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CIVIL ENGINEERING LAND PLANNING

Planning
Civil Engineering
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Concept Design
Feasibility Studies

DRAINAGE REPORT

for

HAWKES RESIDENCE DRIVEWAY AND HOUSE PAD IMPROVEMENTS

174 Alexander Valley Road
Healdsburg, CA
APN 091-070-025

DRAINAGE
★APPROVED★
FEB 06 2017
PERMIT AND RESOURCE
MANAGEMENT DEPARTMENT

REGISTERED PROFESSIONAL ENGINEER
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Report Date: November 22nd, 2016

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Project Narrative:

The proposed Hawkes residence at 174 Alexander Valley Road, in Healdsburg, California. The project includes grading and drainage improvements for a proposed driveway and a pad for a future house on the property. The existing property consists of hilly terrain with slopes ranging from 5 to 20-percent, mostly planted to vineyard. Drainage analysis is required to determine the 10-year hydrology, to find the required volume detention and ensure sufficient capacity for all permanent pipes and swales.

Proposed improvements will create additional runoff, which will be conveyed, treated, and stored. Drop inlets, area drains, swales, and stormdrain pipes are proposed to direct runoff away from the proposed improvements, to rock outlets and dissipaters. These features will ultimately direct runoff along the existing slope and roadside swale after treatment.

Drainage analysis is required to:

- Determine the 10-year hydrology to adequately size drainage conveyances for the improvements.
- Calculate volume capture and water quality treatment required for 85th percentile 24-hour storm.
- Address post-project runoff quantity and quality.

Refer to the attached hydrology maps, which show the existing and proposed tributary areas and drainage features. The capacity map shows the locations of the proposed storm water treatment and capture features in the post-development condition.

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Design Parameters

Hydrology

For the purposes of this drainage report, we used The Sonoma County Water Agency Flood Control Design Criteria (1983) as a guideline for estimating the 10-year storm runoff.

Review of the Sonoma County Water Agency (SCWA) Flood Control Design Criteria handbook provides the following mathematical models and constant values used in the hydraulic analysis:

Annual Precipitation (Plate B-3)	40 inches/year
K-Factor (Plate B-4)	1.4
Design Storm Event	10-Year
Initial Time of Concentration	15 min
Rainfall Intensity (Plate B-2)	varies - see calculations
Runoff Coefficient	varies - see calculations
Manning's Coefficient	0.012 HDPE
	0.030 Earth Swales
	0.035 Rock Swales

Capacity Analysis for Storm Drains and Swales

Hydraulic analysis was used to determine the 10-year depth of flow for all the proposed pipes and swales. The channel calculator within the Hydraflow Express Extension of AutoCAD Civil 3D was used to perform capacity calculations for the pipes and swales. Refer to attached capacity analyses for input and output of these calculations. Refer to the capacity map for identification of the pipes, swales, and dissipater. The geometric parameters used in the calculator match the features detailed on the improvement plans.

The analyzed pipes and swales consist of the only 9" swale, the only 12" swale, the only 18" pipe, the only 14" pipe, and the 8" pipe collected the largest flow, which also has the shallowest slope. The calculations show they are adequately sized, thus it follows that the rest of the pipes and swales are adequately sized. This analysis demonstrates that the stormdrain system meets the requirements of the SCWA Flood Control Design Criteria for the 10-year event.

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Stormwater Treatment & Volume Capture

In accordance with the County of Sonoma's Grading Ordinance, the project has been designed to maintain off-site natural drainage patterns and limit post-development storm water levels in compliance with the permit authority's best management practices guide. Limiting post-development storm water levels includes maintaining the pre-project runoff quantities and minimizing pollutant discharges.

There are several pollutants of concern for this project. Erosion is expected from grading activities and will be addressed by placing straw wattles along hillsides and inlets and providing rock rip rap at culvert outlets. Sediment, nutrients and pesticides are possible with landscaping activities and will be reduced by natural buffer strips and through the infiltration of storm water in the stormdrain dissipater. These features will also help to reduce metal and TPH (total petroleum hydrocarbons) expected from automobile use of the driveway. These controls will provide treatment before the storm water re-enters the existing waterways.

Storm water will be captured, stored and infiltrated in order to maintain pre-project runoff quantities. The County's Best Management Practices Guide provides several options for calculating the required storm water volume to be mitigated. Volume calculations for this project were performed using the guidelines from the *City of Santa Rosa and County of Sonoma, Storm Water Low Impact Development Technical Design Manual, dated August 2011.* Spreadsheets adapted from The Storm Water Calculator worksheets provided by the City of Santa Rosa were utilized to determine the required flow and volume of water to be addressed. These spreadsheets and maps are attached at the end of the report. Total volume capture requirement was calculated to be zero, since the weighted curve numbers for the pre- and post-construction conditions were calculated to be approximately equal.

A stormdrain dissipater will be utilized to provide volume capture and to reduce pollutants in the storm water. The dissipater trench will minimize pollutants above ground by slowing water runoff and allowing pollutants to settle and infiltrate into native soil.

The attached calculations show the proposed stormdrain dissipater will provide 151 ft^3 of volume retention, which is more than sufficient to adequately retain the additional runoff created by the proposed improvements during the 85^{th} percentile 24-hour storm event for the entire site.

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Weighted Curve Number

FOR 85th PERCENTILE 24 HOUR STORM EVENT

Date: 11/22/2016 Project: 174 Alexander Valley Rd, Healdsburg CA Sheet: 1 of 1

Weighted Curve Number - Soil Group C & D - Tributary 1

Tributary Area	Total Area (SF)	Vegetated Area (SF)	Vegetated CN	Hardscape Area (SF)	Hardscape CN	Roof Area (SF)	Roof CN	DG/Gravel Area (SF)	DG/Gravel CN	Asphalt Area (SF)	Asphalt CN	Composite CN
PRE	322494	322406	80	88	98	0	98	0	89	0	93	**80**
POST	322494	311993	80	0	98	3932	98	0	89	6569	93	**80**

Weighted Runoff Coefficient

Date: 11/22/2016 Project: 174 Alexander Valley Rd Healdsburg, CA

Runoff Coefficient Worksheet (Capacity Analysis)							
Trib #1A				Trib #1B			
Surface	RC	Area (sq.ft)	R.C. x A	Surface	RC	Area (sq.ft)	R.C. x A
Pervious	0.45	47500	21375	Pervious	0.45	202619	91178.55
DG/Gravel	0.7	0	0	DG/Gravel	0.7	0	0
Pavement	0.9	0	0	Pavement	0.9	6102	5491.8
Hardscape	0.9	0	0	Hardscape	0.9	0	0
Roof	0.9	0	0	Roof	0.9	0	0
	Subtotal	47500	21375		Subtotal	208721	96670.35
	0.45	Weighted Runoff Coefficient			**0.46**	Weighted Runoff Coefficient	
Trib #1C							
Surface	RC	Area (sq.ft)	R.C. x A				
Grass	0.45	4427	1992.15				
DG/Gravel	0.7	0	0				
Pavement	0.9	0	0				
Hardscape	0.9	0	0				
Roof	0.9	0	0				
	Subtotal	4427	1992.15				
	0.45	Weighted Runoff Coefficient					

RATIONAL METHOD DRAINAGE STUDY

Date: 11/22/2016

Project: 174 Alexander Valley Rd Healdsburg, CA

Storm: **10-Year and 100-Year**

Sheet: 1 of 1

POST DEVELOPMENT							
Tributary	Acreage	Runoff Coefficient	Time of Concentration	i_{10}=7.08/t^0.526	Q_{10}=CiAK	i_{100}=10.15/t^0.529	Q_{100}=CiAK
1a	1.090	0.45	15.00	1.70	1.379	2.42	1.962
1b	4.792	0.46	15.00	1.70	6.239	2.42	8.872
1c	0.102	0.45	10.00	2.11	0.159	3.00	0.227

Note: the inlets, pipes, & swales to be analyzed for worst-case scenarios are in bold.

CAPACITY					
Drainage Feature	Tributary	Q10	Q100		
Swale #1	**1A**	**1.379**	1.962	**1.3%**	**9", Earth**
Pipe 1A	1A	1.379	1.962	17.0%	8" HDPE
Pipe 1B	1B	6.239	8.872	1.3%	14" HDPE
Pipe 1C	**1A+1B**	**7.618**	10.833	**1.0%**	**18" HDPE**
Swale #2	**1B**	**6.239**	8.872	**1.0%**	**15", Rock**
Pipe 1D	1A+1B	7.618	10.833	2.1%	18", HDPE
Pipe 2A	**1C**	**0.159**	0.227	**1.0%**	**8" HDPE**
Pipe 2B	1C	0.159	0.227	12.8%	8" HDPE

Grate Capacity Analysis:

DI #1	**N/A Side Opening**	**1.379**	1.962	12x12
DI #2	**1C**	**0.159**	0.227	8" Round
DI #3	1C	0.159	0.227	8" Round
DI #4	**N/A Side Opening**	**6.239**	8.872	24x24

Volume Retention Calculations
174 Alexander Valley Road
11/22/2016

Volume in Dissipater Pipe:

Pipe Size (in)	Area (sf)	Length (ft)	Volume (cf)
24	3.14	35.0	109.90

Volume in Dissipater Rock:

Area (sf)	Length (ft)	Porosity	Volume (cf)
4.00	35.00	0.3	42.00

Total Volume :	**151.90**

Calculated required detention: 0 ft^3

STORM WATER CALCULATOR*

*For example only, go to www.srcity.org/stormwaterlid for the latest version of the calculator

Project:	Hawkes Residence
Address/Location:	174 Alexander Valley Road
Designer:	Tom Connell
Date:	November 22, 2016
Inlet Number/Tributary Area/BMP:	Trib 1

NOTE: In order for this calculator to function properly **macros must be enabled.**

Physical Tributary Area that drains to Inlet/BMP = 322,494 ft^2

This portion of the Storm water Calculator is designed to account for pollution prevention measures implemented on site. Additional information and description of these measures can be found in the Fact Sheets in Appendix F and in Chapter 4 of the narrative.

Disconnected Roof Drains [1]

Input:

Select disconnection condition: Runoff is directed across landscape; Width of area: 10'to 14'

Condition Factor = 0.45

Method 1: **Based on the total rooftop drainage area - to be used if rooftop information is known.**

Input:

Enter amount of rooftop area that drain to disconnected downspouts = 0 ft^2

Rooftop Area Factor = 0.00 Rooftop Area Factor= (Total Rooftop Disconnected Area/Tributary Area)

Solution:

Area reduction = (Physical Tributary Area x Conditional Factor x Rooftop Area Factor)

(322,494 x 0.45 x 0.00) = 0.00 ft^2 **Rooftop Drainage Area Reduction**

Method 2: **Based on density (units per acre) - to be used if rooftop information is unknown.**

Input:

Enter percent of rooftop area to be disconnected from downspouts: 0 %

Select Density: 1 Units per Acre

Density Reduction Factor= 0.08

Solution:

Area reduction = (Physical Tributary Area x Conditional Factor x Percent Disconnected x Density Factor)

(322,494 x 0.45 x 0.00 x 0.08) = 0.00 ft^2 **Density Reduction**

NOTE:
Either Method 1 (rooftop area) or Method 2 (density) can be used. Providing input for both methods will cause an error. If rooftop area information is available, Method 1 should be used.

[1] *See "Impervious Area Disconnection" Fact Sheet in Appendix E for further details.*

[2] See "Interceptor Trees" Fact Sheet in Appendix E for further details and see "Plant and Tree List" in Appendix G for approved trees.

[3] See "Vegetated Buffer Strip" and "Bovine Terrace" Fact Sheets in Appendix E for further details.

[4] *Total area reductions due to pollution Prevention Measures cannot exceed 50% of the physical Tributary Area.*

[5] *Per the "Urban Hydrology For Small Watersheds" TR-55 manual.*

[6] *Q in feet of depth as defined by the "Urban Hydrology For Small Watersheds" TR-55 Manual.*

[7] *From Sonoma County Water Agency Flood Control Design Criteria.*

[8] *Hydrologic soil type based of infiltration rate of native soil as defined by "Urban Hydrology For Small Watersheds" TR-55 Manual.*

[9] *Composite CN calculated per "Worksheet 2 Part 1 of the Urban Hydrology For Small Watersheds" TR-55 manual.*

[10] *From "Using Site Design to Meet Development Standards For Storm water Quality" by the Bay Area Storm water Management Agencies Association (BASMAA).*

APPENDIX C
STORM WATER CALCULATOR

Paved Area Disconnection [1]

Paved Area Type (select from drop down list): Not Directly-connected Paved Area
Multiplier = 1

Enter area of alternatively designed paved area: 0 ft^2

Area Reduction = 0.00 ft^2

INSTRUCTIONS:
Calculates the area reduction credit for driveways designed to minimize runoff. Enter type and area of alternate design.

Interceptor Trees [2]

Number of new *Evergreen Trees* that qualify as interceptor trees= 0 New Evergreen Trees

Area Reduction due to new Evergreen Trees= 0 ft^2 (200 ft^2/tree)

NOTE:
Total Interceptor Area Reduction is limited to 50% of the physical tributary area.

Number of new *Deciduous Trees* that qualify as interceptor trees= 0 New Deciduous Trees

Area Reduction due to new Deciduous Trees= 0 ft^2 (100 ft^2/tree)

Enter square footage of qualifying existing tree canopy = 0 Existing Tree Canopy

Allowed reduction credit for existing tree canopy= 0 ft^2 Allowed credit for existing tree canopy = 50 % of actual canopy square footage

Area Reduction = 0 ft^2 = Sum of areas managed by evergreen + deciduous + existing canopy

INSTRUCTIONS:
Calculates the area reductions credit due to interceptor trees. Includes both new and existing trees. Enter the number of new deciduous and evergreen trees and the canopy area of existing trees.

Buffer Strips & Bovine Terraces [3]

Enter area draining to a Buffer Strip or Bovine Terrace = 0 ft^2

Buffer Factor = 0.7

Solution:

Area Reduction = (Area draining to Buffer Strip or Bovine Terrace) x (Buffer Factor) =

Area Reduction = 0.00 ft^2

INSTRUCTIONS:
Calculates the area reduction credit due to buffer strips and/or bovine terraces. Runoff Must be direct to these features as sheet flow. Enter the area draining to these features.

Revised Tributary Area due to Pollution Prevention Measures

Physical Tributary Area = 322,494 ft^2

Tributary Area Reduction due to Pollution Prevention Measures [4] = 0.00 ft^2

Reduced Tributary Area to be used for Calculations = 322,494 ft^2

This worksheet calculates the quantity of storm water that needs to be addressed (captured and/or treated) to comply with the NPDES Storm Water Permit issued to the City of Santa Rosa and County of Sonoma by the North Coast Regional Water Quality Control Board.

Design Goal: 100% Volume Capture

Capture (infiltration and/or reuse) of 100% of the volume of runoff generated by the 85th percentile 24 hour storm event.

INSTRUCTIONS:
This Design Goal of 100% Capture is the ideal condition and if achieved satisfies all requirements so that no additional treatment is required and pages 4 and 5 of this calculator do not need to be completed.

NOTE:
If the Design Goal of 100% Capture is not achieved, 100% Treatment AND Volume Capture must be achieved and both pages 4 and 5 of this calculator need to be completed.

Formulas:

$$S = \frac{1000}{CN} - 10$$

Where:
S= Potential maximum retention after runoff (in)[5]
CN= Curve Number [5]

$$Q = \frac{[(P \cdot K) - (0.2 \cdot S)]^2}{[(P \cdot K) + (0.8 \cdot S)]} \times \frac{1ft}{12"}$$

Where:
Q= Runoff depth (ft) [6]
P= Precipitation (in) = 0.92
K= Seasonal Precipitation Factor [7]

0.92 inches in the Santa Rosa area, based on local historical data.

$$V = (Q)(A_r)$$

Where:
V= Volume of Storm Water to be Retained (ft^3)
A_r= Reduced Tributary Area including credit for Pollution Prevention Measures (ft^2)

Input: (Pick data from drop down lists or enter calculated values)

A_r = 322,494 ft^2
K [7] = 1.40

Drop down Lists
Select post development hydrologic soil type within tributary area [8] = D: 0 - 0.05 in/hr infiltration (transmission) rate
Select post development ground cover description [5] = Row Crops - Contoured - Poor

CN_{POST} = 88
OR: Composite post development CN [9] = 80

NOTE:
Entering a calculated composite CN will override selections made from the pull down menu above. Calculation worksheet should be used for all composite calculations and included with submittal.

Solution:

Volume of storm water - Post Development

S_{POST} = 2.50 in

$$S_{POST} = \frac{1000}{80} - 10$$

Q_{POST} = 0.01574 ft

$$Q_{POST} = \frac{[(0.92 * 1.40) - (0.2 * 2.50)]^2}{[(0.92 * 1.40) + (0.8 * 2.50)]} \times \frac{1ft}{12in}$$

V_{GOAL} = 5076.06 ft^3

$$V_{GOAL} = (0.01574)(322,494)$$

Where:
S_{POST}= Post development potential maximum retention after runoff (in).
Q_{POST}= *Q in feet of depth as defined by the "Urban Hydrology For Small Watersheds" TR-55 Manual.*
V_{GOAL}= Post Development Volume of Storm Water to be Retained (ft^3)

Requirement 1: 100% Treatment

Treatment of 100% of the flow generated by 85th percentile 24 hour mean annual rain event (0.2 in/hr).

Formula:

$Q_{TREATMENT}$ = (0.2 in/hr)(A_r)(C_{POST})(K) cfs

Where:

$Q_{TREATMENT}$ = Design flow rate required to be treated (cfs)
C_{POST} = Rational method runoff coefficient for the developed condition [10]
A_r = Reduced Tributary Area including credit for Pollution Prevention Measures (in Acres)
K = Seasonal Precipitation Factor [7]

Input:

A_r =	322,494	ft² =	7.40	Acres
C_{POST} [10] =	0.46			
K [7] =	1.4			

Solution:

$Q_{TREATMENT}$ = 0.91951 cfs

$Q_{TREATMENT}$ = (0.2)(7.40)(0.46)(1.35)

C value note:
The C value used for this calculation is smaller than the value used for hydraulic Flood Control design.
The table of values can be found her
This smaller value should not be used to size the overflow bypass.

NOTE:
The Flow Rate calculated here should only be used to size the appropriate BMP. All associated overflow inlets and systems should be sized for the Flood Control event.

INSTRUCTIONS:
If the Design Goal of 100% Capture on page 3 of this calculator is not achieved; then Requirement 1-100% Treatment, this page of the calculator, AND Requirement 2- Volume Capture, page 5 of the calculator, **must** be achieved.

Requirement 2: Delta Volume Capture

No increase in volume of runoff leaving the site due to development for the 85th percentile 24 hour storm event.

Formulas:

$S = \frac{1000}{CN} - 10$

Where:
S= Potential maximum retention after runoff (in)[5]
CN= Curve Number [5]

$Q = \frac{[(P \cdot K)-(0.2 \cdot S)]^2}{[(P \cdot K)+(0.8 \cdot S)]} \times \frac{1ft}{12in}$

Where:
Q= Runoff depth (ft) [6]
P= Precipitation (in) = 0.92 — *0.92 inches in the Santa Rosa area, based on local historical data.*
K= Seasonal Precipitation Factor [7]

$V = (Q)(A_r)$

Where:
V= Volume of Storm Water to be Retained (ft^3)
A_r= Reduced Tributary Area including credit for Pollution Prevention Measures (ft^2)

Input: (Pick data from drop down lists or enter calculated values)

A_r = 322,494 ft^2
K[7] = 1.4

Drop down Lists

Select hydrologic soil type within tributary area[8] = D: 0 - 0.05 in/hr infiltration (transmission) rate
Select predevelopment ground cover description [5] = Row Crops - Contoured - Poor
Select post development ground cover description [5] = Residential - 2 acre lots
CN_{PRE} = 88
CN_{POST} = 82
OR
Composite Predevelopment CN [9] = 80
Composite Post development CN [9] = 80

Solution:

Pre Development Storm Water Runoff Volume

S_{PRE} = 2.50 in — $S_{PRE} = \frac{1000}{80} - 10$

Where:
S_{PRE}= Pre development potential maximum retention after runoff (in).

Q_{PRE} = 0.01574 ft — $Q_{PRE} = \frac{[(0.92*1.40)-(0.2*2.50)]^2}{[(0.92*1.40)+(0.8*2.50)]} \times \frac{1ft}{12in}$

Q_{PRE}= *Q in feet of depth as defined by the "Urban Hydrology For Small Watersheds" TR-55 Manual.*

V_{PRE} = 5076.06 ft^3 — V_{PRE}= (0.01574)(322,494)

V_{PRE}= Pre Development Volume of Storm Water Generated (ft^3)

Post Development Storm Water Runoff Volume

S_{POST} = 2.50 in — $S_{POST} = \frac{1000}{80} - 10$

Where:
S_{POST}= Post development potential maximum retention after runoff (in).

Q_{POST} = 0.01574 ft — $Q_{POST} = \frac{[(0.92*1.40)-(0.2*2.50)]^2}{[(0.92*1.40)+(0.8*2.50)]} \times \frac{1ft}{12in}$

Q_{POST}= *Q in feet of depth as defined by the "Urban Hydrology For Small Watersheds" TR-55 Manual.*

V_{POST} = 5076.06 ft^3 — V_{POST}= (0.01574)(322,494)

V_{POST}= Post Development Volume of Storm Water Generated (ft^3)

Solution: Volume Capture Requirement

Increase in volume of storm water that must be retained onsite (may be infiltrated or reused).

Delta Volume Capture= (V_{POST}-V_{PRE})

Delta Volume Capture= (5,076.06) - (5,076.06)

V_{DELTA} = 0.00 ft^3

Where:
Delta Volume Capture= The increase in volume of storm water generated by the 85th percentile 24 hour storm event due to development that must be retained onsite (may be infiltrated or reused).

INSTRUCTIONS:
If the Design Goal of 100% Capture on page 3 of this calculator is not achieved; then Requirement 1-100% Treatment, page 4 of the calculator, AND Requirement 2- Volume Capture, this page of the calculator, must be achieved.

NOTE:
If the amount of volume generated after development is less than or equal to that generated before development, Requirement 2-Volume Capture is not required.

($C_{POST} \leq C_{PRE}$ or $CN_{POST} \leq CN_{PRE}$)

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GRATE FLOW CAPACITY FOR STANDARD GRATES

DESIGN CRITERIA

1. GRATE IS IN SUMP AREA (LOW POINT)
2. Q = 3.0 x P x $H^{3/2}$ = WEIR DISCHARGE IN **C.F.S.**

   WHERE

   P = 1/2 PERIMETER IN FEET (ASSUME 35→40 PERCENT OF THE PERIMETER IS BLOCKED WITH DEBRIS AND 10→15 PERCENT IS TAKEN UP BY THE GRATE BEARING BARS)

   H = WATER DEPTH IN FEET ABOVE GRATE (WATER DEPTHS GREATER THAN 0.4 FEET ARE NOT APPLICABLE. RECOMMENDED DEPTH FOR DESIGN PURPOSES IS 0.2 FEET)

FLOW CAPACITY TABLE

INSIDE GRATE DIMENSION a" x b"	P = a + b IN FEET	H= 0.1'	H= 0.2'	H= 0.3'	H= 0.4'
		Q (cfs)	Q (cfs)	Q (cfs)	Q (cfs)
12 x 12	2.00	0.19	0.54	0.99	1.52
16 x 16	2.67	0.25	0.72	1.32	2.03
16 x 24	3.33	0.32	0.89	1.64	2.53
24 x 24	4.00	0.38	1.07	1.97	3.04
24 x 30	4.50	0.43	1.21	2.22	3.42
30 x 30	5.00	0.47	1.34	2.46	3.79
24 x 36	5.00	0.47	1.34	2.46	3.79
36 x 36	6.00	0.57	1.61	2.96	4.55
24 x 48	6.00	0.57	1.61	2.96	4.55
36 x 48	7.00	0.66	1.88	3.45	5.31
48 x 48	8.00	0.76	2.15	3.94	6.07

Side Opening (Not Applicable)

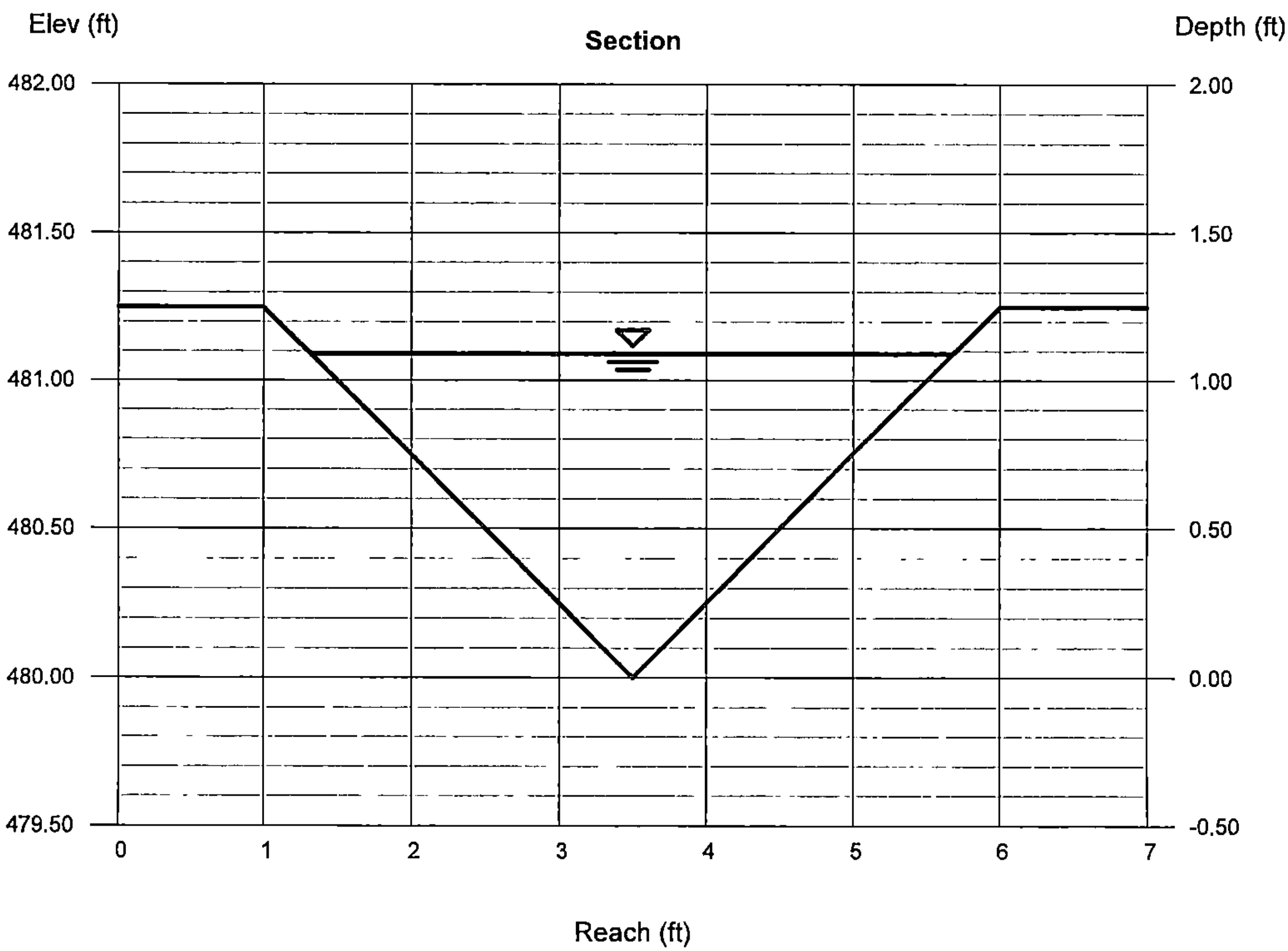
Side Opening (Not Applicable)

8" Area Drains:
P = 1/2 x (8/12)x3.14 = 1.04 ft
Q = 3x1.04x0.2^(3/2) = 0.28 cfs, 0.28 cfs > 0.19 cfs (Q 10yr)

Channel Report

11-22-16 Swale 2 Worst-Case Scenario

Triangular		**Highlighted**	
Side Slopes (z:1)	= 2.00, 2.00	Depth (ft)	= 1.09
Total Depth (ft)	= 1.25	Q (cfs)	= 6.240
		Area (sqft)	= 2.38
Invert Elev (ft)	= 480.00	Velocity (ft/s)	= 2.63
Slope (%)	= 1.00	Wetted Perim (ft)	= 4.87
N-Value	= 0.035	Crit Depth, Yc (ft)	= 0.91
		Top Width (ft)	= 4.36
Calculations		EGL (ft)	= 1.20
Compute by:	Known Q		
Known Q (cfs)	= 6.24		



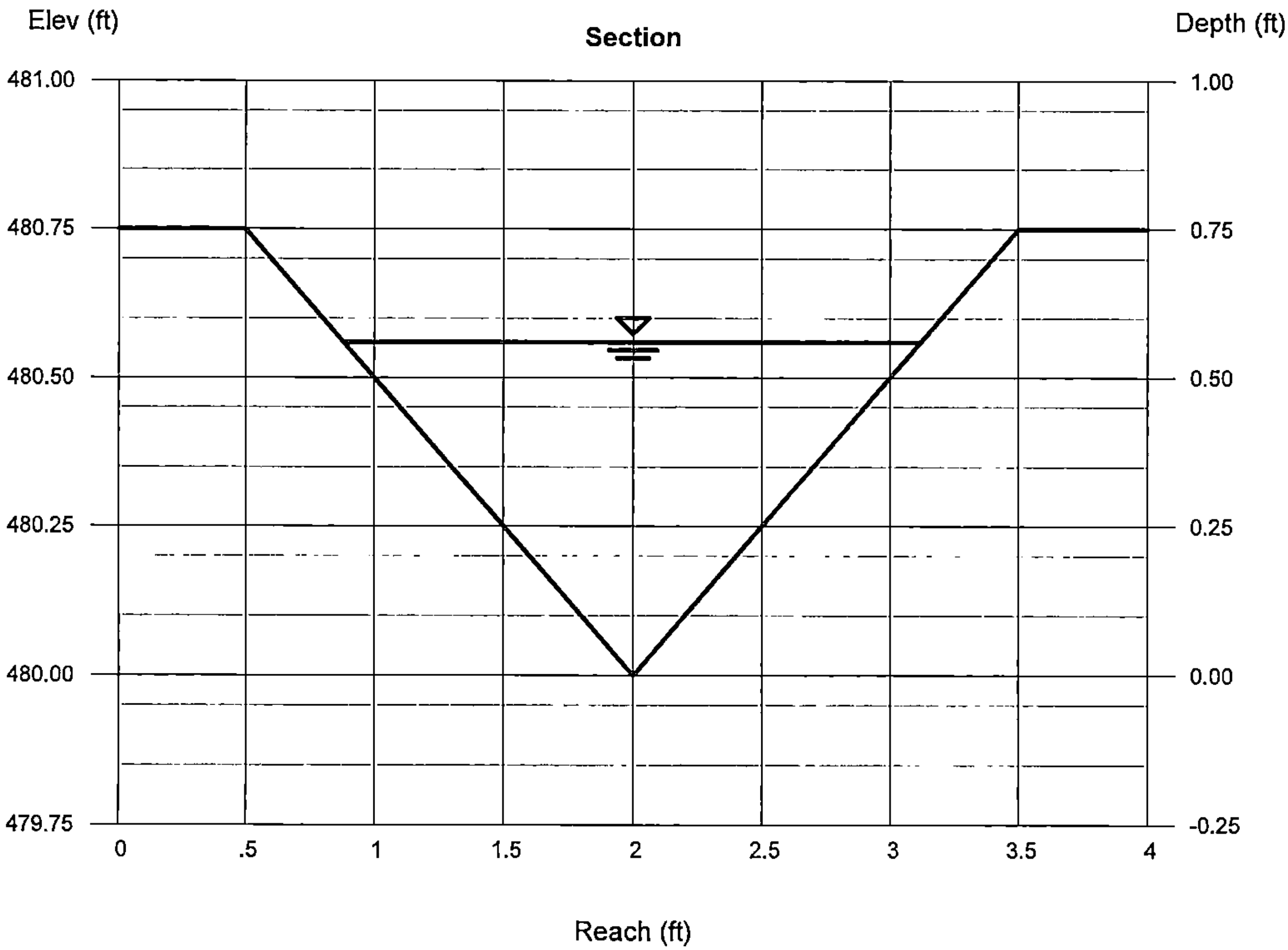
Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Nov 22 2016

11-22-16 Swale 1 Worst-Case Scenario

Triangular	
Side Slopes (z:1)	= 2.00, 2.00
Total Depth (ft)	= 0.75
Invert Elev (ft)	= 480.00
Slope (%)	= 1.30
N-Value	= 0.030
Calculations	
Compute by:	Known Q
Known Q (cfs)	= 1.38

Highlighted	
Depth (ft)	= 0.56
Q (cfs)	= 1.380
Area (sqft)	= 0.63
Velocity (ft/s)	= 2.20
Wetted Perim (ft)	= 2.50
Crit Depth, Yc (ft)	= 0.50
Top Width (ft)	= 2.24
EGL (ft)	= 0.64



Channel Report

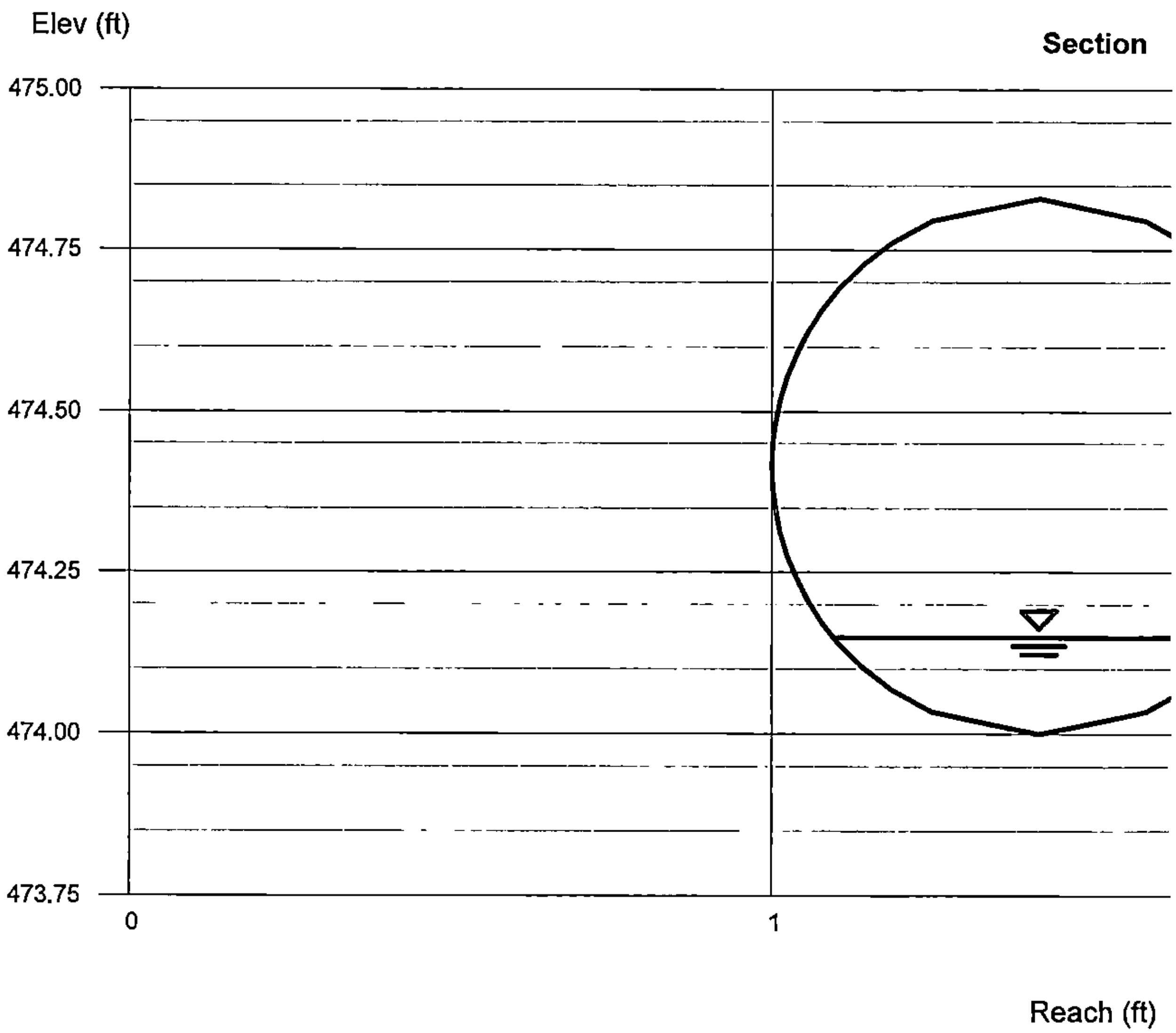
11-22-16 Pipe 2A Worst-Case Scenario

Circular
Diameter (ft) = 0.83

Invert Elev (ft) = 474.00
Slope (%) = 1.00
N-Value = 0.012

Calculations
Compute by: Known Q
Known Q (cfs) = 0.16

Highlighted
Depth (ft) = 0.15
Q (cfs) = 0.159
Area (sqft) = 0.07
Velocity (ft/s) = 2.37
Wetted Perim (ft) = 0.73
Crit Depth, Yc (ft) = 0.18
Top Width (ft) = 0.64
EGL (ft) = 0.24

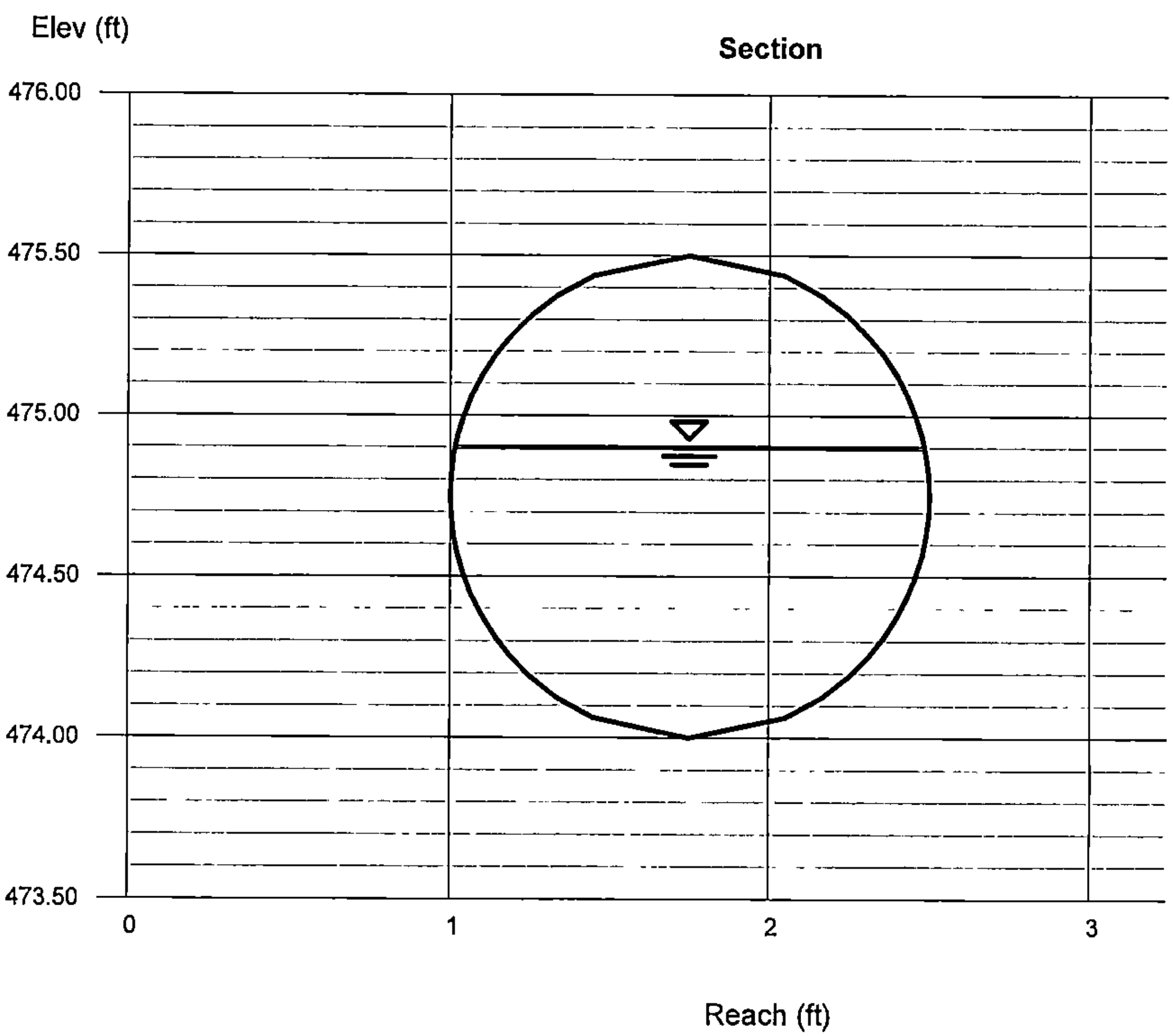


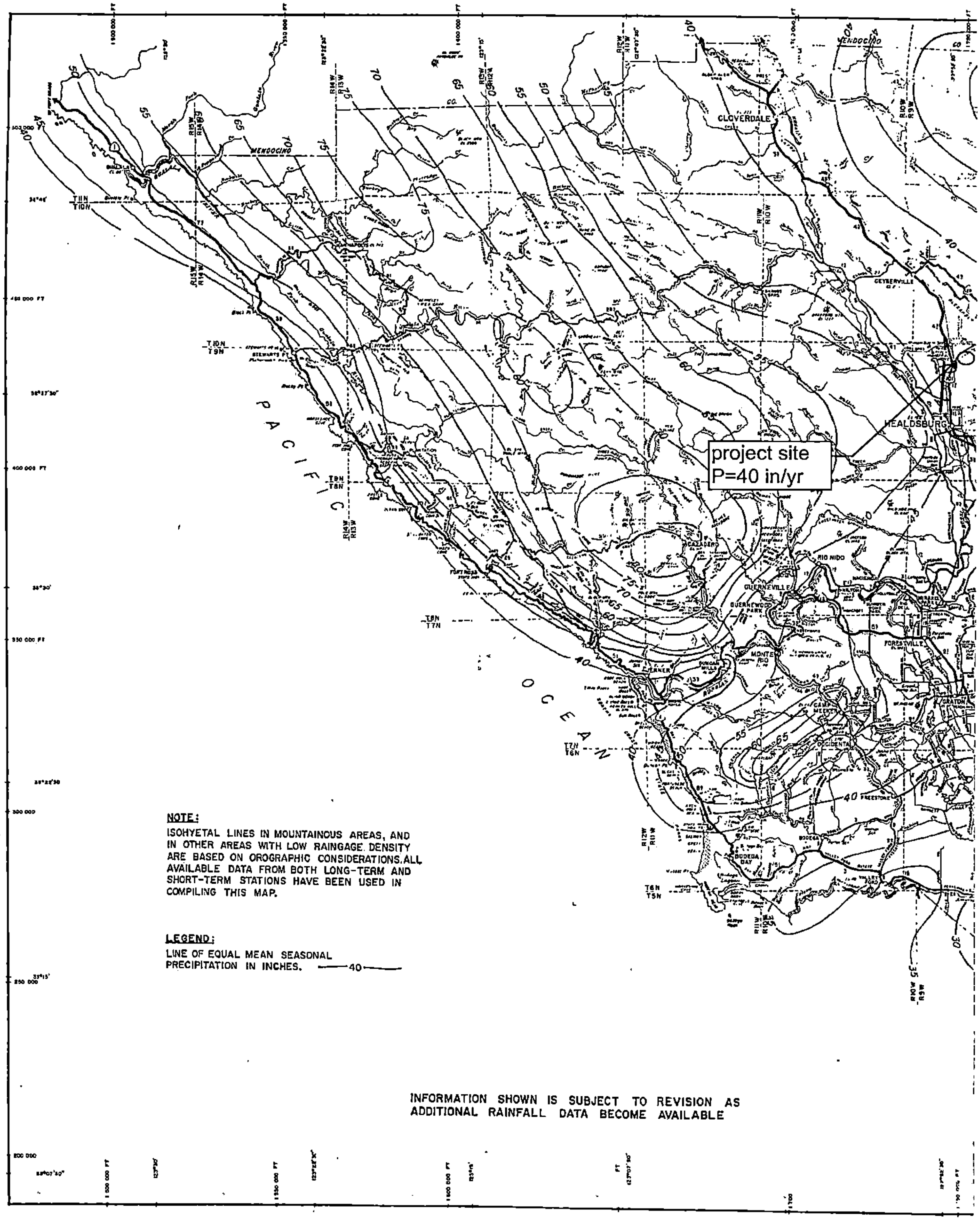
Channel Report

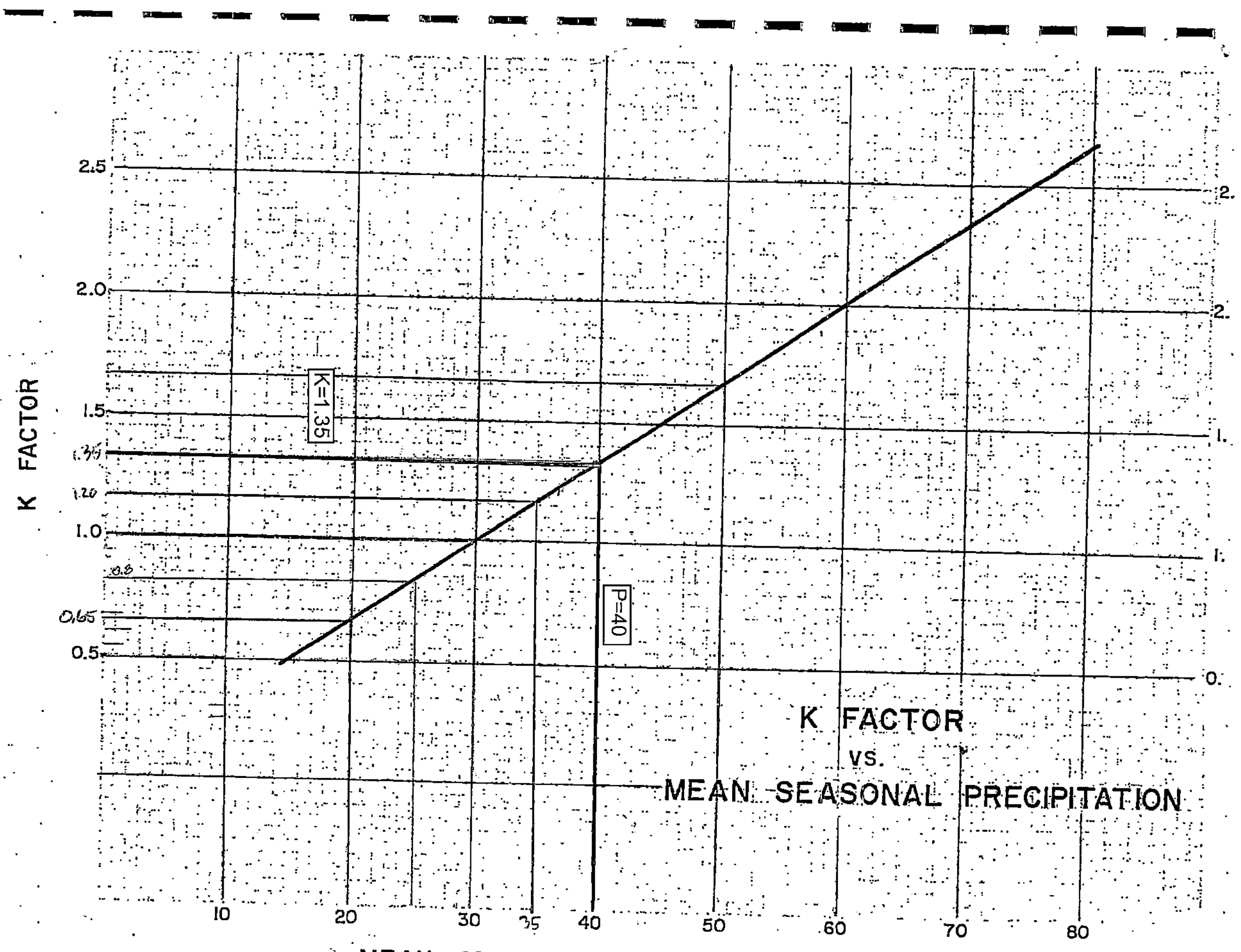
Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, Nov 22 2016

11-22-16 Pipe 1C Worst-Case Scenario

Circular		**Highlighted**	
Diameter (ft)	= 1.50	Depth (ft)	= 0.90
		Q (cfs)	= 7.620
		Area (sqft)	= 1.11
Invert Elev (ft)	= 474.00	Velocity (ft/s)	= 6.86
Slope (%)	= 1.00	Wetted Perim (ft)	= 2.66
N-Value	= 0.012	Crit Depth, Yc (ft)	= 1.07
		Top Width (ft)	= 1.47
Calculations		EGL (ft)	= 1.63
Compute by:	Known Q		
Known Q (cfs)	= 7.62		




project site
P=40 in/yr
NOTE:
ISOHYETAL LINES IN MOUNTAINOUS AREAS, AND IN OTHER AREAS WITH LOW RAINGAGE DENSITY ARE BASED ON OROGRAPHIC CONSIDERATIONS. ALL AVAILABLE DATA FROM BOTH LONG-TERM AND SHORT-TERM STATIONS HAVE BEEN USED IN COMPILING THIS MAP.
LEGEND:
LINE OF EQUAL MEAN SEASONAL PRECIPITATION IN INCHES. ——40——
INFORMATION SHOWN IS SUBJECT TO REVISION AS ADDITIONAL RAINFALL DATA BECOME AVAILABLE
PACIFIC
OCEAN
MENDOCINO
CLOVERDALE
GEYSERVILLE
HEALDSBURG
CAZADERO
RIO NIDO
GUERNEVILLE
GUERNEWOOD PARK
FORESTVILLE
MONTE RIO
CAMP MEEKER
OCCIDENTAL
FREESTONE
BODEGA
BODEGA BAY
JENNER
STEWARTS PT
GRATON



2-66

PLATE No. B-4

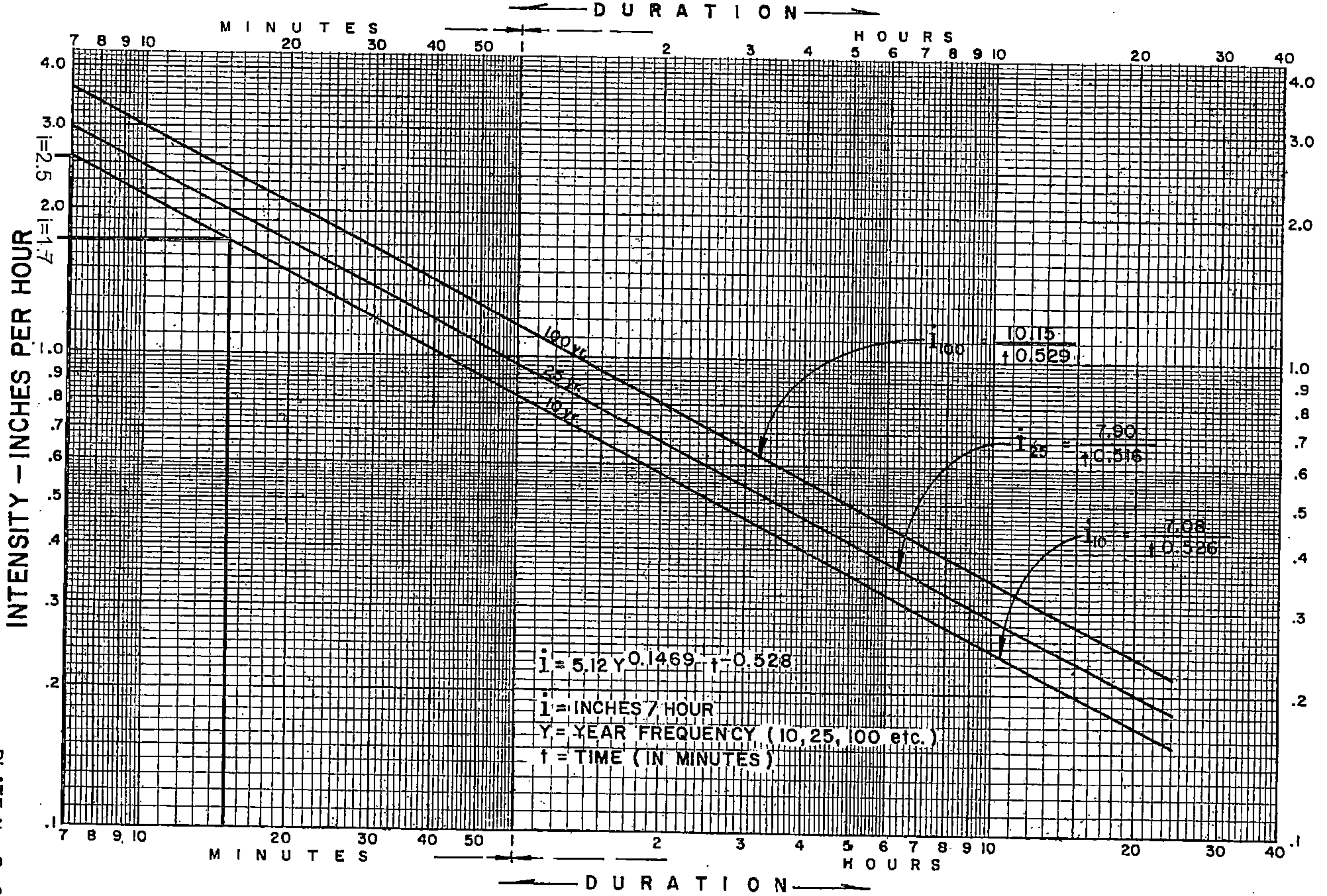
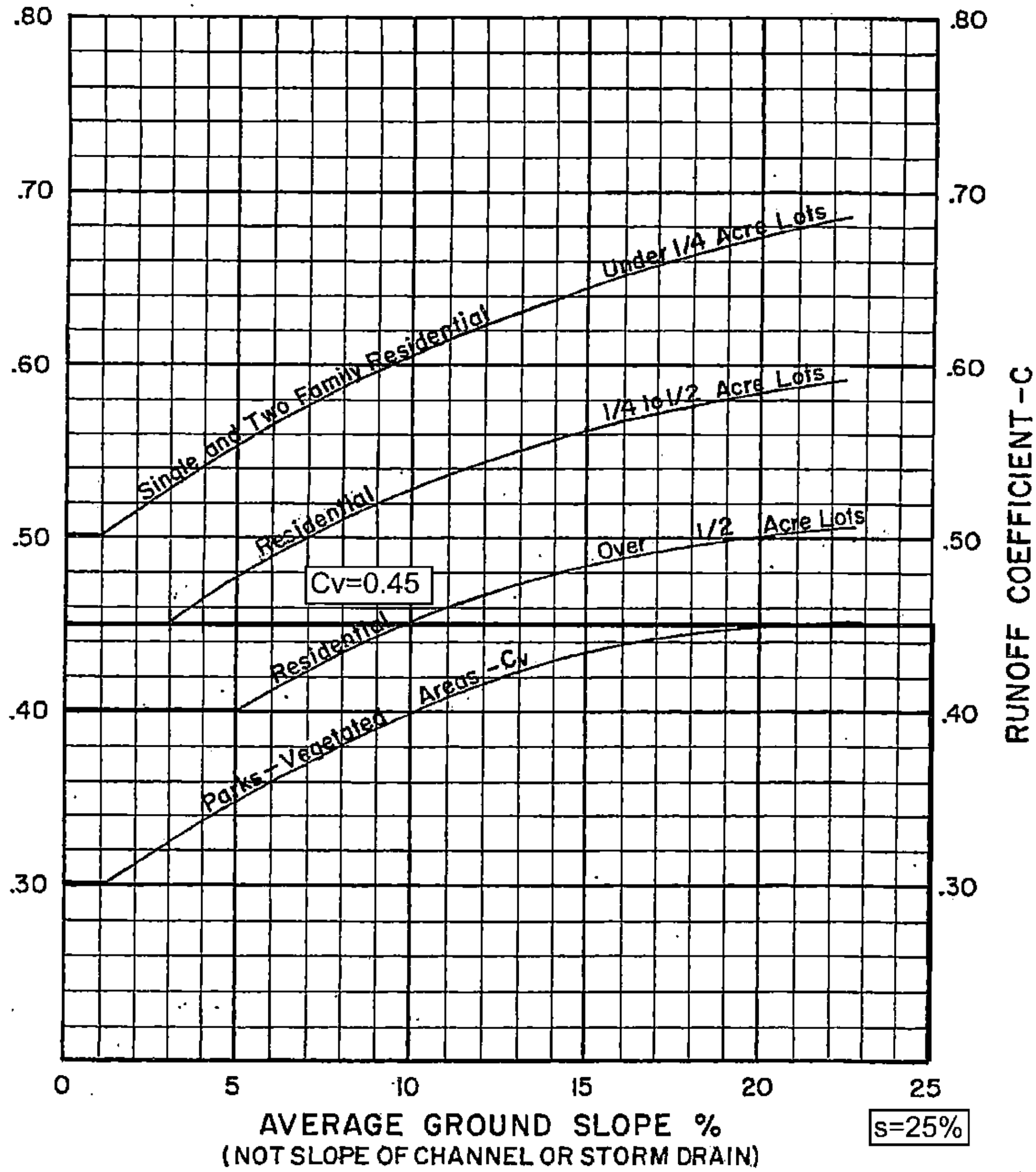


PLATE No. B-2

NOTE: THE INFORMATION SHOWN IS SUBJECT TO ANNUAL REVISION AS ADDITIONAL RAINFALL DATA BECOMES AVAILABLE.

RAINFALL INTENSITY vs DURATION

RUNOFF COEFFICIENTS FOR RATIONAL FORMULA



NOTE: Commercial, Industrial & Multiple Residential Areas

$C_P = 0.9$ (Based on paving, roofs, etc.)

When vegetated area exceeds 20% of total, C_V from vegetated curve may be used to reduce above C_P as follows:

$$C_T = C_V \frac{A_V}{A_T} + C_P \frac{A_P}{A_T}$$

SONOMA COUNTY WATER AGENCY

118-2
7/64

Map Scale: 1:1,620 if printed on A landscape (11" x 8.5") sheet.

N

0 20 40 80 120 Meters

0 50 100 200 300 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points
- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Sonoma County, California
Survey Area Data: Version 9, Sep 30, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 14, 2011—Aug 15, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Sonoma County, California (CA097)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
CgD	Clough gravelly loam, 9 to 15 percent slopes	D	3.6	67.0%
LmG	Los Gatos gravelly loam, 30 to 75 percent slopes	C	1.8	33.0%
Totals for Area of Interest			**5.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

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

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	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.