406.1008 (Ref 8)
*** Impervious surface computed as sum of Equipment/Roofs + Pavement (from Calc 52.5406.1002)
**** Transformer Containment area does not drain to Bioswales and is not included in total areas listed.

The stormwater runoff to the wetland for various storms was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).

SUPERSEDED 9/14/10
See Pg 5A

Hydrology Modeling – HEC-HMS

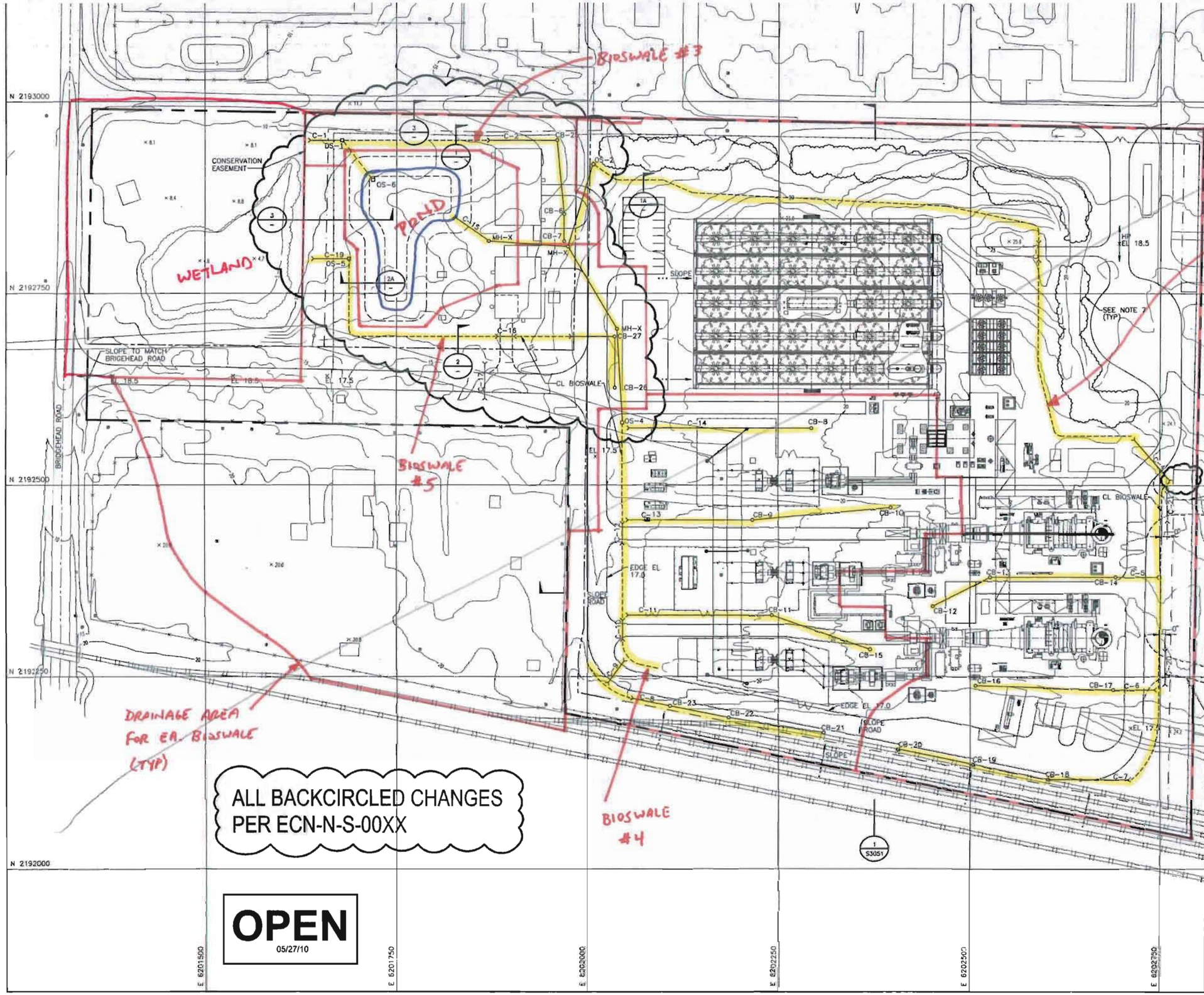
For the runoff peak flow rate analysis, the entire site was modeled as one drainage area for the pre-construction (existing) condition (Reference 9) and separated into distinct drainage areas for the post-construction (proposed) condition (bioswales, and direct runoff to pond and wetland areas). See Page 6 for the boundary delineation of these areas. The drainage areas are summarized in the table below, with measurements taken from References 8 & 9 and also using AutoCAD.

Summary of Drainage Areas (in acres & square miles)

Ground Cover Type	Existing Site Acreage*	Post-Construction Site Acreage					
		Bioswale **				Direct to Pond	Direct to Wetland
		1+2	3	4	5		
Vineyard / Undisturbed	19.85	-	REMOVED IN REVISION 1	-	-	-	1.93
Gravel	3.96	2.30		2.51	2.87	0.1	-
Railroad Yard	0.94	-		-	0.94	-	-
Wetland	0.40	-		-	-	-	0.40
Lawn (Poor Coverage <50%)	-	4.55		0.54	0.95	1.28	0.47
Impervious Surface ***	-	2.75		1.21	1.32	0.30	0.28 (ex. roads)
Transformer Contain ****	-	0.10		0.12	-	-	-
Open Graded Aggregate	-	1.57		-	-	-	-
Total Acres:	25.15	11.17		4.26	6.08	1.68	3.08
Total (Sq. Mi.):	**0.0393**	**0.0175**	**0**	**0.0067**	**0.0095**	**0.0026**	**0.0048**
		0.0411 sq. mi. (Total Post-Construction)					

* Existing site acreage as determined in BV Calc 52.5406.1003 (Ref 9)
** Post-construction areas as determined in BV Calc 52.5406.1008 (Ref 8)
*** Impervious surface computed as sum of Equipment/Roofs + Pavement (from Calc 52.5406.1002)
**** Transformer Containment area does not drain to Bioswales and is not included in total areas listed.

The stormwater runoff to the wetland for various storms was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).



ALL BACKCIRCLED CHANGES PER ECN-N-S-00XX

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Void 9/14/10 superseded see pl 6a CAK

Redbook Oakley Project #163994 Stormwater Analysis

File 52.5946.1007 page 6 of 31

By CK
Date 6/17/10
Ver: PW
Date: 6/18/10

Bdc Dwg 163994-SS-3001 Rev 1

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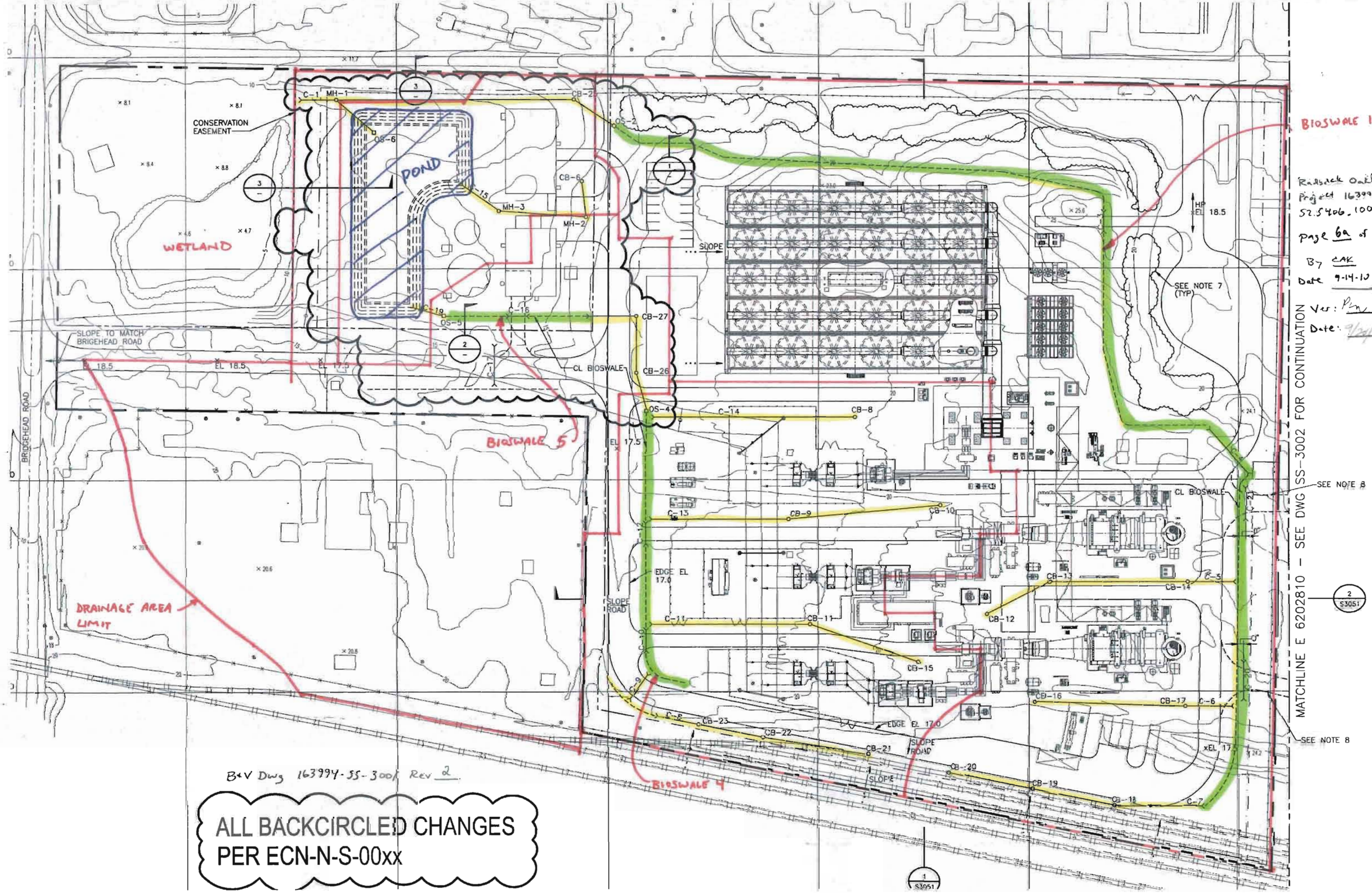


Railback Outfall
Project 163994
52.5406.1007
Page 6a of 31
By CAK
Date 9-14-10
Ver: Rev
Date: 9/23/10

Section 1.0 – Determine the Time of Concentration (Tc) and Lag Time

For the pre-construction condition, the time of concentration of 0.54 hours (32.4 minutes) and lag time of 19.4 minutes were determined in Reference 9 – see Attachment 6.

For the post-construction condition, the peak flow from the plant area to the wetland will be most impacted by the peak runoff from the area draining through Bioswale 5. This is due to the proximity of Bioswale 5 to the wetland and the runoff conditions from Bioswale 5 being similar to the remainder of the plant. Bioswales 1+2 and 4 are routed through the detention pond (which significantly reduces the peak flows through the outlet control structure) while the drainage area for Bioswale 3 is relatively small and therefore contributes little flow.

Therefore the Tc and Lag Time for the area draining to Bioswale 5 will be determined and applied to the model for all bioswale area drainage (Bioswales 1-5). Using the same Lag Time for each bioswale area within the model will result in a conservative peak flow determination from the plant area, since all areas into the bioswales are modeled to peak concurrently.

Bioswale 5 (Post-Construction condition)
Time of concentration (T_c) can be calculated as:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$ (Ref. 4, Eq. 6-11)

Where:

T_{sheet} = travel time in sheet flow to drainage basin;
$T_{shallow}$ = travel time in shallow concentrated flow;
$T_{channel}$ = travel time in open channels.

The flow path from the hydraulically most distant point of this drainage area to the outlet structure for Bioswale 5 is identified as shown on Page 8. The total flow length is measured to be approximately 900 feet (using AutoCAD).

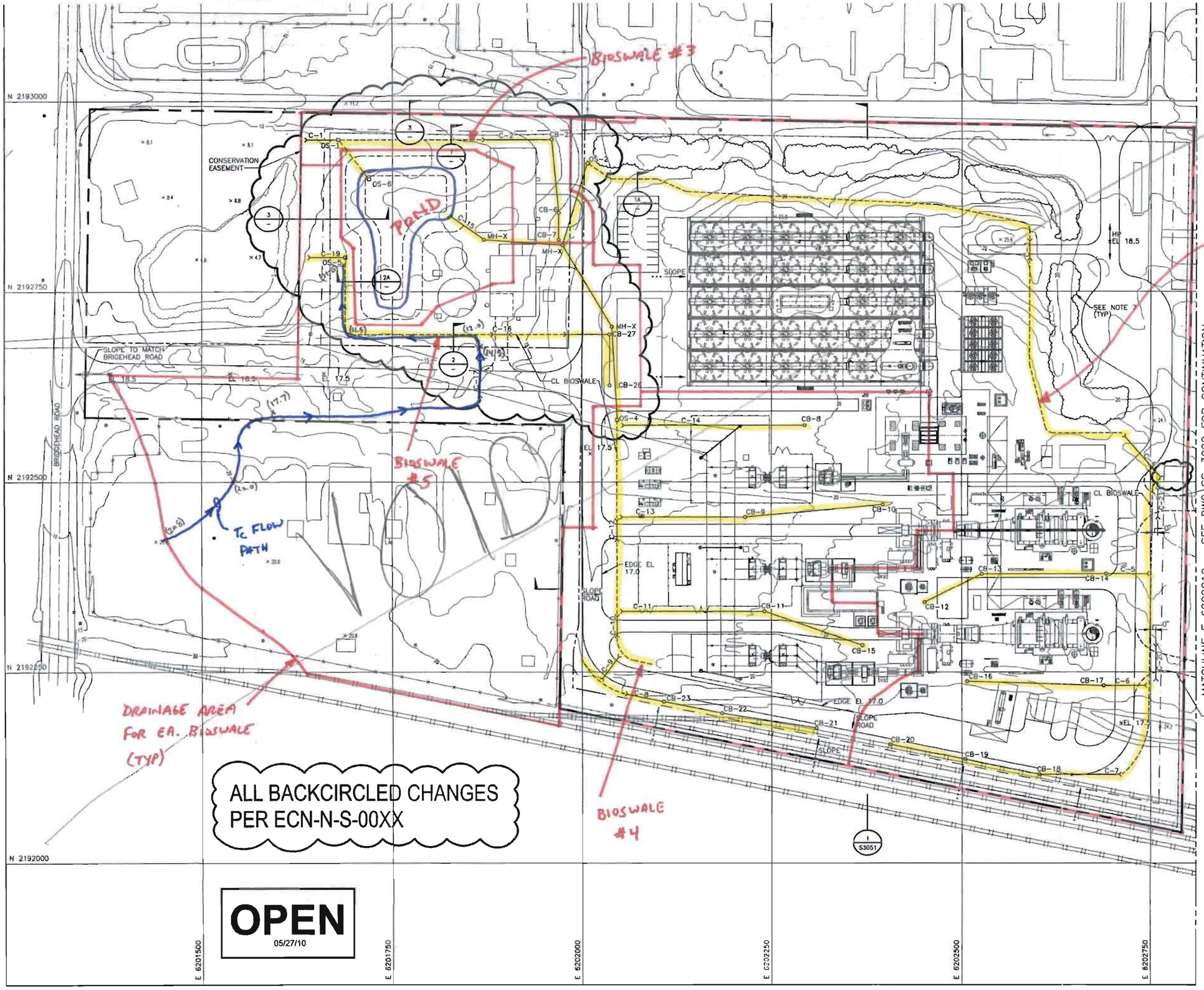
(1) Sheet Flow

Sheet flow travel time can be calculated as:

$$T_{sheet} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$ (Ref. 2, Eq. 3-3)

Where:

n = roughness coefficient;
L = flow length (ft);
P_2 = 2-year, 24-hour rainfall (in);
s = land slope (ft/ft).



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Radback Oakley
Project # 163994
Stormwater Analysis
File S2.5406.1007
Page 8 of 31
By: C. Kantola
6/17/10
Ver: PCN
Date: 6/18/10

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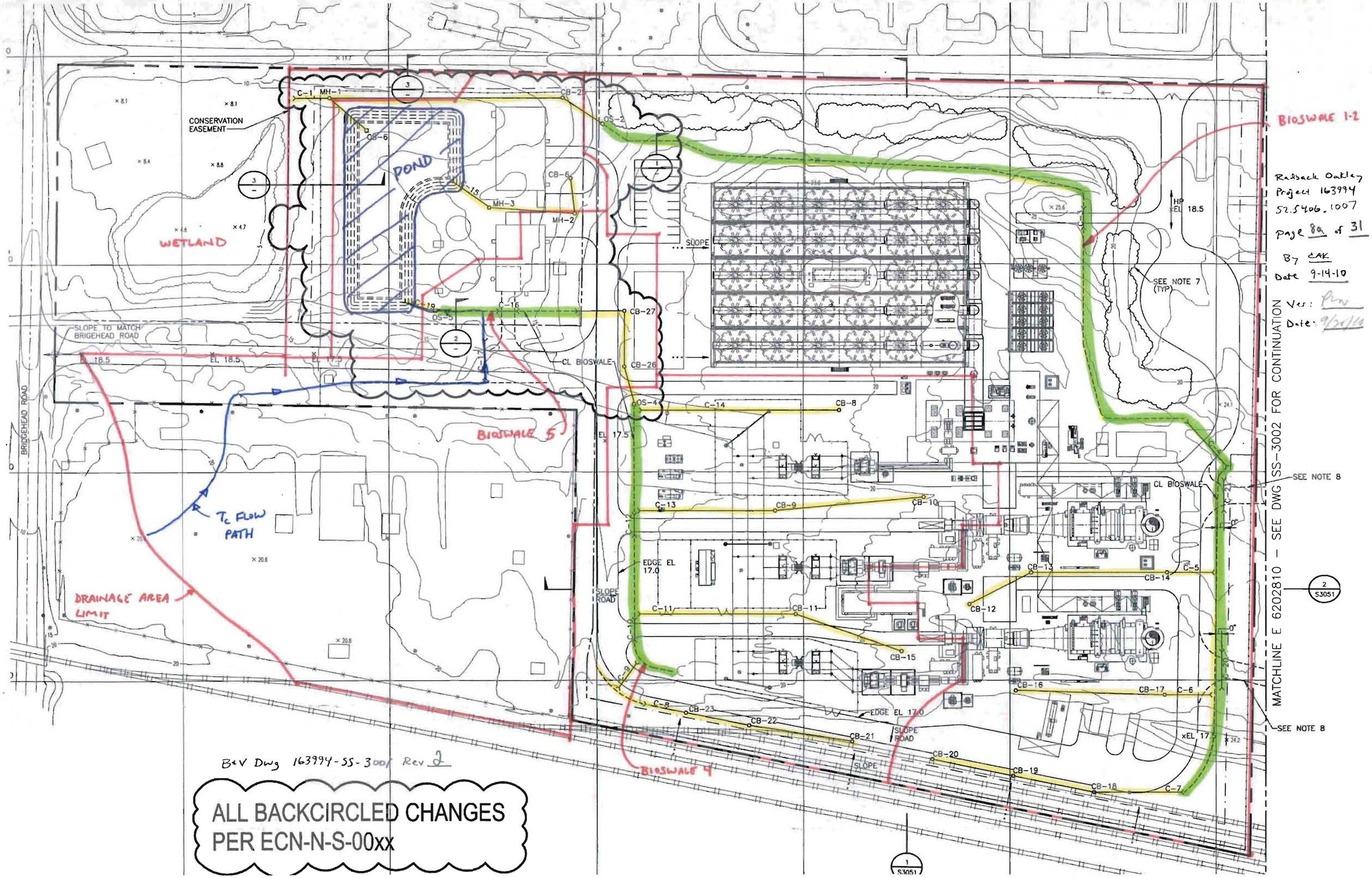
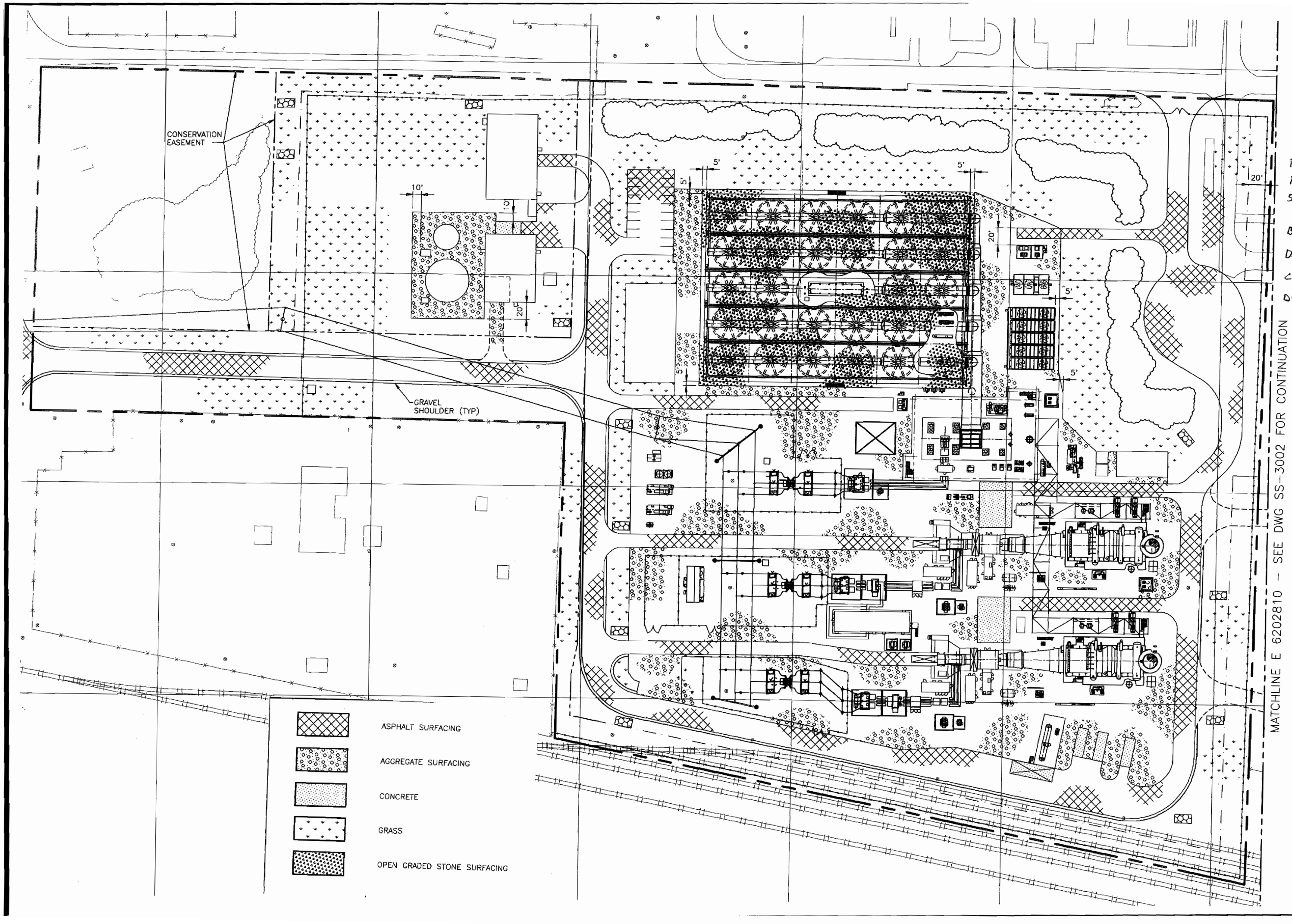


Radback Oakley
Project 163994
52.5406.1007
Page 8a of 31
By CAK
Date 9-14-10
Ver: Rev
Date: 9/21/10

B+V Dwg 163994-SS-3001 Rev 2

ALL BACKCIRCLED CHANGES PER ECN-N-S-00xx



Radbacke Oakley
Project 163994
52.5406.

BY: C. Kantola
Date: 9-14-10
Chk: Pkrs
Date: 9/20/10

Note: This page is a portion of B&Y Drawing 163994-SS-3201 REV. 0

Roughness coefficient n = 0.011 for "smooth surfaces (gravel)". (Ref. 2, Table 3-1)

Per Ref. 2, "After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow". Therefore sheet flow length will be limited to a maximum of 300 feet. BV Drawing SS-3001 and AutoCAD data show that the ground slope for sheet flow can be separated into two sections, each approximately 120 feet long. L = 120 ft.

2-year, 24-hour rainfall P_2 = 1.6 inch for this site per Ref. 5 (see Page 10).

The land slope for the first sheet flow section is from EL 20.80 to the 20.0 contour. This slope is (20.8-20.0)/120 = 0.0067 ft/ft

Thus, $T_{sheet} = \dfrac{0.007 \times (0.011 \times 120)^{0.8}}{1.6^{0.5} \times 0.0067^{0.4}}$ = 0.051 hour = 3.1 minutes for sheet flow 1.

The land slope for the second sheet flow section is from EL 20.0 to EL 17.7 at the edge of the access road (data from AutoCAD). This slope is (20.0-17.7)/120 = 0.0192 ft/ft

Thus, $T_{sheet} = \dfrac{0.007 \times (0.011 \times 120)^{0.8}}{1.6^{0.5} \times 0.0192^{0.4}}$ = 0.034 hour = 2.0 minutes for sheet flow 2.

The sum of sheet flow travel times is: T_{sheet} = 3.1 min + 2.0 min = <u>5.1 minutes</u>

(2) Shallow Concentrated Flow
From AutoCAD, the flow length for shallow concentrated flow is measured as L = 365 feet from EL 17.7 to the top of bioswale 5 at EL 14.5.

The average watercourse slope = (17.7-14.5) / 365 = 0.0088 ft/ft.

Based on a slope of 0.0088 ft/ft, from Ref. 2, Figure 3-1, the average velocity (V) for "unpaved" surface is found to be: V = 1.5 ft/sec.

Thus the travel time for shallow concentrated flow is calculated to be:

$$T_{shallow} = \frac{L}{3600 \times V} = \frac{365}{3600 \times 1.5} = 0.07 \text{ hour} = \underline{4.2 \text{ minutes}}.$$

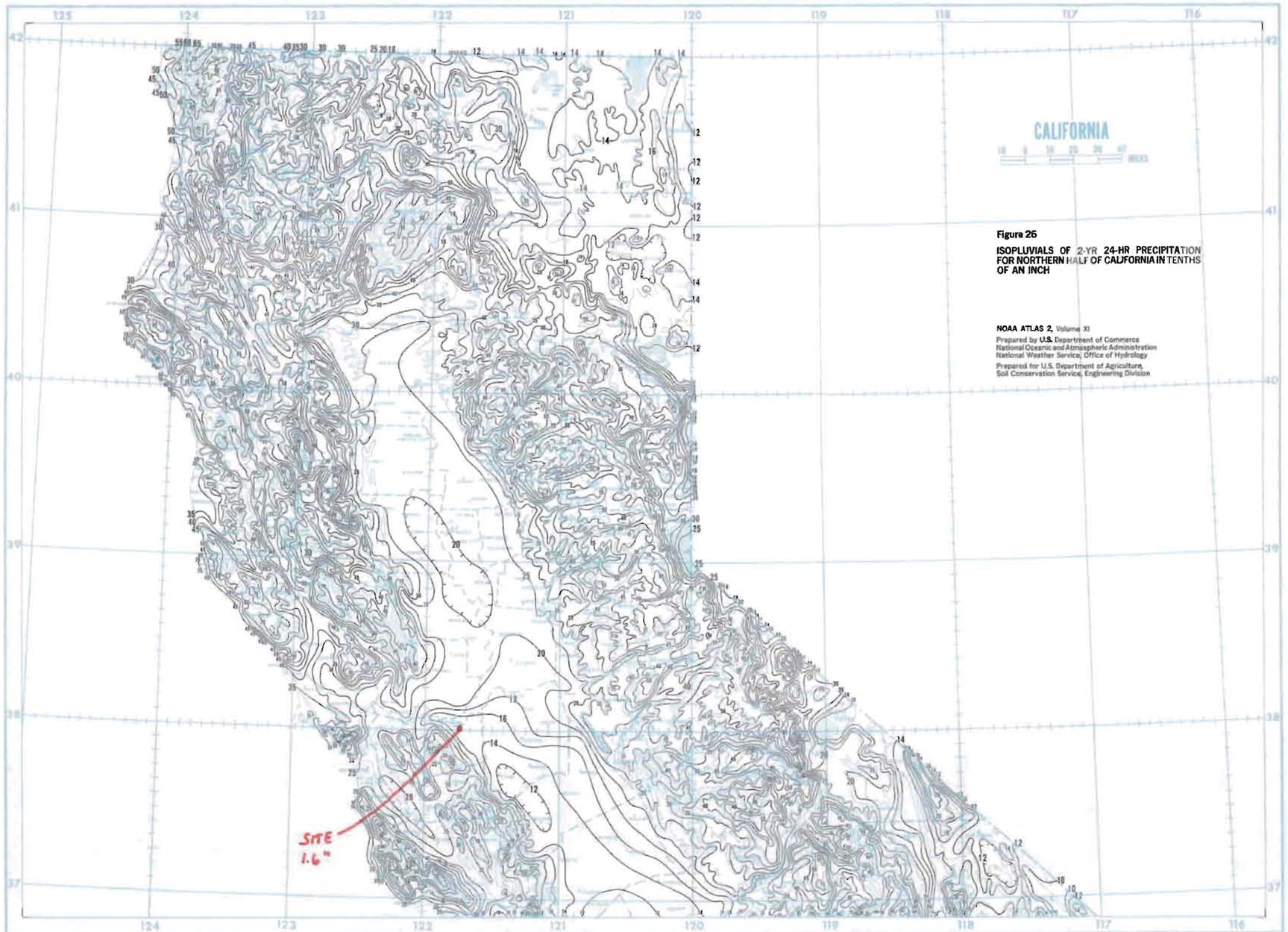


Figure 26

ISOPLUVIALS OF 2-YR 24-HR PRECIPITATION FOR NORTHERN HALF OF CALIFORNIA IN TENTHS OF AN INCH

NOAA ATLAS 2, Volume XI

Prepared by U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Office of Hydrology

Prepared for U.S. Department of Agriculture,
Soil Conservation Service, Engineering Division

~~Rev 2~~ Radback ~~Fowler~~ Oakley Project
Stormwater Analysis

Project # 163994
page ~~X~~ ~~of~~ ~~of~~ 10 of 31
52.5406 . ~~DRS~~
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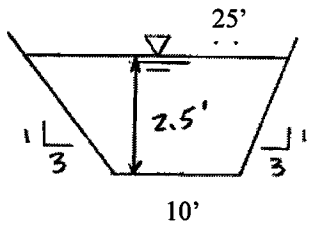
Note:
This page is from Ref. ~~X~~ 5

CK 6/17/10
Ver: PLW
Date: 6/18/10

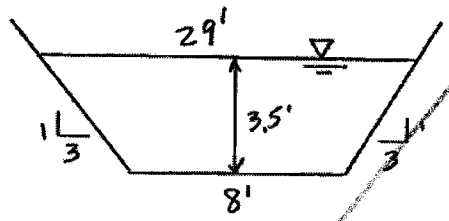
(3) Open Channel Flow

Calculate open channel flow within the bioswales. There are two differing bioswale cross-sections in Bioswale 5 and Individual travel times for each section are calculated below. From Reference 8, the bioswale cross-sections are shown below:



Section 2

DWG SS-3001



Section 2A

DWG SS-3001

Travel time for each portion of open channel flow is calculated by

T_t (hours) = $\frac{L}{3600 \times V}$ where L = length of flow path (feet) and V = flow velocity (ft/sec)

Length of flow path is measured from the site grading plan (Refer to Page 8)

For open channel flow, V is based on Manning's equation where V = $\frac{1.49}{n} \times R^{2/3} \times \sqrt{s}$

R is the hydraulic radius, defined as R = $\frac{Area}{WettedPerimeter}$

For Bioswale 5 / Section 2 (a trapezoidal channel):

Area, A (trapezoidal channel) = (10 ft + 25 ft)/2 x 2.5 ft = 43.75 sf

Wetted Perimeter, P (trapezoidal channel) = 10 ft + 2 x $\sqrt{(2.5^2 + (2.5 \times 3)^2)}$ = 25.8 ft

Hydraulic Radius, R = A / P = 43.75 sf / 25.8 ft = 1.7 ft

The bioswale can be described as an earthen channel, straight & uniform with short grass and few weeds. This corresponds to a Manning's 'n' = 0.027 (Refer to Reference 7).

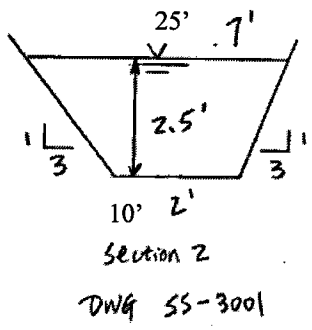
The swale from C16 to the point the swale turns north has a length L = 175 ft and grade from EL 12.0 to 11.5, the slope is calculated as (12.0 – 11.5) / 175 = 0.0029 ft/ft

The resulting full-flow velocity in the swale is V = $\frac{1.49}{0.027} \times 1.7^{2/3} \times \sqrt{0.0029}$ = 4.2 ft/s

Superseded 9/14/10
See Pg 11A

(3) Open Channel Flow

Calculate open channel flow within the bioswales. The cross-section and travel time for Bioswale 5 are calculated below. From Reference 8, the bioswale cross-section is shown below:



Travel time for the portion of open channel flow is calculated by

T_t (hours) = $\frac{L}{3600 \times V}$ where L = length of flow path (feet) and V = flow velocity (ft/sec)

Length of flow path is measured from the site grading plan (Refer to Page 8)

For open channel flow, V is based on Manning's equation where V = $\frac{1.49}{n} \times R^{2/3} \times \sqrt{s}$

R is the hydraulic radius, defined as R = $\frac{Area}{WettedPerimeter}$

For Bioswale 5 / Section 2 (a trapezoidal channel):

Area, A (trapezoidal channel) = (10 ft + 25 ft)/2 x 2.5 ft = 43.75 sf

Wetted Perimeter, P (trapezoidal channel) = 10 ft + 2 x $\sqrt{(2.5^2 + (2.5 \times 3)^2)}$ = 25.8 ft

Hydraulic Radius, R = A / P = 43.75 sf / 25.8 ft = 1.7 ft

The bioswale can be described as an earthen channel, straight & uniform with short grass and few weeds. This corresponds to a Manning's 'n' = 0.027 (Refer to Reference 7).

The swale from C16 to the basin has a length L = 75 ft and grade from EL 12.0 to 11.8, the slope is calculated as (12.0 – 11.8) / 75 = 0.0027 ft/ft

The resulting full-flow velocity in the swale is V = $\frac{1.49}{0.027} \times 1.7^{2/3} \times \sqrt{0.0027}$ = 4.1 ft/s

Thus the travel time for open channel flow in this swale section is calculated to be:

$$T_{open} = \frac{L}{3600 \times V} = \frac{175}{3600 \times 4.2} = 0.011 \text{ hour} = 0.7 \text{ minutes}$$

For Bioswale 5 / Section 2a (a trapezoidal channel):

Area, A (trapezoidal channel) = (8 ft + 29 ft)/2 x 3.5 ft = 64.75 sf

Wetted Perimeter, P (trapezoidal channel) = 8 ft + 2 x $\sqrt{(3.5^2 + (3.5 \times 3)^2)}$ = 30.1 ft

Hydraulic Radius, R = A / P = 64.75 sf / 30.1 ft = 2.15 ft

Manning's 'n' = 0.027 as noted above.

The swale from the point the swale turns north to OS-5 a length L = 120 ft and grade from EL 11.5 to 11.0, the slope is calculated as (11.5 – 11.0) / 120 = 0.0042 ft/ft

The resulting full-flow velocity in the swale is $V = \frac{1.49}{0.027} \times 2.15^{2/3} \times \sqrt{0.0042}$ = 6.0 ft/s

Thus the travel time for open channel flow in this swale section is calculated to be:

$$T_{open} = \frac{L}{3600 \times V} = \frac{120}{3600 \times 6.0} = 0.006 \text{ hour} = 0.4 \text{ minutes}$$

The sum of open channel flow travel times is: T_{open} = 0.4 min + 0.7 min = <u>1.1 minutes</u>

In summary, the time of concentration is calculated to be:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$ = 5.1 min + 4.2 min + 1.1 min = <u>10.4 minutes</u>.

Per Ref. 4, "For ungaged watersheds, the SCS suggests that the UH (unit hydrograph) lag time may be related to the time of concentration, T_c, as: $T_{lag} = 0.6\ T_c$". See Page 13.
The SCS UH lag time (T_{lag}) is an input parameter into the HEC-HMS computer program.
Thus T_{lag} = 0.6 x 10.4 = 6.2 minutes; (use 6 minutes in model for Bioswale areas).

The areas draining directly to the pond and wetland areas have significantly different runoff characteristics than the main plant, therefore a different Lag Time is used in the model. Since the drainage areas are small, the times of concentration will be very short. Per Reference 10, use a minimum starting Tc in drainage basin of 0.1 hr.

Thus model input for the direct runoff to the pond and wetland areas can be determined:

Tc = 0.1 hr = 6 minutes and T_{lag} = 0.6 x 6 = 3.6 minutes

Superseded 9/14/10
See pg 12A

Thus the travel time for open channel flow in this swale section is calculated to be:

$$T_{open} = \frac{L}{3600 \times V} = \frac{75}{3600 \times 4.1} = 0.005 \text{ hour} = 0.3 \text{ minutes}$$

In summary, the time of concentration is calculated to be:

$T_c = T_{sheet} + T_{shallow} + T_{channel}$ = 5.1 min + 4.2 min + 0.3 min= 9.6 minutes.

Per Ref. 4, "For ungaged watersheds, the SCS suggests that the UH (unit hydrograph) lag time may be related to the time of concentration, T_c, as: $T_{lag} = 0.6\ T_c$". See Page 13. The SCS UH lag time (T_{lag}) is an input parameter into the HEC-HMS computer program. Thus T_{lag} = 0.6 x 9.6 = 5.8 minutes; (use 6 minutes in model for Bioswale areas).

The areas draining directly to the pond and wetland areas have significantly different runoff characteristics than the main plant, therefore a different Lag Time is used in the model. Since the drainage areas are small, the times of concentration will be very short. Per Reference 10, use a minimum starting Tc in drainage basin of 0.1 hr.

Thus model input for the direct runoff to the pond and wetland areas can be determined:

Tc = 0.1 hr = 6 minutes and T_{lag} = 0.6 x 6 = 3.6 minutes

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UH can be found from the dimensionless form, which is included in HEC-HMS, by multiplication.

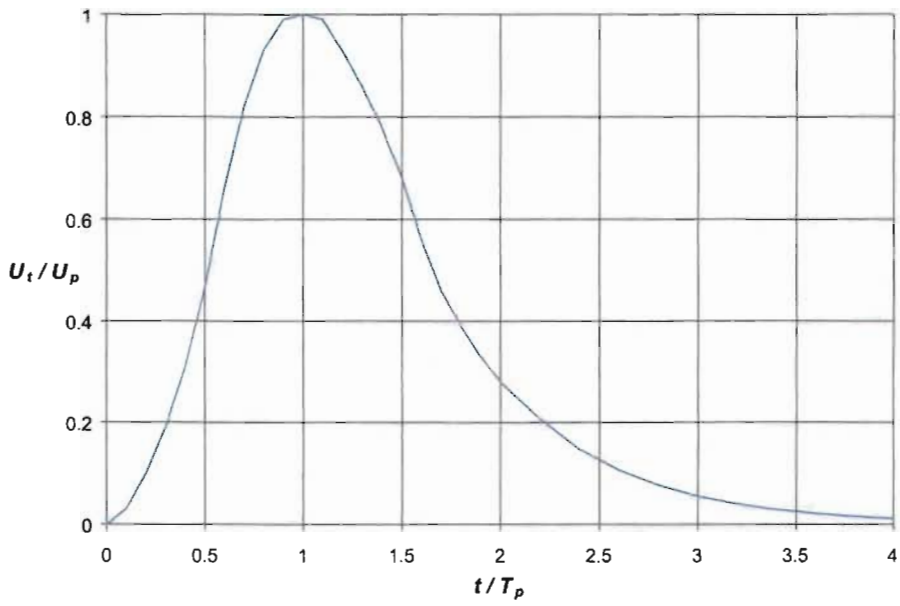


Figure 6-2. SCS unit hydrograph

Estimating the SCS UH Model Parameters

The SCS UH lag can be estimated via calibration, using procedures described in Chapter 9, for gaged headwater subwatersheds.

For ungaged watersheds, the SCS suggests that the UH lag time may be related to time of concentration, t_c, as:

$$t_{lag} = 0.6\, t_c \tag{6-10}$$

Time of concentration is a quasi-physically based parameter that can be estimated as

$$t_c = t_{sheet} + t_{shallow} + t_{channel} \tag{6-11}$$

where t_{sheet} = sum of travel time in sheet flow segments over the watershed land surface; $t_{shallow}$ = sum of travel time in shallow flow segments, down streets, in gutters, or in shallow rills and rivulets; and $t_{channel}$ = sum of travel time in channel segments.

NOTE: THIS PAGE IS FROM REF. 4.

Identify open channels where cross section information is available. Obtain cross sections from field surveys, maps, or aerial photographs. For these channels, estimate velocity by Manning's equation:

$$V = \frac{CR^{2/3}S^{1/2}}{n} \tag{6-12}$$

where V = average velocity; R = the hydraulic radius (defined as the ratio of channel cross-section area to wetted perimeter); S = slope of the energy grade

Section 2.0 – Rainfall Distribution

From Ref. 2, Figure B-2, the rainfall distribution for the site in Contra Costa County, California should be Type I distribution.

From Ref. 14, the 24-hour rainfall amounts for the site are: (See Pages 15 & 16)

Storm Event	100-year	10-year	Small event*
Rainfall	3.9 in.	2.6 in.	1.0 in.

* A smaller "typical" rain event of 0.75-1.0 inch was requested to be modeled by CEC

Section 3.0 – Determine Composite SCS Curve Number, Initial Abstraction & Impervious %

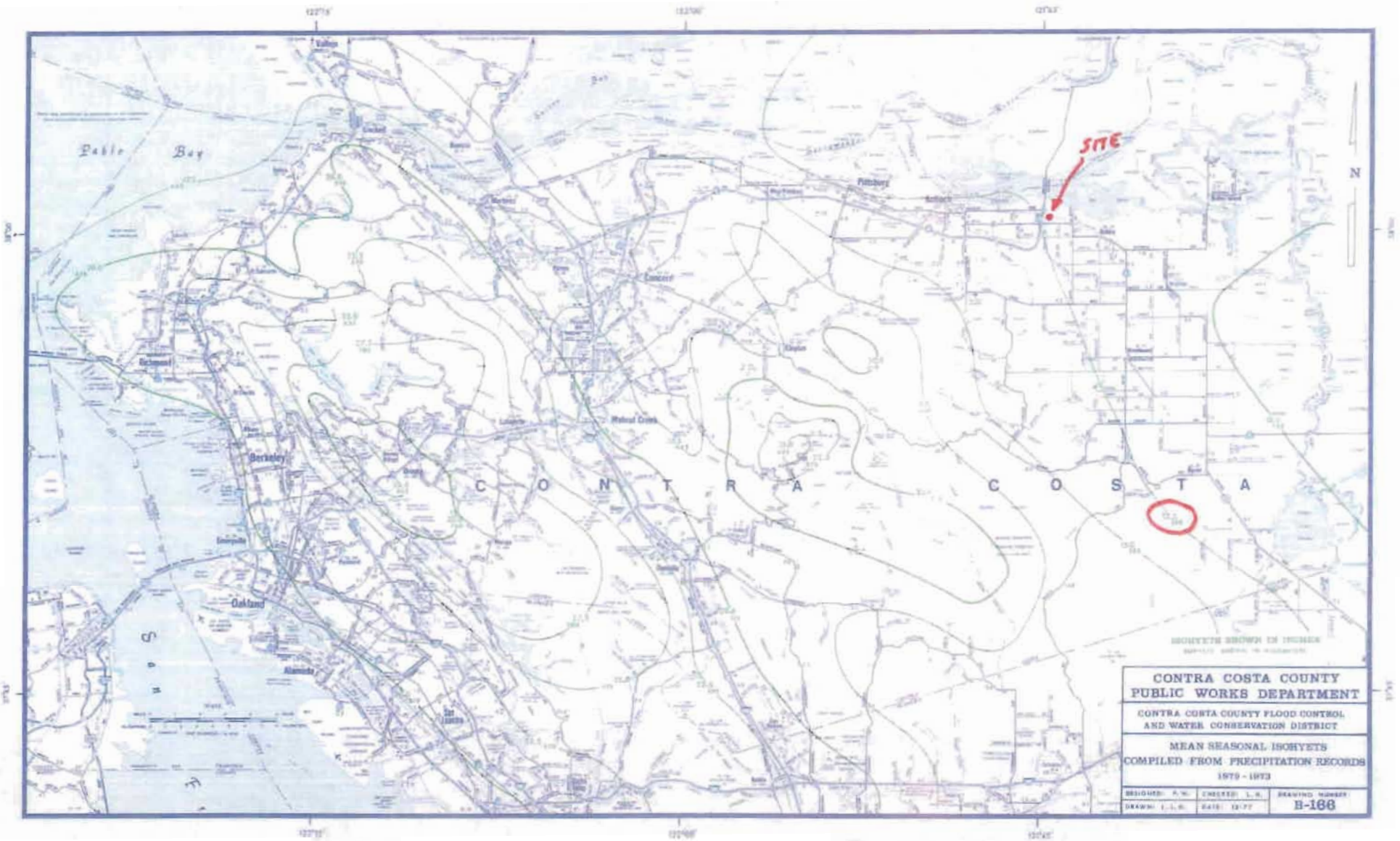
"SCS Curve Number" method was used in the HEC-HMS computer program to calculate the loss rate for the drainage area. The SCS Curve Number (CN), Initial Abstraction (Ia) and Impervious % for the pre-construction site were determined in Reference 9 – see attachment 5.

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". See Attachment 4. Per Ref. 2, this type of soil can be classified as Hydrologic Soil Group A soil.

The proposed site drainage areas as determined earlier are summarized below, with individual CN values assigned to each type of ground cover (for Group A soils). CN values are based on Reference 2, Tables 2-2a and 2-2b.

For the pre-construction condition, the SCS Curve Number (CN = 70), Initial Abstraction (Ia = 0.857) and Impervious (% = ~~0~~) were determined in Reference 9 – see Attachment 6.

2.6%
Rev 1 9/14/10 CAK



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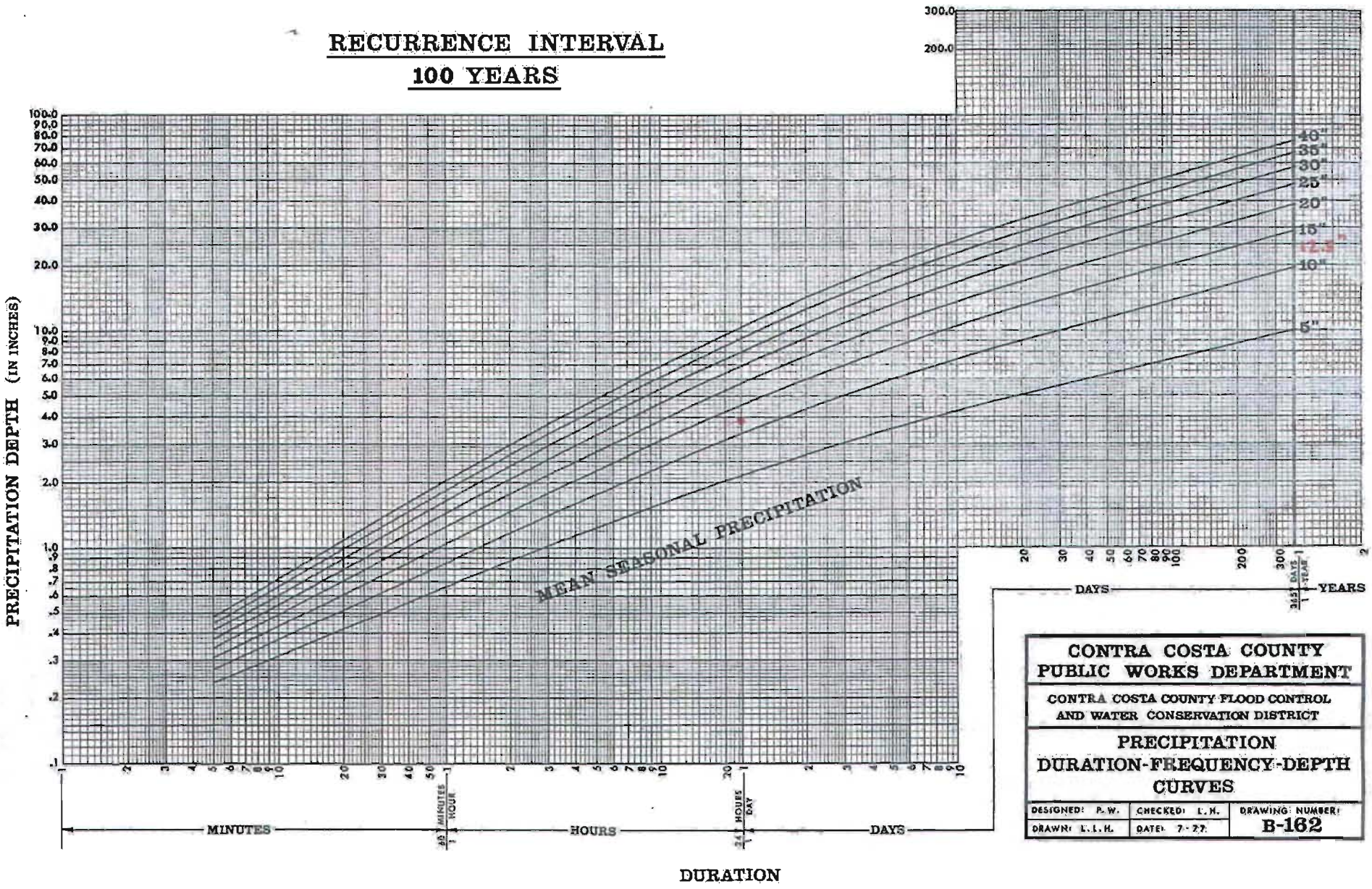
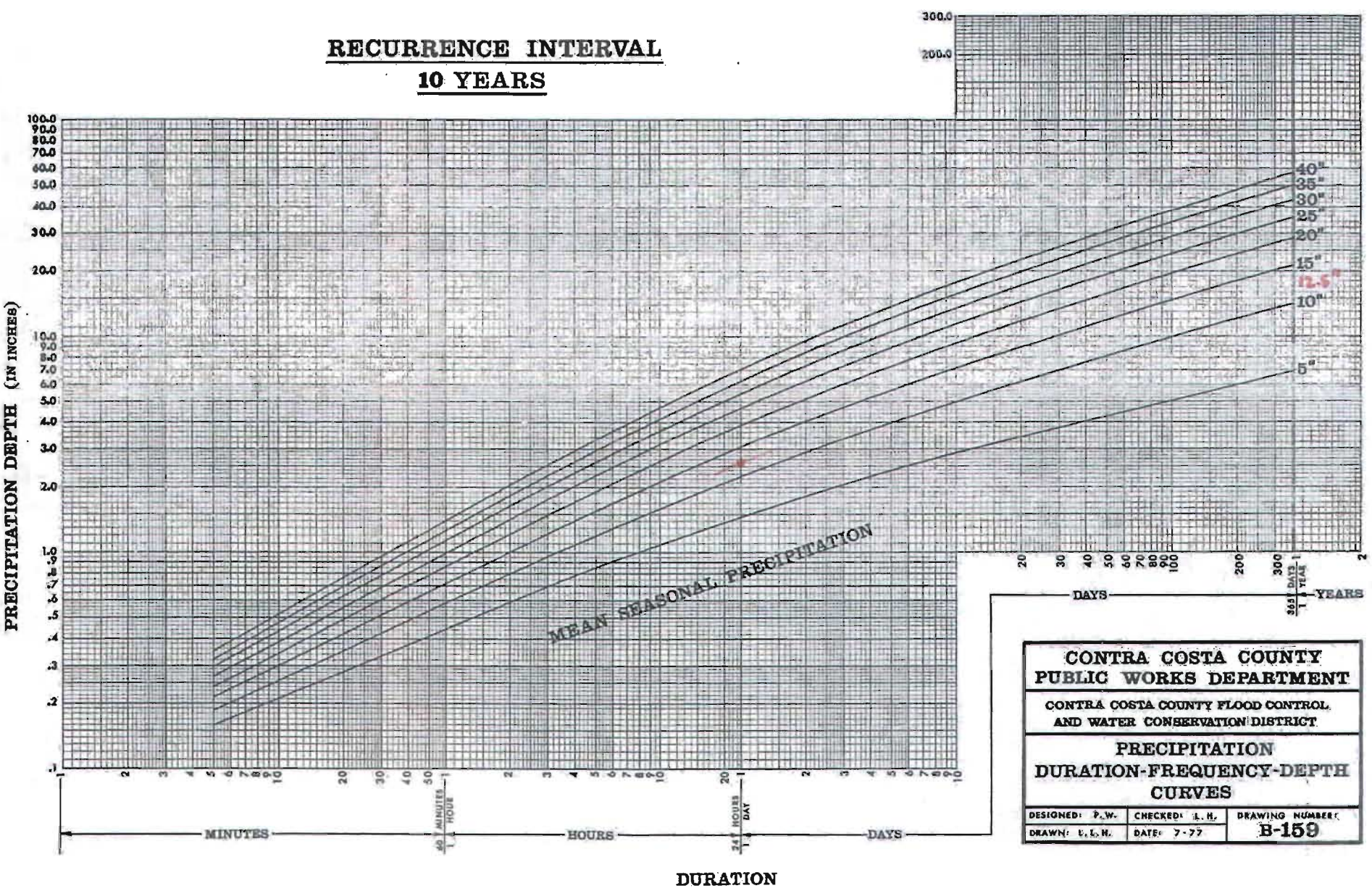
MSP = 12.5"



MSP = 12.5" (DWG B-166)

24-HR = 3.9" (ABOVE)



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(FROM REF. 14) ✓ PMW 6/18/10

MSP = 12.5" (DWG B-166)

24-HR = 2.6" (ABOVE)

Bioswale 1+2 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.30 ac.	174.8
Lawn (Poor Coverage <50%)	68	4.55 ac.	309.4
Impervious Surface	98	2.75 ac.	269.5
Open Graded Aggregate	68	1.57 ac.	106.76
Total		11.17 ac.	860.46
Composite CN = 860.46 / 11.17 = 77			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = 0.597 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Superseded 9/14/10
See pg 17A

Bioswale 1+2 (Post-Construction): Curve Number (CN) and Impervious Area

HMS Subbasin: _*1+2 CN* Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Gravel	76	2.30 ac.	174.8
Lawn (Poor Coverage <50%)	68	4.55 ac.	309.4
Impervious Surface not directly connected (75% x 2.75 ac. Total)	98	2.06 ac.	202.1
Open Graded Aggregate	68	1.57 ac.	106.76
Total		10.48 ac.	793.1
Composite CN = 793.1 / 10.48 = 76			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/76 - 10)$ = <u>0.632 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 25% of the impervious areas contributing to Bioswale 1+2 are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_1+2 Imp**".

2.75 acres impervious x 0.25 directly connected = 0.69 ac = 0.0011 sq. mi.

Impervious % = 100%

Bioswale 3 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.45 ac.	30.6
Impervious Surface	98	0.14 ac.	13.7
Total		0.59 ac.	44.3
Composite CN = 44.3 / 0.59 = 75			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

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The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/75 - 10)$ = 0.667 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Removed ~~Superseded~~ 9/14/10

Bioswale 4 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	2.51 ac.	190.8
Lawn (Poor Coverage <50%)	68	0.54 ac.	36.7
Impervious Surface	98	1.21 ac.	118.6
Total		4.26 ac.	346.1
Composite CN = 346.1 / 4.26 = 81			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/81 - 10)$ = 0.469 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Superseded 9/14/10
See pg 19A

Bioswale 4 (Post-Construction): Curve Number (CN) and Impervious Area)

HMS Subbasin: _4 CN Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Gravel	76	2.51 ac.	190.8
Lawn (Poor Coverage <50%)	68	0.54 ac.	36.7
Impervious Surface not directly connected (75% x 1.21 ac. Total)	98	0.91 ac.	88.9
Total		3.96 ac.	316.4
Composite CN = 316.4 / 3.96 = 80			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/80 - 10)$ = <u>0.500 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 25% of the impervious areas contributing to Bioswale 4 are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_4 Imp**".

1.21 acres impervious x 0.25 directly connected = 0.30 ac = 0.0005 sq. mi.

Impervious % = 100%

Bioswale 5 (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Gravel	76	3.35 ac.	254.6
Railroad Yard (similar to gravel)	76	0.94 ac.	71.4
Lawn (Poor Coverage <50%)	68	1.50 ac.	102
Impervious Surface	98	0.88 ac.	86.2
Total		6.67 ac.	514.2
Composite CN = 514.2 / 6.67 = 77			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = <u>0.597 inch</u>.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

Superseded 9/14/10
See pg 20A

Bioswale 5 (Post-Construction): Curve Number (CN) and Impervious Area)

HMS Subbasin: _5 CN Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Gravel	76	2.87 ac.	218.1
Railroad Yard (similar to gravel)	76	0.94 ac.	71.4
Lawn (Poor Coverage <50%)	68	0.95 ac.	64.6
Impervious Surface not directly connected (50% x 1.32 ac. Total)	98	0.66 ac.	64.7
Total		5.42 ac.	418.8
Composite CN = 418.8 / 5.42 = 77			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/77 - 10)$ = <u>0.597 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 50% of the impervious areas contributing to Bioswale 5 are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_5 Imp**".

1.32 acres impervious x 0.50 directly connected = 0.66 ac = 0.0010 sq. mi.

Impervious % = 100%

Direct to Pond (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Lawn (Poor Coverage <50%)	68	0.85 ac.	57.8
Impervious Surface	98	0.13 ac.	12.74
Total		0.98 ac.	70.54
Composite CN = 514.2 / 6.67 = 72			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/72 - 10)$ = 0.778 inch.

The "SCS Curve Number" method also requires the input of "% impervious" in the computer program. Reference 3 states that "the composite curve number should not include any impervious area that will be specified separately as the percentage of impervious area". As computed above, the impervious areas are factored into the CN for the drainage area and therefore the value for Impervious % would not include those areas. An allocation of 1% impervious area is input into the model to allow for a small increase in impervious areas during final design.

superseded 9/14/10
See pg 21A

Direct to Pond (Post-Construction): Curve Number (CN) and Impervious Area)

HMS Subbasin: _*Pond CN* Ground Cover Type	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Lawn (Poor Coverage <50%)	68	1.28 ac.	87.0
Gravel	76	0.1 ac.	7.6
Impervious Surface not directly connected (75% x 0.30 ac. Total)	98	0.23 ac.	22.5
Total		1.61 ac.	116.7
Composite CN = 116.7 / 1.61 = 73			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/73 - 10)$ = <u>0.740 inch</u>.

Impervious % = 0 (all directly connected impervious modeled separately, see below)

A separate subbasin was created to model the area of impervious surface that could be considered directly connected to the storm drainage system. Upon review of the surfacing plan for the site, it is estimated that 25% of the impervious areas contributing directly to the Pond are located sufficiently close to storm catch basins and swales to be considered directly connected. This area is modeled as subbasin "**_Pond Imp**".

0.30 acres impervious x 0.25 directly connected = 0.08 ac = 0.0001 sq. mi.

Impervious % = 100%

Direct to Wetland (Post-Construction)

Ground Cover Type	SCS CN (Group A Soil)	Proposed Site Acreage, A	CN x A
Wetland	98	0.4 ac.	39.2
Impervious Surface	98	0.27 ac.	26.5
Vineyard / Undisturbed Area	68	1.93 ac.	131.2
Total		2.6 ac.	196.9
Composite CN = 196.9 / 2.6 = 76			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on a composite CN of 77, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/76 - 10)$ = 0.632 inch.

Impervious % = 1% (Consistent with other drainage areas)

A summary of the pre- and post-construction basin parameter values determined above and input into the HEC-HMS model are included in the table below:

Condition	Area (sq. mi.)	Composite CN	Initial Abstraction (in)	Impervious %	Lag Time (min)
Pre-Construction					
Entire Site	0.0393	70	0.857	1	19.4
Post-Construction					
Bioswale 1-2	0.0175	77	0.597	1	6.0
Bioswale 3	0.0009	75	0.667	1	6.0
Bioswale 4	0.0067	81	0.469	1	6.0
Bioswale 5	0.0104	77	0.597	1	6.0
Direct to Pond	0.0015	72	0.778	1	3.6
Direct to Wetland	0.0041	76	0.632	1	3.6

Direct to Wetland (Post-Construction): Curve Number (CN) and Impervious Area)

HMS Subbasin: _*Wetland CN* **Ground Cover Type**	**SCS CN (Group A Soil)**	**Proposed Site Acreage, A**	**CN x A**
Wetland	98	0.4 ac.	39.2
Impervious Surface	98	0.28 ac.	27.4
Vineyard / Undisturbed Area	68	1.93 ac.	131.2
Lawn (Poor Coverage <50%)	68	0.47 ac.	32.0
Total		3.08 ac.	229.8
Composite CN = 229.8 / 3.08 = 75			

The "SCS Curve Number" method also requires the input of initial abstraction (initial loss) in the computer program. The initial abstraction accounts for all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration (Ref. 2).

The initial abstraction (I_a) can be estimated to be:

$I_a = 0.2\ S$ (Ref. 2, Eq. 2-2) Where: $S = \frac{1000}{CN} - 10$ (Ref. 2, Eq. 2-4)

Based on the composite CN, the initial abstraction is calculated to be:

$I_a = 0.2 \times (1000/75 - 10)$ = 0.667 inch.

Impervious % = 0 (all impervious area not directly connected, factored in CN above)

Summary table for pre- and post-construction basin parameter values (HEC-HMS input):

Condition	**Area (sq. mi.)**	**Composite CN**	**Ia (in)**	**Imperv %**	**Lag Time (min)**
Pre: Entire Site	0.0393	70	0.857	2.6	19.4
Post: Bioswale 1+2 CN	0.0164	76	0.632	0	6.0
Post: Bioswale 1+2 Imp	0.0011	98	0.041	100	6.0
Post: Bioswale 4 CN	0.0062	80	0.500	0	6.0
Post: Bioswale 4 Imp	0.0005	98	0.041	100	6.0
Post: Bioswale 5 CN	0.0085	77	0.597	0	6.0
Post: Bioswale 5 Imp	0.0010	98	0.041	100	6.0
Post: Direct to Pond CN	0.0025	73	0.740	0	3.6
Post: Direct to Pond Imp	0.0001	98	0.041	100	3.6
Post: Direct to Wetland	0.0048	75	0.667	0	3.6

Section 4.0 – Elevation versus Area and Outflow Rate

The proposed pond and each bioswale provide volumetric storage for runoff and also ~~has~~ have an outlet control structure to limit flows entering the wetland area. The relationship of Elevation versus Area and Elevation versus Discharge Flow Rate are used within the HEC-HMS model to accurately determine flow rates within the system. For the bioswales, areal measurements are based on the length of swale multiplied by the width of the swale. The swale width at each elevation is based on the bottom width plus the width with 3H:1V side slopes for each depth (each 1-foot of depth increases the width by 6 feet (3 feet on each side)).

For example, Bioswale 1-2 is 1,323 feet long, 2 foot wide at EL 12.5 and 3H:1V slopes.

Area at EL 12.5 = 1,323 ft x 2 ft = 2646 sf (0.06 ac)

Area at EL 13.0 = 1,323 ft x [2 ft + (3 H:V x 0.5' depth x 2 (slope on both sides)]
= 1,323 x 5 ft wide = 6,615 sf (0.15 ac)

Using the above method, Elevation vs Area tables are determined and included for each Bioswale in the following pages. Each table includes the elevation and area up to one foot above the rim of the control structure. This is to consider the effects of flow into the structure when water levels exceed the rim elevation.

For purposes of determining elevation versus discharge rate, the rim of the outlet structure is modeled as a weir. Using the weir equation $Q = C \times L \times H^{3/2}$ the flow rate at each elevation can be determined by considering the head (H) above the weir (rim elevation). The length of the weir is the circumference of the outlet structure which is dependent on the diameter of pipe selected for the standpipe. L = Circumference = π x diameter.

Thus for Bioswale 1-2, the elevation – discharge table can be determined:

Rim EL = 15.5 (per Reference 9)

Discharge at 0.1' intervals can be determined:

At EL 15.6, H = 15.6 – 15.5 = 0.1 ft
L = π x 24" (diameter) * 1 ft / 12 in = 6.28 ft
C = 3.1 (per Reference 12)

Discharge at EL 15.6 $Q = 3.1 \times 6.28 \times 0.1^{3/2} = 0.62$ cfs

Discharge at EL 15.7 $Q = 3.1 \times 6.28 \times 0.2^{3/2} = 1.74$ cfs

Using the above method, Elevation vs Discharge tables are determined and included for each Bioswale in the following pages. Note that any orifices placed within the vertical barrel of the standpipe will allow discharge prior to peaking over the rim elevation. For the purposes of this calculation the peak flow is determined without allowing orifice flow, to be conservative and maximize peak flows in the system.

Superseded 9/14/10 See pg 23A

Section 4.0 – Elevation versus Area and Outflow Rate

The proposed pond and each bioswale provide volumetric storage for runoff and also have an outlet control structure to control flows discharging to the wetland area. The relationship of Elevation vs. Area and Elevation vs. Discharge Rate are used within the HEC-HMS model to accurately model flow rates within the system. For the bioswales, areal measurements are based on the length of swale multiplied by the width of the swale. The swale width at each elevation is based on the bottom width plus the width with 3H:1V side slopes for each depth (each 1-foot of depth increases the width by 6 feet (3' on each side)).

For example, Bioswale 1-2 is 1,323 feet long, 2 foot wide at EL 12.5 and 3H:1V slopes.

Area at EL 12.5 = 1,323 ft x 2 ft = 2646 sf (0.06 ac)

Area at EL 13.0 = 1,323 ft x [2 ft + (3 H:V x 0.5' depth x 2 (slope on both sides)]
= 1,323 x 5 ft wide = 6,615 sf (0.15 ac)

Using the above method, Elevation vs Area tables are determined and included for each Bioswale in the following pages:

For purposes of determining elevation versus discharge rate, orifice flow (low-flow orifices) and weir flow (overflow rim) are modeled. Using the orifice equation $Q = C \times A \times \sqrt{(2\ g\ H)}$ and the weir equation $Q = C \times L \times H^{3/2}$ the flow rate at each elevation can be determined by considering the head (H) above the orifice (low-flow) and weir (rim elevation). The orifice sizing is based on allowing the water quality flow rate generated by a 0.2 in/hr storm intensity to pass with 1 foot of head, to maintain hydration of the wetland area. The length of the weir is the circumference of the outlet structure (L = Circumference = л x diameter).

Thus for Bioswale 1-2, the elevation – discharge table can be determined:

Rim EL = 15.5, Bottom EL = 12.5 (per Reference 9)

Discharge at 0.1' intervals can be determined:

At EL 15.6, Orifice: H = 15.6 – 12.5 = 3.1 ft

Qo = 0.62 x 0.218 (see Pg 24a) x $\sqrt{(2 \times 32.2 \times 3.1')}$ = 1.91 cfs

Weir: H = 15.6 – 15.5 = 0.1 ft

L = л x 24" (diameter) * 1 ft / 12 in = 6.28 ft

C = 3.1 (per Reference 12)

$Qw = 3.1 \times 6.28 \times 0.1^{3/2} = 0.62$ cfs

Discharge at EL 15.6 Q = 1.91 cfs (orifice) + 0.62 cfs (weir) = 2.53 cfs

Discharge at EL 15.7 Q = 1.94 cfs (orifice) + 1.74 cfs (weir) = 3.68 cfs

Elevation vs Discharge tables follow for each outlet control structure (bioswales and pond).

Bioswale 1-2

Bottom Width = 2 ft; Length = 1,323 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.5	2	2646	0.06
13.0	5	6615	0.15
14.0	11	14553	0.33
15.0	17	22491	0.51
15.5	20	26460	0.6
16.0	23	30429	0.69
16.5	26	34398	0.78

Standpipe diameter = 24"; Rim Elevation = 15.5 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
12.5 (bottom)	0
15.5 (rim)	0
15.6	0.62
15.7	1.74
15.8	3.2
15.9	4.93
16.0	6.88
16.1	9.05
16.2	11.4
16.3	13.93
16.4	16.62
16.5	19.47

Superseded 9/14/10
See pg 24A

Bioswale 1-2

Bottom Width = 2 ft; Length = 1,323 ft; Bottom Elevation = 12.5 ft

The following tables summarize the Elevation vs. Area and Discharge for HEC-HMS input.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.5	2	2646	0.06
13.0	5	6615	0.15
14.0	11	14553	0.33
15.0	17	22491	0.51
15.5	20	26460	0.6
16.0	23	30429	0.69
16.5	26	34398	0.78

Standpipe diameter = 24"; Rim Elevation = 15.5 ft

Drainage Area & Runoff Coefficient:

A = 11.17 (Areas summarized on summary on Page 5a)

C = 2.3 x 0.65 (gravel) + (4.55 + 1.57) x 0.25 (lawn) + 2.75 x 0.95 (impervious) / 11.17 = 0.5

Water quality flow rate: Q = CIA = 0.5 x 0.2 in/hr x 11.17 ac = 1.12 cfs

Orifice equation: $Q=CA\sqrt{(2gh)}$ for 1.12 cfs with h=1.0' and C=0.62, yields A = 0.2245 sf

Ten 2-inch orifices can be used to provide an area of 0.2180 sf (use in orifice equation)

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
12.5 (bottom)	0.00 (orifice)	15.9	6.93 (orifice + weir)
13.0	0.77 (orifice)	16.0	8.91 (orifice + weir)
14.0	1.33 (orifice)	16.1	11.11 (orifice + weir)
15.0	1.71 (orifice)	16.2	13.49 (orifice + weir)
15.5 (rim)	1.88 (orifice)	16.3	16.04 (orifice + weir)
15.6	2.53 (orifice + weir)	16.4	18.76 (orifice + weir)
15.7	3.68 (orifice + weir)	16.5	21.64 (orifice + weir)
15.8	5.17 (orifice + weir)		

Bioswale 3

Bottom Width = 2 ft; Length = 187 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
11.0	2	374	0.01
12.0	8	1496	0.03
13.0	14	2618	0.06
14.0	20	3740	0.08

Standpipe diameter = 24"; Rim Elevation = 13.0 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

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Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
11.0 (bottom)	0
13.0 (rim)	0
13.1	0.62
13.2	1.74
13.3	3.2
13.4	4.93
13.5	6.88
13.6	9.05
13.7	11.4
13.8	13.93
13.9	16.62
14	19.47

~~Superseded~~
Removed 9/14/10

Bioswale 4

Bottom Width = 2 ft; Length = 391 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.5	2	782	0.01
13.0	5	1955	0.04
14.0	11	4301	0.09
15.0	17	6647	0.15
15.5	20	7820	0.17
16.0	23	8993	0.2
16.5	26	10166	0.23

Standpipe diameter = 24"; Rim Elevation = 15.5 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
12.5 (bottom)	0
15.5 (rim)	0
15.6	0.62
15.7	1.74
15.8	3.2
15.9	4.93
16.0	6.88
16.1	9.05
16.2	11.4
16.3	13.93
16.4	16.62
16.5	19.47

Superseded 9/14/10
See Pg 26A

Bioswale 4

Bottom Width = 2 ft; Length = 391 ft

The following tables summarize the Elevation vs. Area and Discharge for HEC-HMS input.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.5	2	782	0.01
13.0	5	1955	0.04
14.0	11	4301	0.09
15.0	17	6647	0.15
15.5	20	7820	0.17
16.0	23	8993	0.2
16.5	26	10166	0.23

Standpipe diameter = 24"; Rim Elevation = 15.5 ft

Drainage Area & Runoff Coefficient:

A = 4.26 (Areas summarized on summary on Page 5a)

C = 2.51 x 0.65 (gravel) + 0.54 x 0.25 (lawn) + 1.21 x 0.95 (impervious) / 4.26 = 0.7

Water quality flow rate: Q = CIA = 0.7 x 0.2 in/hr x 4.26 ac = 0.60 cfs

Orifice equation: $Q=CA\sqrt{(2gh)}$ for 0.60 cfs with h=1.0' and C=0.62, yields A = 0.1199 sf

Five 2-inch orifices can be used to provide an area of 0.1090 sf (use in orifice equation)

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
12.5 (bottom)	0.00 (orifice)	15.9	5.93 (orifice + weir)
13.0	0.38 (orifice)	16.0	7.89 (orifice + weir)
14.0	0.66 (orifice)	16.1	10.08 (orifice + weir)
15.0	0.86 (orifice)	16.2	12.44 (orifice + weir)
15.5 (rim)	0.94 (orifice)	16.3	14.99 (orifice + weir)
15.6	1.57 (orifice + weir)	16.4	17.69 (orifice + weir)
15.7	2.71 (orifice + weir)	16.5	20.55 (orifice + weir)
15.8	4.19 (orifice + weir)		

Bioswale 5

Section 2: Bottom Width = 10 ft; Length = 265 ft

Section 2a: Bottom Width = 8 ft; Length = 120 ft

Using the method for area determination provided on Page 23, the following table summarizes the relationship of elevation versus area of the bioswale for input to HEC-HMS.

Elevation – Area Summary

Elevation (ft)	Width (ft)		Area (sf)		Total Area (ac)
	Section 2	Section 2a	Section 2	Section 2a	
11.0	-	8	-	960	0.02
12.0	10	14	2650	1680	0.09
13.0	16	20	4240	2400	0.15
14.0	22	26	5830	3120	0.2
14.5	25	29	6625	3480	0.23
15.0	28	32	7420	3840	0.25
15.5	31	35	8215	4200	0.28

Standpipe diameter = 36"; Rim Elevation = 14.5 ft

Using the method for weir flow discharge provided on Page 23, the following table summarizes the relationship of elevation versus discharge at the outlet of the bioswale for input to HEC-HMS. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)
11.0 (bottom)	0
14.5 (rim)	0
14.6	0.92
14.7	2.61
14.8	4.8
14.9	7.39
15.0	10.32
15.1	13.57
15.2	17.1
15.3	20.9
15.4	24.93
15.5	29.2

Superseded 9/14/10
See pg 27A

Bioswale 5

Section 2: Bottom Width = 10 ft; Length = 145 ft

The following tables summarize the Elevation vs. Area and Discharge for HEC-HMS input.

Elevation – Area Summary

Elevation (ft)	Width (ft)	Area (sf)	Area (ac)
12.0	10	1450	0.03
13.0	16	2320	0.05
14.0	22	3190	0.07
14.5	25	3625	0.08
15.0	28	4060	0.09
15.5	31	4495	0.10

Standpipe diameter = 36"; Rim Elevation = 14.5 ft

Drainage Area & Runoff Coefficient:

A = 6.08 (Areas summarized on summary on Page 5a)

C = (2.87 + 0.94) x 0.65 (gravel) + 0.95 x 0.25 (lawn) + 1.32 x 0.95 (impervious) / 6.08= 0.65

Water quality flow rate: Q = CIA = 0.65 x 0.2 in/hr x 6.08 ac = 0.8 cfs

Orifice equation: $Q=CA\sqrt{(2gh)}$ for 0.80 cfs with h=1.0' and C=0.62, yields A = 0.1589 sf

Seven 2-inch orifices can be used to provide an area of 0.1526 sf (use in orifice equation)

Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
12.0 (bottom)	0.00 (orifice)	15.0	11.64 (orifice + weir)
13.0	0.76 (orifice)	15.1	14.91 (orifice + weir)
14.0	1.07 (orifice)	15.2	18.46 (orifice + weir)
14.5 (rim)	1.20 (orifice)	15.3	22.28 (orifice + weir)
14.6	2.14 (orifice + weir)	15.4	26.33 (orifice + weir)
14.7	3.86 (orifice + weir)	15.5	30.62 (orifice + weir)
14.8	6.07 (orifice + weir)		
14.9	8.68 (orifice + weir)		

Pond

The proposed pond will provide additional storage capacity for the stormwater runoff from the post-construction site conditions. Below is a table summarizing the relationship of Elevation versus Area (areas measured using AutoCAD).

Elevation – Area Summary

Elevation (ft)	Pond Area (acres)
8.5	0.18
9.0	0.21
10.0	0.26
11.0	0.31
12.0	0.37
13.0	0.43
14.0	0.50
15.0	0.56

The pond outlet structure consists of orifice holes in the vertical standpipe to reduce peak flows and also allows discharge through the rim via weir flow. The method for determining weir flow is consistent with the weir discharge for bioswales. For orifice flow through the standpipe barrel, the orifice equation $Q = C \times A \times \sqrt{2gh}$ is used to determine discharge by considering the head (h) above the orifice discharge elevation. In the pond this elevation is set at EL 10.0 per Reference 11. A is the orifice area. For this calculation, nine 1-inch holes are provided at EL 10.0 to limit maximum flows to 0.5 cfs until the water level is at EL 14.0 (rim). PLN 6/18/10

The elevation – discharge table can be determined:

Orifice EL = 10.0

Discharge at each depth can be determined:

At EL 14.0 (rim), H = 14.0 – 10.0 = 4.0 ft

A = $9 \times (\pi \times r^2)$ = 9 x (π x (0.5 in / 12 in/ft)^2) in = 0.495 sf

C = 0.62 (per Reference 13)

Discharge at EL 14.0 Q = $0.62 \times 0.0495 \times \sqrt{2 \times 32.2 \times 4.0}$ = 0.49 cfs (< 0.50 cfs)

Discharge at EL 12.0 Q = $0.62 \times 0.0495 \times \sqrt{2 \times 32.2 \times 2.0}$ = 0.35 cfs

Superseded 9/14/10
See pg 28A

Pond

The proposed pond will provide additional storage capacity for the stormwater runoff from the post-construction site conditions. Below is a table summarizing the relationship of Elevation versus Area (areas measured using AutoCAD).

Elevation – Area Summary

Elevation (ft)	Pond Area (acres)
8.5	0.33
9.0	0.35
10.0	0.41
11.0	0.48
12.0	0.54
13.0	0.61

The pond outlet structure consists of orifice holes in the vertical standpipe to reduce peak flows and also allows discharge through the rim via weir flow. The method for determining weir flow is consistent with the weir discharge for bioswales. For orifice flow through the standpipe barrel, the orifice equation Q = $C \times A \times \sqrt{2gh}$ is used to determine discharge by considering the head (h) above the orifice discharge elevation. In the pond this elevation is set at EL 8.75 per Reference 11. A is the orifice area. For this calculation, orifices are provided to discharge the water quality volume (WQV) between 24-48 hours.

Per B&V Calc 52.5406.1008 the WQV is 0.30 ac-ft. which is stored in the pond at EL 9.34'.
The average head for the orifice equation is 2/3 of the maximum head of 9.34-8.75 = 0.39'
The target dewatering time is 24 hours for the WQV.
Therefore the average flow rate Q = (0.3 ac-ft x 43560 sf/ac)/ (24 hr x 3600 s/hr) = 0.151 cfs
Orifice equation: Q=CA√(2gh) for 0.151 cfs with h=0.39' and C=0.62, yields A = 0.0486 sf
Eight 1-inch orifices can be used to provide an area of 0.044 sf (use in orifice equation)

The elevation – discharge table can be determined:

Orifice EL = 8.75

Discharge at each depth can be determined:

At EL 12.0 (rim), H = 12.0 – 8.75 = 3.25 ft

A = $8 \times (\pi \times r^2)$ = 11 x (π x (0.5 in / 12 in/ft)^2) in = 0.044 sf

C = 0.62 (per Reference 13)

Discharge at EL 10.0 Q = $0.62 \times 0.044 \times \sqrt{2 \times 32.2 \times 1.25}$ = 0.24 cfs

Discharge at EL 12.0 Q = $0.62 \times 0.044 \times \sqrt{2 \times 32.2 \times 3.25}$ = 0.39 cfs

Standpipe diameter = 36"; Rim Elevation = 14.0 ft

Using the method for weir flow discharge provided on Page 23, and the orifice discharge method on the previous page, the following table summarizes the relationship of elevation versus discharge (weir and orifice) at the pond outlet. This data is input into the HEC-HMS model. Weir discharge is calculated at 0.1-foot intervals due to the rapid increase in discharge as the depth increases. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Pond Elevation – Discharge Summary

Elevation (ft)	Orifice Discharge (cfs)	Weir Discharge (cfs)	Total Discharge (cfs)
8.5 (bottom)	-	-	0
10.0 (orifice)	0	-	0
11.0	0.25	-	0.25
12.0	0.35	-	0.35
13.0	0.43	-	0.43
14.0	0.49	0	0.49
14.1	0.5	0.92	1.42
14.2	0.5	2.61	3.11
14.3	0.51	4.8	5.31
14.4	0.52	7.39	7.91
14.5	0.52	10.32	10.84
14.6	0.53	13.57	14.1
14.7	0.53	17.1	17.63
14.8	0.54	20.9	21.44
14.9	0.55	24.93	25.48
15.0	0.55	29.2	29.75

Superseded 9/14/10

See Pg 29A

Standpipe diameter = 36"; Rim Elevation = 14.0 ft

The following table summarizes the relationship of elevation versus discharge (weir and orifice) at the pond outlet for input into the HEC-HMS model. Weir discharge is calculated at 0.1-foot intervals due to the rapid increase in discharge as the depth increases. Refer to Page 30 for discussion of weir / orifice flow into riser pipe.

Pond Elevation – Discharge Summary

Elevation (ft)	Discharge (cfs)	Elevation (ft)	Discharge (cfs)
8.5 (bottom)	0.00 (below orifice)	12.3	5.21 (orifice + weir)
8.75	0.00 (orifice)	12.4	7.81 (orifice + weir)
9.0	0.11 (orifice)	12.5	10.7 (orifice + weir)
10.0	0.24 (orifice)	12.6	14.0 (orifice + weir)
11.0	0.33 (orifice)	12.7	17.5 (orifice + weir)
12.0 (rim)	0.39 (orifice)	12.8	21.3 (orifice + weir)
12.1	1.32 (orifice + weir)	12.9	25.4 (orifice + weir)
12.2	3.02 (orifice + weir)	13.0	29.7 (orifice + weir)

The capacity of each riser pipe is determined for weir flow and orifice flow based on the peak head above the rim elevation for each outlet control structure. To determine the elevation at which the flow transitions from weir flow over the riser rim to orifice flow when the rim becomes submerged, the value of the head, H that results in weir flow equal to orifice flow is computed. This head value is compared to the peak elevation in the bioswales and pond to determine if weir flow or orifice flow would govern.

Weir flow, Qw = Cw x L x $H^{3/2}$

Orifice Flow, Qo = $Co \times A \times \sqrt{2gH}$

Gravitational Constant, g = 32.2

Setting Qw = Qo, the above equations are reduced to solve for H: $H = \frac{8.025 \times Co \times A}{Cw \times L}$

Weir Coefficient, Cw = 3.1

Orifice Coeff, Co = 0.62

Area, A and Length, L are dependent on the diameter of the riser pipe.

For a 24" riser pipe, A = л x r^2 = 3.14 x $(1\ ft)^2$ = 3.14 sf

L = л x d = 3.14 x 2 ft = 6.28 ft

For a 36" riser pipe, A = л x r^2 = 3.14 x $(1.5\ ft)^2$ = 7.07 sf

L = л x d = 3.14 x 3 ft = 9.42 ft

The Head, H at which weir flow is equal to orifice flow is thus:

For a 24" riser $H = \frac{8.025 \times 0.62 \times 3.14}{3.1 \times 6.28}$ = 0.8 ft. Weir flow will govern up to 0.8' above rim

For a 36" riser $H = \frac{8.025 \times 0.62 \times 7.07}{3.1 \times 9.42}$ = 1.2 ft. Weir flow will govern up to 1.2' above rim

Referring to the HEC-HMS output in Attachment 2, the maximum head above the riser is for Bioswale 1-2 (Peak elevation – rim elevation = 15.99 ft – 15.5 ft = 0.5' of head). This is below the minimum head that results in orifice flow (0.8' for 24" riser). Therefore the use of the weir flow discharge values is correct for all overflow structures for this calculation.

Section 5.0 HEC-HMS Output

The parameters determined in Sections 1.0 through 4.0 were input into the HEC-HMS computer program. The outflow from the wetland is specified in the HEC-HMS program to be 0 at all times (no outflow). The peak discharge rate to the wetland for each storm event was calculated by running the HEC-HMS program. The table below summarizes the runoff rate produced in the pre-construction and post-construction site conditions for each storm event. The output results are included in Attachment 2.

Summary of Runoff Peak Flow Rates to Wetland

Rainfall Event	Pre-Construction Peak Flow Rate to Existing Wetland	Post-Construction Peak Flow Rate to Existing Wetland
1-inch	0.3 ~~0.1~~ cfs	0.2 ~~0.1~~ cfs
10-year	3.6 ~~3.2~~ cfs	2.2 ~~3.1~~ cfs
100-year	12.3 ~~11.8~~ cfs	4.8 ~~9.1~~ cfs

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Conclusion:

Based on the HEC-HMS analysis for the pre- and post-construction conditions, the peak flows to the wetland area will be changed as a result of the proposed development. The increase in runoff volume due to the proposed development is attenuated within the proposed bioswales and detention pond. By installing the bioswales and pond along with outlet control structures, the peak flows are controlled in the post-development condition and result in equal-to or less-than pre-developed conditions.

Radback Oakley Project

Project # 163994

Stormwater Analysis

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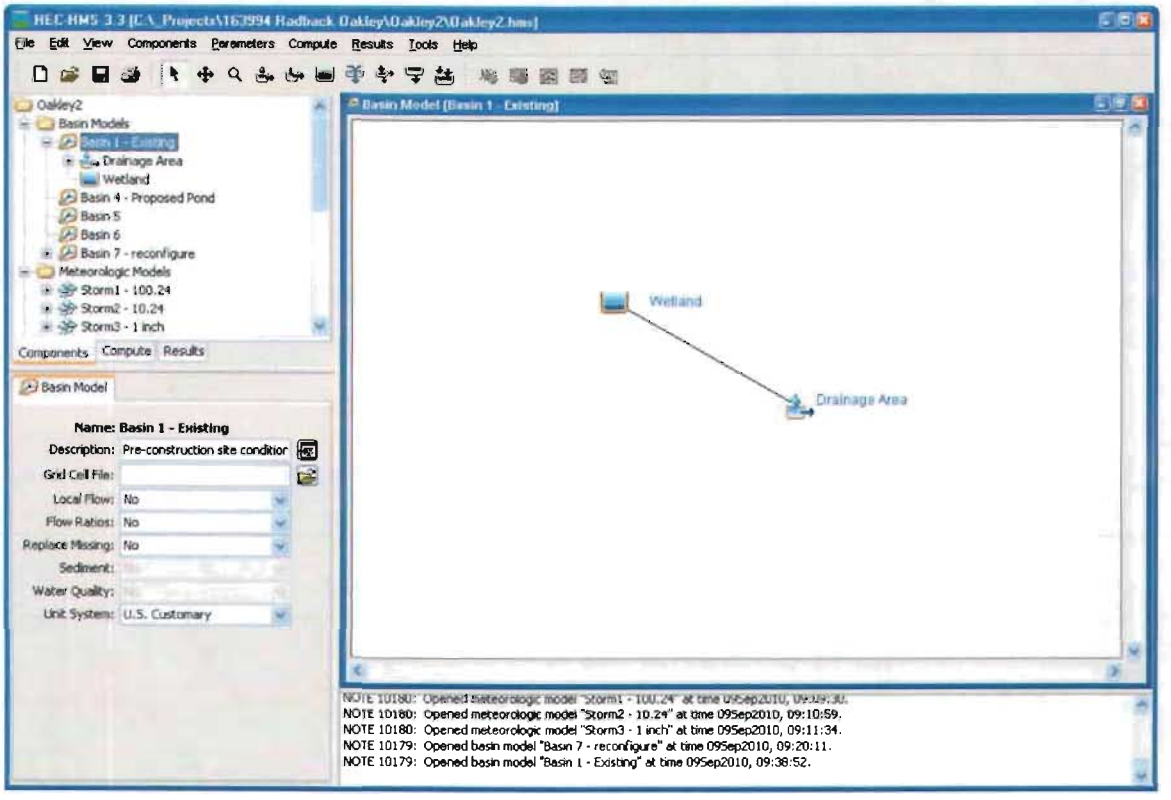
CAK

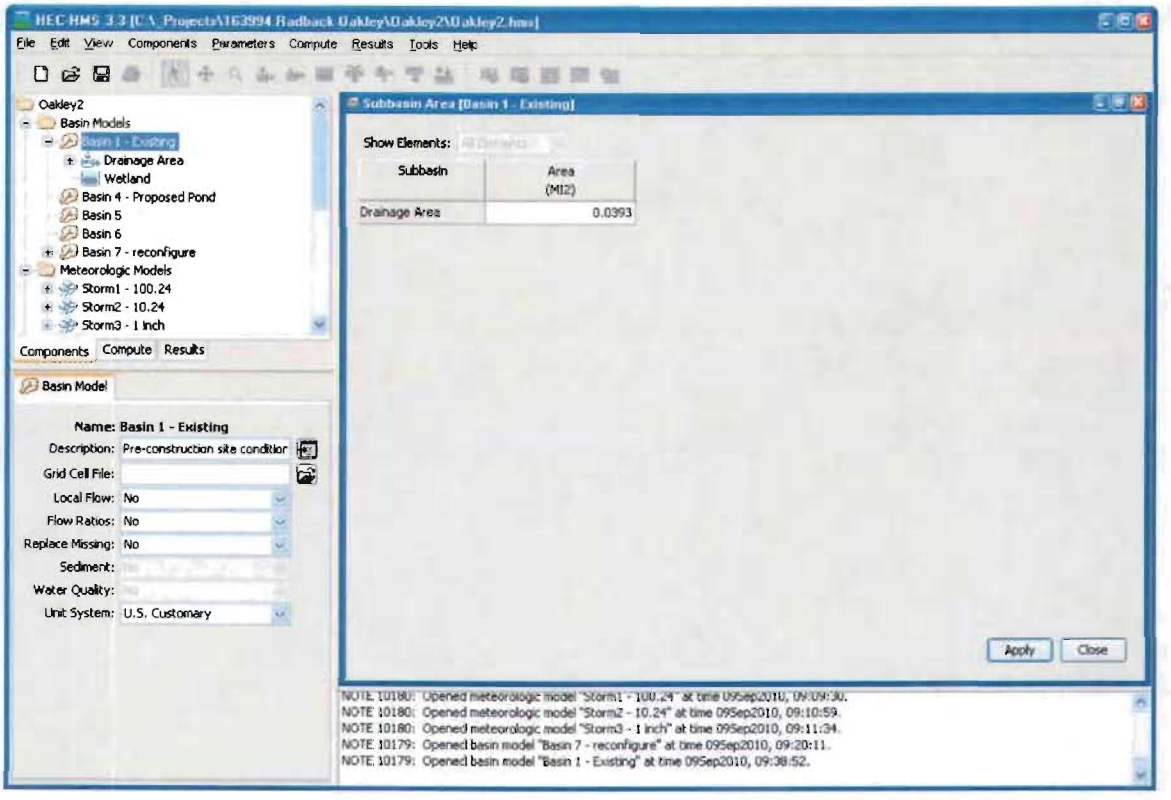
Attachment 1

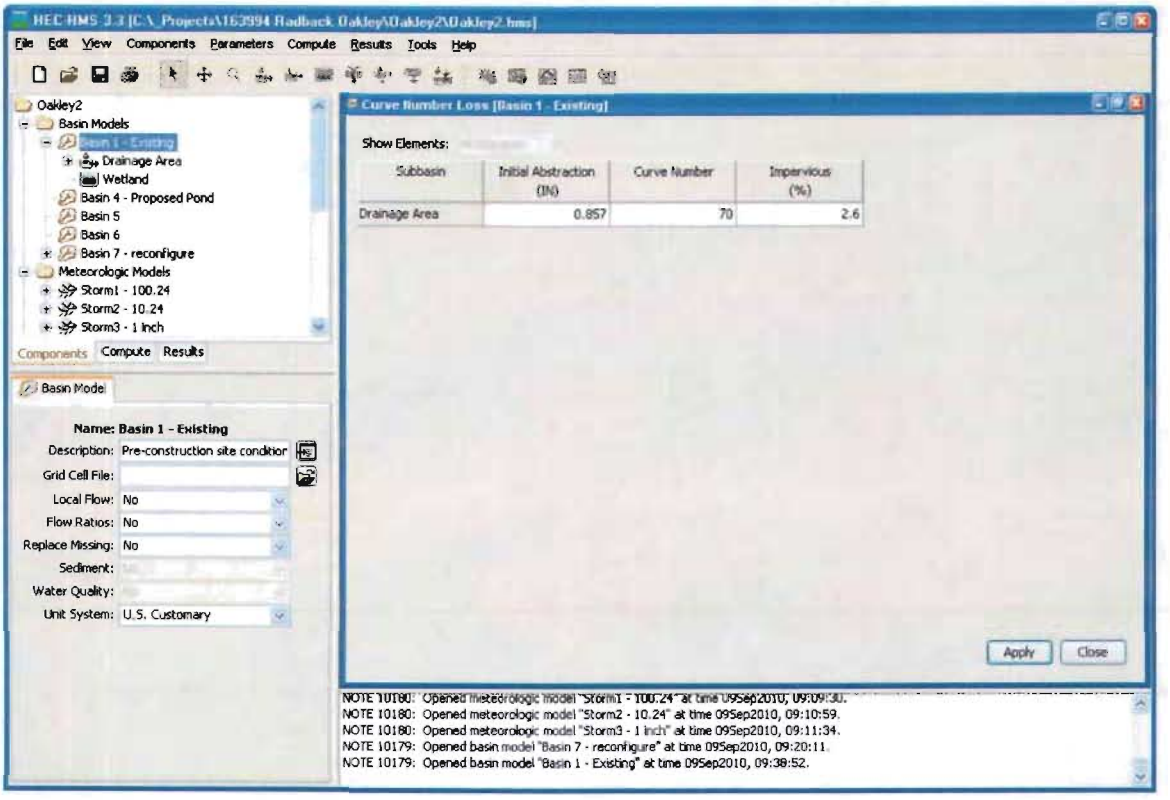
~~Reference~~

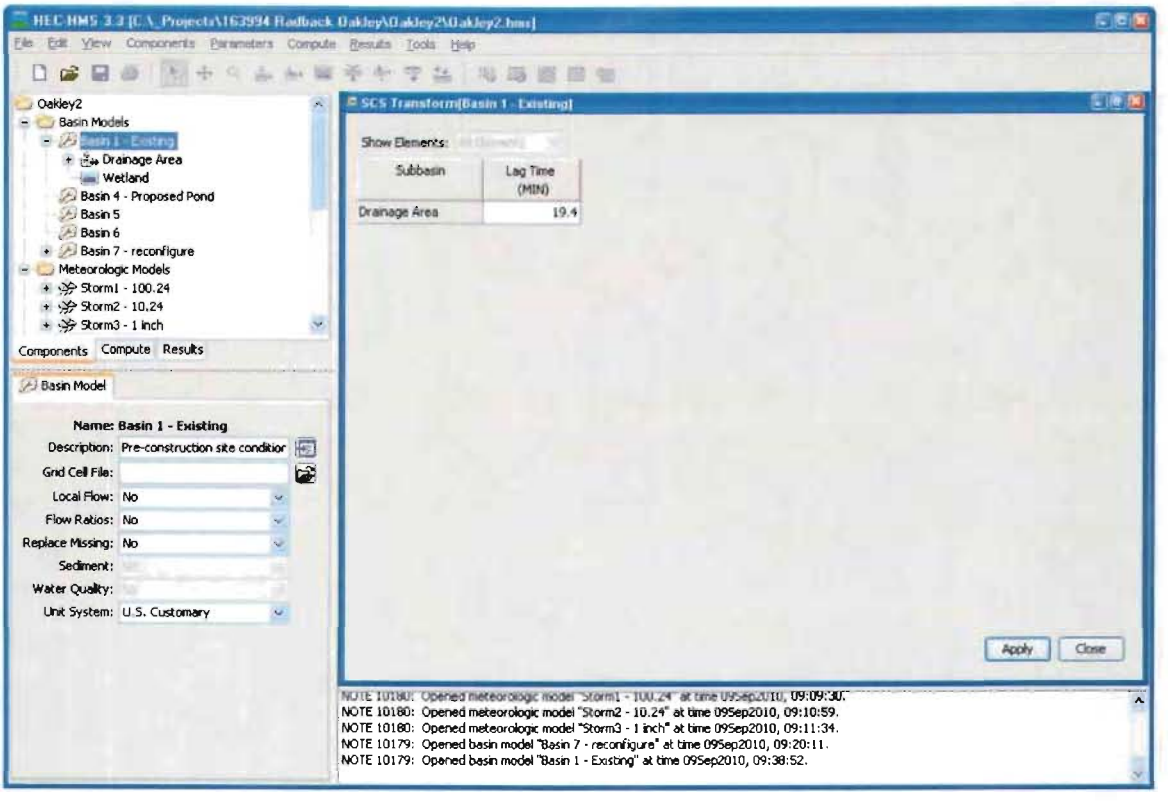
HEC-HMS INPUT

HEC-HMS Input – Basin Model 1 (Existing Condition)

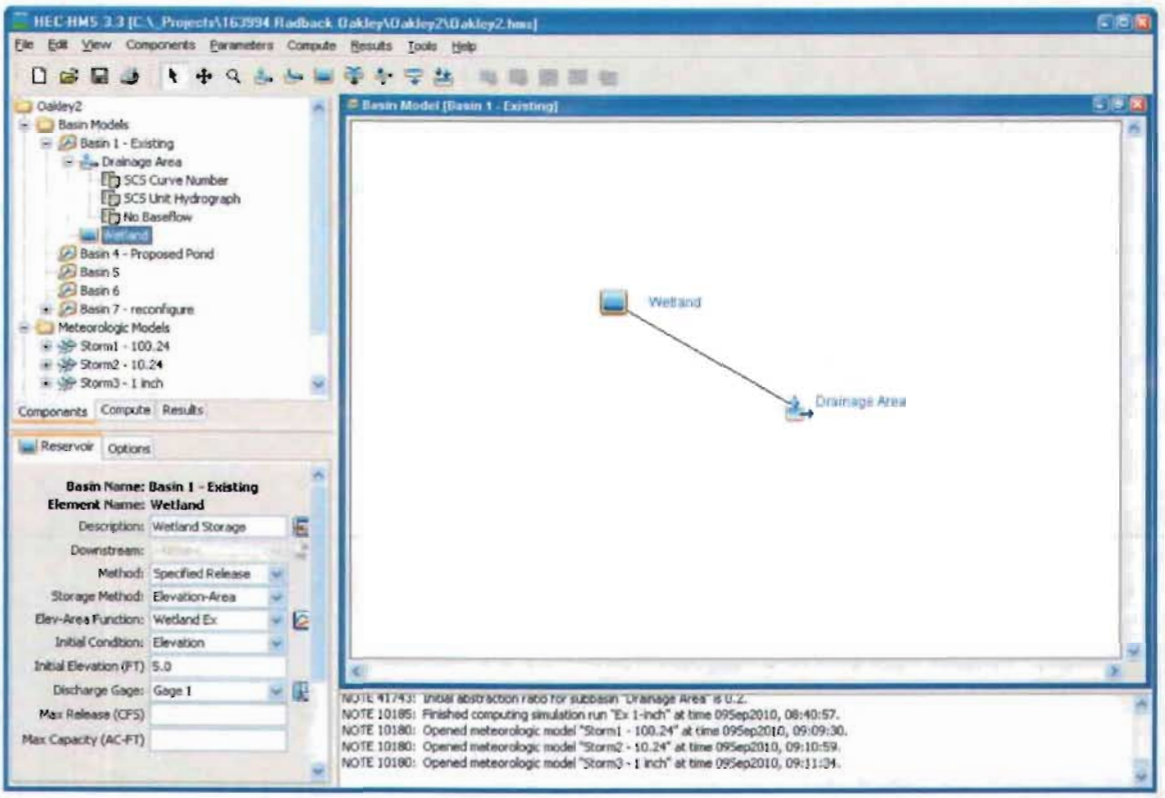


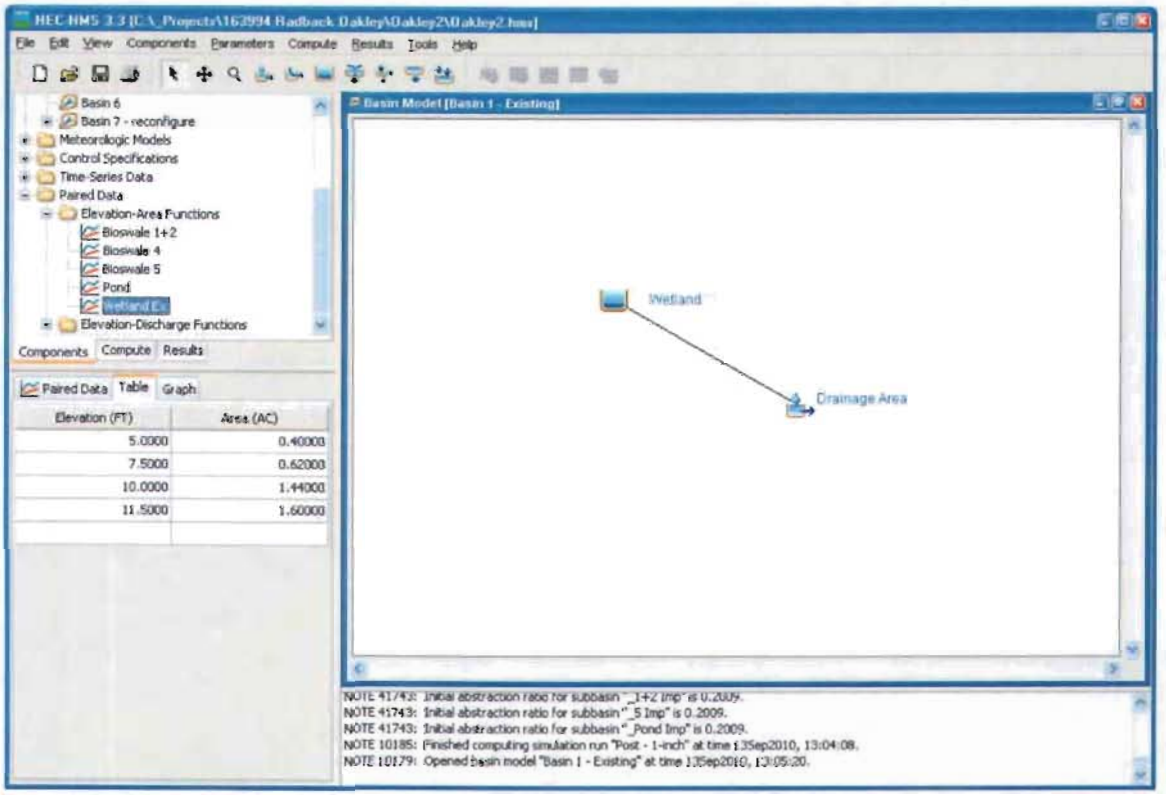



HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Oakley2
Basin Models
Basin 1 - Existing
Drainage Area
Wetland
Basin 4 - Proposed Pond
Basin 5
Basin 6
Basin 7 - reconfigure
Meteorologic Models
Storm1 - 100.24
Storm2 - 10.24
Storm3 - 1 inch
Components Compute Results
Basin Model
Name: Basin 1 - Existing
Description: Pre-construction site condition
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
Curve Number Loss [Basin 1 - Existing]
Show Elements:
Subbasin
Initial Abstraction (IN)
Curve Number
Impervious (%)
Drainage Area 0.857 70 2.6
Apply Close
NOTE 10180: Opened meteorologic model "Storm2 - 10.24" at time 09Sep2010, 09:10:59.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.


HEC-HMS 3.3 [C:_Projects\163994 Radback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Oakley2
Basin Models
Basin 1 - Existing
Drainage Area
Wetland
Basin 4 - Proposed Pond
Basin 5
Basin 6
Basin 7 - reconfigure
Meteorologic Models
Storm1 - 100.24
Storm2 - 10.24
Storm3 - 1 inch
Components Compute Results
Basin Model
Name: Basin 1 - Existing
Description: Pre-construction site condition
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
SCS Transform [Basin 1 - Existing]
Show Elements:
Subbasin
Lag Time (MIN)
Drainage Area 19.4
Apply Close
NOTE 10180: Opened meteorologic model "Storm2 - 10.24" at time 09Sep2010, 09:10:59.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.

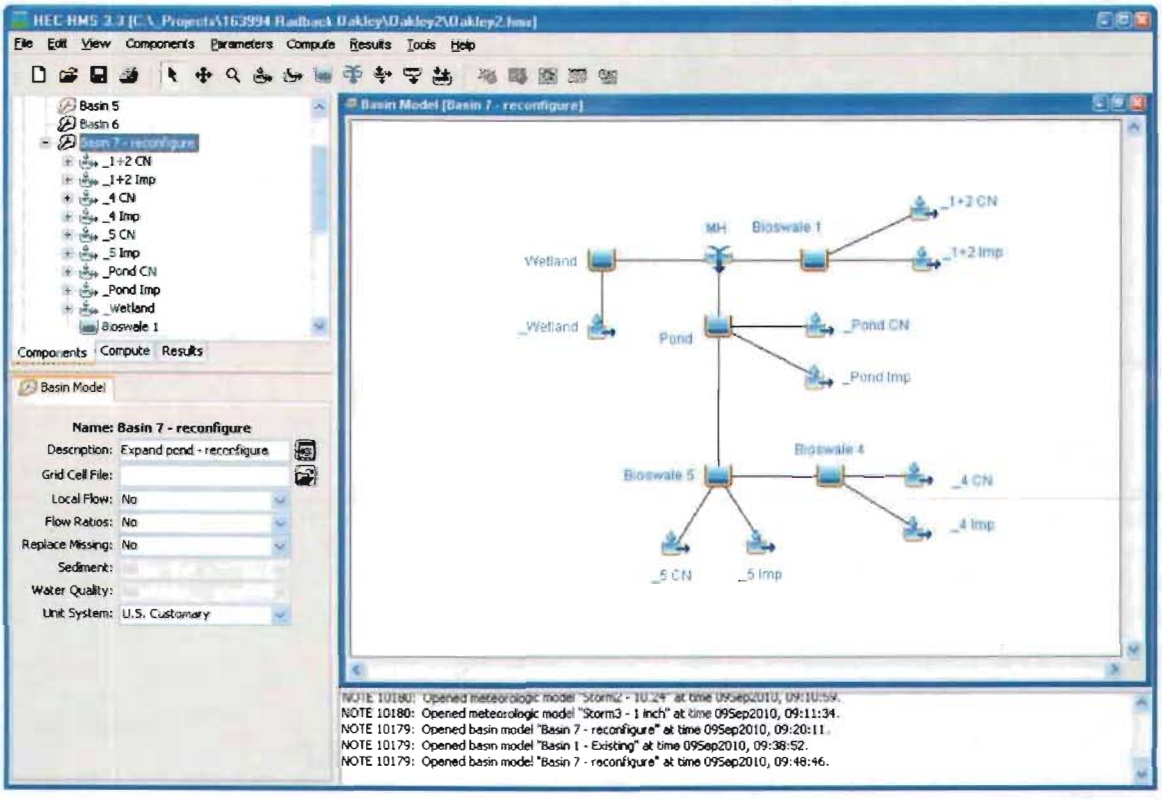
Wetland Storage Capacity Data

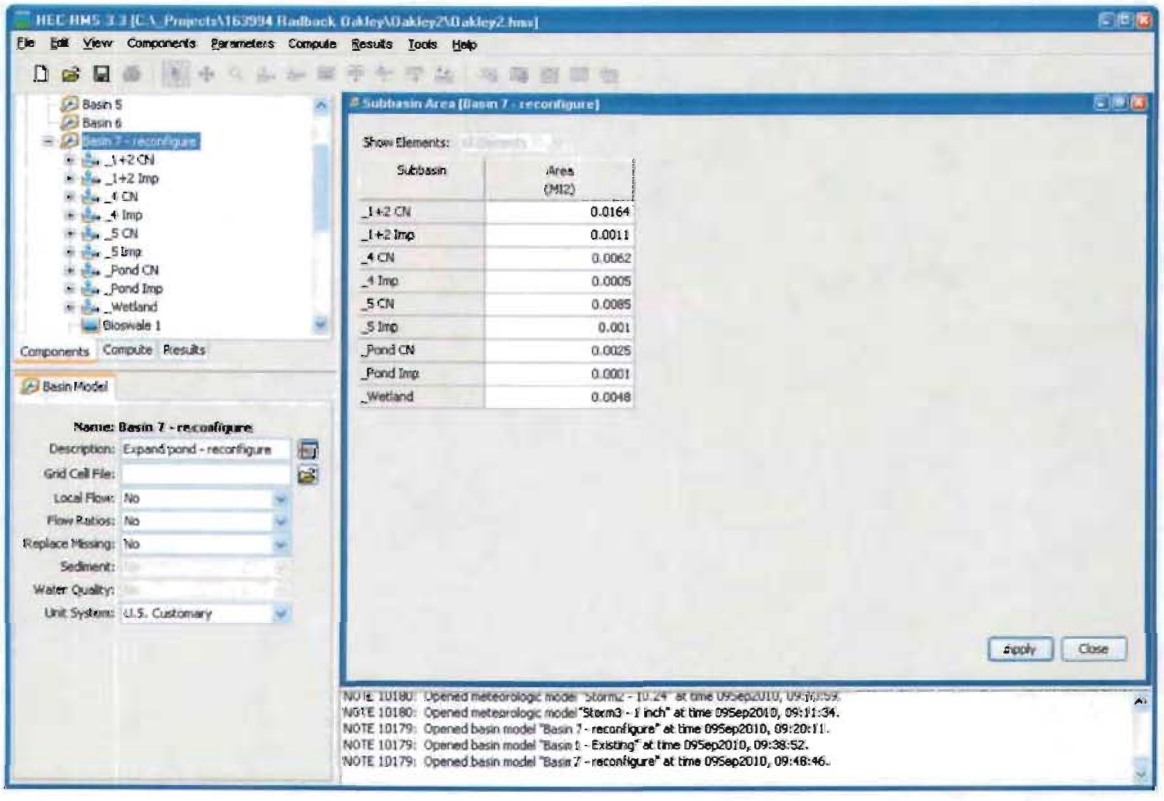




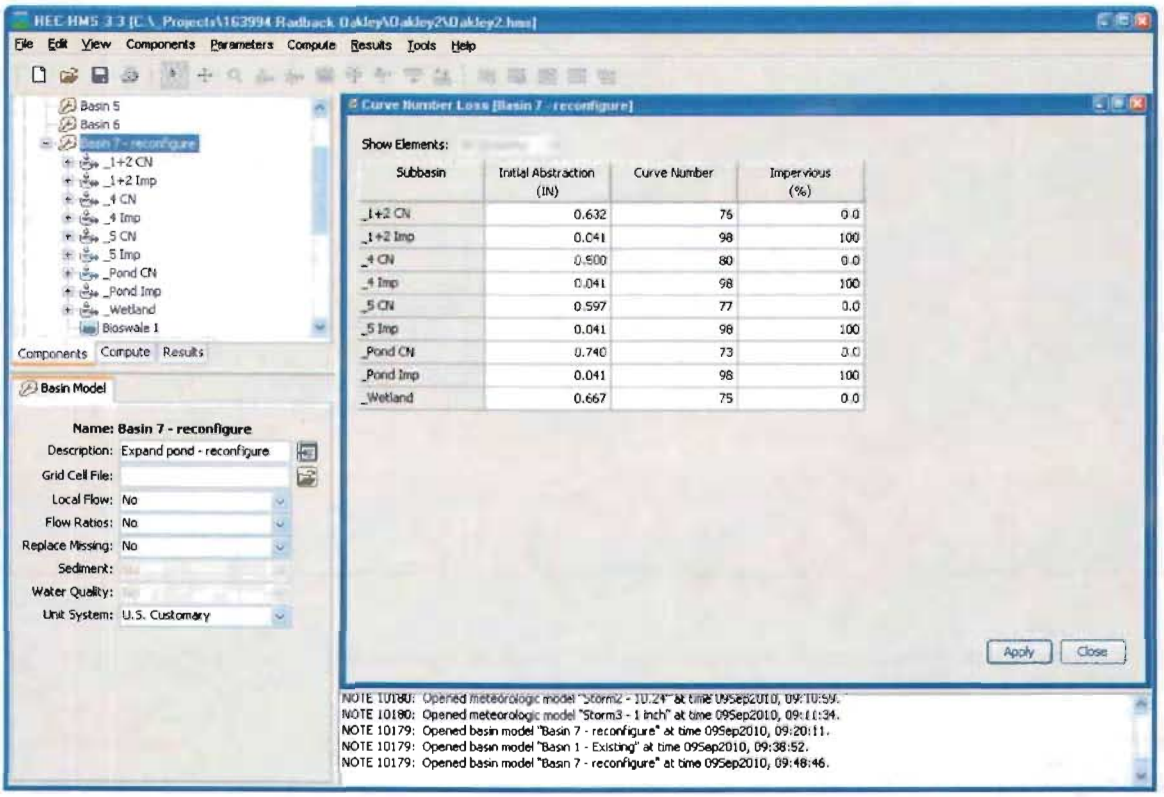
HEC-HMS Input – Basin Model 7 (Post-Construction Condition)

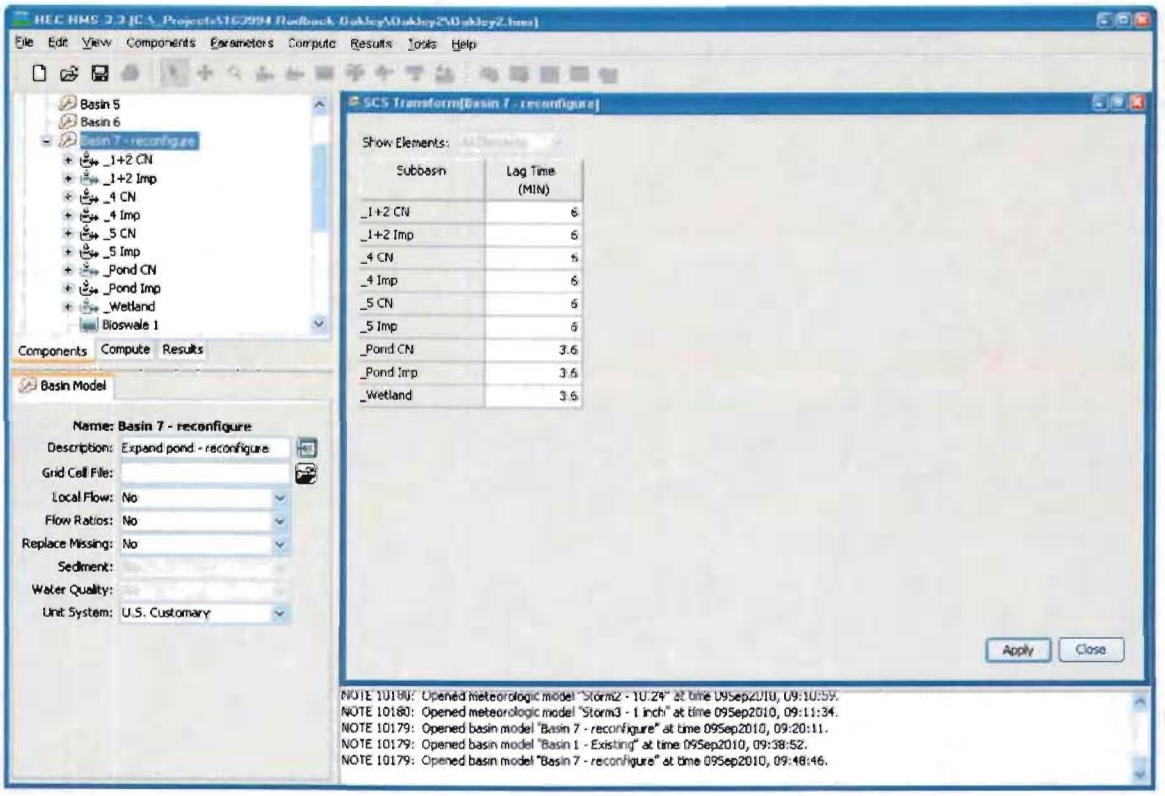
Subbasin Data



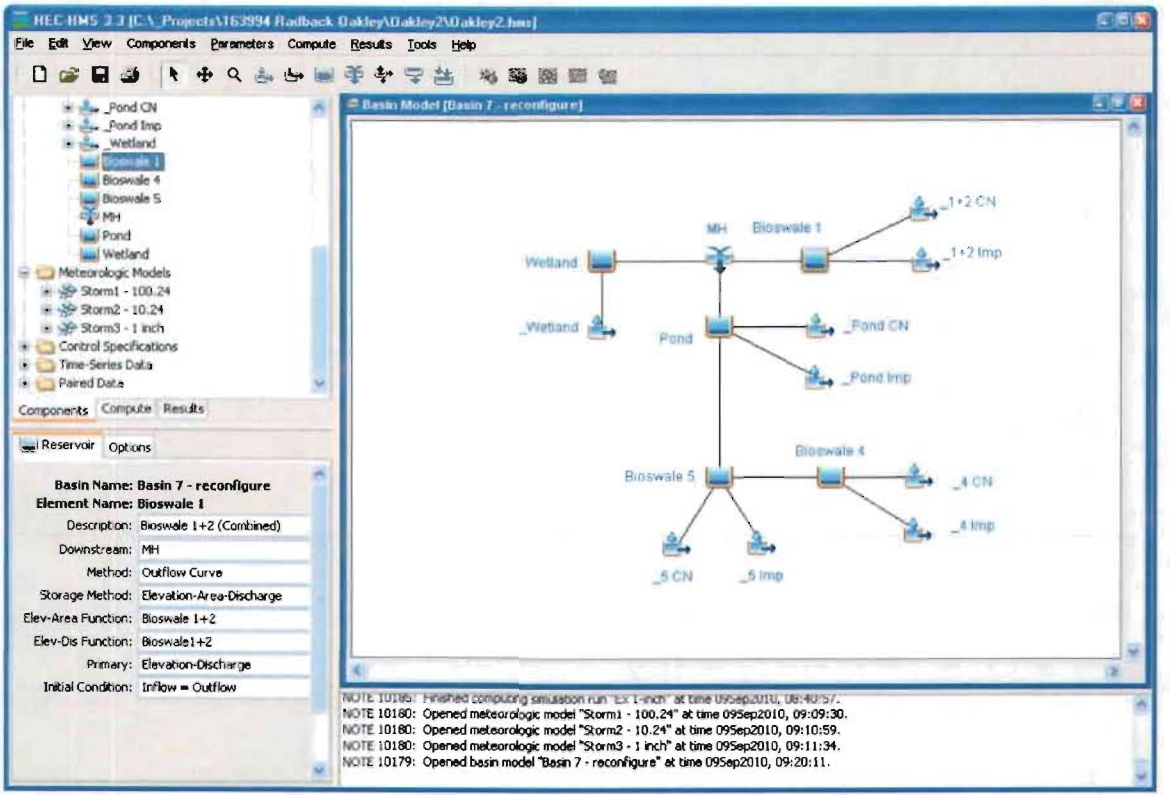


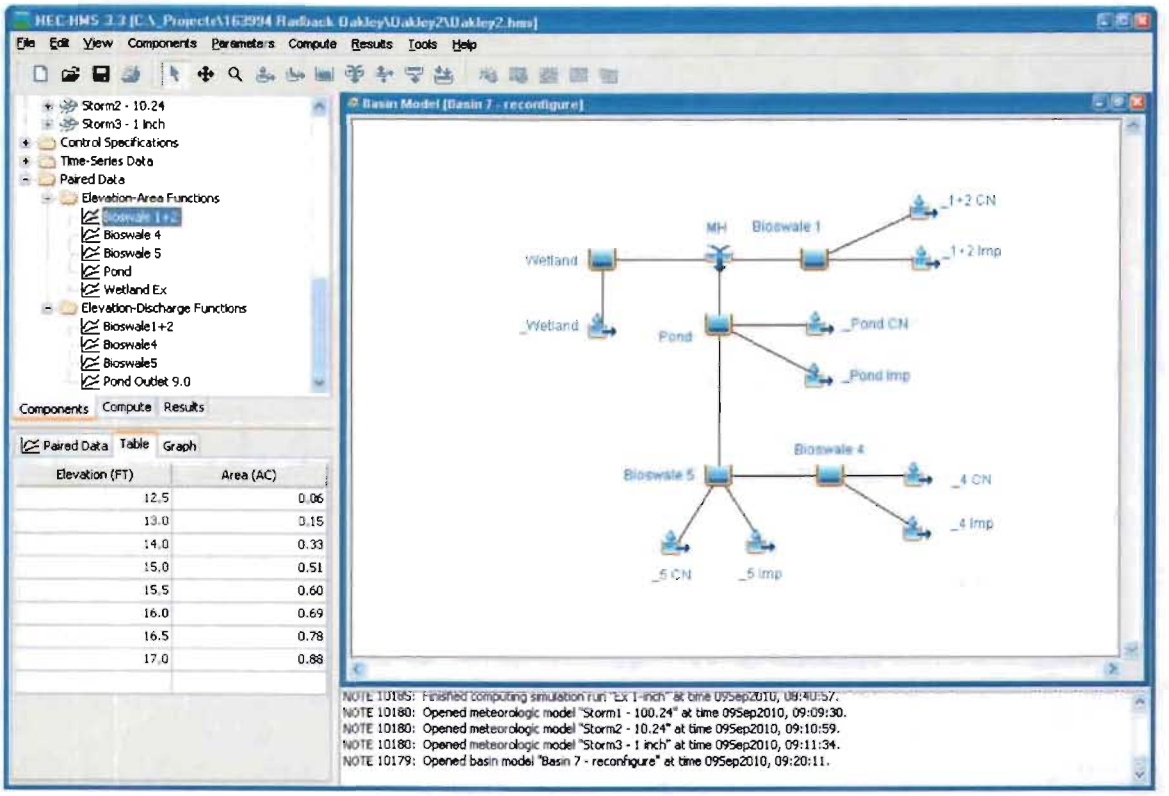
Subbasin	Area (MI2)
_1+2 CN	0.0164
_1+2 Imp	0.0011
_4 CN	0.0062
_4 Imp	0.0005
_5 CN	0.0085
_5 Imp	0.001
_Pond CN	0.0025
_Pond Imp	0.0001
_Wetland	0.0048

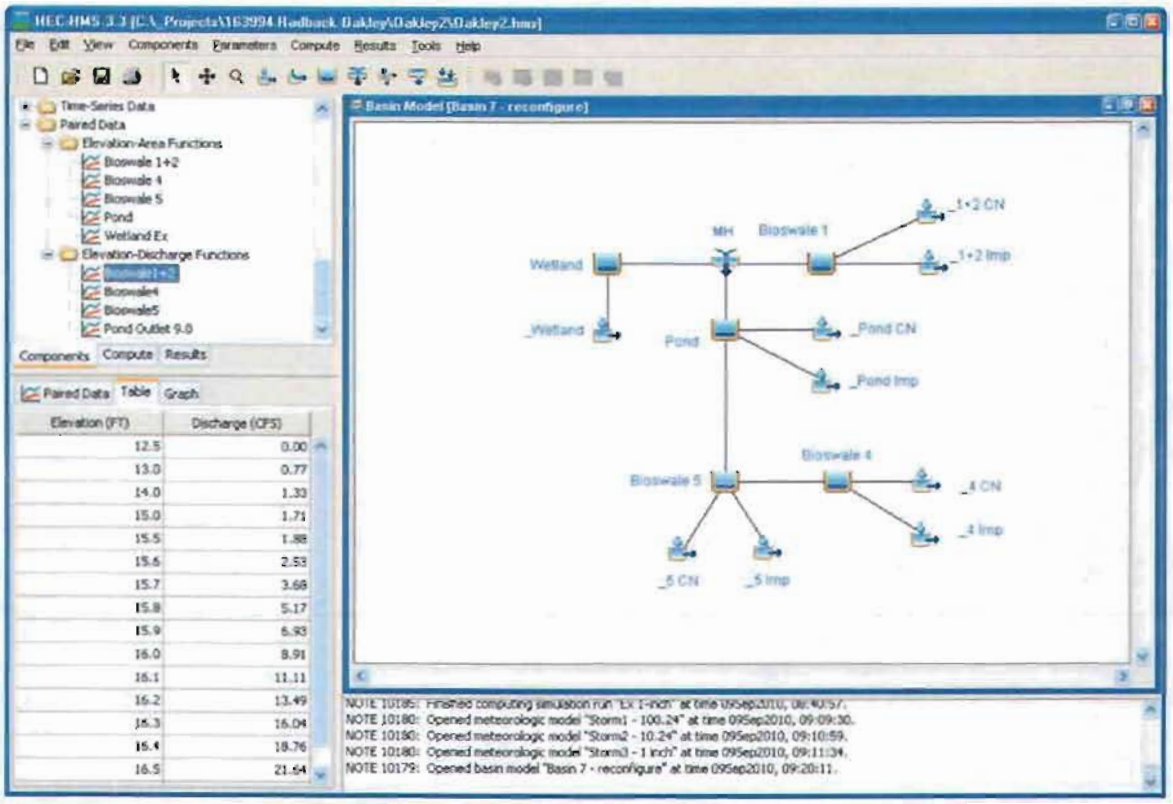

HEC-HMS 3.3 [C:_Projects\163994 Redback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Basin 5
Basin 6
Basin 7 - reconfigure
_1+2 CN
_1+2 Imp
_4 CN
_4 Imp
_5 CN
_5 Imp
_Pond CN
_Pond Imp
_Wetland
Bioswale 1
Components Compute Results
Basin Model
Name: Basin 7 - reconfigure
Description: Expand pond - reconfigure
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
Curve Number Loss [Basin 7 - reconfigure]
Show Elements:
Subbasin | Initial Abstraction (IN) | Curve Number | Impervious (%)
_1+2 CN | 0.632 | 76 | 0.0
_1+2 Imp | 0.041 | 98 | 100
_4 CN | 0.500 | 80 | 0.0
_4 Imp | 0.041 | 98 | 100
_5 CN | 0.597 | 77 | 0.0
_5 Imp | 0.041 | 98 | 100
_Pond CN | 0.740 | 73 | 0.0
_Pond Imp | 0.041 | 98 | 100
_Wetland | 0.667 | 75 | 0.0
Apply
Close
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.


HEC-HMS 3.3 [C:_Projects\163994 Redback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Basin 5
Basin 6
Basin 7 - reconfigure
_1+2 CN
_1+2 Imp
_4 CN
_4 Imp
_5 CN
_5 Imp
_Pond CN
_Pond Imp
_Wetland
Bioswale 1
Components Compute Results
Basin Model
Name: Basin 7 - reconfigure
Description: Expand pond - reconfigure
Grid Cell File:
Local Flow: No
Flow Ratios: No
Replace Missing: No
Sediment:
Water Quality:
Unit System: U.S. Customary
SCS Transform [Basin 7 - reconfigure]
Show Elements:
Subbasin | Lag Time (MIN)
_1+2 CN | 6
_1+2 Imp | 6
_4 CN | 6
_4 Imp | 6
_5 CN | 6
_5 Imp | 6
_Pond CN | 3.6
_Pond Imp | 3.6
_Wetland | 3.6
Apply
Close
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.

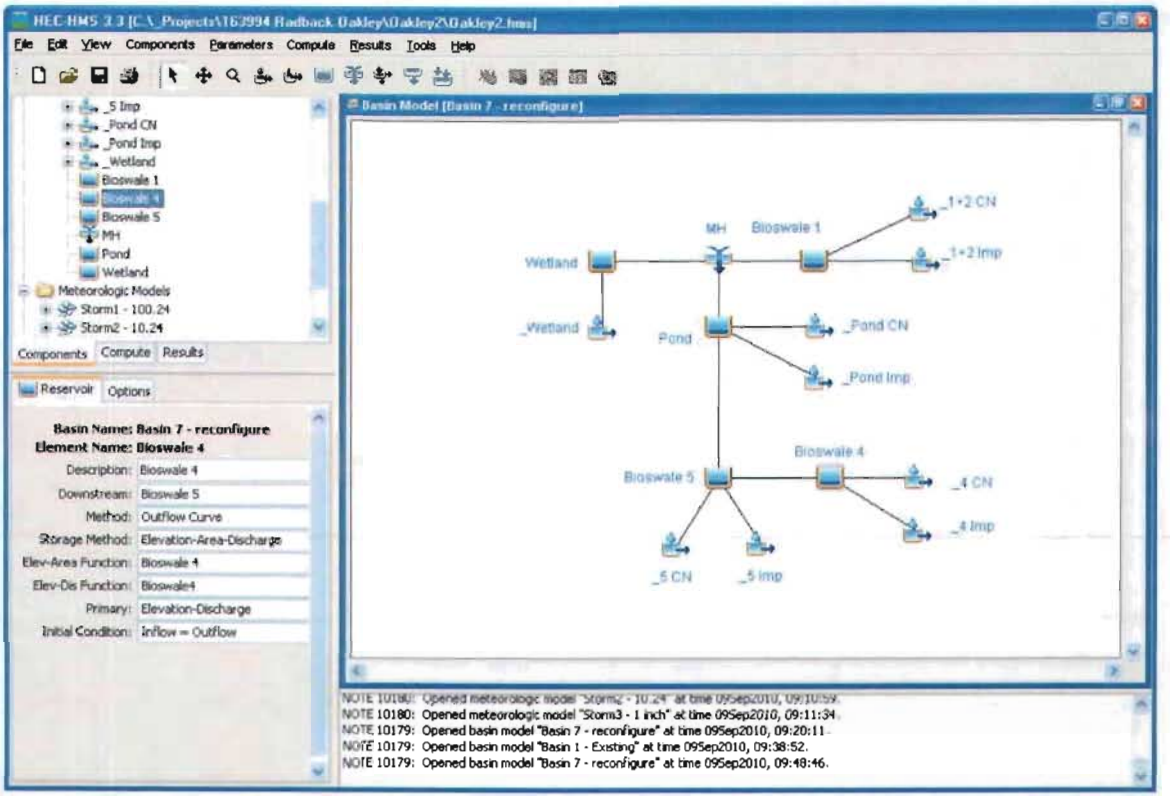
Bioswale 1 Storage Capacity & Discharge Data

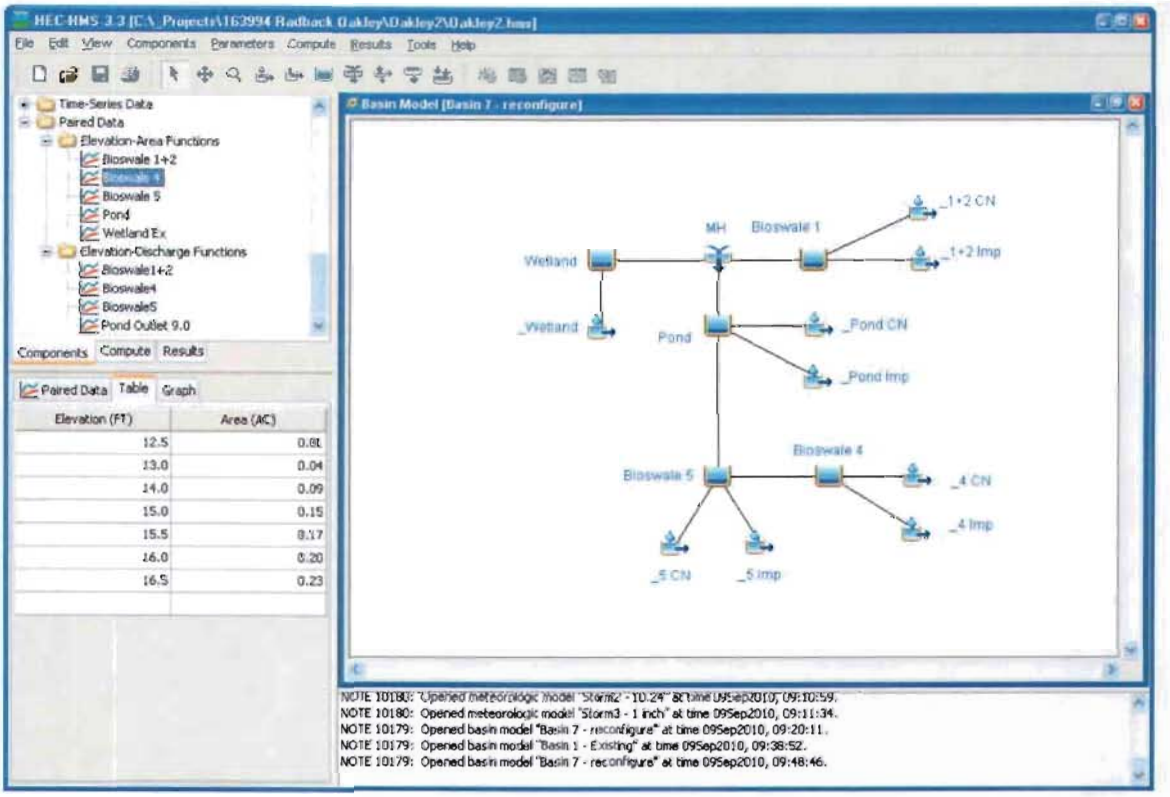


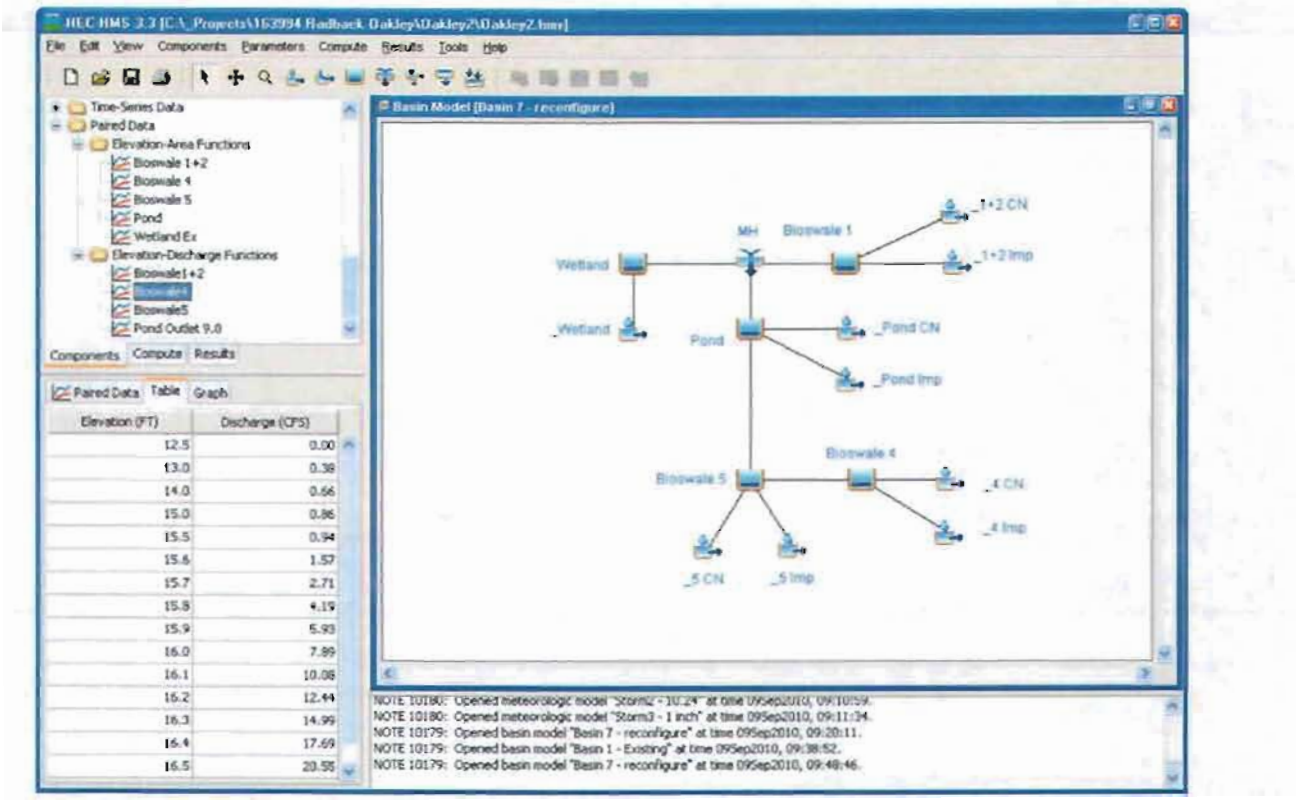



HEC-HMS 3.3 [C:_Projects\163994 Hedback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Bioswale5
Pond Outlet 9.0
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
12.5 0.00
13.0 0.77
14.0 1.33
15.0 1.71
15.5 1.88
15.6 2.53
15.7 3.68
15.8 5.17
15.9 6.93
16.0 8.91
16.1 11.11
16.2 13.49
16.3 16.04
16.4 18.76
16.5 21.64
Basin Model [Basin 7 - reconfigure]
Wetland
MH
Bioswale 1
_1+2 CN
_1+2 Imp
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 10180: Opened meteorologic model "Storm1 - 100.24" at time 09Sep2010, 09:09:30.
NOTE 10180: Opened meteorologic model "Storm2 - 10.24" at time 09Sep2010, 09:10:59.
NOTE 10180: Opened meteorologic model "Storm3 - 1 inch" at time 09Sep2010, 09:11:34.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.

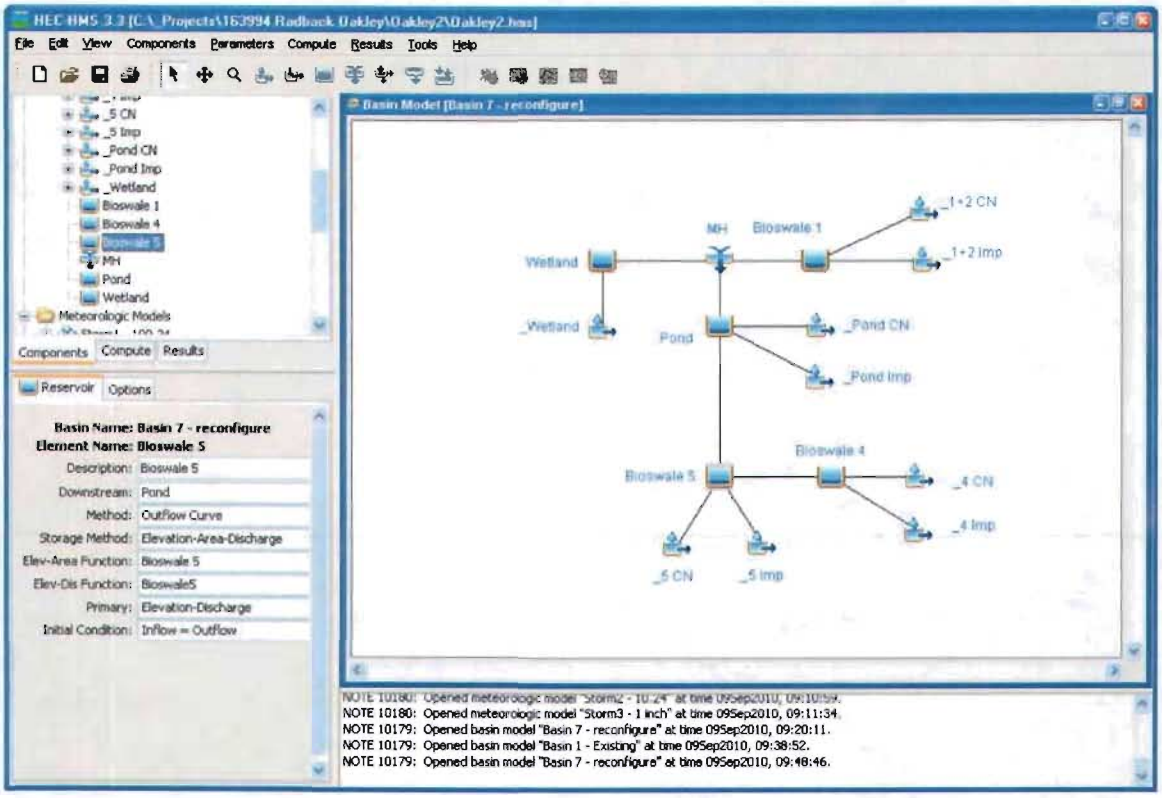
Bioswale 4 Storage Capacity & Discharge Data

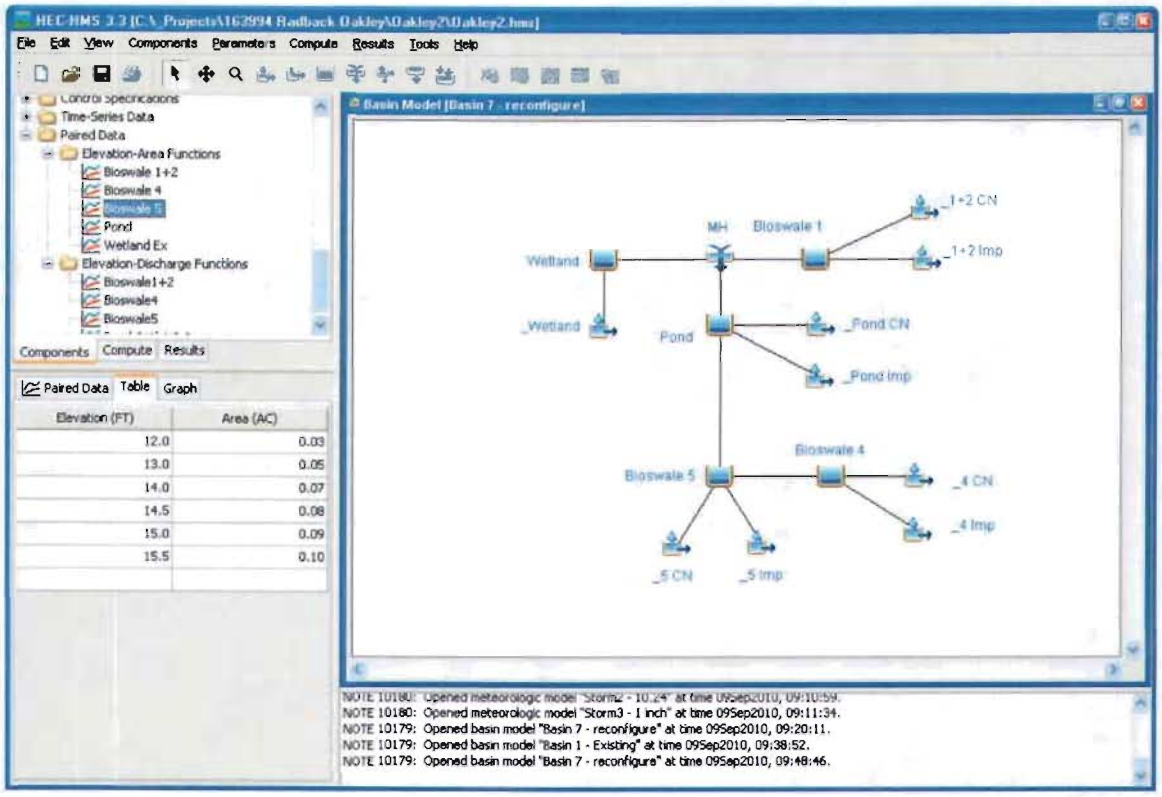


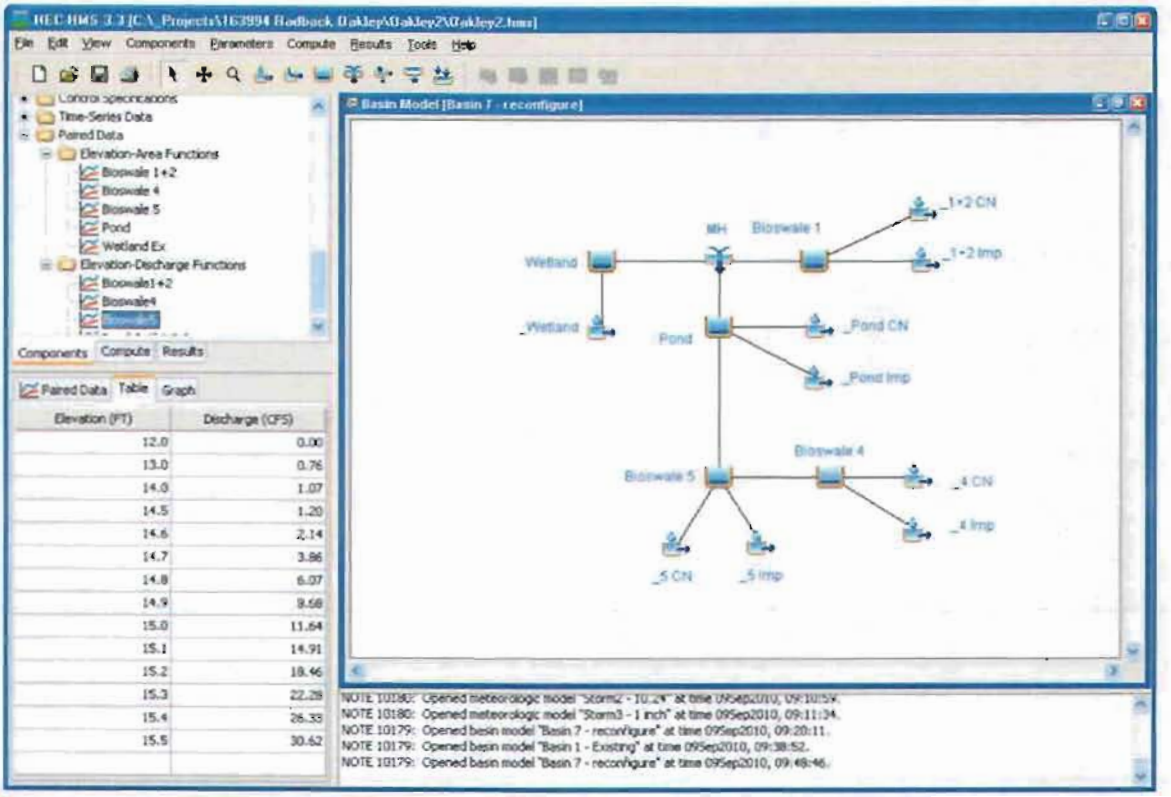



HEC-HMS 3.3 [C:_Projects\163994 Radbeck Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Bioswale5
Pond Outlet 9.0
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
12.5 0.00
13.0 0.38
14.0 0.66
15.0 0.86
15.5 0.94
15.6 1.57
15.7 2.71
15.8 4.19
15.9 5.93
16.0 7.89
16.1 10.08
16.2 12.44
16.3 14.99
16.4 17.69
16.5 20.55
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.

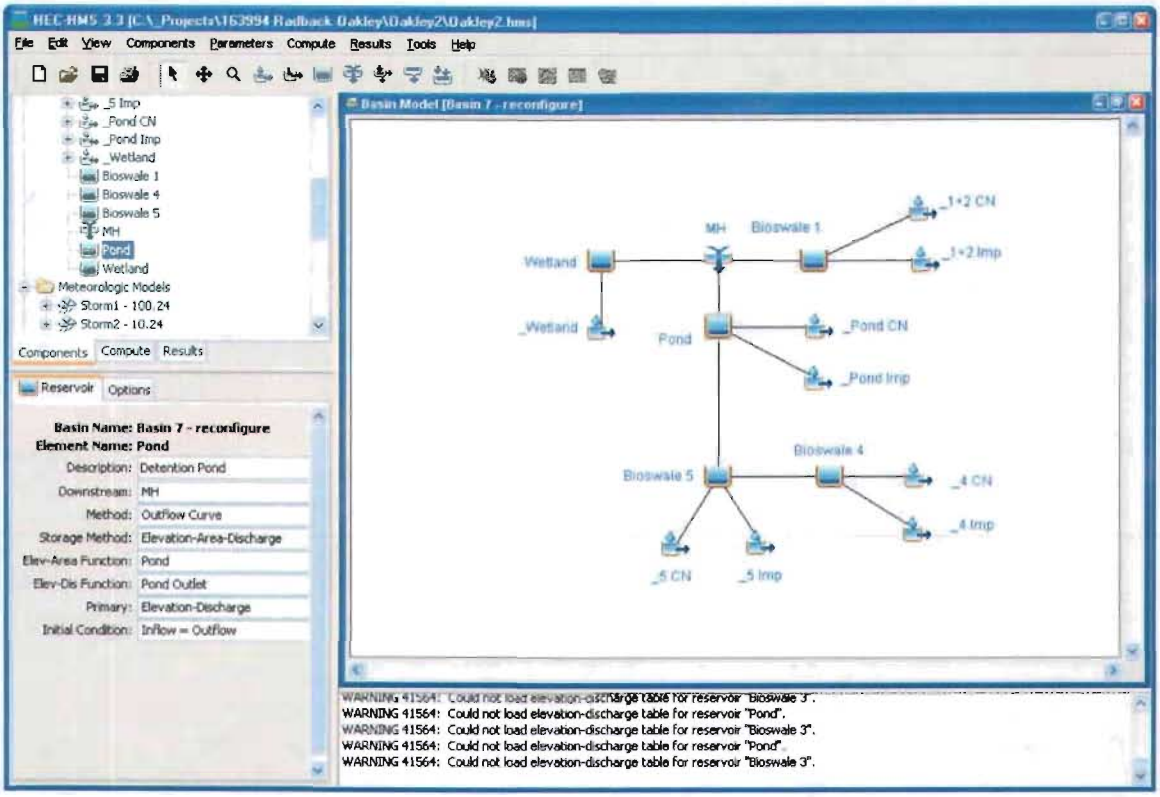
Bioswale 5 Storage Capacity & Discharge Data

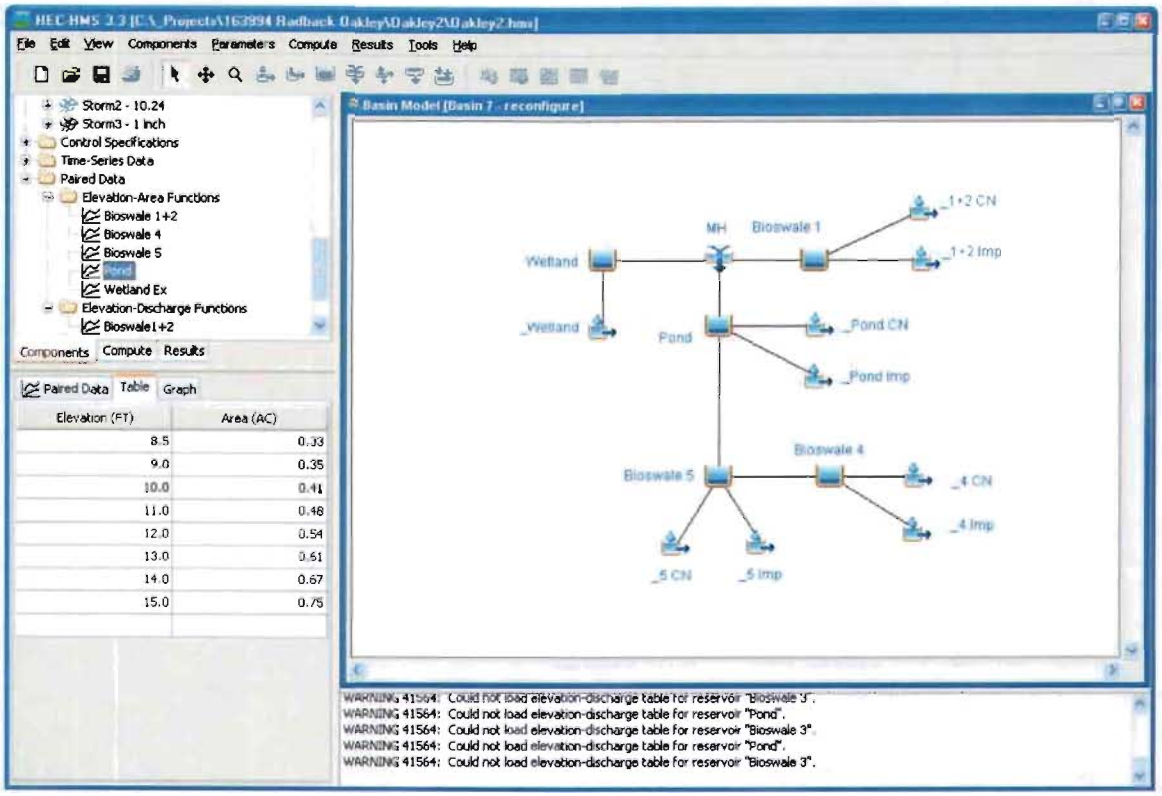


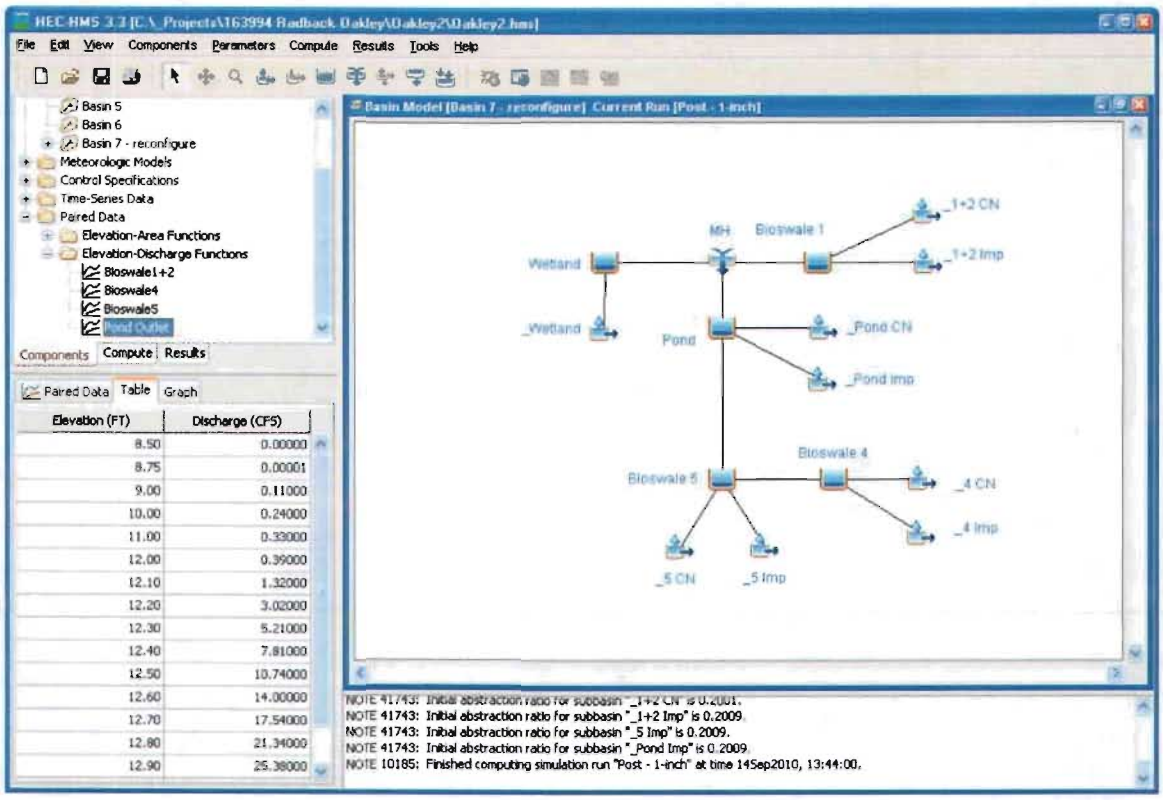



HEC-HMS 3.3 [C:_Projects\163994 Hodback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
Control Specifications
Time-Series Data
Paired Data
Elevation-Area Functions
Bioswale 1+2
Bioswale 4
Bioswale 5
Pond
Wetland Ex
Elevation-Discharge Functions
Bioswale1+2
Bioswale4
Components Compute Results
Paired Data Table Graph
Elevation (FT) Discharge (CFS)
12.0 0.00
13.0 0.76
14.0 1.07
14.5 1.20
14.6 2.14
14.7 3.86
14.8 6.07
14.9 9.68
15.0 11.64
15.1 14.91
15.2 18.46
15.3 22.28
15.4 26.33
15.5 30.62
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:20:11.
NOTE 10179: Opened basin model "Basin 1 - Existing" at time 09Sep2010, 09:38:52.
NOTE 10179: Opened basin model "Basin 7 - reconfigure" at time 09Sep2010, 09:48:46.

Pond Storage Capacity & Discharge Data

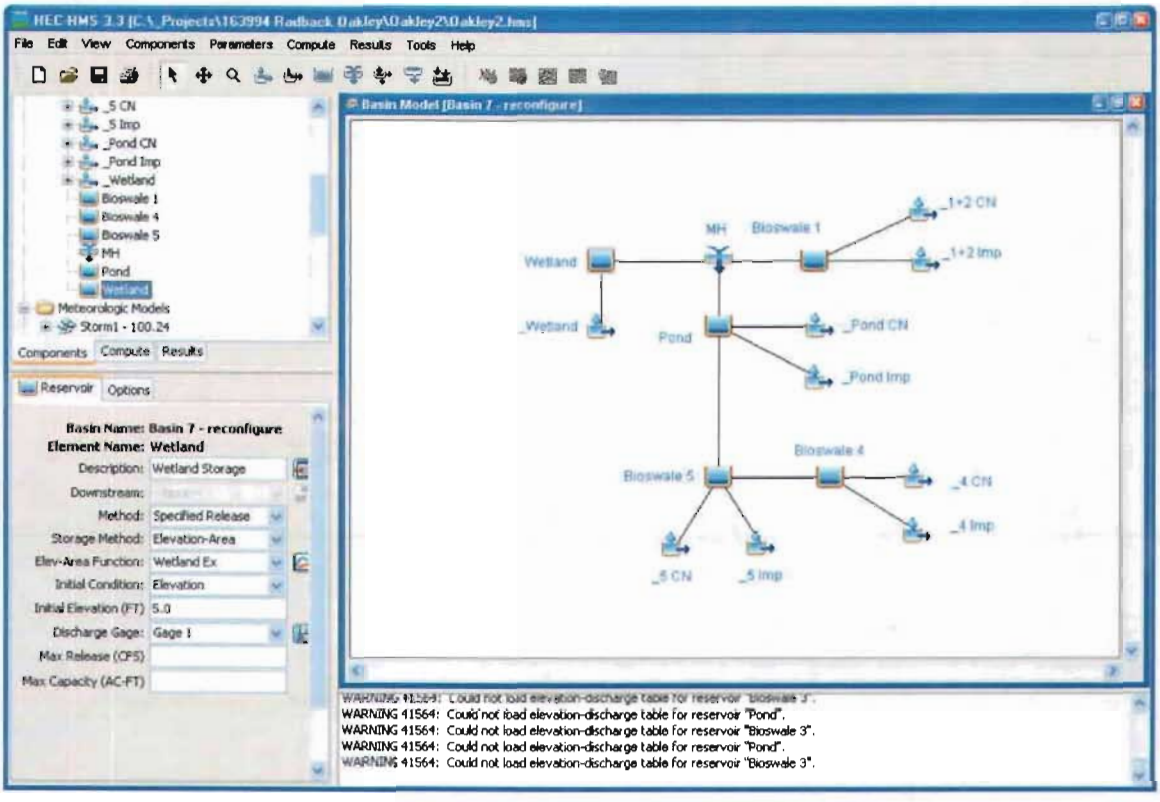


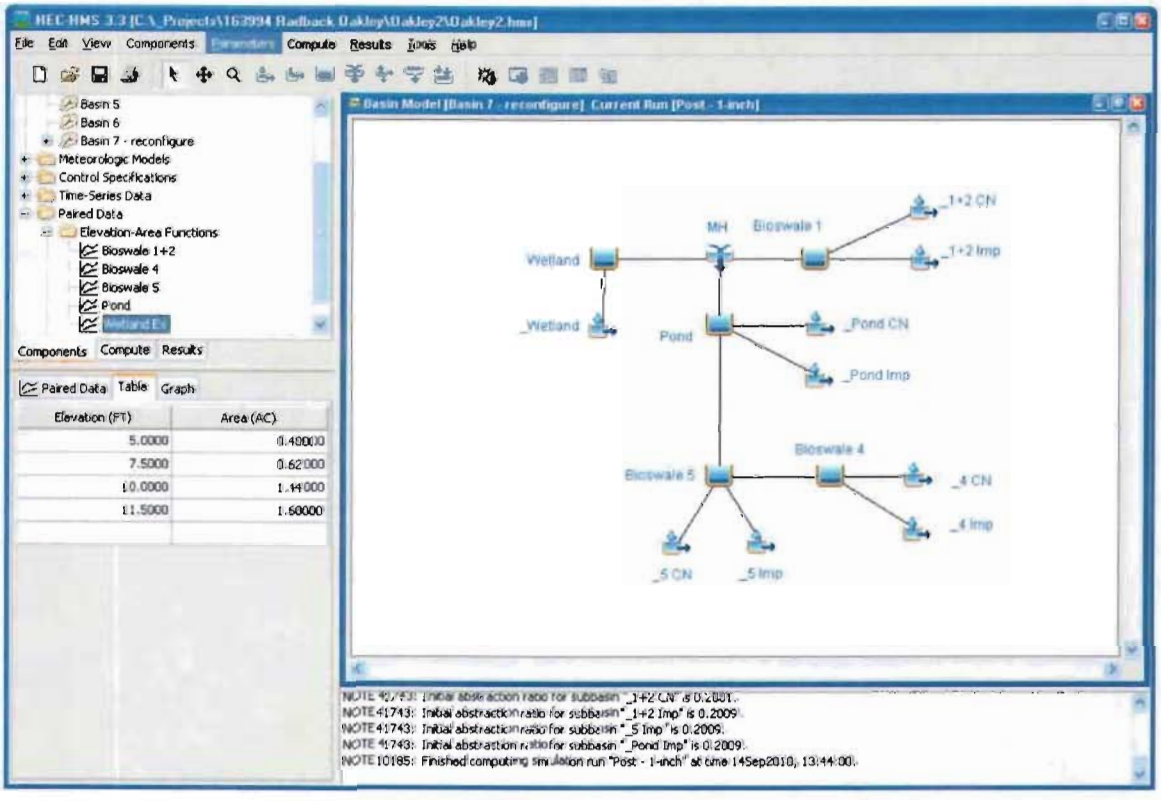


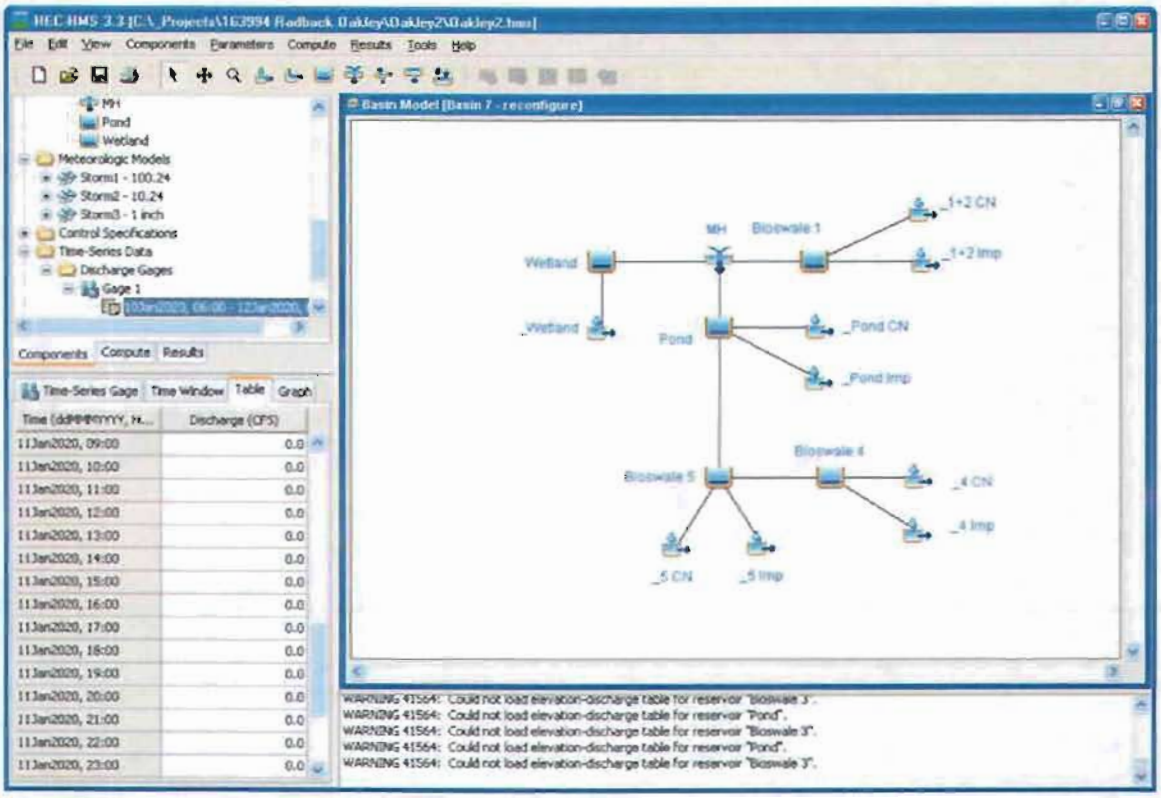


Elevation (FT)	Discharge (CFS)
8.50	0.00000
8.75	0.00001
9.00	0.11000
10.00	0.24000
11.00	0.33000
12.00	0.39000
12.10	1.32000
12.20	3.02000
12.30	5.21000
12.40	7.81000
12.50	10.74000
12.60	14.00000
12.70	17.54000
12.80	21.34000
12.90	25.38000

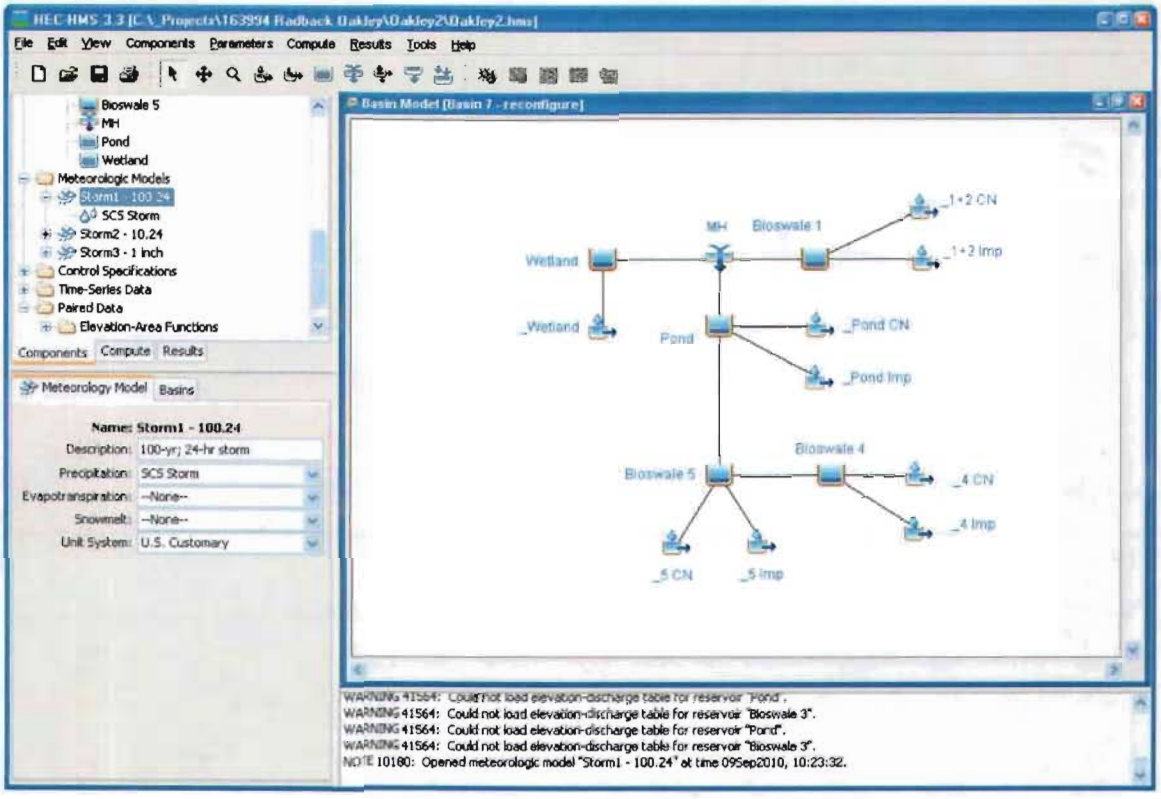
Wetland Storage Capacity Data

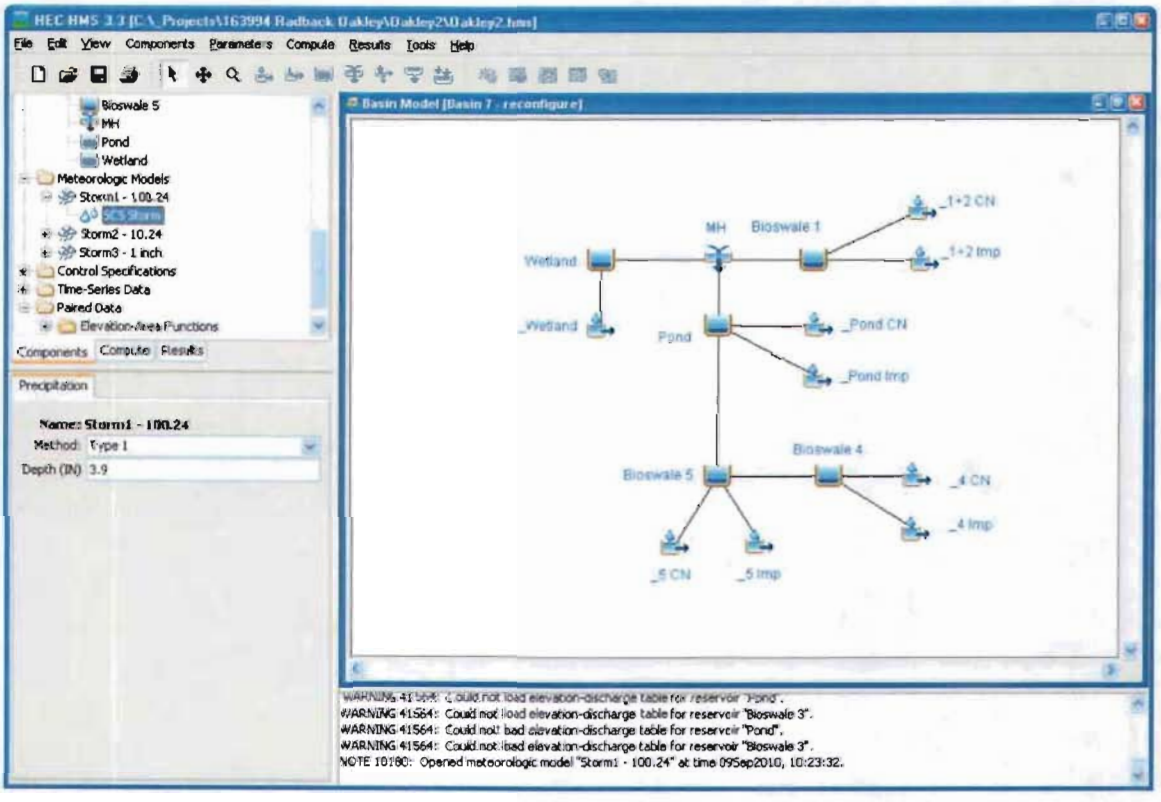




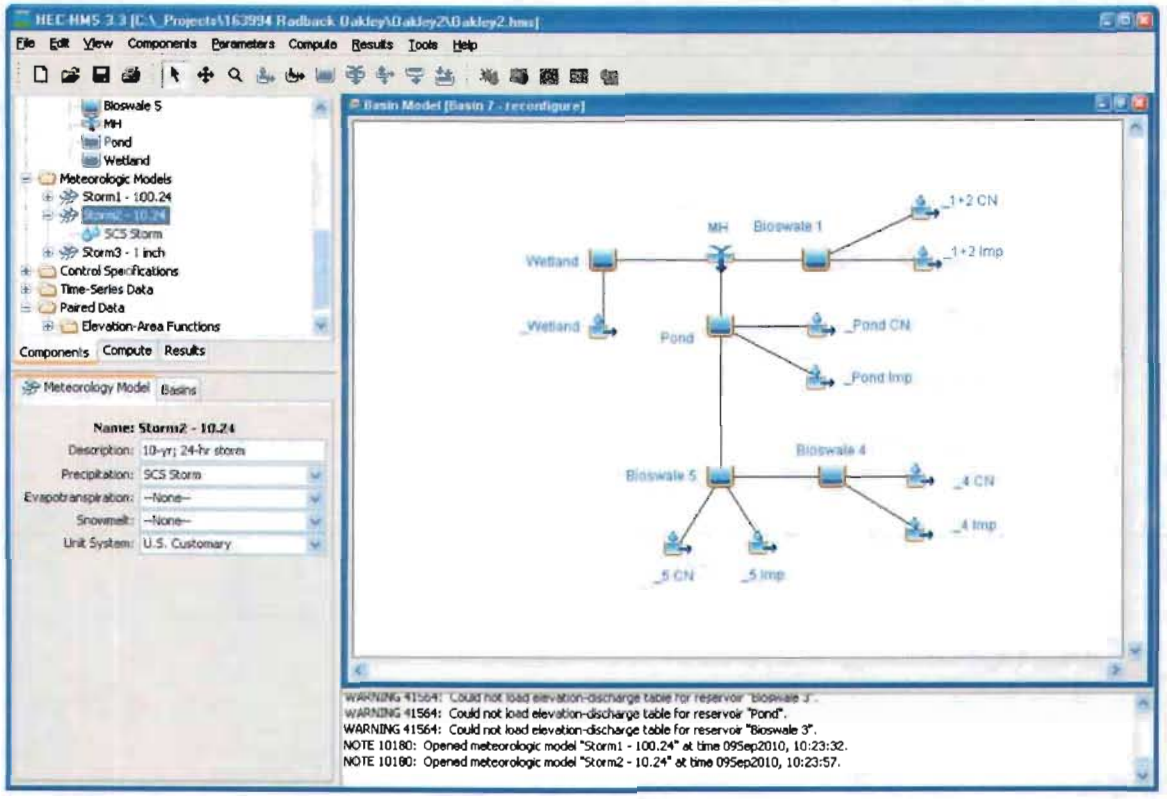

HEC-HMS 3.3.1[C:_Projects\163994 Redback Oakley\Oakley2\Oakley2.hms]
File Edit View Components Parameters Compute Results Tools Help
MH
Pond
Wetland
Meteorologic Models
Storm1 - 100.24
Storm2 - 10.24
Storm3 - 1 inch
Control Specifications
Time-Series Data
Discharge Gages
Gage 1
Components Compute Results
Time-Series Gage Time Window Table Graph
Time (ddMMMYYYY, H... Discharge (CFS)
11Jan2020, 09:00 0.0
11Jan2020, 10:00 0.0
11Jan2020, 11:00 0.0
11Jan2020, 12:00 0.0
11Jan2020, 13:00 0.0
11Jan2020, 14:00 0.0
11Jan2020, 15:00 0.0
11Jan2020, 16:00 0.0
11Jan2020, 17:00 0.0
11Jan2020, 18:00 0.0
11Jan2020, 19:00 0.0
11Jan2020, 20:00 0.0
11Jan2020, 21:00 0.0
11Jan2020, 22:00 0.0
11Jan2020, 23:00 0.0
Basin Model [Basin 7 - reconfigure]
MH
Bioswale 1
_1+2 CN
_1+2 Imp
Wetland
_Wetland
Pond
_Pond CN
_Pond Imp
Bioswale 4
Bioswale 5
_4 CN
_4 Imp
_5 CN
_5 Imp
WARNING 41564: Could not load elevation-discharge table for reservoir "Bioswale 3".
WARNING 41564: Could not load elevation-discharge table for reservoir "Pond".
WARNING 41564: Could not load elevation-discharge table for reservoir "Bioswale 3".
WARNING 41564: Could not load elevation-discharge table for reservoir "Pond".
WARNING 41564: Could not load elevation-discharge table for reservoir "Bioswale 3".

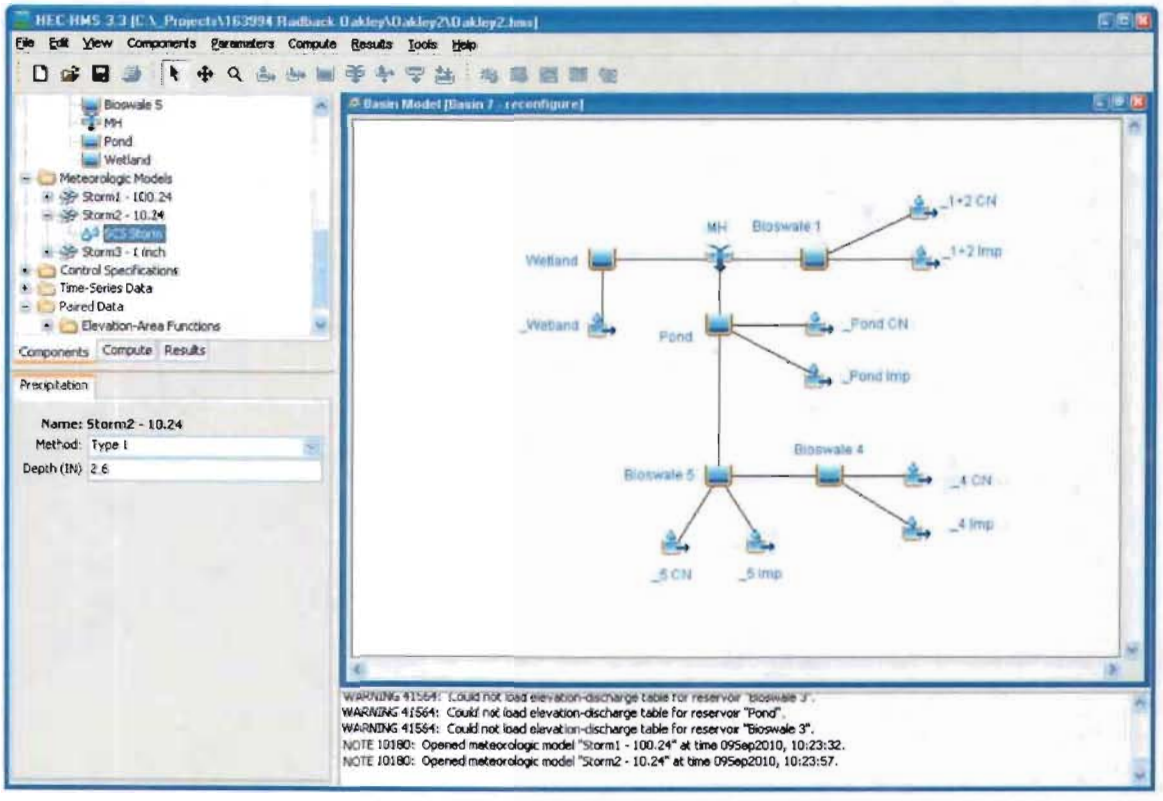
HEC-HMS Input – Meteorologic Model Storm1 – 100-year, 24-hour storm



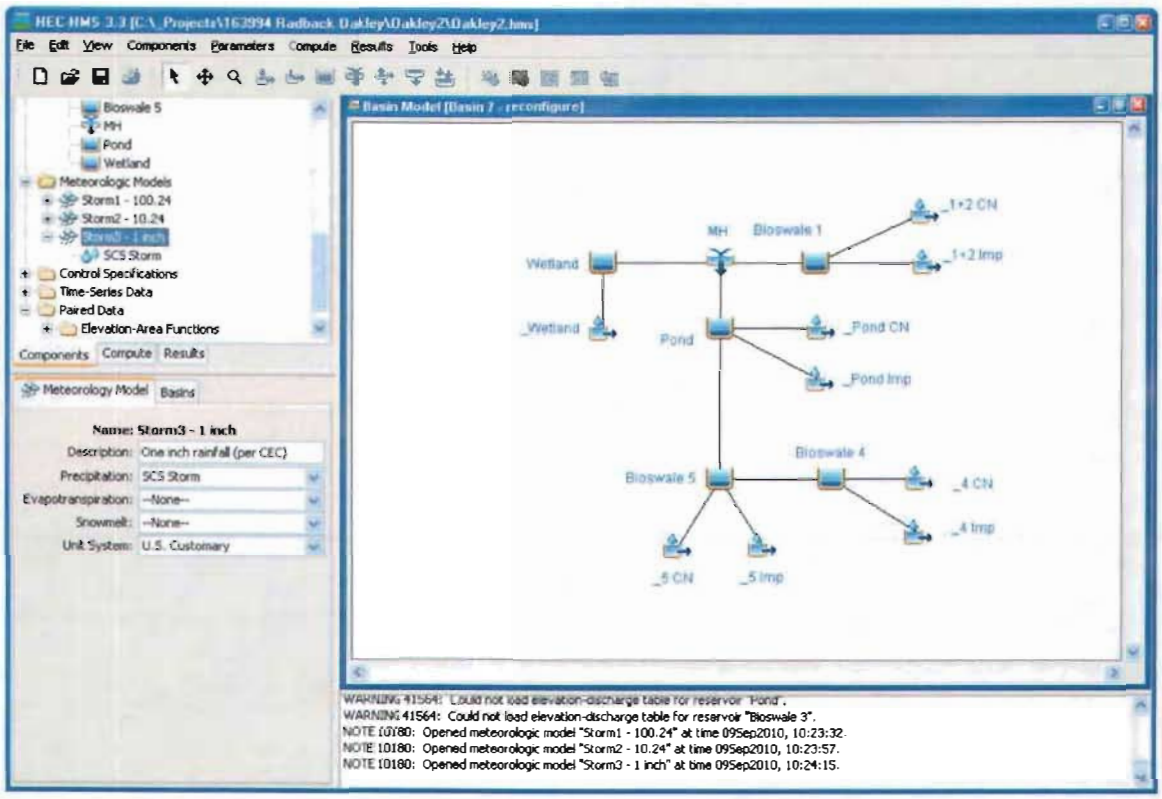


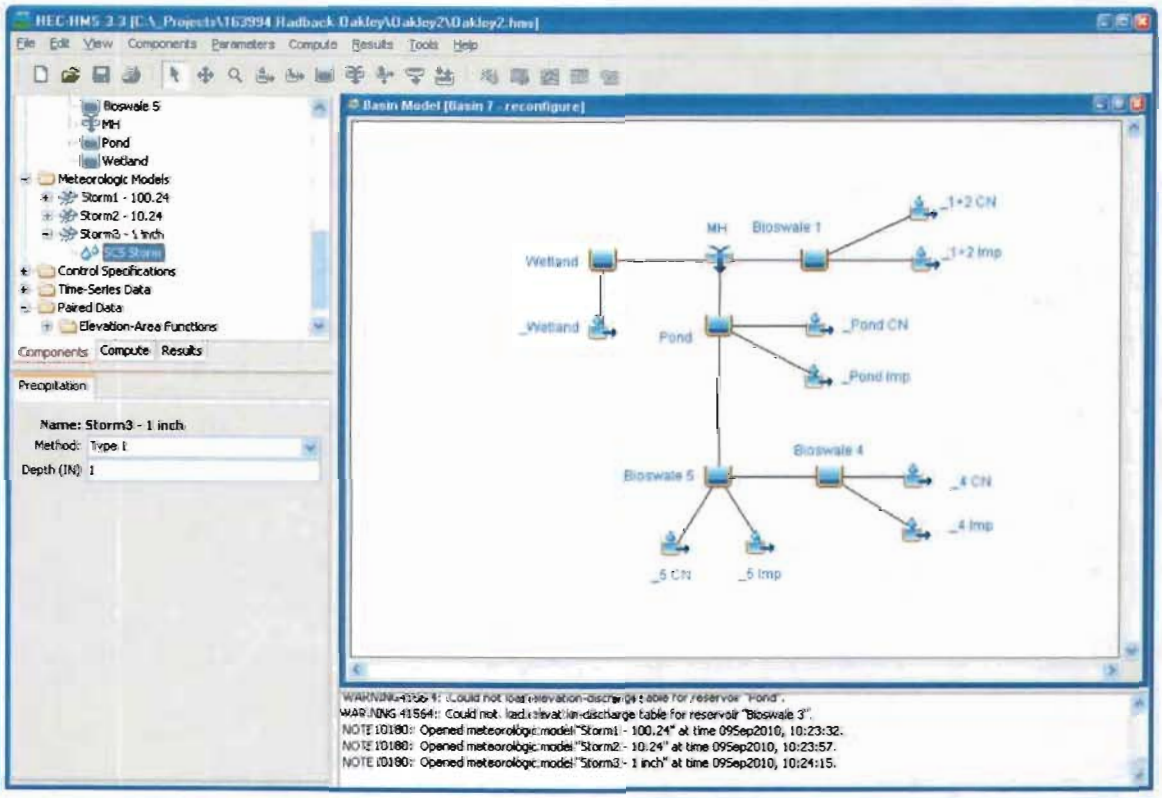
HEC-HMS Input – Meteorologic Model Storm2 – 10-year, 24-hour storm



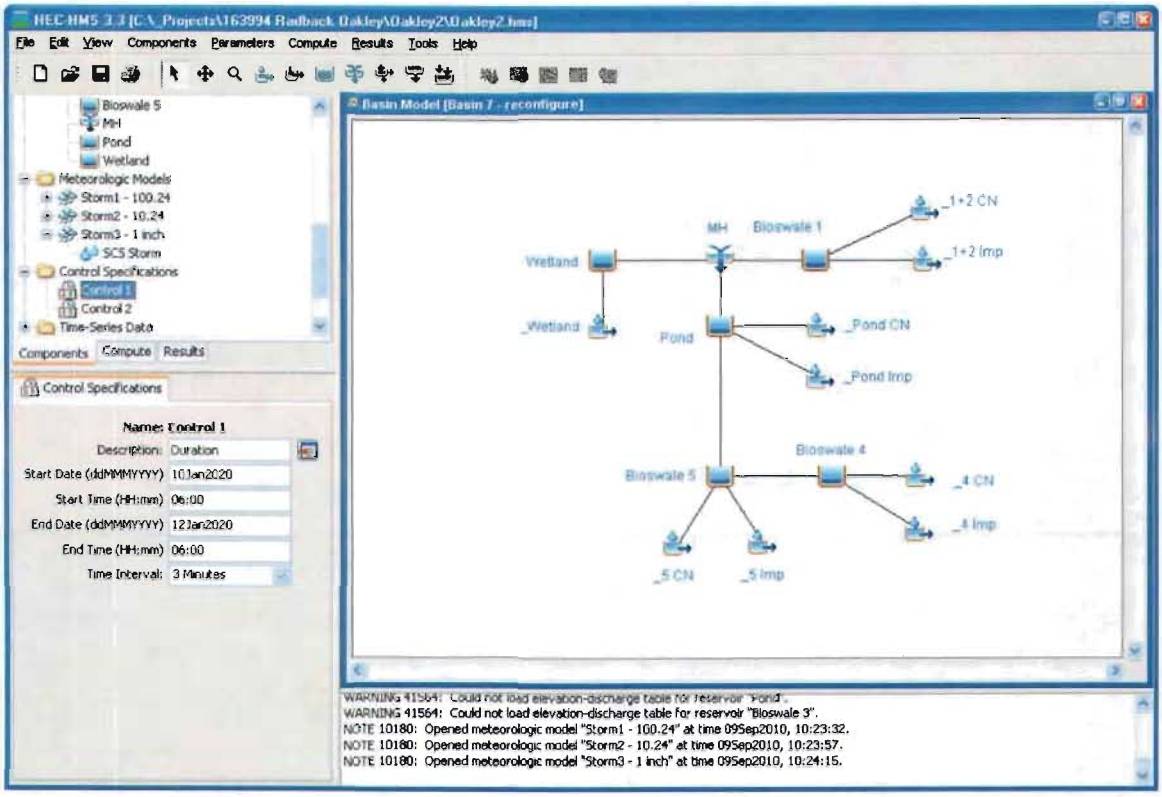


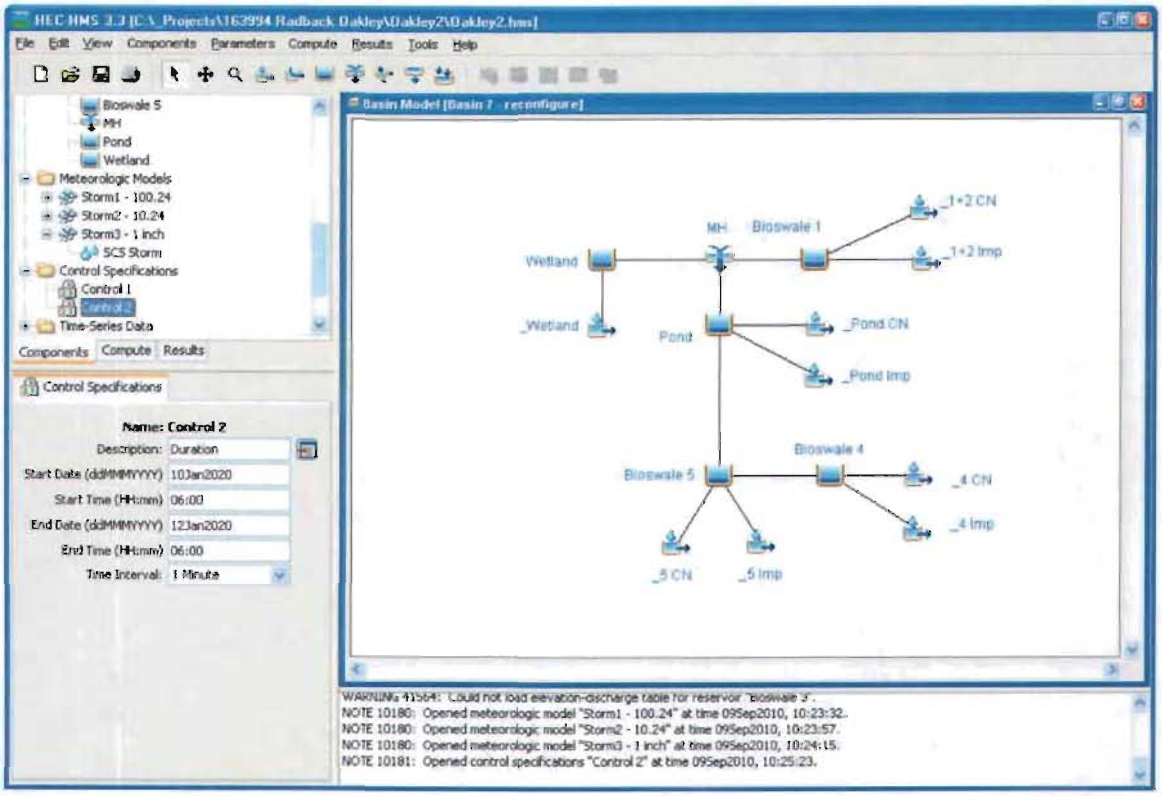
HEC-HMS Input – Meteorologic Model Storm3 – 1-inch rainfall





HEC-HMS Input – Control Data





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Attachment 2

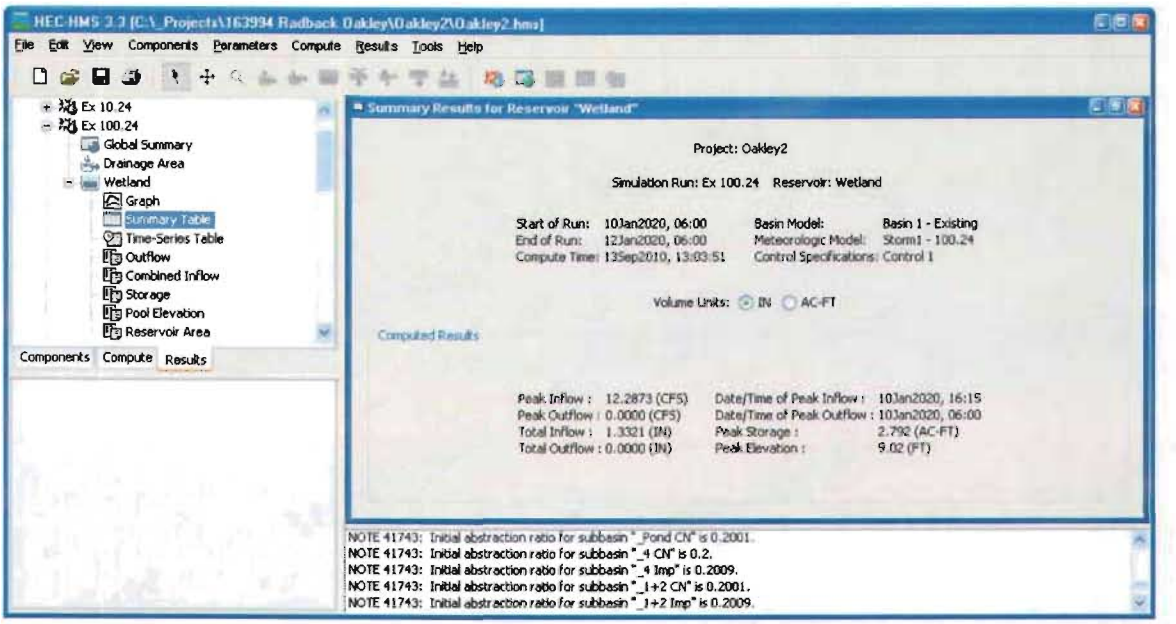
~~Reference~~

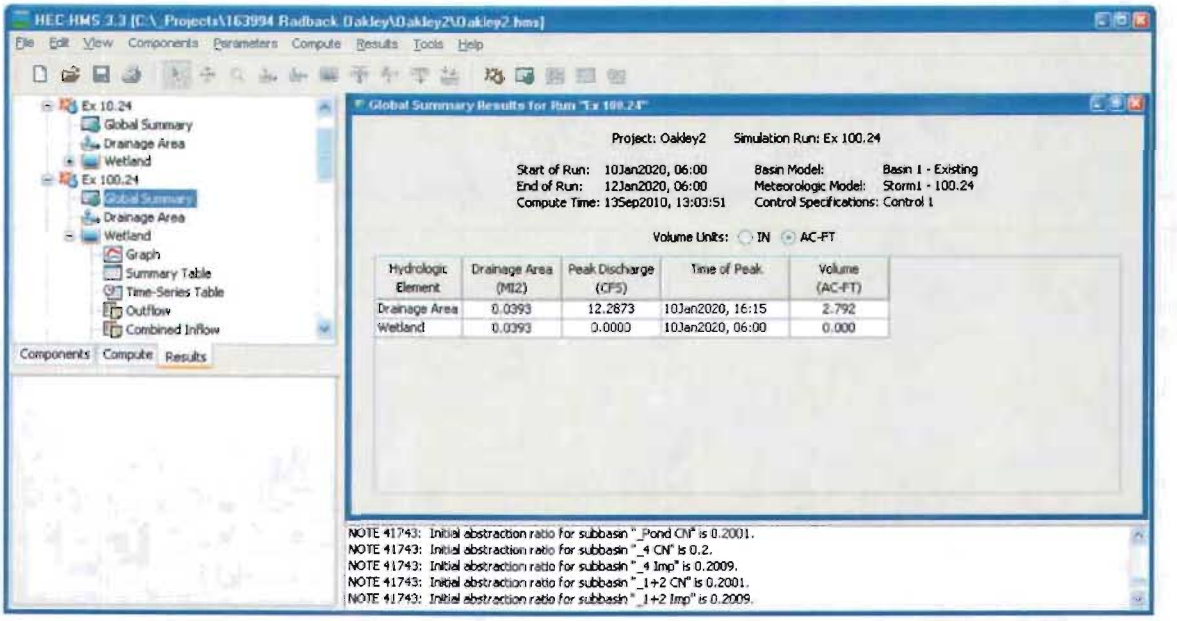
HEC-HMS OUTPUT

Description Key for HEC-HMS Input/Output Data

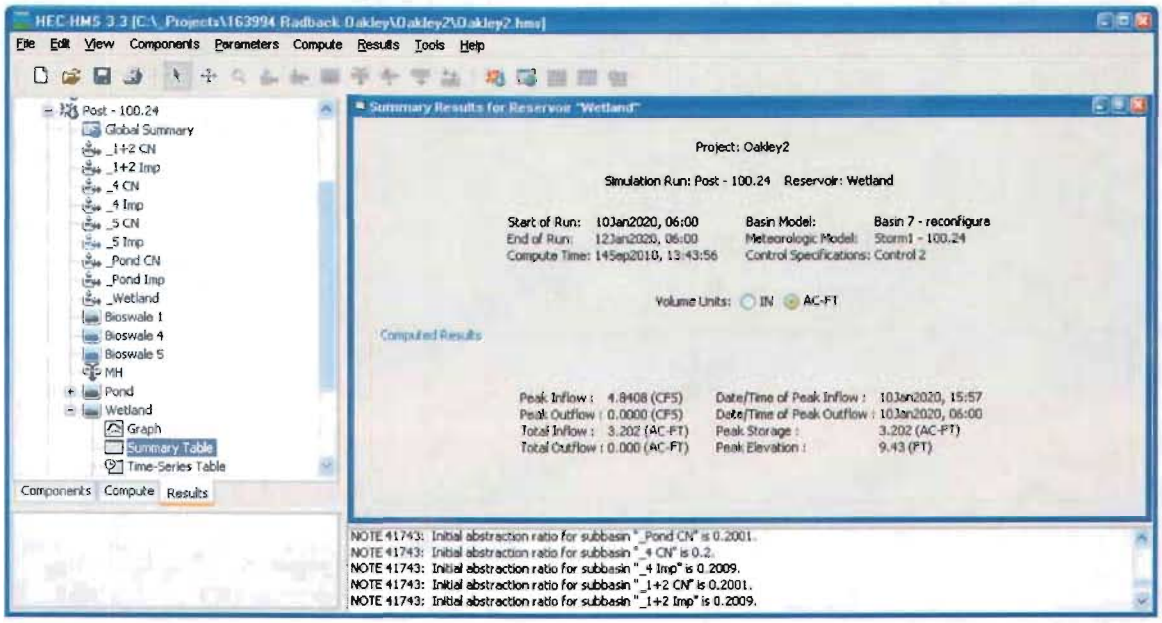
Hydrologic Element	Description
_1+2	Drainage area flowing to Bioswale 1+2
~~_3~~	~~Drainage area flowing to Bioswale 3~~
_4	Drainage area flowing to Bioswale 4
_5	Drainage area flowing to Bioswale 5
_Pond	Drainage area flowing directly to Pond
_Wetland	Drainage area flowing directly to Wetland
Bioswale 1+2	Flow from Bioswale 1+2 outlet (to MH1)
Bioswale 3	Flow from Bioswale 3 outlet (to MH2)
Bioswale 4	Flow from Bioswale 4 outlet (to MH1)
Bioswale 5	Flow from Bioswale 5 outlet (to Wetland)
MH1	Flow from Bioswales 1+2 and 4 (to Pond)
MH2	Flow from Pond and Bioswale 3 (to Wetland)
Pond	Flow from Pond Outlet (to MH2)
Wetland	Flow from Wetland (set to 0.0)

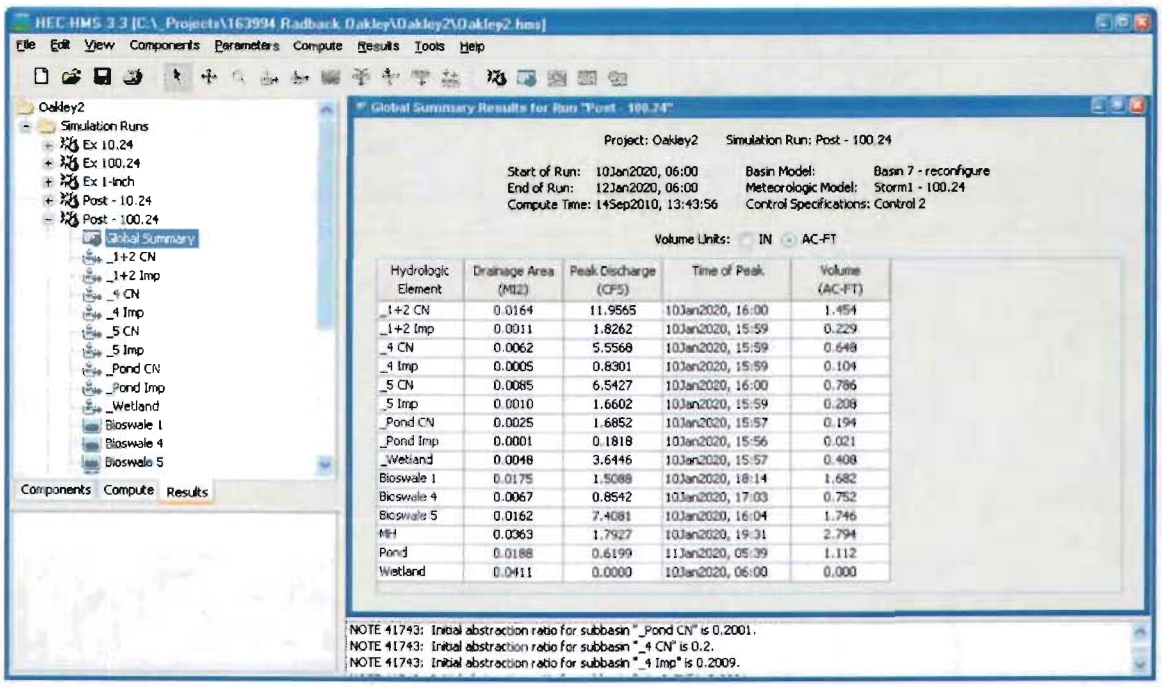
HEC-HMS Output – Pre-Construction 100-Year, 24-Hour Flow to Wetland





HEC-HMS Output – Post-Construction 100-Year, 24-Hour Flow to Wetland

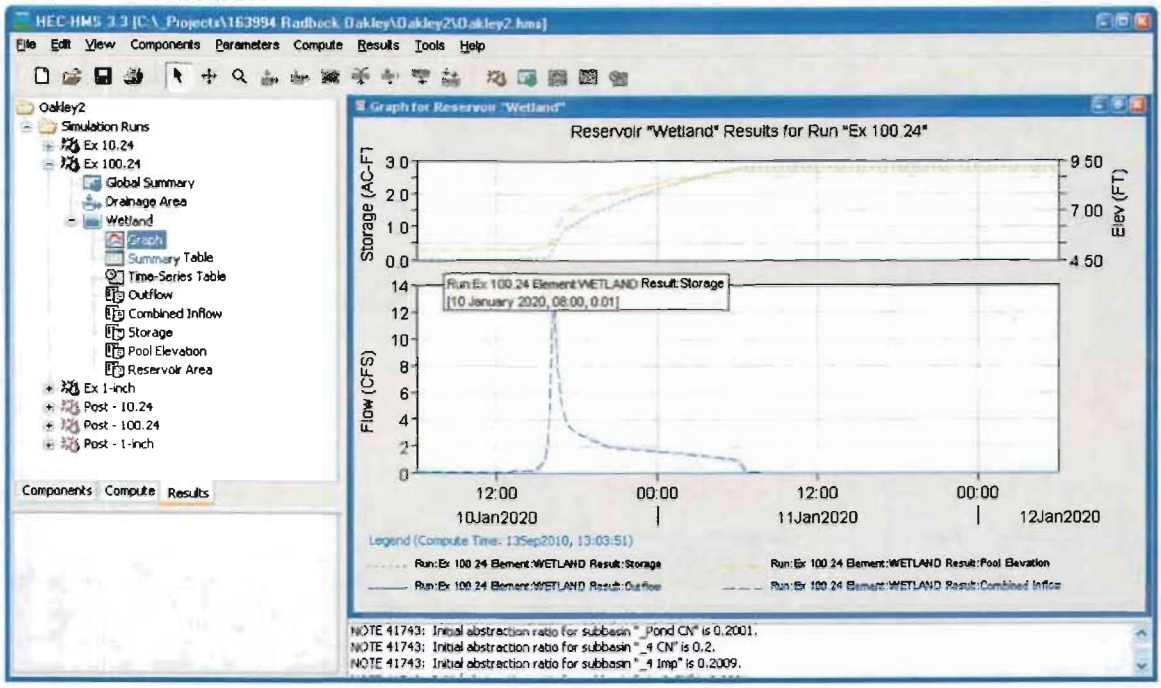




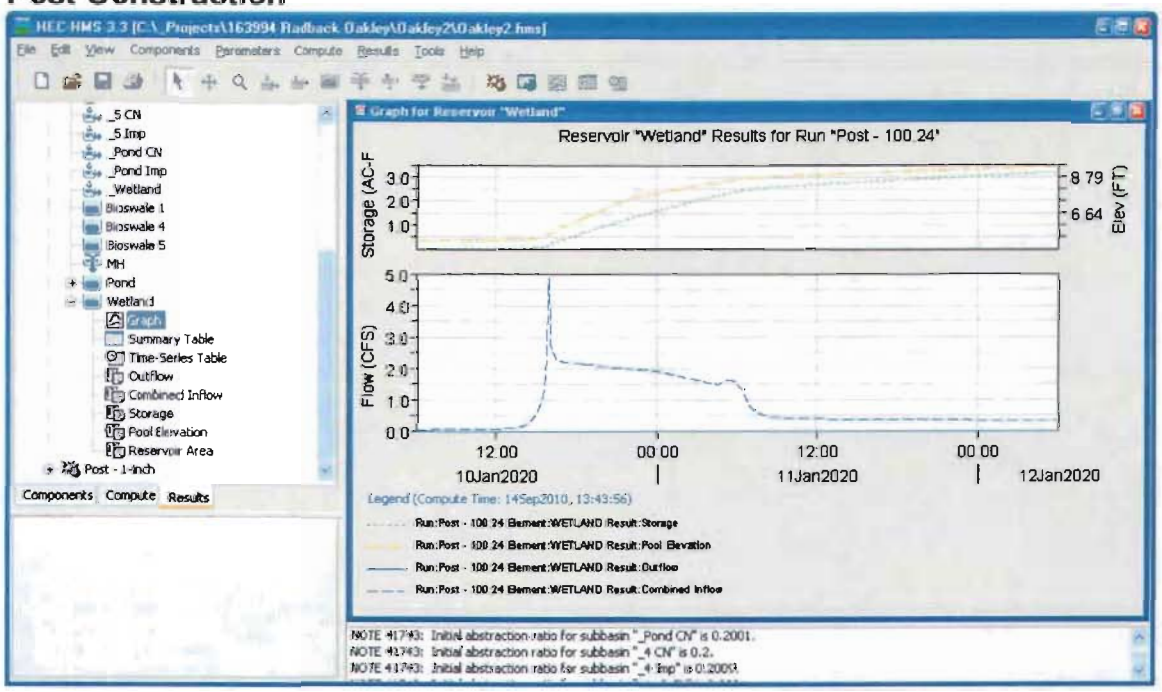
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
_1+2 CN	0.0164	11.9565	10Jan2020, 16:00	1.454
_1+2 Imp	0.0011	1.8262	10Jan2020, 15:59	0.229
_4 CN	0.0062	5.5568	10Jan2020, 15:59	0.648
_4 Imp	0.0005	0.8301	10Jan2020, 15:59	0.104
_5 CN	0.0085	6.5427	10Jan2020, 16:00	0.786
_5 Imp	0.0010	1.6602	10Jan2020, 15:59	0.208
_Pond CN	0.0025	1.6852	10Jan2020, 15:57	0.194
_Pond Imp	0.0001	0.1818	10Jan2020, 15:56	0.021
_Wetland	0.0048	3.6446	10Jan2020, 15:57	0.408
Bioswale 1	0.0175	1.5088	10Jan2020, 18:14	1.682
Bioswale 4	0.0067	0.8542	10Jan2020, 17:03	0.752
Bioswale 5	0.0162	7.4081	10Jan2020, 16:04	1.746
MH	0.0363	1.7927	10Jan2020, 19:31	2.794
Pond	0.0188	0.6199	11Jan2020, 05:39	1.112
Wetland	0.0411	0.0000	10Jan2020, 06:00	0.000

HEC-HMS Output – Comparison Graphs 100-Year, 24-Hour Flow to Wetland

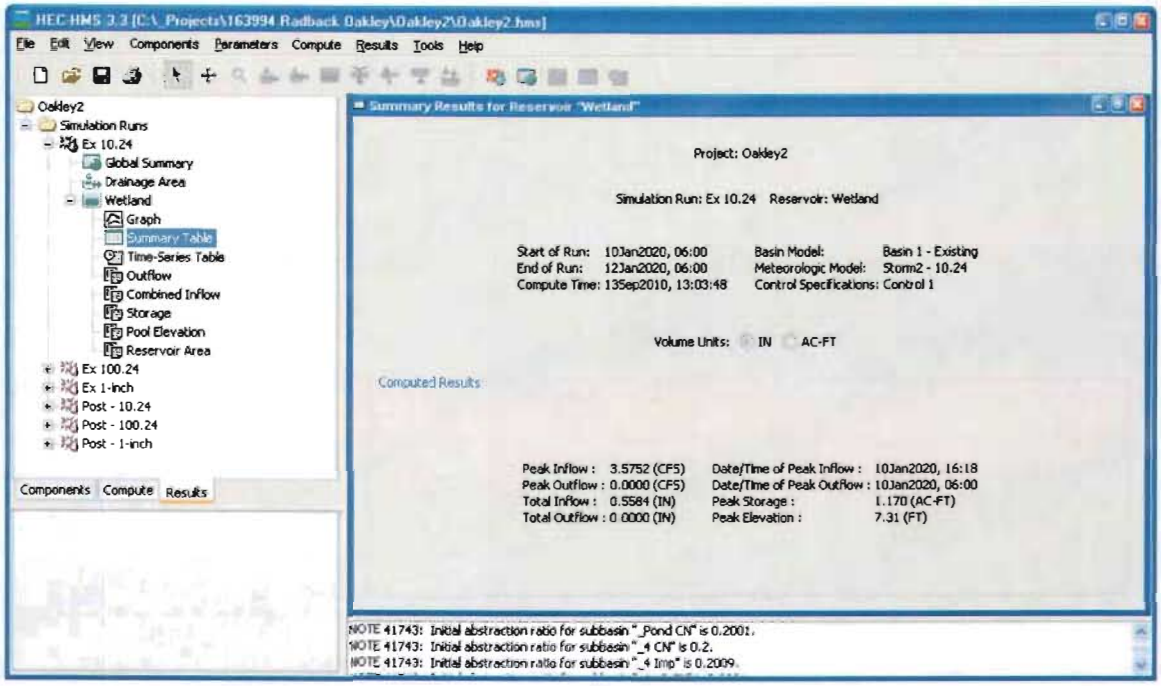
Pre-Construction

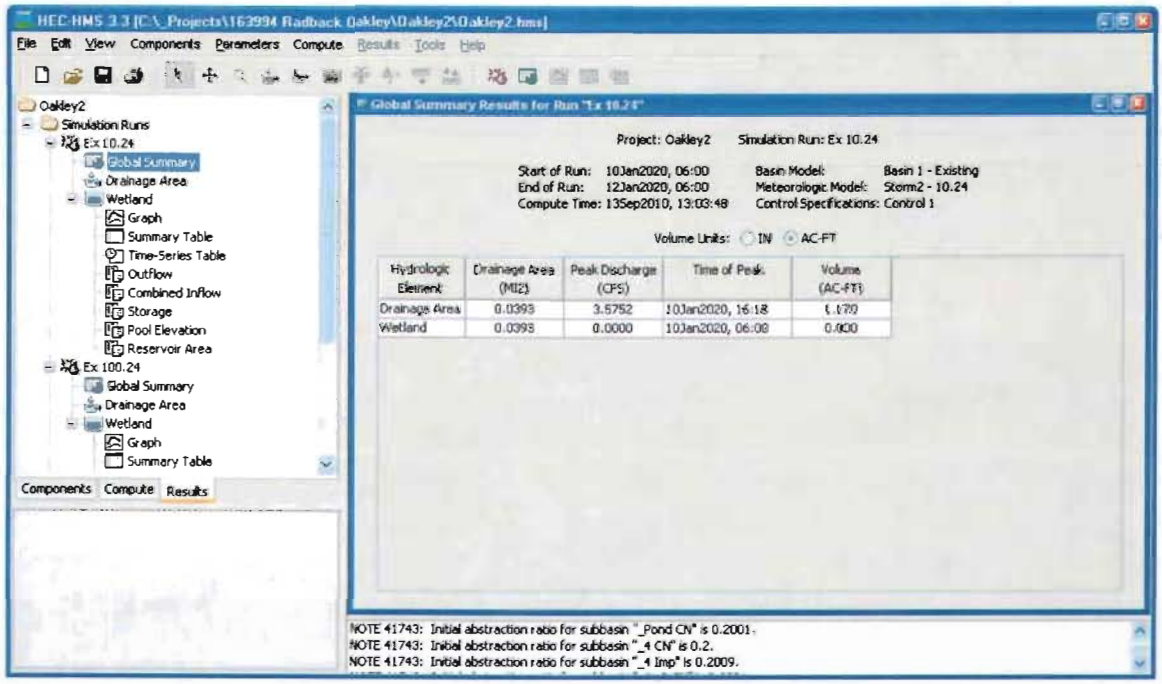


Post-Construction



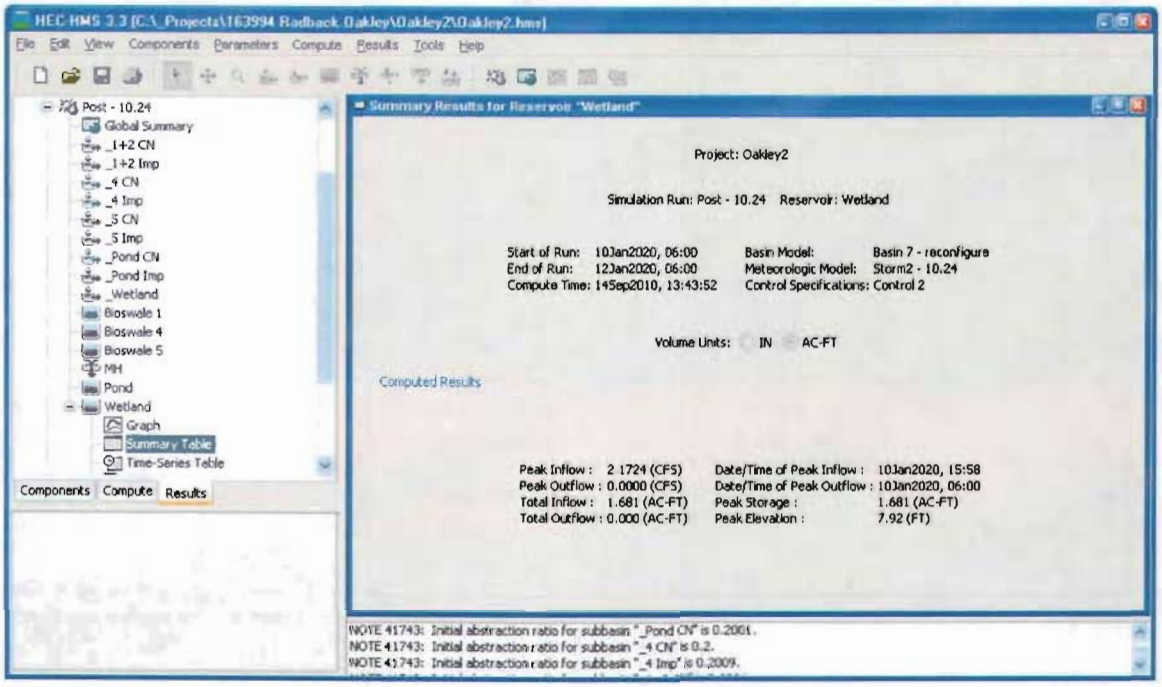
HEC-HMS Output – Pre-Construction 10-Year, 24-Hour Flow to Wetland

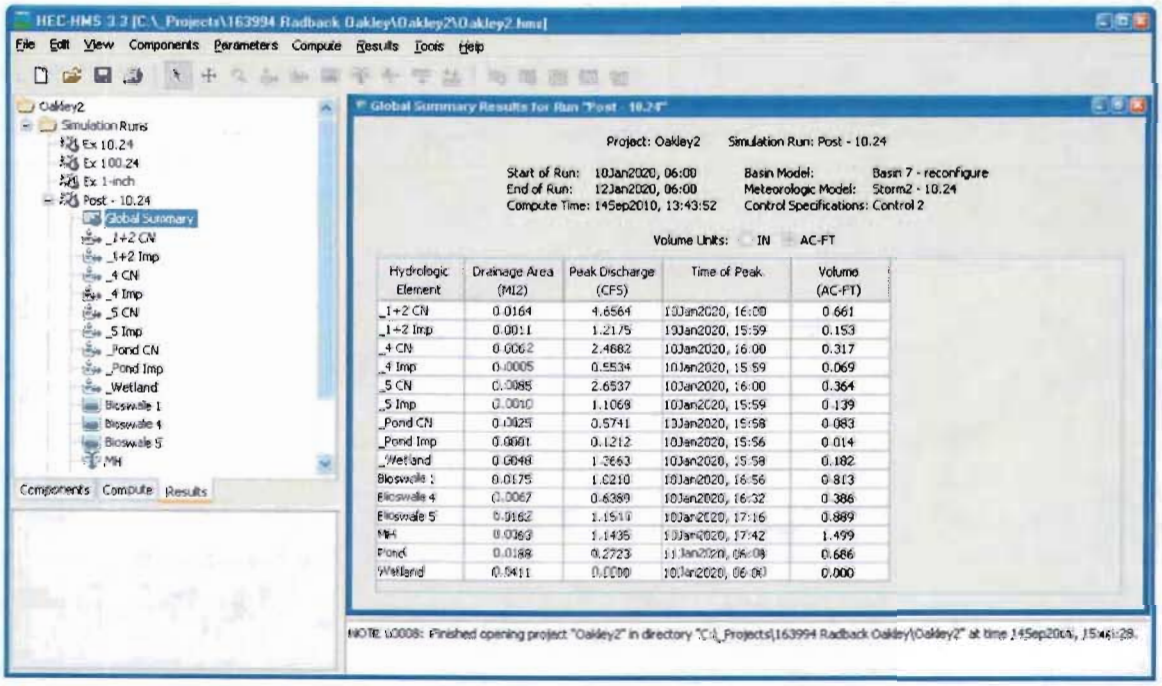




Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
Drainage Area	0.0393	3.5752	10Jan2020, 16:18	1.170
Wetland	0.0393	0.0000	10Jan2020, 06:00	0.000

HEC-HMS Output – Post-Construction 10-Year, 24-Hour Flow to Wetland

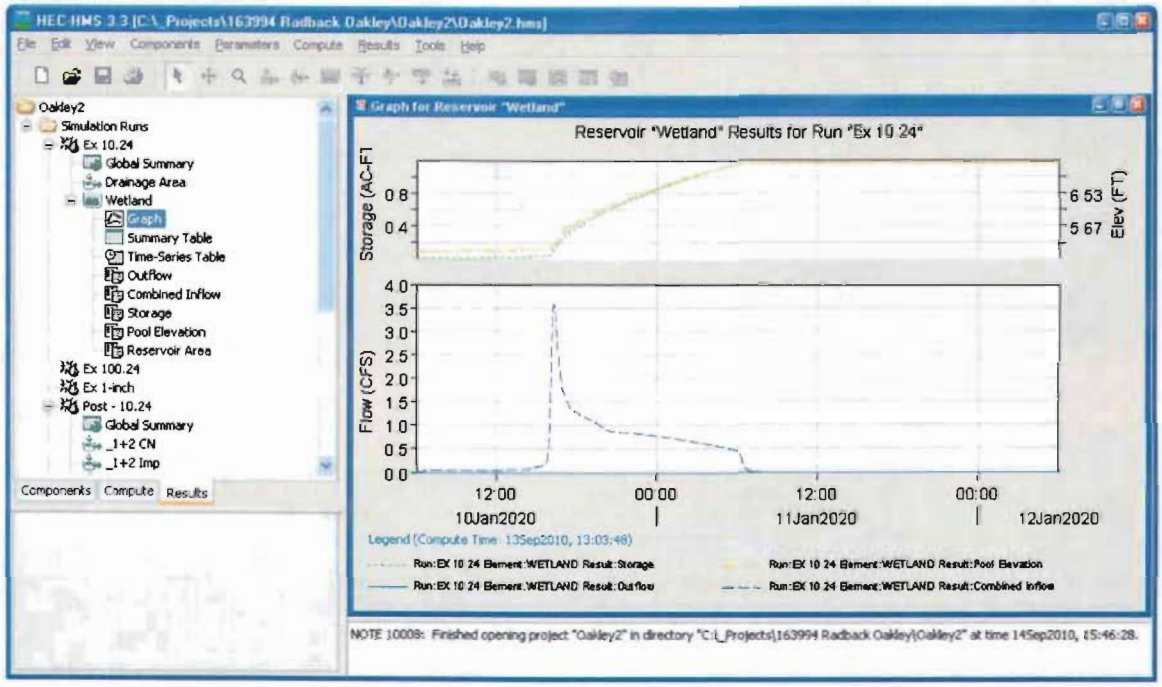




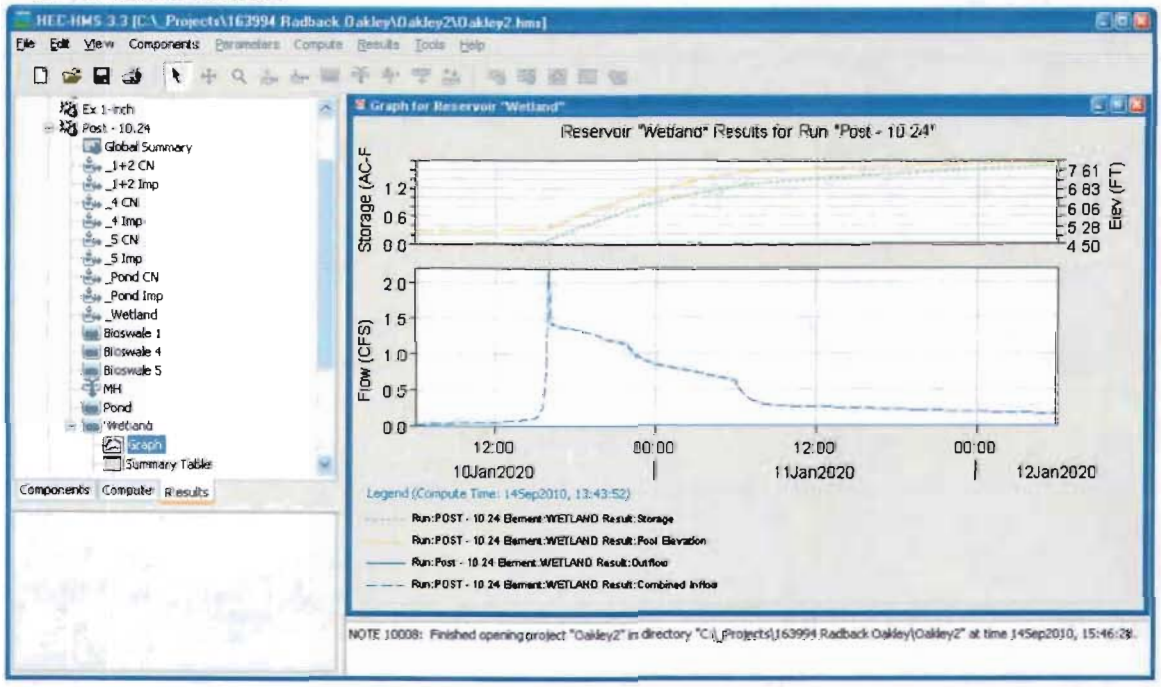
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
_1+2 CN	0.0164	4.6564	10Jan2020, 16:00	0.661
_1+2 Imp	0.0011	1.2175	10Jan2020, 15:59	0.153
_4 CN	0.0062	2.4682	10Jan2020, 16:00	0.317
_4 Imp	0.0005	0.5534	10Jan2020, 15:59	0.069
_5 CN	0.0085	2.6537	10Jan2020, 16:00	0.364
_5 Imp	0.0010	1.1068	10Jan2020, 15:59	0.139
_Pond CN	0.0025	0.5741	10Jan2020, 15:58	0.083
_Pond Imp	0.0001	0.1212	10Jan2020, 15:56	0.014
_Wetland	0.0048	1.2663	10Jan2020, 15:58	0.182
Bioswale 1	0.0175	1.0210	10Jan2020, 16:56	0.813
Bioswale 4	0.0067	0.6389	10Jan2020, 16:32	0.386
Bioswale 5	0.0162	1.1510	10Jan2020, 17:16	0.889
MH	0.0369	1.1435	10Jan2020, 17:42	1.499
Pond	0.0188	0.2723	11Jan2020, 06:08	0.686
Wetland	0.5411	0.0000	10Jan2020, 06:00	0.000

HEC-HMS Output – Comparison Graphs 10-Year, 24-Hour Flow to Wetland

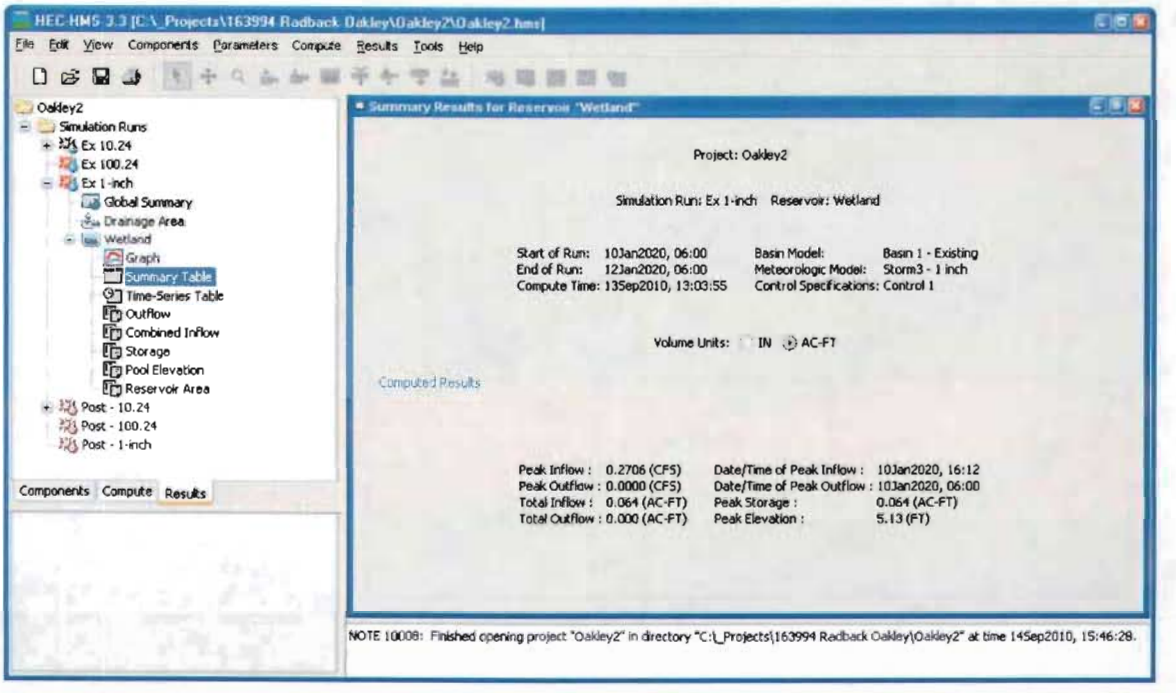
Pre-Construction

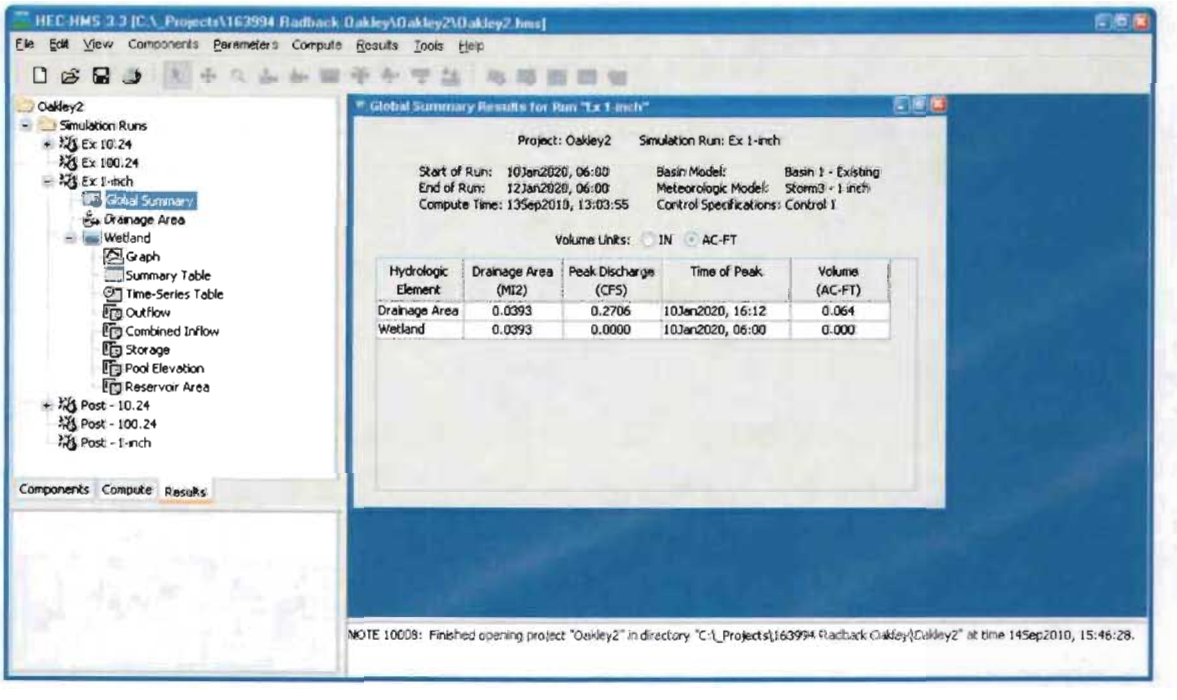


Post-Construction

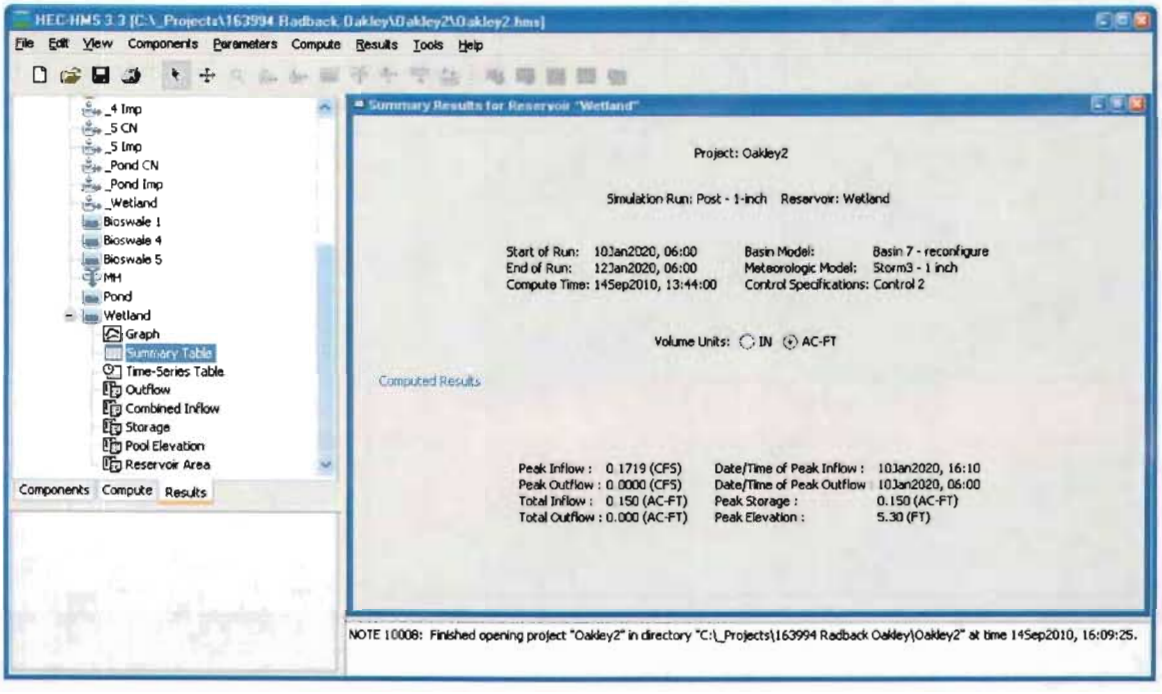


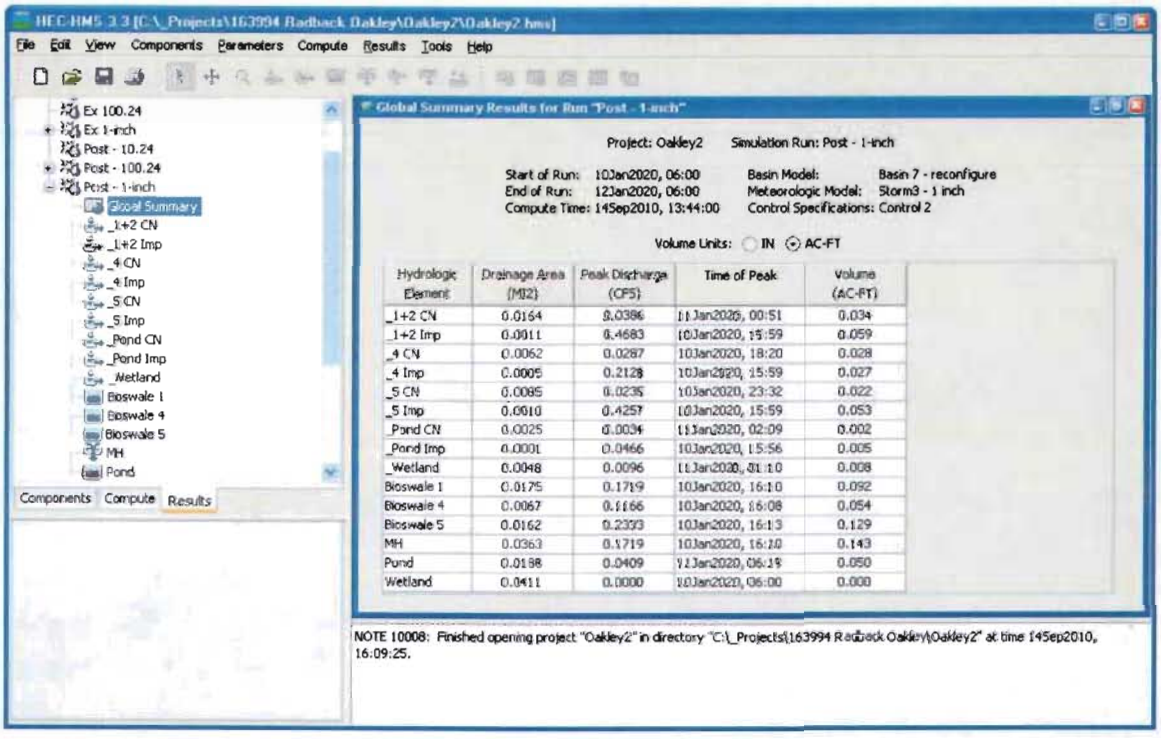
HEC-HMS Output – Pre-Construction 1-Inch Rainfall Flow to Wetland





HEC-HMS Output – Post-Construction 1-Inch Rainfall Flow to Wetland

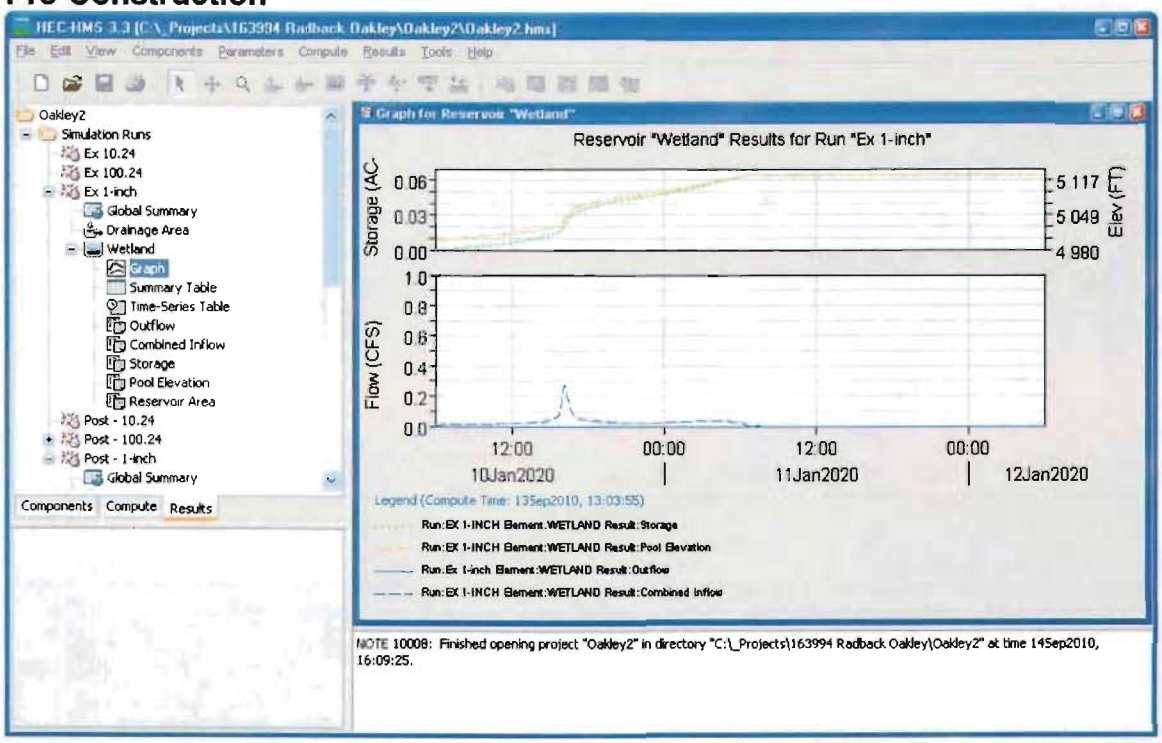




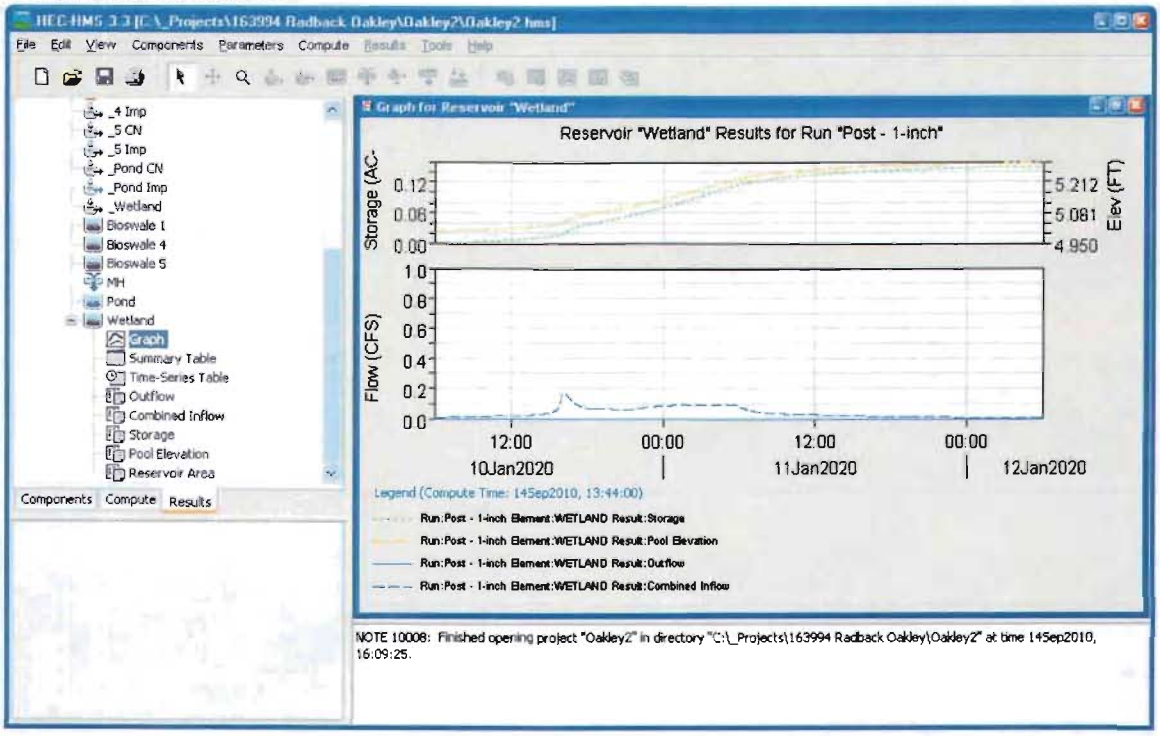
Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
_1+2 CN	0.0164	0.0386	11Jan2020, 00:51	0.034
_1+2 Imp	0.0011	0.4683	10Jan2020, 15:59	0.059
_4 CN	0.0062	0.0287	10Jan2020, 18:20	0.028
_4 Imp	0.0005	0.2128	10Jan2020, 15:59	0.027
_5 CN	0.0085	0.0235	10Jan2020, 23:32	0.022
_5 Imp	0.0010	0.4257	10Jan2020, 15:59	0.053
_Pond CN	0.0025	0.0034	11Jan2020, 02:09	0.002
_Pond Imp	0.0001	0.0466	10Jan2020, 15:56	0.005
_Wetland	0.0048	0.0096	11Jan2020, 01:10	0.008
Bioswale 1	0.0175	0.1719	10Jan2020, 16:10	0.092
Bioswale 4	0.0067	0.1166	10Jan2020, 16:08	0.054
Bioswale 5	0.0162	0.2393	10Jan2020, 16:13	0.129
MH	0.0363	0.1719	10Jan2020, 16:10	0.143
Pond	0.0188	0.0409	11Jan2020, 06:19	0.050
Wetland	0.0411	0.0000	10Jan2020, 06:00	0.000

HEC-HMS Output – Comparison Graphs 1-Inch Event Flow to Wetland

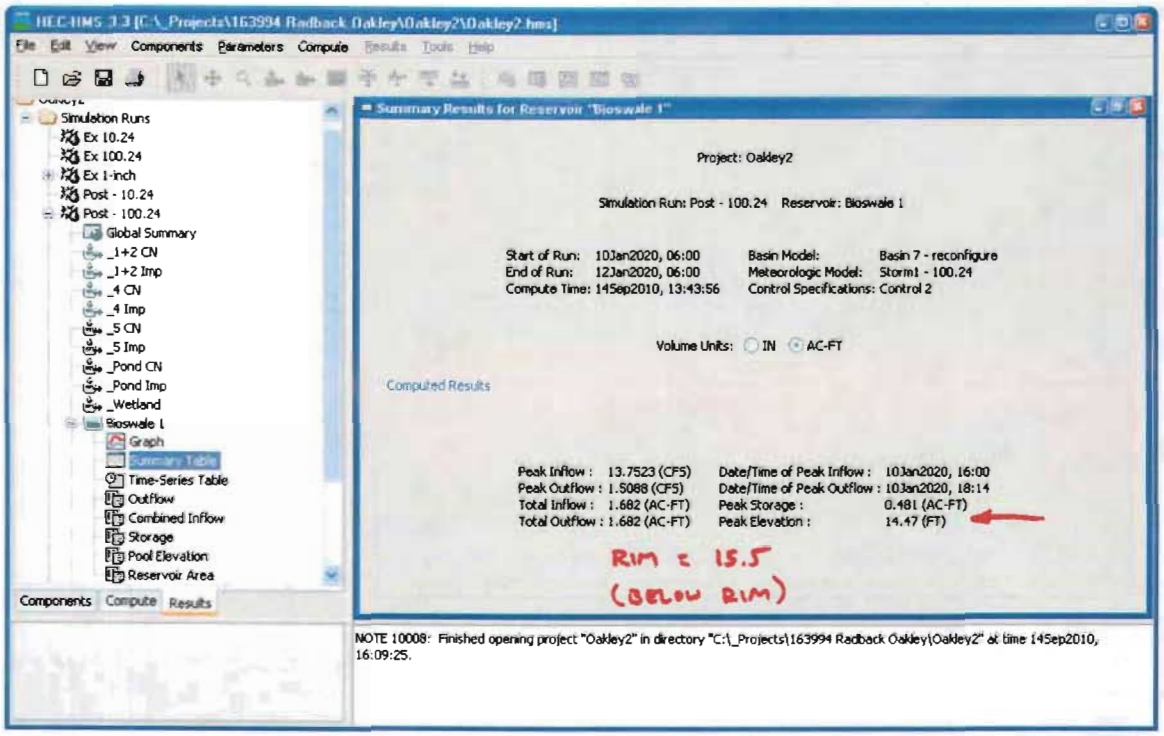
Pre-Construction



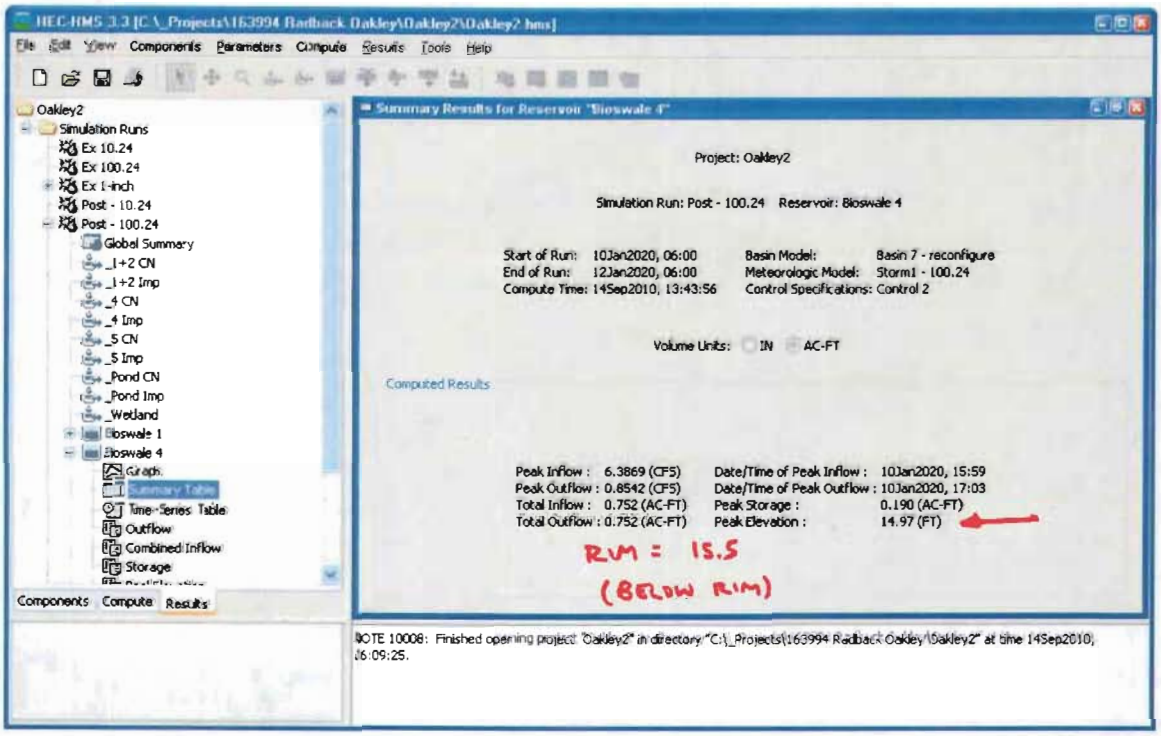
Post-Construction



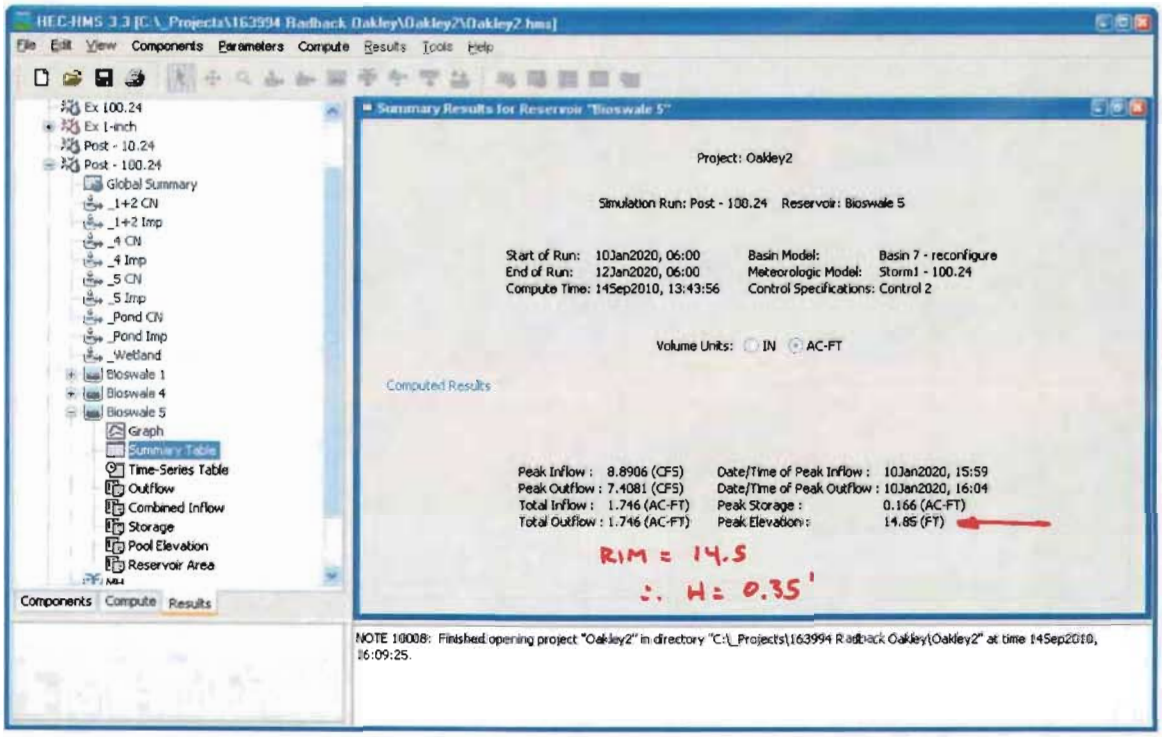
HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Bioswale 1-2



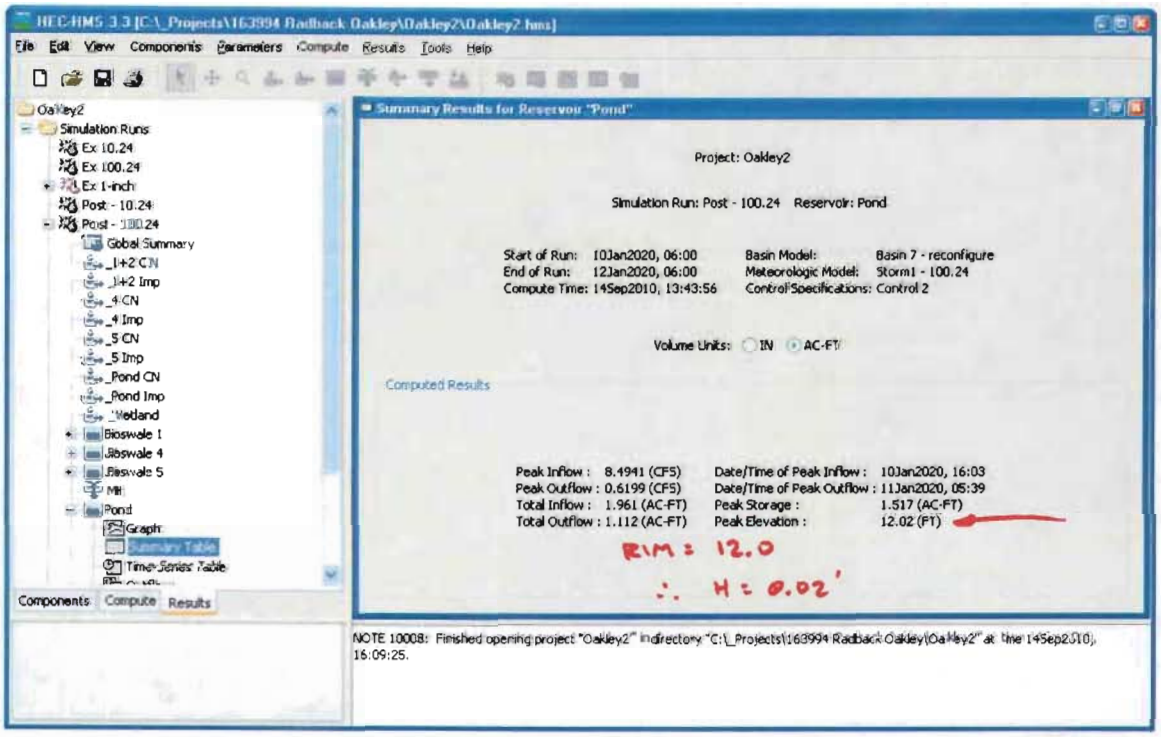
HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Bioswale 4



HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Bioswale 5



HEC-HMS Output – Post Construction 100-Year, 24-Hour Flow Pond



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Attachment 3

Reference 2

Select Pages

Chapter 2 Estimating Runoff

SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in appendix A for determining the HSG classification for disturbed soils.

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.

2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

[1] Average runoff condition, and I_a=0.2S

[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

Table 3-1 Roughness coefficients (Manning's n) for sheet flow

Surface description	n [1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses [2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Chapter 3 Time of Concentration and Travel Time

Travel time (T_t) is the time it takes water to travel from one location to another in a watershed. T_t is a component of time of concentration (T_c), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. T_c is computed by summing all the travel times for consecutive components of the drainage conveyance system.

T_c influences the shape and peak of the runoff hydrograph. Urbanization usually decreases T_c, thereby increasing the peak discharge. But T_c can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

Factors affecting time of concentration and travel time

Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time (T_t) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

T_t = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

Time of concentration (T_c) is the sum of T_t values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

T_c = time of concentration (hr)
m = number of flow segments

Figure 3-1 Average velocities for estimating travel time for shallow concentrated flow

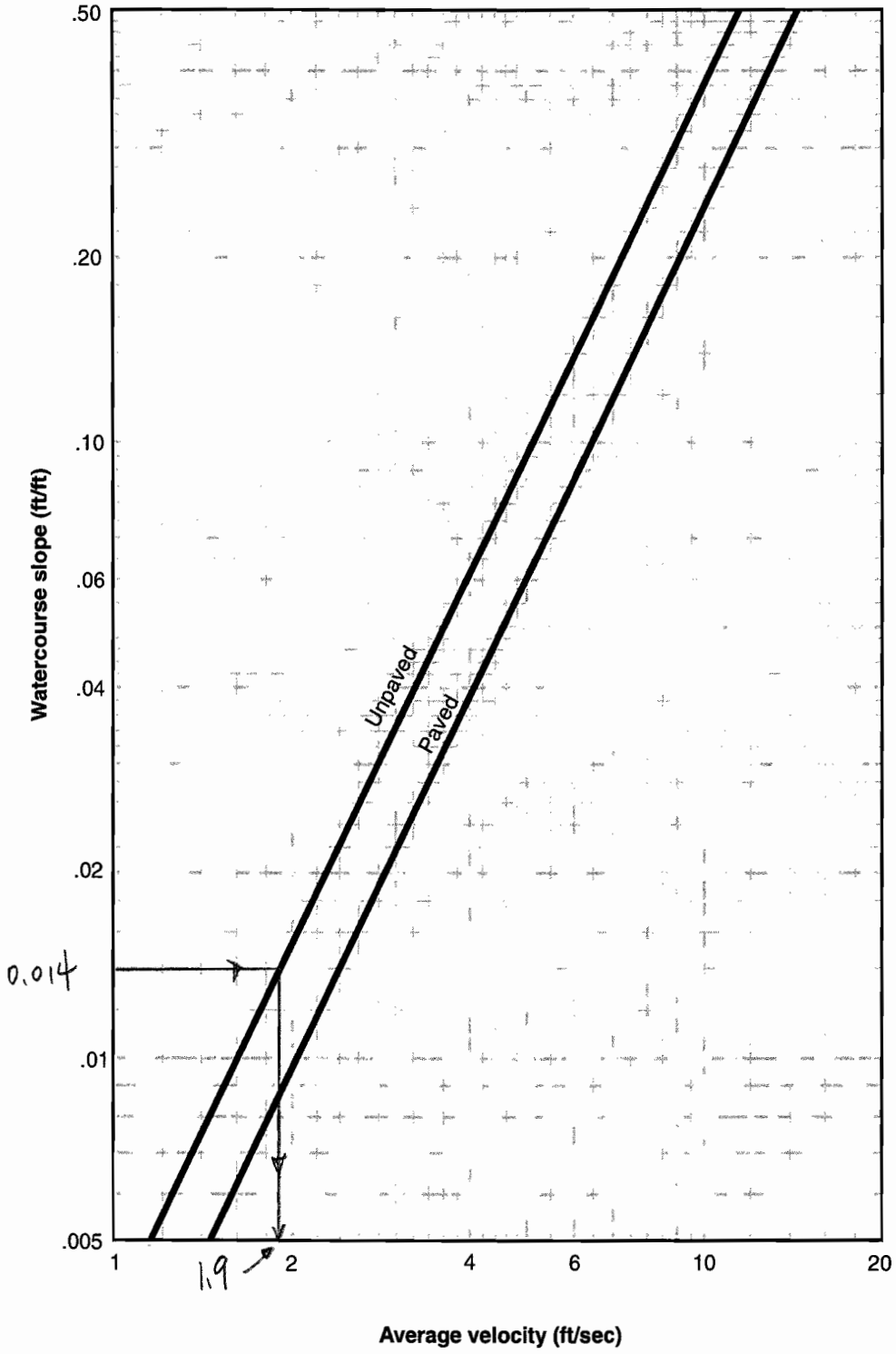
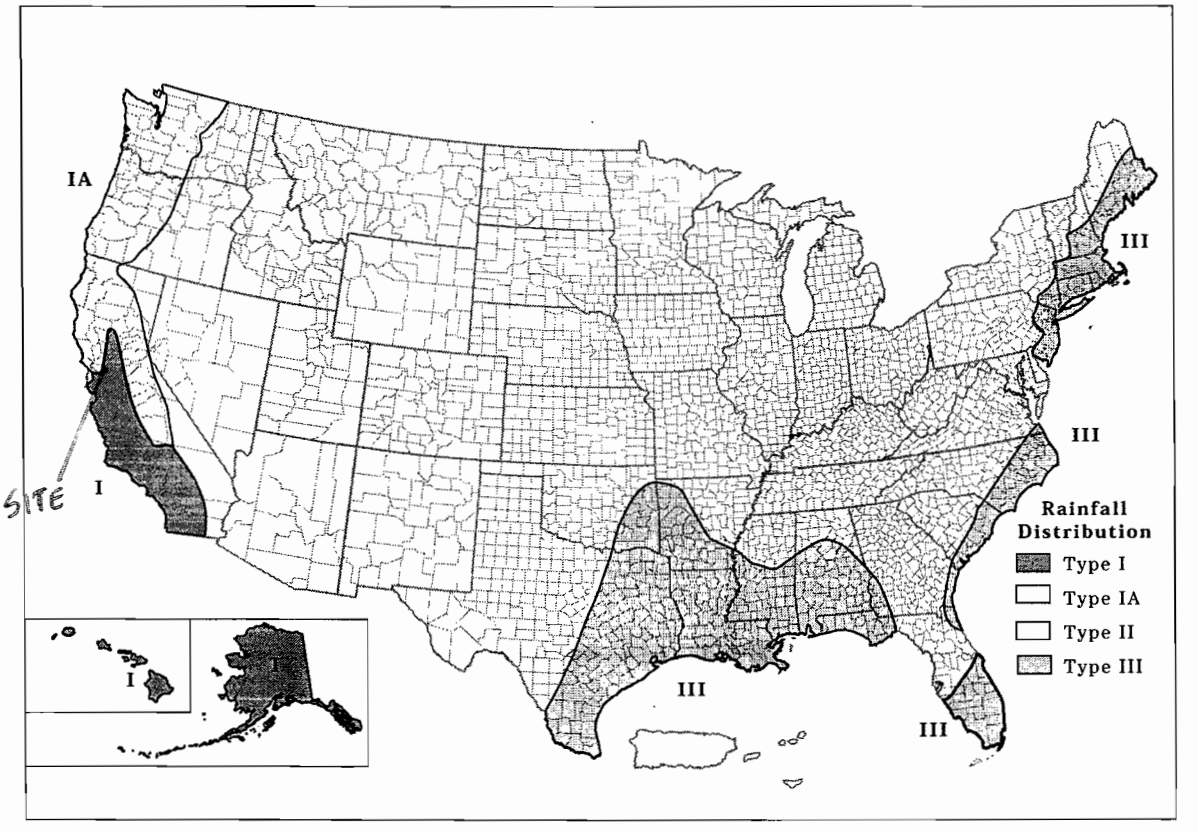


Figure B-2 Approximate geographic boundaries for NRCS (SCS) rainfall distributions



Rainfall data sources

This section lists the most current 24-hour rainfall data published by the National Weather Service (NWS) for various parts of the country. Because NWS Technical Paper 40 (TP-40) is out of print, the 24-hour rainfall maps for areas east of the 105th meridian are included here as figures B-3 through B-8. For the area generally west of the 105th meridian, TP-40 has been superseded by NOAA Atlas 2, the Precipitation-Frequency Atlas of the Western United States, published by the National Ocean and Atmospheric Administration.

East of 105th meridian

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States for durations from 30 minutes to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 40. Washington, DC. 155 p.

West of 105th meridian

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-frequency atlas of the Western United States. Vol. I Montana; Vol. II, Wyoming; Vol III, Colorado; Vol. IV, New Mexico; Vol V, Idaho; Vol. VI, Utah; Vol. VII, Nevada; Vol. VIII, Arizona; Vol. IX, Washington; Vol. X, Oregon; Vol. XI, California. U.S. Dept. of Commerce, National Weather Service, NOAA Atlas 2. Silver Spring, MD.

Alaska

Miller, John F. 1963. Probable maximum precipitation and rainfall-frequency data for Alaska for areas to 400 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. of Commerce, Weather Bur. Tech. Pap. No. 47. Washington, DC. 69 p.

Hawaii

Weather Bureau. 1962. Rainfall-frequency atlas of the Hawaiian Islands for areas to 200 square miles, durations to 24 hours and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 43. Washington, DC. 60 p.

Puerto Rico and Virgin Islands

Weather Bureau. 1961. Generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and Virgin Islands for areas to 400 square miles, durations to 24 hours, and return periods from 1 to 100 years. U.S. Dept. Commerce, Weather Bur. Tech. Pap. No. 42. Washington, DC. 94 P.

Appendix A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

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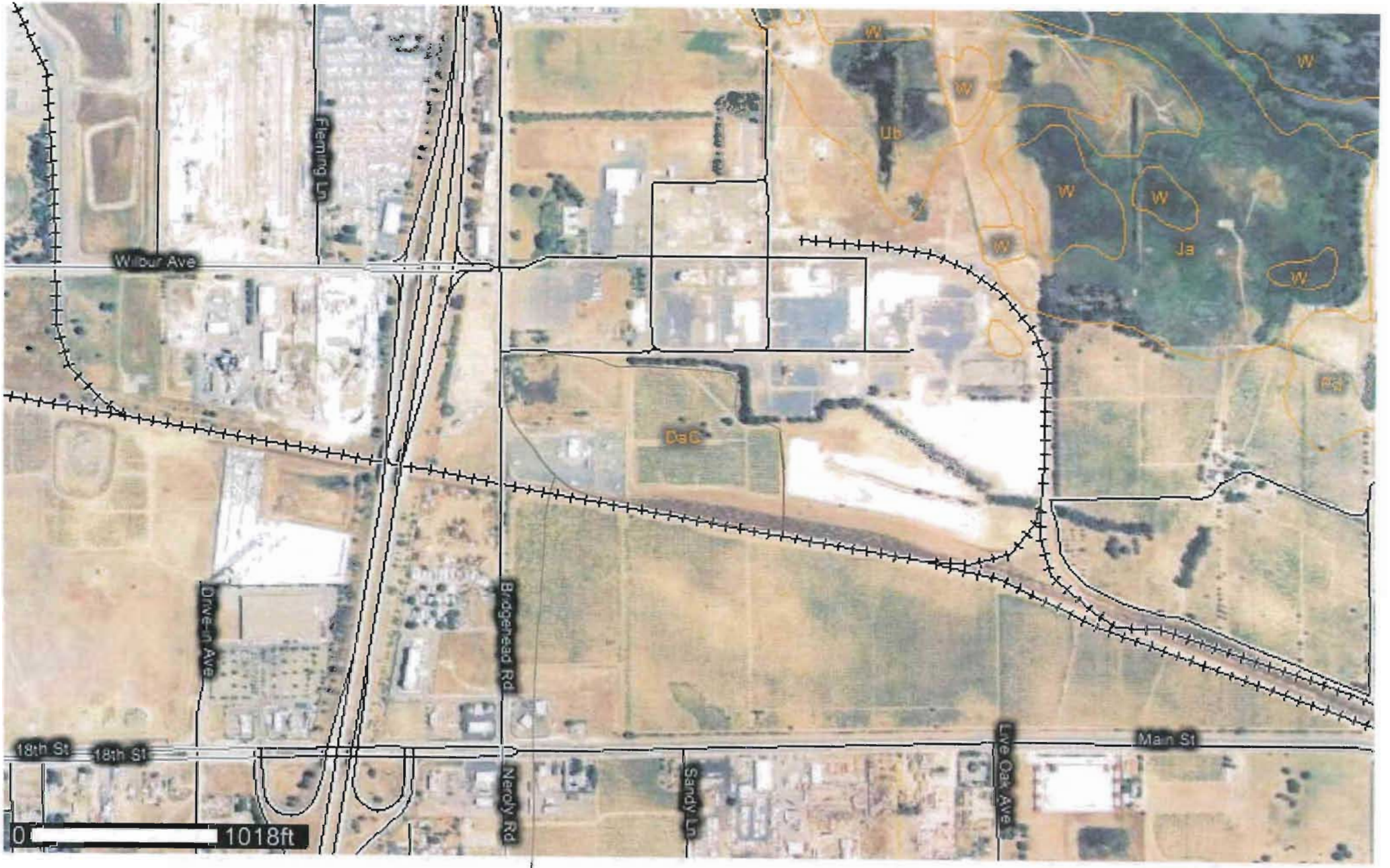
Select pages

(printed out from the online web soil survey)



Project site

Map Unit Description

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions in this report, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. All the soils of a series have major horizons that are similar in composition, thickness, and arrangement. Soils of a given series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Additional information about the map units described in this report is available in other soil reports, which give properties of the soils and the limitations, capabilities, and potentials for many uses. Also, the narratives that accompany the soil reports define some of the properties included in the map unit descriptions.

Contra Costa County, California

DaC—DELHI SAND, 2 TO 9 PERCENT SLOPES

Map Unit Setting

Elevation: 10 to 150 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Delhi and similar soils: 85 percent
Minor components: 15 percent

Description of Delhi

Setting

Landform: Flood plains, terraces, alluvial fans
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from igneous and sedimentary rock

Properties and qualities

Slope: 2 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability (nonirrigated): 6e

Typical profile

0 to 5 inches: Sand
5 to 60 inches: Sand

Minor Components

Unnamed

Percent of map unit: 12 percent

Laugenour

Percent of map unit: 3 percent

Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

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IMP Sizing for Bioswale #1-2

Refer to Page 5, the total drainage area for bioswale #1-2 is measured to be: 491,168 ft^2 (11.28 ac). The bioswale is measured to be 1,323 feet long.

Six drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; (5) Transformer Containment; and (6) Open-Graded Aggregates (ACC Area).

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	54,900
DMA-2	Asphalt Pavement	65,113
DMA-3	Gravel Surfacing	100,200
DMA-4	Grass/Landscape	198,264
DMA-5	Transformer Containment	4,491
DMA-6	Open-Graded Aggregates	68,200

Runoff Coefficients

Dense-graded aggregate (Caltran Class 2 aggregate) will be utilized as the materials for aggregate surfacing. After being compacted, the dense-graded aggregate is estimated to have a runoff coefficient of 0.5 to 0.7. See communications with Contra Costa County Clean Water Program (Attachment 6). Use 0.6 in this calculation.

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Open Graded Aggregates" will have a runoff coefficient of 0.1. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (54{,}900x1+65{,}113x1+100{,}200x0.6+198{,}264x0.1+4{,}491x0+68{,}200x0.1)$$

$$= 206{,}779\ ft^2.$$

IMP Sizing for Bioswale #3

Refer to Page 5, the total drainage area for bioswale #3 is measured to be: 25,711 ft^2 (0.59 ac). The bioswale #3 is measured to be 187 feet long.

Three drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; and (3) Grass/Landscape.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	3,873
DMA-2	Asphalt Pavement	2,086
DMA-3	Grass/Landscape	19,752

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (3{,}873\text{x}1.0+2{,}086\text{x}1.0+19{,}752\text{x}0.1)$$

$$= 7{,}934\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

IMP Sizing for Bioswale #4

Refer to Page 5, the total drainage area for bioswale #4 is measured to be: 190,955 ft^2 (4.38 ac). The bioswale #4 is measured to be 391 feet long.

Five drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; and (5) Transformer Containment.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	19,314
DMA-2	Asphalt Pavement	33,262
DMA-3	Gravel Surfacing	109,208
DMA-4	Grass/Landscape	23,692
DMA-5	Transformer Containment	5,479

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (19{,}314 \times 1.0 + 33{,}262 \times 1.0 + 109{,}208 \times 0.6 + 23{,}692 \times 0.1 + 5{,}479 \times 0)$$

$$= 120{,}470\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

IMP Sizing for Bioswale #5

Refer to Page 5, the total drainage area for bioswale #5 is measured to be: 290,529 ft^2 (6.67 ac) (natural gas facility included). The bioswale #5 is measured to be 385 feet long total.

Four drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; and (4) Grass/Landscape.

Including Railroad yard
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The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	12,670
DMA-2	Asphalt Pavement	25,905
DMA-3	Gravel Surfacing	186,725
DMA-4	Grass/Landscape	65,229

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (12{,}670\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 157{,}133\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

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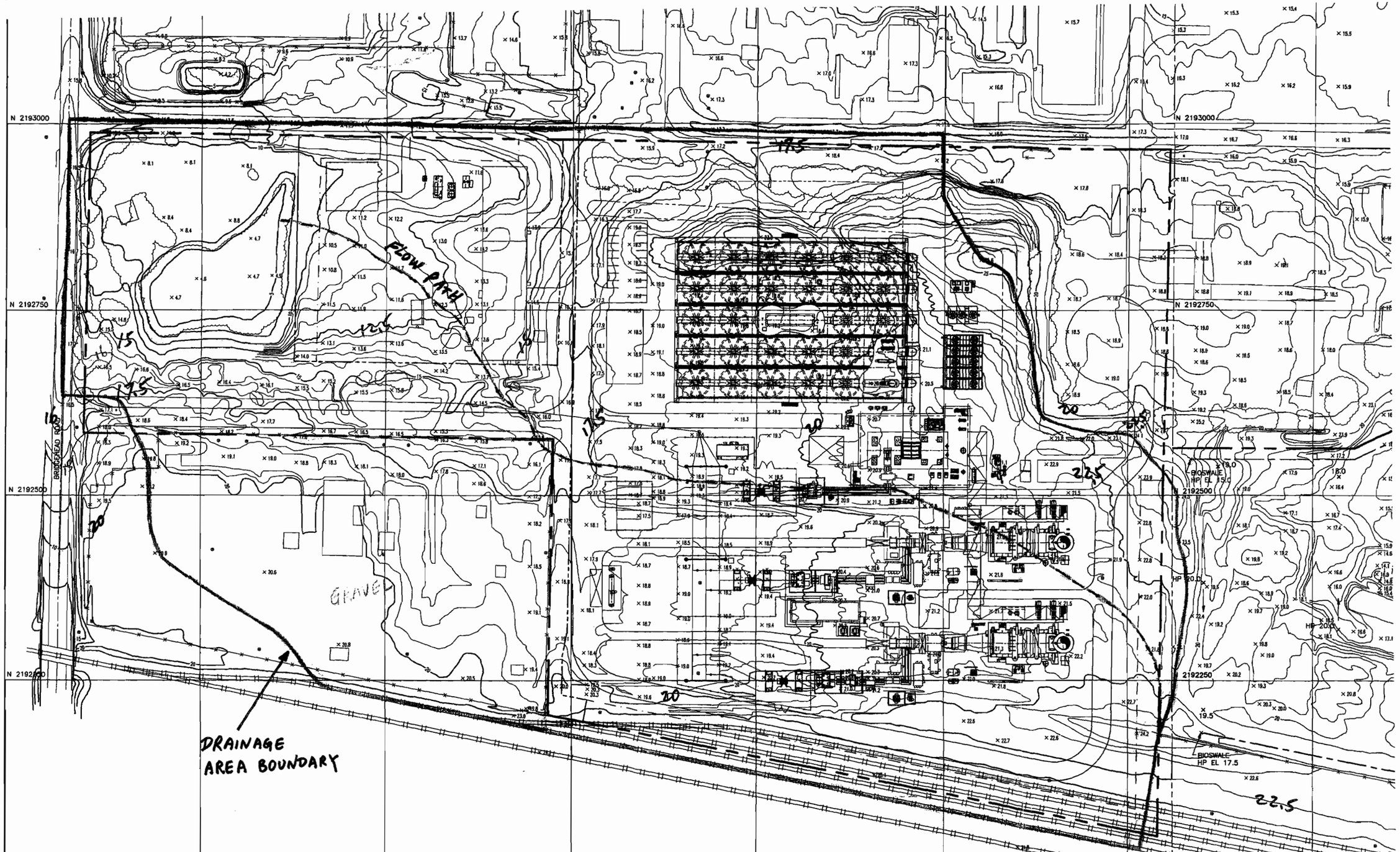
Attachment 6

Reference 9

Select pages



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prepared by: J zhong
Date: 3/4/09
checked by: PW
Date: 3/6/09

NOTE: THIS PAGE IS A PORTION OF B&V Drawing 163994-SS-3001 Rev A.

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Hydrology Modeling – HEC-HMS

PRE-CONSTRUCTION

There is one drainage area that will drain to the wetland. See Page 5 for the boundary delineation of this area. This drainage area generally has four types of ground cover: (1) Vineyard, 19.85 acres; (2) Gravel Pavement, 3.96 acres; (3) Railroad Yard, 0.94 acres; and (4) Wetland, 0.40 acres. The total area of this drainage area is 25.15 acres (0.0393 mile^2). The measurements of the above areas were made by using AutoCAD.

The stormwater runoff to the wetland for a 100-year 24-hour storm event was modeled by using a computer program, HEC-HMS version 3.3, developed by the US Army Corps of Engineers (Ref. 3).

Section 1.0 Determine the Time of Concentration

Time of concentration (T_c) can be calculated as:

$$T_c = T_{sheet} + T_{shallow} + T_{channel} \qquad \text{(Ref. 4, Eq. 6-11)}$$

Where:

T_{sheet} = travel time in sheet flow;
$T_{shallow}$ = travel time in shallow concentrated flow;
$T_{channel}$ = travel time in open channels.

There is no open channel flow on this site. Thus $T_{channel} = 0$.

The flow path from the hydraulically most distant point of this drainage area to the wetland is identified as shown on Page 5.

The total flow length is measured to 1490 feet.

(1) Sheet Flow

Sheet flow travel time can be calculated as:

$$T_{sheet} = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{(Ref. 2, Eq. 3-3)}$$

Where:

n = roughness coefficient;
L = flow length (ft);
P_2 = 2-year, 24-hour rainfall (in);
s = land slope (ft/ft).

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Attachment 7

Reference 11

Incremental Storage Volume = $\left(\frac{AreaHi + AreaLo}{2} \times (ElevHi - ElevLo)\right)$

For the volume between elevations 5.0 and 7.5:

Incremental Storage Volume = $\left(\frac{0.62 + 0.40}{2} \times (7.5 - 5.0)\right)$ = 1.28 ac-ft

Wetland Elevation – Area – Storage Summary (See Ref. 9, Pg 11)

Elevation (ft)	Wetland Area (acre)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
5.0	0.40	-	-
7.5	0.62	1.28	1.28
10.0	1.44	2.57	3.85
11.5	1.6	2.28	6.13

There is an outlet control structure proposed between the pond and wetland that will allow water to flow from the pond into the wetland when the water level in the pond is above elevation 10.0. The volume retained in the pond below elevation 10.0 prior to allowing discharge into the wetland is determined by calculating the total incremental storage provided below elevation 10.0 as shown in the table on the following page.

Retained Volume to Elevation 10.0 = 0.10 ac-ft + 0.23 ac-ft = 0.33 ac-ft

This storage volume reduces the runoff that reaches the wetland. The wetland water-surface elevation in the post-construction site condition takes this into account.

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Attachment 8

Reference 12

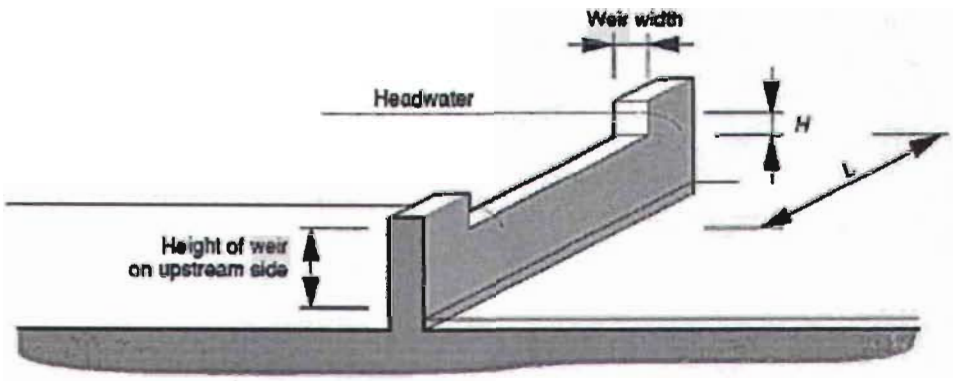

Figure 6.16 Dimensions of a rectangular weir.

WEIRS

A weir is a shelf that water falls over, such as the top of a barrel pipe, a timber check dam, or the crest of a concrete dam.

Weir discharge is governed by the simple principle that as head increases upstream of a weir, the flow over it increases. The type of material is irrelevant as long as the weir has only enough width for structural strength and water does not contact it long enough to be slowed down by friction.

A weir that is straight and level, with vertical sides, like that in Figure 6.16, is referred to as a rectangular weir. Discharge over this type of weir is predicted by the weir equation (U.S. Bureau of Reclamation, 1974, p. 373):

$$q = C\,L\,H^{3/2}$$

where

q = discharge, cfs

C = coefficient (no units) equal to 3.3 where a weir has significant height on the upstream side, such as at a dam or a barrel pipe, or 3.09 where a weir has no upstream height, such as at a drop structure in a channel

USE C = 3.1

L = horizontal length of crest, ft

H = head of water above the crest, ft

Introduction to Stormwater

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Radback Oakley Project

Project # 163994

Stormwater Analysis

CK 6/17/10

pages 2

52.5406.1007

Attachment 9

Reference 7

Type of channel	Values of the roughness coefficient n		
	Minimum	Normal	Maximum
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.014
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	**0.013**	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	—
8. On irregular excavated rock	0.022	0.027	—
d. Concrete bottom float with sides of			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement, rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	**0.013**	0.015
2. In cement mortar	0.012	**0.015**	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	—
2. Rough	0.016	0.016	—
j. Vegetal cover	0.030	—	0.500
C. *Excavated or Dredged*			
C–1 General			
a. Earth, straight and uniform			
1. Clean and recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	**0.022**	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	$\boxed{0.027}$	0.033
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033

Use n=0.027 for vegetated ditch

Radback Oakley Project

Project # 163994

Stormwater

Analysis

Ck 6/17/10

pages 2

52.5406.1007

Attachment 10

Reference 13

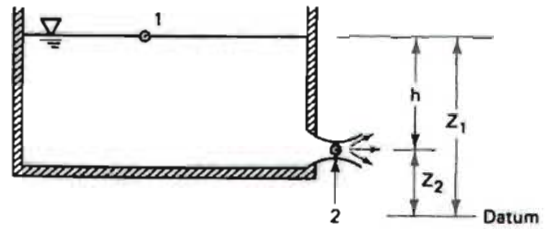

FIGURE 8–4 Schematic diagram of flow through an orifice.

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 \tag{8–13}$$

This can be simplified by making the following assumptions: (1) The pressure at both points is atmospheric, therefore $p_1 = p_2$; (2) The surface area of the pool A_1 is very large relative to the area of the orifice A_2, so from the continuity equation, V_1 is essentially 0; and (3) $z_1 - z_2 = h$. Thus, Equation 8–13 becomes

$$h = V_2^2/2g \tag{8–14}$$

Solving for V_2 and substituting it into the continuity equation yields

$$q = AV = A\sqrt{2gh} \tag{8–15}$$

Equation 8–15 depends on two assumptions that are not always true: there are no losses and the pressure is atmospheric across the opening of the orifice; it is actually atmosphere at a point below the orifice, called the vena contracta, where the cross-sectional area is a minimum. Because of these violations, the discharge will be less than that given by Equation 8–15. The actual discharge through the orifice is estimated by applying a discharge coefficient C_d to Equation 8–15:

$$q = C_d A\sqrt{2gh} \tag{8–16}$$

in which C_d is called the discharge coefficient. Equation 8–16 is referred to as the orifice equation. For some design problems, the q of Equation 8–16 is multiplied by an efficiency factor f to reflect other types of losses that limit the discharge rate. Values of C_d range from 0.5 to 1.0, with a value of 0.6 often used. C_d is dimensionless.

use 0.62

Example 8–3

A forklift is accidentally driven into the side of an above-ground storage tank and it punctures an 11-in.^{2} hole 6 in. above the ground. In order to complete the environmental report, the engineer needs to estimate the amount of petroleum that leaked out of the tank during the 25 min between the time of the puncture and the time that the hole was plugged. The surface elevation of the petroleum above the ground was 8.46 ft after the leak was stopped. The tank has a diameter of 40 ft. The engineer estimates the discharge coefficient is 0.55, which is less than the 0.6 value because of the additional losses created by the jagged edges of the hole. Thus, the estimated discharge is

$$q = C_d A\sqrt{2gh} = 0.55\left(\frac{11}{144}\right)[2\,(32.2)\,(8.46 - 0.5)]^{0.5}$$
$$= 0.951\ \text{ft}^3/\text{sec}$$

IMP Sizing for Plant Area

BLACK & VEATCH Building a world of difference.

CALCULATION RECORD

Client Name: Radback Energy Page 1 of 19

Project Name: Oakley Generating Station Project No.: 163994

Calculation Title: IMP Sizing for Plant Area

Calculation No./File No.: 52.5406.1008

Verification Method: ☒ Check and Review ☐ Alternate Calculations

Objective To determine the minimum required size of bioswales to satisfy Stormwater C.3 requirements for treatment and flow control for the plant area for the proposed Oakley Generating project.

Unverified Assumptions Requiring Subsequent Verification

No.	Assumption	Verified By	Date

Refer to Page _____ of this calculation for additional assumptions.

This Section Used for Software-Generated Calculations

Program Name/Number: _____ Version: _____

Standard B&V Application Used? ☐ Yes ☐ No

If no, list approved deviation permit number below and attach approved deviation permit.

Review and Approval

Rev	Prepared By	Date	Verified By	Date	Approved By	Date
0	C Kantola	15 June 2010	PLNelson	6/18/10	PLNelson	16 June 2010
1	C Kantola	9/13/10	PLNelson	9/21/10	PLNelson	9/21/10

Purpose

To determine the minimum required size of bioswales to satisfy Stormwater C.3 requirements for treatment and flow control for the plant area for proposed Tenaska Project.

References

1. Black & Veatch Drawing:
   - 163994-SS-3001, Rev. ~~1~~ 2, "Grading & Drainage - Site Plan - Sheet 1"
   - 163994-SS-3201, Rev. 0, "Surfacing/Fencing/Roadway - Site Plan - Sheet 1"
   - 163994-SS-3050, Rev. ~~1~~ 2, "Site Sections and Details"
   - 163994-SS-1002, Rev. 2, "General Arrangement – Site"
2. Contra Costa Clean Water Program; Stormwater C.3 Guidebook; Stormwater Quality Requirements for Development Applications; Fourth Edition; September 10, 2008.
3. Contra Costa County Public Works Department; Mean Seasonal Isohyets Compiled from Precipitation Records 1879-1973; Drawing No. B-166; December 1977.
4. US Department of Agriculture, Natural Resources Conservation Service; Web Soil Survey; http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.
5. US Department of Agriculture; Urban Hydrology for Small Watersheds, 2nd Edition; Technical Release 55 (TR-55); June 1986.
6. Email Communications between Black & Veatch and Contra Costa Clean Water Program; March 2009.

Definition of Units and Constants

English units will be used.

Example of Common Unit Designations:

Rainfall amount in inches (in)
Drainage area in acres (ac)

Attachments

1. Black & Veatch Drawings SS1002, SS-3001, SS-3201 and SS-3050
2. Reference 2 – Select Pages
3. Reference 3 – Drawing No. B-166
4. Reference 4 – Select Pages
5. Reference 5 – Select Pages
6. Email Communications

BLACK & VEATCH					
	OWNER	Radback Energy		COMP'D BY	C. Kantola
	PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010
	PROJECT NO.	163994	File No. 52.5406.1008	CKD BY PLN	
	TITLE	IMP Sizing		DATE 6/18/10	
				PAGE 3	OF 19

Summary:

Three ~~Four~~ bioswales will be constructed within the plant area to collect and infiltrate stormwater.
Based on the Stormwater C.3 requirements (Ref 2), the required bioswale surface area and volume for each bioswale are listed in the following table. The design bioswale length, shape, design surface area and volume are presented in the following table. The design bioswales in the plant area have sufficient surface areas and volume to satisfy the Stormwater C.3 requirements.

IMP ID	Shape	Length (feet)	Side Slope	Bottom Width (feet)	Design Surface Area (ft^2)	Design Volume (ft^3)	Required Surface Area (ft^2)	Required Volume (ft^3)
Bioswale #1-2	Trapezoidal	1,323	3 (h) to 1 (v)	2	26,460	43,659	13,042	10,806
~~Bioswale #3~~	~~Trapezoidal~~	~~187~~	~~3 (h) to 1 (v)~~	~~2~~	~~2,618~~	~~2,092~~	~~500~~	~~415~~
Bioswale #4	Trapezoidal	391	3 (h) to 1 (v)	2	7,820	12,903	7,598	6,296
Bioswale #5	Trapezoidal	385	3 (h) to 1 (v)	10 ft for first ~~265~~ 145 ft long section; ~~8 ft for remaining 120 ft long section~~	10,105	16,714	9,910	8,211

Rev 1 Deleted Bioswale 3

Note: Treatment to meet C.3 requirements is provided within proposed detention basin for Bioswales #4 + 5. Bioswale #1-2 will remain
See Pages 9a-9c for basin sizing calculations

Rev 1
9/13/10 ✓ PLN 9/17/10
CAK

IMP Sizing for Plant Area

The generation area primarily consists of two combustion turbines, two heat recovery steam generators (HRSG), one air cooled condenser (ACC), three switchyards, one water treatment building, one warehouse building, two water storage tanks, one administration building, and other miscellaneous equipment/facilities. See B&V Drawing SS-1002 for plant general arrangement (Attachment 1). Plant loop road and major equipment access roads will be constructed within the plant. The areas adjacent to the buildings and equipment will have gravel surfacing. Other areas will be covered with vegetated grass. See B&V Drawing SS-3001 for proposed site surfacing of the plant (Attachment 1). The existing trees on this project site will be preserved.

~~Four~~ Three bioswales and a detention pond will be constructed within the plant site to collect and infiltrate stormwater. See Page 5 for the locations of bioswales and delineated drainage area for each bioswale and pond. Drop and/or outlet control structures will be installed at the end of each bioswale such that sufficient depth (volume) of stormwater has to be collected ~~in the bioswale~~ before downstream discharge can occur. Low flow orifices are provided to maintain hydration of the existing wetland PLN 9/17/10

An existing natural gas distribution facility is located west of the project and is outside the project limits. This area is generally covered by gravel surfacing. From the topography, most of the natural gas facility drains towards the wetland. After constructing the plant access road from Bridgehead Road, this area will continue to drain towards the wetland via a culvert being installed underneath the access road. The natural gas facility will be included in the IMP sizing for bioswale #5 since the stormwater from this area will flow to and accumulate in this bioswale.

NRCS Soil Group

Based on the soil survey information from the US Department of Agriculture Natural Resources Conservation Service (NRCS), the project site in Contra Costa County, California is covered by "Delhi Sand". See Attachment 4. From the description of "Delhi Sand" by NRCS, this soil layer is "somewhat excessively drained"; the capacity of the most limiting layer to transmit water is "high to very high (5.95 to 19.98 in/hr)". Per Ref. 5, this type of soil can be classified as Hydrologic Soil Group A soil.

BIOSWALE #3

POND

BIOSWALE #1-2

BIOSWALE #5

BIOSWALE #4

DRAINAGE AREA FOR EA. BIOSWALE (TYP)

VOID CAK
Superseded 9/13/10
See page 5a

ALL BACKCIRCLED CHANGES
PER ECN-N-S-00XX

OPEN
05/27/10

Scale 1" = 125'

page 5 of 19
Roadback Energy
Oakley Project
Proj # 163994
File 52.5406.1008
By: C. Kantola
Date: 6/15/10
Checked by: PLW
Date: 6/17/10

MATCHLINE E 6202810 – SEE DWG SS-3002 FOR CONTINUATION

ABBRE

APPROX
ASPH
AVG
BND
BLDG
B/MH
BOC
BOD
BOP
BU
C
CB
CD
CHDPE
CL
CLR
CMH
CND
CONC
CO
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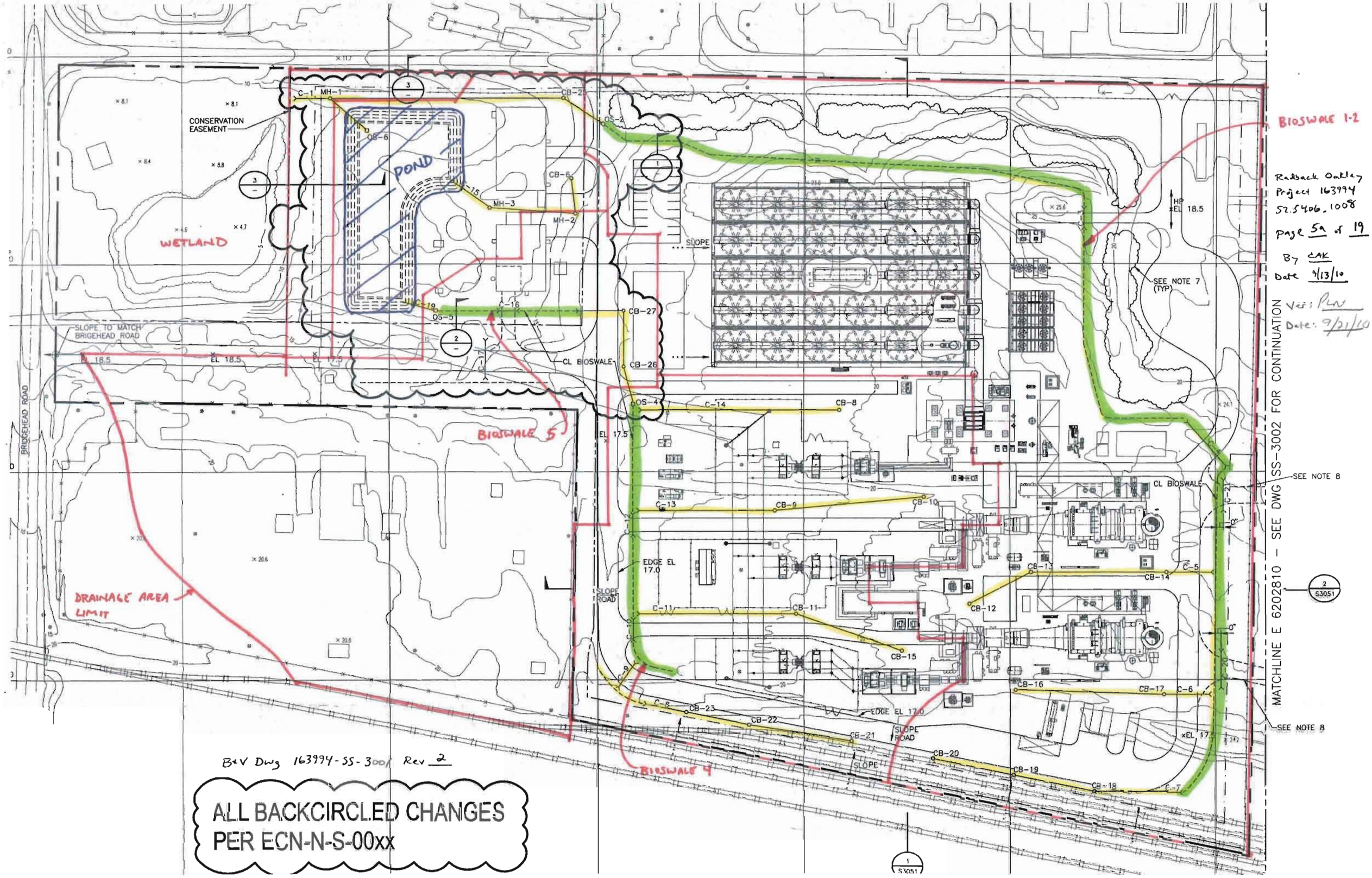


Radback Oakley
Project 163994
52.5406.1008
Page 5a of 19
By CAK
Date 9/13/10
Ver: PLN
Date: 9/21/10

B+V Dwg 163994-SS-3001 Rev 2

ALL BACKCIRCLED CHANGES
PER ECN-N-S-00xx

IMP Sizing for Bioswale #1-2

Refer to Page 5, the total drainage area for bioswale #1-2 is measured to be: 491,168 ft^2 (11.28 ac). The bioswale is measured to be 1,323 feet long.

Six drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; (5) Transformer Containment; and (6) Open-Graded Aggregates (ACC Area).

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	54,900
DMA-2	Asphalt Pavement	65,113
DMA-3	Gravel Surfacing	100,200
DMA-4	Grass/Landscape	198,264
DMA-5	Transformer Containment	4,491
DMA-6	Open-Graded Aggregates	68,200

Runoff Coefficients

Dense-graded aggregate (Caltran Class 2 aggregate) will be utilized as the materials for aggregate surfacing. After being compacted, the dense-graded aggregate is estimated to have a runoff coefficient of 0.5 to 0.7. See communications with Contra Costa County Clean Water Program (Attachment 6). Use 0.6 in this calculation.

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Open Graded Aggregates" will have a runoff coefficient of 0.1. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (54{,}900 \times 1 + 65{,}113 \times 1 + 100{,}200 \times 0.6 + 198{,}264 \times 0.1 + 4{,}491 \times 0 + 68{,}200 \times 0.1)$$

$$= 206{,}779\ ft^2.$$

IMP Sizing Factors

Since the project site is covered by hydrologic group A soil, the subsurface reservoir volume (V_2) is not needed per Stormwater C.3 Guidebook. From this guidebook, for "treatment and flow control", the IMP sizing factor for the area (A) of bioswale is 0.07. The IMP sizing factor for the surface reservoir volume (V_1) of bioswale is 0.058. (Ref. 2, Table 4-6).

Rain Adjustment Factor

Per the Isohyetal Map by Contra Costa County Public Works, Figure B-166 (Ref. 3), the mean annual precipitation (MAP) at the project site is 12.5 inches. Consequently, for group A soils,

$$\text{Rain Adjustment Factor} = \frac{0.0009 \times (MAP - 20.2) + 0.07}{0.07} \qquad \text{(Ref. 2, Equation 4-3)}$$

$$= \frac{0.0009 \times (12.5 - 20.2) + 0.07}{0.07}$$

$$= 0.901.$$

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

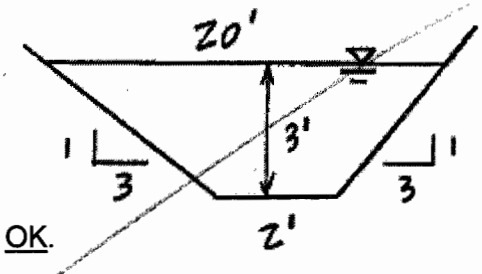
$$= 206{,}779 \times 0.07 \times 0.901 = 13{,}041 \text{ ft}^2.$$

The required minimum surface reservoir volume (V_1) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 206{,}779 \times 0.058 \times 0.901 = 10{,}806 \text{ ft}^3.$$

The proposed bioswale #1 is 1,323 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.5. Outlet structure OS-3 will be installed at the end of bioswale #1. See B&V Drawing SS-3001 (Attachment 1). The top of grate elevation of OS-3 will be at EL 15.5 (see Drawing SS-3050). The effective depth of the bioswale is: 15.5 – 12.5 = 3 feet.



The surface area of bioswale #1 is:

$20 \times 1{,}323 = 26{,}460\ ft^2 > 13{,}041\ ft^2$, OK.

The volume of bioswale #1 is:

$\frac{2+20}{2} \times 3 \times 1{,}323 = 43{,}659\ ft^3 > 10{,}806\ ft^3$, OK.

Conclusion: The proposed size of bioswale #1 is sufficient to meet the Stormwater C.3 requirements.

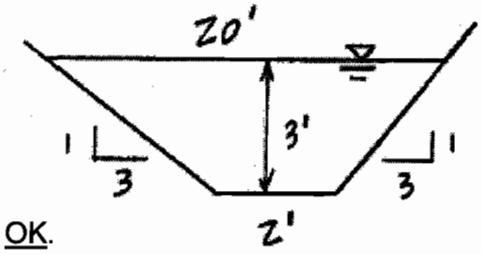
Orifices starting approximately 9" above the bottom of the bioswale will be installed in the outlet control structure to discharge stormwater runoff from less intensive storm events to the wetland to maintain hydration of the wetland.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

Superseded 9/13/10
See pg 8A

The surface area of bioswale #1 is:

$20 \times 1{,}323 = 26{,}460\ ft^2 > 13{,}041\ ft^2$, OK.



The volume of bioswale #1 is:

$$\frac{2+20}{2} \times 3 \times 1{,}323 = 43{,}659\ ft^3 > 10{,}806\ ft^3, \text{ OK.}$$

Conclusion: The proposed size of bioswale #1 is sufficient to meet the Stormwater C.3 requirements.

Low-flow orifices will be installed starting at the bottom of the outlet control structure to discharge stormwater runoff from less intensive storm events to the wetland, to maintain hydration of the wetland.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

BLACK & VEATCH					
OWNER	Radback Energy		COMP'D BY	C. Kantola	
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010	
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PLN	
TITLE	IMP Sizing		DATE	6/18/10	
			PAGE	9	OF 19

Soil Type	IMP Name
A	Bioswale #1-2

DMA Name	DMA Area (ft^2)	Post-Project Surface Type	DMA Runoff Factor	DMA Area x Runoff Factor	IMP Sizing Factor	Rain Adjustment Factor	Minimum Area or Volume	Proposed Area or Volume	
DMA-1	54,900	Equipment / Roofs	1.00	54,900					
DMA-2	65,113	Asphalt Pavement	1.00	65,113					
DMA-3	100,200	Gravel Surfacing	0.60	60,120					
DMA-4	198,264	Landscape, Group A Soil	0.10	19,826					
DMA-5	4,491	Transformer Containment	0.00	0					
DMA-6	68,200	Open Graded Aggregates	0.10	6,820					
			Total:	206,779	0.070	0.901	13,042	26,460	IMP Area (ft^2)
					0.058	0.901	10,806	43,659	V_1 (ft^3)
					NA	0.901	NA	NA	V_2 (ft^3)
								Orifice Size:	NA

IMP Sizing for Detention Basin

Contra Costa's Clean Water Program (CCCWP) allows volume-based treatment facilities to be used for providing treatment for stormwater runoff from development sites. Due to limited space on site, bioswales of sufficient size and volume cannot be installed for all areas of the site and therefore a portion of the site will have stormwater treatment provided within the proposed detention basin. CCCWP provides a "Unit Basin Storage Size for 80% Capture" chart showing the relationship of several site parameters and the required storage volume required to meet the treatment goal.

The input parameters that are required to use the Unit Basin chart are the mean annual precipitation, directly connected impervious areas (DCIA – the relative coverage of land by impervious surfaces), and the acreage of the project site draining to the treatment facility (i.e. the detention basin). The relative coverage of land by impervious surfaces can be determined by estimating the areas of each surface type within the drainage area. Several surface types are anticipated for the project site and are summarized in the table below. The areas draining to the detention basin are from "Bioswale 4", "Bioswale 5", and "Direct to Pond".

Typically, impervious surface types are limited to buildings and paved areas. As discussed with Mr. Mark Lindley, PE in a telephone conversation on September 3, 2010, the proposed gravel surfaces should be accounted for, in the estimation of the DCIA value. For purposes of estimating DCIA, it is assumed that a factor of 50% of the total gravel area be included in DCIA since runoff from the gravel areas will be greater than the lawn but less than fully impervious areas. The table below summarizes the values for those areas to determine the DCIA used for the Unit Basin sizing. Data was obtained from B&V Calc 52.5406.1006.

Summary of Post-Construction Drainage Areas to Basin (in acres)

Surface Type	Bio 4	Bio 5	Pond	Total	Impervious Factor	DCIA Acreage
Gravel	2.51	2.87	0.1	5.48	50%	2.74
Railroad Yard	-	0.94	-	0.94	50%	0.47
Lawn	0.54	0.95	1.28	2.77	0%	0
Impervious	1.21	1.32	0.30	2.83	100%	2.83
Total Acres:	4.26	6.08	1.68	12.02	-	6.04

%DCIA = 6.04 ac. / 12.02 ac. = 50.2%, therefore interpolate between values of 45% and 60% on Unit Basin chart.

Per CCC Drawing B-166 in Reference 3, the mean precipitation is 12.5 inches.

For a mean precipitation value of 12.5 inches and %DCIA = 50%, the Unit Basin Storage Size for 80% Capture on the left side of the chart shows a value of 0.025 feet. See Page 9c.

Determine the treatment volume (water quality volume) required for the drainage area:

12.02 acres (draining to pond) x 0.025 feet (per chart) = 0.30 ac-ft WQV

The proposed detention basin storage table is shown below. Interpolating from the cumulative storage column, the minimum treatment volume is met at EL 9.34 ft, well below the pond overflow elevation which is at EL 12.0.

Pond Elevation – Area – Storage Summary

Elevation (ft)	Pond Area (acres)	Incremental Storage (ac-ft)	Cumulative Storage (ac-ft)
8.5	0.33	-	-
9.0	0.35	0.17	0.17
10.0	0.41	0.38	0.55
11.0	0.48	0.44	0.99
12.0	0.54	0.51	1.50
13.0	0.61	0.57	2.08

Conclusion: The proposed size of the detention basin is sufficient to meet the Stormwater C.3 requirements using the Unit Basin Sizing chart methodology.

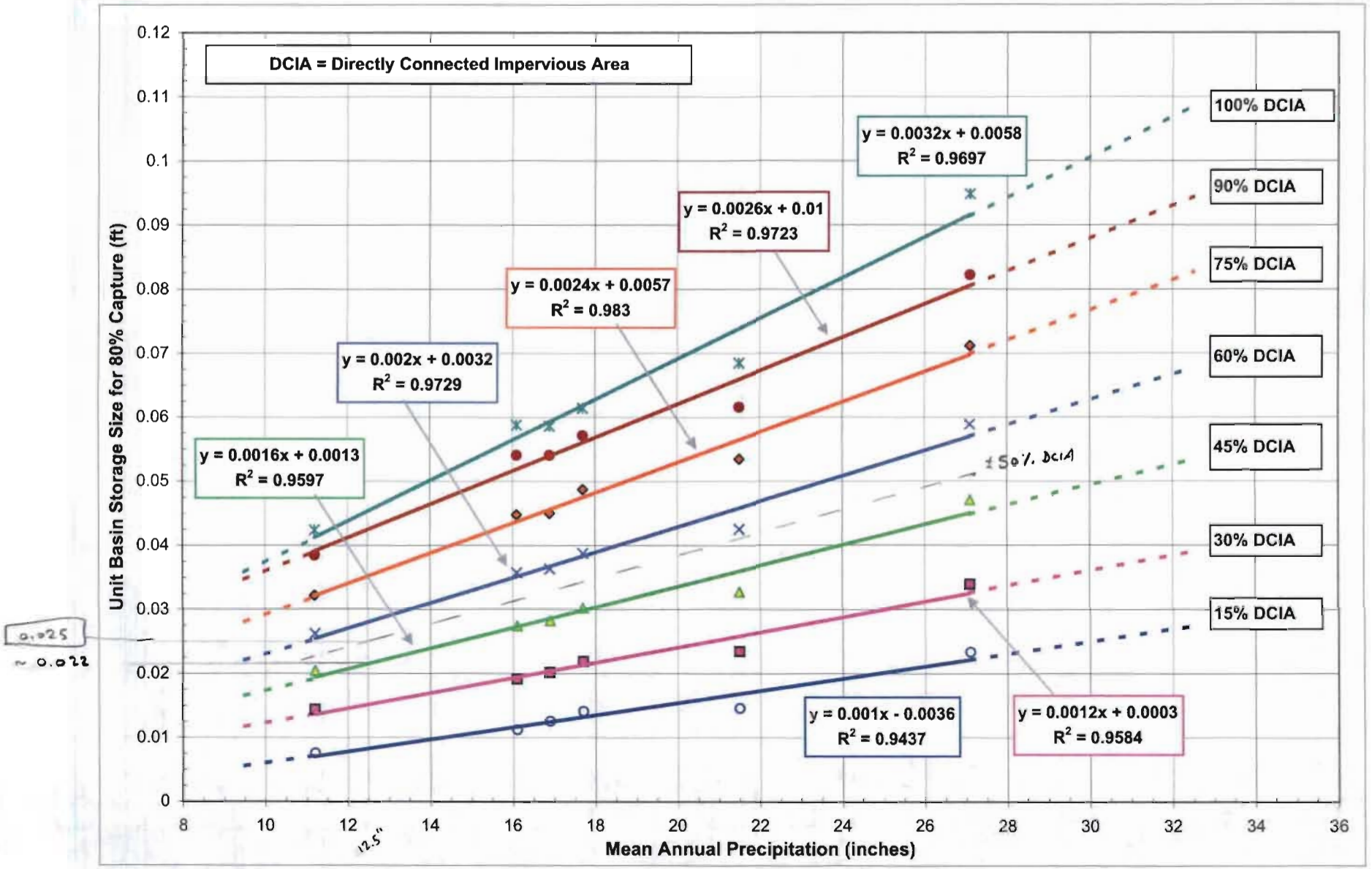
Low-flow orifices starting approximately 3" above the bottom of the pond (EL 8.75') will be installed in the outlet structure to drain the WQV in 24-48 hours.

Average head for the orifice equation is 2/3 of the maximum head of 9.34'-8.75' = 0.39'
The target dewatering time is 24 hours for the WQV. Therefore the average flow rate

Q = (0.3 ac-ft x 43560 sf/ac) / (24 hr x 3600 s/hr) = 0.151 cfs

Orifice equation: $Q=CA\sqrt{(2gh)}$ for 0.151 cfs with h=0.39' and C=0.62, yields A = 0.0486 sf
Eight 1-inch orifices can be used to provide an area of 0.044 sf (use in orifice equation)
Actual average release rate = 0.62 x 0.044 x $\sqrt{(2 \times 32.2 \times 0.39')}$ = 0.137 cfs

Time to drain WQV: (0.3 ac-ft x 43,560 sf/ac) / (0.137 cfs x 3600 s/hr) = 26.5 hours
This is less than the recommended 48-hour maximum time.



Radback Energy
Oakley Gen Station
Proj 163994

File 52.5406.1008
By: C. Kantola
Date: 9/13/10
Rev 1

Pg 9e of 19
Verified
Date 9/21/10

VOID

IMP Sizing for Bioswale #3

Refer to Page 5, the total drainage area for bioswale #3 is measured to be: 25,711 ft^2 (0.59 ac). The bioswale #3 is measured to be 187 feet long.

Three drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; and (3) Grass/Landscape.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	3,873
DMA-2	Asphalt Pavement	2,086
DMA-3	Grass/Landscape	19,752

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (3{,}873 \times 1.0 + 2{,}086 \times 1.0 + 19{,}752 \times 0.1)$$

$$= 7{,}934 \text{ ft}^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

Removed 9/13/10

$$= 7{,}934 \times 0.07 \times 0.901 = 500 \text{ ft}^2.$$

The required minimum surface reservoir volume (V_1) of the bioswale is:

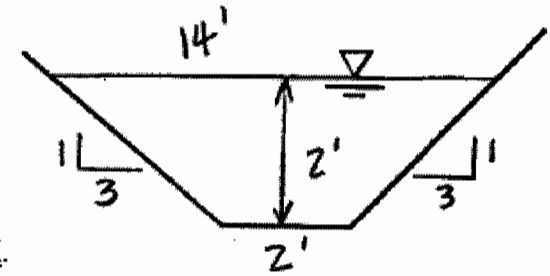
$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 7{,}934 \times 0.058 \times 0.901 = 415 \text{ ft}^3.$$

The proposed bioswale #3 is 187 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 11.0. Drop structure DS-1 will be installed at the end of bioswale #3. See B&V Drawing SS-3001. The top of grate elevation of DS-1 will be at EL 13.0 (see Drawing SS-3050). The effective depth of the bioswale is: 13.0 – 11.0 = 2 feet.

The surface area of bioswale #3 is:

$14 \times 187 = 2{,}618 \text{ ft}^2 > 500 \text{ ft}^2$, OK.



The volume of bioswale #3 is:

VOID

$$\frac{2+14}{2} \times 2 \times 187 = 2992 \text{ ft}^3 > 415 \text{ ft}^3, \text{ OK.}$$

Conclusion: The proposed size of bioswale #3 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

Removed 9/13/10

BLACK & VEATCH					
OWNER	Radback Energy		COMP'D BY	C. Kantola	
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010	
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PLN	
TITLE	IMP Sizing		DATE	6/18/10	
			PAGE	12	OF 19

Soil Type	IMP Name
A	Bioswale #3

DMA Name	DMA Area (ft^2)	Post-Project Surface Type	DMA Runoff Factor	DMA Area x Runoff Factor
DMA-1	3,873	Equipment / Roofs	1.00	3,873
DMA-2	2,086	Asphalt Pavement	1.00	2,086
DMA-3	19,752	Landscape, Group A Soil	0.10	1,975
			Total:	7,934

IMP Sizing Factor	Rain Adjustment Factor	Minimum Area or Volume	Proposed Area or Volume	
0.070	0.901	500	2,618	IMP Area (ft^2)
0.058	0.901	415	2,992	V_1 (ft^3)
NA	0.901	NA	NA	V_2 (ft^3)
			Orifice Size:	NA

VOID

Removed 9/13/10

IMP Sizing for Bioswale #4

Refer to Page 5, the total drainage area for bioswale #4 is measured to be: 190,955 ft^2 (4.38 ac). The bioswale #4 is measured to be 391 feet long.

Five drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; (4) Grass/Landscape; and (5) Transformer Containment.

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	19,314
DMA-2	Asphalt Pavement	33,262
DMA-3	Gravel Surfacing	109,208
DMA-4	Grass/Landscape	23,692
DMA-5	Transformer Containment	5,479

VOID

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0. The "Transformer Containment" will have no runoff since all the runoff will go to oil-water separator which discharges to the sanitary sewer and will not be discharged on site.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (19{,}314\text{x}1.0+33{,}262\text{x}1.0+109{,}208\text{x}0.6+23{,}692\text{x}0.1+5{,}479\text{x}0)$$

$$= 120{,}470\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Removed 9/13/10

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 120{,}470 \times 0.07 \times 0.901 = 7{,}598 \text{ ft}^2.$$

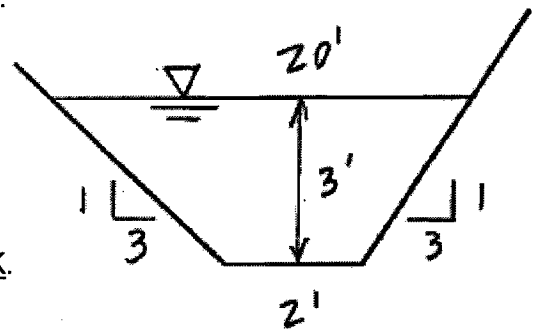
The required minimum surface reservoir volume (V_1) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 120{,}470 \times 0.058 \times 0.901 = 6{,}296 \text{ ft}^3.$$

VOID

The proposed bioswale #4 is 391 feet long. The bioswale cross section will be trapezoidal. Bottom width = 2 feet. Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.5. Outlet structure OS-4 will be installed at the end of bioswale #4. See B&V Drawing SS-3001. The top of grate elevation of OS-4 will be at EL 15.5 (see Drawing SS-3050). The effective depth of the bioswale is: 15.5 – 12.5 = 3 feet.



The surface area of bioswale #4 is:

$20 \times 391 = 7{,}820 \text{ ft}^2 > 7{,}598 \text{ ft}^2$, OK.

The volume of bioswale #4 is:

$\frac{2+20}{2} \times 3 \times 391 = 12{,}903 \text{ ft}^3 > 6{,}296 \text{ ft}^3$, OK.

Conclusion: The proposed size of bioswale #4 is sufficient to meet the Stormwater C.3 requirements.

Orifices starting approximately 9" above the bottom of the bioswale will be installed in the outlet control structure to discharge stormwater runoff from less intensive storm events to the wetland to maintain hydration of the wetland.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

Removed 9/13/10

BLACK & VEATCH					
OWNER	Radback Energy		COMP'D BY	C. Kantola	
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010	
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PCN	
TITLE	IMP Sizing		DATE	6/17/10	
			PAGE	15	OF 19

Soil Type	IMP Name
A	Bioswale #4

DMA Name	DMA Area (ft^2)	Post-Project Surface Type	DMA Runoff Factor	DMA Area x Runoff Factor
DMA-1	19,314	Equipment / Roofs	1.00	19,314
DMA-2	33,262	Asphalt Pavement	1.00	33,262
DMA-3	109,208	Gravel Surfacing	0.60	65,525
DMA-4	23,692	Landscape, Group A Soil	0.10	2,369
DMA-5	5,479	Transformer Containment	0.00	0
			Total:	120,470

IMP Sizing Factor	Rain Adjustment Factor	Minimum Area or Volume	Proposed Area or Volume	
0.070	0.901	7,598	7,820	IMP Area (ft^2)
0.058	0.901	6,296	12,903	V_1 (ft^3)
NA	0.901	NA	NA	V_2 (ft^3)
			Orifice Size:	NA

VOID

Removed 9/13/10

IMP Sizing for Bioswale #5

Refer to Page 5, the total drainage area for bioswale #5 is measured to be: 290,529 ft^2 (6.67 ac) (natural gas facility included). The bioswale #5 is measured to be 385 feet long total.

Four drainage management areas (DMA) were identified based on the type of ground covers: (1) Equipment/Roofs; (2) Asphalt Pavement; (3) Gravel Surfacing; and (4) Grass/Landscape.

Including Railroad yard
PW 6/17/10

The measured areas are shown in the following table. The measurements were made by using AutoCAD.

DMA Name	Post-Project Surface Type	DMA Area (ft^2)
DMA-1	Equipment/Roofs	12,670
DMA-2	Asphalt Pavement	25,905
DMA-3	Gravel Surfacing	186,725
DMA-4	Grass/Landscape	65,229

VOID

Runoff Coefficients

From Table 4-2 of the Stormwater C.3 Guidebook, the "Grass/Landscape" will have a runoff coefficient of 0.1 for Group A Soil for treatment and flow control. The "Equipment/Roofs" and "Asphalt Pavement" will have a runoff coefficient of 1.0.

Use 0.6 for dense-graded aggregate surfacing (see Page 6).

Consequently,

$$\sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} = (12{,}670\text{x}1.0+25{,}905\text{x}1.0+186{,}725\text{x}0.6+89{,}695\text{x}0.1)$$

$$= 157{,}133\ ft^2.$$

IMP sizing factor = 0.07 for the area (A) of bioswale; IMP sizing factor = 0.058 for the surface reservoir volume (V_1). See Page 7.

Rain adjustment factor = 0.901. See Page 7.

Removed 9/13/10

Minimum Area and Minimum Volume of IMP

Per Ref. 2, Equation 4-7, the required minimum area (A) of the bioswale is:

$$\text{Min. IMP Area A} = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 157{,}133 \times 0.07 \times 0.901 = 9{,}910 \text{ ft}^2.$$

The required minimum surface reservoir volume (V_1) of the bioswale is:

$$\text{Min. IMP Volume } (V_1) = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

$$= 157{,}133 \times 0.058 \times 0.901 = 8{,}211 \text{ ft}^3.$$

The proposed bioswale #5 is 385 feet long total. The bioswale cross section will be trapezoidal. Bottom width = 10 feet for the first 265 feet long section (Section 2 on SS-3001) and 8 feet for the remaining 120 feet long section (Section 2A on SS-3001). Side slope = 3 (h) to 1 (v). The bottom of the bioswale is at EL 12.0 for Section 2 and EL 11.0 for Section 2A. Outlet structure OS-5 will be installed at the end of bioswale #5. See B&V Drawing SS-3001. The top of grate elevation of OS-5 will be at EL 15.0 (see Drawing SS-3050). The effective depth of the bioswale is: 14.5 – 11.0 = 3.5 feet for Section 2A and 14.5 – 12.0 = 2.5 feet for Section 2. See Dwg SS-3001 in Attachment 1.

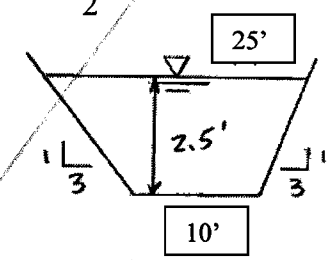
VOID

The surface area of bioswale #5 is:

$25 \times 265 + 29 \times 120 = 10{,}105 \text{ ft}^2 > 9{,}910 \text{ ft}^2$, OK.

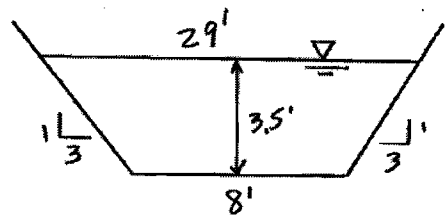
The volume of bioswale #5 is:

$$\frac{2+25}{2} \times 2.5 \times 265 + \frac{8+29}{2} \times 3.5 \times 120 = 16{,}714 \text{ ft}^3 > 8{,}211 \text{ ft}^3, \text{ OK.}$$



Section 2

DWG SS-3001



Section 2A

DWG SS-3001

Removed 9/13/10

An orifice will be installed in the outlet structure for bioswale #5 to discharge stormwater runoff from less intensive storm events to the wetland to allow the wetland continue to have water. See Dwg SS-3001 (Attachment 1).

Conclusion: The proposed size of bioswale #5 is sufficient to meet the Stormwater C.3 requirements.

A spreadsheet was prepared for the above calculations to follow the format by Contra Costa County Clean Water Program. See next page.

VOID

Removed 9/13/10

BLACK & VEATCH					
OWNER	Radback Energy		COMP'D BY	C. Kantola	
PLANT	Oakley Generating	Unit No.	DATE	15-Jun-2010	
PROJECT NO.	163994	File No. 52.5406.1008	CKD BY	PLN	
TITLE	IMP Sizing		DATE	6/17/10	
			PAGE	19	OF 19

Soil Type	IMP Name
A	Bioswale #5

DMA Name	DMA Area (ft^2)	Post-Project Surface Type	DMA Runoff Factor	DMA Area x Runoff Factor	IMP Sizing Factor	Rain Adjustment Factor	Minimum Area or Volume	Proposed Area or Volume	
DMA-1	12,670	Equipment / Roofs	1.00	12,670					
DMA-2	25,905	Asphalt Pavement	1.00	25,905					
DMA-3	186,725	Gravel Surfacing	0.60	112,035					
DMA-4	65,229	Landscape, Group A Soil	0.10	6,523					
			Total:	157,133	0.070	0.901	9,910	10,105	IMP Area (ft^2)
					0.058	0.901	8,211	16,714	V_1 (ft^3)
					NA	0.901	NA	NA	V_2 (ft^3)
								Orifice Size:	NA

VOID

Revised 9/13/10

Radback Oakley Project

CAK 6/15/10

163994 File # 52.5406.1008

pgs 5

IMP Sizing for plant area

Attachment 1

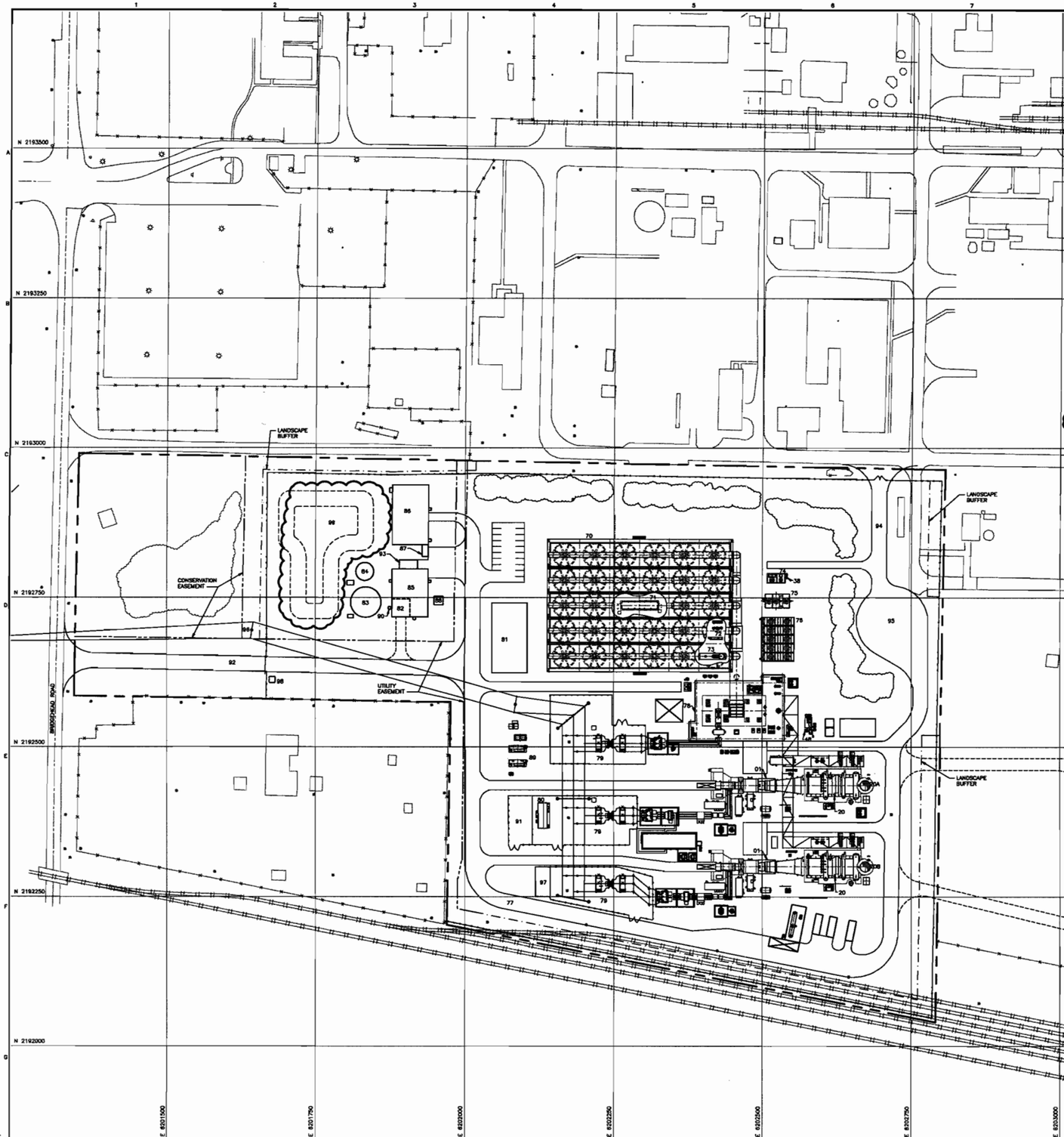
Black & Veatch Dwgs

SS-1002

-3001

-3201

-3050



FACILITIES LEGEND

ID	FACILITY	STRUCTURE HEIGHT	TIEDOWN LOCATION NORTH	TIEDOWN LOCATION EAST	REMARKS
01	COMBUSTION TURBINE	70'	–	–	–
20	HEAT RECOVERY STEAM GENERATOR (HRSG)	103'	–	–	–
20A	HRSG EXHAUST STACK A	135'	2192436.00	6202665.00	CL EXHAUST STACK
20B	HRSG EXHAUST STACK B	135'	2192300.00	6202665.00	CL EXHAUST STACK
38	SAFETY SHOWER EYEWASH STATION	–	–	–	–
45	AUXILIARY BOILER	50'	2192527.61	6202572.26	CL EXHAUST STACK
70	AIR COOLED CONDENSER (ACC)	124'	–	–	–
71	ACC ELECTRICAL ENCLOSURE	14'	–	–	–
72	CONDENSER AIR EXTRACTION SKIDS	6'	–	–	–
73	ACC CONDENSATE COLLECTION TANK	28'	–	–	–
74	WET SURFACE AIR COOLER CHEMICAL FEED SKIDS	6'	–	–	–
75	WET SURFACE AIR COOLER	23'	2192744.67	6202523.00	CL COOLER
76	CLOSED CYCLE COOLING WATER HEAT EXCHANGER	19'	–	–	–
77	LOOP ROAD	–	–	–	–
78	STEAM TURBINE FOUNDATION	–	–	–	–
79	SWITCHYARD	18' & 45'	–	–	–
80	SWITCHYARD CONTROL ENCLOSURE	12'	–	–	–
81	CONTROL & ADMIN BUILDING	14'	–	–	–
82	FIRE WATER PUMP ROOM	20'	–	–	–
83	FIRE/SERVICE WATER STORAGE TANK	32'	–	–	–
84	DEMIN WATER STORAGE TANK	24'	–	–	–
85	WATER TREATMENT BUILDING	20'	–	–	–
86	WAREHOUSE/MAINTENANCE BUILDING	18'	–	–	–
87	LUBRICANT STORAGE SHED	10'	–	–	–
88	WASTE WATER LIFT STATION (IF REQUIRED)	–	–	–	–
89	GAS COMPRESSORS & GAS CONDITIONING	13'	–	–	–
90	DIESEL FIRE PUMP EXHAUST	16'	2192732.52	6201874.72	CL EXHAUST STACK
91	GAS METERING STATION	–	–	–	–
92	ACCESS ROAD	–	–	–	–
93	LEASED MIX BED EXCHANGER CONCRETE SLAB	–	–	–	–
94	EMERGENCY ACCESS ROAD	–	–	–	–
95	CUL DA SAC (TURNAROUND)	–	–	–	–
96	230KV POWER POLE	108'	–	–	–
97	OUTAGE MAINTENANCE TRAILERS AREA	–	–	–	–
98	GUARD HOUSE	–	–	–	–
99	STORM WATER POND	–	–	–	–

NOTES

1. COORDINATES ARE BASED ON CALIFORNIA COORDINATE SYSTEM CCS83, ZONE 3. ELEVATION ARE BASED ON, NGVD 29 DATUM. BENCHMARK IS NATIONAL GEODETIC SURVEY BENCH MARK "M 845", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE. ELEVATION = 11.168 FEET. TO OBTAIN DUPONT PLANT DATUM ELEVATION, ADD 0.70 FEET TO THE ELEVATIONS SHOWN. TOPOGRAPHIC DATA IS BASED ON AERIAL PHOTOGRAPH DATED JUNE 11, 2001. AERIAL SURVEY INFORMATION WAS OBTAINED BY RONALD GREENWELL & ASSOCIATES, INC.
2. SEE PLANT ARRANGEMENT DRAWING SM-2001, FOR LEGEND OF MAIN POWER BLOCK.
3. PROPERTY AND EASEMENT BOUNDARY INFORMATION IS BASED UPON DRAWING EXHIBIT D, BY RONALD GREENWELL & ASSOCIATES, INC. REVISION DATED 05/FEB/09.

GENERAL LEGEND

- NEW FENCE
- EXISTING FENCE
- PROPERTY BOUNDARY (SEE NOTE 3)
- EASEMENT BOUNDARY (SEE NOTE 3)
- LANDSCAPE BUFFER

ALL BACKCIRCLED CHANGES PER ECN-N-S-0004

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
3	18/JUN/10	ISSUED FOR PERMITTING	RJS	DVK		PLH	DVK
2	16/APR/09	ISSUED PER ECN-N-S-0003	NAW	PLH		PLH	DVK
1	30/MAR/09	ISSUED PER ECN-N-S-0001	NAW	PLH		PLH	DVK
0	13/MAR/09	ISSUED FOR PERMITTING	NAW	PLH		PLH	DVK

SCALE: 1" = 60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA

SIGNED _____ REG NO. _____
DATE _____

BLACK & VEATCH CORPORATION

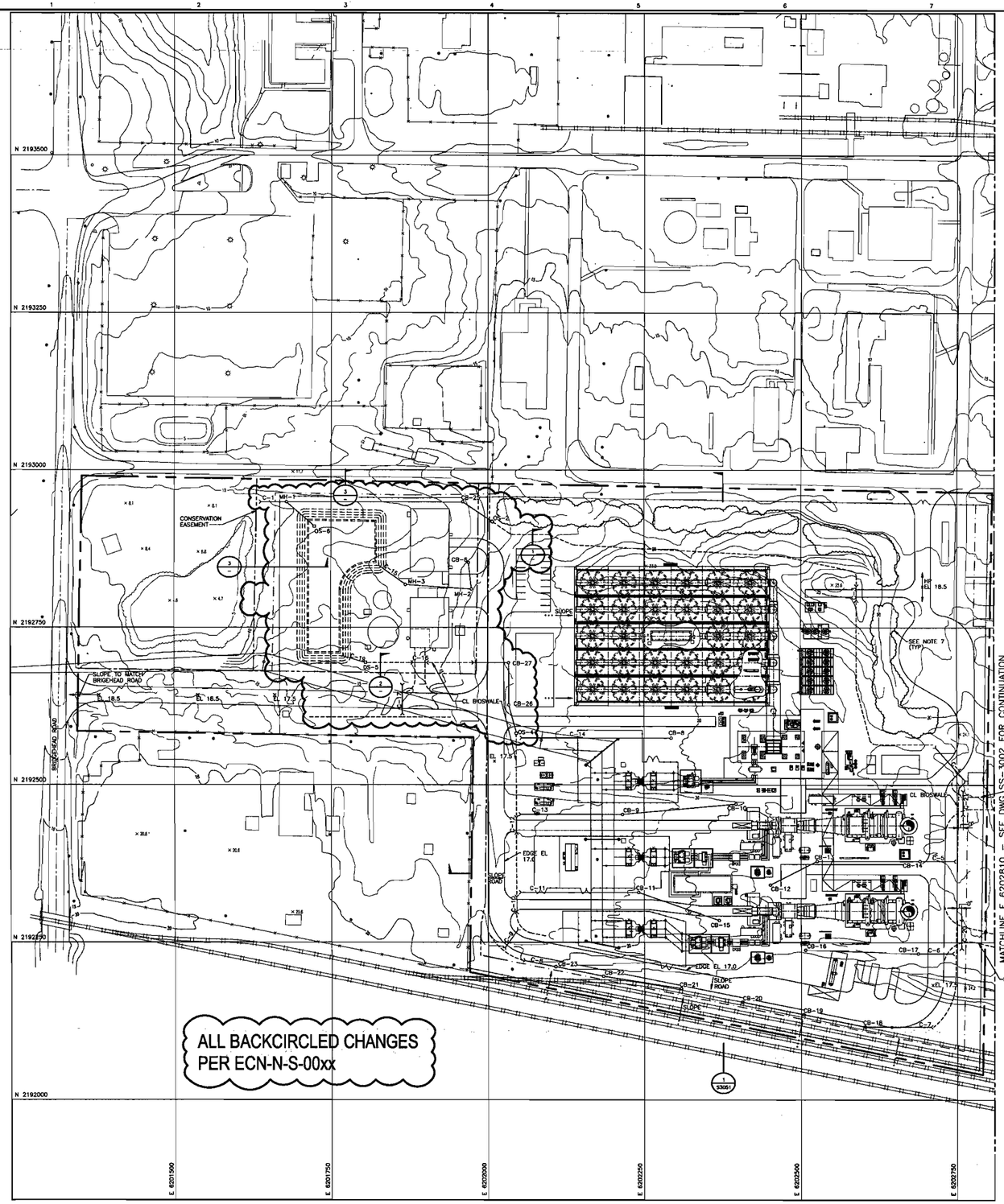
ENGINEER PLH DRAWN NAW
CHECKED DATE

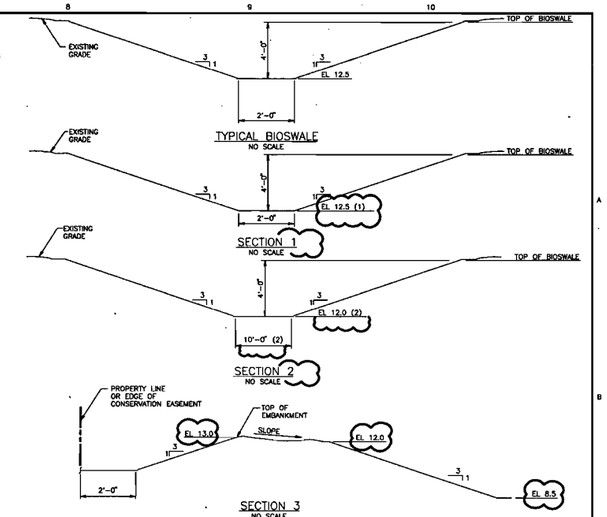
CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

GENERAL ARRANGEMENT SITE

PROJECT 163994 DRAWING NUMBER SS-1002 REV 3
CODE
AREA

ACAD 16.1s (LMS Tech)
SCALE(1) 1:1
SCALE(2) 1:1
06/18/10 07:44:32





ABBREVIATIONS APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

APPROX	-	APPROXIMATE	LTR	-	LATER
ASPH	-	ASPHALT	MAX	-	MAXIMUM
AVG	-	AVERAGE	MH	-	MANHOLE
BND	-	BEND	MIN	-	MINIMUM
BLDG	-	BUILDING	MJ	-	MECHANICAL JOINT
B/MH	-	BOTTOM OF MANHOLE ELEVATION	MSL	-	MEAN SEA LEVEL
BOC	-	BOTTOM OF CONDUIT ELEVATION	NO.	-	NUMBER
BOG	-	BOTTOM OF DUCTBANK ELEVATION	NTS	-	NOT TO SCALE
BOP	-	BOTTOM OF PIPE ELEVATION	OD	-	OUTSIDE DIAMETER
BU	-	BELL-UP	OWS	-	OIL WATER SEPARATOR
C	-	CULVERT	OWMH	-	OILYWASTE MANHOLE
CB	-	CATCH BASIN	PC	-	POINT OF CURVATURE
CD	-	CABLE DUCT	PE	-	PLAIN END
CHDPE	-	CORRUGATED HIGH DENSITY POLYETHYLENE PIPE	PI	-	POINT OF INTERSECTION
			PLCS	-	PLACES
CL	-	CENTERLINE	PM	-	PLANT MANHOLE
CLR	-	CLEAR	POT	-	POINT OF TANGENT
CMH	-	CHEMICAL MANHOLE	PT	-	PIPE TERMINATION
CND	-	CONDUIT	PVC	-	POLYVINYL CHLORIDE PIPE
CONC	-	CONCRETE	QTY	-	QUANITY
CO	-	CLEAN OUT	R	-	RADIUS
CS	-	CARBON STEEL	RCP	-	REINFORCED CONCRETE PIPE
CW	-	CIRCULATING WATER	RD	-	ROOF DRAIN
DB	-	DUCTBANK	REV	-	REVISION
DBC	-	DIRECT BURIED CABLE	RGS	-	RIGID GALVANIZED STEEL
DET	-	DETAIL	RR	-	RAILROAD
DIA	-	DIAMETER	SECT	-	SECTION
DIP	-	DUCTILE IRON PIPE	SIM	-	SIMILAR
DWG	-	DRAWING	SLS	-	SANITARY LIFT STATION
DWP	-	DOUBLE WALL PIPE	SMH	-	SANITARY MANHOLE
EC	-	ELECTRICAL CONDUIT	STMH	-	STORM MANHOLE
ECC	-	ECCENTRIC	STRL	-	STRUCTURAL
EF	-	EACH FACE	T/C	-	TOP OF CONCRETE ELEVATION
EHH	-	ELECTRICAL HANDHOLE	T/G	-	TOP OF GRADE ELEVATION
EL	-	ELEVATION	THH	-	TELEPHONE SERVICE HANDHOLE
EMH	-	ELECTRICAL MANHOLE	T/MH	-	TOP OF MANHOLE ELEVATION
EW	-	EACH WAY	T/P	-	TOP OF PAVEMENT ELEVATION
FC	-	FIELD CHECK	TP	-	MECH PIPE TERMINAL POINT
FDN	-	FOUNDATION	TYP	-	TYPICAL
FF	-	FLAT FACE	UGL	-	UNDERGROUND LIGHTING CONDUIT
FRP	-	FIBERGLASS REINFORCED PIPE	UNO	-	UNLESS NOTED OTHERWISE
GR	-	GRADE	VERT	-	VERTICAL
HDM	-	HOT DRAIN MANHOLE	WGT	-	WEIGHT
HDPE	-	HIGH DENSITY POLYETHYLENE PIPE	WTR	-	WATER
HP	-	HIGH POINT	W/	-	WITH
HYD	-	HYDRANT	W/O	-	WITHOUT
ID	-	INSIDE DIAMETER	WP	-	WORK POINT
INV	-	INVERT	XFMR	-	TRANSFORMER
JBX	-	JUNCTION BOX			
L	-	LENGTH			
LP	-	LOW POINT			

LEGEND APPLICABLE TO ALL S3000 DRAWINGS

	NEW CULVERT		NEW SLIDE GATE
	CL BIOSWALE		NEW SWING GATE
1 / S3000	SECTION OR DETAIL NUMBER / DRAWING DESIGNATION NUMBER		EXISTING POWER POLE
× 326.5	FINISHED SPOT ELEVATIONS	CB-101	NEW CATCH BASIN
			NEW DROP STRUCTURE
BM-1	SURVEY MONUMENT/CONTROL POINT		PROPERTY LINE
	EXISTING FENCE		BOUNDARY LINE
	NEW SECURITY FENCE	126	EXISTING CONTOURS
	TEMPORARY CONSTRUCTION FENCE		GRADE TO DRAIN (DIRECTION OF ARROW)
TR-1	EROSION CONTROL METHOD		

NOTES APPLICABLE TO ALL SS-3000 SERIES DRAWINGS

1. COORDINATES ARE BASED ON CALIFORNIA COORDINATE SYSTEM CCS83, ZONE 3. ELEVATION ARE BASED ON, NGVD 29 DATUM. BENCHMARK IS NATIONAL GEODETIC SURVEY BENCH MARK "W 563", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE. ELEVATION = 11.188 FEET. TO OBTAIN DUPONT PLANT DATUM ELEVATION, ADD 0.70 FEET TO THE ELEVATIONS SHOWN. TOPOGRAPHIC DATA IS BASED ON AERIAL PHOTOGRAPH DATED JUNE 11, 2001. AERIAL SURVEY INFORMATION WAS OBTAINED BY RONALD GREENWELL & ASSOCIATES, INC.
2. NEW GRADE ELEVATIONS SHOWN ON THE SITE GRADING AND DRAINAGE PLANS INDICATE FINISH GRADE UNLESS NOTED OTHERWISE.
3. ALL CUT AND FILL SLOPES SHALL BE 3 HORIZONTAL TO 1 VERTICAL OR FLATTER, UNLESS NOTED OTHERWISE.
4. SEE DWG SS-3050 FOR GRADING AND DRAINAGE DETAILS INCLUDING CULVERT, CATCH BASIN, DROP AND OUTLET STRUCTURE CHARTS.
5. TOP OF CONCRETE ELEVATIONS AND FINISH FLOOR ELEVATIONS FOR ALL EQUIPMENT AND BUILDINGS IS EL 18.0. FINISH GRADE ADJACENT TO ALL FOUNDATIONS IS EL 17.5.
6. CL OF ALL PAVED ROADS IS EL 17.5 UNO.
7. TREES TO REMAIN. GRADE TO REMAIN UNCHANGED WITHIN 20' OF TREE BASE.
8. TEMPORARY ROAD FROM LAYDOWN AREA. ROAD AND CULVERT UNDER ROAD TO BE REMOVED AT END OF CONSTRUCTION.

OPEN
09/22/10

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDC	APP
2	OPEN		ARS	CAK		PLN	DVR
1	18/JUN/10	ISSUED FOR PERMITTING	RUS	CAK		PLN	DVR
0	18/APR/09	ISSUED FOR PERMITTING	NAW	PLN		PLN	DVR

SCALE: 1"=60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA
SIGNED
DATE REG NO.

BLACK & VEATCH CORPORATION

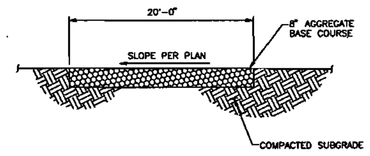
ENGINEER PLN DRAWN NAW
CHECKED DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

GRADING AND DRAINAGE - SITE PLAN - SHEET 1

PROJECT DRAWING NUMBER REV
163994-SS-3001 1
CODE
AREA

BEL30576 AVR/2010 ACAD 16.1a (LMS Tech) EL 16.2-1



TYPICAL CONSTRUCTION LAYDOWN ROAD
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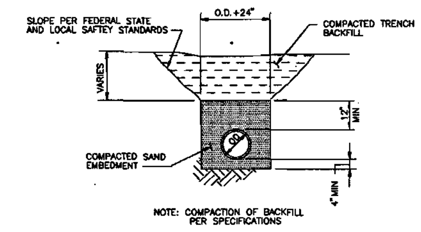
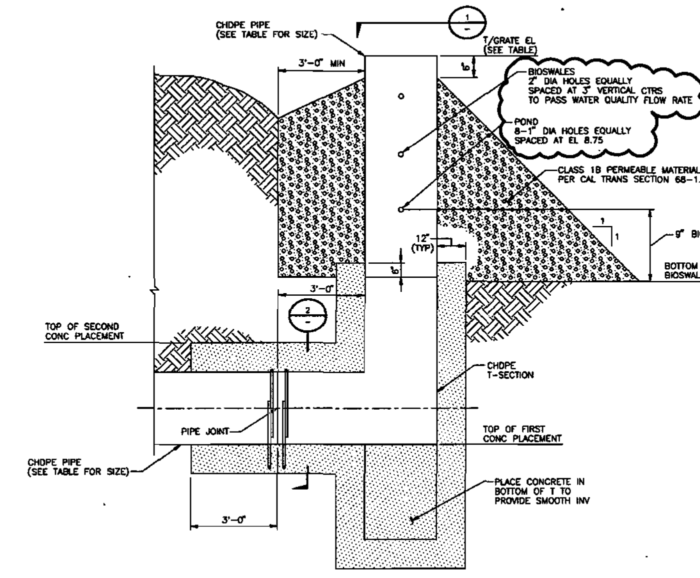
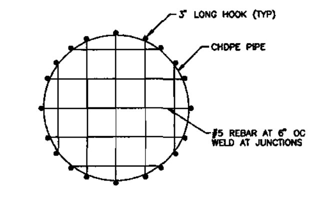


TYPICAL PIPE EMBEDMENT
NO SCALE



TYPICAL OUTLET STRUCTURE DETAIL
NO SCALE



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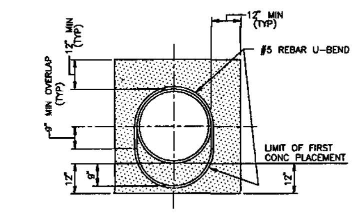

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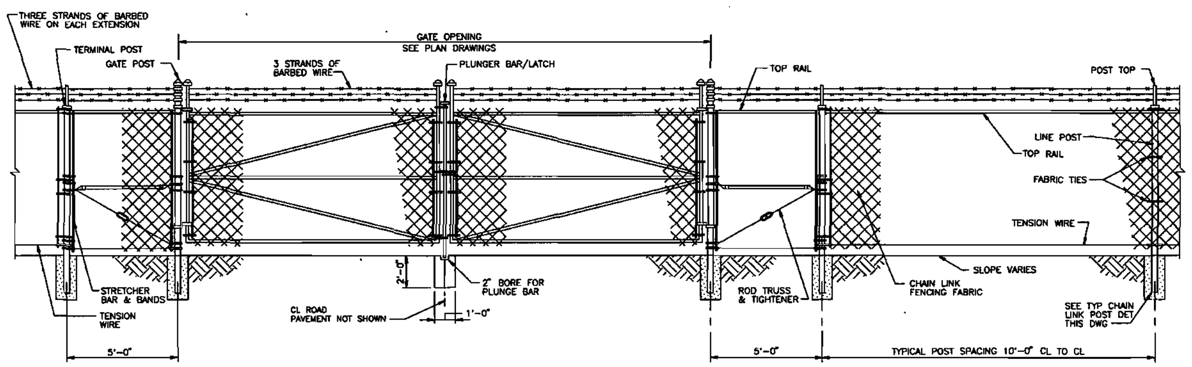

TYPICAL CHAIN LINK SECURITY FENCE AND GATE DETAIL
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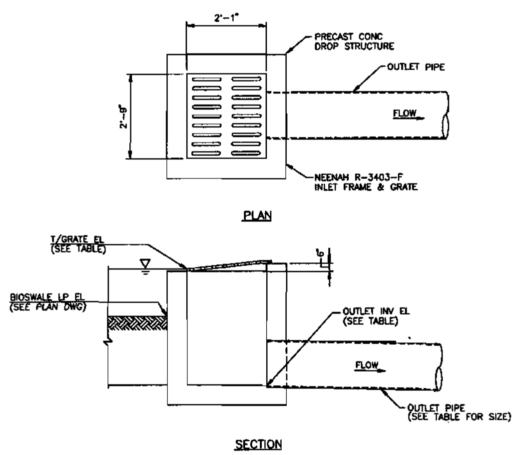

TYPICAL BIOSWALE DROP STRUCTURE DETAIL
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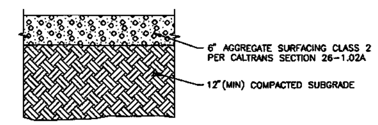

TYPICAL AGGREGATE SURFACING SECTION
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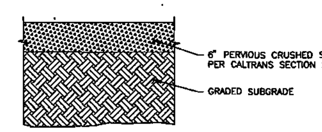

TYPICAL PERVIOUS CRUSHED STONE SURFACING SECTION
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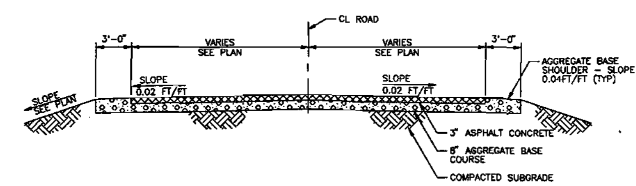
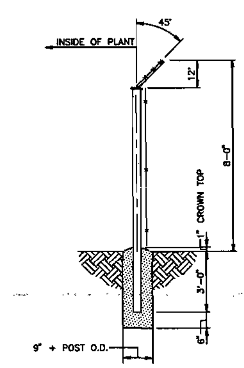


TYPICAL PAVED ROAD
NO SCALE
SEE DWG SS-3201



TYPICAL SECURITY FENCE POST DETAIL
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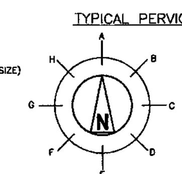


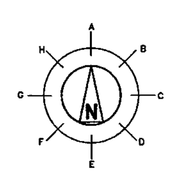
CULVERT NO.	INLET INV ELEVATION	OUTLET INV ELEVATION	LENGTH	PIPE DIAMETER	PIPE MATERIAL	REMARKS
C-1	8.2	8.0	–	24"	–	
C-2						NOT USED
C-3	13.0	13.0	–	18"	–	
C-4	13.2	13.0	–	18"	–	
C-5	13.1	12.9	–	12"	–	
C-6	13.1	12.9	–	12"	–	
C-7	13.3	13.0	–	12"	–	
C-8	13.2	13.0	–	12"	–	
C-9	13.0	13.0	–	12"	–	
C-10	13.0	13.0	–	15"	–	
C-11	13.4	12.6	–	12"	–	
C-12	13.0	13.0	–	18"	–	
C-13	13.4	12.6	–	12"	–	
C-14	13.5	12.5	–	12"	–	
C-15	10.3	10.0	–	18"	–	
C-16	12.5	12.5	–	18"	–	
C-17	14.7	14.4	–	12"	–	
C-18	12.8	12.5	–	18"	–	
C-19	10.5	10.0	–	18"	–	
C-20	13.0	13.0	–	18"	–	
C-21	13.0	13.0	–	18"	–	

CULVERT TABLE

CATCH BASIN AND MAN HOLE TABLE

STRUCTURE NO.	CENTERLINE COORDINATES		TOP OF GRATE ELEVATION	INLET & OUTLET PIPE INFORMATION																REMARKS
				A		B		C		D		E		F		G		H		
	NORTH	EAST		INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	
CB-6	–	–	16.0	–	–	–	–	–	–	–	–	12.3	18"	–	–	–	–	–	–	
CB-7	NOT USED																			
CB-8	–	–	17.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13.5	12"	
CB-9	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	–	–	13.4	12"	–	–	
CB-10	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	–	–	–	–	–	–	
CB-11	–	–	17.0	–	–	–	–	–	–	13.4	12"	–	–	–	–	13.4	12"	–	–	
CB-12	–	–	17.0	–	–	13.6	12"	–	–	–	–	–	–	–	–	–	–	–	–	
CB-13	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	13.4	12"	–	–	–	–	
CB-14	–	–	17.0	–	–	–	–	13.1	12"	–	–	–	–	–	–	13.1	12"	–	–	
CB-15	–	–	17.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13.6	12"	
CB-16	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	–	–	–	–	–	–	
CB-17	–	–	17.0	–	–	–	–	13.1	12"	–	–	–	–	–	–	13.1	12"	–	–	
CB-18	–	–	16.5	–	–	13.2	12"	–	–	–	–	–	–	–	–	13.2	12"	–	–	
CB-19	–	–	16.5	–	–	–	–	13.4	12"	–	–	–	–	–	–	13.4	12"	–	–	
CB-20	–	–	16.5	–	–	–	–	13.6	12"	–	–	–	–	–	–	–	–	–	–	
CB-21	–	–	16.5	–	–	–	–	–	–	–	–	–	–	–	–	13.6	12"	–	–	
CB-22	–	–	16.5	–	–	–	–	13.4	12"	–	–	–	–	–	–	13.4	12"	–	–	
CB-23	–	–	16.5	–	–	–	–	13.2	12"	–	–	–	–	–	–	13.2	12"	–	–	
CB-24	NOT USED																			
CB-25	–	–	15.0	–	–	–	–	–	–	11.6	18"	–	–	–	–	11.8	18"	–	–	
CB-26	–	–	16.0	13.2	18"	–	–	–	–	–	–	13.2	18"	–	–	–	–	–	–	
CB-27	–	–	16.5	–	–	–	–	–	–	–	–	12.8	18"	–	–	12.8	18"	–	–	
MH-1	–	–	13.0	–	–	–	–	8.2	24"	8.7	18"	–	–	–	–	8.2	24"	–	–	
MH-2	–	–	17.0	11.2	18"	–	–	–	–	–	–	–	–	–	–	11.0	18"	–	–	
MH-3	–	–	16.5	–	–	–	–	10.3	18"	–	–	–	–	–	–	–	–	10.3	18"	

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST



DROP (DS) AND OUTLET (OS) STRUCTURE TABLE

STRUCTURE NO.	CENTERLINE COORDINATES		TOP OF GRATE ELEVATION	INLET & OUTLET PIPE INFORMATION																REMARKS
				A		B		C		D		E		F		G		H		
	NORTH	EAST		INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	
DS-1	NOT USED		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-2	–	–	15.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11.8	18"	
OS-3	NOT USED																			
OS-4	–	–	15.5	13.5	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-5	–	–	14.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.5	18"	
OS-6	–	–	14.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8.5	24"	

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST

OPEN
09/22/10

ALL BACKCIRCLED CHANGES PER ECN-N-S-00xx

NOTES

1. FILTER FABRIC SHALL BE UV-STABILIZED NONWOVEN GEOTEXTILE HAVING A MINIMUM WEIGHT OF 135 g/M^2 PER CALTRANS SS 88-1.03.
2. SEE DWG SS-3001 FOR GENERAL NOTES AND LEGEND.

NOT TO BE USED FOR CONSTRUCTION
THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
2	OPEN		ARE	CAK		PLN	DVW
1	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAK		PLN	DVW
0	16/APR/09	ISSUED FOR PERMITTING	NAW	PLN		PLN	DVW

60' 30' 0 60' 120'
SCALE: 1"=60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA
SIGNED
DATE REG NO.

BLACK & VEATCH CORPORATION
ENGINEER PLN DRAWN NAW
CHECKED DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
SITE
SECTIONS AND DETAILS

PROJECT DRAWING NUMBER: 163994-SS-3050
REV: 1
CODE
AREA

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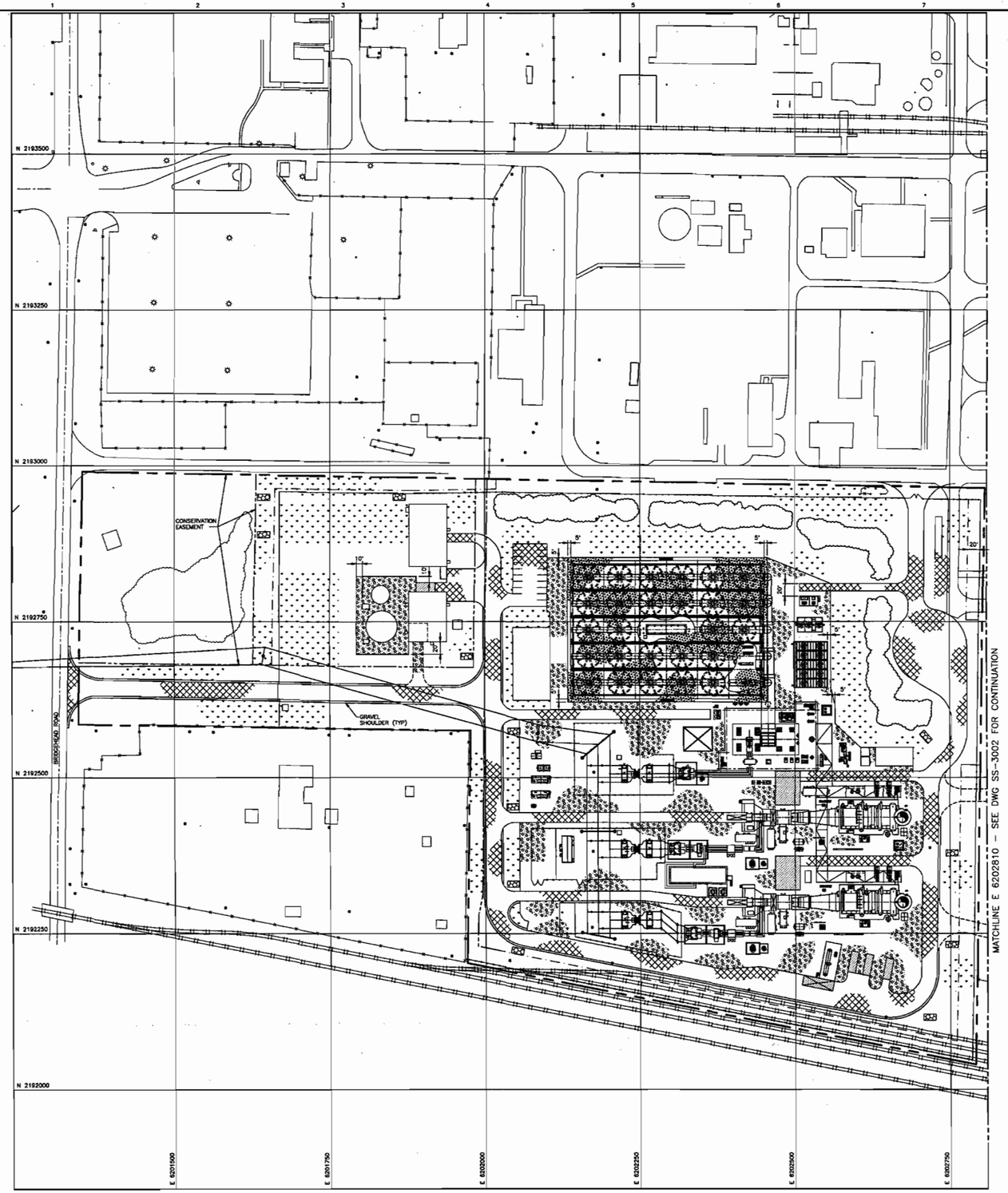

SITE SURFACING LEGEND

- ASPHALT SURFACING
- AGGREGATE SURFACING
- CONCRETE
- GRASS
- OPEN GRADED STONE SURFACING
- RIPRAP
- EXISTING FACILITY
- NEW FACILITY
- NATURAL SOIL

NOTES

1. SEE DRAWING SS-3001 FOR GENERAL NOTES AND LEGEND.

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NO	DATE	REVISIONS AND RECORD OF ISSUE	DRAWN	CHK	DE	APP
0	16/APR/09	ISSUED FOR PERMITTING	NAW	PLN		PLN/DVW

SCALE: 1"=60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA

SIGNED _____ DATE _____ REG NO. _____

BLACK & VEATCH CORPORATION

ENGINEER PLN | DRAWN NAW | CHECKED | DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

SURFACING/FENCING/ROADWAY – SITE PLAN – SHEET 1

PROJECT / DRAWING NUMBER: 163994–SS–3201 | REV: 0

CODE | AREA

ACAD 16.1s (LMS Tech)
SPU37/62
DAVIDW
01/09/09 11:11:38
1=1

CAK 6/15/10

pgs 5

Radback Oakley Project

163994 File # 52.5406.1008

IMP Sizing for plants area

Attachment 2

~~Black & Veatch Dwgs~~

Reference 2

Select Pages

(Runoff factor) x (tributary area) ≤ 2 x (self-retaining area) *Equation 4-1*

For treatment-only sites, and

(Runoff factor) x (tributary area) ≤ 1 x (self-retaining area) *Equation 4-2*

for sites subject to flow-control requirements. Use the runoff factors in Table 4-2.

Prolonged ponding is a potential problem at higher impervious/pervious ratios. In your design, ensure that the pervious area soils can handle the additional run-on and are sufficiently well-drained.

Runoff from self-treating and self-retaining areas does not require any further treatment or flow control.

TABLE 4-2. Runoff factors to be used when sizing IMPs.

Surface	Treatment and Flow Control	Treatment only
Roofs	1.0	1.0
Concrete or Asphalt	1.0	1.0
Pervious Concrete	0.1	0.1
Porous Asphalt	0.1	0.1
Grouted Unit Pavers	1.0	1.0
Solid Unit Pavers	0.5	0.2
Crushed Aggregate	0.1	0.1
Turfblock	0.1	0.1
Landscape, Group A Soil	0.1	0.1
Landscape, Group B Soil	0.3	0.1
Landscape, Group C Soil	0.5	0.1
Landscape, Group D Soil	0.7	0.1

Areas draining to IMPs are used to calculate the required size of the IMP. On most densely developed sites—such as commercial and mixed-use developments and small-lot residential subdivisions—most DMAs will drain to IMPs.

The CCCWP has developed sizing factors (ratios of IMP area to impervious DMA area). For each IMP design, factors are provided for:

TABLE 4-6. Sizing Factors

Treatment and Flow Control	NRCS Soil Group			
IMP	**A**	**B**	**C**	**D**
Bioretention Facility				
A	0.07	0.11	0.06	0.05
V_1	0.058	0.092	0.050	0.042
V_2	N/A	N/A	0.066	0.055
Flow-through Planter				
A	N/A	N/A	0.06	0.05
V_1	N/A	N/A	0.050	0.042
V_2	N/A	N/A	0.066	0.055
Dry Well				
A	0.05	0.06	N/A	N/A
V	0.130	0.204	N/A	N/A
Cistern + bioretention facility				
A (bioretention facility)	*0.04*	*0.04*	*0.04*	*0.04*
V (cistern)	0.193	0.228	0.088	0.060

* Cistern sized for flow control when used in conjunction with a treatment IMP. IMP underdrain required in B, C and D soils.

Treatment Only

Bioretention Facility				
A	*0.04*	*0.04*	*0.04*	*0.04*
Flow-through Planter				
A	*0.04*	*0.04*	*0.04*	*0.04*
Dry Well (treatment only)				
A	0.02	0.04	N/A	N/A
V	0.068	0.136	N/A	N/A

Units Notes:
A = ft^2 of IMP footprint per ft^2 of tributary impervious area (unitless)
V, V_1, V_2 = ft^3 per ft^2 of equivalent tributary impervious area (ft.)

STEP 5: OBTAIN SIZING AND RAIN ADJUSTMENT FACTORS FOR EACH IMP

For each of the IMPs, obtain the appropriate **area** sizing factor from Table 4-6.

Sizing factors for treatment-only IMPs (in *italics*) do not require any adjustment for differing rainfall patterns.

Both area (A) and volume (V_1, V_2) sizing factors for treatment-plus-flow-control IMPs, however, must be adjusted to account for the effects of differing rainfall patterns on pre-project and post-project runoff.

Use the equations below to compute the rainfall adjustment:

Equation 4-3

$$\text{For Group A soils, } Rain\ Adjustment = \frac{0.0009 \times \left(MAP_{project\ site} - 20.2\right) + 0.07}{0.07}$$

Equation 4-4

$$\text{For Group B soils, } Rain\ Adjustment = \frac{-0.0005 \times \left(MAP_{project\ site} - 20.2\right) + 0.11}{0.11}$$

Equation 4-5

$$\text{For Group C soils, } Rain\ Adjustment = \frac{-0.0022 \times \left(MAP_{project\ site} - 20.2\right) + 0.06}{0.06}$$

Equation 4-6

$$\text{For Group D soils, } Rain\ Adjustment = \frac{-0.0022 \times \left(MAP_{project\ site} - 20.2\right) + 0.05}{0.05}$$

where *MAP* is the mean annual precipitation at the site as shown on the isohyetal map, Contra Costa County Public Works Figure B-166, available on the CCCWP C.3 web pages.

► STEP 6: CALCULATE MINIMUM AREA AND VOLUME OF EACH IMP

The minimum area and storage volumes of each IMP are found by summing up the contributions of each tributary DMA and multiplying by the adjusted sizing factor for the IMP.

Equation 4-7

$$Min.\ IMP\ Area\ or\ Volume = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

Bioretention facilities and flow-through planters have two storage volumes. V_1 is the floodable volume above the soil layer. V_2 is the storage volume below the soil layer, calculated by multiplying the volume of gravel by an assumed porosity of 0.4. See Figure 4-6. Note these volumes can be configured in a variety of practical combinations of depth and area to best fit into your landscape design.

Cisterns and dry wells have a single storage volume (V).

V is calculated using Equation 4-8:

Equation 4-8

$$Min.V = \sum \begin{pmatrix} DMA & DMA \\ Square & \times Runoff \\ Footage & Factor \end{pmatrix} \times \begin{pmatrix} IMP\,Volume \\ Sizing \\ Factor \end{pmatrix} \times \begin{pmatrix} Rain \\ Adjustment \\ Factor \end{pmatrix}$$

Use the format of Table 4-7 to present the calculations of the required minimum area and volumes of the receiving IMP:

TABLE 4-7. Format for presenting calculations of minimum IMP Areas and Volumes

DMA Name	*DMA Area (square feet)*	*Post-project surface type*	*DMA Runoff factor*	*DMA Area × runoff factor*	*Soil Type:*	*IMP Name*			
					IMP Sizing factor	*Rain Adjust-ment Factor*	*Minimum Area or Volume*	*Proposed Area or Volume*	
			Total						***IMP Area***
									V or V1
									V2
								Orifice Size:	

► STEP 7: DETERMINE IF IMP AREA AND VOLUME ARE ADEQUATE

Sizing and configuring IMPs may be an iterative process. After computing the minimum IMP area using Steps 1–6, review the site plan to determine if the reserved IMP area is sufficient. If so, the planned IMPs will meet the Provision C.3 sizing requirements. If not, revise the plan accordingly. Revisions may include:

Radback Oakley Project

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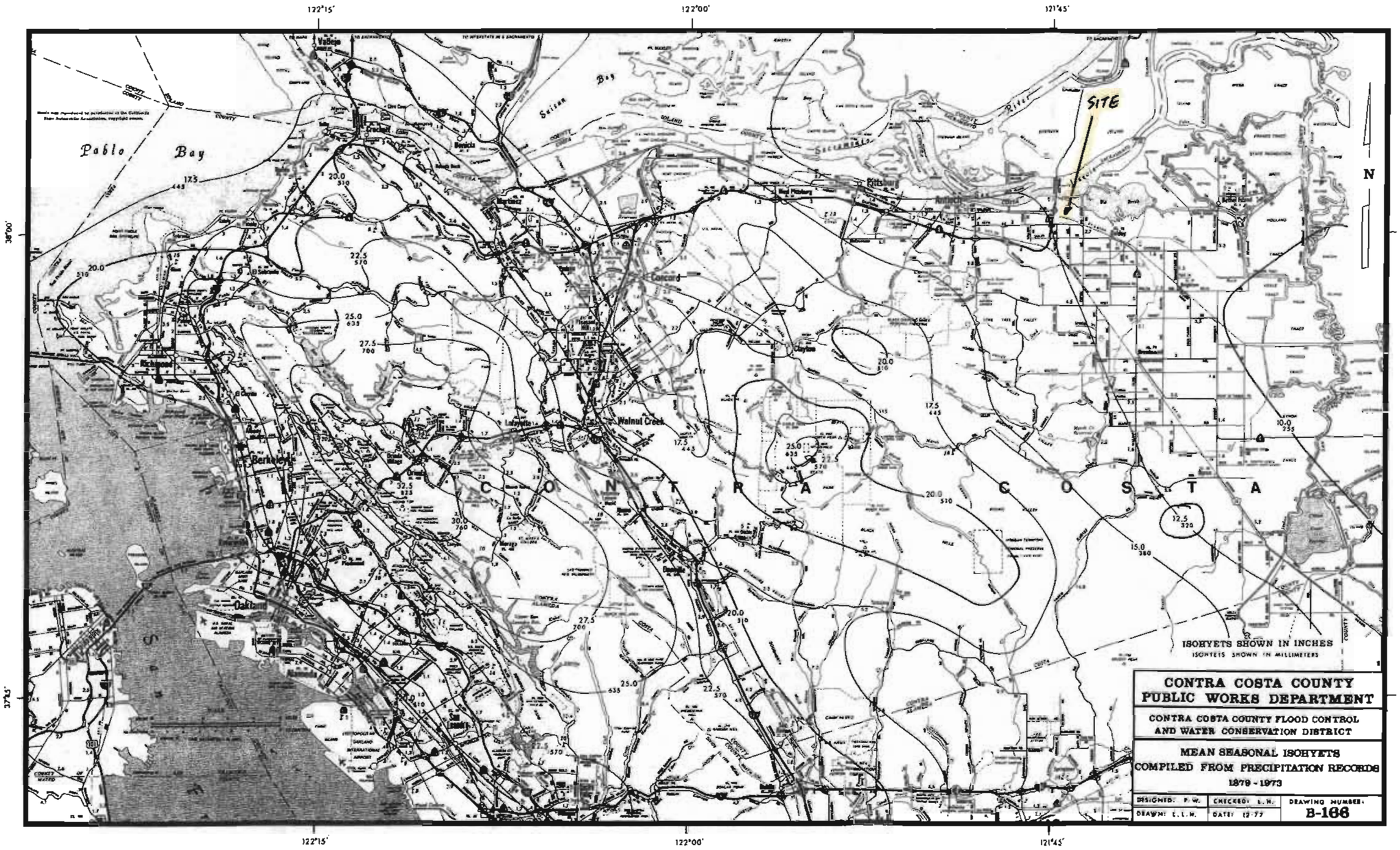
pgs 2

IMP sizing for plant area

Attachment 3

Reference 3

Dwg No B-166


122°15'
122°00'
121°45'
38°00'
37°45'
Pablo Bay
Suisun Bay
Sacramento River
Vallejo
Crockett
Benicia
Martinez
Pittsburg
Antioch
Concord
Clayton
Walnut Creek
Lafayette
Orinda
Danville
San Ramon
Richmond
El Sobrante
Berkeley
Emeryville
Oakland
Alameda
Hercules
SITE
N
C O N T R A C O S T A
ISOHYETS SHOWN IN INCHES
ISOHYETS SHOWN IN MILLIMETERS
CONTRA COSTA COUNTY
PUBLIC WORKS DEPARTMENT
CONTRA COSTA COUNTY FLOOD CONTROL
AND WATER CONSERVATION DISTRICT
MEAN SEASONAL ISOHYETS
COMPILED FROM PRECIPITATION RECORDS
1879 - 1973
DESIGNED: F.W.
CHECKED: E.H.
DRAWING NUMBER:
DRAWN: E.L.H.
DATE: 12-77
B-166

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163994 File # 52.5406.1008

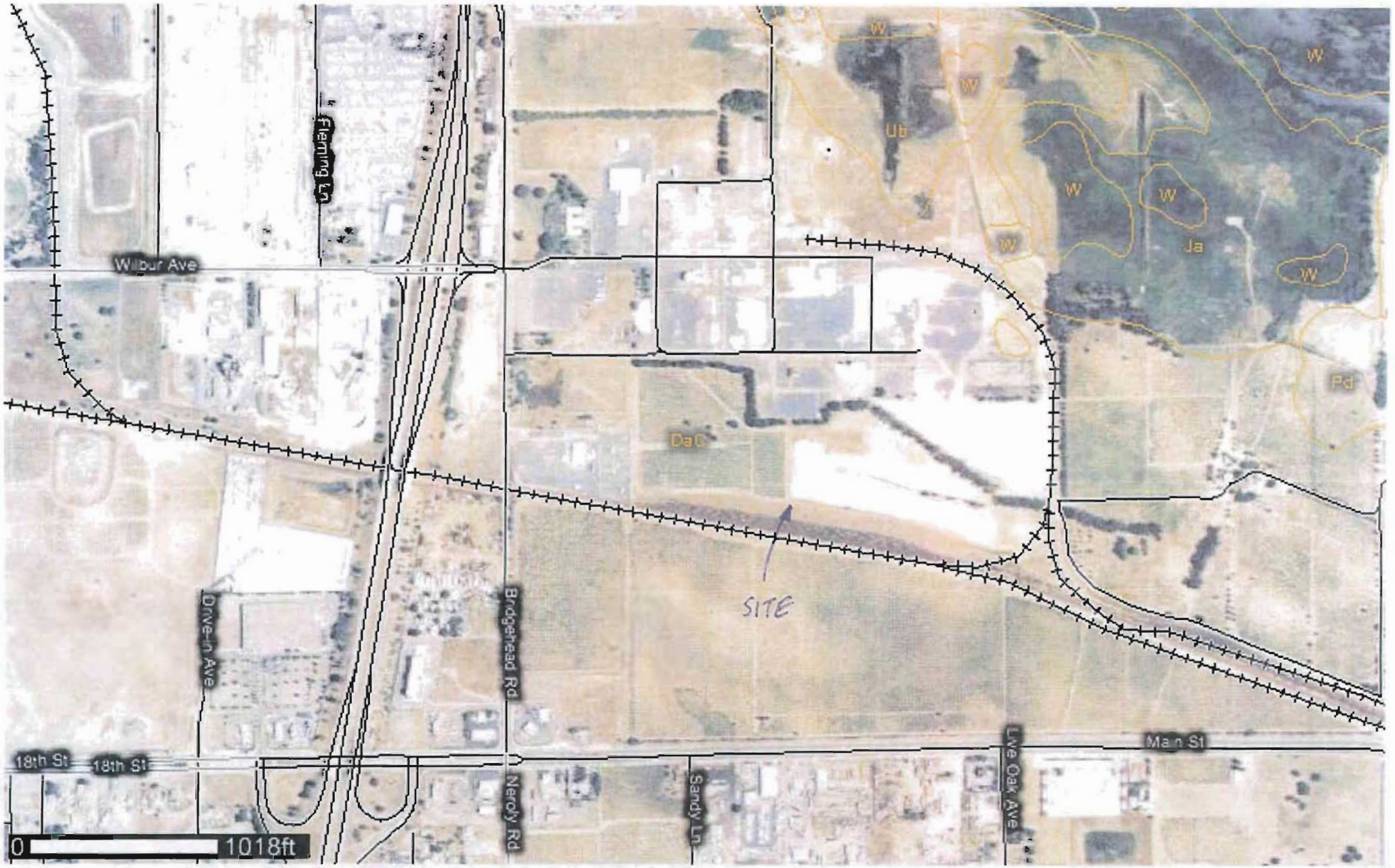
pgs 4

IMP sizing for plant area

Attachment 4

Reference 4

Select Pages


Fleming Ln
Wilbur Ave
Drive-In Ave
Bridgehead Rd
Nerdy Rd
Sandy Ln
Live Oak Ave
Main St
18th St
18th St
SITE
Ub
Ja
Pd
DaC
W
0
1018ft

Contra Costa County, California

DaC—DELHI SAND, 2 TO 9 PERCENT SLOPES

Map Unit Setting

Elevation: 10 to 150 feet
Mean annual precipitation: 12 to 14 inches
Mean annual air temperature: 59 degrees F
Frost-free period: 260 to 300 days

Map Unit Composition

Delhi and similar soils: 85 percent
Minor components: 15 percent

Description of Delhi

Setting

Landform: Flood plains, terraces, alluvial fans
Landform position (three-dimensional): Tread, talf
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Eolian deposits derived from igneous and sedimentary rock

Properties and qualities

Slope: 2 to 9 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Capacity of the most limiting layer to transmit water (Ksat): High to very high (5.95 to 19.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 2.0 mmhos/cm)
Available water capacity: Low (about 4.2 inches)

Interpretive groups

Land capability classification (irrigated): 3s
Land capability (nonirrigated): 6e

Typical profile

0 to 5 inches: Sand
5 to 60 inches: Sand

Minor Components

Unnamed

Percent of map unit: 12 percent

Laugenour
Percent of map unit: 3 percent

Data Source Information

Soil Survey Area: Contra Costa County, California
Survey Area Data: Version 8, Jul 22, 2008

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163994 File # 52.5406.1008

pgs 2

IMP sizing for plant area

Attachment 5

Reference 5

select page

Appendix A Hydrologic Soil Groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be co siderably altered and the listed group classification n no longer apply. In these circumstances, use the follc ing to determine HSG according to the texture of the new surface soil, provided that significant compactic has not occurred (Brakensiek and Rawls 1983).

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silt clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a hi water table that creates a drainage problem. Once tl soils are effectively drained, they are placed in a dif ent group. For example, Ackerman soil is classified A/D. This indicates that the drained Ackerman soil i group A and the undrained soil is in group D.

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Pgs 3

IMP sizing for plant area

Attachment 6

E-Mail communication w/ Contra Costa County Clean Water Program

Zhong, Jimmy

From: Dan Cloak [dan@dancloak.com]
Sent: Monday, March 02, 2009 3:54 PM
To: 'Tom Dalziel'; Zhong, Jimmy
Subject: RE: Stormwater C.3 Question

Hi,

It is correct that dense-graded aggregates are not very pervious. Why not use an open-graded aggregate, such as ½ in. crushed rock? Be sure to use a rigid frame around the gravel area.

"Porous Pavements" by Bruce Ferguson is a good reference for porous pavement design.

If dense-graded aggregate is used, I would suggest a runoff coefficient of 0.5 to 0.7, depending on slope.

Dan

From: Tom Dalziel [mailto:tdalz@pw.cccounty.us]
Sent: Monday, March 02, 2009 11:04 AM
To: Zhong, Jimmy; Dan@dancloak.com
Subject: RE: Stormwater C.3 Question

Hi Dan,

Can you review and respond, as appropriate, to Jimmy on my behalf?

Thanks.

Tom Dalziel
Assistant Program Manager
Contra Costa Clean Water Program
tdalz@pw.cccounty.us
Ph. (925) 313-2392, Fax (925) 313-2301

From: Zhong, Jimmy [mailto:ZhongJ@bv.com]
Sent: Wednesday, February 25, 2009 1:11 PM
To: Tom Dalziel
Subject: Stormwater C.3 Question

Tom,

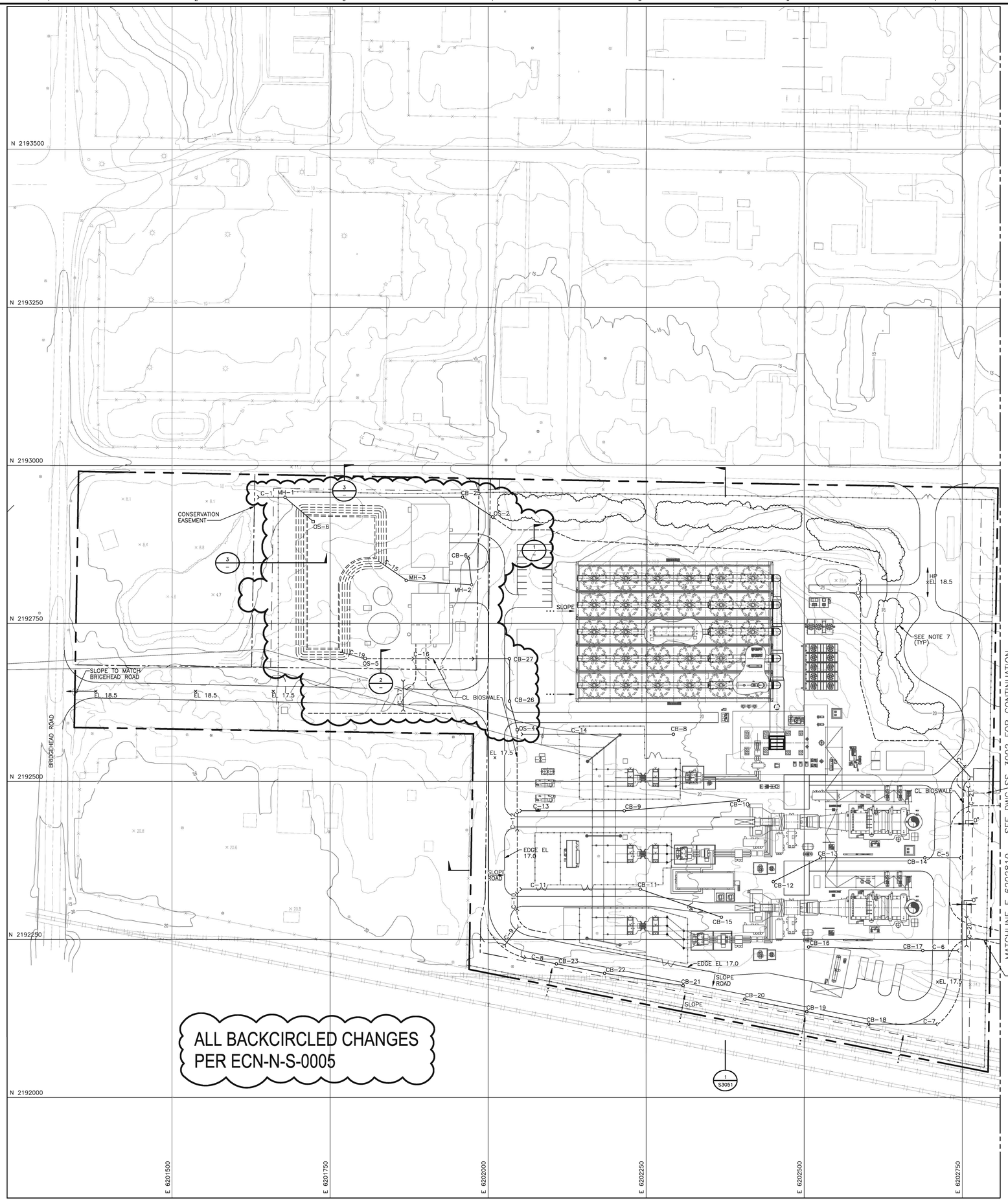
I talked to you and Dan this morning regarding runoff factor for Class 2 aggregates (Caltran Standard Specification Section 26). After our phone call, I had a discussion with my supervisor. He indicated that this type of material is **dense-graded** aggregate which is typically used as pavement base material. After being compacted, this type of material is not that pervious based on his experience. Dense-graded aggregates have much lower porosity than open-graded aggregates after compaction. As such, my supervisor thinks the runoff factor of 0.1 can apply to open-graded aggregate but may not be able to apply to dense-graded aggregate. Would you please forward this email to Dan and ask him again if a runoff factor of 0.1 can still be applied to Class 2 aggregates (compacted)? If not, what kind of runoff factor should be used?

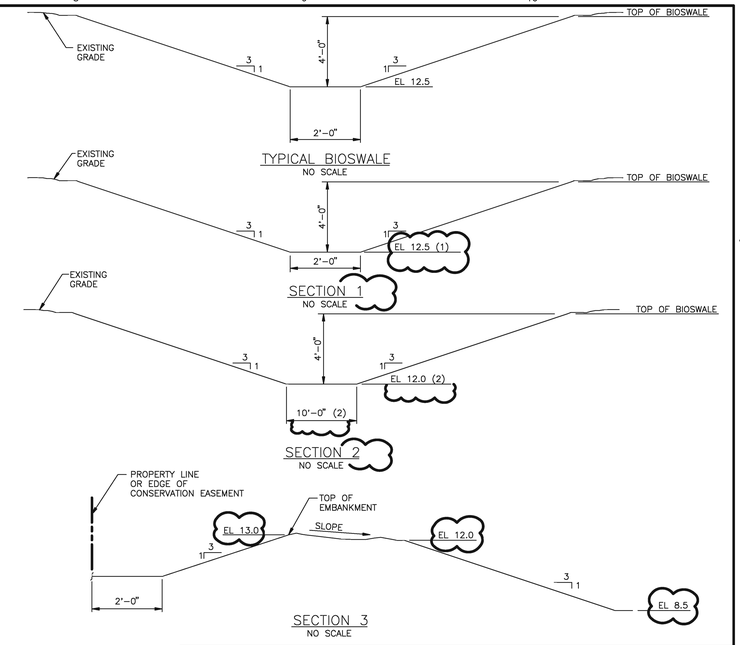
I apologize if I did not communicate clearly this morning on the type of material we are using and for any confusions it caused.

Thanks again for your help.

Jimmy Zhong, P.E.
Geotechnical/Civil Engineer
Energy Division
Black & Veatch Corporation
3550 Green Court, Ann Arbor, MI 48105
P: (734) 622-8533 F: (734) 622-8700

IMP Sizing for Plant Area





ABBREVIATIONS APPLICABLE TO ALL SS–3000 SERIES DRAWINGS

APPROX	–	APPROXIMATE	LTR	–	LATER
ASPH	–	ASPHALT	MAX	–	MAXIMUM
AVG	–	AVERAGE	MH	–	MANHOLE
BND	–	BEND	MIN	–	MINIMUM
BLDG	–	BUILDING	MJ	–	MECHANICAL JOINT
B/MH	–	BOTTOM OF MANHOLE ELEVATION	MSL	–	MEAN SEA LEVEL
BDC	–	BOTTOM OF CONDUIT ELEVATION	NO.	–	NUMBER
BOD	–	BOTTOM OF DUCTBANK ELEVATION	NTS	–	NOT TO SCALE
BOP	–	BOTTOM OF PIPE ELEVATION	OD	–	OUTSIDE DIAMETER
BU	–	BELL–UP	OWS	–	OIL WATER SEPARATOR
C	–	CULVERT	OWMH	–	OILYWASTE MANHOLE
CB	–	CATCH BASIN	PC	–	POINT OF CURVATURE
CD	–	CABLE DUCT	PE	–	PLAIN END
CHDPE	–	CORRUGATED HIGH DENSITY POLYETHYLENE PIPE	PI	–	POINT OF INTERSECTION
			PLCS	–	PLACES
CL	–	CENTERLINE	PM	–	PLANT MANHOLE
CLR	–	CLEAR	POT	–	POINT OF TANGENT
CMH	–	CHEMICAL MANHOLE	PT	–	PIPE TERMINATION
CND	–	CONDUIT	PVC	–	POLYVINYL CHLORIDE PIPE
CONC	–	CONCRETE	QTY	–	QUANITY
CO	–	CLEAN OUT	R	–	RADIUS
CS	–	CARBON STEEL	RCP	–	REINFORCED CONCRETE PIPE
CW	–	CIRCULATING WATER	RD	–	ROOF DRAIN
DB	–	DUCTBANK	REV	–	REVISION
DBC	–	DIRECT BURIED CABLE	RGS	–	RIGID GALVANIZED STEEL
DET	–	DETAIL	RR	–	RAILROAD
DIA	–	DIAMETER	SECT	–	SECTION
DIP	–	DUCTILE IRON PIPE	SIM	–	SIMILAR
DWG	–	DRAWING	SLS	–	SANITARY LIFT STATION
DWP	–	DOUBLE WALL PIPE	SMH	–	SANITARY MANHOLE
EC	–	ELECTRICAL CONDUIT	STMH	–	STORM MANHOLE
ECC	–	ECCENTRIC	STRL	–	STRUCTURAL
EF	–	EACH FACE	T/C	–	TOP OF CONCRETE ELEVATION
EHH	–	ELECTRICAL HANDHOLE	T/G	–	TOP OF GRADE ELEVATION
EL	–	ELEVATION	THH	–	TELEPHONE SERVICE HANDHOLE
EMH	–	ELECTRICAL MANHOLE	T/MH	–	TOP OF MANHOLE ELEVATION
EW	–	EACH WAY	T/P	–	TOP OF PAVEMENT ELEVATION
FC	–	FIELD CHECK	TP	–	MECH PIPE TERMINAL POINT
FDN	–	FOUNDATION	TYP	–	TYPICAL
FF	–	FLAT FACE	UGL	–	UNDERGROUND LIGHTING CONDUIT
FRP	–	FIBERGLASS REINFORCED PIPE	UNO	–	UNLESS NOTED OTHERWISE
GR	–	GRADE	VERT	–	VERTICAL
HDM	–	HOT DRAIN MANHOLE	WGT	–	WEIGHT
HDPE	–	HIGH DENSITY POLYETHYLENE PIPE	WTR	–	WATER
HP	–	HIGH POINT	W/	–	WITH
HYD	–	HYDRANT	W/O	–	WITHOUT
ID	–	INSIDE DIAMETER	WP	–	WORK POINT
INV	–	INVERT	XFMR	–	TRANSFORMER
JBX	–	JUNCTION BOX			
L	–	LENGTH			
LP	–	LOW POINT			

LEGEND APPLICABLE TO ALL S3000 DRAWINGS

	NEW CULVERT		NEW SLIDE GATE
	CL BIOSWALE		NEW SWING GATE
1 / S3000	SECTION OR DETAIL NUMBER / DRAWING DESIGNATION NUMBER		EXISTING POWER POLE
× 326.5	FINISHED SPOT ELEVATIONS	CB–101	NEW CATCH BASIN
			NEW DROP STRUCTURE
BM–1	SURVEY MONUMENT/CONTROL POINT		PROPERTY LINE
	EXISTING FENCE		BOUNDARY LINE
	NEW SECURITY FENCE	126	EXISTING CONTOURS
	TEMPORARY CONSTRUCTION FENCE		GRADE TO DRAIN (DIRECTION OF ARROW)
TR–1	EROSION CONTROL METHOD		

NOTES APPLICABLE TO ALL SS–3000 SERIES DRAWINGS

1. COORDINATES ARE BASED ON CALIFORNIA COORDINATE SYSTEM CCS83, ZONE 3. ELEVATION ARE BASED ON, NGVD 29 DATUM. BENCHMARK IS NATIONAL GEODETIC SURVEY BENCH MARK "W 563", LOCATED ADJACENT TO THE FLAGPOLE AT THE DUPONT PLANT ENTRANCE, ELEVATION = 11.168 FEET. TO OBTAIN DUPONT PLANT DATUM ELEVATION, ADD 0.70 FEET TO THE ELEVATIONS SHOWN. TOPOGRAPHIC DATA IS BASED ON AERIAL PHOTOGRAPH DATED JUNE 11, 2001. AERIAL SURVEY INFORMATION WAS OBTAINED BY RONALD GREENWELL & ASSOCIATES, INC.
2. NEW GRADE ELEVATIONS SHOWN ON THE SITE GRADING AND DRAINAGE PLANS INDICATE FINISH GRADE UNLESS NOTED OTHERWISE.
3. ALL CUT AND FILL SLOPES SHALL BE 3 HORIZONTAL TO 1 VERTICAL OR FLATTER, UNLESS NOTED OTHERWISE.
4. SEE DWG SS–3050 FOR GRADING AND DRAINAGE DETAILS INCLUDING CULVERT, CATCH BASIN, DROP AND OUTLET STRUCTURE CHARTS.
5. TOP OF CONCRETE ELEVATIONS AND FINISH FLOOR ELEVATIONS FOR ALL EQUIPMENT AND BUILDINGS IS EL 18.0. FINISH GRADE ADJACENT TO ALL FOUNDATIONS IS EL 17.5.
6. CL OF ALL PAVED ROADS IS EL 17.5 UNO.
7. TREES TO REMAIN. GRADE TO REMAIN UNCHANGED WITHIN 20' OF TREE BASE.
8. TEMPORARY ROAD FROM LAYDOWN AREA. ROAD AND CULVERT UNDER ROAD TO BE REMOVED AT END OF CONSTRUCTION.

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
3	22/SEP/10	ISSUED FOR PERMITTING	ARB	CAK		PLN	DVW
1	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAK		PLN	DVW
0	16/APR/09	ISSUED FOR PERMITTING	NAW	PLN		PLN	DVW

SCALE: 1" = 60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA

SIGNED

DATE REG NO.

BLACK & VEATCH CORPORATION

ENGINEER PLN DRAWN NAW

CHECKED DATE

CONTRA COSTA GENERATING STATION LLC

CONTRA COSTA COMBINED CYCLE FACILITY

GRADING AND DRAINAGE – SITE PLAN – SHEET 1

PROJECT DRAWING NUMBER 163994–SS–3001 REV 2

CODE

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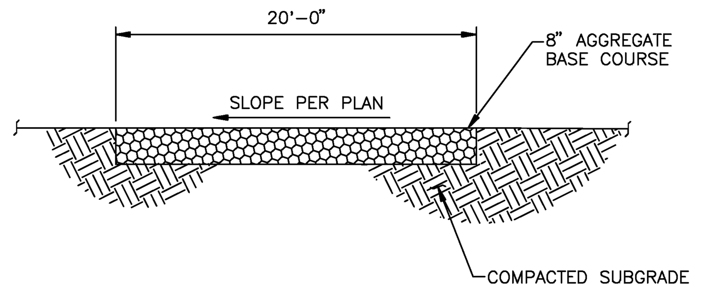
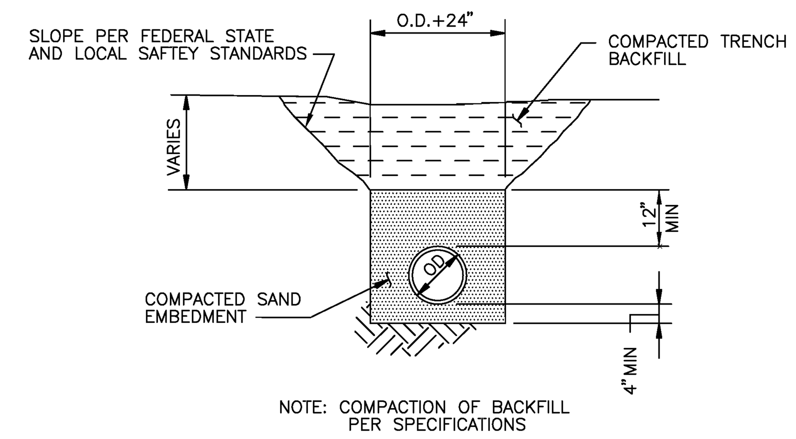


TYPICAL CONSTRUCTION LAYDOWN ROAD
NO SCALE



NOTE: COMPACTION OF BACKFILL PER SPECIFICATIONS

TYPICAL PIPE EMBEDMENT
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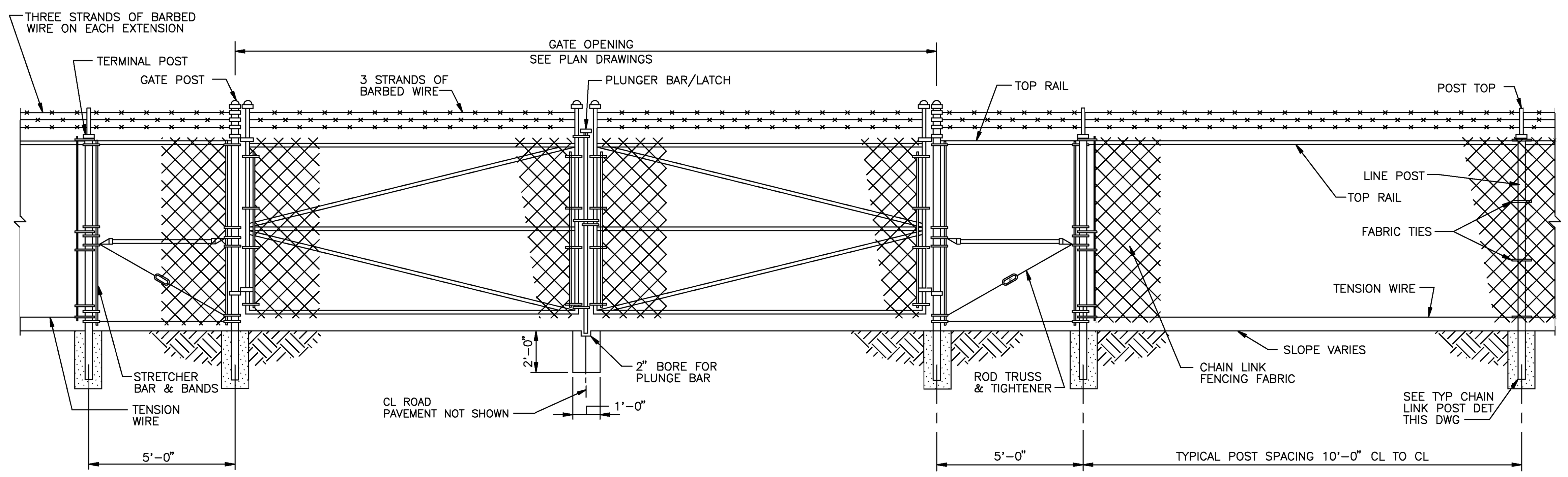

TYPICAL CHAIN LINK SECURITY FENCE AND GATE DETAIL
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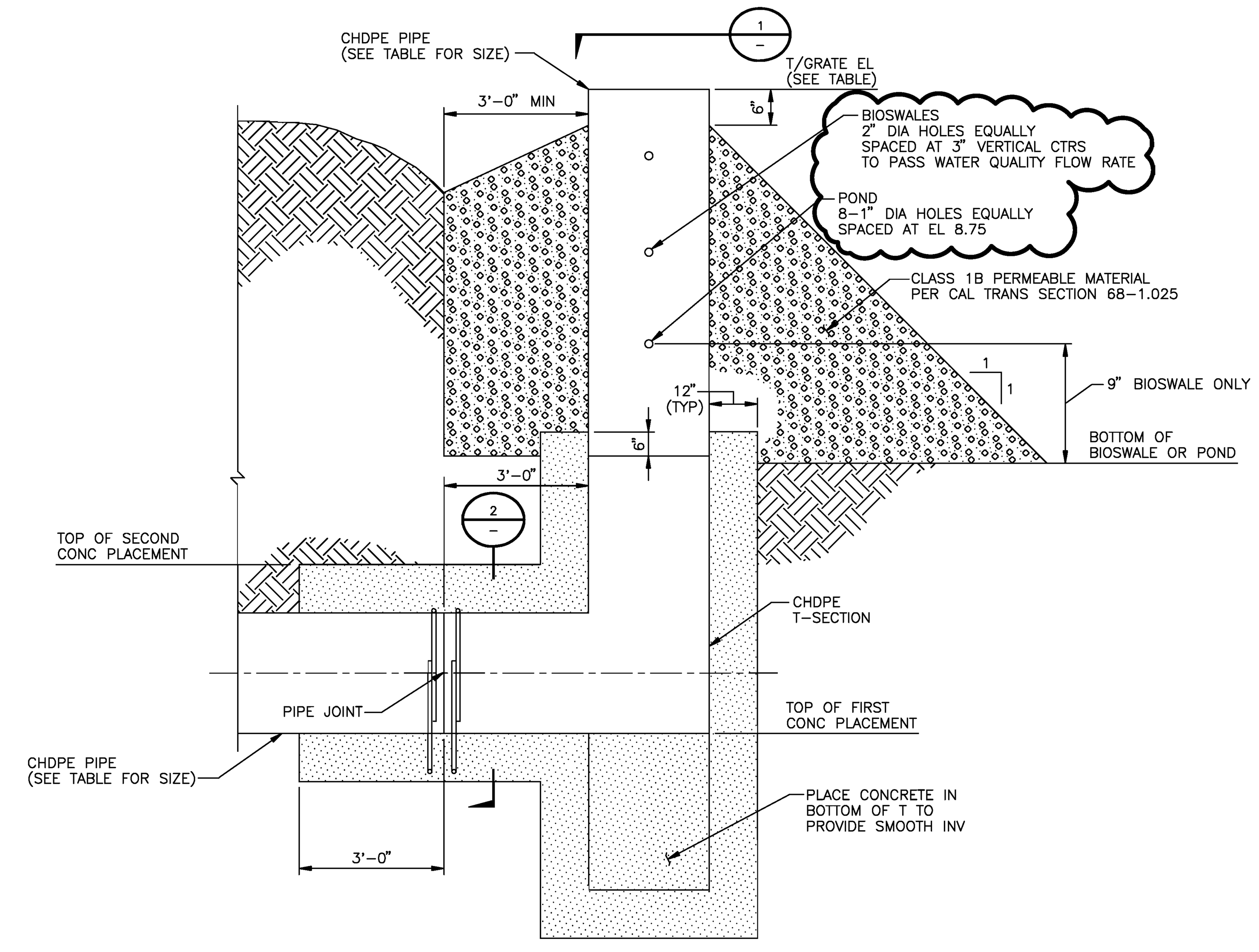

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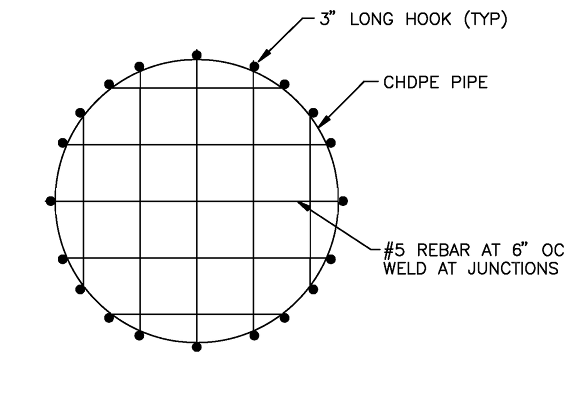

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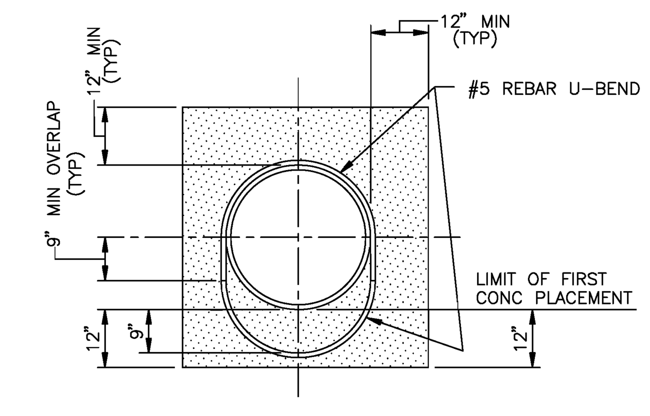

SECTION 2
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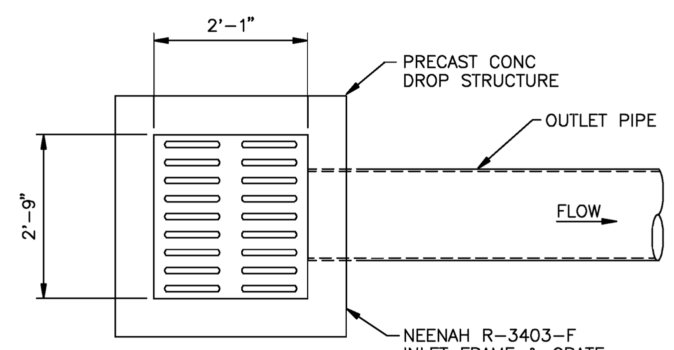
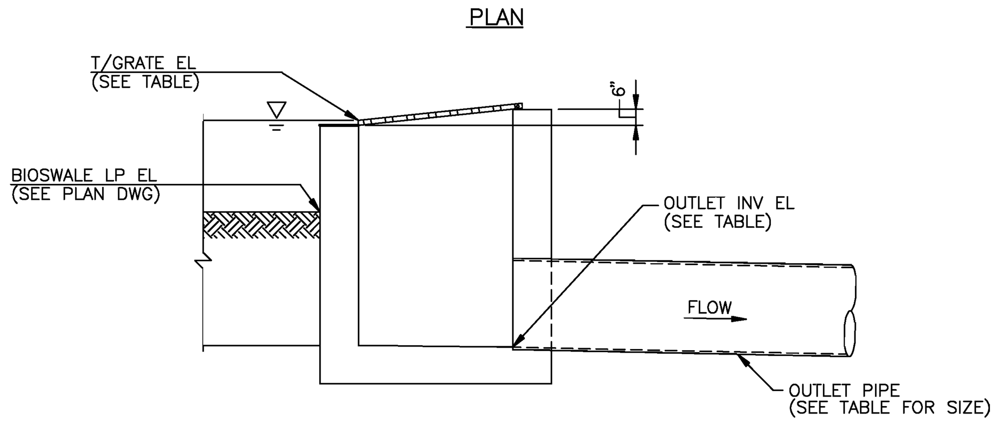


PLAN



SECTION

TYPICAL BIOSWALE DROP STRUCTURE DETAIL
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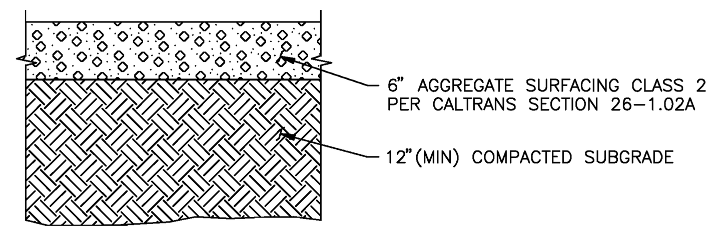

TYPICAL AGGREGATE SURFACING SECTION
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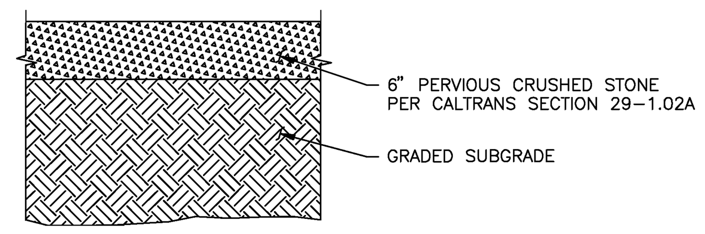

TYPICAL PERVIOUS CRUSHED STONE SURFACING SECTION
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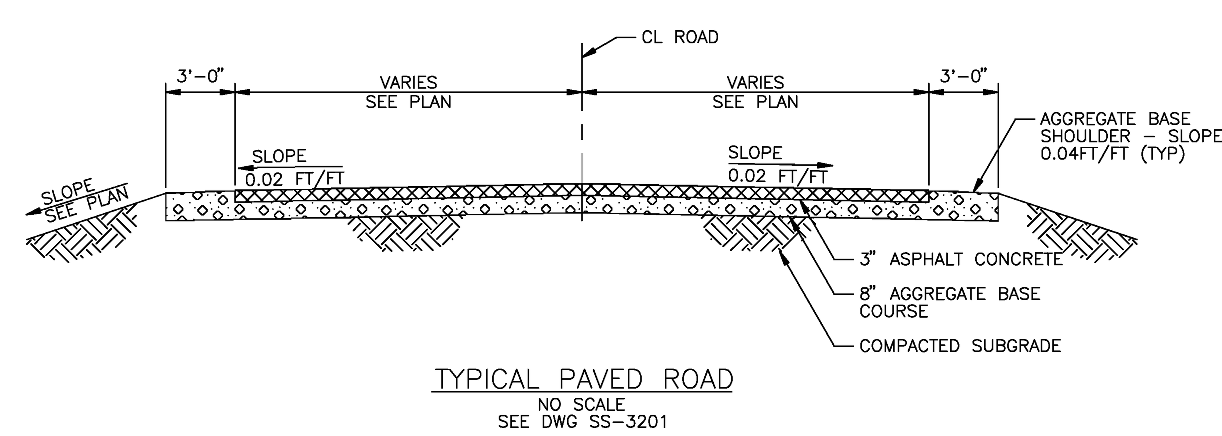
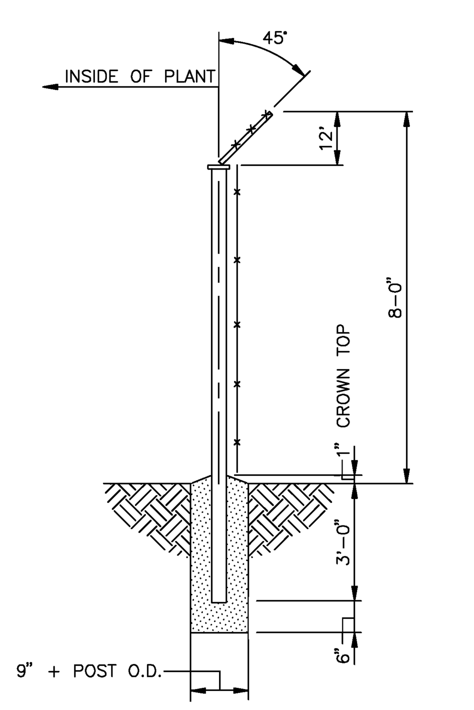
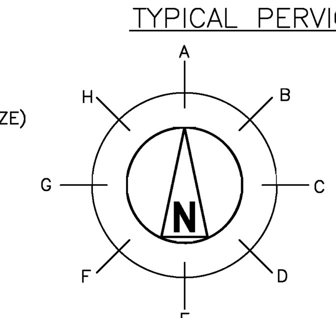


TYPICAL PAVED ROAD
NO SCALE
SEE DWG SS-3201



TYPICAL SECURITY FENCE POST DETAIL
NO SCALE

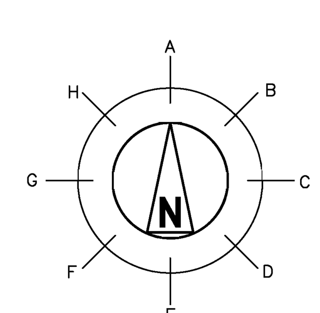
CULVERT TABLE						
CULVERT NO.	INLET INV ELEVATION	OUTLET INV ELEVATION	LENGTH	PIPE DIAMETER	PIPE MATERIAL	REMARKS
C-1	8.2	8.0	–	24"	–	
C-2						NOT USED
C-3	13.0	13.0	–	18"	–	
C-4	13.2	13.0	–	18"	–	
C-5	13.1	12.9	–	12"	–	
C-6	13.1	12.9	–	12"	–	
C-7	13.3	13.0	–	12"	–	
C-8	13.2	13.0	–	12"	–	
C-9	13.0	13.0	–	12"	–	
C-10	13.0	13.0	–	15"	–	
C-11	13.4	12.6	–	12"	–	
C-12	13.0	13.0	–	18"	–	
C-13	13.4	12.6	–	12"	–	
C-14	13.5	12.5	–	12"	–	
C-15	10.3	10.0	–	18"	–	
C-16	12.5	12.5	–	18"	–	
C-17	14.7	14.4	–	12"	–	
C-18	12.8	12.5	–	18"	–	
C-19	10.5	10.0	–	18"	–	
C-20	13.0	13.0	–	18"	–	
C-21	13.0	13.0	–	18"	–	



CATCH BASIN AND MAN HOLE TABLE

STRUCTURE NO.	CENTERLINE COORDINATES		TOP OF GRATE ELEVATION	INLET & OUTLET PIPE INFORMATION																REMARKS
				A		B		C		D		E		F		G		H		
	NORTH	EAST		INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	
CB-6	–	–	16.0	–	–	–	–	–	–	–	–	12.3	18"	–	–	–	–	–	–	
CB-7	NOT USED																			
CB-8	–	–	17.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13.5	12"	
CB-9	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	–	–	13.4	12"	–	–	
CB-10	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	–	–	–	–	–	–	
CB-11	–	–	17.0	–	–	–	–	–	–	13.4	12"	–	–	–	–	13.4	12"	–	–	
CB-12	–	–	17.0	–	–	13.6	12"	–	–	–	–	–	–	–	–	–	–	–	–	
CB-13	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	13.4	12"	–	–	–	–	
CB-14	–	–	17.0	–	–	–	–	13.1	12"	–	–	–	–	–	–	13.1	12"	–	–	
CB-15	–	–	17.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13.6	12"	
CB-16	–	–	17.0	–	–	–	–	13.4	12"	–	–	–	–	–	–	–	–	–	–	
CB-17	–	–	17.0	–	–	–	–	13.1	12"	–	–	–	–	–	–	13.1	12"	–	–	
CB-18	–	–	16.5	–	–	13.2	12"	–	–	–	–	–	–	–	–	13.2	12"	–	–	
CB-19	–	–	16.5	–	–	–	–	13.4	12"	–	–	–	–	–	–	13.4	12"	–	–	
CB-20	–	–	16.5	–	–	–	–	13.6	12"	–	–	–	–	–	–	–	–	–	–	
CB-21	–	–	16.5	–	–	–	–	–	–	–	–	–	–	–	–	13.6	12"	–	–	
CB-22	–	–	16.5	–	–	–	–	13.4	12"	–	–	–	–	–	–	13.4	12"	–	–	
CB-23	–	–	16.5	–	–	–	–	13.2	12"	–	–	–	–	–	–	13.2	12"	–	–	
CB-24	NOT USED																			
CB-25	–	–	15.0	–	–	–	–	–	–	11.6	18"	–	–	–	–	11.8	18"	–	–	
CB-26	–	–	16.0	13.2	18"	–	–	–	–	–	–	13.2	18"	–	–	–	–	–	–	
CB-27	–	–	16.5	–	–	–	–	–	–	–	–	12.8	18"	–	–	12.8	18"	–	–	
MH-1	–	–	13.0	–	–	–	–	8.2	24"	8.7	18"	–	–	–	–	8.2	24"	–	–	
MH-2	–	–	17.0	11.2	18"	–	–	–	–	–	–	–	–	–	–	11.0	18"	–	–	
MH-3	–	–	16.5	–	–	–	–	10.3	18"	–	–	–	–	–	–	–	–	10.3	18"	

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST



DROP (DS) AND OUTLET (OS) STRUCTURE TABLE

STRUCTURE NO.	CENTERLINE COORDINATES		TOP OF GRATE ELEVATION	INLET & OUTLET PIPE INFORMATION																REMARKS
				A		B		C		D		E		F		G		H		
	NORTH	EAST		INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	INV EL	DIA	
DS-1	NOT USED	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-2	–	–	15.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11.8	18"	
OS-3	NOT USED																			
OS-4	–	–	15.5	13.5	18"	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
OS-5	–	–	14.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	10.5	18"	
OS-6	–	–	14.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8.5	24"	

ALL DIMENSIONS ARE IN FEET, EXCEPT DIAMETER, WHICH IS IN INCHES
FOR PIPELINE MATERIAL SEE PIPELINE LIST

ALL BACKCIRCLED CHANGES PER ECN-N-S-0005

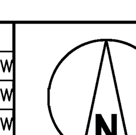
NOTES

1. FILTER FABRIC SHALL BE UV-STABILIZED NONWOVEN GEOTEXTILE HAVING A MINIMUM WEIGHT OF 135 g/M^2 PER CALTRANS SS 88-1.03.
2. SEE DWG SS-3001 FOR GENERAL NOTES AND LEGEND.

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	APP
2	22/SEP/10	ISSUED FOR PERMITTING	ARB	CAK		PLN	DVW
1	18/JUN/10	ISSUED FOR PERMITTING	RJS	CAK		PLN	DVW
0	16/APR/09	ISSUED FOR PERMITTING	NAW	PLN		PLN	DVW



60' 30' 0 60' 120'
SCALE: 1"=60'

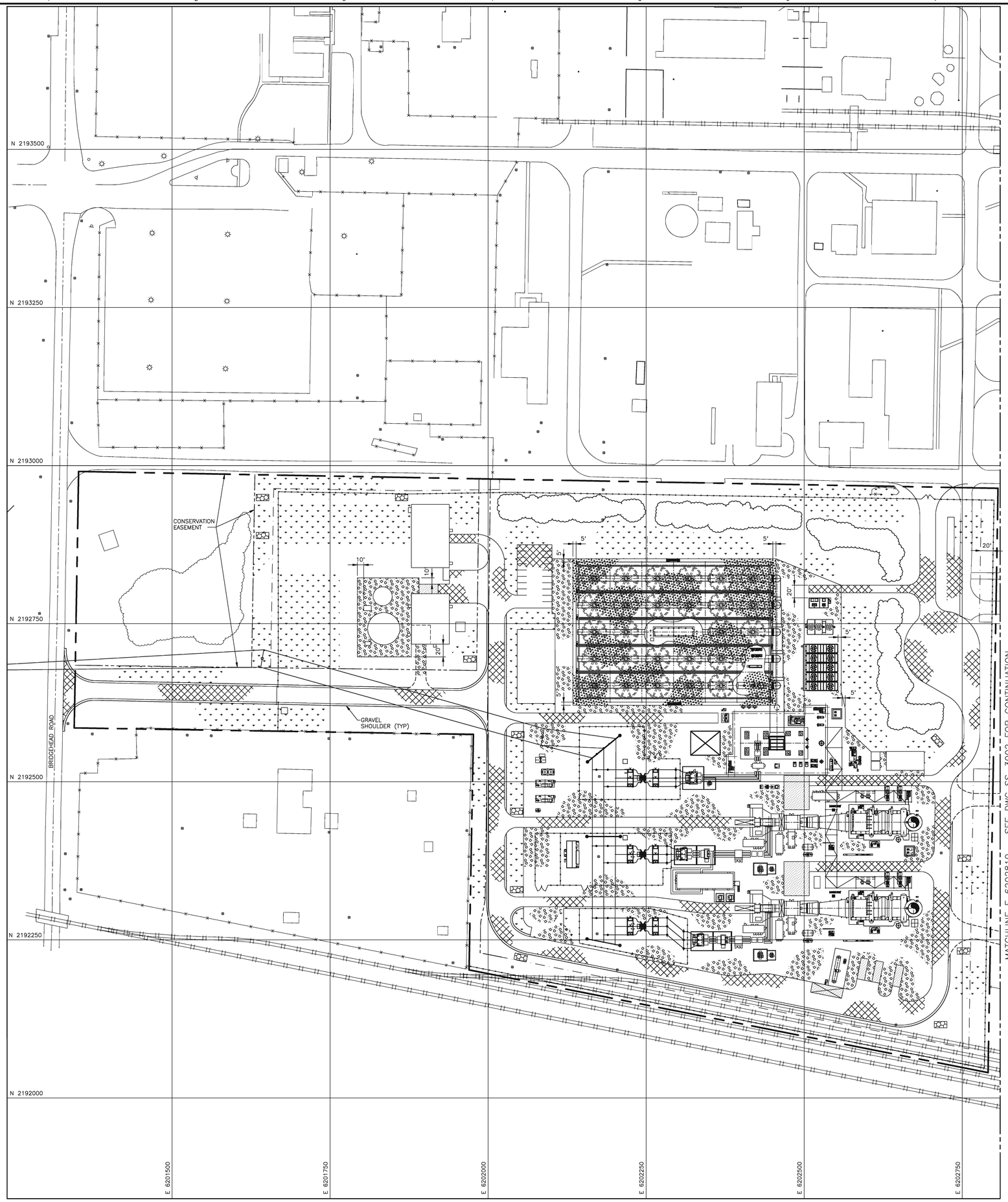
I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA
SIGNED
DATE ________ REG NO. ________

BLACK & VEATCH CORPORATION
ENGINEER PLN | DRAWN NAW
CHECKED | DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY
SITE
SECTIONS AND DETAILS

PROJECT | DRAWING NUMBER 163994-SS-3050 | REV 2
CODE
AREA

BEL30576 E1 ACAD 16.1s (LMS Tech)
A1APL017 1=1
09/22/10 15:52:09



SITE SURFACING LEGEND

- ASPHALT SURFACING
- AGGREGATE SURFACING
- CONCRETE
- GRASS
- OPEN GRADED STONE SURFACING
- RIPRAP
- EXISTING FACILITY
- NEW FACILITY
- NATURAL SOIL

NOTES

1. SEE DRAWING SS–3001 FOR GENERAL NOTES AND LEGEND.

NOT TO BE USED FOR CONSTRUCTION

THE DISTRIBUTION AND USE OF THE NATIVE FILE FORMAT OF THIS DRAWING OUTSIDE OF BLACK & VEATCH IS UNCONTROLLED AND SHALL BE USED FOR REFERENCE PURPOSES ONLY.

NO	DATE	REVISIONS AND RECORD OF ISSUE	DRN	DES	CHK	PDE	PLN	DVW	APP
0	16/APR/09	ISSUED FOR PERMITTING	NAW	PLN			PLN	DVW	

60' 30' 0 60' 120'
SCALE: 1"=60'

I HEREBY CERTIFY THAT THIS DOCUMENT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY REGISTERED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF CALIFORNIA

SIGNED
DATE REG NO.

BLACK & VEATCH CORPORATION

ENGINEER PLN | DRAWN NAW
CHECKED | DATE

CONTRA COSTA GENERATING STATION LLC
CONTRA COSTA COMBINED CYCLE FACILITY

SURFACING/FENCING/ROADWAY – SITE PLAN – SHEET 1

PROJECT DRAWING NUMBER: 163994–SS–3201
REV: 0
CODE
AREA

ACAD 16.1s (LMS Tech)
SPU3716Z E1 1=1
A4SP017 04/15/09 14:11:39

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA
1516 NINTH STREET, SACRAMENTO, CA 95814
1-800-822-6228 – WWW.ENERGY.CA.GOV

APPLICATION FOR CERTIFICATION FOR THE *OAKLEY GENERATING STATION*

Docket No. 09-AFC-4
PROOF OF SERVICE
(Revised 8/13/2010)

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*indicates change

DECLARATION OF SERVICE

I, Mary Finn, declare that on September 28, 2010, I served and filed copies of the attached Oakley Generating Station Project (09-AFC-4) Supplemental Information Item #4: Revised Stormwater Drainage Design. 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: **[http://www.energy.ca.gov/sitingcases/contracosta/index.html].** 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 Unit, in the following manner:

(*Check all that Apply*)

For service to all other parties:

sent electronically to all email addresses on the Proof of Service list;

___x__ by personal delivery;

_____ by delivering on this date, for mailing with the United States Postal Service with first-class postage thereon fully prepaid, to the name and address of the person served, for mailing that same day in the ordinary course of business; that the envelope was sealed and placed for collection and mailing on that date to those addresses **NOT** marked "email preferred."

AND

For filing with the Energy Commission:

X **sending an original paper copy and one electronic copy, mailed and emailed respectively, to the address below (preferred method);**

OR

_____depositing in the mail an original and 12 paper copies, as follows:

CALIFORNIA ENERGY COMMISSION
Attn: Docket No. 09-AFC-4
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512
docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct, that I am employed in the county where this mailing occurred, and that I am over the age of 18 years and not a party to the proceeding.

Mary Finn