COUNTY OF EL DORADO
DEPARTMENT OF TRANSPORTATION

INTEROFFICE MEMORANDUM

Date: 11/23/2010

To: File

From: Chandra Ghimire, PE Chandra Ghimire 11/23/'10

REGISTERED PROFESSIONAL ENGINEER
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Subject: Gerle Creek Crossing Bridge Drainage Design Report, 77118

1. Introduction

1.1. General

Wentworth Springs Road at Gerle Creek is located in the Sierra Nevada Mountains in northeastern El Dorado County, approximately 3.5 miles north of the intersection of Wentworth Springs Road and Ice House Road (see Figure 1). The Project consists of a single 16 ft wide by 125 ft long bridge over the perennial Gerle Creek. A prefabricated steel truss bridge is proposed to replace the existing low water crossing. The Wentworth Springs Road at Gerle Creek Bridge Project is a federally funded project through the Federal Highway Administration (FHWA).

Historically, several structures have been washed away by floods and spring runoff which includes:

- A log bridge with stone abutments that was constructed in 1922.
- A concrete bridge that was built slightly upstream of the proposed bridge location in 1944 (which remnants are still visible), washed out in winter of 1963/1964.
- A railroad flat car that was placed as a bridge in the mid to late 1960s, washed out in winter of 1980.

Since 1980, vehicles have crossed by fording the creek. The purpose of the Project is to replace the low water crossing with a 16 ft wide prefabricated steel truss bridge to be located immediately upstream of the existing low water crossing through Gerle Creek. A bridge crossing will reduce the amount of sediment and contaminants that enter Gerle Creek from vehicle crossings. A bridge crossing will also reduce the turbidity of the creek from tires disturbing the streambed.

Wentworth Springs Road is primarily used by off-highway vehicles (OHVs). The increase in the numbers and types of vehicles using the both Wentworth Springs Road and nearby Rubicon Trail has resulted in a need for greater management in order to provide both environmental protection and visitor safety.

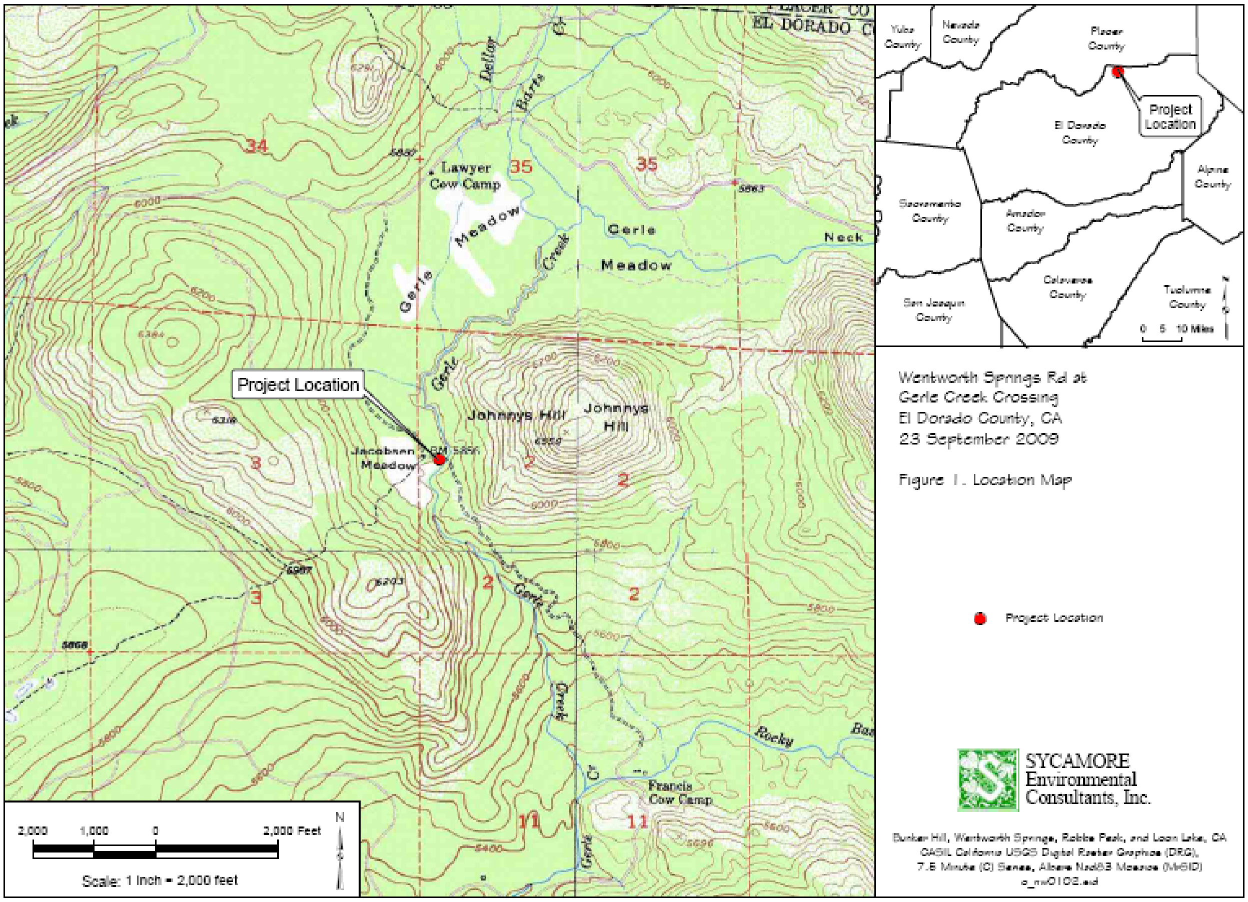

Figure 1: Gerle Creek Bridge Location (*Sycamore Environmental Consultants, Inc.*)

1.2. Purpose

The purpose of this drainage analysis is to develop 10-year, 50-year and 100-year peak flow to provide a hydraulic evaluation for the proposed bridge location. This report is intended to detail and document the hydrologic parameters and assumptions used to forecast the flows applicable to design a bridge at Gerle Creek. The report also summarizes the potential scour condition for the proposed bridge location.

2. Background

The drainage analysis is necessary to ensure that the proposed bridge will meet the specific design standards provided by El Dorado County Department of Transportation (EDCDOT) and California Department of Transportation (Caltrans). EDCDOT does not provide specific freeboard design criteria. However, the County has a practice of designing 3 ft minimum freeboard for 50-year event flood and 2 ft minimum freeboard for 100-year event flood. The proposed bridge design will satisfy the following standard:

1. County of El Dorado Drainage Manual, dated March 1995
2. Caltrans Local Assistance Procedure Manual, Chapter 11, dated July 23, 2006
    - The basic rule for hydraulic design of bridges is that; they should be designed to pass the two percent (2%) probability flood or tide (Q50) or the flood-of-record, whichever is greater without causing objectionable backwater, excessive flow velocities, or encroaching on through traffic lanes. Sufficient freeboard, the

vertical clearance between the lowest structural member, and the water surface elevation of the design flood should be provided. A minimum freeboard of 2 feet is often assumed for preliminary bridge design.
- The bridge should be able to withstand the effects of the base flood, Q_{100} without failure.

3. Caltrans Memo to Designers 1-23 dated October 2003
    - Adequate freeboard should be provided above the design flood to pass anticipated drift. A site specific drift evaluation must be performed to determine the horizontal (clear span) and vertical drift way requirement.
    - Convey a flood having a one percent (1%) chance of being exceeded in any given year (base flood designation Q100). No freeboard added to the base flood.
    - Bridge foundation should not fail due to scour from base flood (Q100).
    - Footings on piles may be located above the lowest anticipated scour level provided the piles are designed for this condition.

3. Previous Studies and Reference Documents

No previous studies in the vicinity exist. The gauge data recorded and provided by SMUD was used to check the reasonableness of the study. Frequency analysis was performed based on twenty-five year gauge data recorded approximately 1.3 miles downstream of the proposed bridge. No known Federal Emergency Management Agency published map has been found in the project vicinity.

4. Hydrology

4.1. Basin Characteristics

The Gerle Creek Basin is approximately 21.19 square miles upstream from the proposed bridge location (Wentworth Springs Road). There are two distinct parts in the Gerle Creek basin: upstream of the Loon Lake (approximately 8 square miles) and downstream of the Loon Lake (approximately 13.19 square miles). The watershed is approximately 7 miles in length and 3 miles in width with, an elongated shape. In general, the basin consists of hilly terrain which is located in Eldorado National Forest at elevation ranges from 5800 ft to 8000 ft. This basin is aligned north-east to south-west with an average slope of the watershed of approximately 12 percent (see Figure 2).

4.2. Soil Characteristics

According to the Foundation Investigation Report prepared by Taber Consultants, dated December 2009, the surface and subsurface soil in the project area are as follows:

- The upper unit was encountered at each test boring location to approximately 3 to 10 ft depth in all test borings. The upper unit consists of gravelly sand with cobbles, small boulder and silt. The deposit is possibly a combination of creek sediment, colluvium from Jonhy's Hill and glacial materials. Larger boulders were observed upstream of the bridge site and may exist within the abutment locations.
- Middle unit was encountered below the upper unit at 3 to 10 ft depth and extended to approximately 23 ft depth in the west bank of the creek. Middle unit extended to approximately to 31 ft depth in east bank of the creek. Middle unit material consists of loose to semi-compact brown and gray sand and silt.
- The lower unit extended to the bottom of all borings. Lower unit material consists of compact to very dense brownish red and gray silty sandy gravel with cobbles.

- Apparent scour was observed at the base of the bank on the southeast side of the creek. The scour area is downstream of the southeastern abutment.

4.3. Climate

The average temperatures in the vicinity of the project are 60°F in June and 32°F in winter. Within last five years, the maximum and the minimum recorded temperatures at Loon Lake are 85°F and 8°F respectively. Winter storm season extends from November to April, and generally moves from west to south-west and travel in a northeasterly to easterly direction.

4.4. Rainfall Data

Generally, the project area receives precipitation in the form of snow and most of the runoff is from the snowmelt. Precipitation data used for model input was obtained from the County of El Dorado Drainage Manual. The Mean Annual Precipitation (MAP) for the project vicinity is 49 inches.

4.5. Time of Concentration

Time of concentration estimations were performed per the County of El Dorado Drainage Manual. Sheet flow is assumed to occur for maximum of 300 ft length and sheet flow travel time is calculated based on the following equation:

$$T_t = \frac{0.007(nL)^{0.08}}{(P_2)^{0.5}S^{0.4}}$$

Where:
T_t = sheet flow travel time, in hr
n = overland-flow roughness coefficient, 0.7 was chosen for this project
L = length of overland flow surface, in ft (maximum 300 ft.)
P_2 = 2-yr, 24-hr rainfall depth in inches
S = land slope, in ft/ft.

The velocity of shallow flow over an unpaved surface is estimated based on the following equation:

$V = 16.1345(\sqrt{S_o})$
Where, V = shallow-concentrated flow velocity, in ft/sec;
S_o = slope, in ft/ft.

Shallow Concentrated Flow travel time is the flow path length divided by the velocity.

The USGS regression equation was used to estimate for 2-year event flow. The channel-flow travel time is the channel length divided by the velocity. See Table 1 for summary of time of concentration. Appendix A provides sheet flow, shallow concentrated flow, channel flow travel times, and total time of concentration.

5. Hydrologic Model Development

Runoff from snowmelt (rain on snow condition-energy budget) was used to achieve the depth of precipitation which then was utilized to USACOE HEC-HMS Program Version 3.4 to develop hydrologic model for Gerle Creek watershed. Figure 2 provides the Gerle Creek basin delineation.

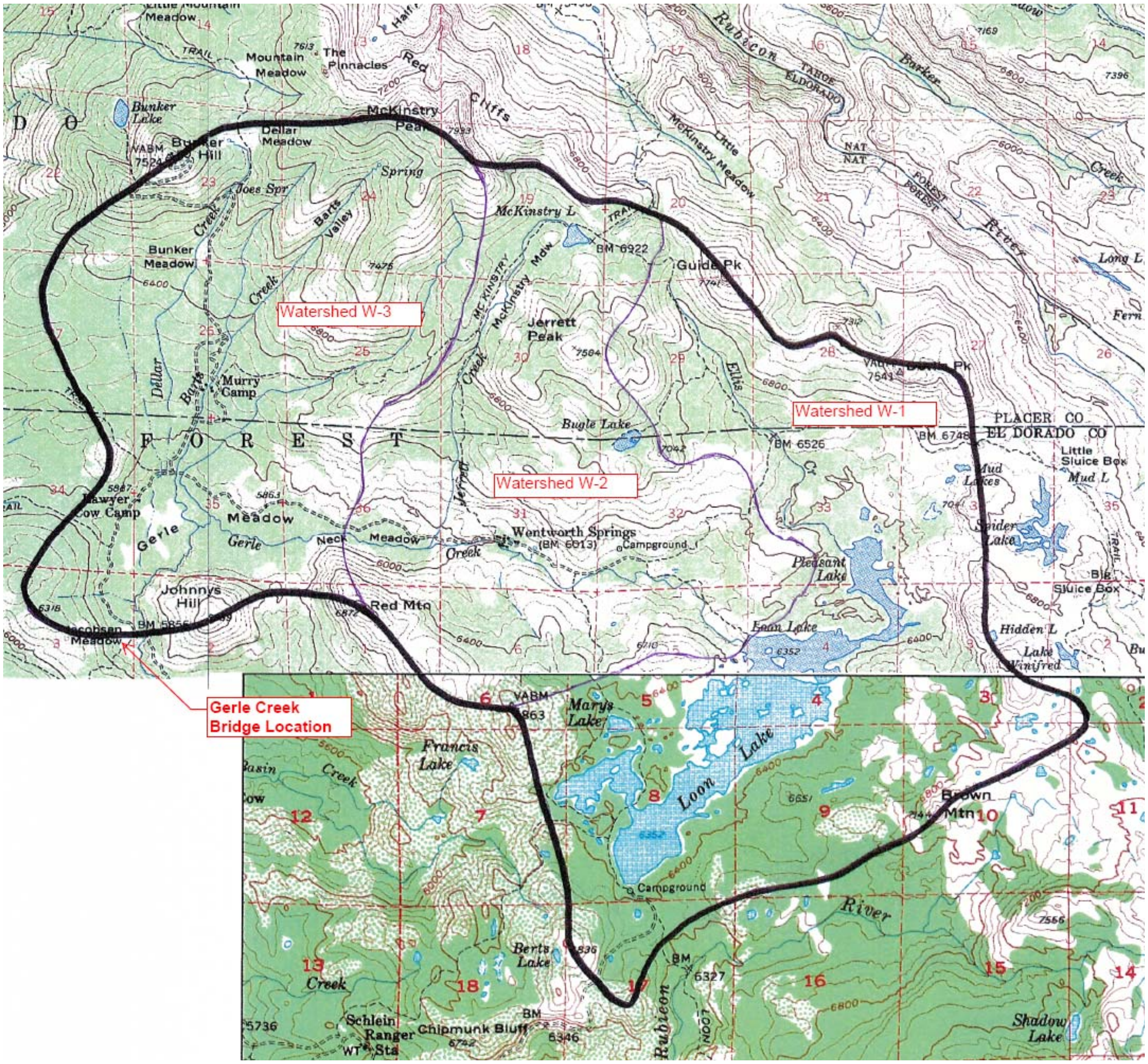

Figure 2: Gerle Creek Basin Delineation

5.1. Hydrologic Parameters

Appendix A provides the HMS model diagram and Mean Annual Precipitation for Gerle Creek shed. Also included in Appendix A are Table A-1 (precipitation depth), Table A-2 (melted precipitation), Table A-3 (sheet and shallow concentrated flow), Table A-4 (channel flow travel time), and Table A-5 (total time of concentration). Parameters used in the hydrologic model were based on concept of the Soil Conservation Service (SCS) Curve Number (CN) method. CN used for the snow condition is higher than the actual soil CN on the ground. The hydrograph used for hydrologic modeling was based on SCS type 1A temporal distribution consistent with the County of El Dorado Drainage Manual. These guidelines recommend using type 1A temporal distribution for projects located an elevation above 1640 ft.

Because the HEC-HMS snowmelt model requires data that is not available in the vicinity of the Project, snow melt has been calculated based on the average temperature, wind velocity and forest cover. A generalized Energy Budget method applicable to partly forested area was chosen from Engineer Manual 1110-2-1406 (USACOE-Runoff from Snowmelt).

The design storms were based on 24-hour duration for 10-year, 50-year and 100 year storm frequency using:

- Rainfall depth provided by the County of El Dorado Drainage Manual dated March 1995, updated August 2008, See Appendix A.
- Hydrologic parameters presented in the County of El Dorado Drainage Manual dated March 1995.

Table 1 summarizes input parameters used for the HEC-HMS hydrologic modeling, including curve number, conveyance and rainfall (rain on snow condition).

Table 1: Hydrologic Model Summary Parameters for Gerle Creek

Parameter			
Basin	**Shed W-1**	**Shed W-2**	**Shed W-3**
Watershed Area (mi^2)	8.47	5.69	7.04
Loss Rate	SCS Curve Number	SCS Curve Number	SCS Curve Number
Transform method	SCS Unit Hydrograph	SCS Unit Hydrograph	SCS Unit Hydrograph
Loss Rates			
Initial Abstraction (in)	0	0	0
Curve Number	95	95	95
Impervious Area (%)	0	0	0
Transformation			
Graph Type	Standard	Standard	Standard
Time of Concentration (min)	133.8	110.11	138.19
Lag Time (min)	80.3	66.1	82.9
Precipitation			
Hydrograph Duration	24 hour	24 hour	24 hour
Temporal Distribution	Type 1A	Type 1A	Type 1A
Mean Annual Precipitation			49
100-year precipitation (in/day)	8.95	8.95	8.95
50-year precipitation (in/day)	8.2	8.2	8.2
10-year precipitation (in/day)	6.33	6.33	6.33
Snowmelt			
100-year (in/day)	3.76	3.76	3.76
50-year (in/day)	2.83	2.83	2.83
10-year (in/day)	1.53	1.53	1.53

5.2. Land Use/Hydrologic Soil Type/Curve Number

Land use was evaluated using Google Earth image which indicates that the watershed consists of forested areas with some open areas and dirt road. The ground is assumed fully saturated after rain and snow. The SCS curve number used in the model is 95 for rain on snow and frozen soil conditions.

5.3. Peak Discharges

Peak discharges were analyzed by both HEC-HMS and USGS regression equation. Appendix B provides the peak flow hydrographs developed from the HEC-HMS models for 10-year, 50-year and 100-year peak flows. Table 2 provides HEC-HMS peak discharge based on hydrologic model parameter listed on Table 1.

Table 2: Hydrograph Analysis Summary of Results

HEC-HMS Node Location	Sub-basin Area (mi^2)	Cumulative Sub-basin Area (mi^2)	10-year Peak Flow (cfs)	50-year Peak Flow (cfs)	100-year Peak Flow (cfs)
W-1	8.47	8.47	725	1640	2296
W-2	5.69	14.15	529	1197	1675
Junction-1		14.15	529	1197	1675
W-3	7.04	21.19	582	1196	1845
Bridge Location		21.19	1110	2509	3510

USGS regression equations are useful for relatively large drainage areas (greater than 0.5 square miles) that experience a significant proportion of storm runoff from snowmelt (USACOE, 2005). Hydrologic input parameters applicable to the USGS regression equations are watershed area (mi^2), altitude index (thousands ft) and mean annual precipitation (inch). Table 3 provides the results from the USGS regression equations. The USGS regression equations are attached in Appendix C.

Table 3: USGS regression equation output

Area (mi^2)	21.19	**Input**
Mean Annual Precipitation (in)	49	
Altitude index (thousands ft)	6.13	
Return Period	**Flow (cfs)**	
2-year, Q_2	387	**Output**
5-year Q_5	951	
10-year, Q_{10}	1370	
25-year, Q_{25}	2225	
50-year, Q_{50}	2918	
100-year, Q_{100}	4003	

Table 2 and table 3 indicate that both both HEC-HMS and USGS equation for Sierra Region produced similar flows. The higher flows between HEC-HMS output and USGS regression equation method were chosen as inputs into the HEC-RAS model. Table 4 provides the peak discharge results used to analyze the proposed bridge hydraulics.

Table 4: Project Location Peak Discharge

Location	Peak Discharge		
	10% Annual Chance (10-year)	**2% Annual Chance (50-year)**	**1% Annual Chance (100-year)**
Gerle Creek Bridge	1370 cfs	2918 cfs	4003 cfs

5.4. Model Reasonableness

There is a SMUD stream gauge approximately 1.3 miles downstream of the study area. Data from the gauge allowed the hydrologic models to be calibrated to the specific events. Though the frequency of the event is unknown, the base flood is greater than the observed event flow which verifies the reasonableness of the model output. A twenty-five year yearly peak flow gauge record is included in Figure 3.

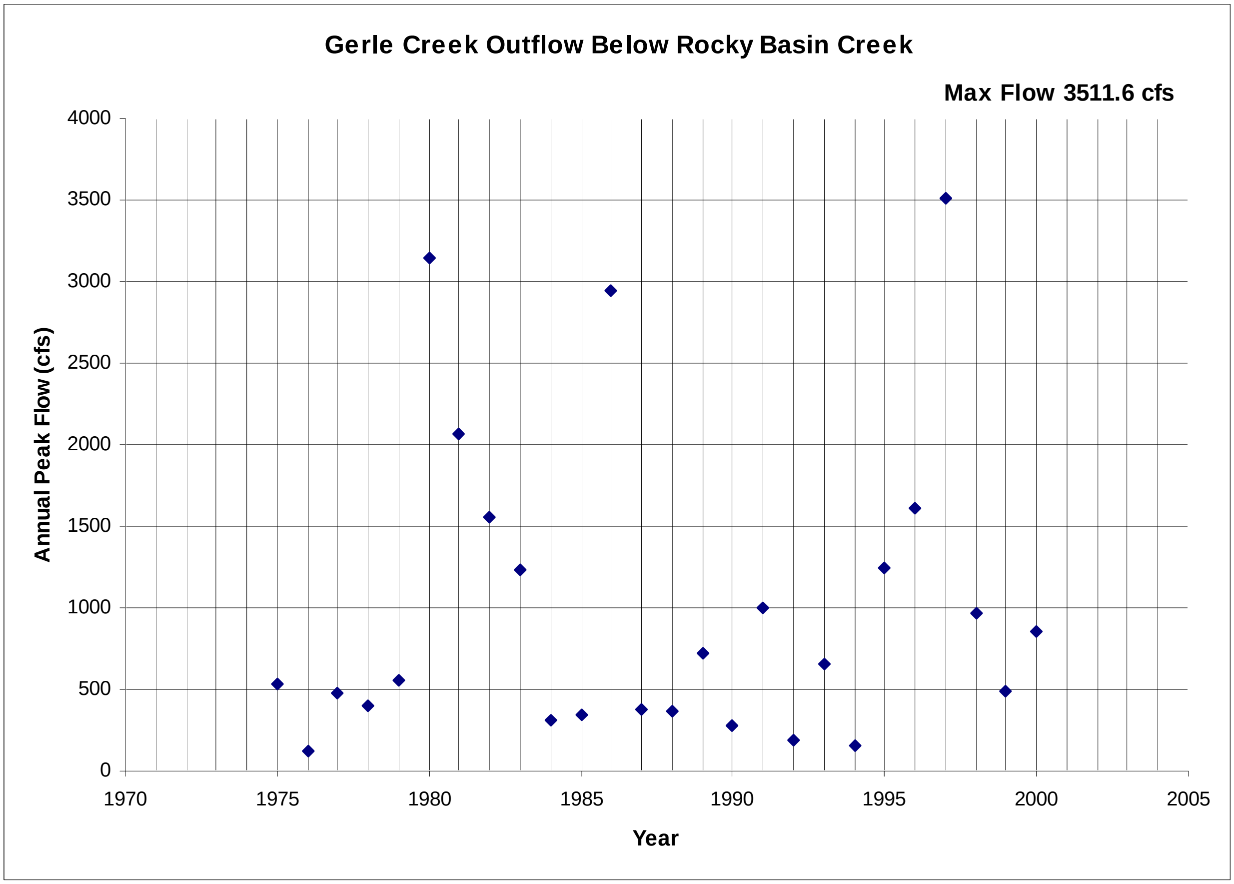

Figure 3: Yearly Peak Flow Recorded Data (1975-2000)

6. Hydraulic Model Development

The hydraulic model was extended approximately 700 ft upstream and 600 ft downstream of the proposed bridge location. A steady-flow model was developed using HEC-RAS version 4.0. Three water surface profiles, corresponding to 10-year, 50-year and 100-year peak discharges were developed.

6.1. Stream Channel Geometry Development

Information used for hydraulic modeling was derived using AutoCAD Civil 3D 2010. For each stream reach four sets of data were used to develop HEC-RAS geometry: 1) stream centerline, 2) cross section cut lines, 3) lines representing left and right banks, and 4) flow paths. AutoCAD surface data are based on an actual topographic survey performed by the County of El Dorado Department of Transportation. Cross sections were developed for the proposed project locations upstream and downstream of the bridge.

During the hydraulic modeling and preparation of this document, only local area coordinate data was available. Since then, conversion to NAD83 has been completed. It has been determined the local area elevation datum of 1000.00 ft is equivalent to an actual elevation of 5840.90 ft above mean sea level.

6.2. Bridge Modeling

The bridge scenarios were modeled using user defined cross sections for computation of energy losses. Table 5 summarizes the proposed bridge dimensions used in HEC-RAS model.

Table 5: Bridge parameters (needs verification)

Bridge Crossing	HEC-RAS River Station	Bridge Length (ft)	Bridge Width (ft)	No of Piers	Proposed Low Chord Elevation (ft)	Approximate Angle of Attack Against the Abutment (deg)
Proposed	15.1	125	16	0	1001.00	20

Proposed construction includes wing walls connecting into the interior corners of the bridge abutments, see drawing included in Appendix D.

6.3. Boundary Condition

Steady flow boundary condition was used for proposed bridge to represent the general channel hydraulics.

- **Proposed Bridge Downstream Boundary Condition:** Normal depth was used and normal depth slope of 0.02 was utilized based existing average ground slope. No FEMA flood elevations are available for the study area.

6.4. Losses

Selection of an appropriate value for Manning's *n* is very significant to the accuracy of the computed water surface profiles. The value of Manning's *n* is highly variable and depends on a number of factors including: surface roughness, vegetation, channel irregularities, channel alignment, scour and deposition, obstruction, sizes and shape of the channel, stage and discharge, seasonal changes, temperature, suspended materials, and bedload.

There are many factors that affect the selection of *n* value for the channel. The most important factors that affect that selection of the channel *n* values are: 1) the type and size of the materials that compose the bed and banks of a channel, and 2) the shape of the channel. Manning's *n* values were estimated by analyzing existing land and aerial photographs of the study area. The estimated roughness coefficients utilized for Gerle Creek and overbank reaches for this report are summarized in Table 6.

Table 6: Estimated Manning's n values for Gerle Creek Hydraulic Model

Reach	East Overbank *n*	Channel *n*	West Overbank *n*
Gerle Creek Entire Reach	0.10	0.04	0.10

6.5. Ineffective Flow Location

The proposed bridge has been analyzed without considering major ineffective areas in the flow direction.

7. Gerle Creek Hydraulic Analysis

- **Proposed Bridge**: Records indicate that three previous bridges have been washed away by flood waters. The proposed structure will replace the existing low water crossing.

8. Hydraulic Model Results

8.1. General

The summary of HEC-RAS output table is included in Appendix E.

8.2. Hydraulic Findings

Table 7 summarizes the hydraulic model results.

Table 7: Summary of the Results at the Bridge Location (Station 15.1).

Profile	Peak Flow (cfs)	WSE	U/S velocity (ft/s)	Freeboard Requirement
10-year	1370	996.06	7.50	-
50-year	2918	997.92	10.00	Minimum 3 ft
100-year	4003	998.97	10.60	Minimum 2 ft

The cross section provided in Appendix E from hydraulic modeling indicates that the 100-year and 50-year event water surfaces are 998.97 ft and 997.92 ft respectively. To maintain minimum 3 ft freeboard for design (50-year event) flood and 2 ft freeboard for base (100-year event) flood, the low chord elevation of the bridge shall be located at or above an elevation of 1001.00 ft.

9. Scour Analysis

9.1. General

Flow velocities at the bridge location were reviewed for purpose of determining scour potential. The minimum design standard for bridge scour is the base flood (100-year event flood). Scour analysis has been performed using the methodology described in Hydraulic Engineering Circular No 18, Evaluating Scour at Bridge (May 2001).

Scour is the result of the erosive action of flowing water, excavating and carrying away materials from the bed and the bank of the stream and from around the piers and abutments of the bridges. The most common cause of the bridge failure is scouring of bed materials around bridge foundations. It should be noted that scour rates are dependent on the particular materials. Loose granular soils are prone to rapid erosion by flowing water while cohesive or cemented soils are more scour resistant.

9.2. Scour Analysis Methodology

No geologic hazards have been identified at the Gerle Creek Bridge site. However, sands found at approximately 15 to 20 ft below ground surface in all borings are considered potentially liquefiable. Apparent scour has been observed at the base of the bank on the southeast side of the creek. The scour area is immediately downstream of the southeastern abutment. This pattern of erosion appears consistent with high flow periods of Gerle Creek. It can be expected that high water events along Gerle Creek coincide with seasonal snow melt (Taber 2009).

A preliminary scour analysis has been computed using the hydraulic model developed and soil data. Particle size distribution report by Taber Consultant approximates the value of mean size fraction of the bed material (D_{50}) to be 0.2 mm for gravelly sand with cobbles, small boulders and silt.

9.3. Long Term Aggradation and Degradation

Long-term aggradation and degradation may be the result of natural or anthropogenic forces. The streambed may be aggrading, degrading, or in relative equilibrium in the vicinity of the bridge crossing. No long term degradation and aggradation data is available at the proposed Gerle Creek bridge location. There is no visible sign of long term aggradation or degradation at the proposed bridge location; therefore, long term aggradation and degradation is assumed to be negligible.

9.4. Contraction Scour

Contraction scour occurs when the flow area of the stream is reduced by natural features or by a bridge. The HEC-RAS program offer options to either manually input one these forms of contraction or to select the default option where the program automatically determines the form of contraction to be used based on critical velocities and mean flow velocities in the channel and overbanks.

As stated before, a value of 0.2 mm was assigned for D_{50} and water temperature was assumed to be 40^{o}F. Contraction scour was computed for the 100-year flood event. Results of the contraction scour are presented in Table 8.

Table 8: Summary of Contraction Scour at the Proposed Bridge

Parameters	100-year Flood		
	East Overbank	**Channel**	**West Overbank**
Contraction Scour			
Scour Depth Ys (ft)	0.30	1.03	0.24
Critical Velocity (ft/s)	1.06	1.32	0.99
Equation	Live	Live	Live

9.5. Local Scour

Local scour consists of pier and abutment scour. Since there are no piers in the proposed bridge, only scour at the abutment is a concern. Scour occurs when the abutment and the embankment obstruct the flow.

Since the east abutment is located outside the base floodplain, no local scour is calculated by model at that abutment. Scour at the west abutment was computed by Froehilich's equation. The user is required to enter the abutment type and skew angles. The program selects values for all of the other variables based on the hydraulic output and the default settings. The results of the abutment scour are presented in Table 9.

Table 9: Summary of Local Scour at the Proposed Bridge

Parameters	100-year Flood	
	East Overbank	**West Overbank**
Scour Depth Y_s (ft)		3.71
$Q_e/A_e=V_e$		1.21
Froude Number		0.20
Equation	Default	Froehlich

9.6. Total Scour

Total scour is the combination of long-term elevation changes (aggradation and degradation), contraction scour, and local scour at each individual pier and abutment location. Since long term bed elevation changes were assumed to be negligible, total scour was computed as the sum of contraction and local scour. The total scour of the proposed bridge is presented in Table 10. Figure 4 represents contraction scour and total scour at the proposed bridge.

Table 10: Summary of Total Scour at the Proposed Bridge

Parameters	100-year Flood		
	East Overbank	**Channel**	**West Overbank**
Total Scour Depth (ft)	0.30	1.02	3.95

Total scour is in the range of 1 to 4 feet for the abutments based on the assumption that the scoured materials are erodible sediment and the east abutment is located outside the base floodplain.

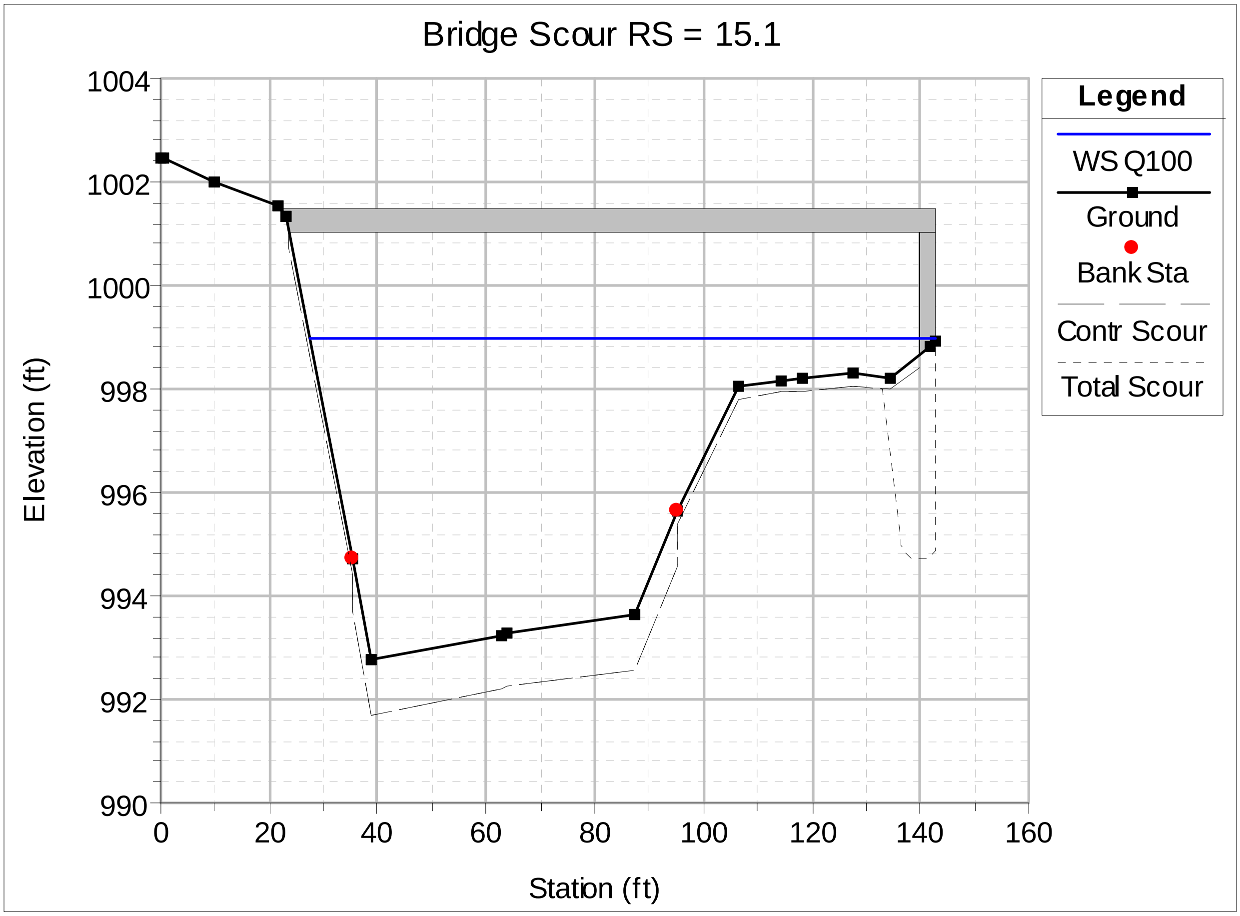

Figure 4: Contraction scour and total scour at the proposed bridge

Rip-rap is recommended for both bank and abutment protection. Based on the upstream velocity from the proposed bridge location, the size of the designed rock is ¼ ton consistent to the Caltrans Highway Design Manual and USACOE EM 1110-2-1601. It is recommended that the designed rocks shall be placed by method B.

10. Conclusion

To satisfy Caltrans hydraulic design requirements and the County design practice for both 50-year and 100-year computed peak flows, it is advised to follow the recommendations below. Table 11 summarizes the recommendations based on Caltrans and the County of El Dorado design criteria.

Table 11: Recommendations

Caltrans Requirement	Summary/Recommendations
• **The proposed bridge will be able to pass the two percent (2%) probability flood or tide (Q_{50}) or the flood-of-record, whichever is greater without causing objectionable backwater, excessive flow velocities, or encroaching on through traffic lanes. Sufficient freeboard, typically a minimum freeboard of 2 feet is often assumed for bridge design.**	• **To meet the minimum requirement of 3 ft freeboard for 50-year event flood and 2 ft freeboard for 100-year event flood, the low chord elevation of the proposed bridge is recommended to be set at or above an elevation of 1001.00.** • **Banks and abutments shall be protected with ¼ ton rip-rap, method B placement.**

11. References

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2. SMUD (2007), Gerle Creek outflow below Rocky Basin Creek, Gauge Data
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20. Department of Water Resources, California Data Exchange Center http://cdec.water.ca.gov/cgi-progs/selectQuery?station_id=LON&dur_code=D&sensor_num=&start_date=01/10/1997+00:00&end_date=08/06/2010+12:36 retrieved on 9/28/2010

Appendix A: HEC-HMS Model

Appendix B: HEC-HMS Model Results

Appendix C: USGS Equations

Appendix D: Bridge Plans and Sections

Appendix E: Summary of HEC-RAS Output

Appendix A: HEC-HMS Model

HEC-HMS

Project : Rubicon

Basin Model : Gerle

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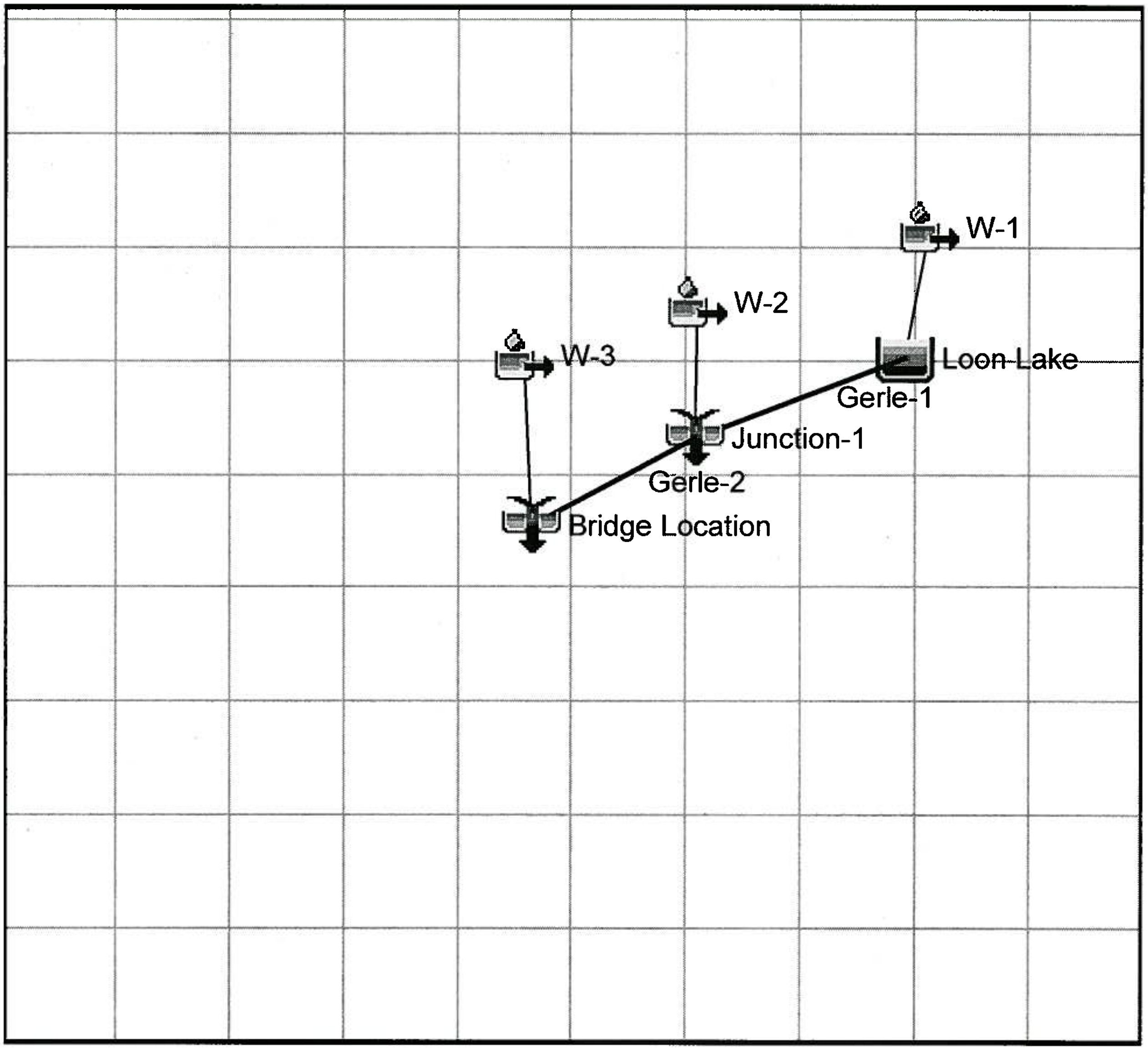


Project: Rubicon Simulation Run: Run 10 year

Start of Run: 01Jan2009, 00:00 Basin Model: Gerle
End of Run: 03Jan2009, 00:00 Meteorologic Model: 10 year 49"
Compute Time: 15Sep2010, 13:59:27 Control Specifications: DP-1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
W-1	8.47	724.5	01Jan2009, 09:20	1.04
Loon Lake	8.47	106.8	02Jan2009, 01:12	0.25
Gerle-1	8.47	106.8	02Jan2009, 01:52	0.25
W-2	5.69	529.3	01Jan2009, 09:04	1.04
Junction-1	14.16	529.3	01Jan2009, 09:04	0.57
Gerle-2	14.16	528.8	01Jan2009, 09:20	0.57
W-3	6.90	582.2	01Jan2009, 09:24	1.04
Bridge Location	21.06	1109.7	01Jan2009, 09:20	0.72

Project: Rubicon Simulation Run: Run 50

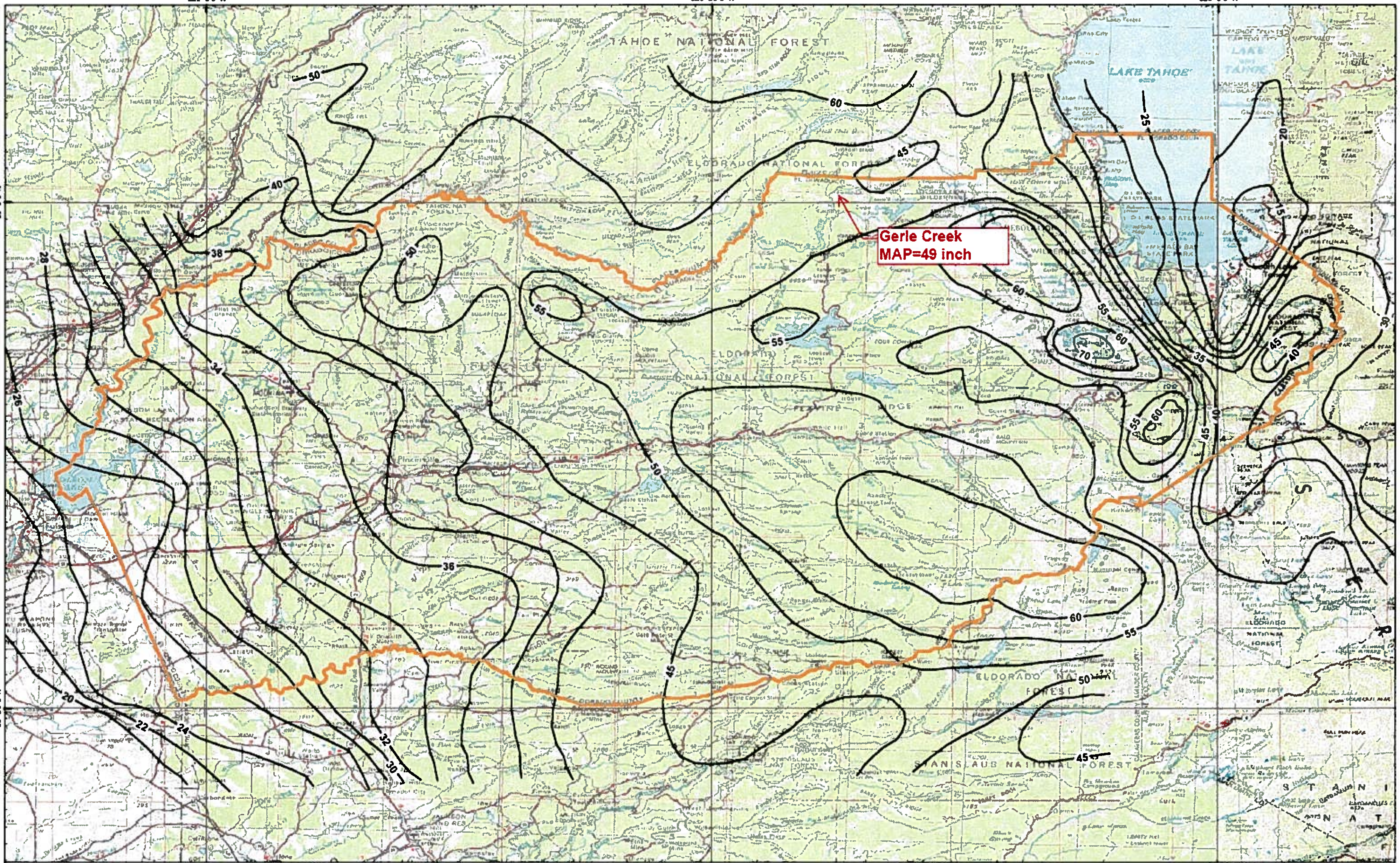
Start of Run: 01Jan2009, 00:00 Basin Model: Gerle
End of Run: 03Jan2009, 00:00 Meteorologic Model: 50 year 49"
Compute Time: 15Sep2010, 13:58:53 Control Specifications: DP-1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
W-1	8.47	1639.6	01Jan2009, 09:16	2.28
Loon Lake	8.47	449.3	01Jan2009, 18:12	1.48
Gerle-1	8.47	449.3	01Jan2009, 18:40	1.47
W-2	5.69	1196.5	01Jan2009, 09:00	2.28
Junction-1	14.16	1196.5	01Jan2009, 09:00	1.80
Gerle-2	14.16	1195.7	01Jan2009, 09:12	1.80
W-3	6.90	1317.7	01Jan2009, 09:20	2.28
Bridge Location	21.06	2508.9	01Jan2009, 09:16	1.96

Project: Rubicon Simulation Run: Run 100

Start of Run: 01Jan2009, 00:00 Basin Model: Gerle
End of Run: 03Jan2009, 00:00 Meteorologic Model: 100 year 49"
Compute Time: 15Sep2010, 13:48:26 Control Specifications: DP-1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
W-1	8.47	2296.0	01Jan2009, 09:16	3.19
Loon Lake	8.47	754.2	01Jan2009, 14:16	2.38
Gerle-1	8.47	754.1	01Jan2009, 14:36	2.38
W-2	5.69	1674.5	01Jan2009, 09:00	3.19
Junction-1	14.16	1674.5	01Jan2009, 09:00	2.71
Gerle-2	14.16	1672.8	01Jan2009, 09:12	2.71
W-3	6.90	1845.0	01Jan2009, 09:20	3.19
Bridge Location	21.06	3509.6	01Jan2009, 09:16	2.87



0 6 12 24 Miles	Mean annual precipitation for El Dorado County, CA
Units are inches per year	County boundary

Note:
Source: Report on El Dorado County design rainfall.
Prepared by Jim Goodridge, August 2005.

MAP mapping
NAD 83

Table A-1: Total Precipitation and Snowmelt Depth

Type/Event	2 yrs	5 yrs	10 yrs	25 yrs	50 yrs	100 yrs
P_r (inch/d)	3.99	5.43	6.33	7.43	8.2	8.95
M (inch/d)	0.63	1.11	1.53	2.24	2.83	3.76

Table A-2: Hydrologic Parameters for Snowmelt

Event	Basin Wind Coeff. (k)	Wind Velocity v (mph)	Saturated Air Temp (T_a °F)	Snowmelt M (inch/day)
2 yrs	0.7	9	37	0.63
5 yrs	0.7	14	39	1.11
10 yrs	0.7	19	40	1.53
25 yrs	0.7	24	42	2.24
50 yrs	0.7	29	43	2.83
100 yrs	0.7	34	45	3.76

Table A-3: Sheet and Shallow Concentrated Flow Travel Time

	Sheet Flow (L =300 ft)					Shallow Concentrated Flow				
	Sheet	Δelev /ΔLs	P_2	Overland Rough	T_{sheet}		Δelev /ΔLs	*Unpaved	**Paved	T_{conc}
Watershed	Ls (ft)	Slope	(in.)	*n*	(min)	L (ft)	Slope	V (ft/s)	V (ft/s)	(min)
W-1	300	0.12	5.43	0.7	30.34	1500	0.12	5.59		4.47
W-2	300	0.18	5.43	0.7	25.79	1500	0.10	5.10		4.90
W-3	300	0.18	5.43	0.7	25.79	1550	0.12	5.59		4.62

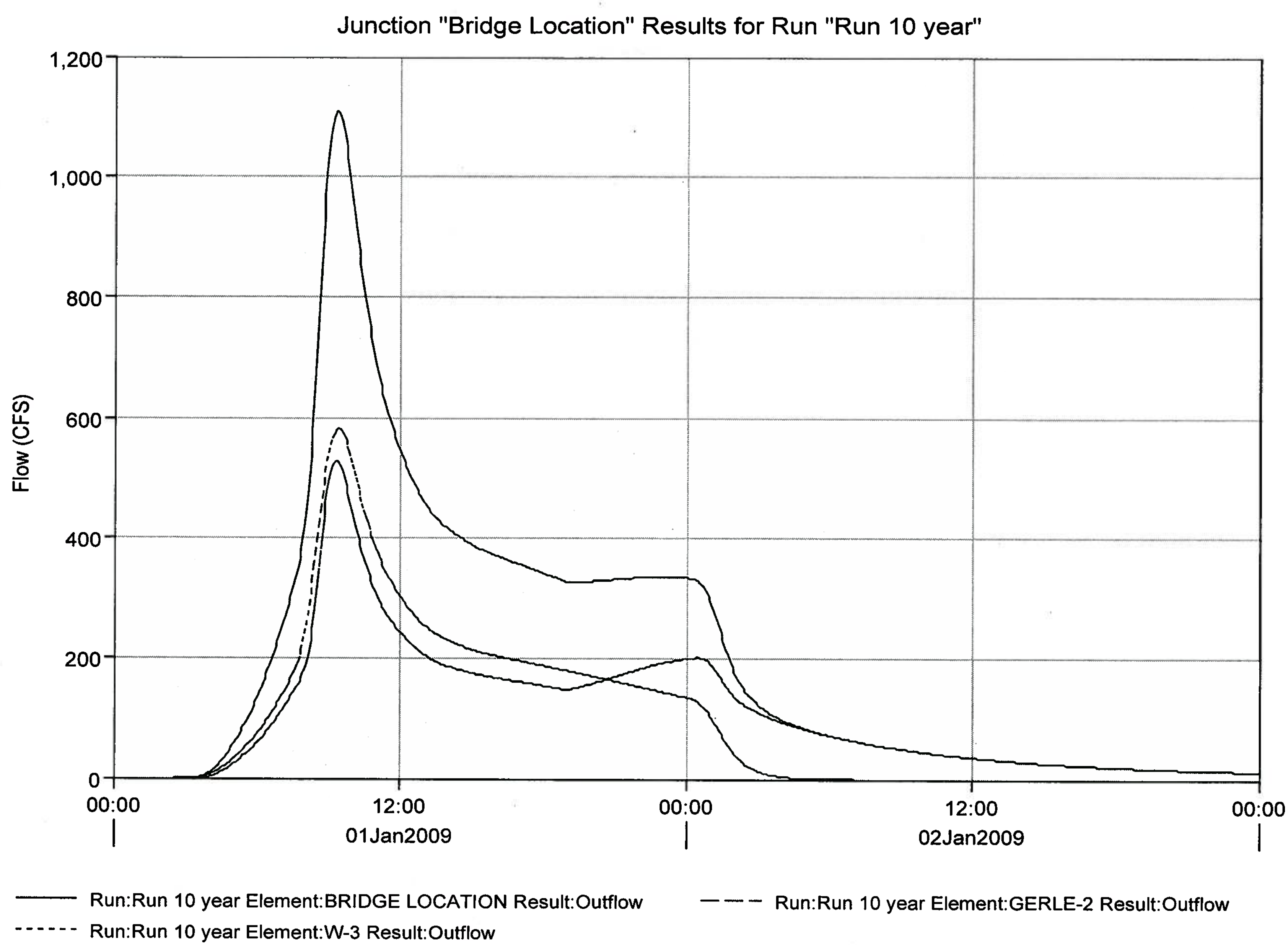
Table A-4: Channel Flow Travel Time

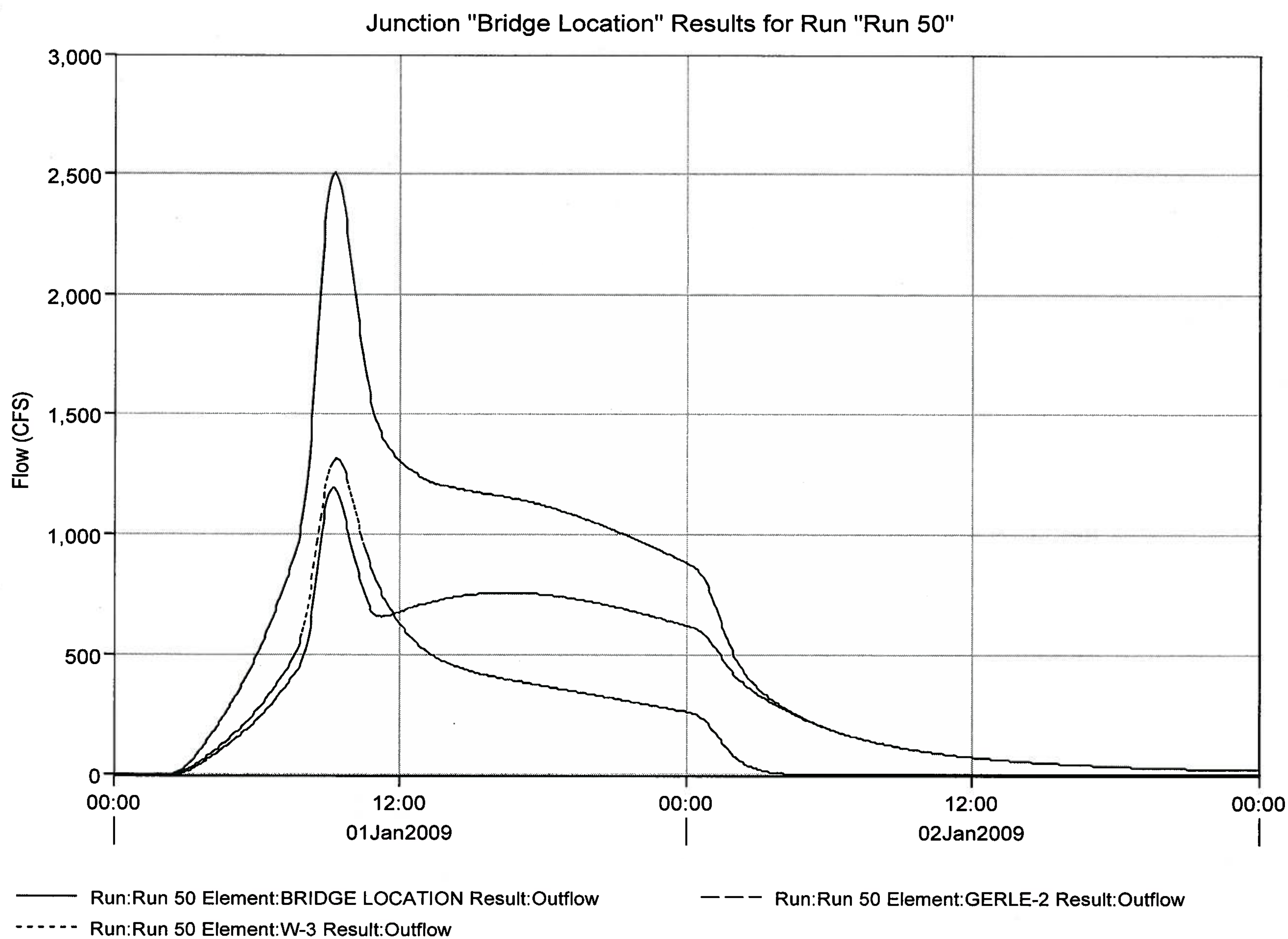
Basin	Length (ft)	Slope	Manning's *n*	T_c (min)	Velocity (ft/s)
W-1	19600	0.08	0.05	99	3.3
W-2	16200	0.06	0.05	79	3.4
W-3	19400	0.04	0.05	108	3
Reach-1	16400	0.03	0.05	For HMS Model	
Reach-2	8750	0.02	0.05	For HMS Model	

Table A-5: Time of Concentration

Total Flow Length (ft)	Basin	Tc,channel flow (min)	Tc,sheet flow (min)	Tc,shallow flow (min)	Total Tc (min)	Tlag=0.6*Tc (min)
21400	W-1	99.0	30.34	4.47	133.80	80.3
18000	W-2	79.4	25.79	4.90	110.11	66.1
21250	W-3	107.8	25.79	4.62	138.19	82.9

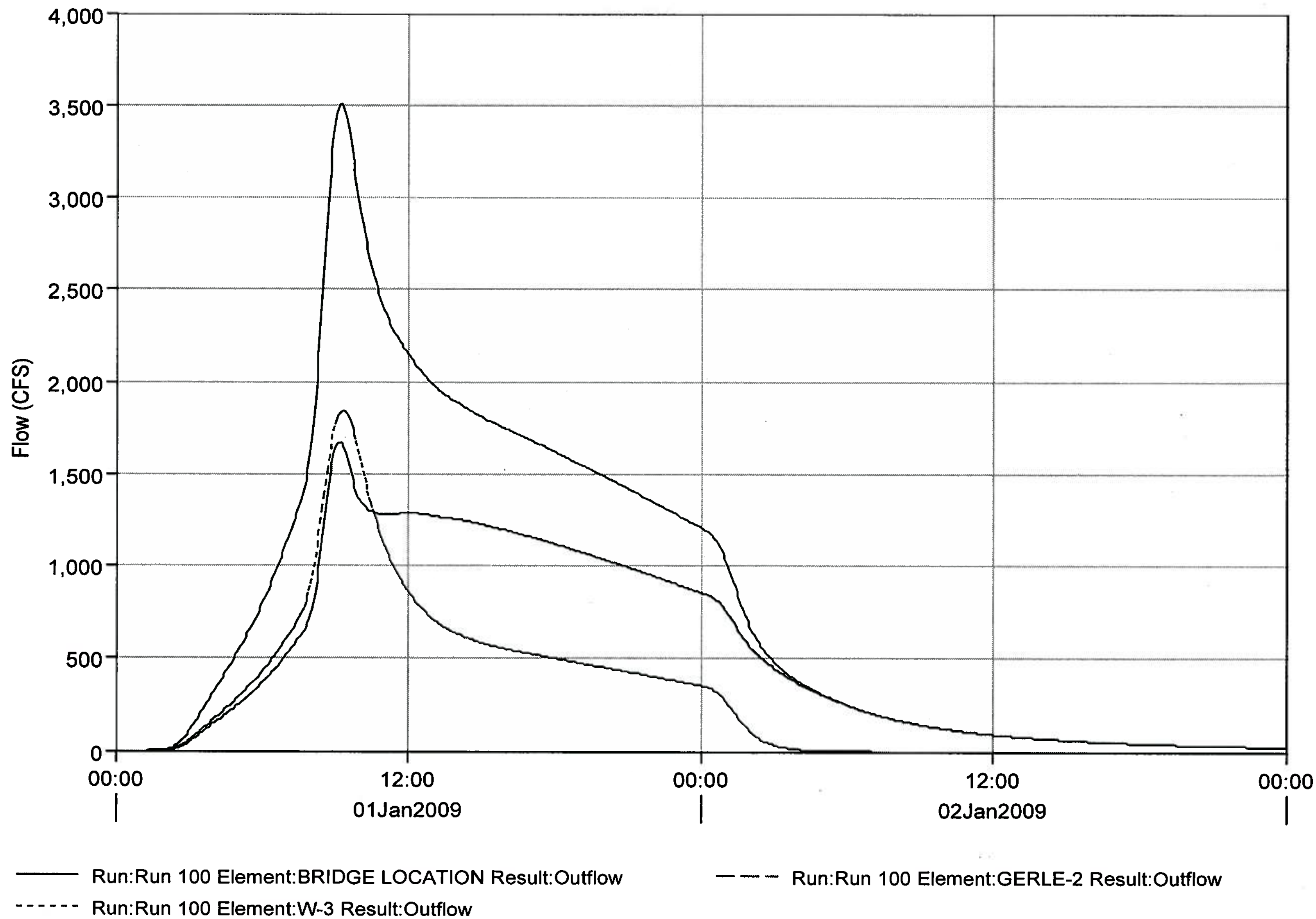
Appendix B: HEC-HMS Model Results


Junction "Bridge Location" Results for Run "Run 10 year"
Flow (CFS)
1,200
1,000
800
600
400
200
0
00:00
12:00
01Jan2009
00:00
12:00
02Jan2009
00:00
Run:Run 10 year Element:BRIDGE LOCATION Result:Outflow
Run:Run 10 year Element:GERLE-2 Result:Outflow
Run:Run 10 year Element:W-3 Result:Outflow



Junction "Bridge Location" Results for Run "Run 50"
Flow (CFS)
3,000
2,500
2,000
1,500
1,000
500
0
00:00
12:00
00:00
12:00
00:00
01Jan2009
02Jan2009
Run:Run 50 Element:BRIDGE LOCATION Result:Outflow
Run:Run 50 Element:GERLE-2 Result:Outflow
Run:Run 50 Element:W-3 Result:Outflow

Junction "Bridge Location" Results for Run "Run 100"



Appendix C: USGS Equations

The following documentation was taken from:

U.S. Geological Survey Water-Resources Investigations Report 94-4002: *Nationwide summary of U.S. Geological Survey regional regression equations for estimating magnitude and frequency of floods for ungaged sites, 1993*

CALIFORNIA

STATEWIDE RURAL

Summary

California is divided into six hydrologic regions (fig. 1). The regression equations developed for these regions are for estimating peak discharges (QT) having recurrence intervals T that range from 2 to 100 years. The explanatory basin variables used in the equations are drainage area (A), in square miles; mean annual precipitation (P), in inches; and an altitude index (H), which is the average of altitudes in thousands of feet at points along the main channel at 10 percent, and 85 percent of the distances from the site to the divide. The variables A and H may be measured from topographic maps. Mean annual precipitation (P) is determined from a map in Rantz (1969). The regression equations were developed from peak-discharge records of 10 years or longer, available as of 1975, at more than 700 gaging stations throughout the State. The regression equations are applicable to unregulated streams but are not applicable to some parts of the State (see fig. 1). The standard errors of estimate for the regression equations for various recurrence intervals and regions range from 60 to over 100 percent. The report by Waananen and Crippen (1977) includes an approximate procedure for increasing a rural discharge to account for the effect of urban development. The influences of fire and other basin changes on flood magnitudes are also discussed.

Procedure

Topographic maps, the hydrologic regions map (fig. 1), the mean annual precipitation from Rantz (1969), and the following equations are used to estimate the needed peak discharges QT, in cubic feet per second, having selected recurrence intervals T.

North Coast Region

$Q2 = 3.52\ A^{0.90}\ P^{0.89}\ H^{-0.47}$
$Q5 = 5.04\ A^{0.89}\ P^{0.91}\ H^{-0.35}$
$Q10 = 6.21\ A^{0.88}\ P^{0.93}\ H^{-0.27}$
$Q25 = 7.64\ A^{0.87}\ P^{0.94}\ H^{-0.17}$
$Q50 = 8.57\ A^{0.87}\ P^{0.96}\ H^{-0.08}$
$Q100 = 9.23\ A^{0.87}\ P^{0.97}$

Northeast Region

$Q2 = 22\ A^{0.40}$
$Q5 = 46\ A^{0.45}$
$Q10 = 61\ A^{0.49}$
$Q25 = 84\ A^{0.54}$
$Q50 = 103\ A^{0.57}$
$Q100 = 125\ A^{0.59}$

Sierra Region

$Q2 = 0.24\ A^{0.88}\ P^{1.58}\ H^{-0.80}$
$Q5 = 1.20\ A^{0.82}\ P^{1.37}\ H^{-0.64}$
$Q10 = 2.63\ A^{0.80}\ P^{1.25}\ H^{-0.58}$
$Q25 = 6.55\ A^{0.79}\ P^{1.12}\ H^{-0.52}$
$Q50 = 10.4\ A^{0.78}\ P^{1.06}\ H^{-0.48}$
$Q100 = 15.7\ A^{0.77}\ P^{1.02}\ H^{-0.43}$

Central Coast Region

$Q2 = 0.0061\ A^{0.92}\ P^{2.54}\ H^{-1.10}$
$Q5 = 0.118\ A^{0.91}\ P^{1.95}\ H^{-0.79}$
$Q10 = 0.583\ A^{0.90}\ P^{1.61}\ H^{-0.64}$
$Q25 = 2.91\ A^{0.89}\ P^{1.26}\ H^{-0.50}$
$Q50 = 8.20\ A^{0.89}\ P^{1.03}\ H^{-0.41}$
$Q100 = 19.7\ A^{0.88}\ P^{0.84}\ H^{-0.33}$

South Coast Region

$Q2 = 0.14\ A^{0.72}\ P^{1.62}$
$Q5 = 0.40\ A^{0.77}\ P^{1.69}$
$Q10 = 0.63\ A^{0.79}\ P^{1.75}$
$Q25 = 1.10\ A^{0.81}\ P^{1.81}$
$Q50 = 1.50\ A^{0.82}\ P^{1.85}$
$Q100 = 1.95\ A^{0.83}\ P^{1.87}$

South Lahontan-Colorado Desert Region

$Q2 = 7.3A^{0.30}$
$Q5 = 53A^{0.44}$
$Q10 = 150A^{0.53}$
$Q25 = 410A^{0.63}$
$Q50 = 700A^{0.68}$
$Q100 = 1080A^{0.71}$

In the North Coast region, use a minimum value of 1.0 for the altitude index (H). Equations are defined only for basins of 25 mi^2 or less in the Northeast and South Lahontan-Colorado Desert regions.

Reference

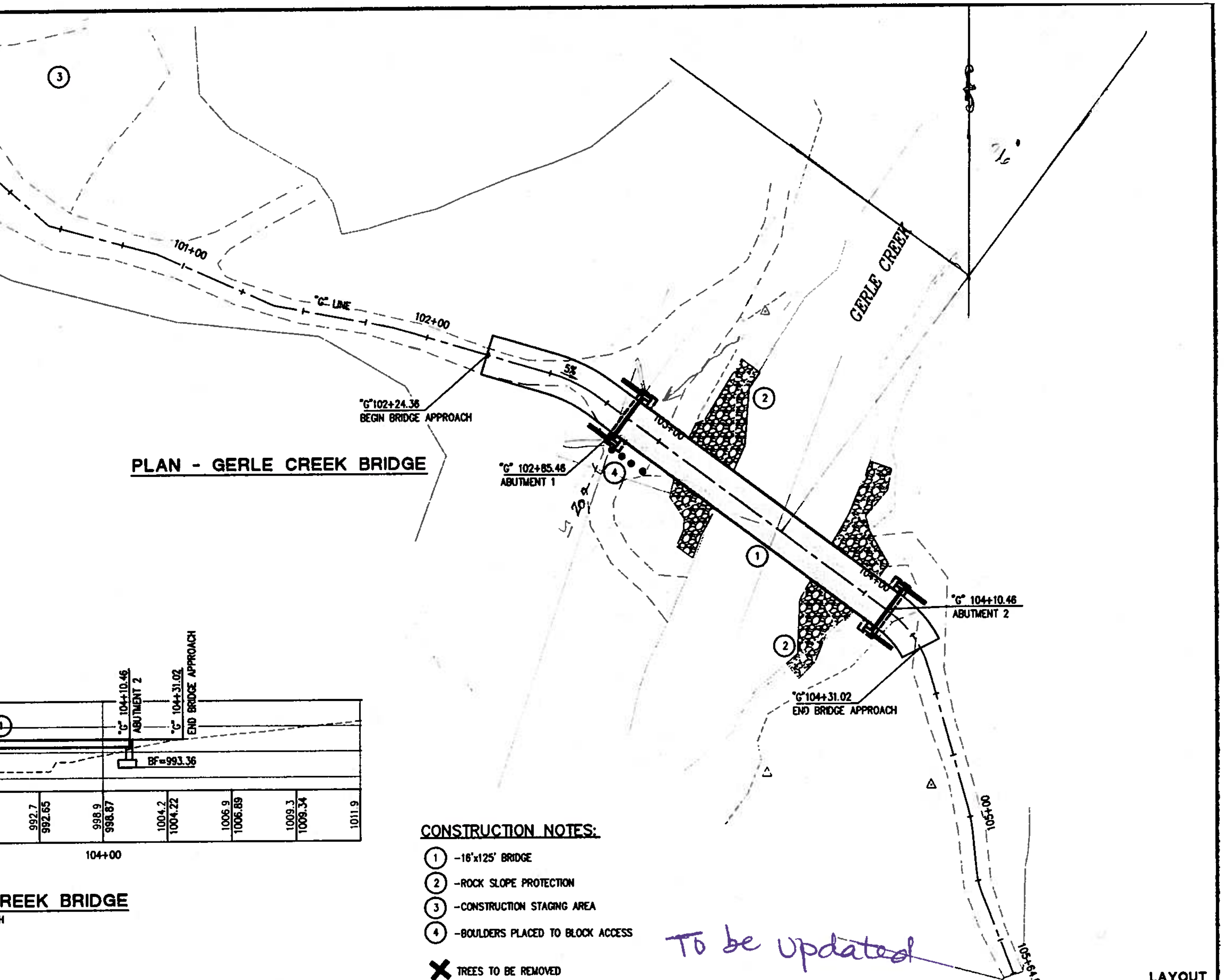
Waananen, A.O., and Crippen, J.R., 1977, Magnitude and frequency of floods in California: U.S. Geological Survey Water-Resources Investigations Report 77-21, 96 p.

Additional Reference

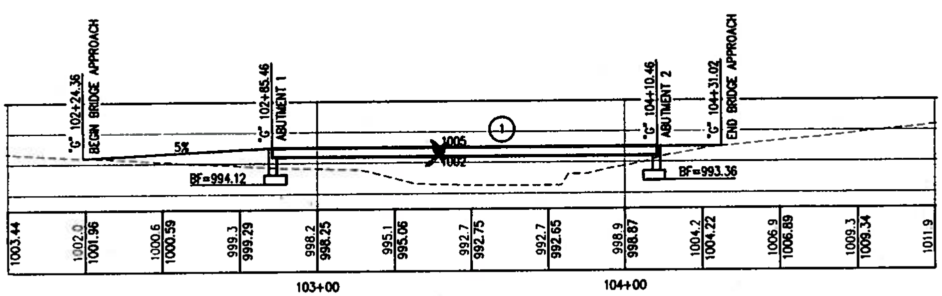
Rantz, S.E., 1969, Mean annual precipitation in the California region: U.S. Geological Survey Open-File Map (Reprinted 1972, 1975).

Figure 1. Flood-frequency region map for California. (PostScript file of Figure 1.)

Appendix D: Bridge Plans and Sections



PLAN - GERLE CREEK BRIDGE



PROFILE - GERLE CREEK BRIDGE

SCALE: 1"=20'V,H

CONSTRUCTION NOTES:

1. -16'x125' BRIDGE
2. -ROCK SLOPE PROTECTION
3. -CONSTRUCTION STAGING AREA
4. -BOULDERS PLACED TO BLOCK ACCESS

X TREES TO BE REMOVED

To be updated

PRELIMINARY 30%

LAYOUT
SCALE : 1" = 20'

PREPARED UNDER THE SUPERVISION OF	DESIGNED: DWH	DRAWN: RR	
REGISTERED CIVIL ENGINEER DATE	CHECKED: DWH	DATE: 9/10/10	
	ROAD NUMBER: 14N340		

EL DORADO COUNTY
DEPARTMENT OF TRANSPORTATION

WENTWORTH SPRINGS ROAD
at GERLE CREEK
BRIDGE REPLACEMENT

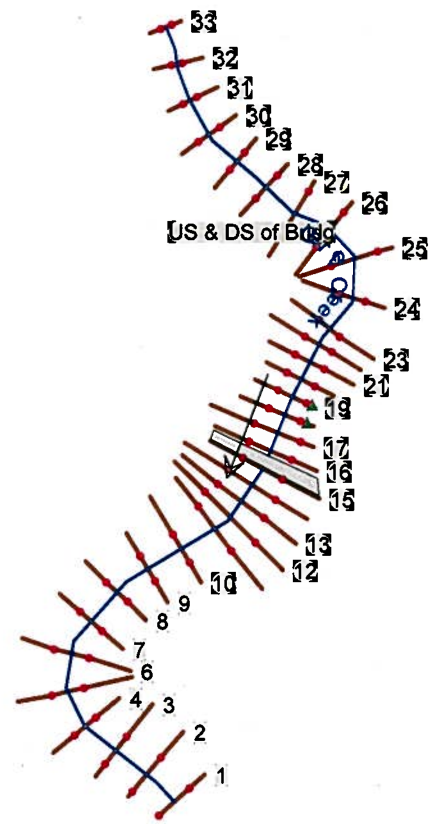
SHEET L-1
2 OF XX
77118

REVISION			
NUMBER	DATE	DESCRIPTION	BY

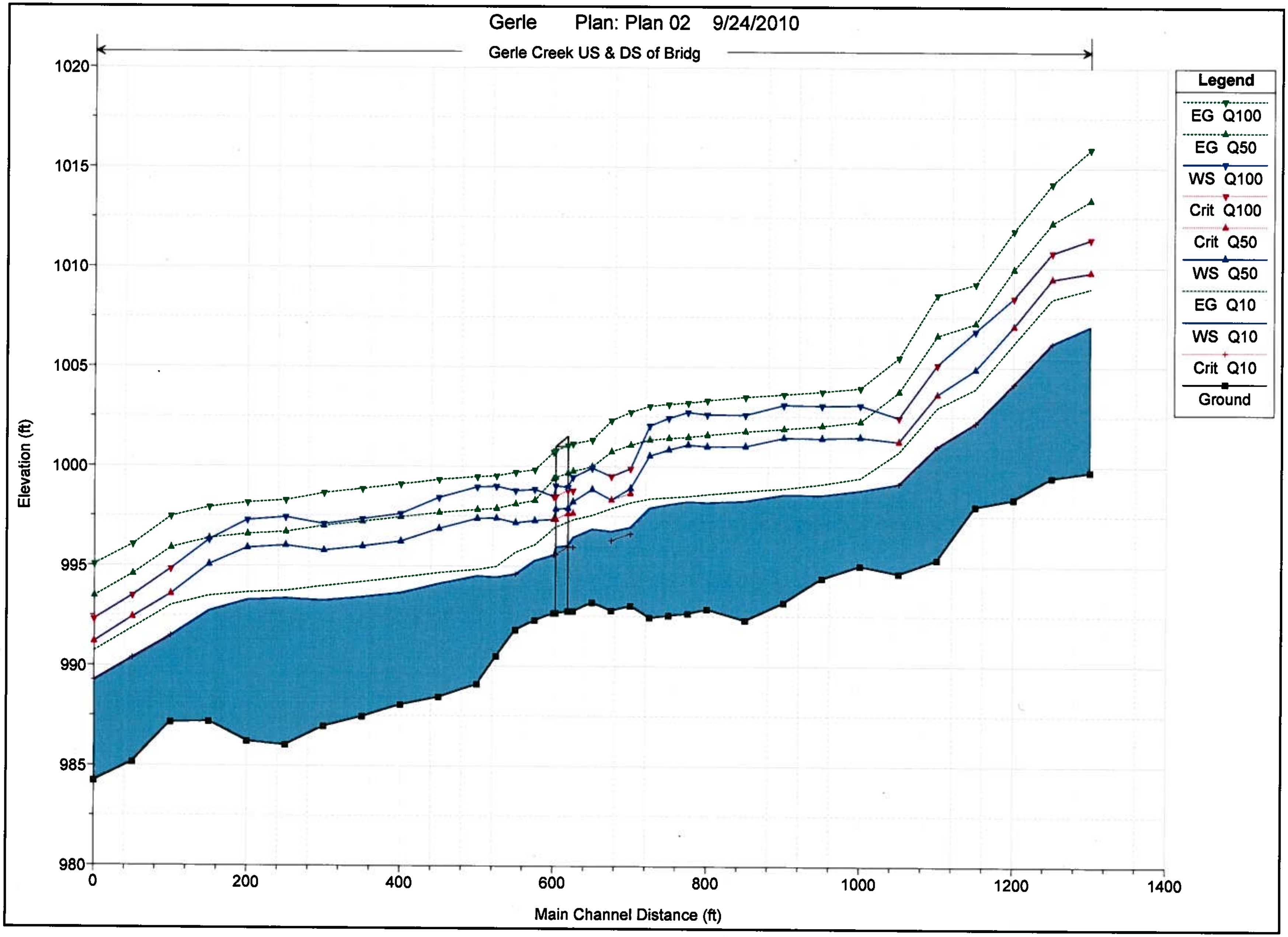
FOR REDUCED PLANS ORIGINAL SCALE IS IN INCHES
0 1 2

Drawing name: C:\Civil 3D Projects\77118 Gerle Creek\CADD Files\Sheets\L-1.dwg Layout Tab: L-1 Sep 10,2010 - 2:29pm BRichards

Appendix E: Summary of HEC-RAS Output



None of the XS's are Geo-Referenced (Geo-Ref user entered XS) (Geo-Ref interpolated XS) (Non Geo-Ref user entered XS) (Non Geo-Ref interpolated XS)


Gerle Plan: Plan 02 9/24/2010
Gerle Creek US & DS of Bridg
Legend
EG Q100
EG Q50
WS Q100
Crit Q100
Crit Q50
WS Q50
EG Q10
WS Q10
Crit Q10
Ground
Elevation (ft)
1020
1015
1010
1005
1000
995
990
985
980
0
200
400
600
800
1000
1200
1400
Main Channel Distance (ft)

HEC-RAS Plan: Plan 01 River: Gerle Creek Reach: US & DS of Bridg

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US & DS of Bridg	33	Q10	1370.00	999.74	1007.07		1008.95	0.008267	11.79	172.53	38.41	0.80
US & DS of Bridg	33	Q50	2918.00	999.74	1009.75	1009.75	1013.38	0.010747	16.84	282.38	43.14	0.97
US & DS of Bridg	33	Q100	4003.00	999.74	1011.40	1011.40	1015.95	0.011127	19.09	353.65	43.14	1.01
US & DS of Bridg	32	Q10	1370.00	999.45	1006.21	1006.21	1008.43	0.011745	13.28	174.24	47.87	0.94
US & DS of Bridg	32	Q50	2918.00	999.45	1009.41	1009.41	1012.23	0.009792	16.03	359.50	64.40	0.92
US & DS of Bridg	32	Q100	4003.00	999.45	1010.73	1010.73	1014.21	0.010632	18.24	444.32	64.40	0.98
US & DS of Bridg	31	Q10	1370.00	998.36	1004.17	1004.17	1006.20	0.012722	12.11	157.53	46.35	0.95
US & DS of Bridg	31	Q50	2918.00	998.36	1007.05	1007.05	1009.91	0.010616	14.97	316.26	63.35	0.94
US & DS of Bridg	31	Q100	4003.00	998.36	1008.48	1008.48	1011.84	0.010466	16.60	409.19	66.78	0.96
US & DS of Bridg	30	Q10	1370.00	998.00	1002.21	1002.21	1003.92	0.014977	10.73	147.00	47.98	0.99
US & DS of Bridg	30	Q50	2918.00	998.00	1004.88		1007.20	0.010066	12.70	289.48	58.89	0.89
US & DS of Bridg	30	Q100	4003.00	998.00	1006.81		1009.19	0.007403	13.01	411.11	67.22	0.80
US & DS of Bridg	29	Q10	1370.00	995.33	1001.04	1001.04	1002.96	0.014268	11.27	135.53	40.25	0.98
US & DS of Bridg	29	Q50	2918.00	995.33	1003.63	1003.63	1006.59	0.011861	14.22	253.32	50.58	0.97
US & DS of Bridg	29	Q100	4003.00	995.33	1005.12	1005.12	1008.62	0.010992	15.64	332.91	56.50	0.96
US & DS of Bridg	28	Q10	1370.00	994.64	999.16	999.16	1000.75	0.015626	10.17	141.99	49.98	0.99
US & DS of Bridg	28	Q50	2918.00	994.64	1001.27	1001.27	1003.76	0.012875	12.87	256.58	58.48	0.98
US & DS of Bridg	28	Q100	4003.00	994.64	1002.47	1002.47	1005.48	0.012064	14.24	330.00	63.73	0.98
US & DS of Bridg	27	Q10	1370.00	995.04	998.83		999.45	0.006109	6.37	230.01	80.64	0.62
US & DS of Bridg	27	Q50	2918.00	995.04	1001.48		1002.26	0.003578	7.26	466.22	96.11	0.53
US & DS of Bridg	27	Q100	4003.00	995.04	1003.09		1003.95	0.002916	7.69	626.31	102.97	0.49
US & DS of Bridg	26	Q10	1370.00	994.40	998.59		999.14	0.005255	6.23	281.55	105.82	0.59
US & DS of Bridg	26	Q50	2918.00	994.40	1001.43		1002.05	0.002859	6.82	588.19	110.04	0.48
US & DS of Bridg	26	Q100	4003.00	994.40	1003.07		1003.77	0.002406	7.29	770.66	112.57	0.45
US & DS of Bridg	25	Q10	1370.00	993.18	998.61		998.91	0.002072	4.54	366.93	107.94	0.38
US & DS of Bridg	25	Q50	2918.00	993.18	1001.46		1001.89	0.001620	5.58	678.86	111.34	0.36
US & DS of Bridg	25	Q100	4003.00	993.18	1003.10		1003.62	0.001496	6.13	863.96	113.57	0.36
US & DS of Bridg	24	Q10	1370.00	992.30	998.30		998.78	0.002766	6.06	349.20	95.83	0.46
US & DS of Bridg	24	Q50	2918.00	992.30	1001.03		1001.76	0.002672	7.80	615.81	99.04	0.48
US & DS of Bridg	24	Q100	4003.00	992.30	1002.61		1003.49	0.002629	8.70	773.17	100.85	0.49
US & DS of Bridg	23	Q10	1370.00	992.85	998.21		998.62	0.002788	5.82	394.47	108.94	0.45
US & DS of Bridg	23	Q50	2918.00	992.85	1001.02		1001.59	0.002437	7.27	709.17	115.80	0.45
US & DS of Bridg	23	Q100	4003.00	992.85	1002.62		1003.31	0.002327	8.03	898.69	119.76	0.46
US & DS of Bridg	22	Q10	1370.00	992.64	998.26		998.52	0.001736	4.70	495.16	128.94	0.36
US & DS of Bridg	22	Q50	2918.00	992.64	1001.11		1001.49	0.001564	5.93	870.98	135.00	0.37
US & DS of Bridg	22	Q100	4003.00	992.64	1002.74		1003.20	0.001502	6.56	1091.86	135.00	0.37
US & DS of Bridg	21	Q10	1370.00	992.55	998.11		998.46	0.002125	5.17	387.75	98.74	0.40
US & DS of Bridg	21	Q50	2918.00	992.55	1000.85		1001.42	0.002102	6.79	678.24	113.32	0.42
US & DS of Bridg	21	Q100	4003.00	992.55	1002.45		1003.13	0.002044	7.54	866.68	121.99	0.43
US & DS of Bridg	20	Q10	1370.00	992.43	997.94		998.39	0.002654	5.70	324.36	80.49	0.43
US & DS of Bridg	20	Q50	2918.00	992.43	1000.55		1001.34	0.002880	7.73	544.90	88.74	0.48
US & DS of Bridg	20	Q100	4003.00	992.43	1002.05		1003.04	0.002922	8.74	681.55	93.49	0.50
US & DS of Bridg	19	Q10	1370.00	993.02	996.96	996.63	998.20	0.010953	9.03	169.97	58.68	0.83
US & DS of Bridg	19	Q50	2918.00	993.02	998.91	998.66	1001.08	0.011182	12.15	290.78	69.42	0.90
US & DS of Bridg	19	Q100	4003.00	993.02	999.90	999.90	1002.72	0.011925	13.97	357.97	74.64	0.96
US & DS of Bridg	18	Q10	1370.00	992.79	996.76	996.30	997.91	0.009837	8.62	167.82	56.52	0.80
US & DS of Bridg	18	Q50	2918.00	992.79	998.33	998.33	1000.75	0.013045	12.63	255.78	68.08	0.98
US & DS of Bridg	18	Q100	4003.00	992.79	999.52	999.52	1002.32	0.011725	13.75	352.36	74.58	0.96
US & DS of Bridg	17	Q10	1370.00	993.19	996.88		997.56	0.006981	6.64	208.85	69.50	0.66
US & DS of Bridg	17	Q50	2918.00	993.19	998.85		999.99	0.006230	8.65	360.80	94.49	0.67
US & DS of Bridg	17	Q100	4003.00	993.19	999.93		1001.33	0.006015	9.64	491.14	136.19	0.68
US & DS of Bridg	16	Q10	1370.00	992.75	996.46	995.96	997.33	0.009561	7.53	185.79	67.12	0.76
US & DS of Bridg	16	Q50	2918.00	992.75	998.24	997.65	999.77	0.009086	9.99	316.53	94.92	0.80
US & DS of Bridg	16	Q100	4003.00	992.75	999.47	998.79	1001.14	0.007520	10.59	455.73	116.37	0.76
US & DS of Bridg	15.1		Bridge									
US & DS of Bridg	15	Q10	1370.00	992.65	995.59	995.59	996.89	0.017943	9.18	149.27	58.56	1.01
US & DS of Bridg	15	Q50	2918.00	992.65	997.36	997.36	999.38	0.014048	11.46	272.06	82.83	0.97
US & DS of Bridg	15	Q100	4003.00	992.65	998.50	998.50	1000.72	0.011569	12.15	393.03	118.41	0.91
US & DS of Bridg	14	Q10	1370.00	992.29	995.30		996.08	0.010218	7.13	206.35	96.01	0.78
US & DS of Bridg	14	Q50	2918.00	992.29	997.28		998.30	0.006559	8.31	419.11	116.83	0.68
US & DS of Bridg	14	Q100	4003.00	992.29	998.85		999.83	0.004379	8.26	612.10	129.25	0.59

HEC-RAS Plan: Plan 01 River: Gerle Creek Reach: US & DS of Bridg (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
US & DS of Bridg	13	Q10	1370.00	991.80	994.63	994.63	995.71	0.018100	8.39	167.29	84.45	1.00
US & DS of Bridg	13	Q50	2918.00	991.80	997.18		998.12	0.005827	7.95	425.36	115.99	0.64
US & DS of Bridg	13	Q100	4003.00	991.80	998.80		999.71	0.003904	7.92	629.72	136.50	0.55
US & DS of Bridg	12	Q10	1370.00	990.48	994.47		995.00	0.007195	5.84	234.90	93.17	0.64
US & DS of Bridg	12	Q50	2918.00	990.48	997.41		997.89	0.002445	5.67	569.43	132.45	0.43
US & DS of Bridg	12	Q100	4003.00	990.48	999.00		999.52	0.001885	5.90	798.94	153.55	0.39
US & DS of Bridg	11	Q10	1370.00	989.09	994.53		994.84	0.002287	4.55	331.13	96.23	0.40
US & DS of Bridg	11	Q50	2918.00	989.09	997.39		997.83	0.001634	5.47	663.09	128.37	0.36
US & DS of Bridg	11	Q100	4003.00	989.09	998.98		999.48	0.001473	5.95	867.99	130.59	0.36
US & DS of Bridg	10	Q10	1370.00	988.45	994.13		994.68	0.003602	6.25	291.47	83.47	0.51
US & DS of Bridg	10	Q50	2918.00	988.45	996.89		997.68	0.003036	7.80	568.05	110.83	0.50
US & DS of Bridg	10	Q100	4003.00	988.45	998.44		999.34	0.002791	8.48	741.61	113.57	0.50
US & DS of Bridg	9	Q10	1370.00	988.06	993.67		994.45	0.004750	7.25	229.50	68.14	0.58
US & DS of Bridg	9	Q50	2918.00	988.06	996.24		997.46	0.004462	9.37	431.14	82.61	0.61
US & DS of Bridg	9	Q100	4003.00	988.06	997.62		999.10	0.004468	10.51	546.42	85.21	0.63
US & DS of Bridg	8	Q10	1370.00	987.47	993.46		994.22	0.004221	7.10	228.98	67.56	0.55
US & DS of Bridg	8	Q50	2918.00	987.47	996.00		997.23	0.004310	9.39	429.52	84.18	0.60
US & DS of Bridg	8	Q100	4003.00	987.47	997.36		998.88	0.004380	10.56	546.10	86.77	0.62
US & DS of Bridg	7	Q10	1370.00	986.97	993.28		994.00	0.003894	6.90	227.84	65.07	0.53
US & DS of Bridg	7	Q50	2918.00	986.97	995.79		997.02	0.004177	9.30	419.82	81.83	0.59
US & DS of Bridg	7	Q100	4003.00	986.97	997.11		998.65	0.004346	10.55	529.93	84.25	0.62
US & DS of Bridg	6	Q10	1370.00	986.03	993.39		993.77	0.001813	5.02	319.12	81.73	0.37
US & DS of Bridg	6	Q50	2918.00	986.03	996.03		996.71	0.002086	6.93	563.80	104.22	0.42
US & DS of Bridg	6	Q100	4003.00	986.03	997.44		998.30	0.002182	7.87	716.90	110.49	0.44
US & DS of Bridg	5	Q10	1370.00	986.22	993.31		993.68	0.001716	5.04	342.54	82.19	0.36
US & DS of Bridg	5	Q50	2918.00	986.22	995.91		996.60	0.002101	7.10	587.59	105.73	0.43
US & DS of Bridg	5	Q100	4003.00	986.22	997.29		998.18	0.002262	8.14	742.04	117.52	0.45
US & DS of Bridg	4	Q10	1370.00	987.20	992.76		993.51	0.004592	7.23	245.24	70.52	0.58
US & DS of Bridg	4	Q50	2918.00	987.20	995.09		996.39	0.005032	9.82	430.61	87.63	0.64
US & DS of Bridg	4	Q100	4003.00	987.20	996.30		997.94	0.005303	11.18	541.10	94.08	0.68
US & DS of Bridg	3	Q10	1370.00	987.17	991.51	991.51	993.04	0.016221	9.94	139.50	49.01	0.99
US & DS of Bridg	3	Q50	2918.00	987.17	993.59	993.59	995.91	0.012629	12.36	266.97	73.10	0.96
US & DS of Bridg	3	Q100	4003.00	987.17	994.85	994.85	997.47	0.010988	13.32	367.27	85.65	0.92
US & DS of Bridg	2	Q10	1370.00	985.17	990.40	990.40	991.88	0.016928	9.79	139.92	47.08	1.00
US & DS of Bridg	2	Q50	2918.00	985.17	992.43	992.43	994.59	0.014733	11.80	249.67	62.85	0.99
US & DS of Bridg	2	Q100	4003.00	985.17	993.51	993.51	996.08	0.013278	12.92	322.81	72.15	0.98
US & DS of Bridg	1	Q10	1370.00	984.23	989.26	989.26	990.74	0.017093	9.78	140.09	47.58	1.00
US & DS of Bridg	1	Q50	2918.00	984.23	991.20	991.20	993.50	0.015136	12.17	241.48	55.86	1.00
US & DS of Bridg	1	Q100	4003.00	984.23	992.32	992.32	995.09	0.014042	13.38	305.76	59.27	0.99

Contraction Scour

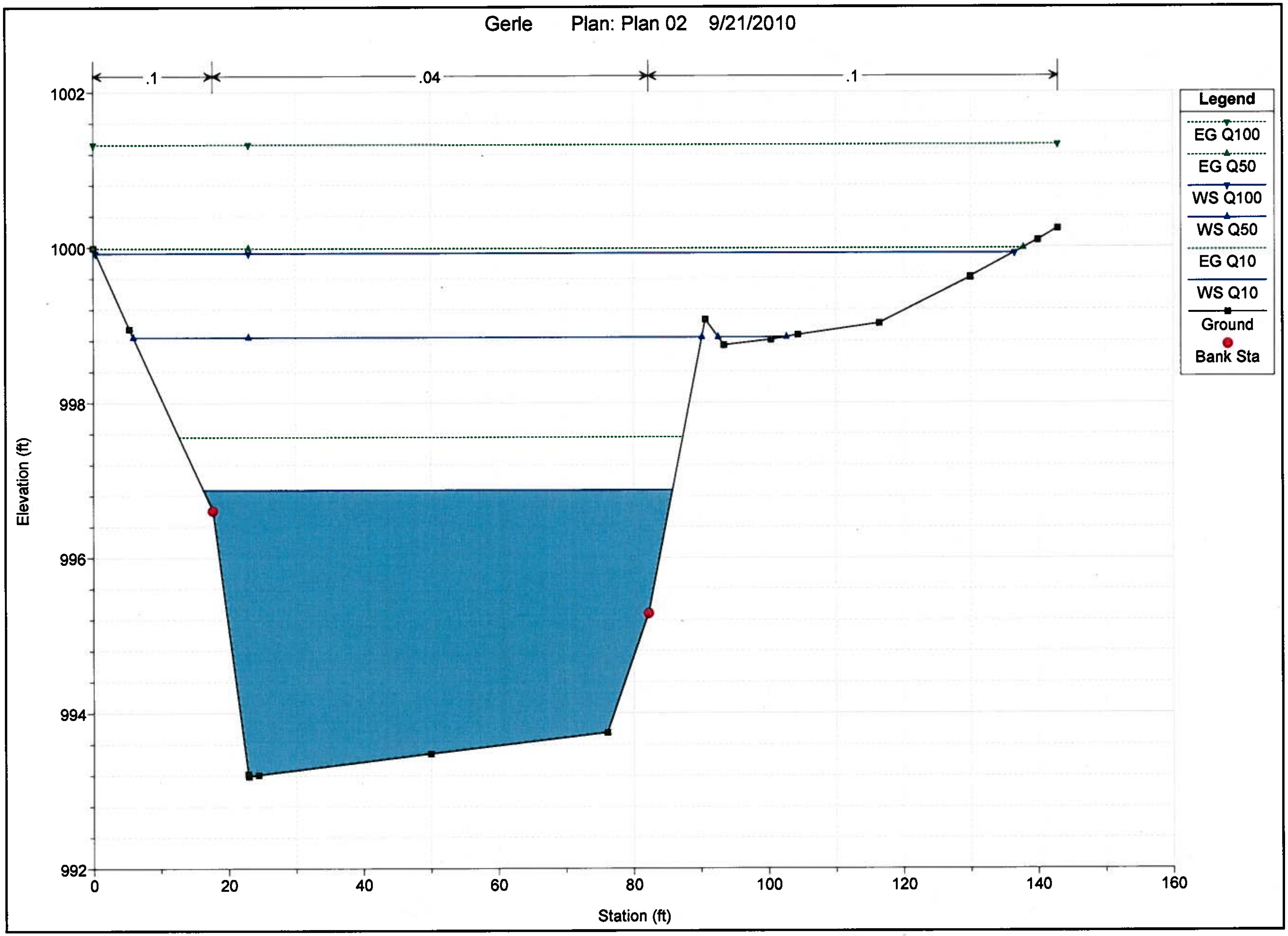
	Left	Channel	Right
Input Data			
Average Depth (ft):	1.66	6.24	1.10
Approach Velocity (ft/s):	1.60	9.64	1.21
Br Average Depth (ft):	2.12	5.53	1.08
BR Opening Flow (cfs):	37.50	3889.20	76.29
BR Top WD (ft):	7.73	60.09	44.70
Grain Size D50 (mm):	0.20	0.20	0.20
Approach Flow (cfs):	46.27	3884.72	72.01
Approach Top WD (ft):	17.38	64.56	54.25
K1 Coefficient:	0.690	0.690	0.690
Results			
Scour Depth Ys (ft):	0.30	1.03	0.24
Critical Velocity (ft/s):	1.06	1.32	0.99
Equation:	Live	Live	Live

Abutment Scour

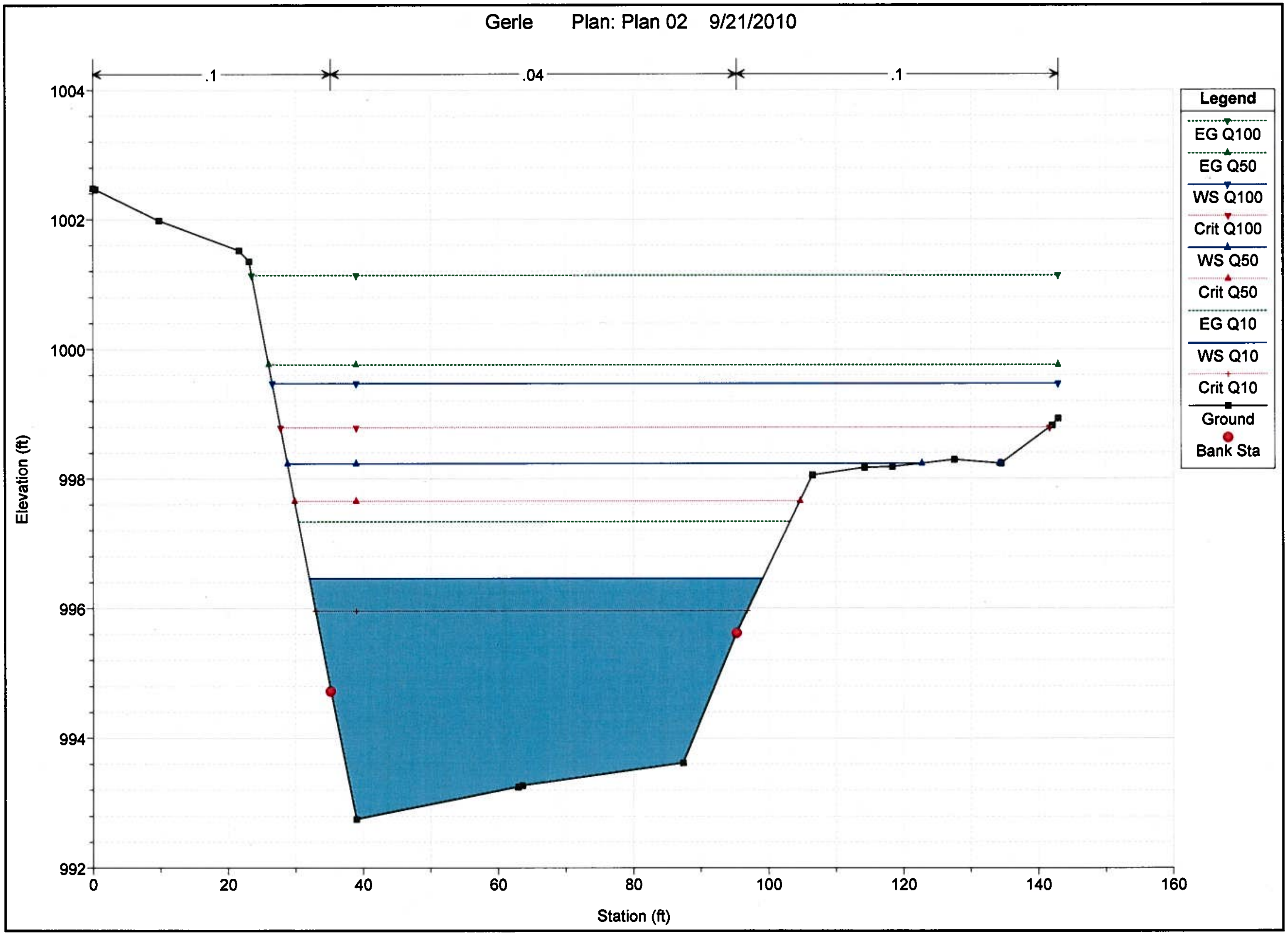
	Left	Right
Input Data		
Station at Toe (ft):	23.79	140.00
Toe Sta at appr (ft):	6.28	126.96
Abutment Length (ft):	17.38	54.25
Depth at Toe (ft):	-1.53	0.81
K1 Shape Coef:	1.00 - Vertical abutment	
Degree of Skew (degrees):	20	20
K2 Skew Coef:	0.82	0.82
Projected Length L' (ft):	5.94	18.55
Avg Depth Obstructed Ya (ft):	1.66	1.10
Flow Obstructed Qe (cfs):	46.27	72.01
Area Obstructed Ae (sq ft):	28.93	59.42
Results		
Scour Depth Ys (ft):		3.71
Qe/Ae = Ve:		1.21
Froude #:		0.20
Equation:	Default	Froehlich

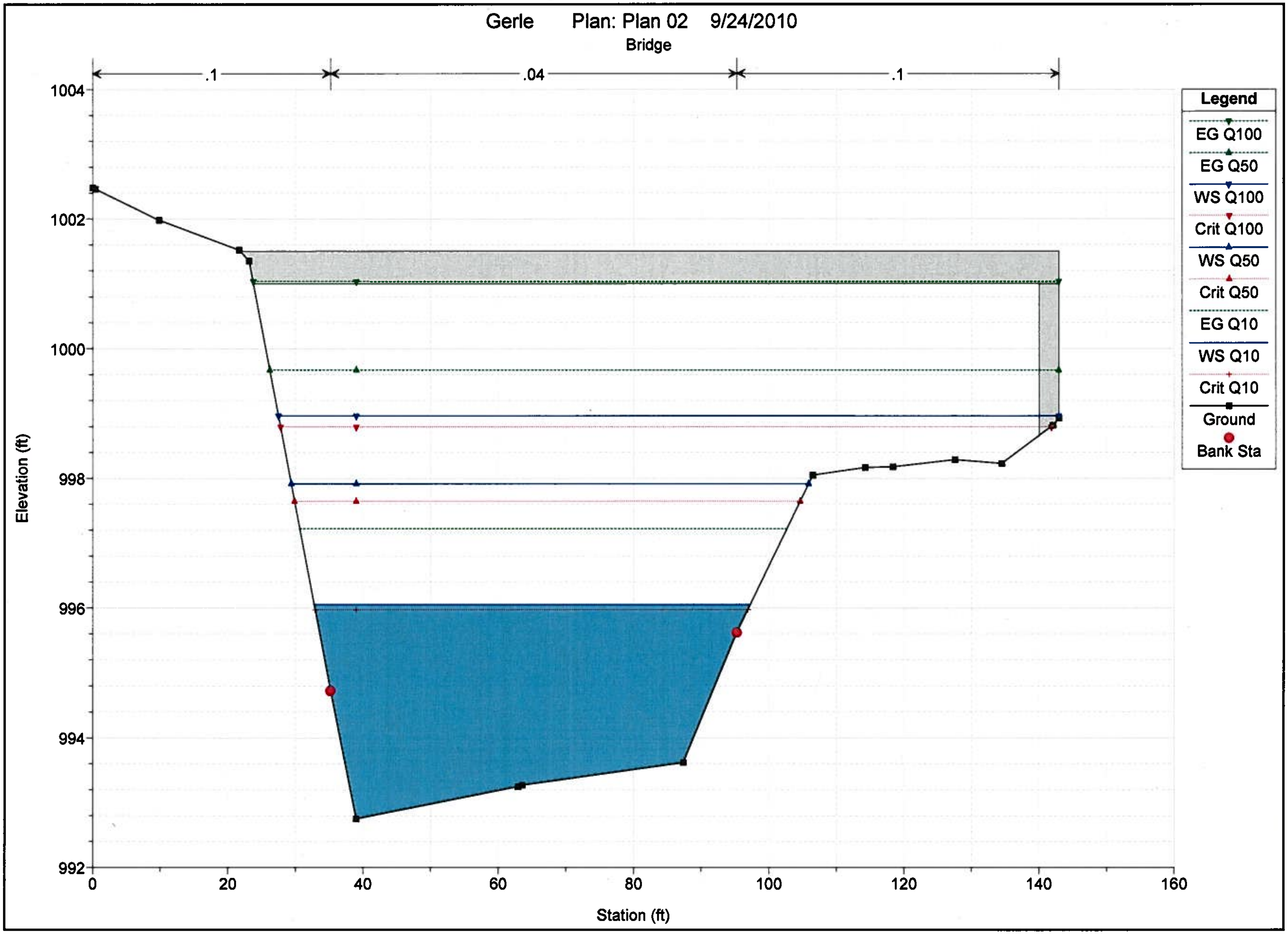
Combined Scour Depths

Right abutment scour + contraction scour (ft):	3.95

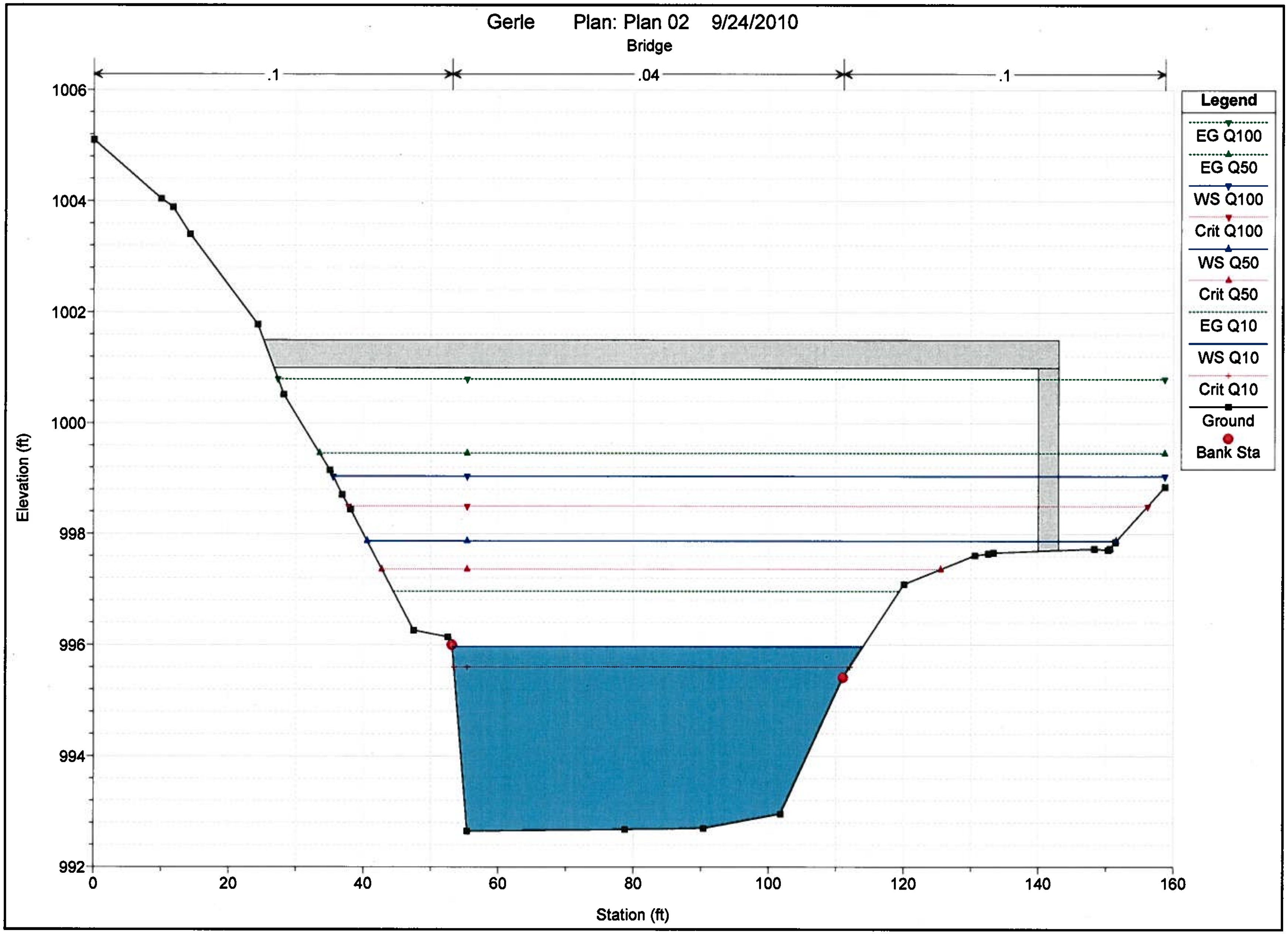


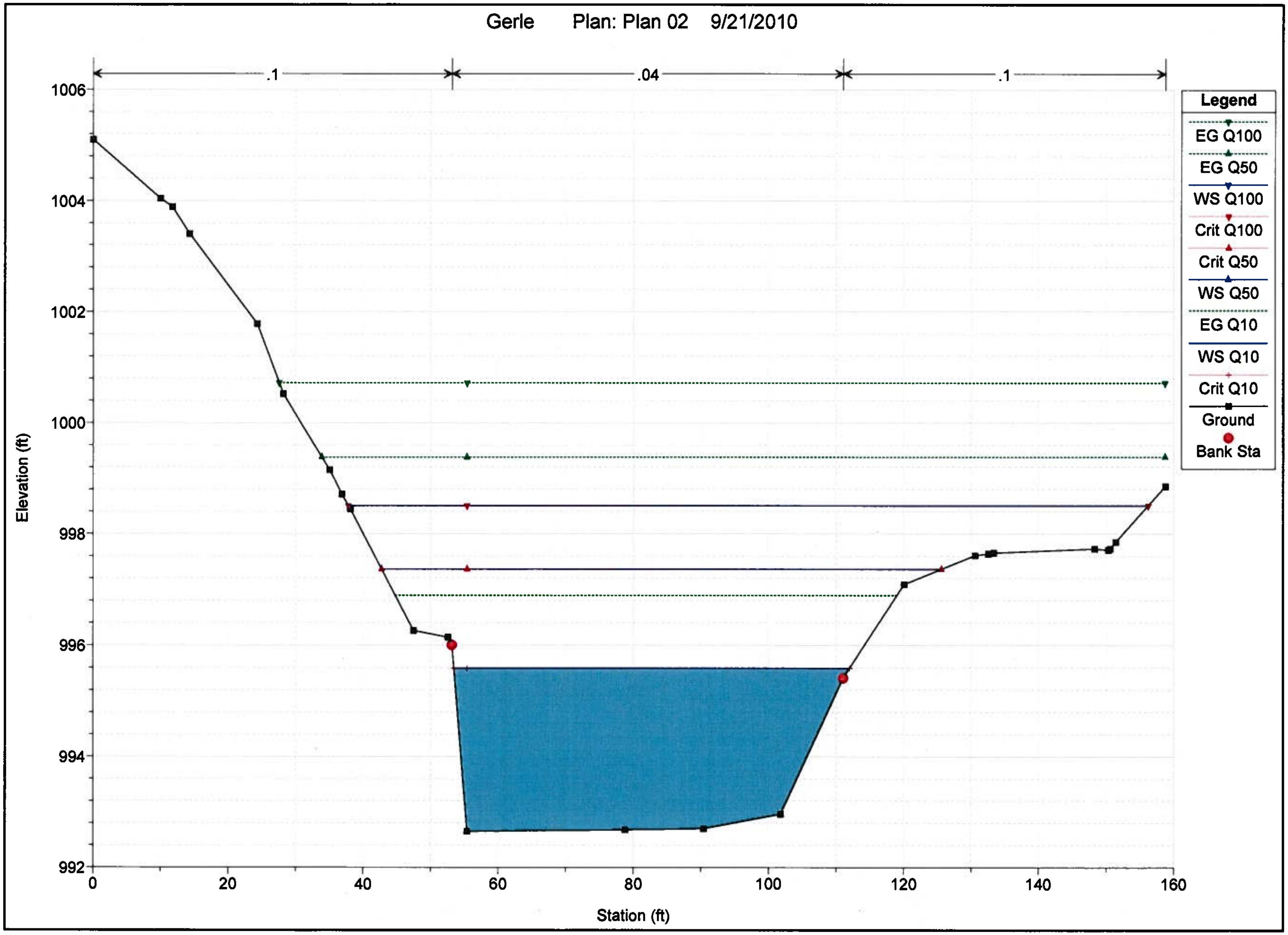
Gerle Plan: Plan 02 9/21/2010
.1
.04
.1
Elevation (ft)
1002
1000
998
996
994
992
Station (ft)
0
20
40
60
80
100
120
140
160
Legend
EG Q100
EG Q50
WS Q100
WS Q50
EG Q10
WS Q10
Ground
Bank Sta

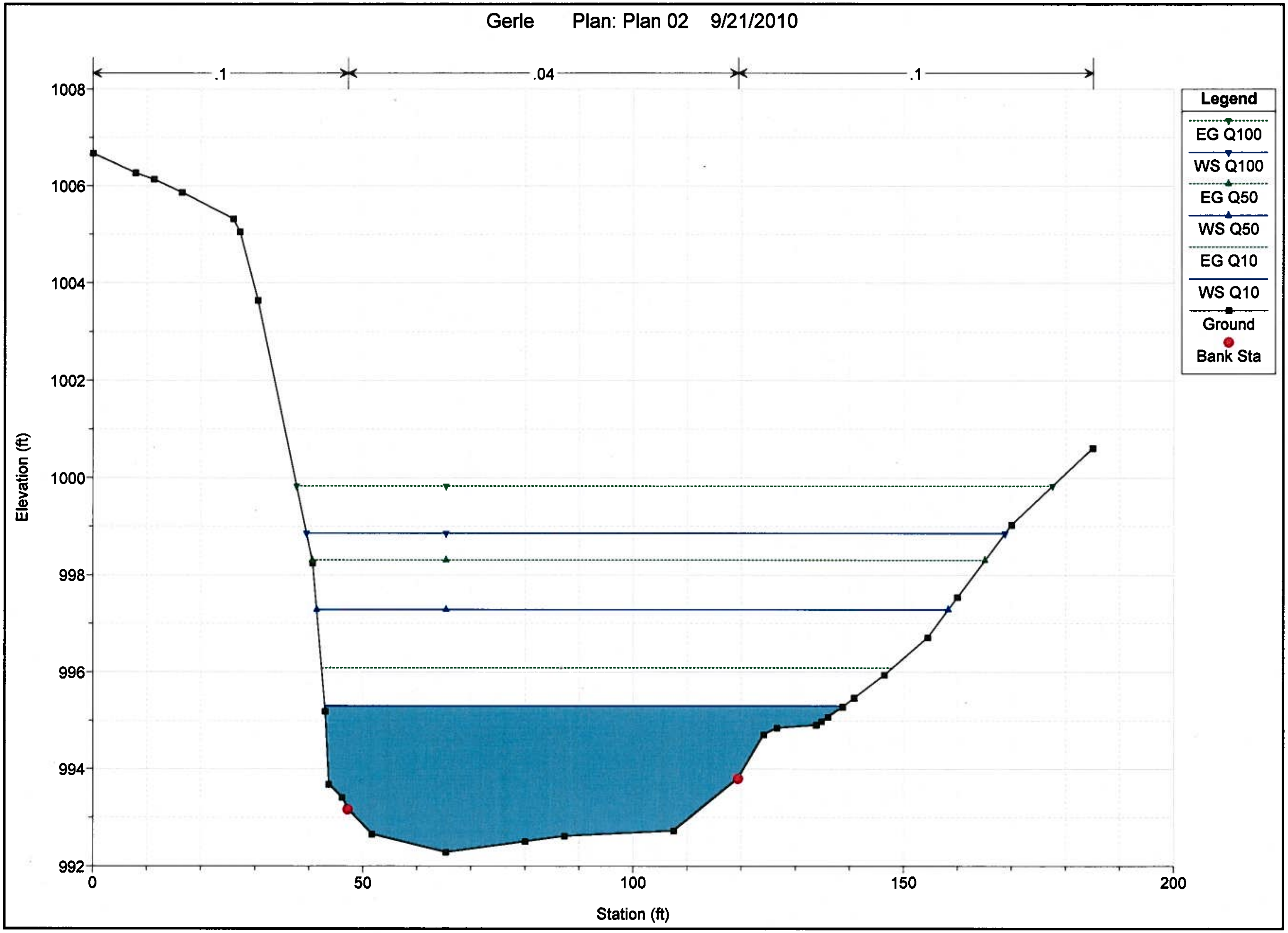

Gerle Plan: Plan 02 9/21/2010
.1
.04
.1
Legend
EG Q100
EG Q50
WS Q100
Crit Q100
WS Q50
Crit Q50
EG Q10
WS Q10
Crit Q10
Ground
Bank Sta
Elevation (ft)
1004
1002
1000
998
996
994
992
Station (ft)
0
20
40
60
80
100
120
140
160



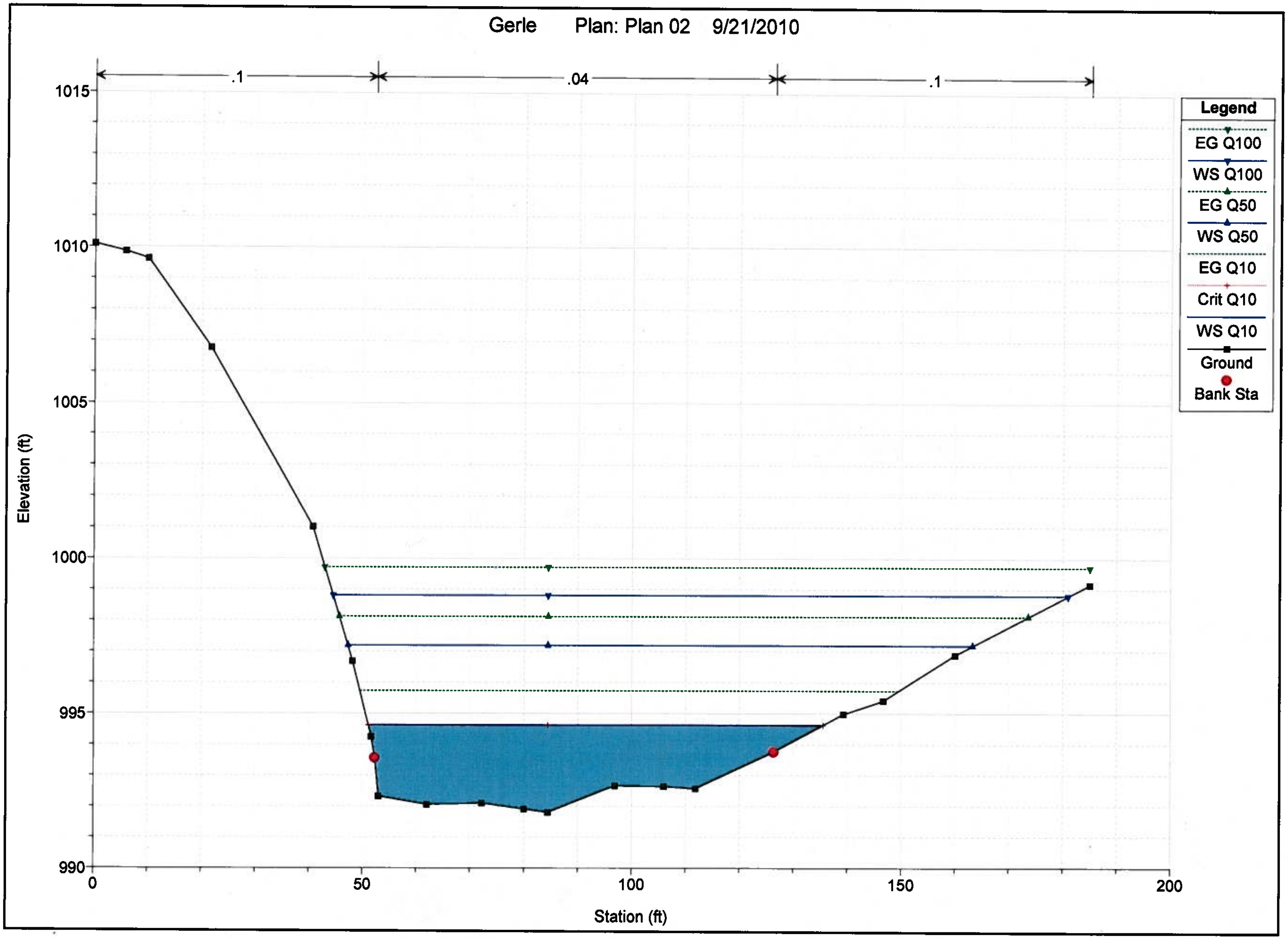
Gerle Plan: Plan 02 9/24/2010
Bridge
.1
.04
.1
Legend
EG Q100
EG Q50
WS Q100
Crit Q100
WS Q50
Crit Q50
EG Q10
WS Q10
Crit Q10
Ground
Bank Sta
Elevation (ft)
1004
1002
1000
998
996
994
992
0
20
40
60
80
100
120
140
160
Station (ft)


Gerle Plan: Plan 02 9/24/2010
Bridge
.1
.04
.1
Legend
EG Q100
EG Q50
WS Q100
Crit Q100
WS Q50
Crit Q50
EG Q10
WS Q10
Crit Q10
Ground
Bank Sta
Elevation (ft)
1006
1004
1002
1000
998
996
994
992
Station (ft)
0
20
40
60
80
100
120
140
160

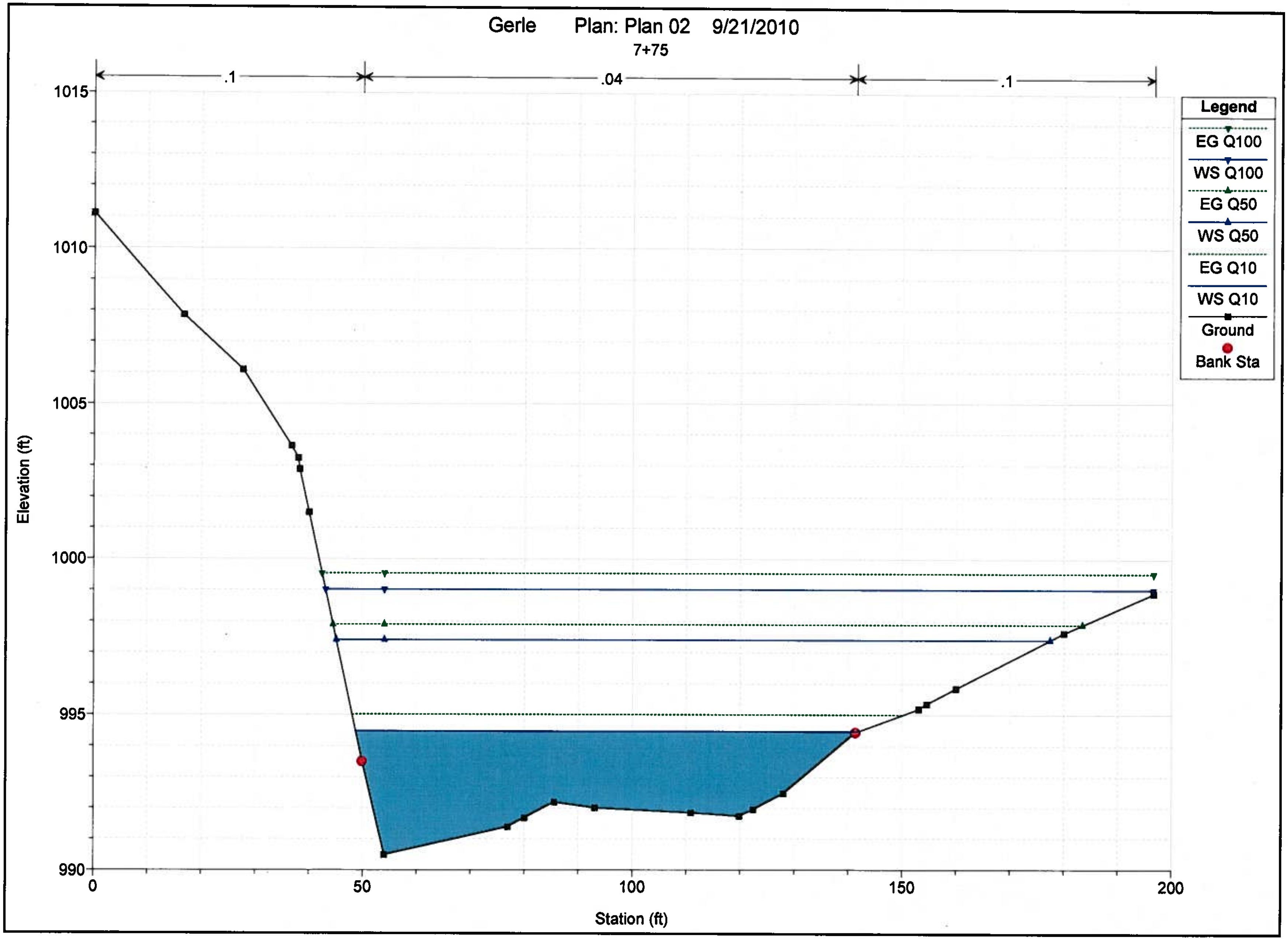

Gerle Plan: Plan 02 9/21/2010
.1
.04
.1
Legend
EG Q100
EG Q50
WS Q100
Crit Q100
Crit Q50
WS Q50
EG Q10
WS Q10
Crit Q10
Ground
Bank Sta
Elevation (ft)
1006
1004
1002
1000
998
996
994
992
Station (ft)
0
20
40
60
80
100
120
140
160



Gerle Plan: Plan 02 9/21/2010
.1
.04
.1
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q10
WS Q10
Ground
Bank Sta
Elevation (ft)
1008
1006
1004
1002
1000
998
996
994
992
Station (ft)
0
50
100
150
200



Gerle Plan: Plan 02 9/21/2010
.1
.04
.1
1015
1010
1005
1000
995
990
Elevation (ft)
0
50
100
150
200
Station (ft)
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q10
Crit Q10
WS Q10
Ground
Bank Sta


Gerle Plan: Plan 02 9/21/2010
7+75
.1
.04
.1
Legend
EG Q100
WS Q100
EG Q50
WS Q50
EG Q10
WS Q10
Ground
Bank Sta
Elevation (ft)
1015
1010
1005
1000
995
990
0
50
100
150
200
Station (ft)