Bill Yen & Associates, Inc.
Civil Engineering ● Site Planning ● Surveying

# CEQA DRAINAGE STUDY
STEEVE TPM 21225
APN 234-120-66
DATE:12/1/2016

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WO1408

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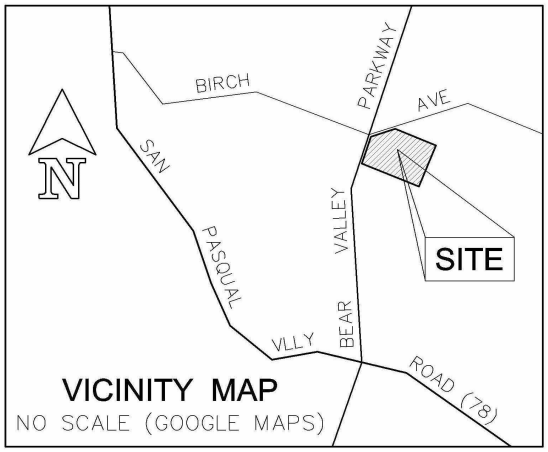
INTRODUCTION

The project is located on Bear Valley Parkway and Birch Avenue, in Escondido, California. It is tentative parcel map TPM 21225 of the County of San Diego. There is also a proposed preliminary grading plan submitted in conjunction with the TPM. The project proposes to subdivide an existing legal parcel into 4 parcels. The APN is 234-120-66 and is a rectangular shape, laying northwest to southeast length wise. The northwest to southeast distance is approximately 551 feet and perpendicularly approximately 407 feet. Its acreage is approximately 4.62 acres.

The property is located in the County of San Diego proper but will be serviced by the City of Escondido utilities and fire department. It is approximately one quarter mile south of Escondido by way of Bear Valley Parkway.




EXISTING CONDITIONS

The existing site is currently undeveloped. Historically the site was utilized as an agricultural site but that activity has since been halted. The site lacks vegetation other than wild chaparral or grass and weeds. Birch Ave is the property's northwest boundary and Bear Valley Parkway is the site's west boundary. The site is considered permeable due to the existing low maintenance vegetation. There is no existing AC paving or concrete paving. There are no existing residences or buildings on site.

Currently there exists a swale on the west side of the property with drainage structures and associated easements which carry discharge from the north side near Birch Ave onto the subject property. The structures were recently added with development that is currently to date ongoing on Bear Valley Parkway and Birch Ave as a road widening improvement project. The discharge flows through the existing onsite swale and exits the property near the southwest corner of the subject site.

PROPOSED CONDITION

The proposed site development will include 4 new single residential buildings and 2 AC paved driveways with a small portion being pervious. The four parcels will each contain one of the four buildings. This will introduce new impermeable building footprints of 3,750, 3,375, 3,375, and

3,750 sq. ft totaling to 14,250 sq. ft. of impermeable area occupied by building. The two larger footprints will be located on parcels 1 and 2 and the smaller footprints on the parcels 3 and 4. The two driveways, located along the north boundary (for parcels 2 and 3) and south boundary (for parcels 1 and 4) of the property, are 8,579 and 11,897 sq. ft., respectively. They total 20,476 sq. ft. of proposed impermeable AC paving area. Additionaly, 444 sq. ft. of pervious paving will be used on the north driveway. The development will also feature individual biofiltration with partial retention systems (parcels1 and 2) and biofiltration systems (parcels 3 and 4) due to the storm water requirements. These will be sized per a separate storm water quality management plan.

The proposed driveway entrance for lots 2 and 3 will be located just north of the entrance point of the swale and so this proposed paving will not impede or obstruct the drainage swale. At the time of the Birch Ave widening project, a 36" culvert, headwall and rip rap have been constructed and installed (see point 1D of the *Exhibit 'A')*.

The proposed driveway entrance for lots 1 and 4 will need to traverse the existing swale. Because of this, a 48" diameter culvert is proposed near the south end of the existing swale (see point 1E of the *Exhibit 'A'* , sheet 2), and will be sized so that there is little to no net effect on the drainage pattern and minimal increase to discharge.

DRAINAGE PATTERN AND CONDITIONS
(Please refer to *Exhibit 'A': Hydrology Study Map* for drainage patterns)

The soils type consists of type C. The figures were based on the *County of San Diego Hydrology Manual*, dated June 2003 (see page 16). The offsite tributary area, which lies to the north of the property, was determined to be type C.

The existing drainage pattern sheet flows from northeast to southwest. The drainage study focuses on the longest path of travel which will enter from the northwest portion of the property at point 1D The tributary area includes a large portion north of the property. Sheet flow will accumulate from northwest of the property. The flow rate at point 1E signifies the total flow rate for the entirety of the tributary area. The tributary area is approximately 35.3 acres.

The drainage flows from point 1A towards Birch Avenue at point 1C. The curb and gutter from Birch Avenue, point 1C, will channel all the runoff before the intersection at Bear Valley Parkway into a concrete spillway located approximately 175 ft east of the intersection at point 1D. At this point the runoff enters the property into an existing natural swale and drains southerly/southwesterly off the property at point 1E.

The sheet flow entering from the east side of the property, see area A3 of the *Exhinbit 'A'*, will also flow into this swale and exit southwest of the property at point 1E. The proposed development will not alter this existing drainage pattern.

Mitigating the extra post $Q_{100}$, see Table 1 below, will be done by the ponding designed into the proposed BMPs. Post $Q_{100}$ will be determined with the overall area. Afterwards, an assessment of the individual tributary areas draining into the BMPs will be calculated (see *Figures A-D*). Summary Table 2 below shows the pre-developed $Q_{100}$, post-developed $Q_{100}$ unmitigated and the post-developed $Q_{100}$ mitigated scenarios.

$Q_{100}$ RESULTS

***Table 1: Pre and Post Development $Q_{100}$***

| At Point 1E | Tributary Area (A) | Weighted Runoff Coefficient (C) | Intensity (I) | $Q_{100}$ | $T_c$ |
|---|---|---|---|---|---|
| Pre- (page 9) | 35.3 AC | 0.385 | 3.7 | 50.3 CFS | 19.1 min |
| Post- (page 10) | 35.3 AC | 0.393 | 3.7 | 51.3 CFS | 19.1 min |

***Table 2: Mitigated $Q_{100}$ as a result of BMPs (see Figures A-D)***

| | Pre-development | Post-development | Post-development, Mitigated by BMP | | | |
|---|---|---|---|---|---|---|
| | | | BMP1 | BMP2 | BMP3 | BMP4 |
| $Q_{100}$ | 50.3 CFS | 51.3 CFS | 0.60 CFS | 0.44 CFS | 0.41 CFS | 0.41 CFS |
| | | | Total Mitigated: 1.86 CFS | | | |

HEC-RAS ANALYSIS: 100-YEAR FLOOD LIMIT OF INUNDATION STUDY

The program *HEC-RAS 4.1.0* (Hydrologic Engineering Centers River Analysis System), issued by the US Army Corps of Engineers, is used to model the channel flow between points 1D and 1E. HEC-RAS is a computer program for modeling water flowing through systems of open swales and computing water surface profiles and cross sections. Some of the additional uses are: bridge and culvert design and analysis, levee studies, and channel modification studies. It can be used for dam breach analysis, though other modeling methods are presently more widely accepted for this purpose.

The program allows for input of topography and flow rate which will help design the culvert exiting the property (see point 1E). The HEC-RAS program models the channel by sampling the elevations at seven stations along the channel. Each station would consist a minimum of seven sampled elevations. Of the minimum seven points, two points will define the left and right bank elevations and one point will define the lowest channel elevation. The channel is modeled as a normal, clean, straight, full, no rifts or deep pools, but with stones and weeds. Therefore a Manning's value of 0.035 will be used throughout the channel as suggested by the HEC-RAS program.

The proposed driveway is modeled by inputting various elevations at the perspective stations. The culvert is modeled as a corrugated metal pipe with headwall. The entrance loss coefficient is 0.7 and exit loss coefficient is 1. The Manning's value for top and bottom of pipe is 0.024 as suggested by HEC-RAS program. The flow rates are entered at the perspective points along the channel, 32 CFS (see page 8, $Q_{100}$ at point 1D, node 2) at the beginning of the channel and 51 CFS (see page 10, $Q_{100}$ at point 1E, node 3 post) at the entrance of the culvert. HEC-RAS can then model the 100 year flood limits of inundation. The culvert size will be 48" to prevent flooding of the roadway.

The calculated inundation limits will be plotted onto the TPM and preliminary grading plans so that the design of the pads and elevations will be such that no issues arise for future flooding and structural failures due to the 100-yr storm event. (See pages 20 through 30). Also, see *Exhibit 'B'* for the inundation limit lines plot.

## CONCLUSION

The estimated 100-year storm runoff will increase by 1.0 CFS, from 50.3 CFS (page 9) to 51.3 CFS (page 10), due to the proposed development. This is a 2.0% increase in runoff and is considered an insignificant increase. A total of 1.86 CFS will be mitigated due to the inclusion of the BMPs. Each of the BMPs will have overflow estimates greater than the post-development time of concentration. This overall CFS increase difference will be dissipated at point 1E by the inclusion of a rip rap energy dissipater (to be designed in final grading design).

Per the HEC-RAS printouts (pages 20 to 30) the plotted inundation lines will not cause a breach of the proposed driveway for parcels 1 and 4, will not reach the elevation of the designed pad for Parcel 1 or 2, and will be completed conveyed by the existing natural swale. Parcels 3 and 4 are not near the swale and at higher elevations and as such will not experience any inundation due to the proposed development.

The HEC-RAS water profile (see page 19) shows that the road will not be breached and that the proposed culvert can sufficiently carry the flow without obstruction. Please refer to the steady flow analysis printouts, pages 31-34.

## REFERENCES

1. 2003 San Diego County Hydrology Manual.
Department of Public Works, Flood Control Section. June.

2. 2006 Hydraflow Express Version 1.0.0.1
Program Released By Intelisolve

3. 2010 HEC-RAS 4.1.0, River Analysis System
Program Released By US Army Corps of Engineers

DECLARATION OF RESPONSIBLE CHARGE

I HEREBY DECLARE THAT I AM THE ENGINEER OF WORK FOR THIS PROJECT, THAT I HAVE EXERCISED RESPONSIBLE CHARGE OVER THE DESIGN OF THE PROJECT AS DEFINED IN SECTION 6703 OF THE BUSINESS AND PROFESSIONS CODE, AND THAT THE DESIGN IS CONSISTENT WITH CURRENT STANDARDS.

I UNDERSTAND THAT THE CHECK OF PROJECT DRAWINGS AND SPECIFICATIONS BY THE COUNTY OF SAN DIEGO IS CONFINED TO A REVIEW ONLY AND DOES NOT RELIEVE ME, AS ENGINEER OF WORK, OF MY RESPONSIBILITIES FOR PROJECT DESIGN.


ENGINEER OF WORK

12/1/2016

WILLIAM YEN, RCE 33730 DATE

**100-Year Runoff Estimate**
Soils Group: C (see ***Soil Hydrologic Groups*** on page 16)
For all point references, see ***Hydrology Study Map*** on Exhibit A

100 year 6-hour rainfall isopluvial: 3.3 inches (page 17)
100 year 24-hour rainfall isopluvial: 6.7 inches (page18)
Use P6 3.3 inches

***PRE-CONSTRUCTION:***

Soils Type is C

| NRCS Elements | County Elements | Runoff Coefficients "C" |
|---|---|---|
| Undisturbed Natural Terrain | Permanent Open Space | 0.30 (area A4) |
| Low Density Residential | Residential, 1.0 DU/A or less | 0.36 (area A3) |
| Low Density Residential | Residential, 2.0 DU/A or less | 0.42 (areas A1 and A2) |

See page 11 for Runoff Coefficient Table

**Area A**
*Point 1A→1B*
The Maximum Overland Flow Length & Initial Time of Concentration is used to determine the initial time of concentration $T_i$ for the watercourse length (see page 13).

$L_{1AB}$ = 70 ft (0.013 mi)
High elevation = 789 ft (point 1A)
Low elevation = 788 ft (point 1B)
$\Delta E$ = 1ft

$T_{1AB}$ = 10.5 minutes (Use 1%, LDR 2, $L_M = L_{1AB}$)

*Point 1B→1C*
From point 1B to point 1C, the remainder time $T_{1BC}$ can be determined with the Kirpich Formula. (see page 14)

$L_{1BC}$ = 1,067 ft (0.20 mi)
High elevation = 788 ft (point 1B)
Low elevation = 716 ft (point 1C)
$\Delta E$ = 72ft

$T_{1BC} = (11.9\ L_{1BC}^3 / \Delta E)^{0.385}$
$= (11.9 \times (0.20\ mi)^3 / 72\ ft)^{0.385}$
= 0.078 hr
= 4.7 min

Total time Tt = $T_{1AB} + T_{1BC}$ = 10.5min + 4.7 min = 15.2 min

*Point 1C→1D*
In order to calculate the time from point 1C to 1D we need to model the $Q_{100}$ through the existing road as modeled as a gutter and roadway. The $Q_{100}$ will be determined with area the discharge due to A1 at point 1C. $Q_{100}$ is

determined using the Rational Method as outlined in the San Diego County *Hydrology Manual*. See page 12 for intensity, page 11 for runoff coefficient.

$Q_{100} = C_{pre}$ x I x A
A1 = 12.8 AC
$C_{pre}$ = 0.42
$P_6$ = 3.3 in
Tt = 15.2 min
I = 7.44 x $P_6$ x $Tt^{-0.645}$ = 7.44 x 3.3 in x 15.2 $min^{-0.645}$ = 4.2 in/hr

Therefore, $Q_{100}$ = 0.42 x 4.2 in/hr x 12.8 AC = 22.6 CFS

$Q_{100}$ = 22.6 CFS (Node 1, point 1C)
Tt = 15.2 min

*Use the 'Gutter and Roadway Discharge - Velocity Chart' from the County Manual (see page 15)*
Distance length from C to D ($L_{1CD}$) = 1,000 ft
Elevation at point 1C = 716
Elevation at point 1D = 684.5
% of Street Slope = 3.2%
$Q_{100}$ = 22.6 CFS

$T_{1CD} = L_{1CD} / V$
= 1000 ft/5.85 FPS (see V on page 15)
= 170.9 s
= 2.8 min

Therefore, total time Tt = 15.2 min + $T_{1DE}$ = 15.2 min + 2.8 min = 18.0 min

From the *Velocity Chart*, we see that V = 5.85 FPS. Therefore $T_{1CD}$ = 2.8 min. Total time from point 1A to 1D is 15.2 + 2.8 min =18.0 min.

*Point 1D→1E*
In order to determine the time for the discharge to travel from point 1D to 1E, we need to calculate the $Q_{100}$ going into point 1D due to areas A1 and A2.

$Q_{100} = C_{pre}$ x I x A
A1 + A2 = 12.8 AC + 6.7 AC = 19.5 AC
$C_{pre}$ = 0.42
$P_6$ = 3.3 in
Tt = 18.0 min
I = 7.44 x $P_6$ x $Tt^{-0.645}$ = 7.44 x 3.3 in x 18.0 $min^{-0.645}$ = 3.9 in/hr (see intensity chart sheet 12)

Therefore, $Q_{100}$ = 0.42 x 3.9 in/hr x 19.5 AC = 31.9 CFS

$Q_{100}$ = 31.9 CFS (Node 2, point 1D)
Tt = 18.0 min

According to HEC-RAS analysis (see page 32, Station 500) the greatest velocity discovered along the existing drainage swale is 5.78 ft/sec. Use this result for the greatest intensity outcome.

To obtain the final time of concentration, and therefore the final intensity, we take the distance of travel, $L_{1DE}$ = 371 ft, and divide it by the velocity.

$T_{1DE} = L_{1DE} / v$
$= 371$ ft/5.8 FPS
$= 64.0$ s
$= 1.1$ min

Therefore, total time Tt = 18.0 min + $T_{1DE}$ = 18.0 min + 1.1 min = 19.1 min

*Total $Q_{100}$ at point 1E*
$Q_{100}$ is determined using the Rational Method as outlined in the San Diego County *Hydrology Manual*. See page 12 for intensity, page 11 for runoff coefficient.

Because there are different urban densities that are included within the defined tributary area, we need to weight the $C_{pre}$ overall in order to find the $Q_{100}$.

$C_{pre} = (A1*0.42)/A + (A2*0.42)/A + (A3*0.36)/A + (A4*0.30)/A$
$= (12.8\ AC*0.42)/35.3\ AC + (6.7\ AC*0.42)/35.3\ AC + (11.2\ AC*0.36)/35.3\ AC + (4.6\ AC*0.30)/35.3\ AC$
$= 0.385$
$Q_{100} = C_{pre}$ x I x A
Area A = 35.3 AC
$P_6 = 3.3$ in
Tt = 19.1 min
$I = 7.44 \times P_6 \times Tt^{-0.645} = 7.44 \times 3.3$ in x 19.1 $min^{-0.645} = 3.7$ in/hr

Therefore, $Q_{100} = 0.385 \times 3.7$ in/hr x 35.3 AC = 50.3 CFS

**$Q_{100}$ = 50.3 CFS (Node 3, point 1E)**
**Tt = 19.1 min**

***POST-CONSTRUCTION:***

The analysis for the post construction drainage will remain the same up to point 1D. The final time of concentration will therefore be affected by the inclusion of the 4 parcel development for the subject proporty and will be reflected as a different runoff coefficient for area A4. It's density indicator will be 1 DU/AC and the runoff coefficient will be 0.36. See chart below.

Soils Type is C

| NRCS Elements | County Elements | Runoff Coefficients "C" |
|---|---|---|
| Low Density Residential | Residential, 1.0 DU/A or less | 0.36 (areas A3 and A4) |
| Low Density Residential | Residential, 2.0 DU/A or less | 0.42 (areas A1 and A2) |

See page 11 for Runoff Coefficient Table

*Total $Q_{100}$ at point 1E*
$Q_{100}$ is determined using the Rational Method as outlined in the San Diego County *Hydrology Manual*. See page 12 for intensity.

As in the pre-development analysis, we need to weight the $C_{post}$ overall in order to find the $Q_{100}$.

$C_{post} = (A1*0.42)/A + (A2*0.42)/A + (A3*0.36)/A + (A4*0.36)/A$
$= (12.8\ AC*0.42)/35.3\ AC + (6.7\ AC*0.42)/35.3\ AC + (11.2\ AC*0.36)/35.3\ AC + (4.6\ AC*0.36)/35.3\ AC$
$= 0.393$
$Q_{100} = C_{pre}$ x I x A
Area A = 35.3 AC
$P_6 = 3.3$ in

Tt = 19.1 min
$I = 7.44 \times P_6 \times Tt^{-0.645} = 7.44 \times 3.3 \text{ in} \times 19.1 \text{ min}^{-0.645} = 3.7 \text{ in/hr}$

Therefore, $Q_{100} = 0.393 \times 3.7 \text{ in/hr} \times 35.3 \text{ AC} = 51.3 \text{ CFS}$

**$Q_{100}$ = 51.3 CFS (Node 3, point 1E)**
**Tt = 19.1 min**

**BMP Mitigation**

The BMPs will be designed to detain a portion of the peak discharge calculated above. For ponding capacity, see *Figures A-D*. Per *Figures A-D*, the ponding capacity for each BMP will either not overflow or will overflow at a greater time than the post-development time of Tt = 19.1 min. This results in the BMPs detaining portions of the calculated flow of 51.3 CFS for longer periods of time than designed, more particularly 1.86 CFS total per *Figures A-D*.

***HEC-RAS 100 YR FLOOD ANALYSIS:***

*HEC-RAS 4.1.0* (Hydrologic Engineering Centers River Analysis System) was used in order to perform a 100 yr inundation limit within the existing swale (see path 1D to 1E). Inputs needed are the $Q_{100}$ at point 1D, node 2 (see River STA 700, page 30) and $Q_{100}$ at point 1E, node 3 post (see River STA 200, page 25).

To determine the inundation limits, ten cross section analyses were taken and inputted into *HEC-RAS* where a steady flow analysis is performed. From the cross sections on pages 21 to 30, the water surface elevations are extracted. See plotted lines on *Exhibit B*.

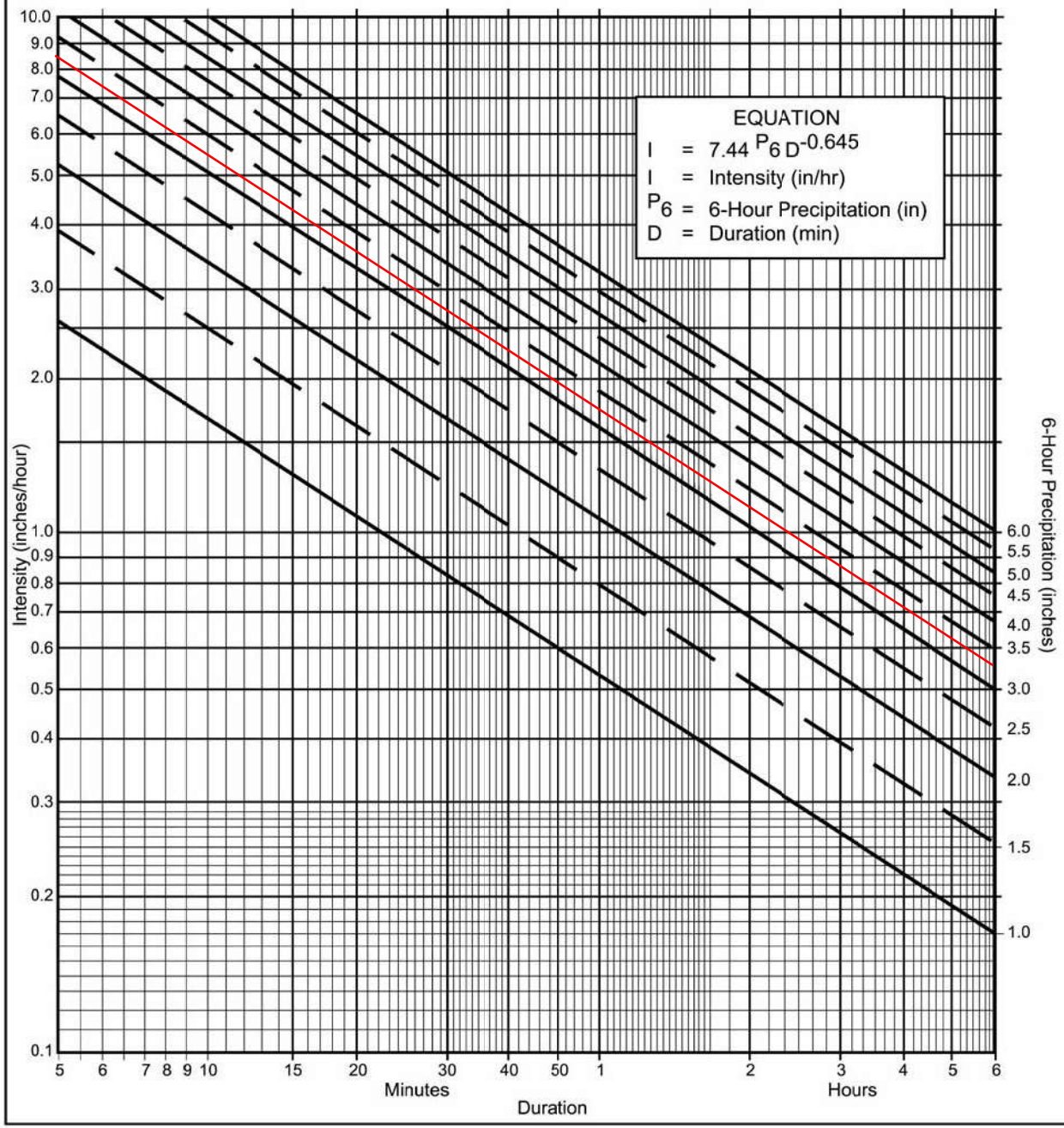
The water profile, see page 19, demonstrates that the existing swale will sufficiently hold the proposed increase in discharge due post-development. Also, pages 31-34 show varying velocities from 1.10 FPS to 5.78 FPS for the different river stations. Averaging the velocities gives us a mean velocity of 3.75 FPS for the length of the swale crossing the subject property. This velocity is considered slow and can be easily dissipated at the outfall of the culvert with a rip rap energy dissipater. This velocity is not considered a potential risk for erosion of the existing swale. Note that the velocity designed coming out of the existing culvert at the northwest end of the property has a value of 5.20 ft/sec which is greater than the mean.

## Table 3-1
## RUNOFF COEFFICIENTS FOR URBAN AREAS

| Land Use | | Runoff Coefficient "C" | | | | |
|---|---|---|---|---|---|---|
| | | | Soil Type | | | |
| NRCS Elements | County Elements | % IMPER. | A | B | C | D |
| Undisturbed Natural Terrain (Natural) | Permanent Open Space | 0* | 0.20 | 0.25 | 0.30 | 0.35 |
| Low Density Residential (LDR) | Residential, 1.0 DU/A or less | 10 | 0.27 | 0.32 | 0.36 | 0.41 |
| Low Density Residential (LDR) | Residential, 2.0 DU/A or less | 20 | 0.34 | 0.38 | 0.42 | 0.46 |
| Low Density Residential (LDR) | Residential, 2.9 DU/A or less | 25 | 0.38 | 0.41 | 0.45 | 0.49 |
| Medium Density Residential (MDR) | Residential, 4.3 DU/A or less | 30 | 0.41 | 0.45 | 0.48 | 0.52 |
| Medium Density Residential (MDR) | Residential, 7.3 DU/A or less | 40 | 0.48 | 0.51 | 0.54 | 0.57 |
| Medium Density Residential (MDR) | Residential, 10.9 DU/A or less | 45 | 0.52 | 0.54 | 0.57 | 0.60 |
| Medium Density Residential (MDR) | Residential, 14.5 DU/A or less | 50 | 0.55 | 0.58 | 0.60 | 0.63 |
| High Density Residential (HDR) | Residential, 24.0 DU/A or less | 65 | 0.66 | 0.67 | 0.69 | 0.71 |
| High Density Residential (HDR) | Residential, 43.0 DU/A or less | 80 | 0.76 | 0.77 | 0.78 | 0.79 |
| Commercial/Industrial (N. Com) | Neighborhood Commercial | 80 | 0.76 | 0.77 | 0.78 | 0.79 |
| Commercial/Industrial (G. Com) | General Commercial | 85 | 0.80 | 0.80 | 0.81 | 0.82 |
| Commercial/Industrial (O.P. Com) | Office Professional/Commercial | 90 | 0.83 | 0.84 | 0.84 | 0.85 |
| Commercial/Industrial (Limited I.) | Limited Industrial | 90 | 0.83 | 0.84 | 0.84 | 0.85 |
| Commercial/Industrial (General I.) | General Industrial | 95 | 0.87 | 0.87 | 0.87 | 0.87 |

*The values associated with 0% impervious may be used for direct calculation of the runoff coefficient as described in Section 3.1.2 (representing the pervious runoff coefficient, Cp, for the soil type), or for areas that will remain undisturbed in perpetuity. Justification must be given that the area will remain natural forever (e.g., the area is located in Cleveland National Forest).
DU/A = dwelling units per acre
NRCS = National Resources Conservation Service

PRE: A1, A2 = 0.42, A3 = 0.36, A4 = 0.30
POST: A1, A2 = 0.42, A3, A4 = 0.36
(SEE ATTACHMENT A FOR AREA BOUNDARIES)




**Directions for Application:**

(1) From precipitation maps determine 6 hr and 24 hr amounts for the selected frequency. These maps are included in the County Hydrology Manual (10, 50, and 100 yr maps included in the Design and Procedure Manual).

(2) Adjust 6 hr precipitation (if necessary) so that it is within the range of 45% to 65% of the 24 hr precipitation (not applicaple to Desert).

(3) Plot 6 hr precipitation on the right side of the chart.

(4) Draw a line through the point parallel to the plotted lines.

(5) This line is the intensity-duration curve for the location being analyzed.

**Application Form:**

(a) Selected frequency 100 year

(b) $P_6$ = 3.3 in., $P_{24}$ = 6.7, $\frac{P_6}{P_{24}}$ = 49.3 %(2)

(c) Adjusted $P_6$(2) = 3.3 in.

(d) $t_x$ = _____ min.

(e) I = _____ in./hr.

PRE, POST SPECIFIC, SEE DRAINAGE CALCULATIONS

Note: This chart replaces the Intensity-Duration-Frequency curves used since 1965.

| P6 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Duration | I | I | I | I | I | I | I | I | I | I | I |
| 5 | 2.63 | 3.95 | 5.27 | 6.59 | 7.90 | 9.22 | 10.54 | 11.86 | 13.17 | 14.49 | 15.81 |
| 7 | 2.12 | 3.18 | 4.24 | 5.30 | 6.36 | 7.42 | 8.48 | 9.54 | 10.60 | 11.66 | 12.72 |
| 10 | 1.68 | 2.53 | 3.37 | 4.21 | 5.05 | 5.90 | 6.74 | 7.58 | 8.42 | 9.27 | 10.11 |
| 15 | 1.30 | 1.95 | 2.59 | 3.24 | 3.89 | 4.54 | 5.19 | 5.84 | 6.49 | 7.13 | 7.78 |
| 20 | 1.08 | 1.62 | 2.15 | 2.69 | 3.23 | 3.77 | 4.31 | 4.85 | 5.39 | 5.93 | 6.46 |
| 25 | 0.93 | 1.40 | 1.87 | 2.33 | 2.80 | 3.27 | 3.73 | 4.20 | 4.67 | 5.13 | 5.60 |
| 30 | 0.83 | 1.24 | 1.66 | 2.07 | 2.49 | 2.90 | 3.32 | 3.73 | 4.15 | 4.56 | 4.98 |
| 40 | 0.69 | 1.03 | 1.38 | 1.72 | 2.07 | 2.41 | 2.76 | 3.10 | 3.45 | 3.79 | 4.13 |
| 50 | 0.60 | 0.90 | 1.19 | 1.49 | 1.79 | 2.09 | 2.39 | 2.69 | 2.98 | 3.28 | 3.58 |
| 60 | 0.53 | 0.80 | 1.06 | 1.33 | 1.59 | 1.86 | 2.12 | 2.39 | 2.65 | 2.92 | 3.18 |
| 90 | 0.41 | 0.61 | 0.82 | 1.02 | 1.23 | 1.43 | 1.63 | 1.84 | 2.04 | 2.25 | 2.45 |
| 120 | 0.34 | 0.51 | 0.68 | 0.85 | 1.02 | 1.19 | 1.36 | 1.53 | 1.70 | 1.87 | 2.04 |
| 150 | 0.29 | 0.44 | 0.59 | 0.73 | 0.88 | 1.03 | 1.18 | 1.32 | 1.47 | 1.62 | 1.76 |
| 180 | 0.26 | 0.39 | 0.52 | 0.65 | 0.78 | 0.91 | 1.04 | 1.18 | 1.31 | 1.44 | 1.57 |
| 240 | 0.22 | 0.33 | 0.43 | 0.54 | 0.65 | 0.76 | 0.87 | 0.98 | 1.08 | 1.19 | 1.30 |
| 300 | 0.19 | 0.28 | 0.38 | 0.47 | 0.56 | 0.66 | 0.75 | 0.85 | 0.94 | 1.03 | 1.13 |
| 360 | 0.17 | 0.25 | 0.33 | 0.42 | 0.50 | 0.58 | 0.67 | 0.75 | 0.84 | 0.92 | 1.00 |

**Intensity-Duration Design Chart - Template**

FIGURE 3-1

Note that the Initial Time of Concentration should be reflective of the general land-use at the upstream end of a drainage basin. A single lot with an area of two or less acres does not have a significant effect where the drainage basin area is 20 to 600 acres.

Table 3-2 provides limits of the length (Maximum Length ($L_M$)) of sheet flow to be used in hydrology studies. Initial $T_i$ values based on average C values for the Land Use Element are also included. These values can be used in planning and design applications as described below. Exceptions may be approved by the "Regulating Agency" when submitted with a detailed study.

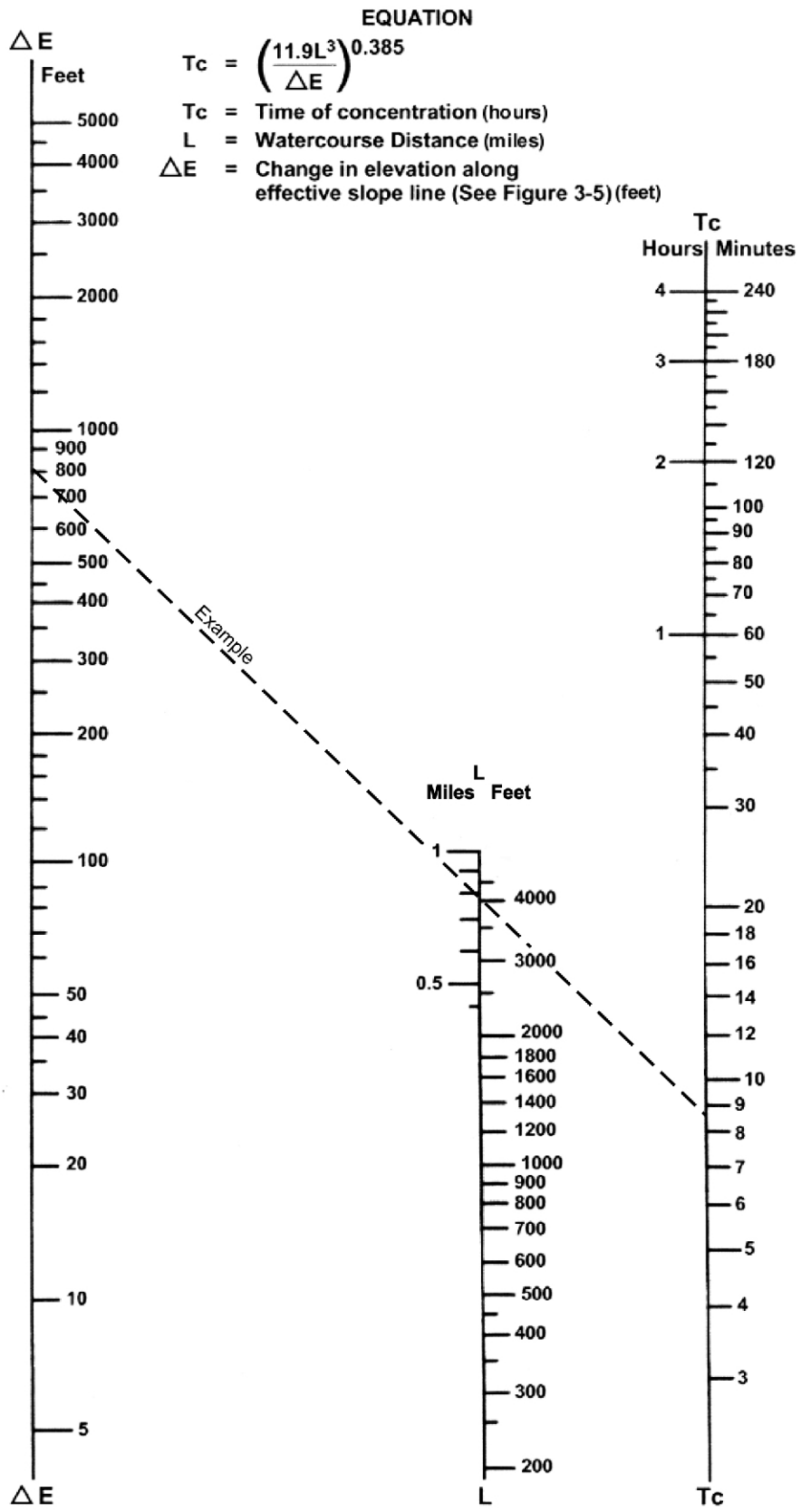
POINT 1A TO 1B (PRE AND POST)

**Table 3-2**

**MAXIMUM OVERLAND FLOW LENGTH ($L_M$)**
**& INITIAL TIME OF CONCENTRATION ($T_i$)**

| Element* | DU/ Acre | .5% | | 1% | | 2% | | 3% | | 5% | | 10% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $L_M$ | $T_i$ | $L_M$ | $T_i$ | $L_M$ | $T_i$ | $L_M$ | $T_i$ | $L_M$ | $T_i$ | $L_M$ | $T_i$ |
| Natural | | 50 | 13.2 | 70 | 12.5 | 85 | 10.9 | 100 | 10.3 | 100 | 8.7 | 100 | 6.9 |
| LDR | 1 | 50 | 12.2 | 70 | 11.5 | 85 | 10.0 | 100 | 9.5 | 100 | 8.0 | 100 | 6.4 |
| LDR | 2 | 50 | 11.3 | 70 | 10.5 | 85 | 9.2 | 100 | 8.8 | 100 | 7.4 | 100 | 5.8 |
| LDR | 2.9 | 50 | 10.7 | 70 | 10.0 | 85 | 8.8 | 95 | 8.1 | 100 | 7.0 | 100 | 5.6 |
| MDR | 4.3 | 50 | 10.2 | 70 | 9.6 | 80 | 8.1 | 95 | 7.8 | 100 | 6.7 | 100 | 5.3 |
| MDR | 7.3 | 50 | 9.2 | 65 | 8.4 | 80 | 7.4 | 95 | 7.0 | 100 | 6.0 | 100 | 4.8 |
| MDR | 10.9 | 50 | 8.7 | 65 | 7.9 | 80 | 6.9 | 90 | 6.4 | 100 | 5.7 | 100 | 4.5 |
| MDR | 14.5 | 50 | 8.2 | 65 | 7.4 | 80 | 6.5 | 90 | 6.0 | 100 | 5.4 | 100 | 4.3 |
| HDR | 24 | 50 | 6.7 | 65 | 6.1 | 75 | 5.1 | 90 | 4.9 | 95 | 4.3 | 100 | 3.5 |
| HDR | 43 | 50 | 5.3 | 65 | 4.7 | 75 | 4.0 | 85 | 3.8 | 95 | 3.4 | 100 | 2.7 |
| N. Com | | 50 | 5.3 | 60 | 4.5 | 75 | 4.0 | 85 | 3.8 | 95 | 3.4 | 100 | 2.7 |
| G. Com | | 50 | 4.7 | 60 | 4.1 | 75 | 3.6 | 85 | 3.4 | 90 | 2.9 | 100 | 2.4 |
| O.P./Com | | 50 | 4.2 | 60 | 3.7 | 70 | 3.1 | 80 | 2.9 | 90 | 2.6 | 100 | 2.2 |
| Limited I. | | 50 | 4.2 | 60 | 3.7 | 70 | 3.1 | 80 | 2.9 | 90 | 2.6 | 100 | 2.2 |
| General I. | | 50 | 3.7 | 60 | 3.2 | 70 | 2.7 | 80 | 2.6 | 90 | 2.3 | 100 | 1.9 |

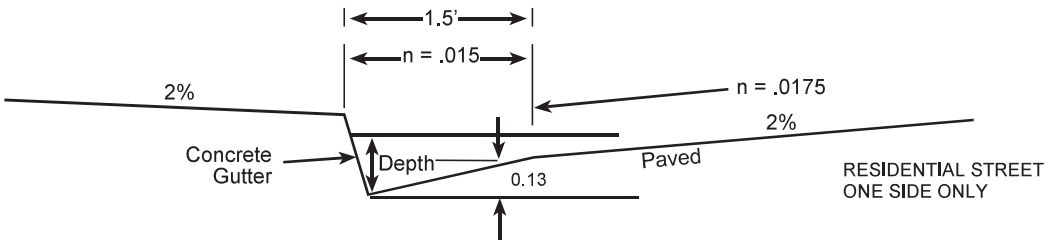
*See Table 3-1 for more detailed description

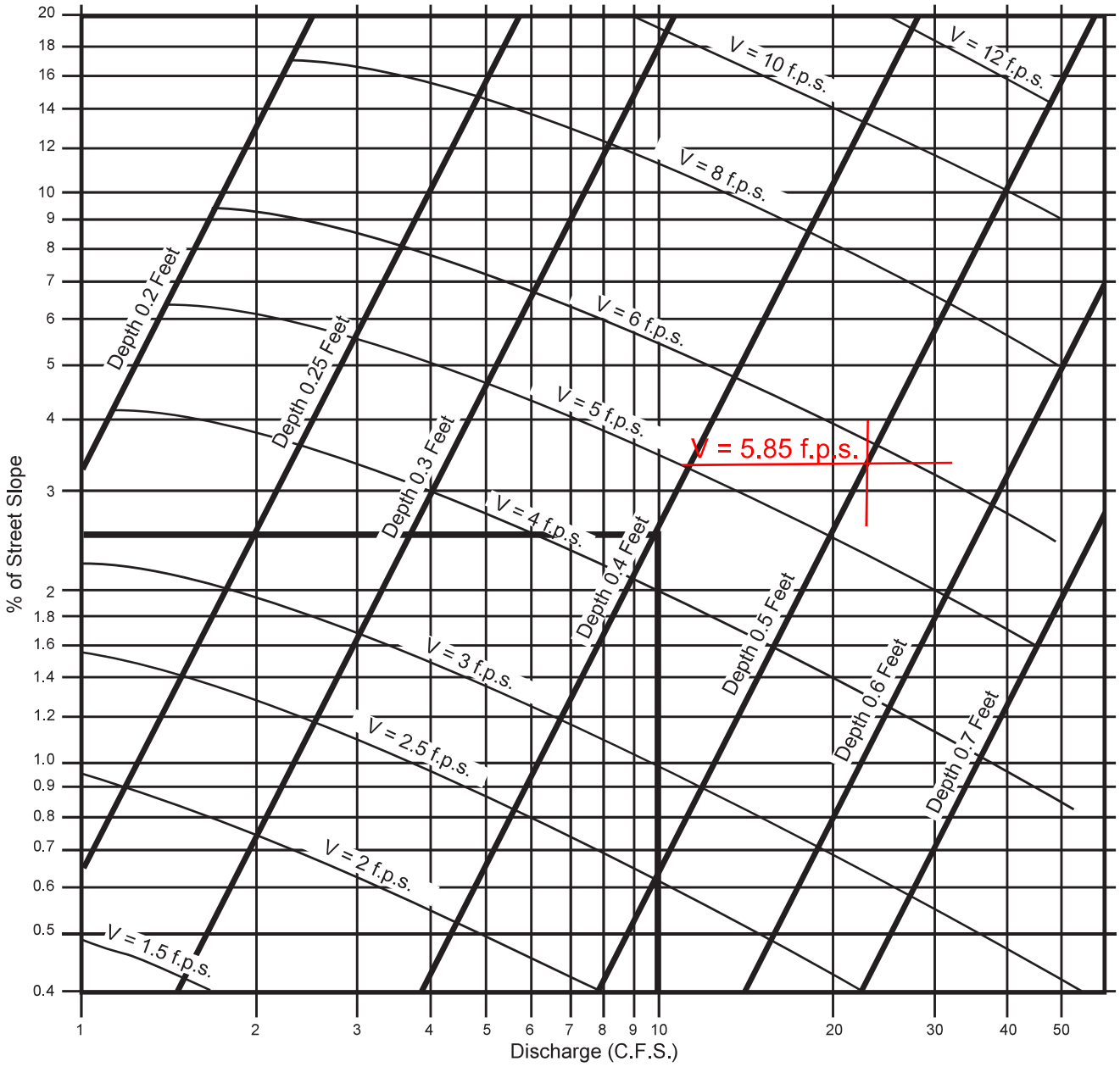



SOURCE: California Division of Highways (1941) and Kirpich (1940)

FIGURE 3-4

Nomograph for Determination of
Time of Concentration (Tc) or Travel Time (Tt) for Natural Watersheds



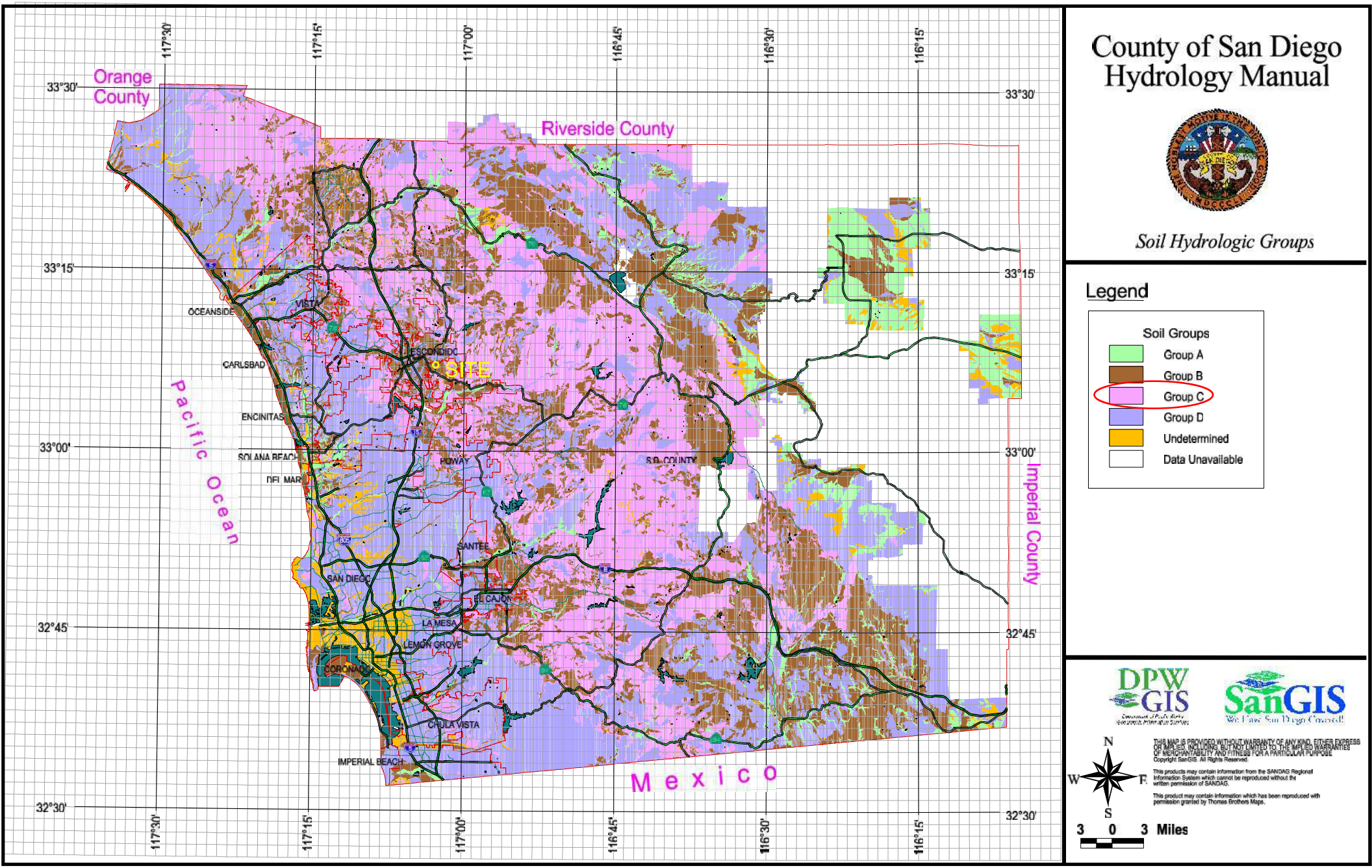



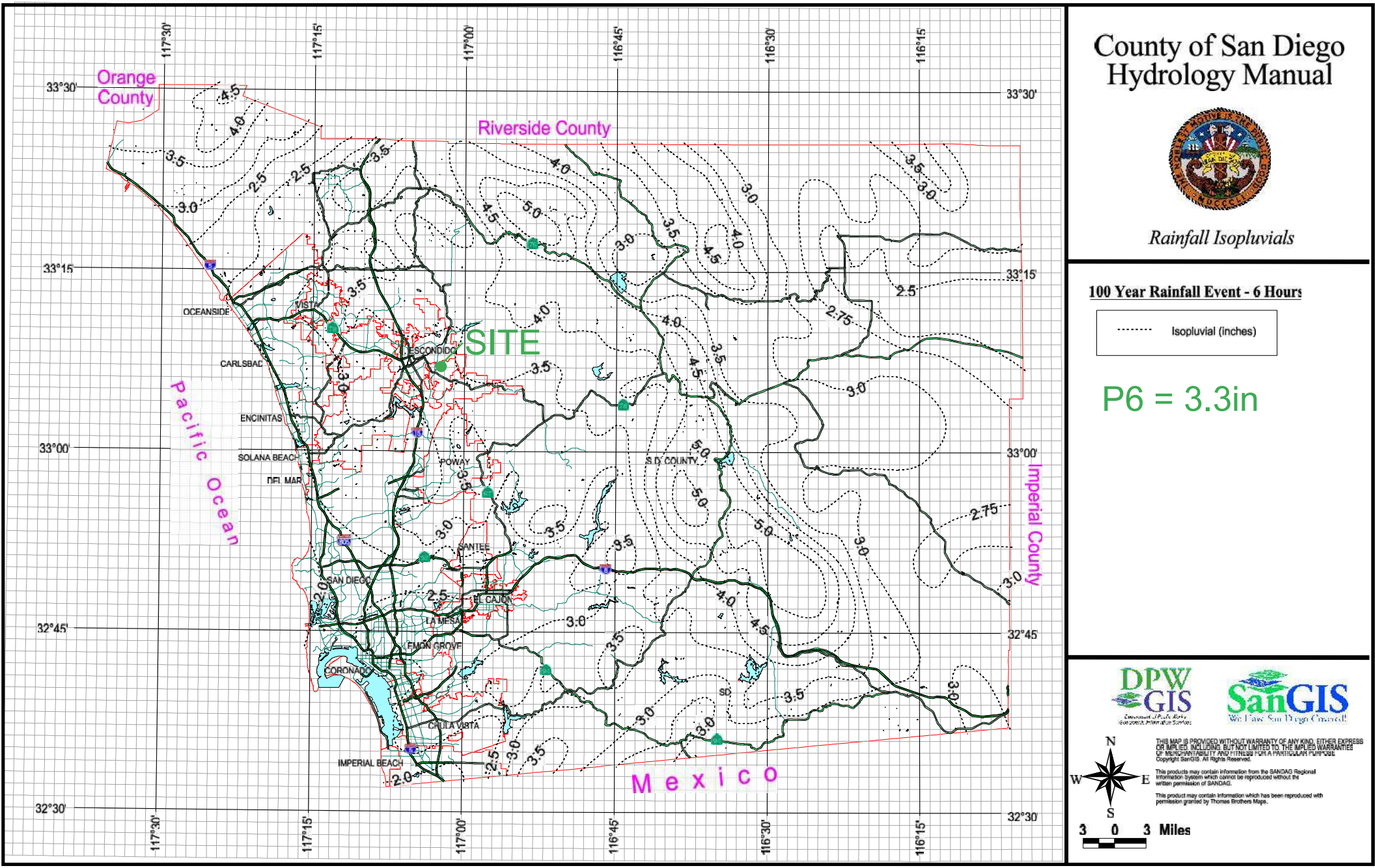

**EXAMPLE:**
**Given: Q = 10 S = 2.5%**
**Chart gives: Depth = 0.4, Velocity = 4.4 f.p.s.**

SOURCE: San Diego County Department of Special District Services Design Manual

**Gutter and Roadway Discharge - Velocity Chart**

FIGURE
**3-6**


County of San Diego
Hydrology Manual
Soil Hydrologic Groups
Legend
Soil Groups
Group A
Group B
Group C
Group D
Undetermined
Data Unavailable
Orange County
Riverside County
Imperial County
Pacific Ocean
Mexico
SITE
OCEANSIDE
CARLSBAD
ESCONDIDO
ENCINITAS
SOLANA BEACH
DEL MAR
POWAY
S.D. COUNTY
SANTEE
SAN DIEGO
EL CAJON
LA MESA
LEMON GROVE
CORONADO
CHULA VISTA
IMPERIAL BEACH
117°30'
117°15'
117°00'
116°45'
116°30'
116°15'
33°30'
33°15'
33°00'
32°45'
32°30'
DPW GIS
SanGIS
N
W
E
S
3 0 3 Miles




# County of San Diego Hydrology Manual

*Rainfall Isopluvials*

**100 Year Rainfall Event - 6 Hours**

Isopluvial (inches)

P6 = 3.3in

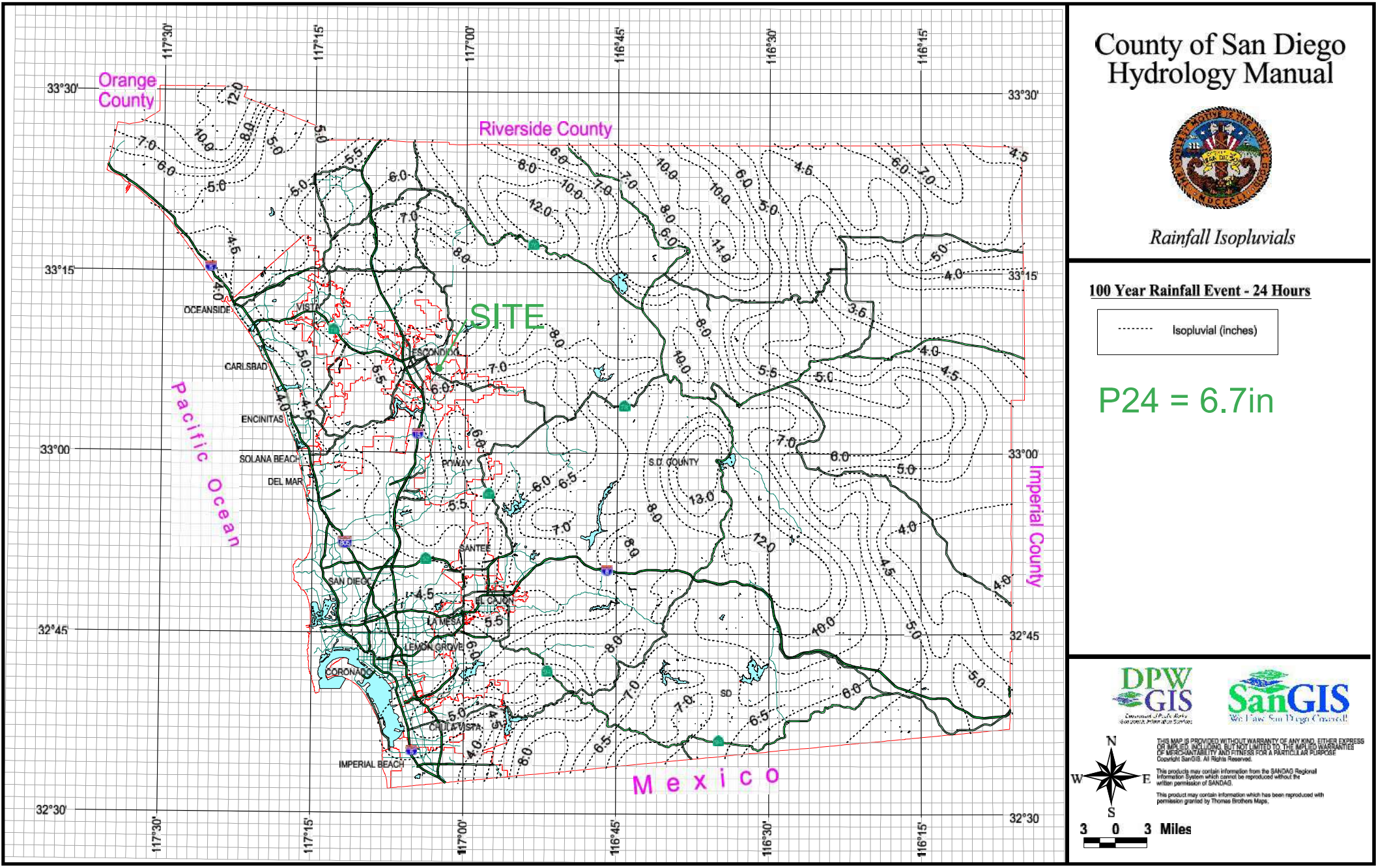
DPW GIS

SanGIS We Have San Diego Covered!

N W E S



3 0 3 Miles




# County of San Diego Hydrology Manual

*Rainfall Isopluvials*

**100 Year Rainfall Event - 24 Hours**

Isopluvial (inches)

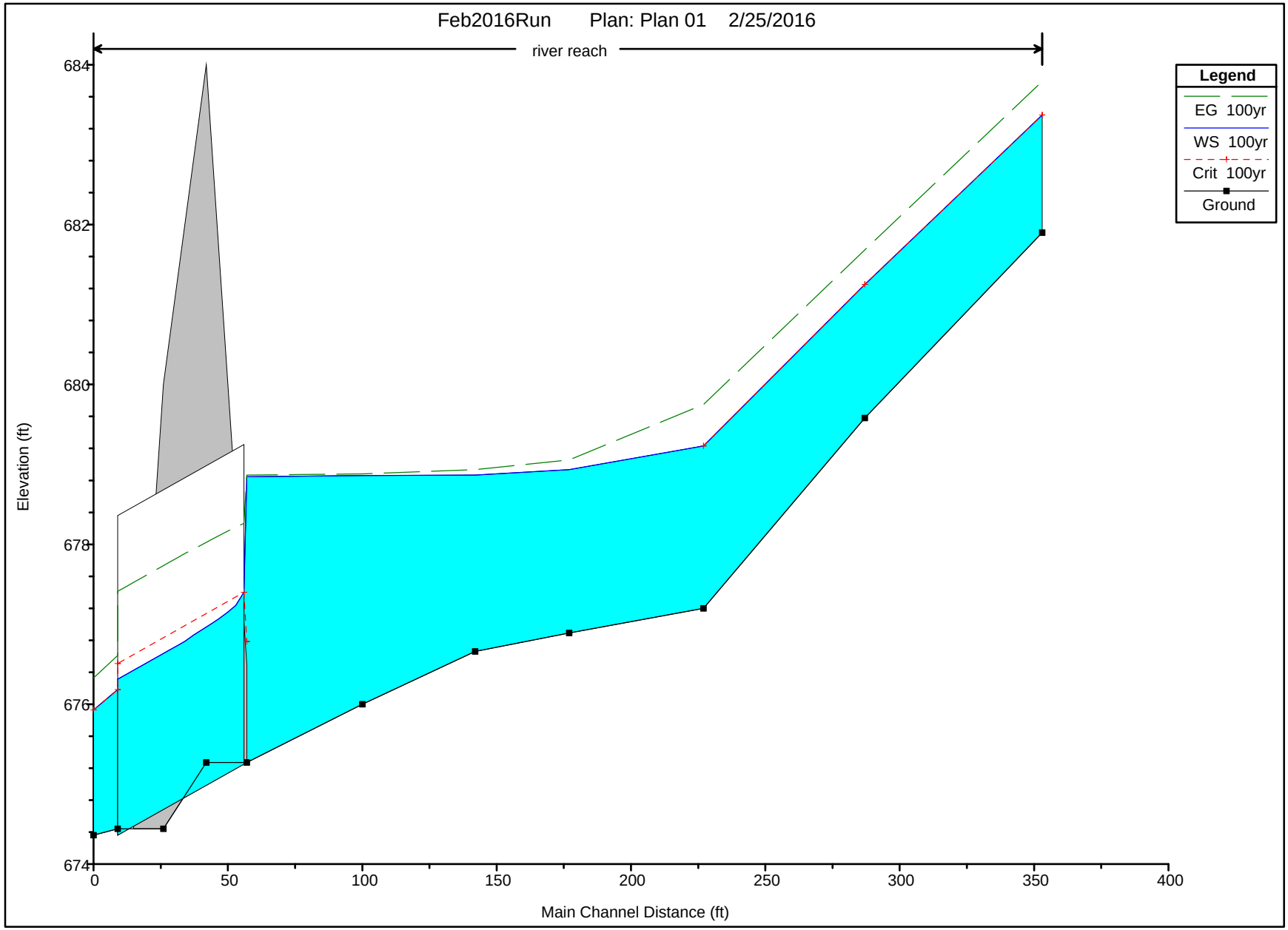
P24 = 6.7in

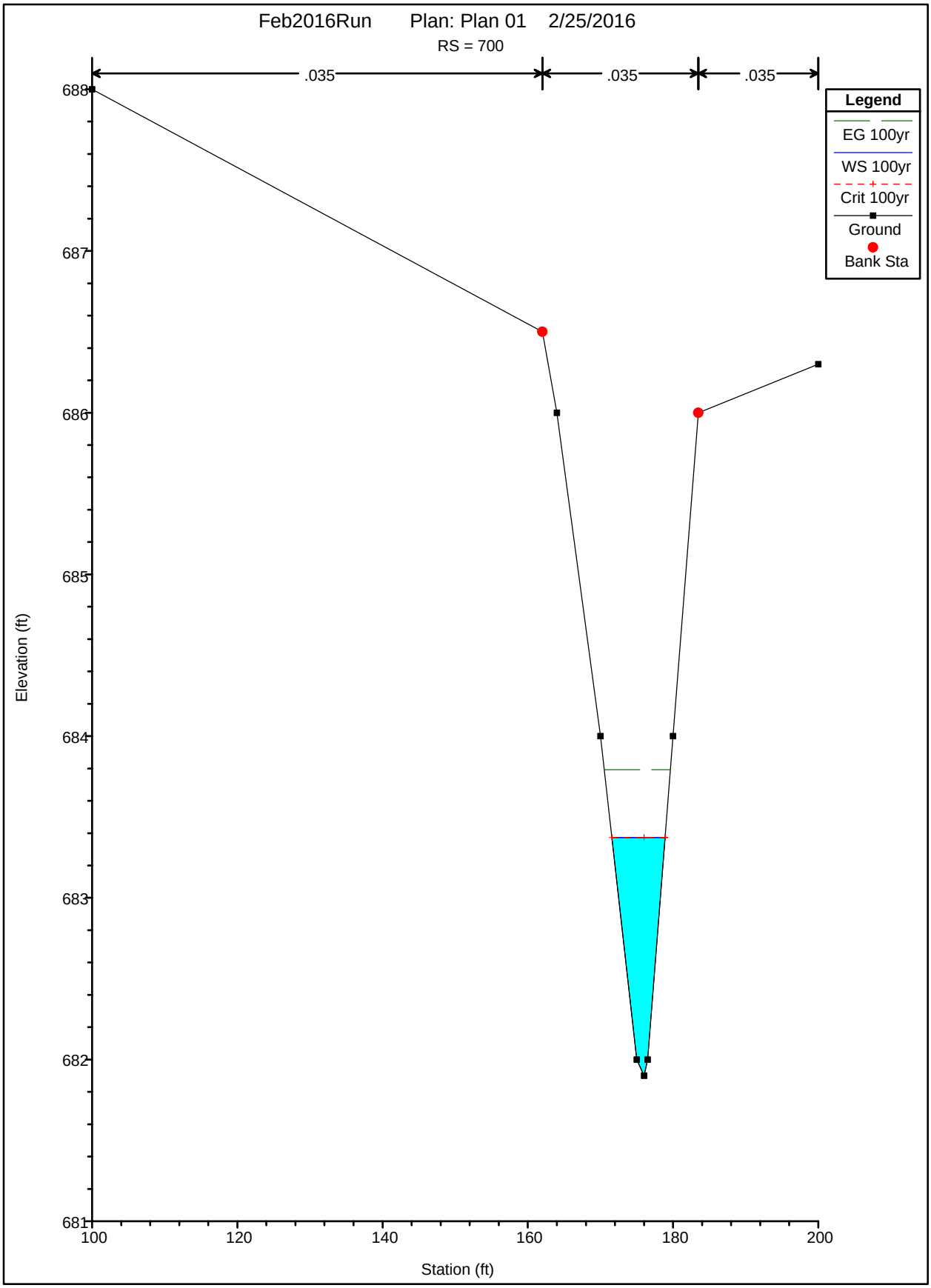
DPW GIS

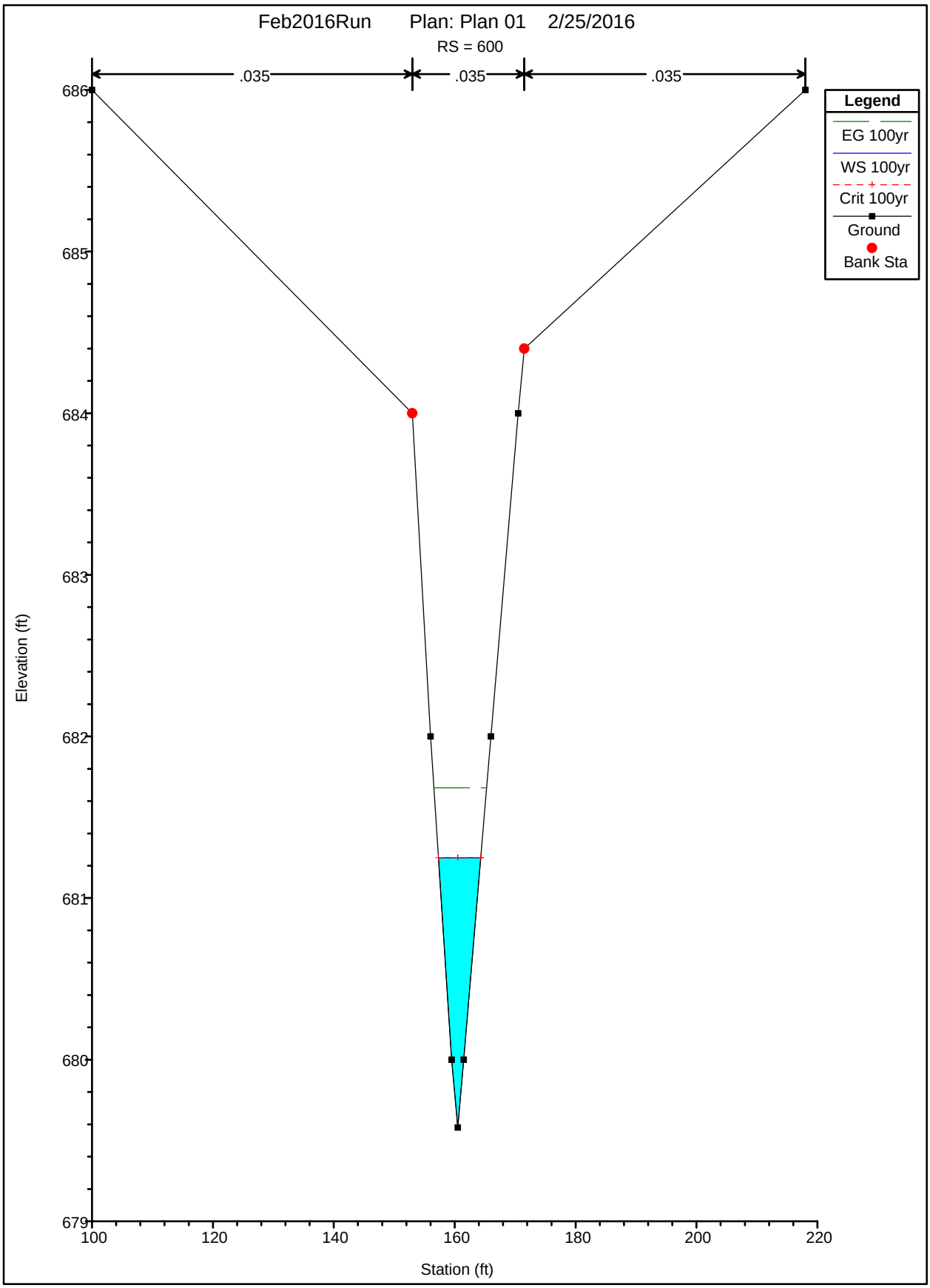
SanGIS

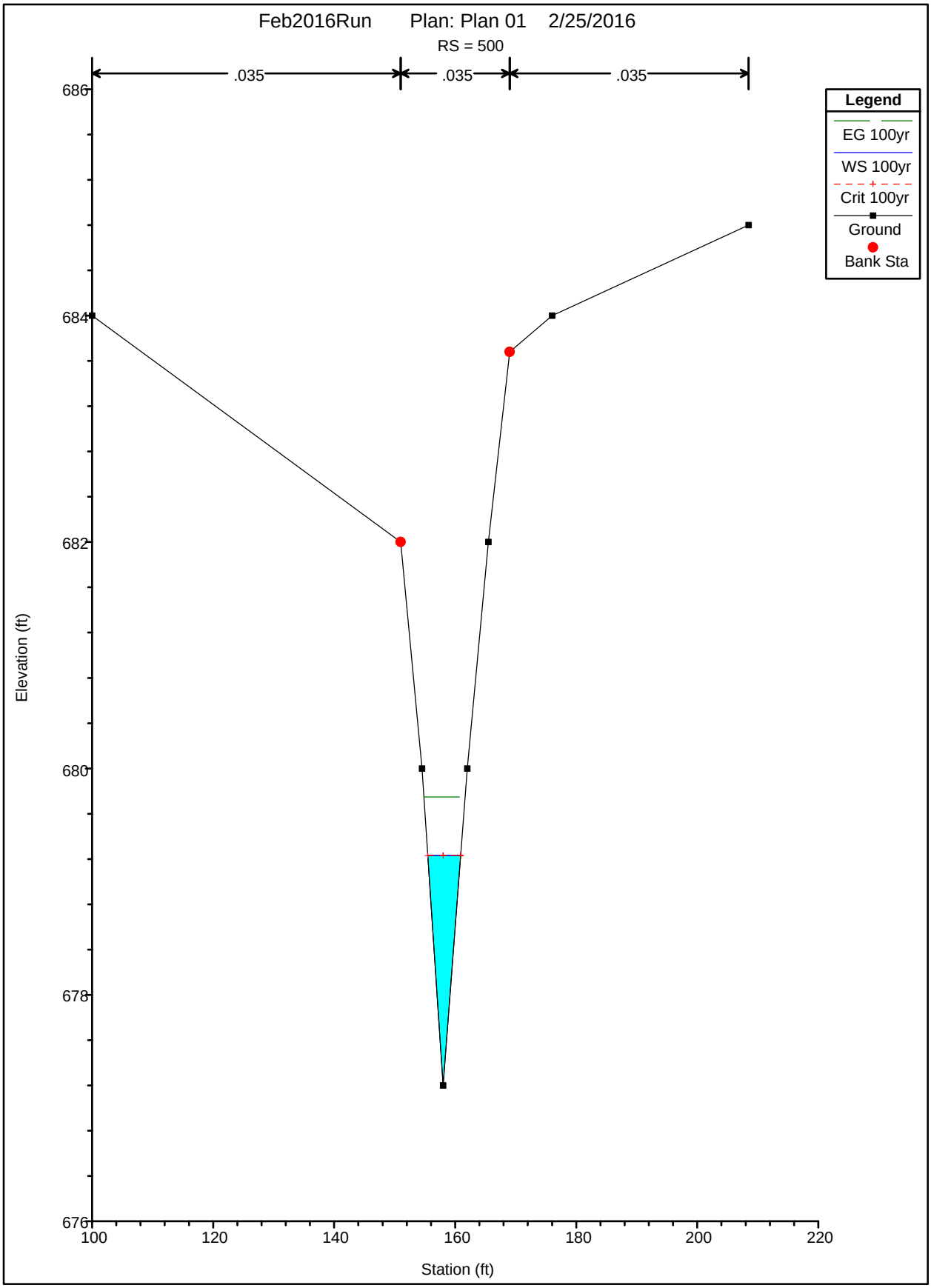
N W E S

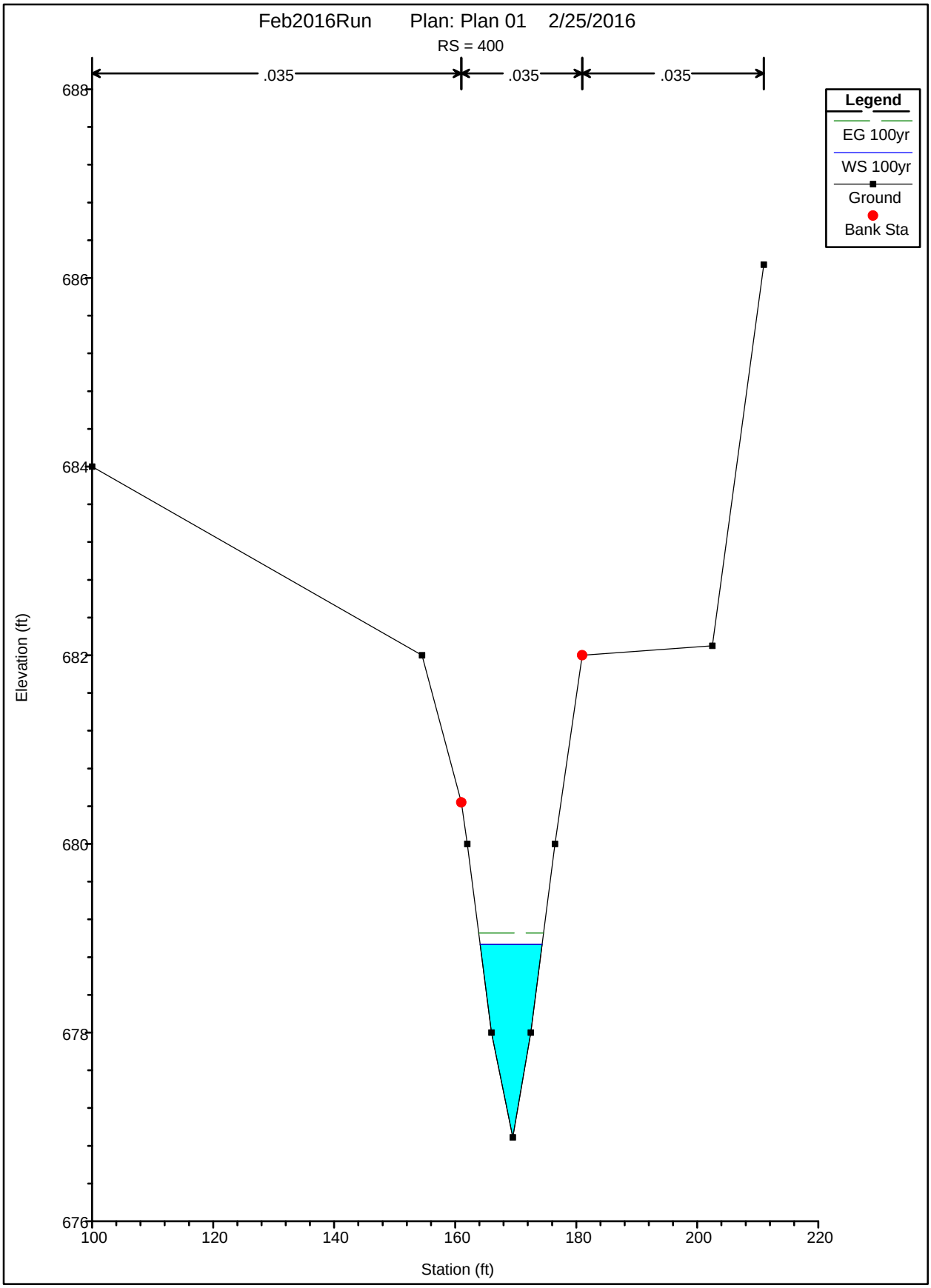
3 0 3 Miles

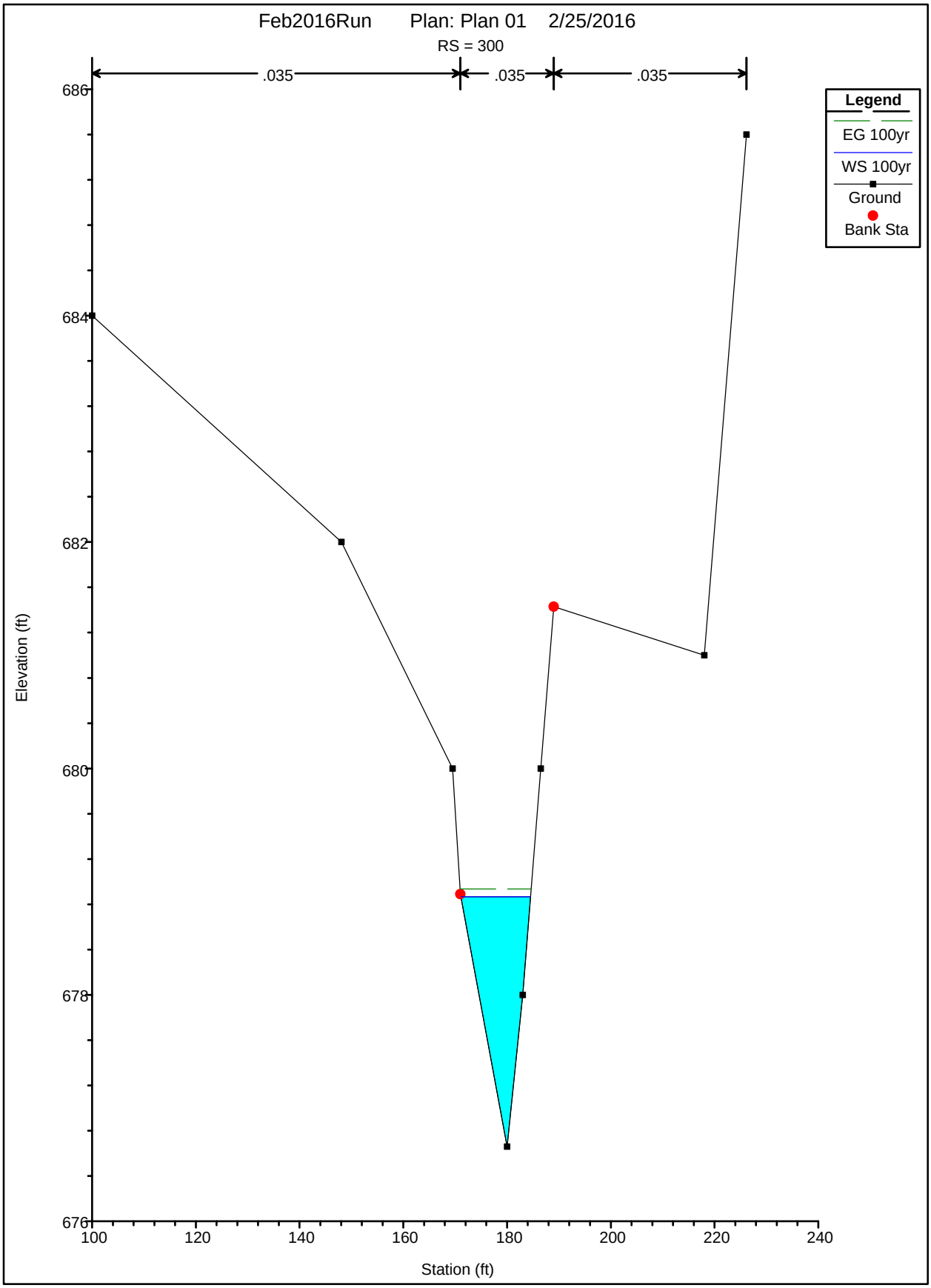

Feb2016Run Plan: Plan 01 2/25/2016
river reach
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Elevation (ft)
684
682
680
678
676
674
0
50
100
150
200
250
300
350
400
Main Channel Distance (ft)

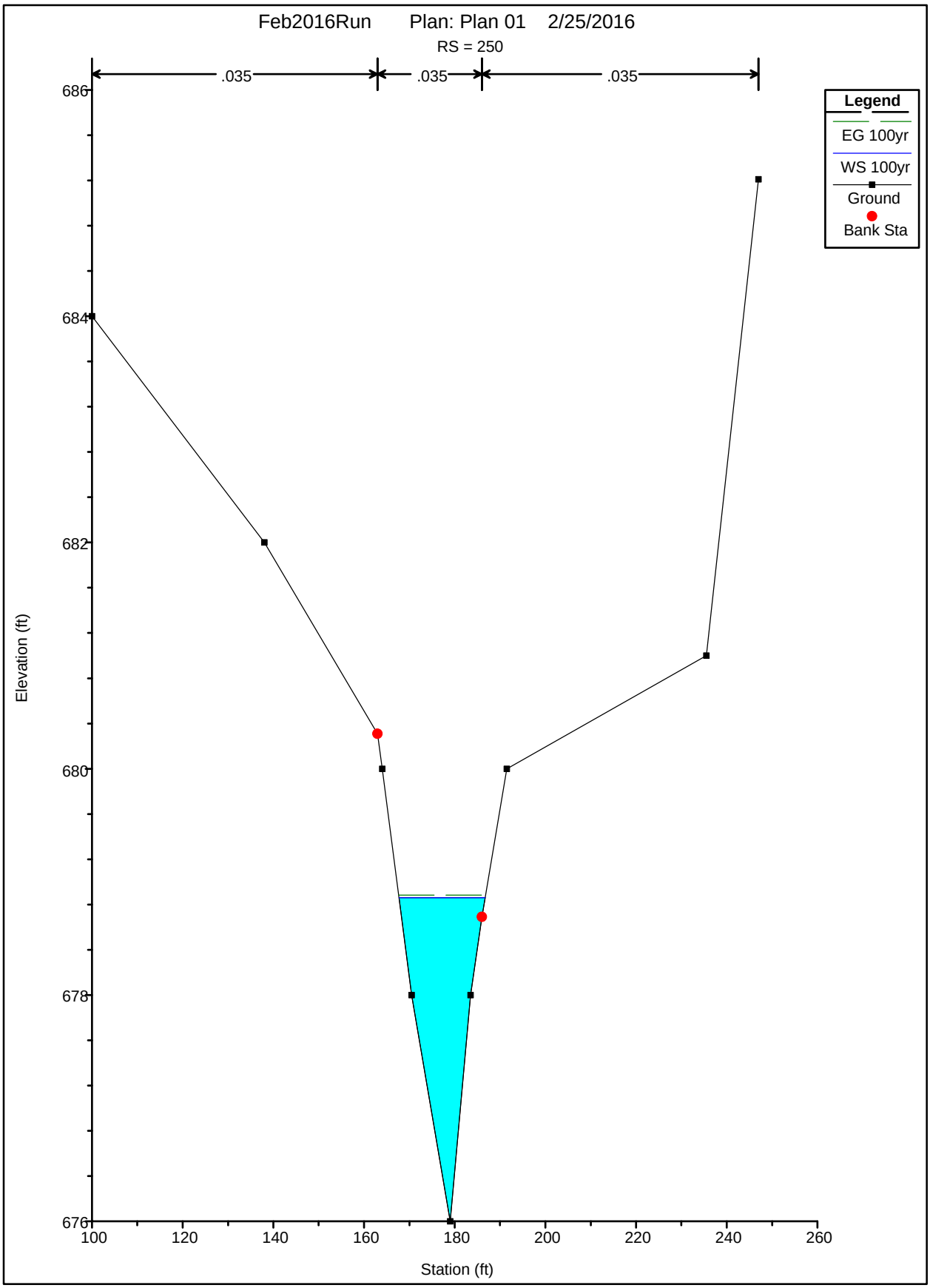

Feb2016Run Plan: Plan 01 2/25/2016
RS = 700
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
688
687
686
685
684
683
682
681
100
120
140
160
180
200
Station (ft)

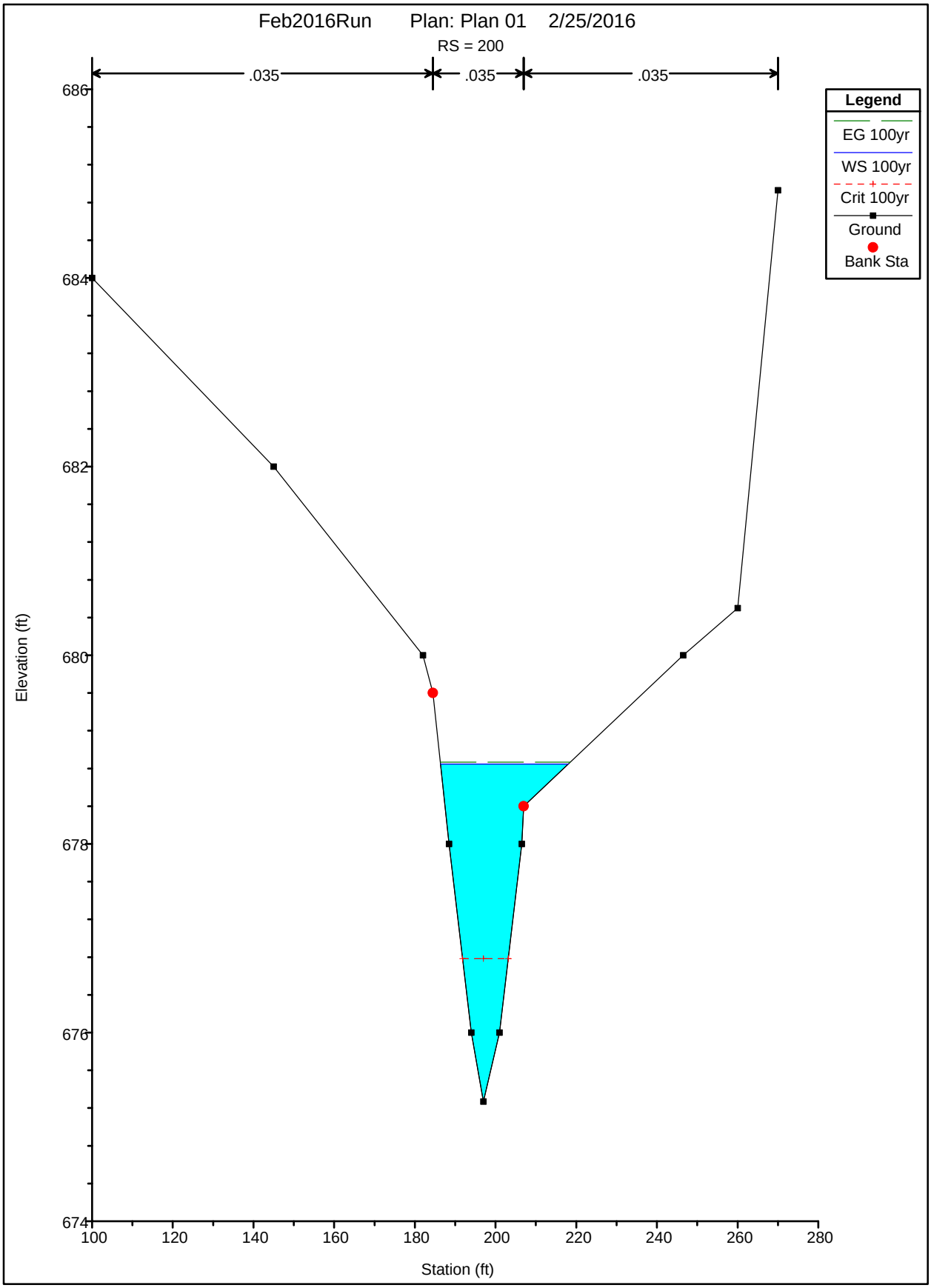

Feb2016Run Plan: Plan 01 2/25/2016
RS = 600
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
686
685
684
683
682
681
680
679
100
120
140
160
180
200
220
Station (ft)

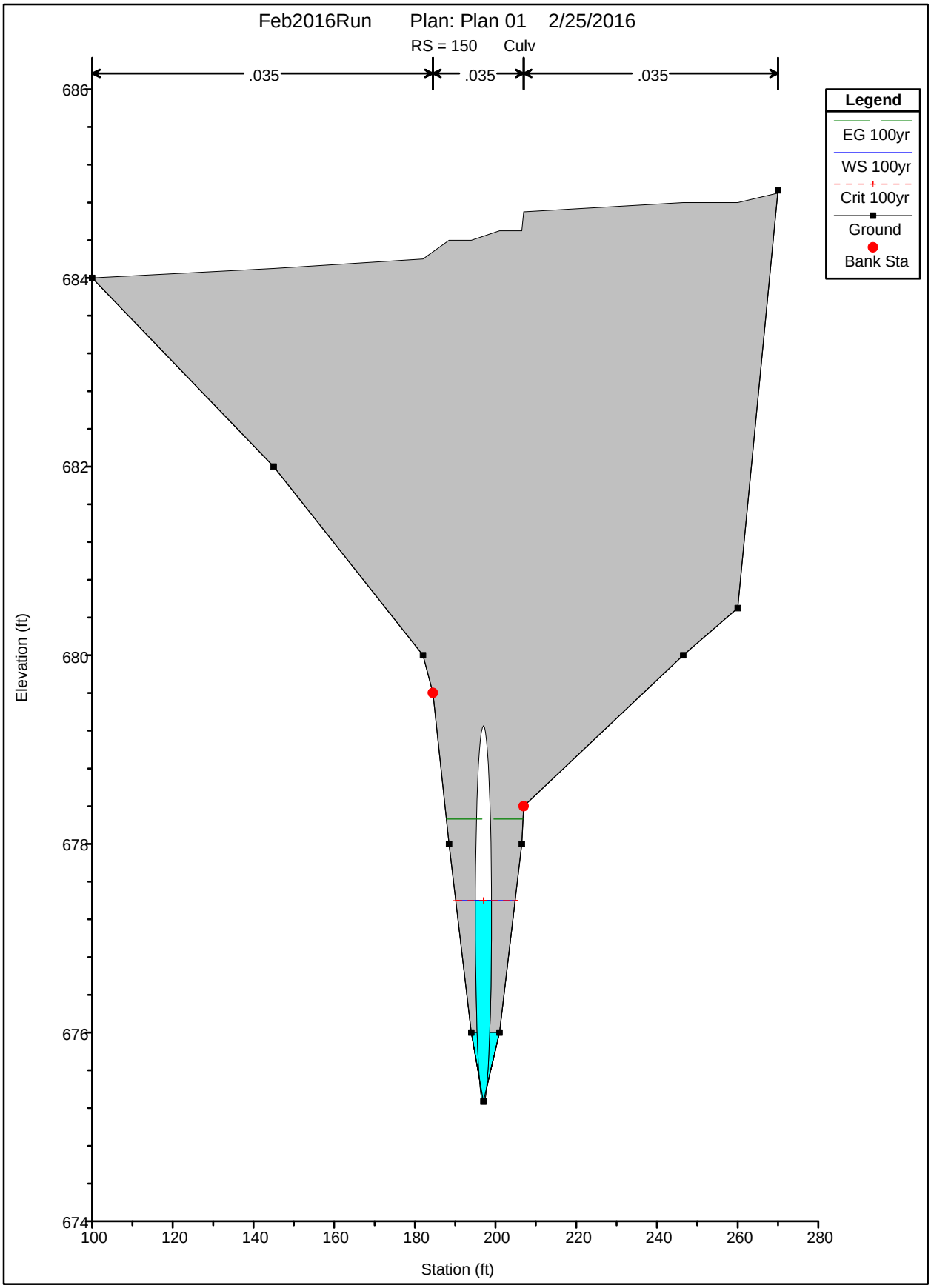

Feb2016Run Plan: Plan 01 2/25/2016
RS = 500
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
686
684
682
680
678
676
100
120
140
160
180
200
220
Station (ft)

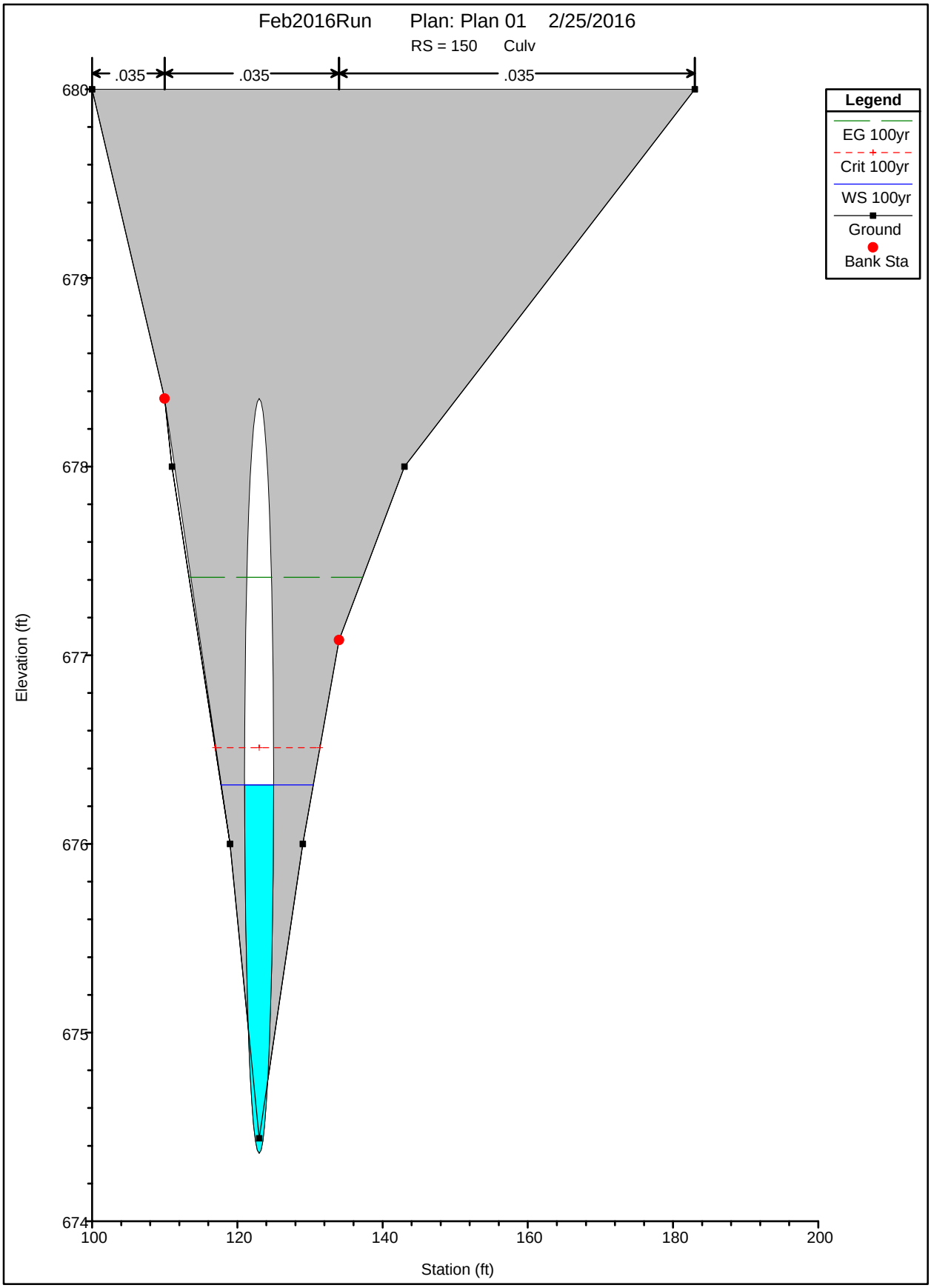

Feb2016Run Plan: Plan 01 2/25/2016
RS = 400
.035
.035
.035
Legend
EG 100yr
WS 100yr
Ground
Bank Sta
Elevation (ft)
688
686
684
682
680
678
676
100
120
140
160
180
200
220
Station (ft)

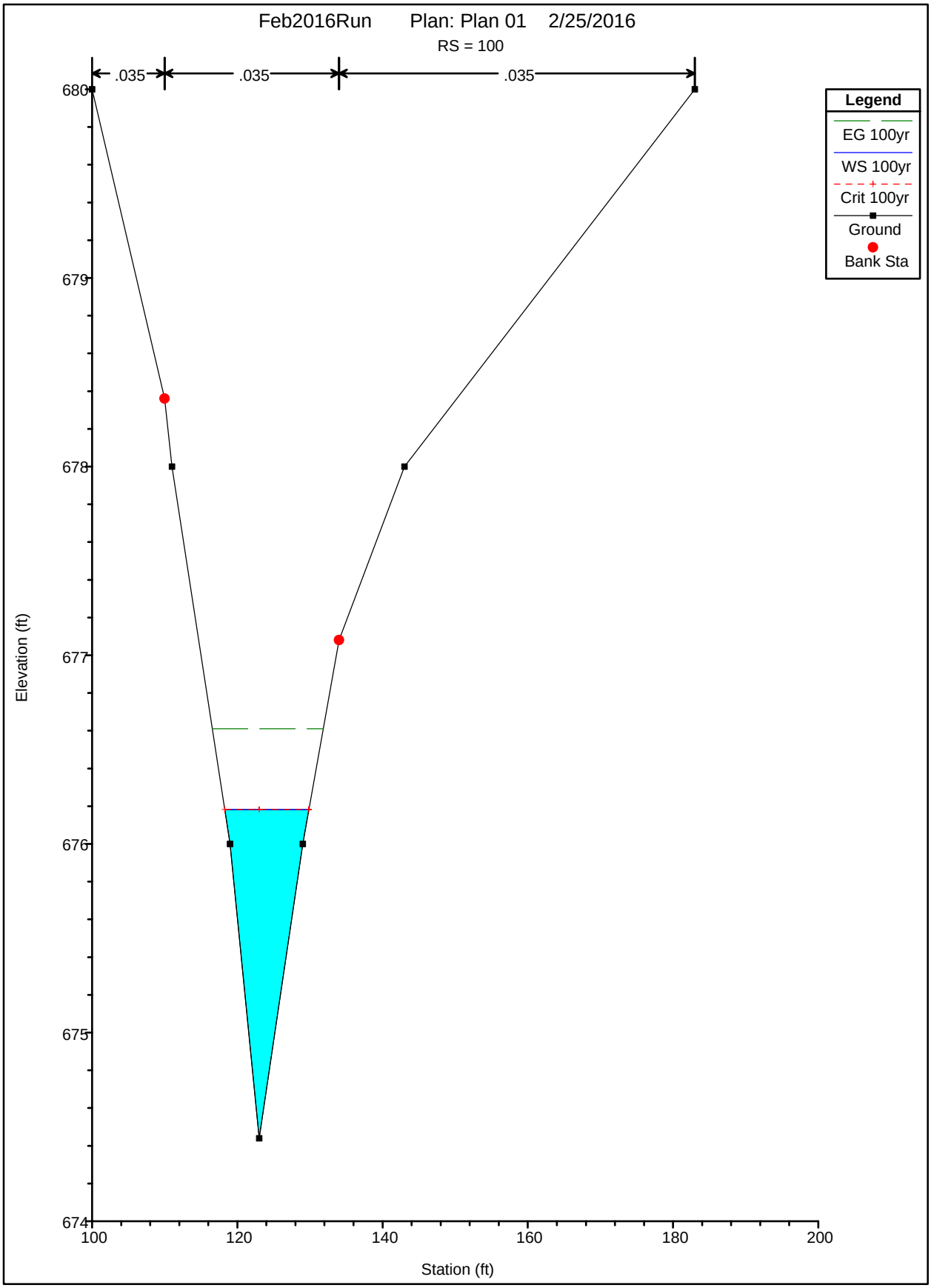

Feb2016Run Plan: Plan 01 2/25/2016
RS = 300
.035
.035
.035
Legend
EG 100yr
WS 100yr
Ground
Bank Sta
686
684
682
680
678
676
Elevation (ft)
100
120
140
160
180
200
220
240
Station (ft)

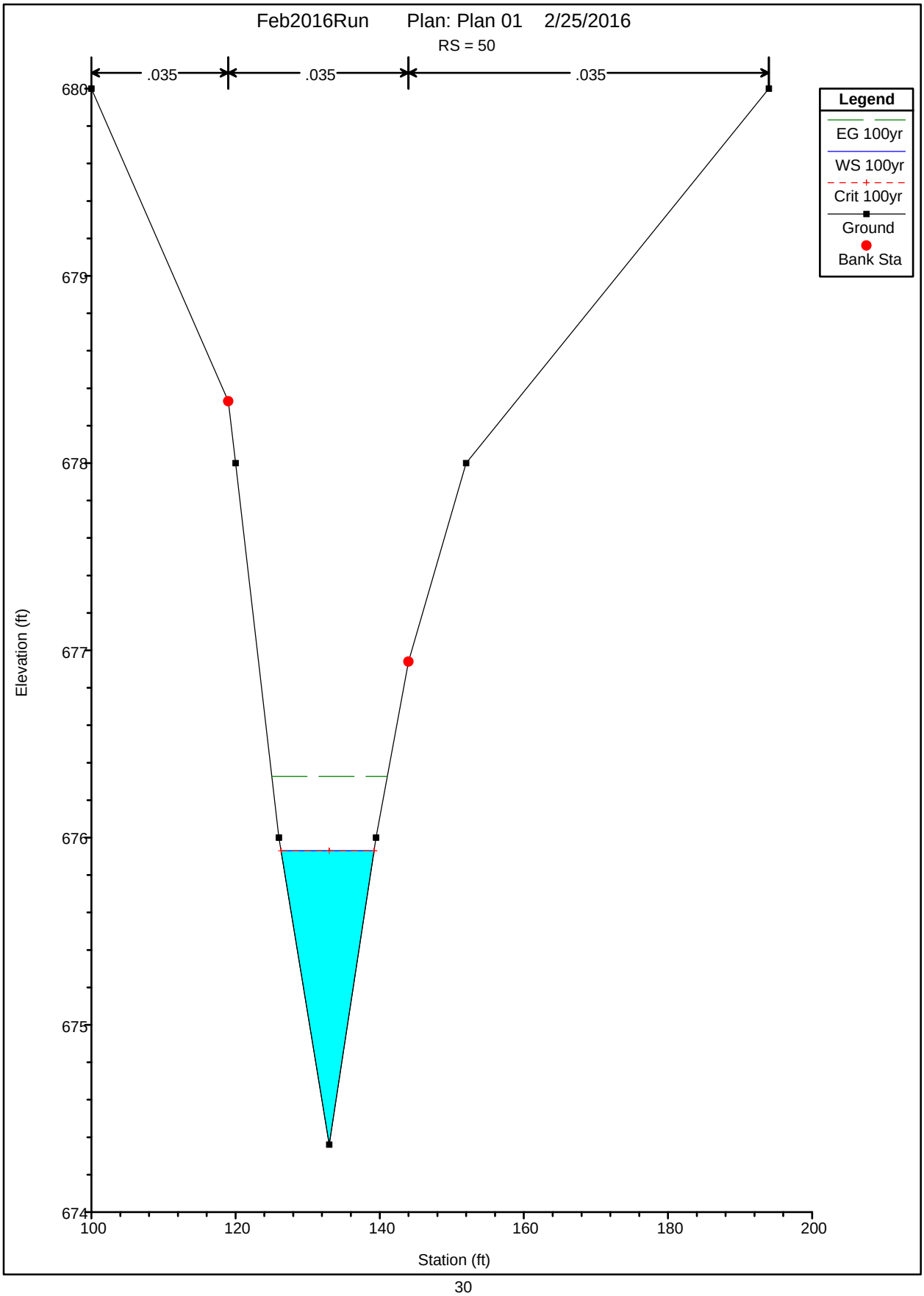

Feb2016Run Plan: Plan 01 2/25/2016
RS = 250
.035
.035
.035
Legend
EG 100yr
WS 100yr
Ground
Bank Sta
686
684
682
680
678
676
Elevation (ft)
100
120
140
160
180
200
220
240
260
Station (ft)


Feb2016Run Plan: Plan 01 2/25/2016
RS = 200
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
686
684
682
680
678
676
674
100
120
140
160
180
200
220
240
260
280
Station (ft)


Feb2016Run Plan: Plan 01 2/25/2016
RS = 150 Culv
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
686
684
682
680
678
676
674
100
120
140
160
180
200
220
240
260
280
Station (ft)


Feb2016Run Plan: Plan 01 2/25/2016
RS = 150 Culv
.035
.035
.035
Legend
EG 100yr
Crit 100yr
WS 100yr
Ground
Bank Sta
Elevation (ft)
680
679
678
677
676
675
674
100
120
140
160
180
200
Station (ft)


Feb2016Run Plan: Plan 01 2/25/2016
RS = 100
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
680
679
678
677
676
675
674
100
120
140
160
180
200
Station (ft)


Feb2016Run Plan: Plan 01 2/25/2016
RS = 50
.035
.035
.035
Legend
EG 100yr
WS 100yr
Crit 100yr
Ground
Bank Sta
Elevation (ft)
680
679
678
677
676
675
674
100
120
140
160
180
200
Station (ft)

Plan: Plan 01  river  reach  RS: 700  Profile: 100yr

| E.G. Elev (ft) | 683.79 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.42 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 683.37 | Reach Len. (ft) | 70.00 | 66.00 | 63.00 |
| Crit W.S. (ft) | 683.37 | Flow Area (sq ft) | | 6.14 | |
| E.G. Slope (ft/ft) | 0.021247 | Area (sq ft) | | 6.14 | |
| Q Total (cfs) | 31.90 | Flow (cfs) | | 31.90 | |
| Top Width (ft) | 7.33 | Top Width (ft) | | 7.33 | |
| Vel Total (ft/s) | 5.20 | Avg. Vel. (ft/s) | | 5.20 | |
| Max Chl Dpth (ft) | 1.47 | Hydr. Depth (ft) | | 0.84 | |
| Conv. Total (cfs) | 218.8 | Conv. (cfs) | | 218.8 | |
| Length Wtd. (ft) | 66.00 | Wetted Per. (ft) | | 7.98 | |
| Min Ch El (ft) | 681.90 | Shear (lb/sq ft) | | 1.02 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 200.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 1.41 | Cum Volume (acre-ft) | | 0.10 | 0.00 |
| C & E Loss (ft) | 0.00 | Cum SA (acres) | | 0.09 | 0.01 |

Errors Warnings and Notes

| | |
|---|---|
| Warning: | The energy equation could not be balanced within the specified number of iterations. The program used critical depth |
| | for the water surface and continued on with the calculations. |
| Warning: | The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the |
| | need for additional cross sections. |
| Warning: | During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated |
| | water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program |
| | defaulted to critical depth. |

Plan: Plan 01  river  reach  RS: 600  Profile: 100yr

| E.G. Elev (ft) | 681.68 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.43 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 681.25 | Reach Len. (ft) | 62.00 | 60.00 | 59.00 |
| Crit W.S. (ft) | 681.25 | Flow Area (sq ft) | | 6.04 | |
| E.G. Slope (ft/ft) | 0.021592 | Area (sq ft) | | 6.04 | |
| Q Total (cfs) | 31.90 | Flow (cfs) | | 31.90 | |
| Top Width (ft) | 7.00 | Top Width (ft) | | 7.00 | |
| Vel Total (ft/s) | 5.28 | Avg. Vel. (ft/s) | | 5.28 | |
| Max Chl Dpth (ft) | 1.67 | Hydr. Depth (ft) | | 0.86 | |
| Conv. Total (cfs) | 217.1 | Conv. (cfs) | | 217.1 | |
| Length Wtd. (ft) | 60.00 | Wetted Per. (ft) | | 7.77 | |
| Min Ch El (ft) | 679.58 | Shear (lb/sq ft) | | 1.05 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 218.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 1.38 | Cum Volume (acre-ft) | | 0.09 | 0.00 |
| C & E Loss (ft) | 0.01 | Cum SA (acres) | | 0.08 | 0.01 |

Errors Warnings and Notes

| | |
|---|---|
| Warning: | The energy equation could not be balanced within the specified number of iterations. The program used critical depth |
| | for the water surface and continued on with the calculations. |
| Warning: | The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the |
| | need for additional cross sections. |
| Warning: | During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated |
| | water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program |
| | defaulted to critical depth. |

Plan: Plan 01  river  reach  RS: 500  Profile: 100yr

| E.G. Elev (ft) | 679.75 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.52 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 679.23 | Reach Len. (ft) | 45.00 | 50.00 | 56.00 |
| Crit W.S. (ft) | 679.23 | Flow Area (sq ft) | | 5.52 | |
| E.G. Slope (ft/ft) | 0.024414 | Area (sq ft) | | 5.52 | |
| Q Total (cfs) | 31.90 | Flow (cfs) | | 31.90 | |
| Top Width (ft) | 5.44 | Top Width (ft) | | 5.44 | |
| Vel Total (ft/s) | 5.78 | Avg. Vel. (ft/s) | | 5.78 | |
| Max Chl Dpth (ft) | 2.03 | Hydr. Depth (ft) | | 1.02 | |
| Conv. Total (cfs) | 204.2 | Conv. (cfs) | | 204.2 | |
| Length Wtd. (ft) | 50.00 | Wetted Per. (ft) | | 6.79 | |
| Min Ch El (ft) | 677.20 | Shear (lb/sq ft) | | 1.24 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 208.50 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.41 | Cum Volume (acre-ft) | | 0.09 | 0.00 |
| C & E Loss (ft) | 0.12 | Cum SA (acres) | | 0.07 | 0.01 |

Errors Warnings and Notes

| | |
|---|---|
| Warning: | The energy equation could not be balanced within the specified number of iterations. The program used critical depth |
| | for the water surface and continued on with the calculations. |
| Warning: | The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. |
| | This may indicate the need for additional cross sections. |
| Warning: | During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated |
| | water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program |
| | defaulted to critical depth. |

Plan: Plan 01  river  reach  RS: 400  Profile: 100yr

| E.G. Elev (ft) | 679.06 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.12 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 678.94 | Reach Len. (ft) | 32.00 | 35.00 | 37.00 |
| Crit W.S. (ft) | | Flow Area (sq ft) | | 11.44 | |
| E.G. Slope (ft/ft) | 0.004120 | Area (sq ft) | | 11.44 | |
| Q Total (cfs) | 31.90 | Flow (cfs) | | 31.90 | |
| Top Width (ft) | 10.24 | Top Width (ft) | | 10.24 | |
| Vel Total (ft/s) | 2.79 | Avg. Vel. (ft/s) | | 2.79 | |
| Max Chl Dpth (ft) | 2.05 | Hydr. Depth (ft) | | 1.12 | |
| Conv. Total (cfs) | 497.0 | Conv. (cfs) | | 497.0 | |
| Length Wtd. (ft) | 35.00 | Wetted Per. (ft) | | 11.06 | |
| Min Ch El (ft) | 676.89 | Shear (lb/sq ft) | | 0.27 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 211.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.11 | Cum Volume (acre-ft) | | 0.08 | 0.00 |
| C & E Loss (ft) | 0.02 | Cum SA (acres) | | 0.06 | 0.01 |

Plan: Plan 01  river  reach  RS: 300  Profile: 100yr

| E.G. Elev (ft) | 678.94 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.07 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 678.87 | Reach Len. (ft) | 44.00 | 42.00 | 41.50 |
| Crit W.S. (ft) | | Flow Area (sq ft) | | 15.09 | |
| E.G. Slope (ft/ft) | 0.002287 | Area (sq ft) | | 15.09 | |
| Q Total (cfs) | 31.90 | Flow (cfs) | | 31.90 | |
| Top Width (ft) | 13.42 | Top Width (ft) | | 13.42 | |
| Vel Total (ft/s) | 2.11 | Avg. Vel. (ft/s) | | 2.11 | |
| Max Chl Dpth (ft) | 2.21 | Hydr. Depth (ft) | | 1.12 | |
| Conv. Total (cfs) | 667.1 | Conv. (cfs) | | 667.1 | |

Plan: Plan 01 river reach RS: 300 Profile: 100yr (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Length Wtd. (ft) | 42.00 | Wetted Per. (ft) | | 14.21 | |
| Min Ch El (ft) | 676.66 | Shear (lb/sq ft) | | 0.15 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 226.17 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.04 | Cum Volume (acre-ft) | | 0.06 | 0.00 |
| C & E Loss (ft) | 0.01 | Cum SA (acres) | | 0.05 | 0.01 |

Errors Warnings and Notes

| | |
|---|---|
| Warning: | The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. |
| | This may indicate the need for additional cross sections. |

Plan: Plan 01 river reach RS: 250 Profile: 100yr

| E.G. Elev (ft) | 678.88 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.02 | Wt. n-Val. | | 0.035 | 0.035 |
| W.S. Elev (ft) | 678.86 | Reach Len. (ft) | 45.50 | 43.00 | 42.00 |
| Crit W.S. (ft) | | Flow Area (sq ft) | | 26.67 | 0.06 |
| E.G. Slope (ft/ft) | 0.000511 | Area (sq ft) | | 26.67 | 0.06 |
| Q Total (cfs) | 31.90 | Flow (cfs) | | 31.89 | 0.01 |
| Top Width (ft) | 19.01 | Top Width (ft) | | 18.29 | 0.71 |
| Vel Total (ft/s) | 1.19 | Avg. Vel. (ft/s) | | 1.20 | 0.18 |
| Max Chl Dpth (ft) | 2.86 | Hydr. Depth (ft) | | 1.46 | 0.08 |
| Conv. Total (cfs) | 1411.3 | Conv. (cfs) | | 1410.8 | 0.5 |
| Length Wtd. (ft) | 42.99 | Wetted Per. (ft) | | 19.17 | 0.73 |
| Min Ch El (ft) | 676.00 | Shear (lb/sq ft) | | 0.04 | 0.00 |
| Alpha | 1.00 | Stream Power (lb/ft s) | 247.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.02 | Cum Volume (acre-ft) | | 0.04 | 0.00 |
| C & E Loss (ft) | 0.00 | Cum SA (acres) | | 0.04 | 0.01 |

Errors Warnings and Notes

| | |
|---|---|
| Warning: | The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. |
| | This may indicate the need for additional cross sections. |

Plan: Plan 01 river reach RS: 200 Profile: 100yr

| E.G. Elev (ft) | 678.87 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.02 | Wt. n-Val. | | 0.035 | 0.035 |
| W.S. Elev (ft) | 678.85 | Reach Len. (ft) | 50.00 | 48.00 | 45.50 |
| Crit W.S. (ft) | 676.78 | Flow Area (sq ft) | | 44.00 | 2.46 |
| E.G. Slope (ft/ft) | 0.000288 | Area (sq ft) | | 44.00 | 2.46 |
| Q Total (cfs) | 51.30 | Flow (cfs) | | 50.65 | 0.65 |
| Top Width (ft) | 31.63 | Top Width (ft) | | 20.62 | 11.01 |
| Vel Total (ft/s) | 1.10 | Avg. Vel. (ft/s) | | 1.15 | 0.26 |
| Max Chl Dpth (ft) | 3.58 | Hydr. Depth (ft) | | 2.13 | 0.22 |
| Conv. Total (cfs) | 3024.2 | Conv. (cfs) | | 2985.9 | 38.3 |
| Length Wtd. (ft) | 48.00 | Wetted Per. (ft) | | 21.78 | 11.02 |
| Min Ch El (ft) | 675.27 | Shear (lb/sq ft) | | 0.04 | 0.00 |
| Alpha | 1.07 | Stream Power (lb/ft s) | 270.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | | Cum Volume (acre-ft) | | 0.01 | |
| C & E Loss (ft) | | Cum SA (acres) | | 0.02 | 0.01 |

Plan: Plan 01 river reach RS: 100 Profile: 100yr

| E.G. Elev (ft) | 676.61 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.43 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 676.18 | Reach Len. (ft) | 9.00 | 9.00 | 10.00 |
| Crit W.S. (ft) | 676.18 | Flow Area (sq ft) | | 9.76 | |

Plan: Plan 01 river reach RS: 100 Profile: 100yr (Continued)

| | | | | | |
|---|---|---|---|---|---|
| E.G. Slope (ft/ft) | 0.020409 | Area (sq ft) | | 9.76 | |
| Q Total (cfs) | 51.30 | Flow (cfs) | | 51.30 | |
| Top Width (ft) | 11.57 | Top Width (ft) | | 11.57 | |
| Vel Total (ft/s) | 5.25 | Avg. Vel. (ft/s) | | 5.25 | |
| Max Chl Dpth (ft) | 1.74 | Hydr. Depth (ft) | | 0.84 | |
| Conv. Total (cfs) | 359.1 | Conv. (cfs) | | 359.1 | |
| Length Wtd. (ft) | 9.00 | Wetted Per. (ft) | | 12.10 | |
| Min Ch El (ft) | 674.44 | Shear (lb/sq ft) | | 1.03 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 183.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | 0.18 | Cum Volume (acre-ft) | | 0.00 | |
| C & E Loss (ft) | 0.01 | Cum SA (acres) | | 0.00 | |

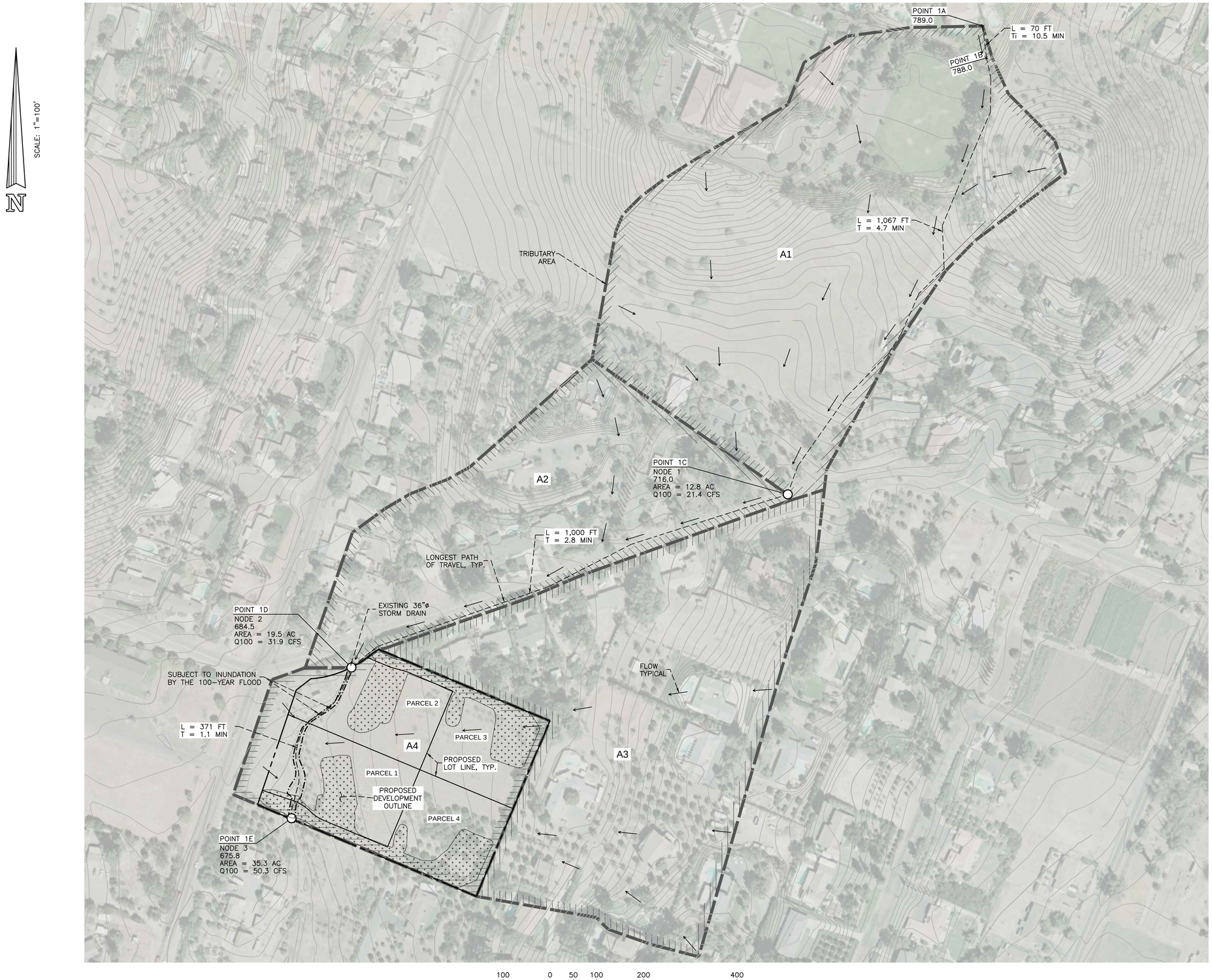
Errors Warnings and Notes

| | |
|---|---|
| Warning: | The energy equation could not be balanced within the specified number of iterations. The program used critical depth |
| | for the water surface and continued on with the calculations. |
| Warning: | During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated |
| | water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program |
| | defaulted to critical depth. |

Plan: Plan 01 river reach RS: 50 Profile: 100yr

| E.G. Elev (ft) | 676.33 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (ft) | 0.40 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (ft) | 675.93 | Reach Len. (ft) | | | |
| Crit W.S. (ft) | 675.93 | Flow Area (sq ft) | | 10.13 | |
| E.G. Slope (ft/ft) | 0.020414 | Area (sq ft) | | 10.13 | |
| Q Total (cfs) | 51.30 | Flow (cfs) | | 51.30 | |
| Top Width (ft) | 12.92 | Top Width (ft) | | 12.92 | |
| Vel Total (ft/s) | 5.06 | Avg. Vel. (ft/s) | | 5.06 | |
| Max Chl Dpth (ft) | 1.57 | Hydr. Depth (ft) | | 0.78 | |
| Conv. Total (cfs) | 359.1 | Conv. (cfs) | | 359.1 | |
| Length Wtd. (ft) | | Wetted Per. (ft) | | 13.29 | |
| Min Ch El (ft) | 674.36 | Shear (lb/sq ft) | | 0.97 | |
| Alpha | 1.00 | Stream Power (lb/ft s) | 194.00 | 0.00 | 0.00 |
| Frctn Loss (ft) | | Cum Volume (acre-ft) | | | |
| C & E Loss (ft) | | Cum SA (acres) | | | |

# EXHIBIT A
# STEEVE TPM 21225
# HYDROLOGY STUDY MAP
# PRE-DEVELOPMENT

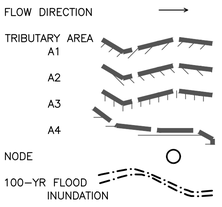



TRIBUTARY AREAS:
A1 = 12.8 AC
A2 = 6.7 AC
A3 = 11.2 AC
A4 = 4.6 AC
A (TOTAL) = 35.3 AC

RUNOFF COEFFICIENTS (SOIL TYPE C)

PRE
A1 – 0.42
A2 – 0.42
A3 – 0.36
A4 – 0.30

LEGEND:




NODE NOTES:
TRIBUTARY BASIN AREA A3 DOES NOT HAVE A NODE FOR ANALYSIS BECAUSE IT WILL FLOW THROUGH A4 DURING PRE-DEVELOPMENT ANALYSIS. A3 AND A4 HAVE BEEN SUBDIVIDED INTO TWO AREAS FOR COEFFICIENT CALCULATION PURPOSES.

PRE-, POST- STUDY NOTES:
THE POST-HYDROLOGY CALCULATIONS UP TO POINT 1D ARE UNALTERED FROM THE PRE-HYDROLOGY CALCULATIONS UP TO POINT 1D. AFTER POINT 1D, THE RUNOFF COEFICCIENT FOR THE POST-DEVELOPMENT CHANGES AND THEREFORE THE Q100 AT POINT 1E CHANGES. SEE RUNOFF COEFFICIENTS ABOVE.

BILL YEN & ASSOCIATES, INC.
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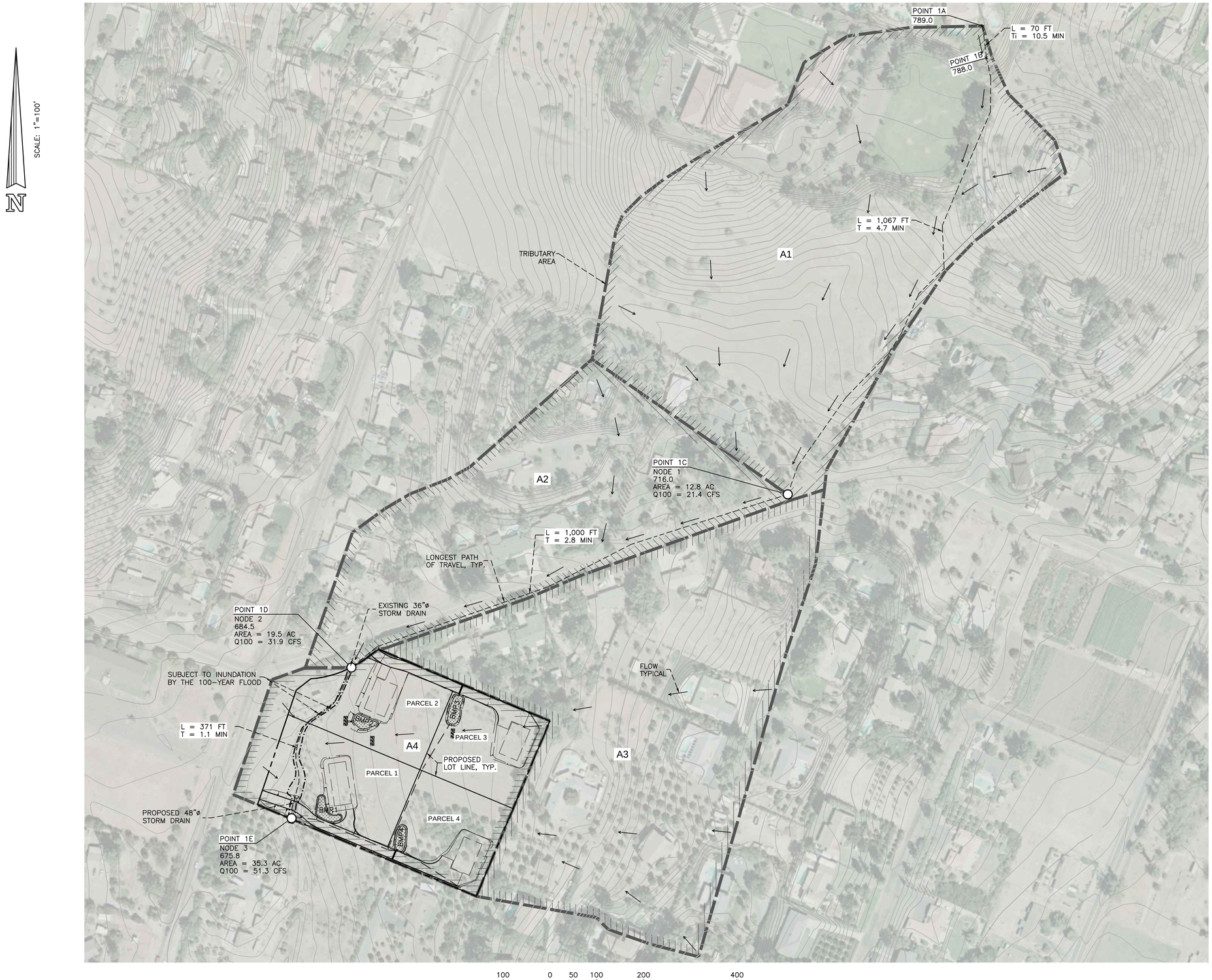
# EXHIBIT A
# STEEVE TPM 21225
# HYDROLOGY STUDY MAP
# POST-DEVELOPMENT

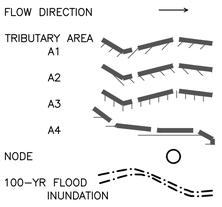



TRIBUTARY AREAS:
A1 = 12.8 AC
A2 = 6.7 AC
A3 = 11.2 AC
A4 = 4.6 AC
A (TOTAL) = 35.3 AC

RUNOFF COEFFICIENTS (SOIL TYPE C)

POST
A1 – 0.42
A2 – 0.42
A3 – 0.36
A4 – 0.36

LEGEND:




## NODE NOTES:

TRIBUTARY BASIN AREA A3 DOES NOT HAVE A NODE FOR ANALYSIS BECAUSE IT WILL BE DIRECTED AROUND AREA A4 DURING POST-DEVELOPMENT ANALYSIS WHERE IT WILL MEET UP WITH THE REMAINING STORM WATER AT POINT 1E.

## PRE-, POST- STUDY NOTES:

THE POST-HYDROLOGY CALCULATIONS UP TO POINT 1D ARE UNALTERED FROM THE PRE-HYDROLOGY CALCULATIONS UP TO POINT 1D. AFTER POINT 1D, THE RUNOFF COEFICCIENT FOR THE POST-DEVELOPMENT CHANGES AND THEREFORE THE Q100 AT POINT 1E CHANGES. SEE RUNOFF COEFFICIENTS ABOVE.

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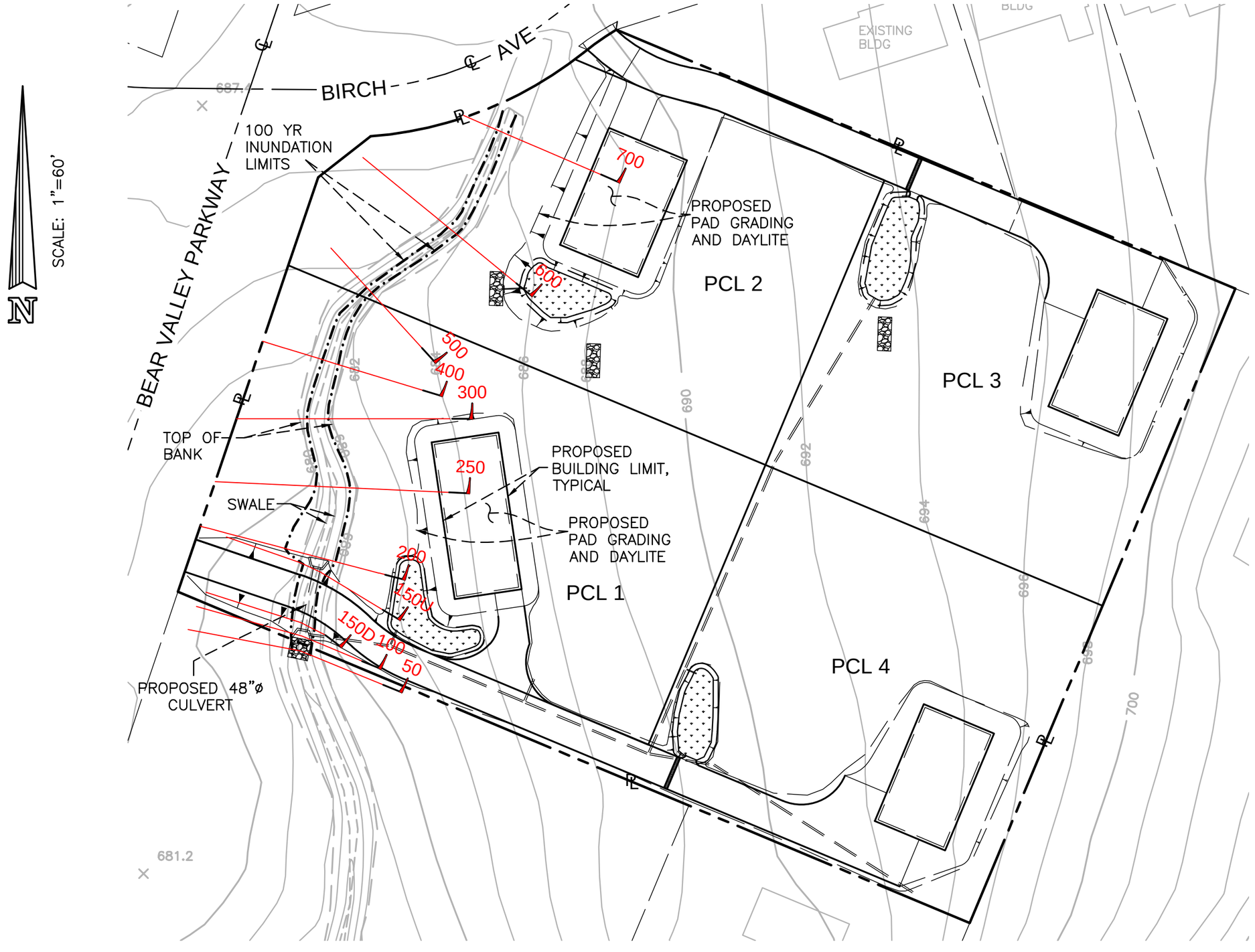
# EXHIBIT B
# STEEVE TPM 21225
# INUNDATION LIMITS
# & CROSS SECTIONS




## RIVER STA WS ELEVATIONS:

$WS^{50}$ = 675.93
$WS^{100}$ = 676.18
$WS^{150D}$ = 677.40
$WS^{150U}$ = 678.85
$WS^{200}$ = 678.86
$WS^{250}$ = 678.87
$WS^{300}$ = 678.94
$WS^{400}$ = 679.23
$WS^{500}$ = 681.25
$WS^{600}$ = 683.37
$WS^{700}$

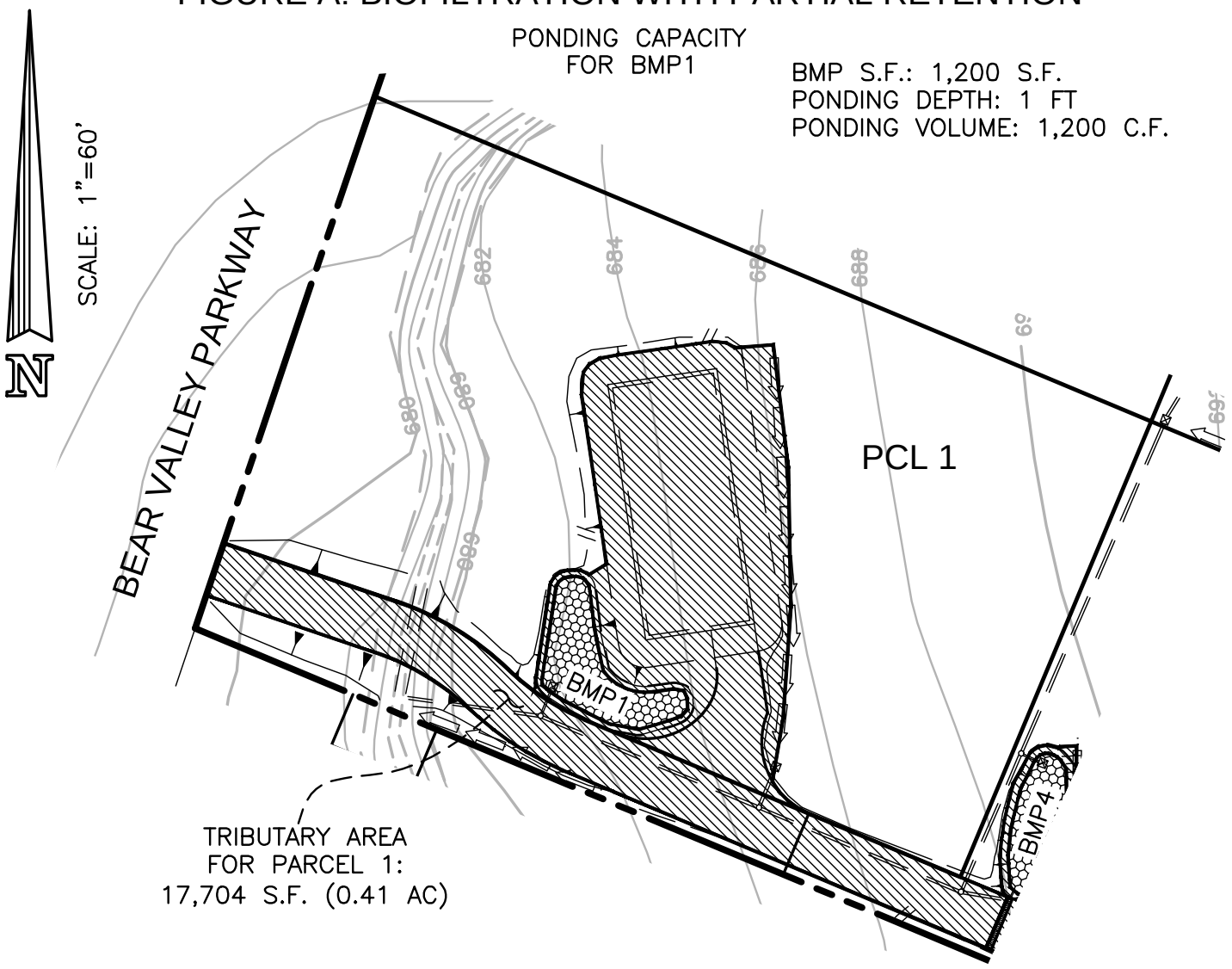
## NOTE:

CROSS SECTIONS ARE TAKEN FROM LEFT BANK TO RIGHT BANK GOING DOWN STREAM (EAST TO WEST). FOR CROSS SECTION PRINTOUTS, SEE PAGES 20–30.

EXHIBIT B: INUNDATION LIMITS AND CROSS SECTIONS

SCALE: 1"=60'

# FIGURE A: BIOFILTRATION WITH PARTIAL RETENTION



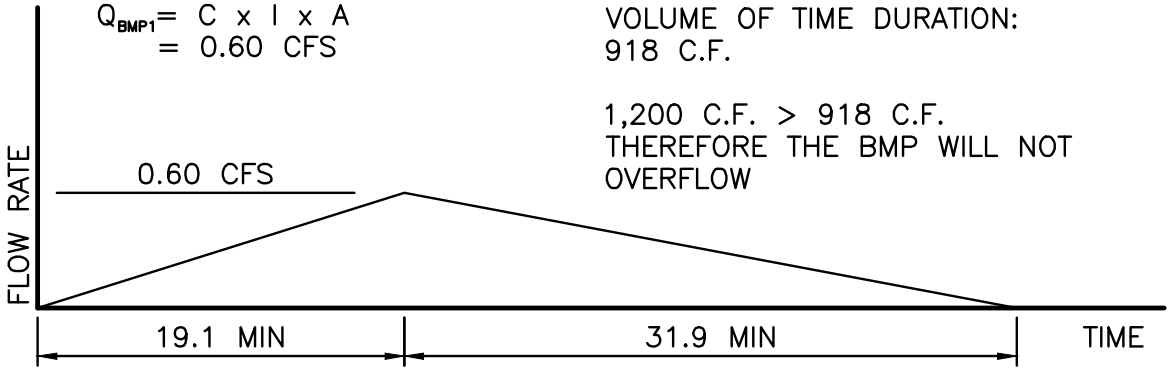

C = 0.393
I = 3.7 IN/HR
A = 0.41 AC

$Q_{BMP1}$ = C x I x A
= 0.60 CFS

BMP1 VOLUME CAPACITY:
1,200 C.F. (PONDING BEFORE OVERFLOW)

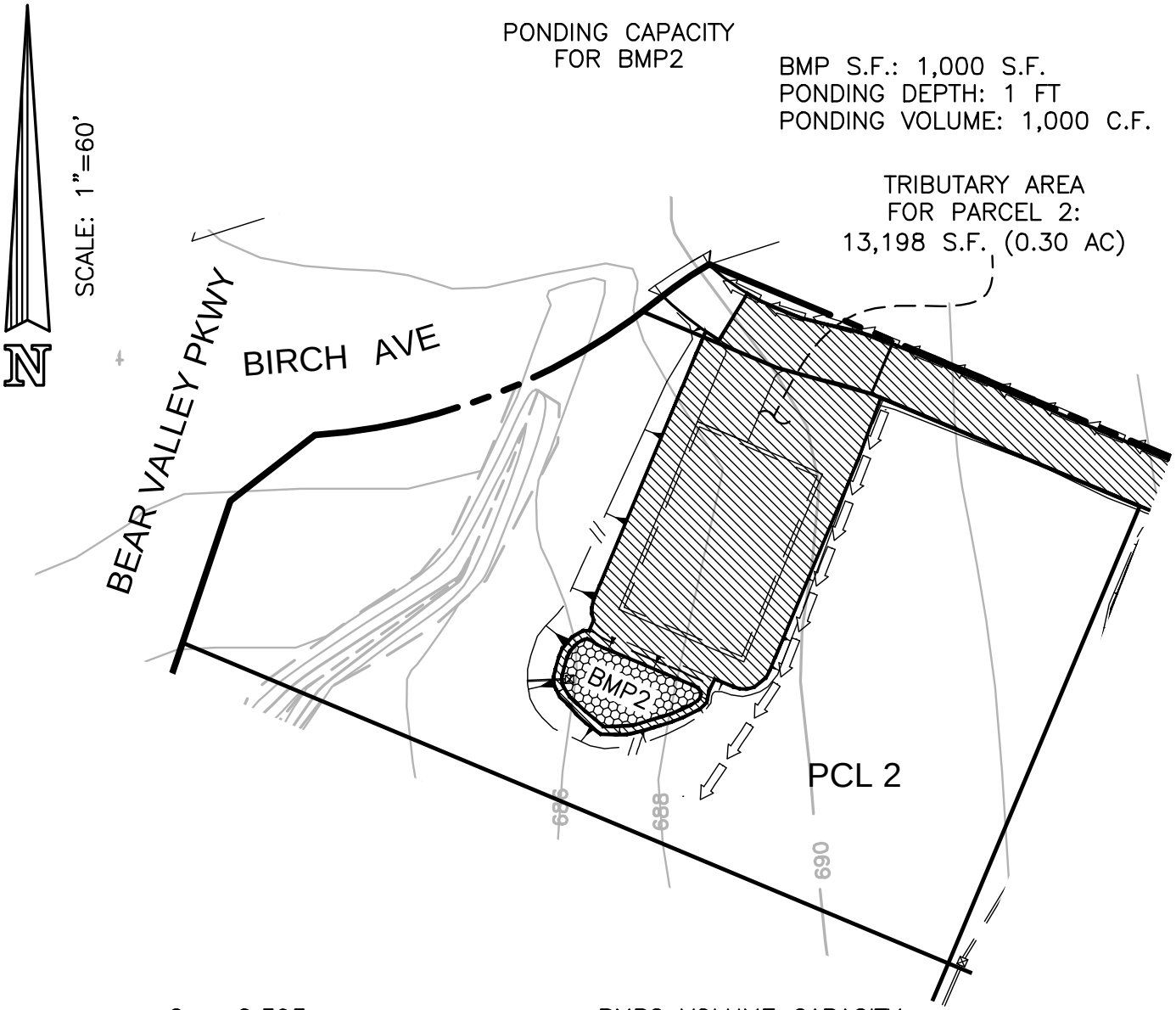
VOLUME OF TIME DURATION:
918 C.F.

1,200 C.F. > 918 C.F.
THEREFORE THE BMP WILL NOT OVERFLOW




NOTE: A TIME DURATION OF 2.67 (18.7 MIN X 2.67 = 51.0 MIN) IS ESTIMATED PER FIGURE 4.5 OF THE HYDROLOGY MANUAL.

# FIGURE B: BIOFILTRATION WITH PARTIAL RETENTION



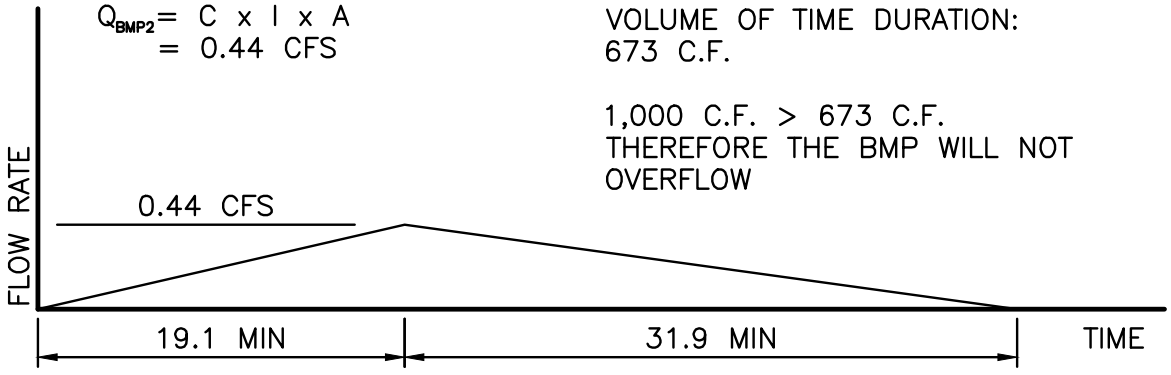

C = 0.393
I = 3.7 IN/HR
A = 0.30 AC

$Q_{BMP2}$ = C x I x A
= 0.44 CFS

BMP2 VOLUME CAPACITY:
1,000 C.F. (PONDING BEFORE OVERFLOW)

VOLUME OF TIME DURATION:
673 C.F.

1,000 C.F. > 673 C.F.
THEREFORE THE BMP WILL NOT OVERFLOW




NOTE: A TIME DURATION OF 2.67 (18.7 MIN X 2.67 = 51.0 MIN) IS ESTIMATED PER FIGURE 4.5 OF THE HYDROLOGY MANUAL.

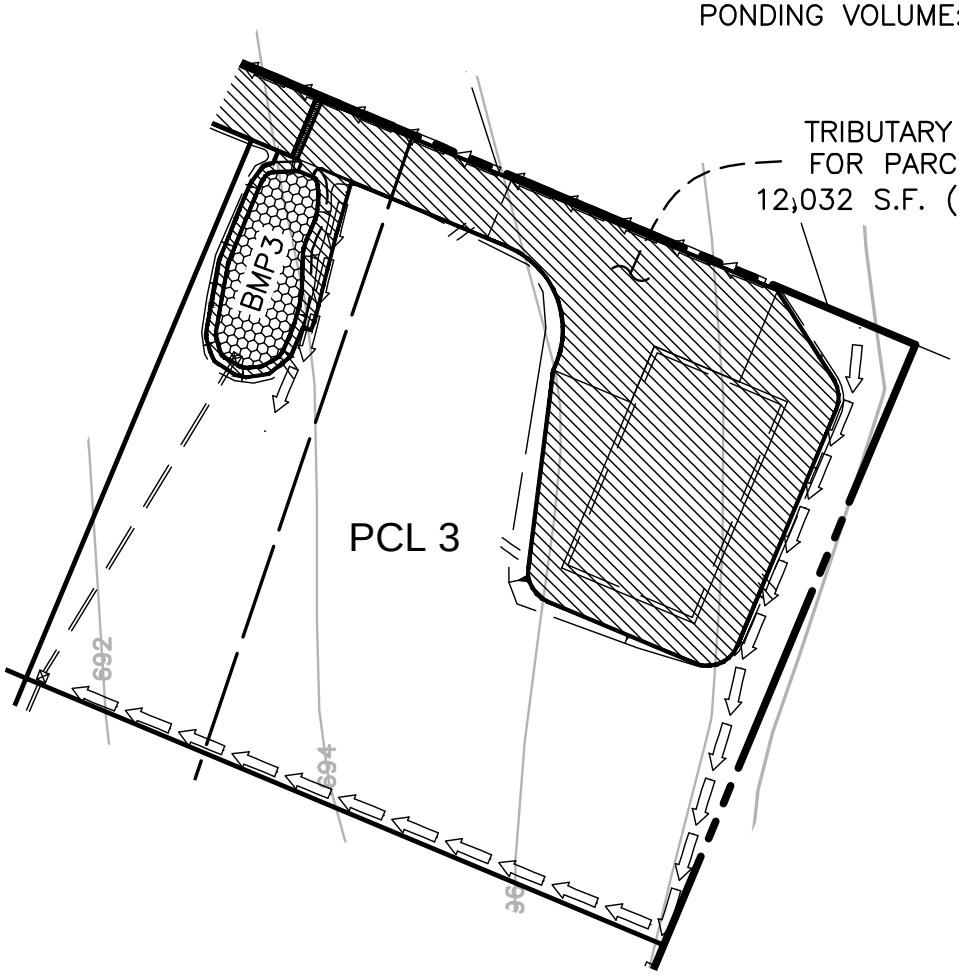
# FIGURE C: BIOFILTRATION

PONDING CAPACITY
FOR BMP3

BMP S.F.: 1,300 S.F.
PONDING DEPTH: 1 FT
PONDING VOLUME: 1,300 C.F.

SCALE: 1"=60'

N



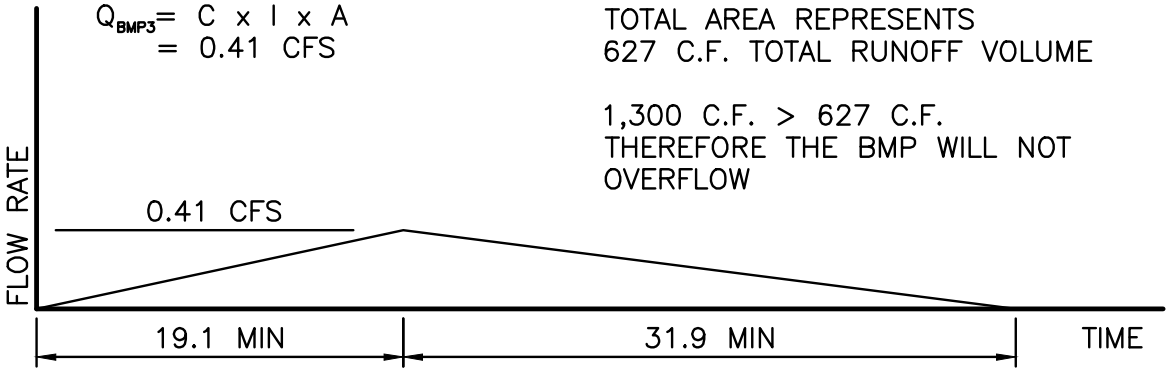

C = 0.393
I = 3.7 IN/HR
A = 0.28 AC

$Q_{BMP3}$ = C x I x A
= 0.41 CFS

BMP3 VOLUME CAPACITY:
1,300 C.F. (PONDING BEFORE OVERFLOW)

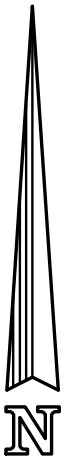
TOTAL AREA REPRESENTS
627 C.F. TOTAL RUNOFF VOLUME

1,300 C.F. > 627 C.F.
THEREFORE THE BMP WILL NOT OVERFLOW




NOTE: A TIME DURATION OF 2.67 (18.7 MIN X 2.67 = 51.0 MIN) IS ESTIMATED PER FIGURE 4.5 OF THE HYDROLOGY MANUAL.

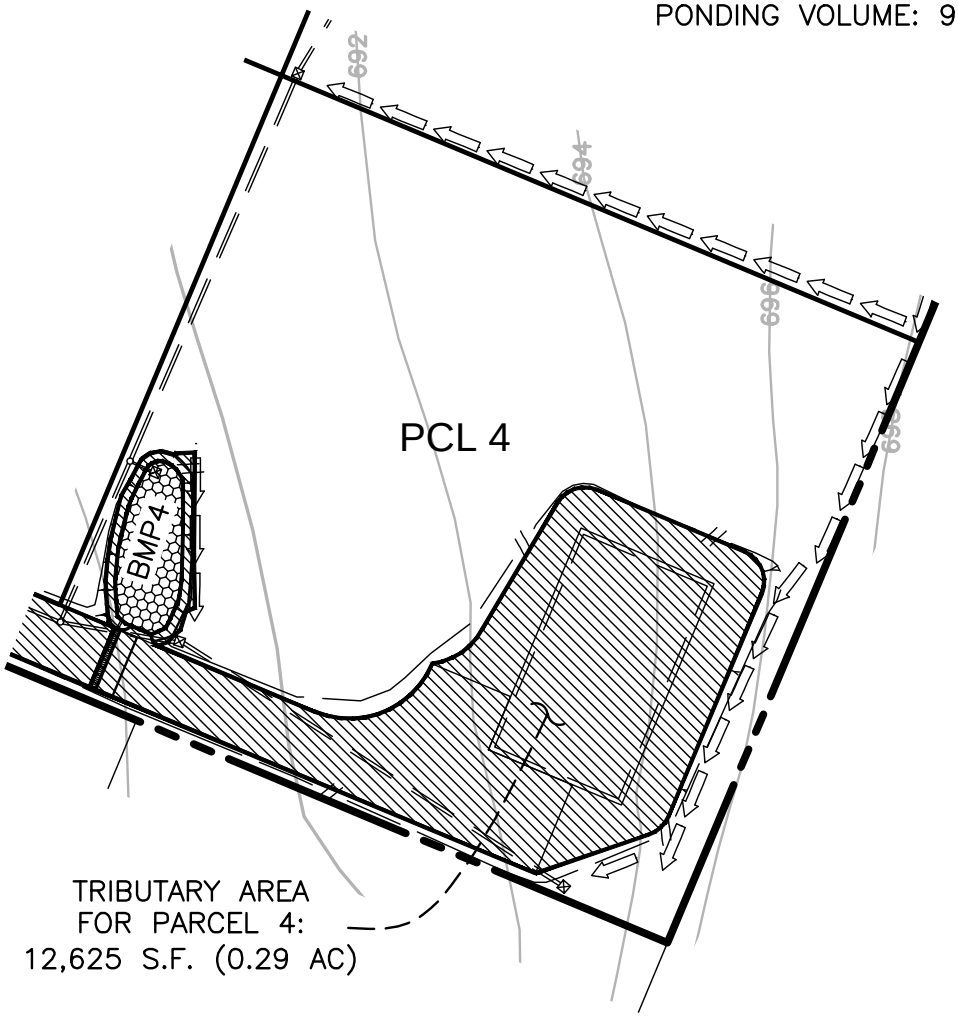
# FIGURE D: BIOFILTRATION




SCALE: 1"=60'

PONDING CAPACITY
FOR BMP4

BMP S.F.: 900 S.F.
PONDING DEPTH: 1 FT
PONDING VOLUME: 900 C.F.




TRIBUTARY AREA
FOR PARCEL 4:
12,625 S.F. (0.29 AC)

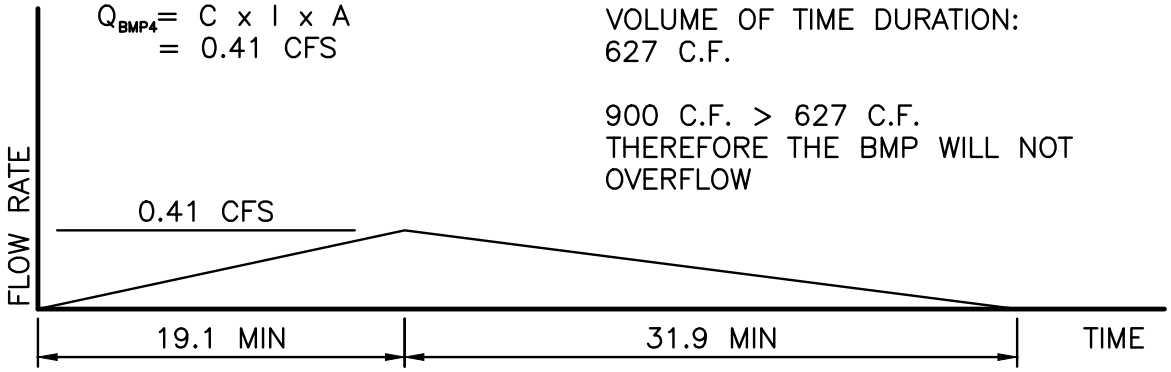
C = 0.393
I = 3.7 IN/HR
A = 0.28 AC

$Q_{BMP4}$= C x I x A
= 0.41 CFS

BMP4 VOLUME CAPACITY:
900 C.F. (PONDING BEFORE OVERFLOW)

VOLUME OF TIME DURATION:
627 C.F.

900 C.F. > 627 C.F.
THEREFORE THE BMP WILL NOT OVERFLOW




NOTE: A TIME DURATION OF 2.67 (18.7 MIN X 2.67 = 51.0 MIN) IS ESTIMATED PER FIGURE 4.5 OF THE HYDROLOGY MANUAL.