

**SAND CREEK
LOCATION HYDRAULIC STUDY**

**SR-210 MIXED FLOW LANE ADDITION PROJECT
FROM HIGHLAND AVENUE TO SAN BERNARDINO
AVENUE**

EA No. 0C7000

Prepared for



San Bernardino Associated Governments

1170 W. 3rd Street, 2nd Floor

December 2012

Prepared by



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1. INTRODUCTION

1.1. GENERAL

The California Department of Transportation (Caltrans), in coordination with the San Bernardino Associated Governments (SANBAG), proposes to widen State Route 210 (SR-210) from just west of Highland Avenue to San Bernardino Avenue in the cities of Highland and Redlands, and the County of San Bernardino, California. The project proposes to add one mixed flow lane in each direction within the median of SR-210, create auxiliary lanes between the Base Line and 5th Street interchanges and add an acceleration lane at the eastbound 5th Street on-ramp. The proposed improvements would include widening of the Highland Avenue undercrossing, Sand Creek bridge, Victoria Avenue undercrossing, City Creek bridge, 5th Street undercrossing, Plunge Creek bridge, Access Road undercrossing, Santa Ana River bridge and Pioneer Avenue undercrossing. Additional project improvements include drainage and water quality treatment facilities, a fiber optic line within the median of SR-210, ramp metering systems at the 5th Street on-ramps and retaining walls and sound walls where needed. This report is prepared to present the hydraulic impacts analyses for the SR-210 widening project for existing and proposed conditions of the Sand Creek Bridges [Bridge No. 54-1075 (L&R)] in the City of Highland. The location of the Sand Creek Bridges is at post mile R27.24 of SR-210 (Exhibit 1).

San Bernardino County is located in the southeastern portion of California. More than 90 percent of San Bernardino County is a desert that contains low mountains, valleys, and dry lake beds. The remainder of the area consists of the San Bernardino Mountains and the San Bernardino Valley in the southwest corner of the county. Climatic conditions in the county vary substantially with the topography and region. In general, the climate of the San Bernardino Valley is similar to coastal southern California, except that it is warmer in summer and is not as foggy. The monthly average of daily extreme temperatures ranges from 37° Fahrenheit (F) minimum to 67° F maximum in January and from 57° F to 96° F in July. The annual rainfall, most of which falls in the summer months, averages to 16 inches in the valley area and from 20 to 30 inches in the mountains. The average annual rainfall in the desert area ranges from 2 to 5 inches.

1.2. SAND CREEK DESCRIPTION

Sand Creek is a graded trapezoidal channel, fortified with rail and wire revetments. It is currently designed to carry the 1-percent annual chance flood (100-year) flood. Patton Basin is a percolation basin that is located north of Highland Avenue and serves as the upstream limit of the current study. Flood flows from Patton Basin discharge over an emergency spillway and continue south along Sand Creek. Within the study reach, Sand Creek has a series of concreted-rock grade control structures as well as grouted-rock slope protection on the channel banks. Access roads are located on both sides of the channel.

1.3. FLOODING HISTORY

Most of the major floods in San Bernardino County have occurred as a result of general winter storms. The principal flood problem in the Sand Creek area is sheet flow flooding. In 1969, flooding up to 2 feet in depth damaged homes, streets, and utilities (FEMA, 2008).

2. HYDRAULICS

2.1. BRIDGE DESIGN CONCEPTS

Each existing Sand Creek Bridge consists of continuous, three span, reinforce concrete box girders, supported by open end diaphragm abutments and two (2) reinforced concrete column bents. Both the abutment and columns are supported by Cast-In-Drilled-Hole (CIDH) concrete piles. The columns have an octagonal shape, with dimensions 8-foot (L) x 4-foot (W) at the top, and taper down to 4-foot (L) x 4-foot (W) within the waterway. The smaller column dimension was used for hydraulic modeling purposes. Each bridge currently has a width of 42-feet, 6-inches. The proposed widening project would be an inside widening that would extend Bridge 54-1075L 15-feet, 9-inches, and Bridge 54-1075R 16-feet, 3-inches. The widening would not result in additional piers to the bridge.



Figure 1: Sand Creek Bridge - Facing South/Downstream

2.2. CHANNEL GEOMETRY

Two-foot contour topography was prepared by Psomas in digital format, based on an aerial mapping survey that was flown on June 18, 2012. The horizontal datum for the topographic data is North American Datum of 1983 (NAD83, EPOCH 2007.00); the vertical datum is North American Vertical Datum of 1988 (NAVD88). The topographic data was used to construct a TIN (Triangular Irregular Network) surface, which was then utilized to generate cross sections for creating the channel geometric data for the hydraulic model. The United States Army Corps of Engineers (ACOE) Hydrologic Engineering Center

River Analysis System (HEC-RAS, version 4.1.0) computer program was used for the current study. HEC-RAS was used to create a one-dimensional, steady state hydraulic model for Sand Creek.

2.3. DESIGN DISCHARGE

The 100-year discharge, or base flood, for Sand Creek upstream of Highland Avenue is 2,496 cubic feet per second (cfs). The watershed area at this point is 3.2 square miles (FEMA, 2008). The 50-year design discharge was not provided in the effective Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) nor was not listed on the as-builts. The floodplain boundary and flood zones for Sand Creek are shown on the Federal Emergency Management Agency (FEMA) effective Flood Insurance Rate Map (FIRM) included in Appendix A.

2.4. HYDRAULIC ANALYSIS

A detailed hydraulic study of Sand Creek was completed BSI Consultants, Inc. (BSI) in 1993 for the City of Highland (FEMA, 2008). The study was a part of the second revision for the original FIS. Detailed Cross-section data for Sand Creek was determined by field and survey information taken from San Bernardino County Flood Control District (SBCFCD) 4-foot contour maps with a scale of 1:2,400. The study limits for the FEMA study were Sand Canyon at the northern limit and Patton Basin at the southern limit as shown on the effective Flood Insurance Rate Map (FIRM). A copy of the effective FIRM can be found in Appendix A. The starting water-surface elevation use for the analysis was critical depth. A Manning's roughness coefficient of 0.038 was used for both the channel and the overbank.

The URS hydraulic model limits were from Patton Basin at the upstream end to approximately 1,100 feet south of SR-210. After a field visit on November 8, 2012, Manning's roughness coefficients were selected to be 0.038 for the channel and 0.025 for the overbanks. The channel roughness coefficient was chosen to account for the rip rap, vegetation, and other debris found in the channel bottom. The overbank roughness coefficient was selected to account for the unpaved access roads found on both sides of the channel. The value of N remains the same for proposed conditions as there is no change in the channel geometry and no ripraps are added. Contraction and expansion coefficients of 0.1 and 0.3, respectively, were used at cross section location upstream and downstream of the Highland Avenue culvert, as well as the SR-210 bridges. The HEC-RAS simulation was run as a mixed-flow regime to account for both subcritical and supercritical flow throughout the reach.

2.5. HYDRAULIC RESULTS

The results of the hydraulic analysis showed a minimal change between the existing and proposed conditions. Table 1 shows a summary of the water surface elevations upstream and downstream of SR-210 for existing and proposed conditions. The HEC-RAS output the existing and proposed conditions models can be found in Appendix B and C, respectively.

Table 1: HEC-RAS Summary for Sand Creek

Plan	Station	Profile	Water Surface Elevation (ft)	Velocity (fps)
Existing	10	100-year	1236.62	7.21
Proposed	10	100-year	1234.61	7.50
Existing	9	100-year	1230.27	11.22
Proposed	9	100-year	1230.27	11.22
Existing	8	100-year	1227.82	14.77
Proposed	8	100-year	1227.79	14.89
Existing	7	100-year	1229.35	8.59
Proposed	7	100-year	1229.33	8.62
Existing	6	100-year	1221.08	11.60
Proposed	6	100-year	1221.08	11.60

3. REFERENCES

FEMA, 2008; Federal Emergency Management Agency, Federal Insurance Administration. (Revised August 2008). Flood Insurance Study, San Bernardino County, California and Incorporated Areas.

LOCATION HYDRAULIC STUDY FORM *

Dist. 8 Co. San Bernardino Rte. SR-210 P.M. R27.24 of SR-210

EA 0C7000 Bridge No. 54-1075 (L&R)

Floodplain Description:

Sand Creek

1. Description of Proposal (include any physical barriers i.e. concrete barriers, soundwalls, etc. and design elements to minimize floodplain impacts)

Existing channels and levees will stay in place. The proposed widening will be an inside widening of 15-feet, 9-inches and 16-feet, 3-inches of the left and right bridges, respectively.

2. ADT: Current 69400 Projected 106000

3. Hydraulic Data: Base Flood Q₁₀₀= 2496 CFS

WSE₁₀₀= 1285.47 The flood of record, if greater than Q₁₀₀:

Q= NA CFS WSE= NA

Overtopping flood Q= NA CFS WSE= NA

Are NFIP maps and studies available? YES X NO _____

4. Is the highway location alternative within a regulatory floodway ?

YES _____ NO X

5. Attach map with flood limits outlined showing all buildings or other improvements within the base floodplain.

Potential Q₁₀₀ backwater damages:

A. Residences? NO X YES _____

B. Other Bldgs? NO X YES _____

C. Crops? NO X YES _____

D. Natural and beneficial

FLOODPLAIN VALUES? NO X YES _____

6. Type of Traffic:

A. Emergency supply or evacuation route? NO _____ YES X

B. Emergency vehicle access? NO _____ YES X

C. Practicable detour available? NO _____ YES X

D. School bus or mail route? NO X YES _____

7. Estimated duration of traffic interruption for 100-year event hours: 0

8. Estimated value of Q₁₀₀ flood damages (if any) – moderate risk level.

A.	Roadway	\$	<u>NA</u>
B	Property	\$	<u>NA</u>
	Total	\$	<u>NA</u>

9. Assessment of Level of Risk Low NA
Moderate NA
High NA

For High Risk projects, during design phase, additional Design Study Risk Analysis
May be necessary to determine design alternative. NA

Signature – Dist. Hydraulic Engineer _____ Date _____
(Item numbers 3,4,5,7,9)

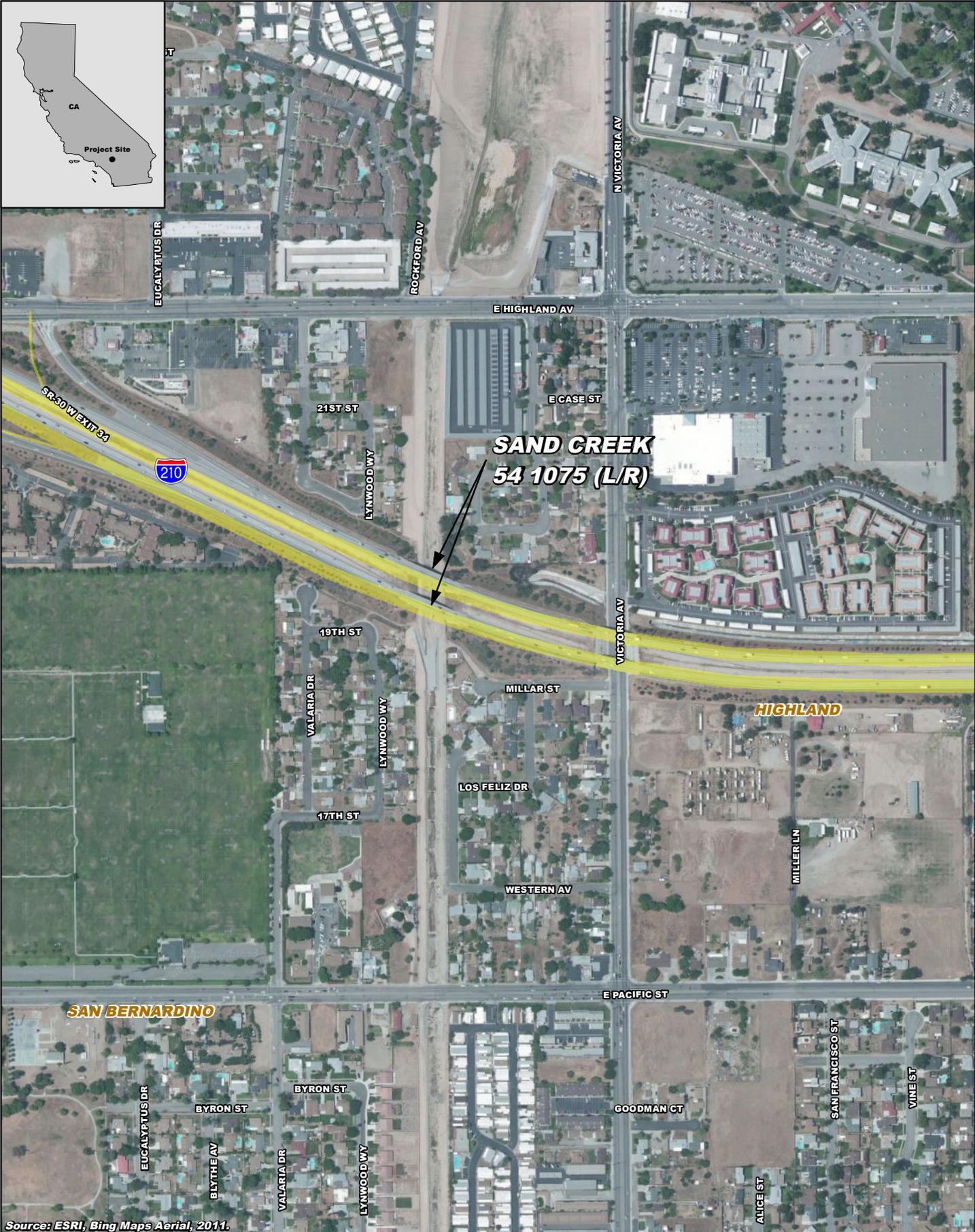
Is there any longitudinal encroachment, significant encroachment, or any support of
incompatible
Floodplain development? NO X YES _____

If yes, provide evaluation and discussion of practicability of alternatives in accordance
with 23 CFR 650.113

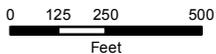
Information developed to comply with the Federal requirement for the Location
Hydraulic Study shall be retained in the project files.

Signature – Dist. Project Engineer _____ Date _____
(Item numbers 1,2,6,8)

* Same as Figure 804.7A Technical Information for Location Hydraulic Study located in Chapter 804 of the Highway Design Manual



Source: ESRI, Bing Maps Aerial, 2011.



Sand Creek
Site Location Map

Exhibit 1



APPENDIX A

FIRM MAP

NOTES TO USERS

is for use in administering the National Flood Insurance Program. It is necessary to identify all areas subject to flooding, particularly from local sources of small size. The community map repository should be updated for possible updated or additional flood hazard information.

In more detailed information in areas where Base Flood Elevations and Floodways have been determined, users are encouraged to consult Profiles and Floodway Data and/or Summary of Stillwater Elevations prepared within the Flood Insurance Study (FIS) report that accompanies this map. Users should be aware that BFEs shown on the FIRM represent whole-foot elevations. These BFEs are intended for flood insurance purposes only and should not be used as the sole source of flood information. Accordingly, flood elevation data presented in the FIS should be utilized in conjunction with the FIRM for purposes of flood and/or floodplain management.

Base Flood Elevations shown on this map apply only to landward of American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Elevations Tables in the Flood Insurance Study report for this jurisdiction. As shown in the Summary of Stillwater Elevations tables should be used for flood and/or floodplain management purposes when they are higher than elevations shown on this FIRM.

Lines of the floodways were computed at cross sections and interpolated cross sections. The floodways were based on hydraulic considerations and to requirements of the National Flood Insurance Program. Floodway and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Areas not in Special Flood Hazard Areas may be protected by flood structures. Refer to Section 2.4 "Flood Protection Measures" of the Insurance Study report for information on flood control structures for this area.

Projection used in the preparation of this map was Universal Transverse Mercator (UTM) zone 11 North. The horizontal datum was NAD 83. GRS80. Differences in datum, spherical projection or UTM zones used in the preparation of FIRMs for adjacent jurisdictions may result in slight positional errors in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same vertical datum. For information regarding differences between the National Geodetic Vertical Datum of 1929 and the American Vertical Datum of 1988, visit the National Geodetic Survey at <http://www.ngs.noaa.gov> or contact the National Geodetic Survey at the following address:

Information Services
NWS/512
Geodetic Survey
#6032
4600 West Highway
Baltimore, Maryland 20910-3282
301-328-2422

For current elevation, description, and/or location information for bench marks shown on this map, please contact the Information Services Branch, National Geodetic Survey at (301) 713-3242, or visit its website at www.ngs.noaa.gov.

Map information shown on this FIRM was derived from digital topography collected by the U.S. Department of Agriculture Farm Service Agency in 2005 and was produced with a 1-meter ground distance.

This map may reflect more detailed and up-to-date stream channel configurations as shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to these new stream channel configurations. As a result, the Flood and Floodway Data tables in the Flood Insurance Study Report (which authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

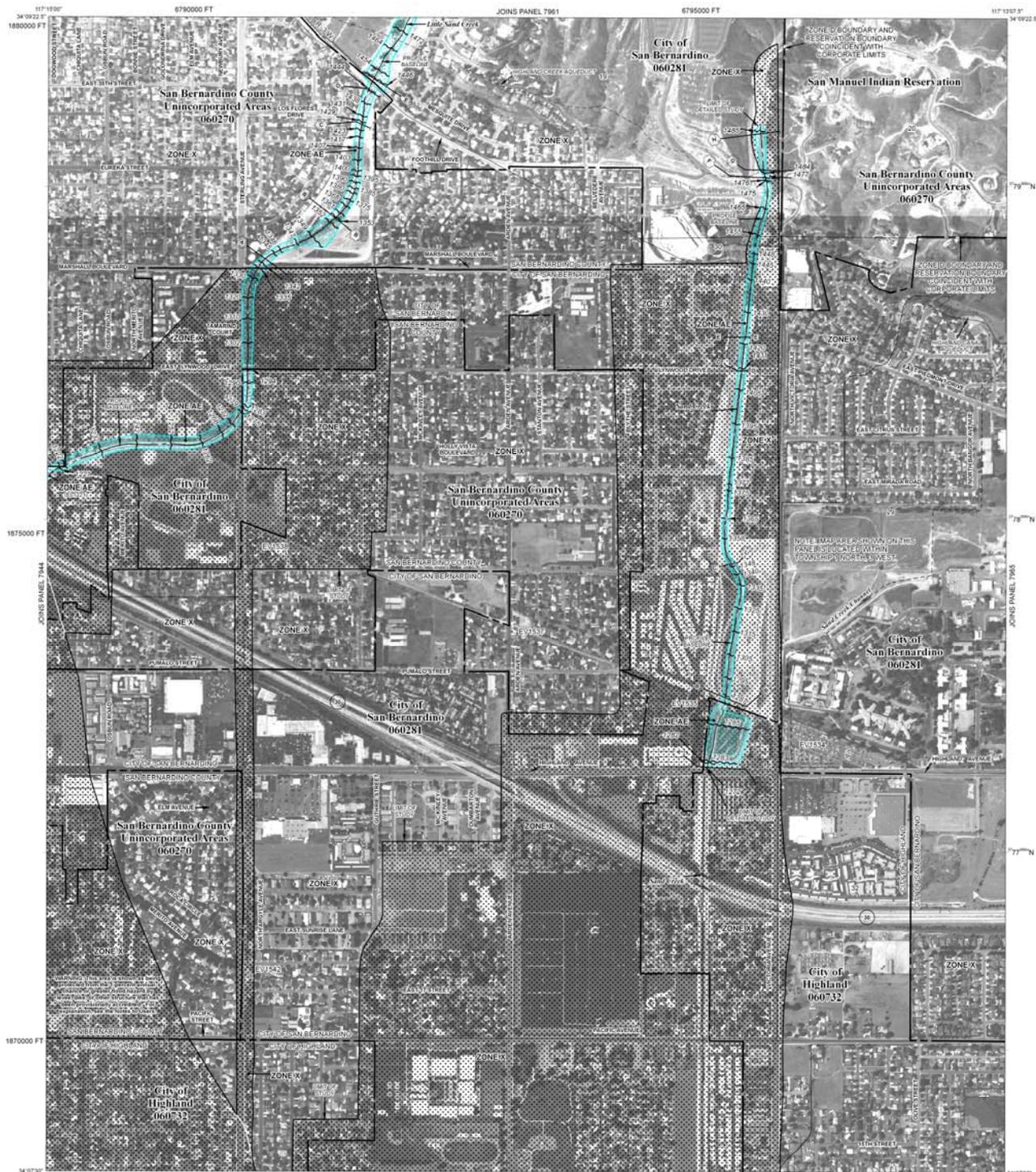
The limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may occur after this map was published, map users should contact appropriate officials to verify current corporate limit locations.

Refer to the separately printed Map Index for an overview map of the County showing the layout of map panels, community map repository addresses, and listing of Communities table containing National Flood Insurance Program data for each community as well as a listing of the panels on which each community is located.

For the FEMA Map Service Center at 1-800-358-9416 for information on products associated with this FIRM. Available products may include printed Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Service Center may also be reached at 1-800-358-9620 and its website at <http://msc.fema.gov/>.

For more questions about this map or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov>.

This map contains levees, dikes, or other structures that have been previously accredited and mapped as providing protection from the 1-percent-annual-chance flood. To maintain accreditation, the levee owner or community is required to submit documentation necessary to comply with 44 CFR Section 65.10 (b) through (d), 2005. Because of the risk of overtopping or failure of the structure, levee owners should take proper precautions to protect lives and minimize property damage in these areas, such as issuing an evacuation plan and encouraging owners to purchase flood insurance.



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Areas are subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard Zones A, AE, AH, AO, AR, AV, V, and VE. The Base Flood Elevation is the water elevation of the 1% annual chance flood.

- ZONE A** No Base Flood Elevations determined.
- ZONE AE** Base Flood Elevations determined.
- ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponds); Base Flood Elevations determined.
- ZONE AD** Flood depths of 1 to 1 foot (usually sheet flow on impervious surfaces); Flood depths determined. For areas of alluvial fan flooding, elevations determined.
- ZONE AR** Special Flood Hazard Area formerly protected from the 1% annual flood by a flood control system that was subsequently determined to be inadequate; the former flood control system is being restored to protection from the 1% annual chance or greater flood.
- ZONE A99** Area to be protected from 1% annual chance flood by a Federal protection system under construction; No Base Flood Elevation determined.
- ZONE V** Coastal flood zone with velocity hazard (wave action); No Base Flood Elevations determined.
- ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain area that must be maintained so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile, and areas protected by levees from the 1% annual chance flood.

OTHER AREAS

ZONE A Areas determined to be outside the 0.2% annual chance floodplain. Areas in which flood hazards are undetermined, but possible.

ZONE D COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zone X from other flood zones
- Boundary dividing Special Flood Hazard Area Zone VE from other flood zones
- Base Flood Elevation line and actual elevation in feet
- Base Flood Elevation value where uniform within zone AE in feet

- Reference to the North American Vertical Datum of 1988
- Cross section line
- Transect line
- Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Eastern Hemisphere
- 1000-meter Universal Transverse Mercator grid values, UTM
- 5000-foot grid ticks; California State Plane coordinates system, zone V (FIPS ZONE 4603), Lambert Conformal Conic projection
- Bench mark (see explanation in Notes to Users section of FIS report)
- River file
- MAP REPOSITORY
- Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL:
FLOOD INSURANCE RATE MAP
March 18, 1996

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL:
August 28, 2006. In order to update the map to reflect the most current flood hazard areas, to update map format, to add roads and road names, and to incorporate previous Letters of Map Revision.

For community map revision history prior to court-awful mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction. To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6633.

MAP SCALE 1" = 600'



NFIP FIRM FLOOD INSURANCE RATE

SAN BERNARDINO COUNTY, CALIFORNIA AND INCORPORATED AREAS

PANEL 7963 OF 9400
(SEE MAP INDEX FOR FIRM PANEL LIST)

COMMUNITY	NUMBER	PANEL
HIGHLAND, CITY OF	060732	7963
SAN BERNARDINO COUNTY	060732	7963
SAN BERNARDINO, CITY OF	060281	7963

Notice to User: This Map Number should be used when placing map orders. The Community Map History table should be used on insurance applications.

MAP NUMBER 06071C
MAP REVISION AUGUST 28, 2006

Federal Emergency Management Agency

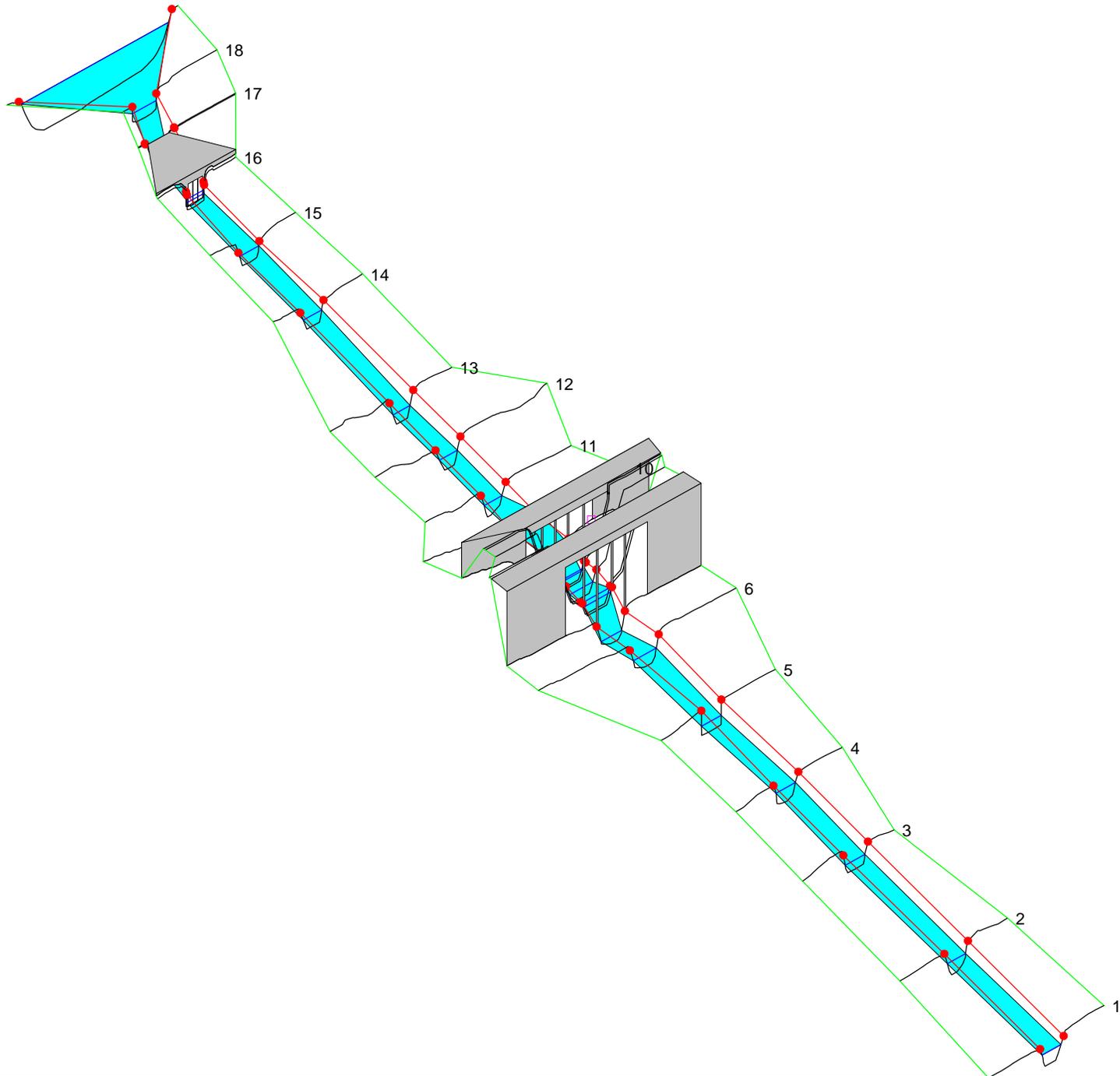
APPENDIX B

HEC-RAS Model Output Files

Existing Condition

Sand Creek LHS Plan: Existing Conditions 12/8/2012

Legend	
	WS 100-year
	Ground
	Bank Sta
	Levee



Plan: Exist Plan Sand Creek 1 RS: 9.5 Profile: 100-year

E.G. US. (ft)	1237.42	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	1236.62	E.G. Elev (ft)	1236.54	1234.19
Q Total (cfs)	2496.00	W.S. Elev (ft)	1234.60	1228.59
Q Bridge (cfs)	2496.00	Crit W.S. (ft)	1234.60	1230.30
Q Weir (cfs)		Max Chl Dpth (ft)	5.03	2.94
Weir Sta Lft (ft)		Vel Total (ft/s)	11.18	18.99
Weir Sta Rgt (ft)		Flow Area (sq ft)	223.32	131.47
Weir Submerg		Froude # Chl	0.99	2.09
Weir Max Depth (ft)		Specif Force (cu ft)	1353.64	1652.29
Min EI Weir Flow (ft)	1258.51	Hydr Depth (ft)	3.92	2.56
Min EI Prs (ft)	1255.00	W.P. Total (ft)	59.18	52.78
Delta EG (ft)	4.11	Conv. Total (cfs)	20108.6	8974.6
Delta WS (ft)	7.69	Top Width (ft)	56.92	51.43
BR Open Area (sq ft)	3104.49	Frctn Loss (ft)	0.45	1.25
BR Open Vel (ft/s)	18.99	C & E Loss (ft)	0.36	1.10
Coef of Q		Shear Total (lb/sq ft)	3.63	12.03
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: Exist Plan Sand Creek 1 RS: 6.5 Profile: 100-year

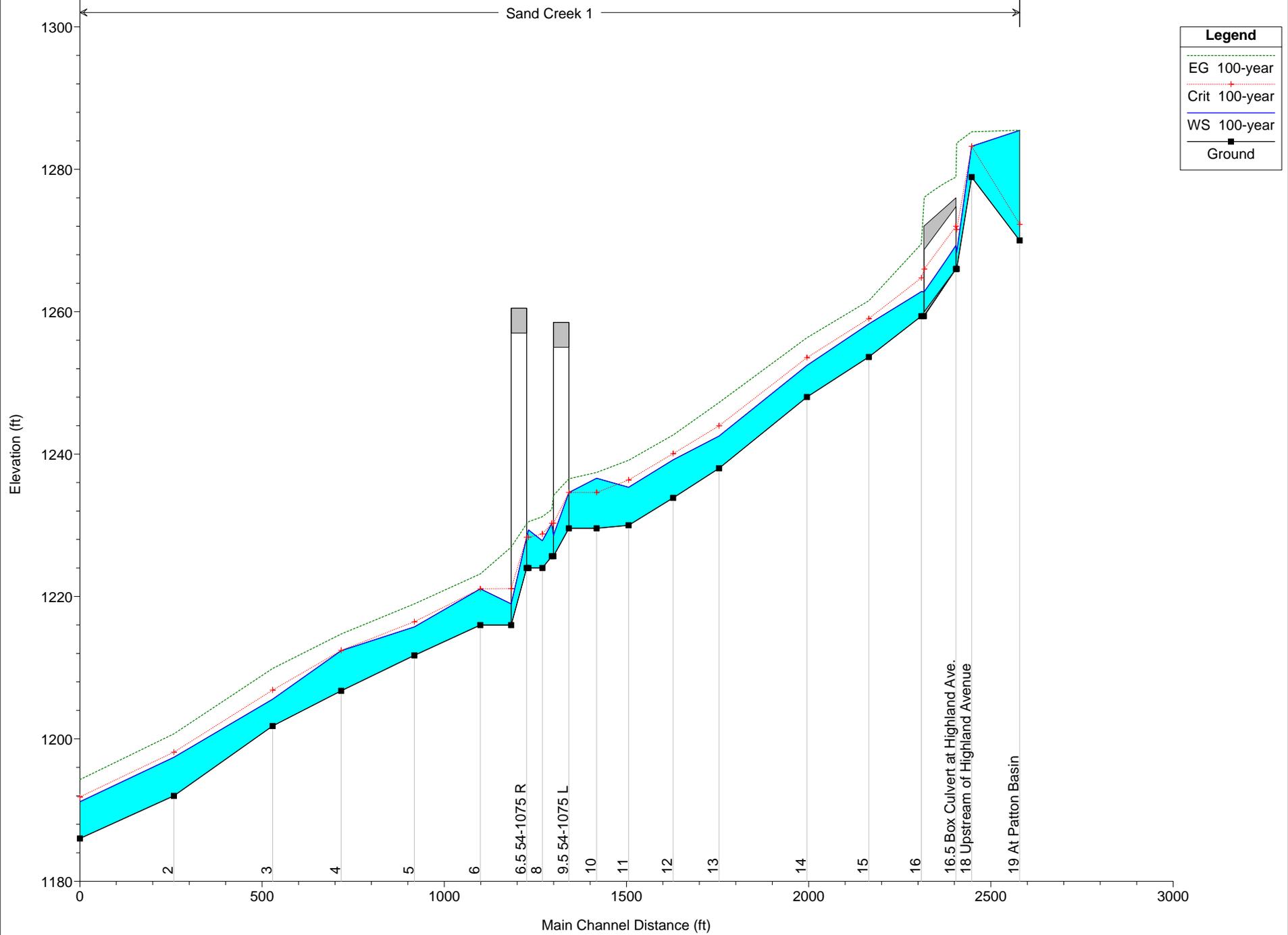
E.G. US. (ft)	1230.49	Element	Inside BR US	Inside BR DS
W.S. US. (ft)	1229.35	E.G. Elev (ft)	1230.22	1226.94
Q Total (cfs)	2496.00	W.S. Elev (ft)	1228.32	1218.96
Q Bridge (cfs)	2496.00	Crit W.S. (ft)	1228.32	1221.11
Q Weir (cfs)		Max Chl Dpth (ft)	4.32	2.98
Weir Sta Lft (ft)		Vel Total (ft/s)	11.06	22.66
Weir Sta Rgt (ft)		Flow Area (sq ft)	225.73	110.13
Weir Submerg		Froude # Chl	0.99	2.63
Weir Max Depth (ft)		Specif Force (cu ft)	1320.75	1896.22
Min EI Weir Flow (ft)	1260.51	Hydr Depth (ft)	3.84	2.31
Min EI Prs (ft)	1257.00	W.P. Total (ft)	61.61	48.90
Delta EG (ft)	7.32	Conv. Total (cfs)	19929.6	7029.4
Delta WS (ft)	8.27	Top Width (ft)	58.77	47.60
BR Open Area (sq ft)	4065.76	Frctn Loss (ft)	0.31	1.46
BR Open Vel (ft/s)	22.66	C & E Loss (ft)	0.53	1.82
Coef of Q		Shear Total (lb/sq ft)	3.59	17.73
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: Exist Plan Sand Creek 1 RS: 16.5 Culv Group: Culvert #1 Profile: 100-year

Q Culv Group (cfs)	2463.21	Culv Full Len (ft)	
# Barrels	3	Culv Vel US (ft/s)	24.86
Q Barrel (cfs)	821.07	Culv Vel DS (ft/s)	29.20
E.G. US. (ft)	1283.68	Culv Inv El Up (ft)	1266.00
W.S. US. (ft)	1268.36	Culv Inv El Dn (ft)	1260.00
E.G. DS (ft)	1267.29	Culv Frctn Ls (ft)	2.85
W.S. DS (ft)	1264.77	Culv Exit Loss (ft)	8.76
Delta EG (ft)	16.39	Culv Entr Loss (ft)	4.78
Delta WS (ft)	3.59	Q Weir (cfs)	
E.G. IC (ft)		Weir Sta Lft (ft)	144.90
E.G. OC (ft)		Weir Sta Rgt (ft)	202.55
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	1269.30	Weir Max Depth (ft)	0.39
Culv WS Outlet (ft)	1262.81	Weir Avg Depth (ft)	0.36
Culv Nml Depth (ft)	2.32	Weir Flow Area (sq ft)	20.48
Culv Crt Depth (ft)	5.99	Min El Weir Flow (ft)	1276.01

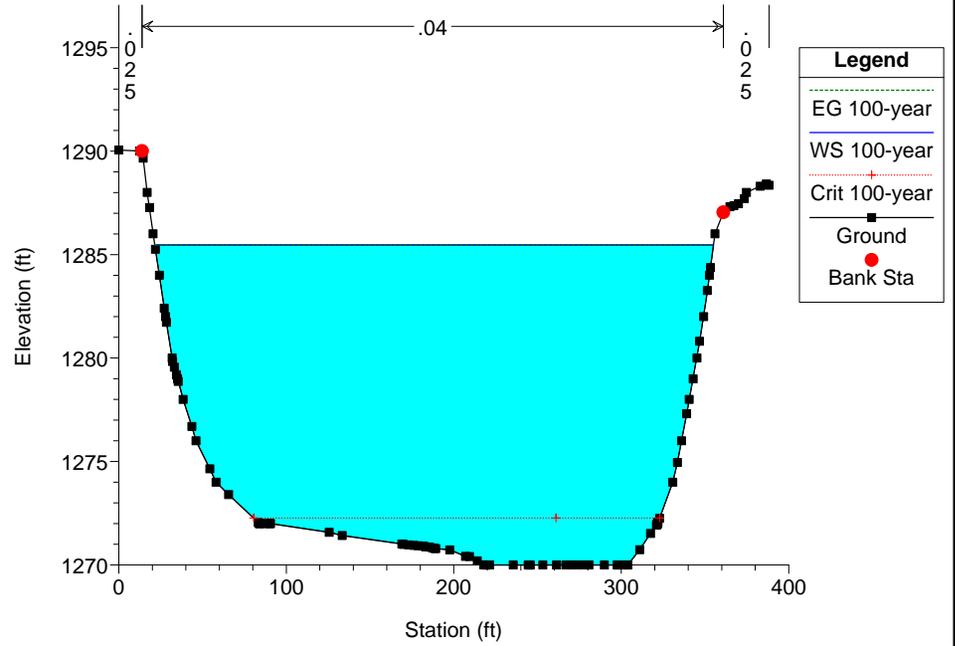
Sand Creek LHS Plan: Existing Conditions 12/8/2012

Sand Creek 1

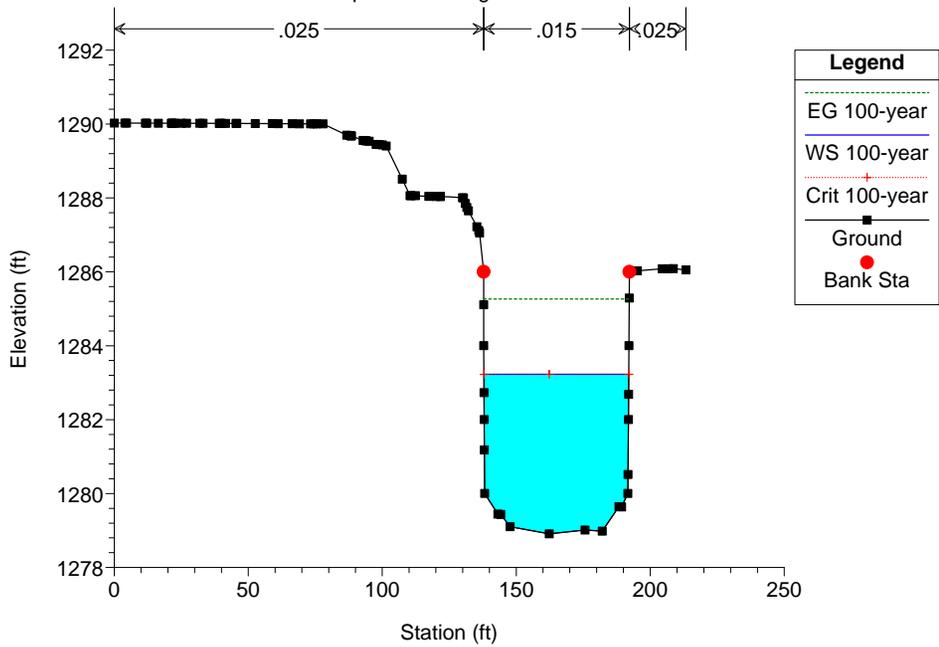


No Data for Plot

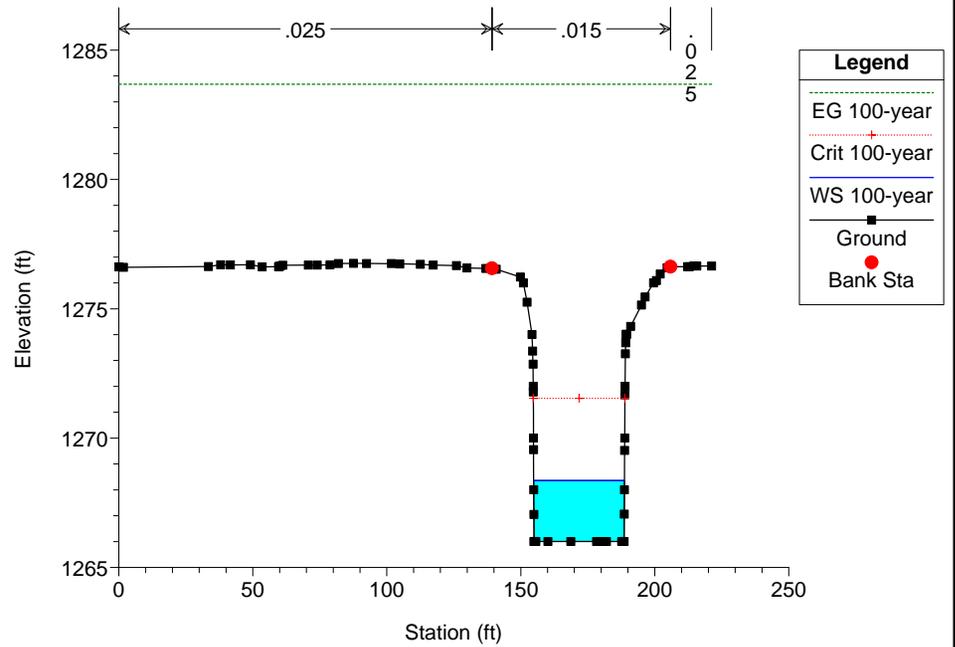
Sand Creek LHS Plan: Existing Conditions 12/8/2012
At Patton Basin

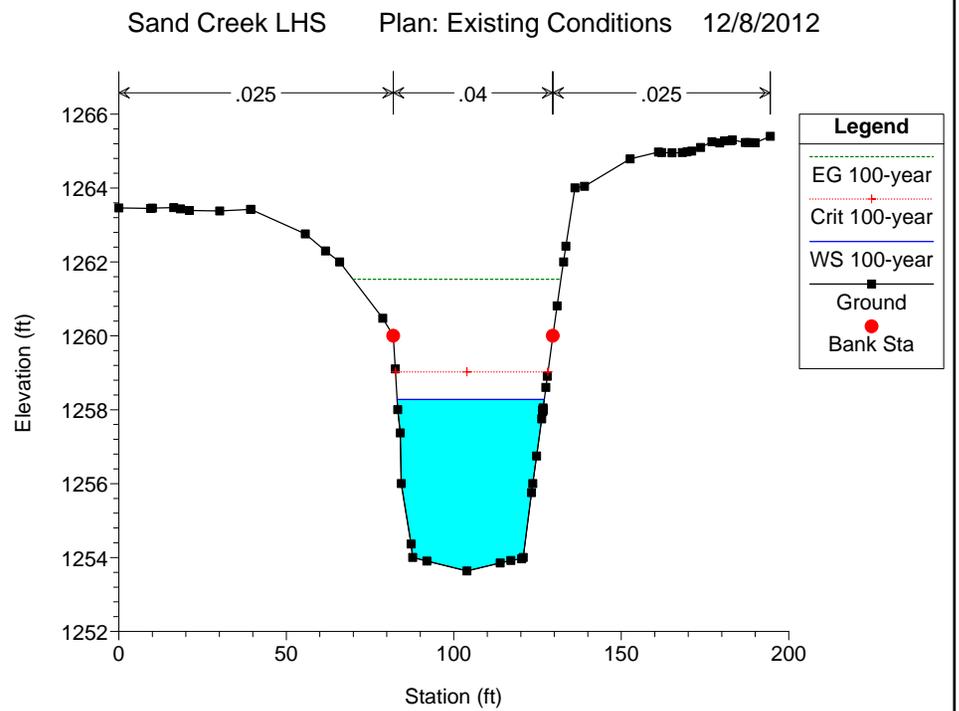
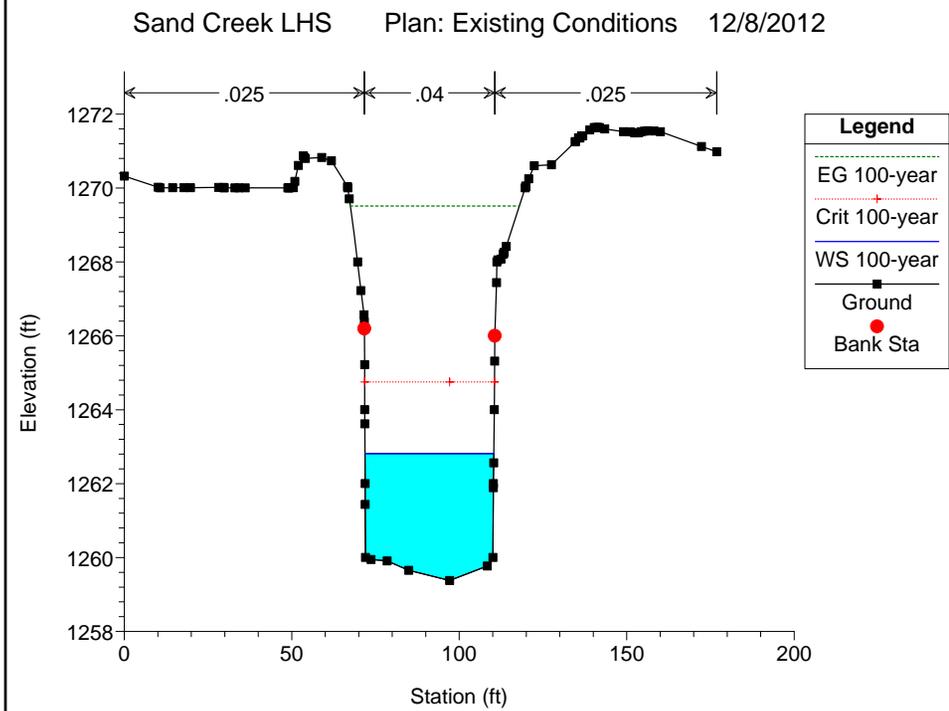
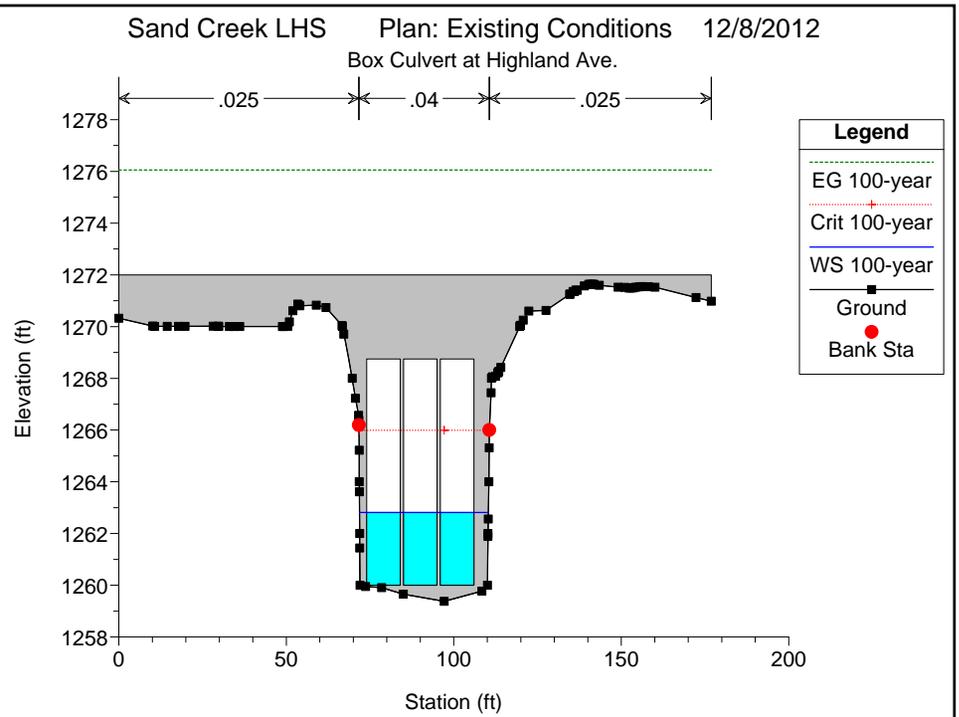
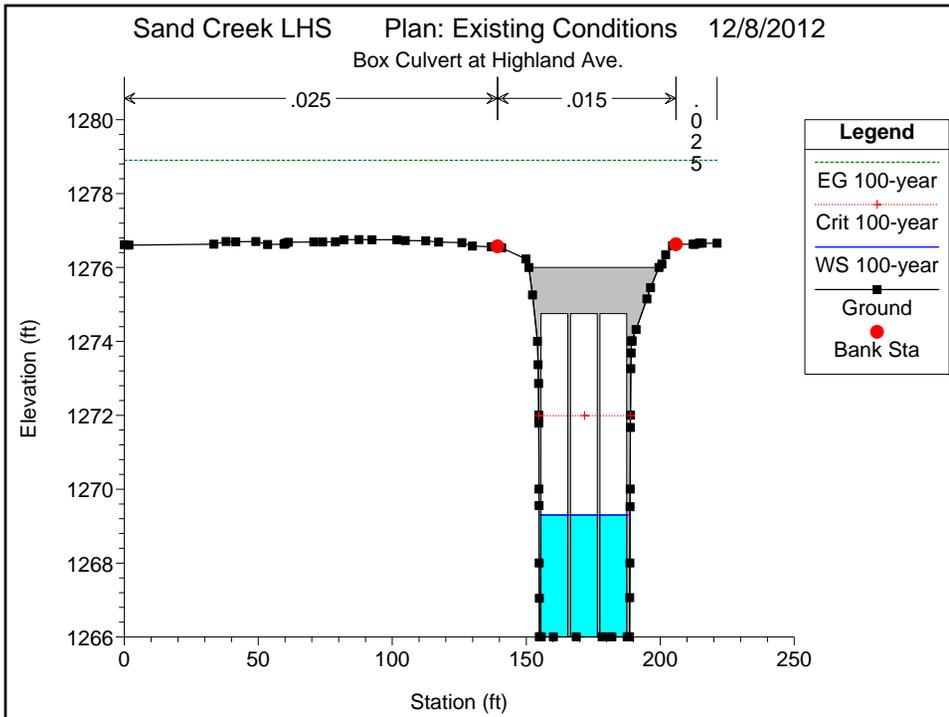


Sand Creek LHS Plan: Existing Conditions 12/8/2012
Upstream of Highland Avenue

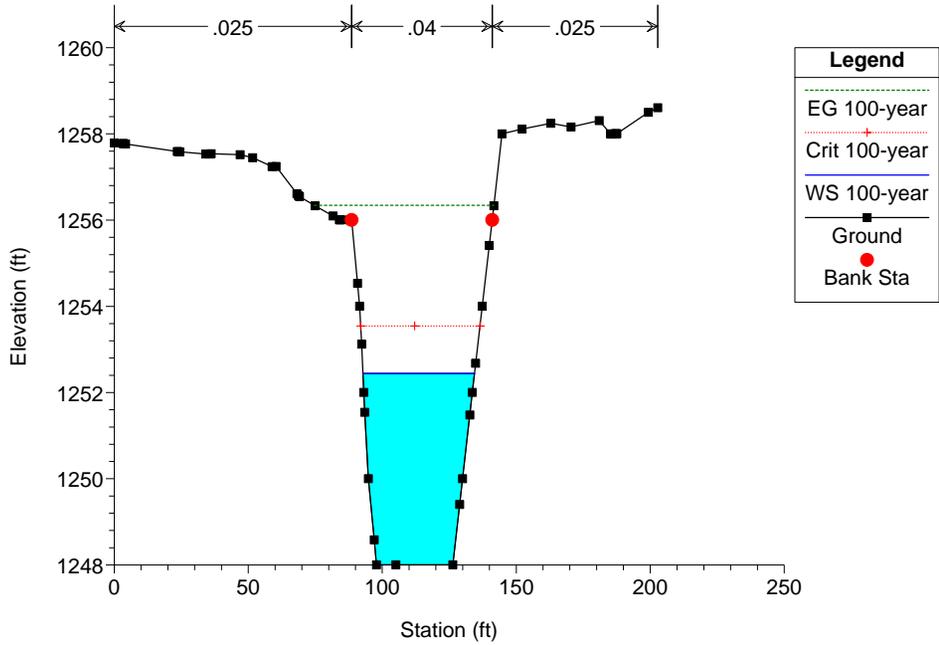


Sand Creek LHS Plan: Existing Conditions 12/8/2012

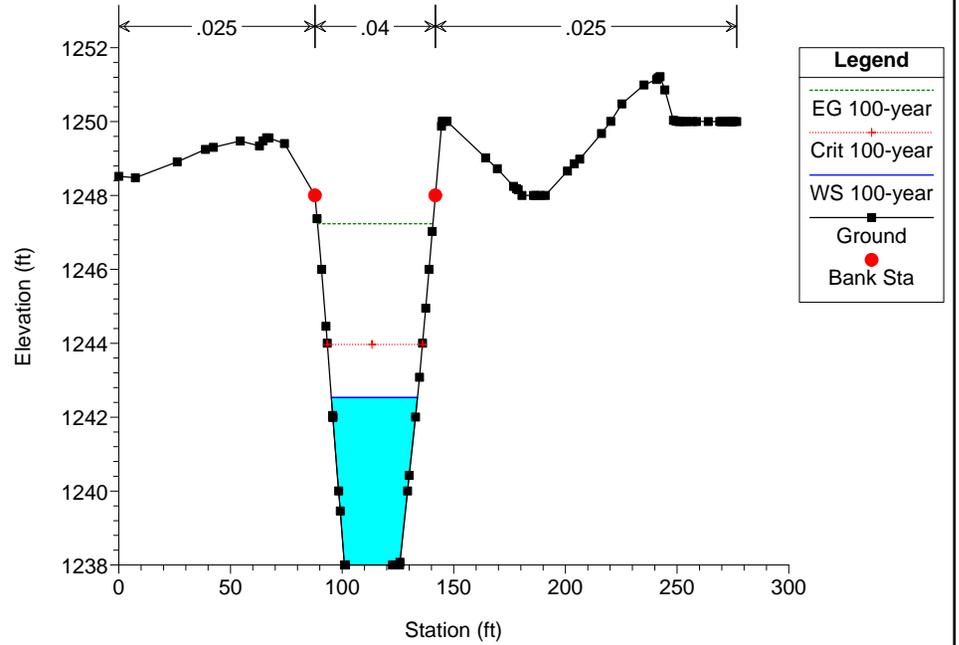




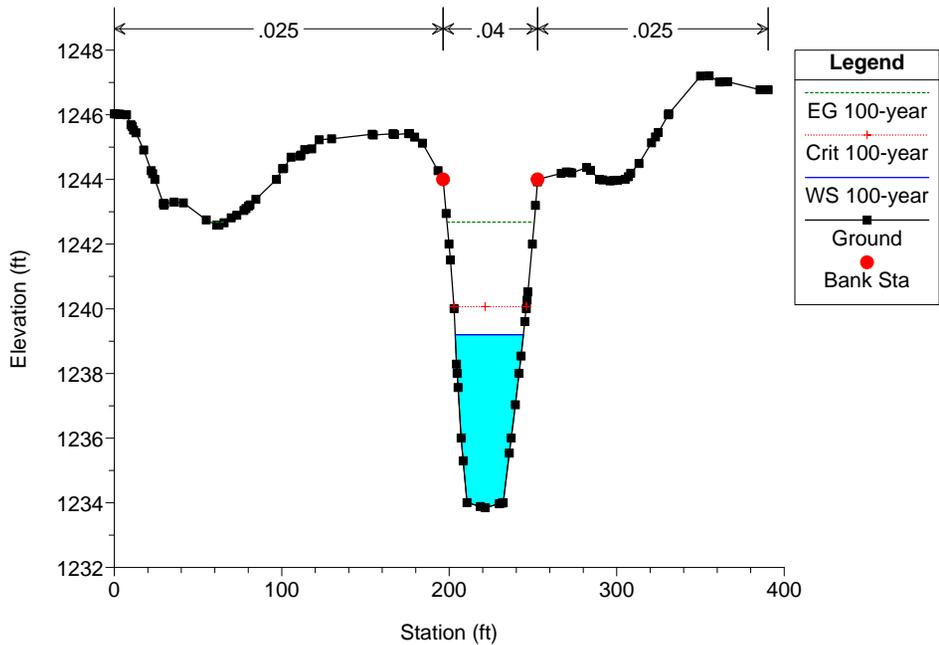
Sand Creek LHS Plan: Existing Conditions 12/8/2012



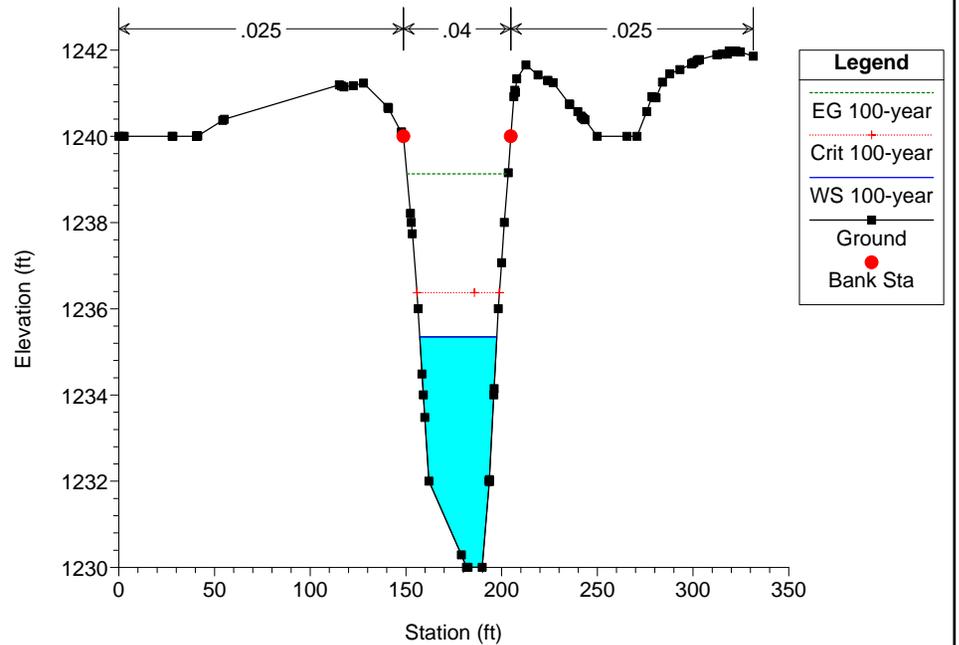
Sand Creek LHS Plan: Existing Conditions 12/8/2012

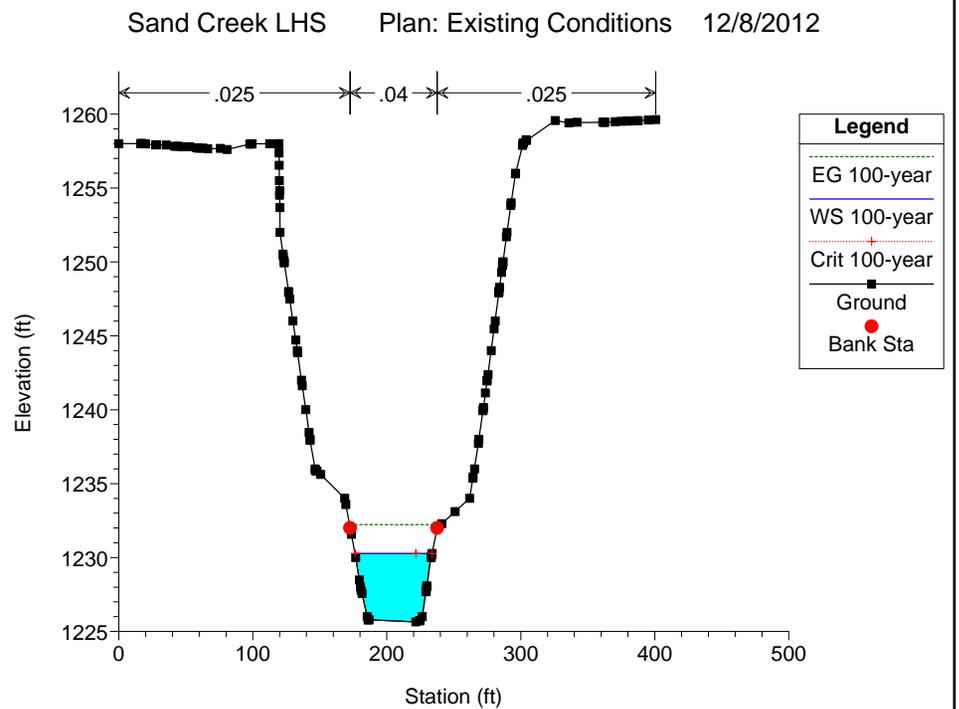
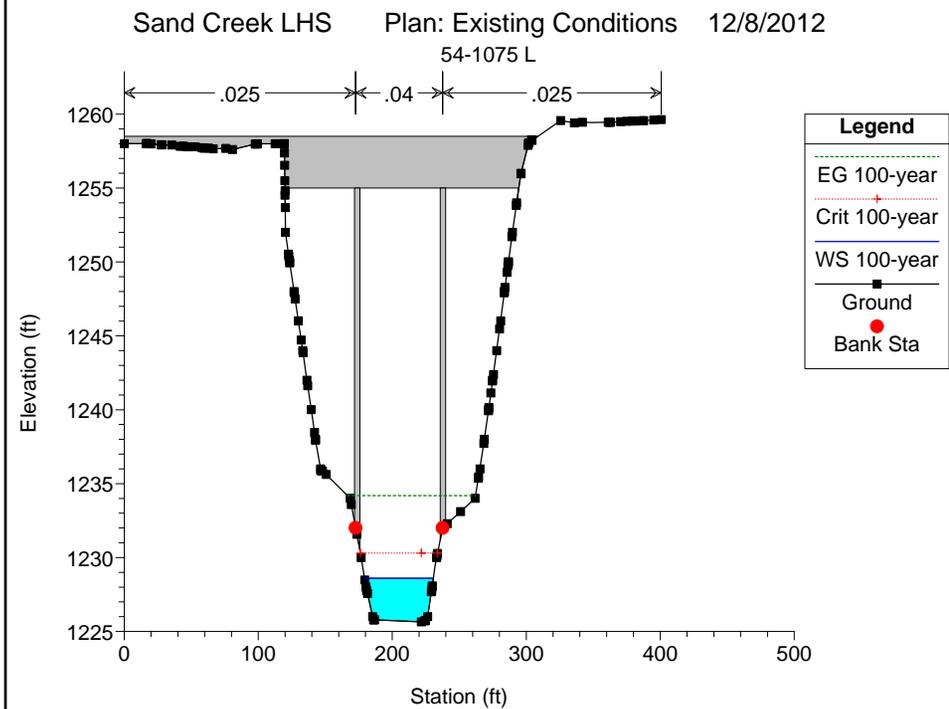
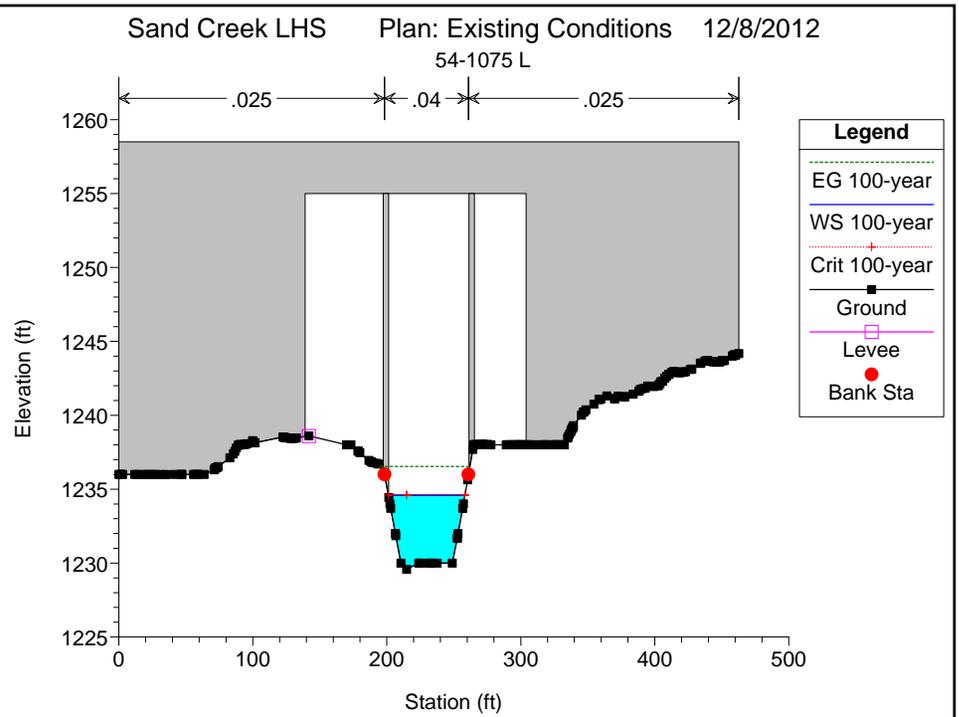
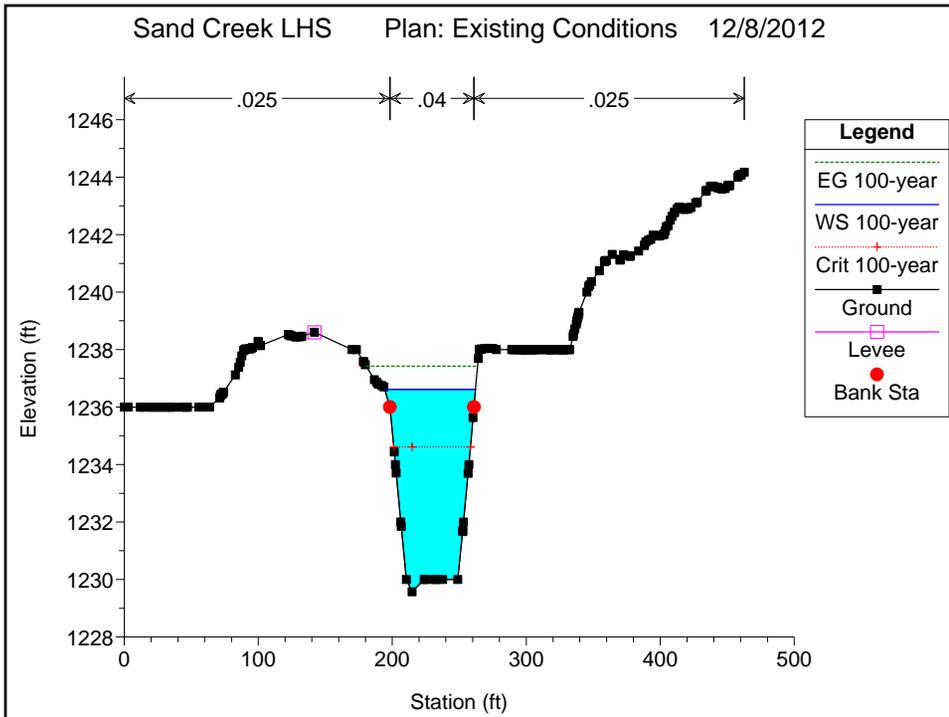


Sand Creek LHS Plan: Existing Conditions 12/8/2012

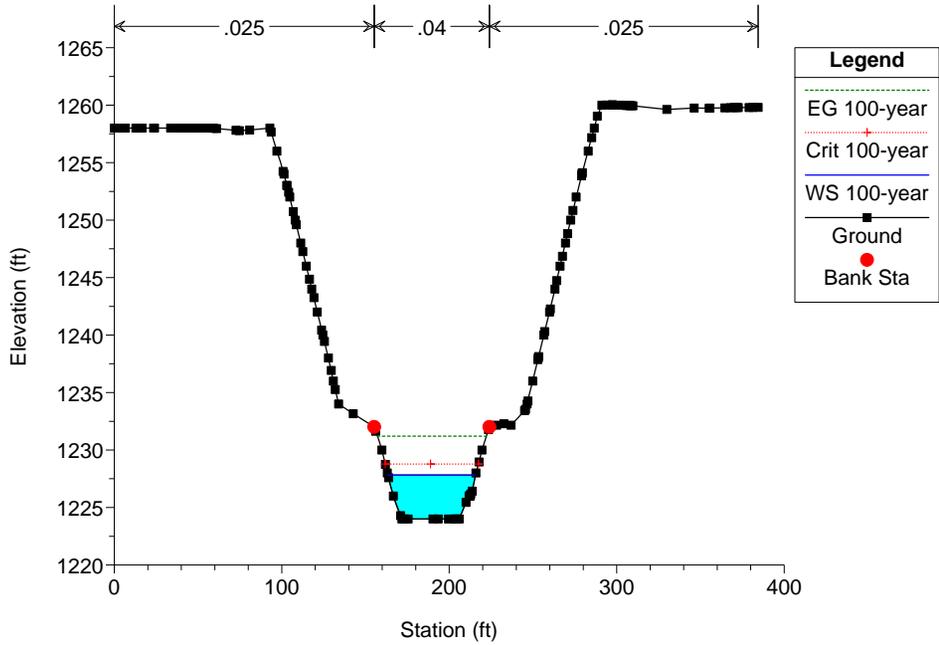


Sand Creek LHS Plan: Existing Conditions 12/8/2012

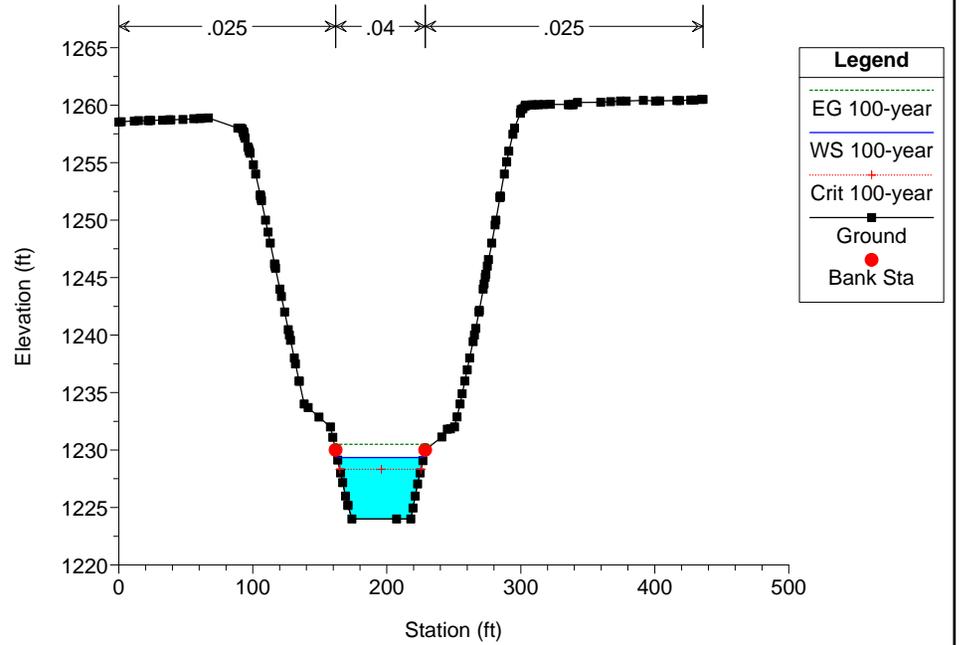




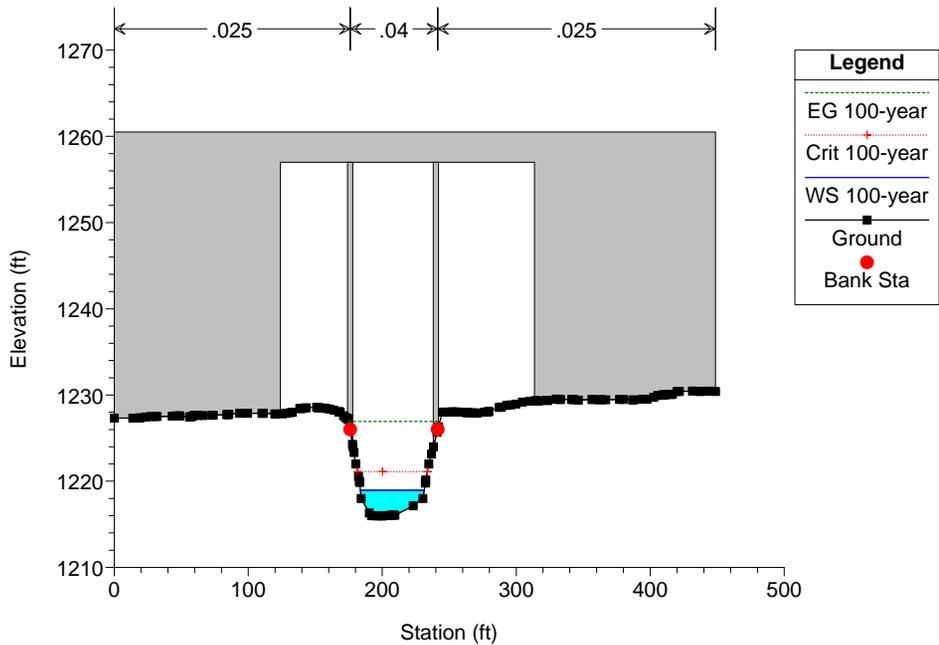
Sand Creek LHS Plan: Existing Conditions 12/8/2012



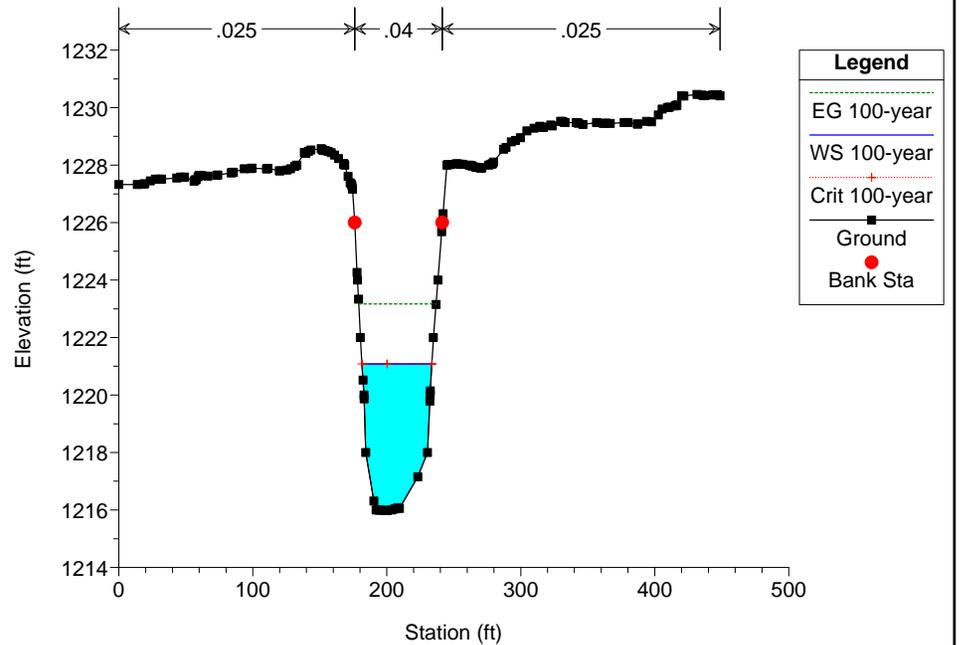
Sand Creek LHS Plan: Existing Conditions 12/8/2012



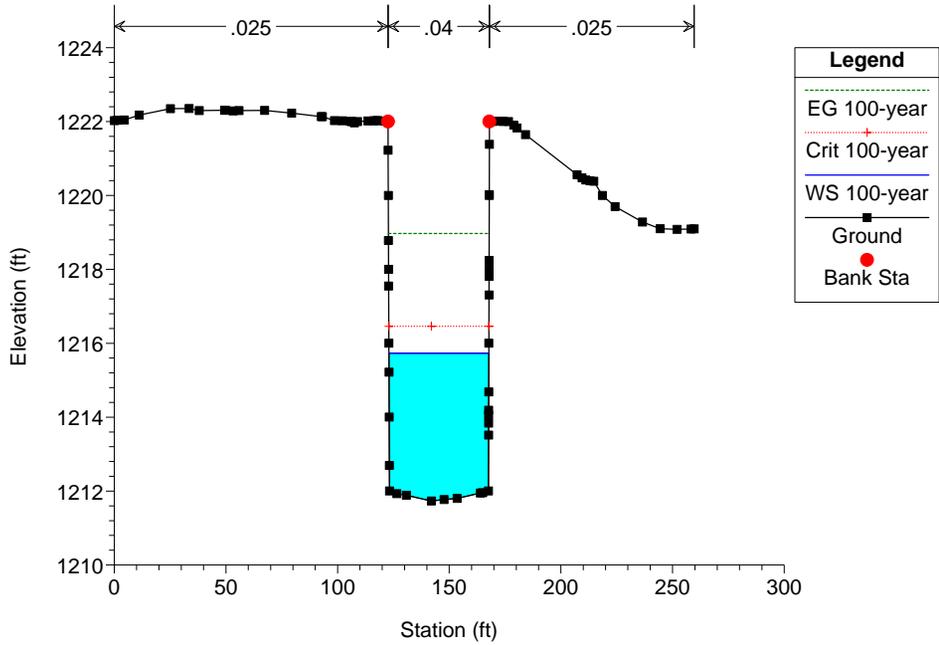
Sand Creek LHS Plan: Existing Conditions 12/8/2012
54-1075 R



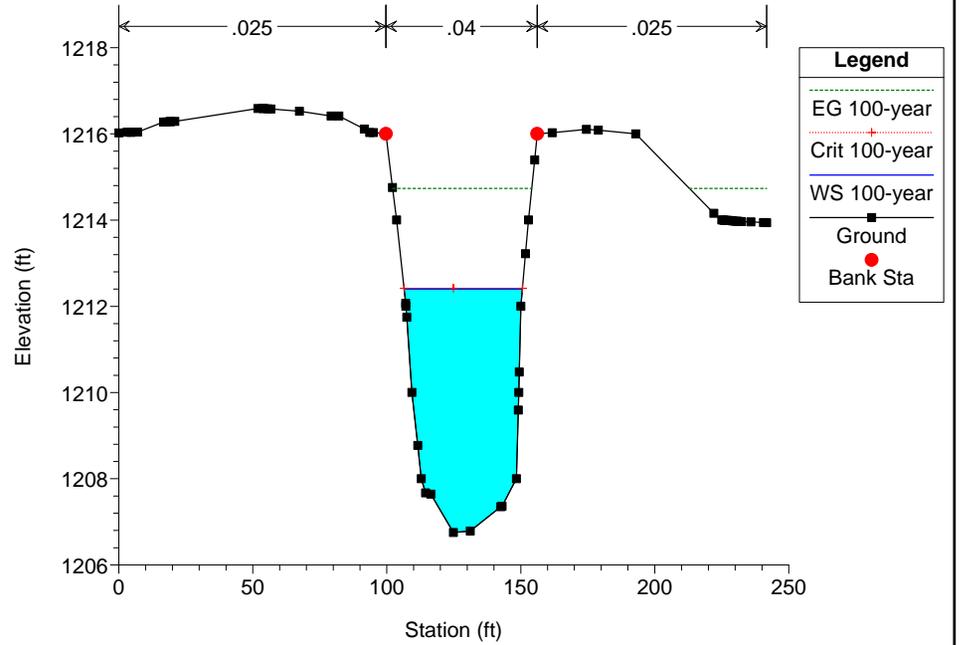
Sand Creek LHS Plan: Existing Conditions 12/8/2012



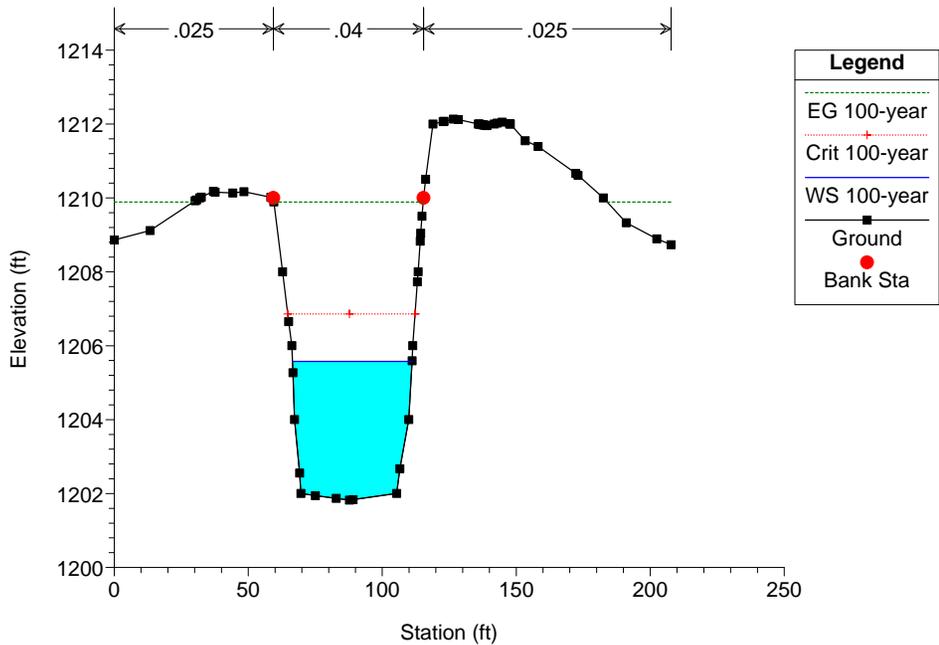
Sand Creek LHS Plan: Existing Conditions 12/8/2012



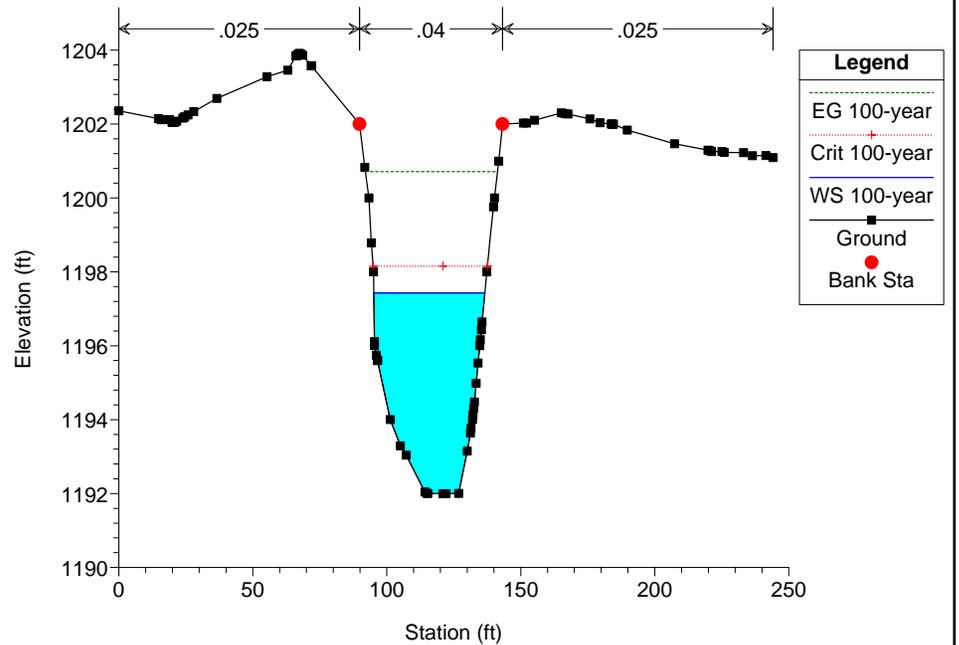
Sand Creek LHS Plan: Existing Conditions 12/8/2012



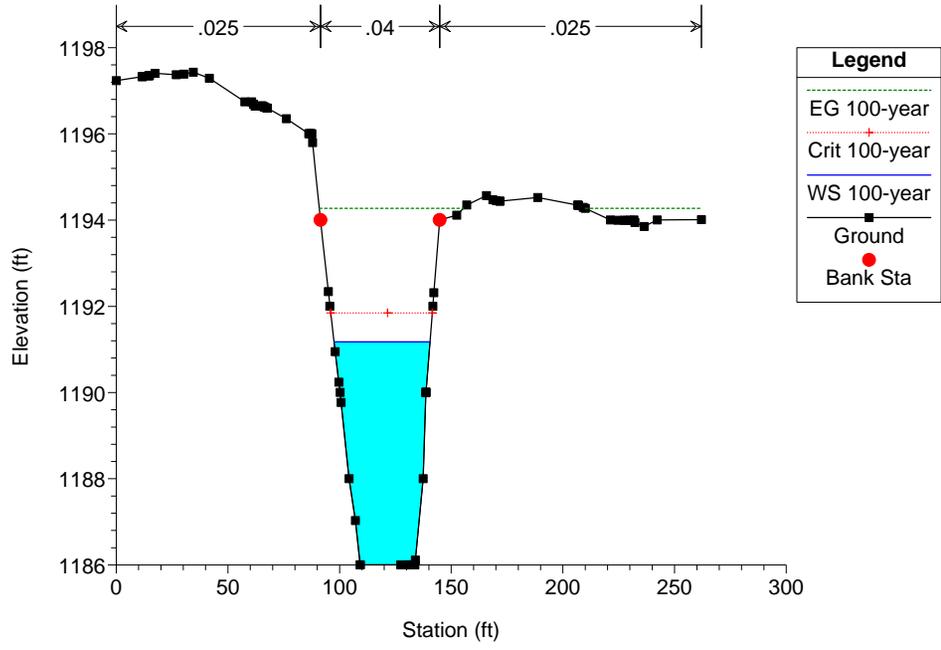
Sand Creek LHS Plan: Existing Conditions 12/8/2012



Sand Creek LHS Plan: Existing Conditions 12/8/2012



Sand Creek LHS Plan: Existing Conditions 12/8/2012



HEC-RAS Plan: Exist Plan River: Sand Creek Reach: 1 Profile: 100-year

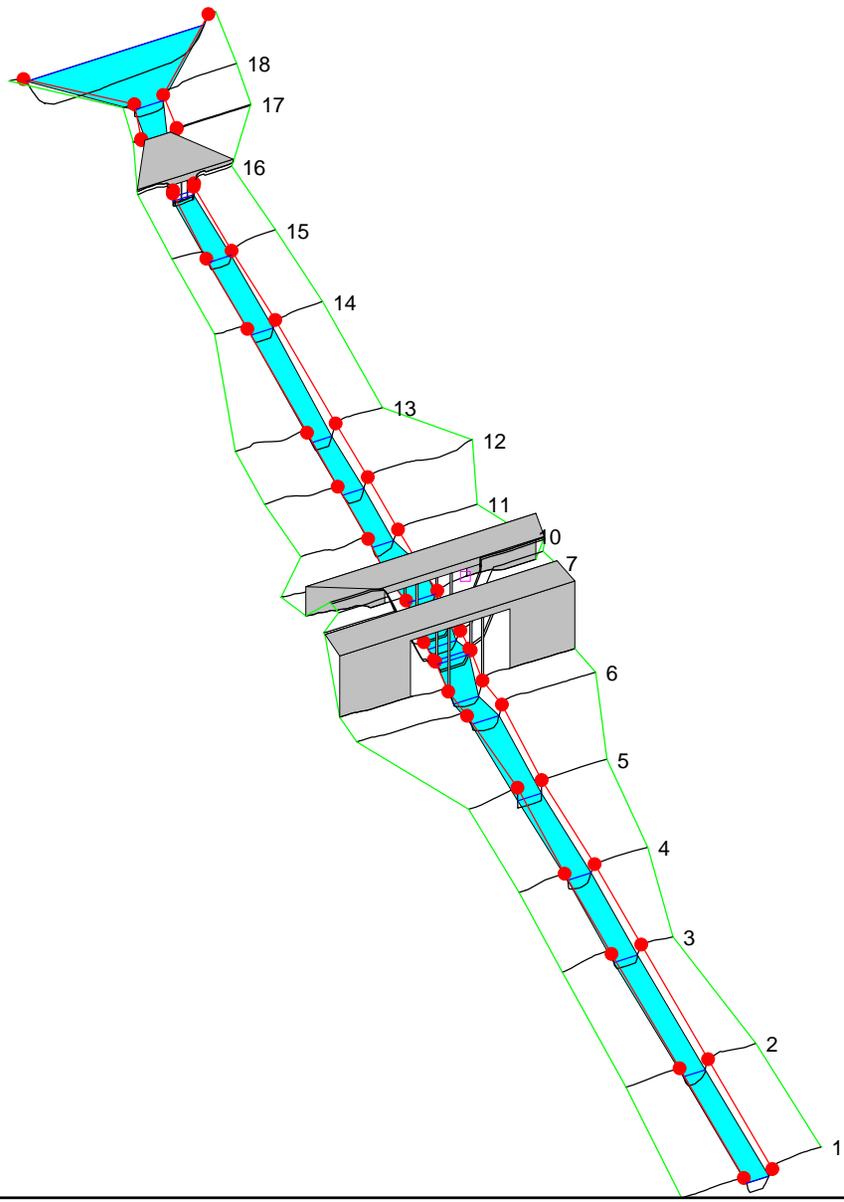
Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
1	19	100-year	2496.00	1270.00	1285.47	1272.27	1285.47	0.000008	0.57	4344.07	333.62	0.03
1	18	100-year	2496.00	1278.91	1283.23	1283.23	1285.26	0.002396	11.45	217.93	54.06	1.01
1	17	100-year	2496.00	1266.00	1268.36	1271.54	1283.68	0.038022	31.41	79.46	33.85	3.61
1	16.5		Culvert									
1	16	100-year	2496.00	1259.38	1262.81	1264.75	1269.51	0.081210	20.78	120.14	38.47	2.07
1	15	100-year	2496.00	1253.64	1258.28	1259.03	1261.53	0.027001	14.47	172.50	43.91	1.29
1	14	100-year	2496.00	1248.00	1252.45	1253.55	1256.34	0.033767	15.85	157.51	41.64	1.44
1	13	100-year	2496.00	1238.00	1242.53	1243.97	1247.24	0.041784	17.41	143.40	38.58	1.59
1	12	100-year	2496.00	1233.85	1239.20	1240.07	1242.68	0.027163	14.97	166.69	40.72	1.30
1	11	100-year	2496.00	1230.00	1235.35	1236.38	1239.13	0.030720	15.60	159.97	40.21	1.38
1	10	100-year	2496.00	1229.57	1236.62	1234.61	1237.42	0.004100	7.21	347.28	67.83	0.54
1	9.5		Bridge									
1	9	100-year	2496.00	1225.65	1230.27	1230.27	1232.22	0.015772	11.22	222.48	57.44	1.00
1	8	100-year	2496.00	1224.00	1227.82	1228.78	1231.21	0.034544	14.77	169.03	52.35	1.45
1	7	100-year	2496.00	1224.00	1229.35	1228.33	1230.49	0.007555	8.59	290.72	64.39	0.71
1	6.5		Bridge									
1	6	100-year	2496.00	1215.98	1221.08	1221.08	1223.17	0.015879	11.60	215.19	52.14	1.01
1	5	100-year	2496.00	1211.73	1215.73	1216.46	1218.97	0.030315	14.44	172.80	44.71	1.29
1	4	100-year	2496.00	1206.75	1212.40	1212.42	1214.74	0.016044	12.25	203.70	44.14	1.01
1	3	100-year	2496.00	1201.82	1205.58	1206.86	1209.89	0.043609	16.67	149.75	44.63	1.60
1	2	100-year	2496.00	1192.00	1197.43	1198.15	1200.71	0.025422	14.54	171.65	41.45	1.26
1	1	100-year	2496.00	1186.00	1191.17	1191.85	1194.27	0.024073	14.13	176.62	42.93	1.23

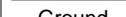
APPENDIX B

HEC-RAS Model Output Files

Proposed Condition

Sand Creek Proposed Plan: Proposed Condition 12/10/2012



Legend	
	WS 100-year
	Ground
	Bank Sta
	Levee

Plan: Prop Plan Sand Creek 1 RS: 9.5 Profile: 100-year

		Element	Inside BR US	Inside BR DS
E.G. US. (ft)	1237.28			
W.S. US. (ft)	1236.41	E.G. Elev (ft)	1236.54	1234.00
Q Total (cfs)	2496.00	W.S. Elev (ft)	1234.60	1228.65
Q Bridge (cfs)	2496.00	Crit W.S. (ft)	1234.60	1230.30
Q Weir (cfs)		Max Chl Dpth (ft)	5.03	3.00
Weir Sta Lft (ft)		Vel Total (ft/s)	11.18	18.56
Weir Sta Rgt (ft)		Flow Area (sq ft)	223.32	134.45
Weir Submerg		Froude # Chl	0.99	2.03
Weir Max Depth (ft)		Specif Force (cu ft)	1353.64	1627.34
Min EI Weir Flow (ft)	1258.51	Hydr Depth (ft)	3.92	2.60
Min EI Prs (ft)	1255.00	W.P. Total (ft)	59.18	53.01
Delta EG (ft)	4.07	Conv. Total (cfs)	21166.9	9778.4
Delta WS (ft)	7.44	Top Width (ft)	56.92	51.63
BR Open Area (sq ft)	3104.49	Frctn Loss (ft)	0.56	1.52
BR Open Vel (ft/s)	18.56	C & E Loss (ft)	0.36	1.02
Coef of Q		Shear Total (lb/sq ft)	3.28	10.32
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: Prop Plan Sand Creek 1 RS: 6.5 Profile: 100-year

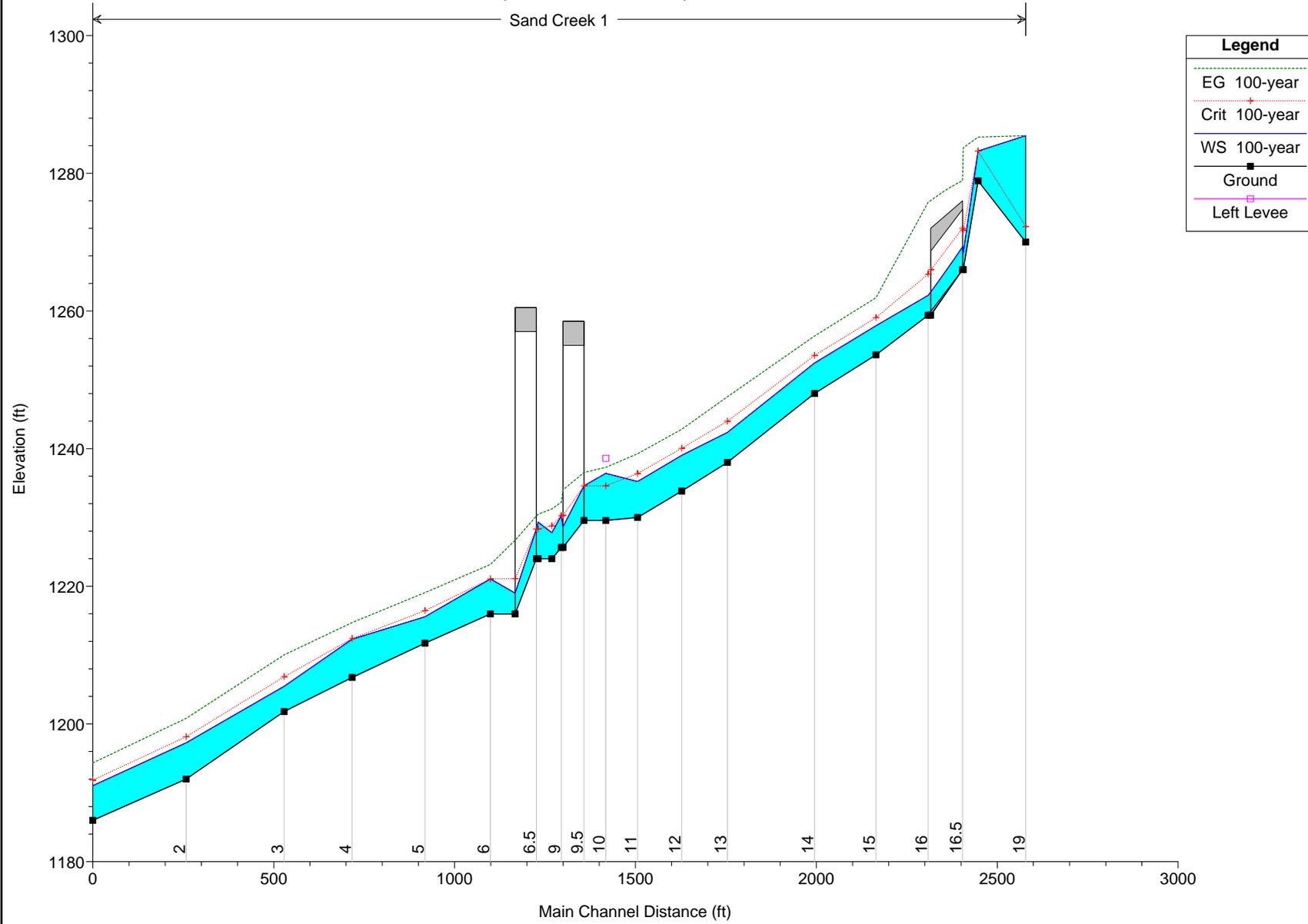
		Element	Inside BR US	Inside BR DS
E.G. US. (ft)	1230.49			
W.S. US. (ft)	1229.33	E.G. Elev (ft)	1230.22	1226.69
Q Total (cfs)	2496.00	W.S. Elev (ft)	1228.32	1219.01
Q Bridge (cfs)	2496.00	Crit W.S. (ft)	1228.32	1221.11
Q Weir (cfs)		Max Chl Dpth (ft)	4.32	3.02
Weir Sta Lft (ft)		Vel Total (ft/s)	11.06	22.25
Weir Sta Rgt (ft)		Flow Area (sq ft)	225.73	112.18
Weir Submerg		Froude # Chl	0.99	2.56
Weir Max Depth (ft)		Specif Force (cu ft)	1320.75	1868.94
Min EI Weir Flow (ft)	1260.51	Hydr Depth (ft)	3.84	2.35
Min EI Prs (ft)	1257.00	W.P. Total (ft)	61.61	49.01
Delta EG (ft)	7.32	Conv. Total (cfs)	20978.5	7618.4
Delta WS (ft)	8.25	Top Width (ft)	58.77	47.67
BR Open Area (sq ft)	4065.76	Frctn Loss (ft)	0.41	1.79
BR Open Vel (ft/s)	22.25	C & E Loss (ft)	0.49	1.74
Coef of Q		Shear Total (lb/sq ft)	3.24	15.34
Br Sel Method	Energy only	Power Total (lb/ft s)	0.00	0.00

Plan: Prop Plan Sand Creek 1 RS: 16.5 Culv Group: Culvert #1 Profile: 100-year

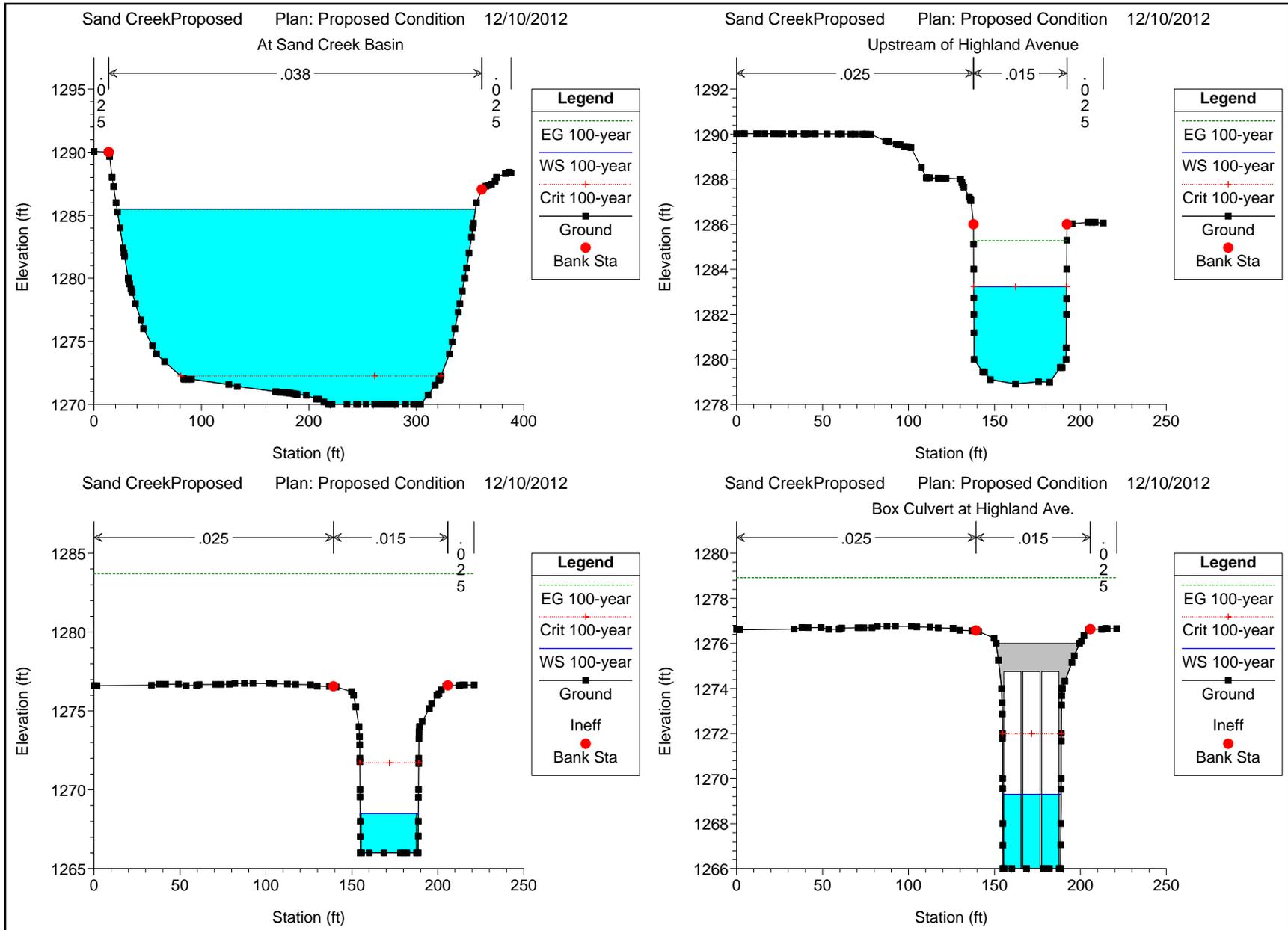
Q Culv Group (cfs)	2463.21	Culv Full Len (ft)	
# Barrels	3	Culv Vel US (ft/s)	24.88
Q Barrel (cfs)	821.07	Culv Vel DS (ft/s)	29.22
E.G. US. (ft)	1283.71	Culv Inv El Up (ft)	1266.00
W.S. US. (ft)	1268.50	Culv Inv El Dn (ft)	1260.00
E.G. DS (ft)	1268.24	Culv Frctn Ls (ft)	2.85
W.S. DS (ft)	1265.36	Culv Exit Loss (ft)	7.82
Delta EG (ft)	15.47	Culv Entr Loss (ft)	4.79
Delta WS (ft)	3.14	Q Weir (cfs)	
E.G. IC (ft)		Weir Sta Lft (ft)	144.90
E.G. OC (ft)		Weir Sta Rgt (ft)	202.55
Culvert Control	Outlet	Weir Submerg	0.00
Culv WS Inlet (ft)	1269.30	Weir Max Depth (ft)	0.39
Culv WS Outlet (ft)	1262.81	Weir Avg Depth (ft)	0.36
Culv Nml Depth (ft)	2.32	Weir Flow Area (sq ft)	20.48
Culv Crt Depth (ft)	5.99	Min El Weir Flow (ft)	1276.01

Sand Creek Proposed Plan: Proposed Condition 12/10/2012

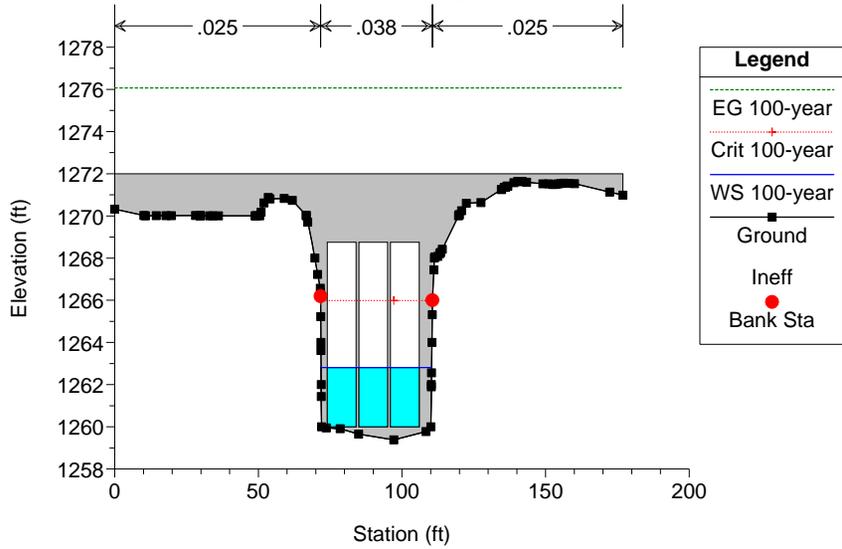
Sand Creek 1



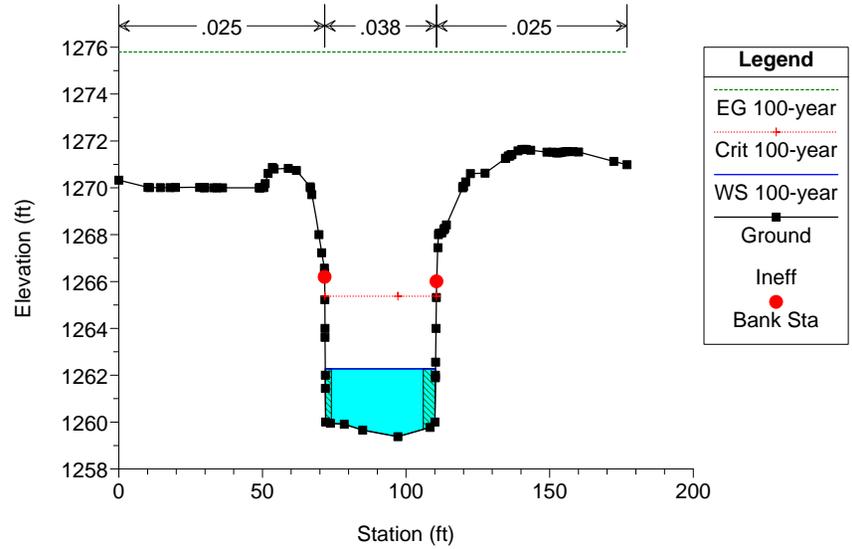
Legend	
EG 100-year	(dotted green line)
Crit 100-year	(dotted red line with '+')
WS 100-year	(solid blue line)
Ground	(solid black line with square)
Left Levee	(solid magenta line with square)



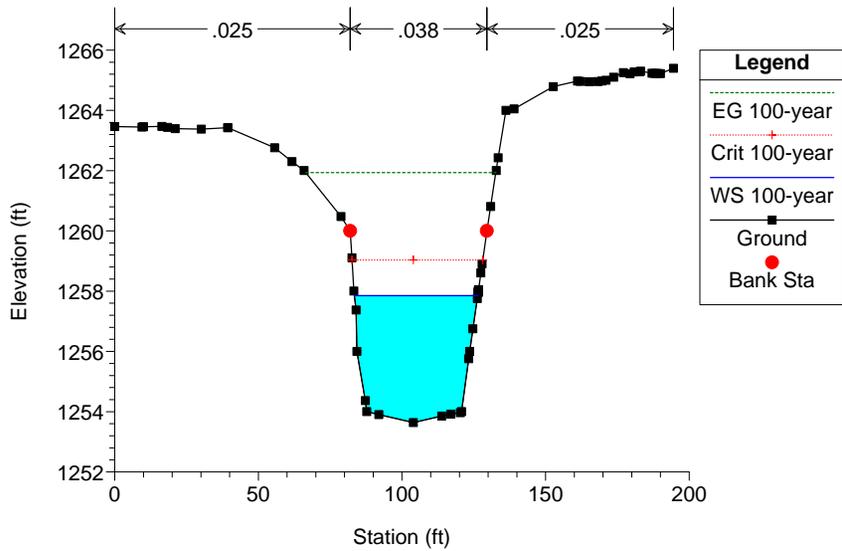
Sand Creek Proposed Plan: Proposed Condition 12/10/2012
 Box Culvert at Highland Ave.



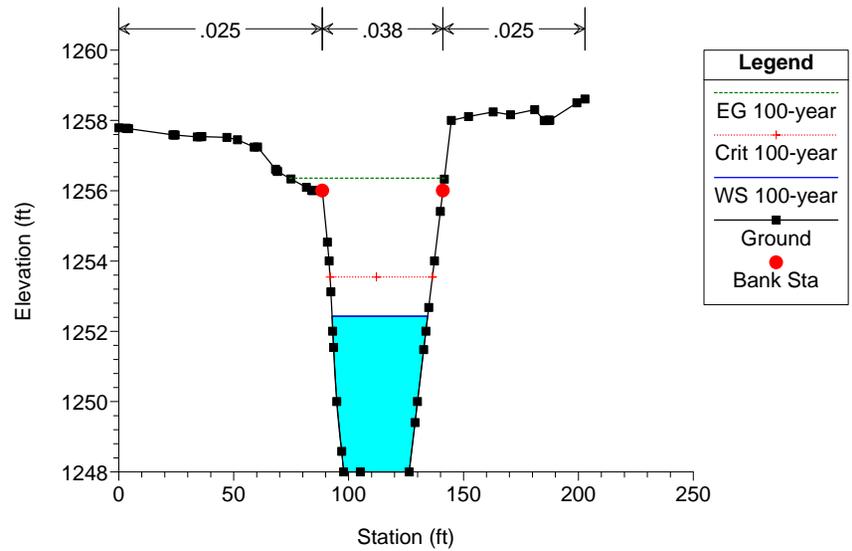
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



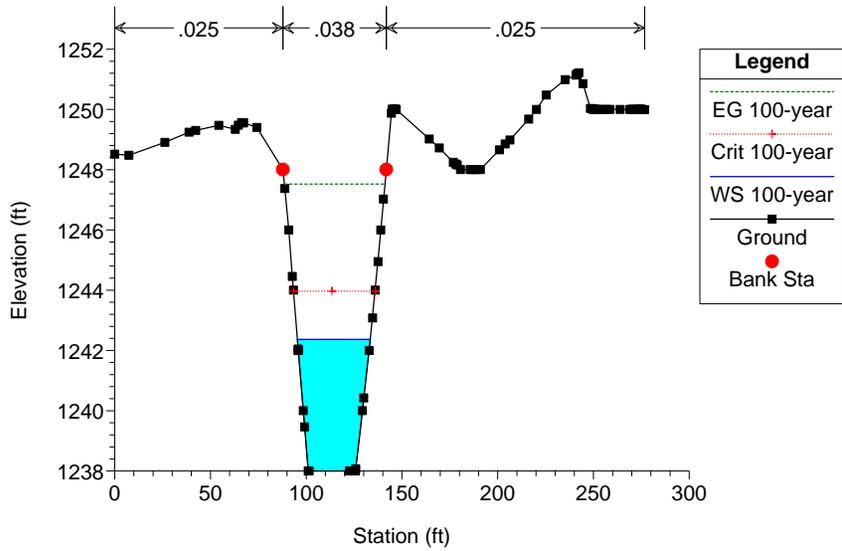
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



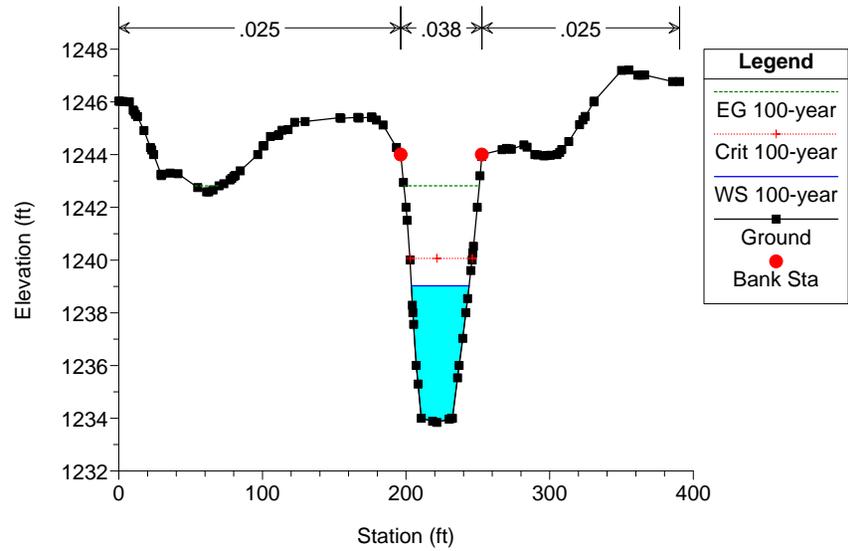
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



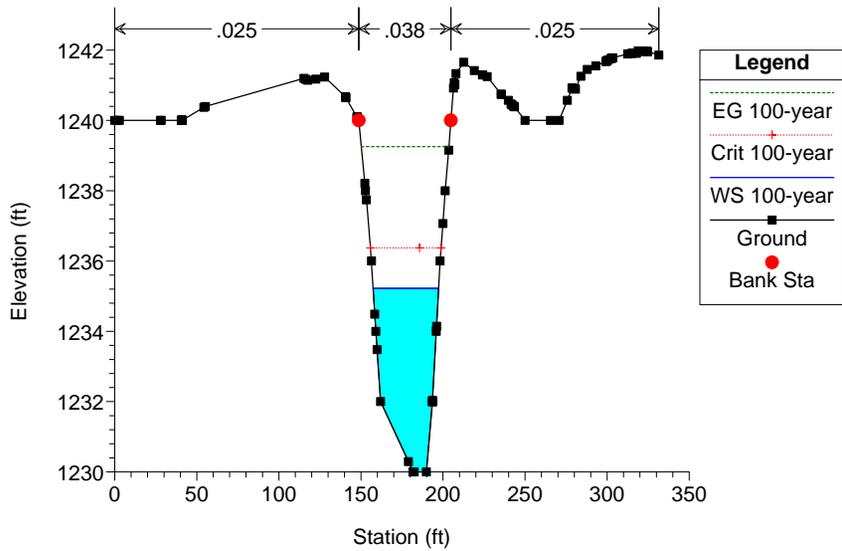
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



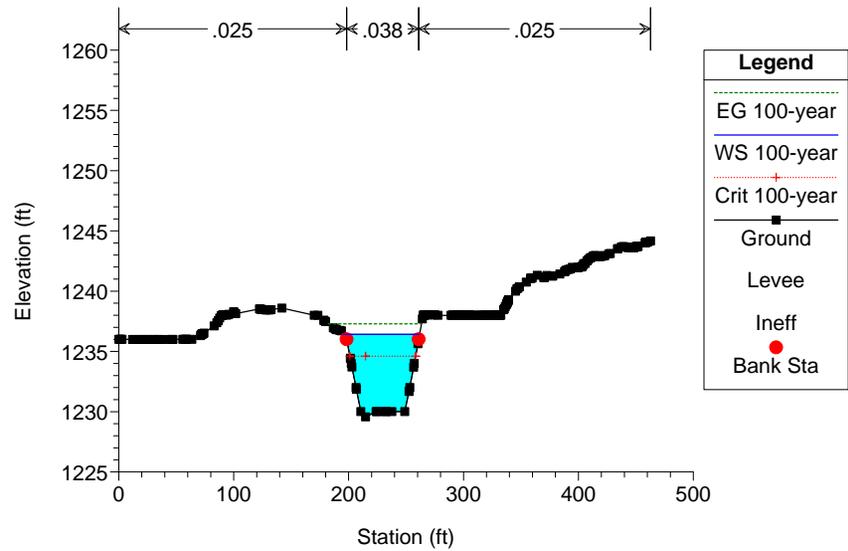
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



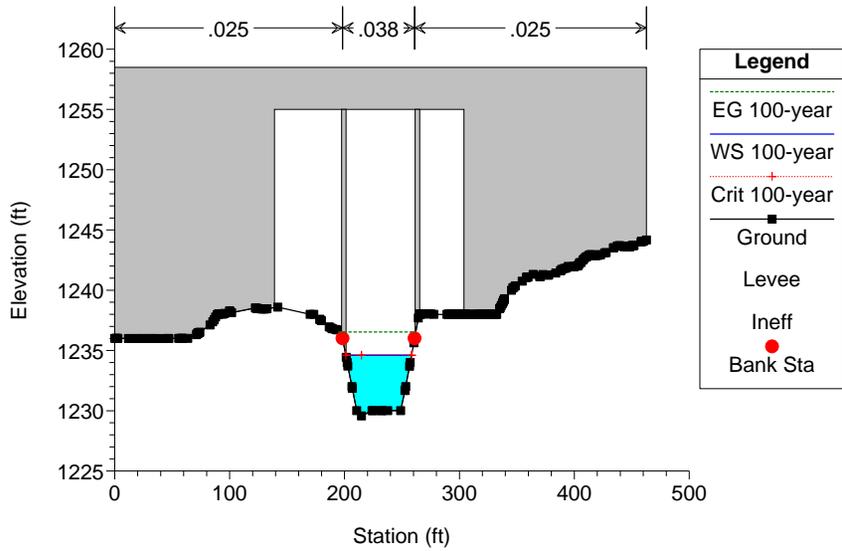
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



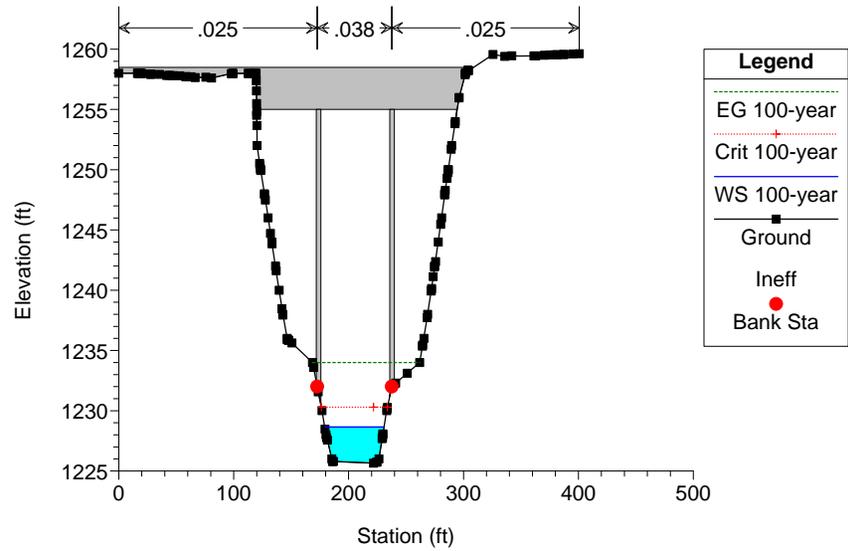
Sand Creek Proposed Plan: Proposed Condition 12/10/2012



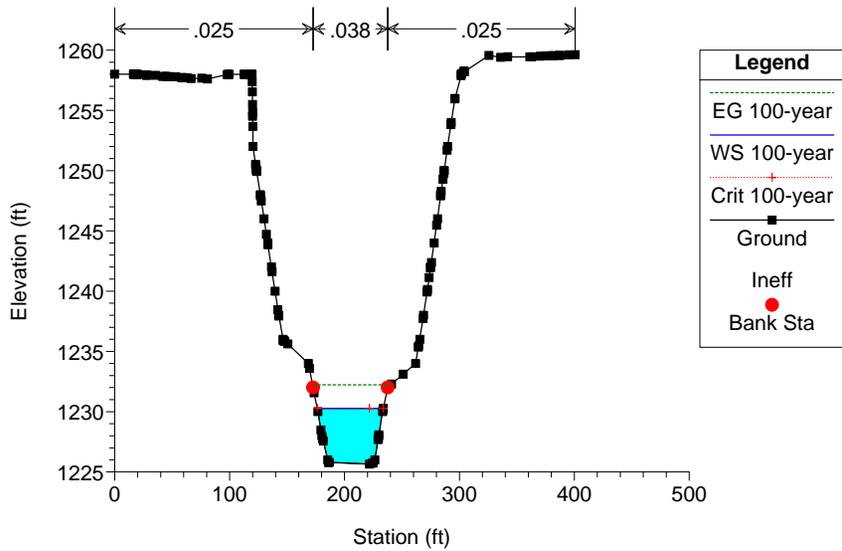
Sand CreekProposed Plan: Proposed Condition 12/10/2012



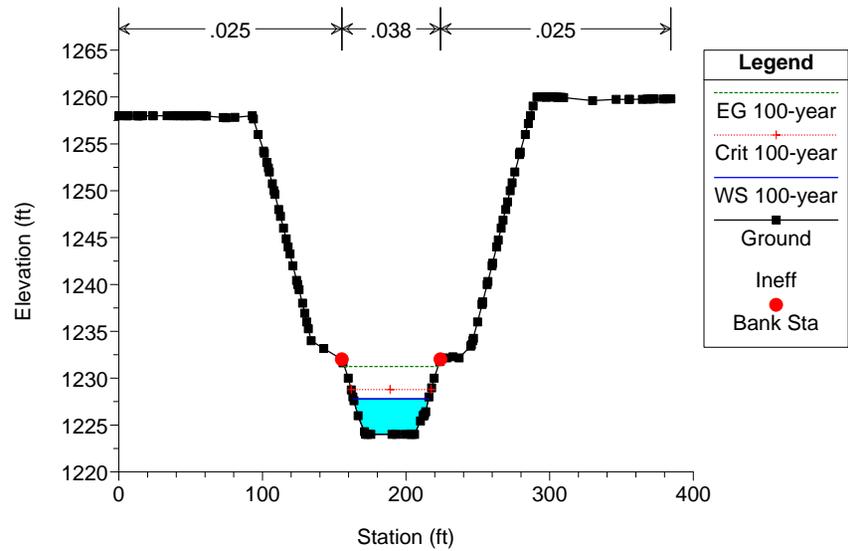
Sand CreekProposed Plan: Proposed Condition 12/10/2012



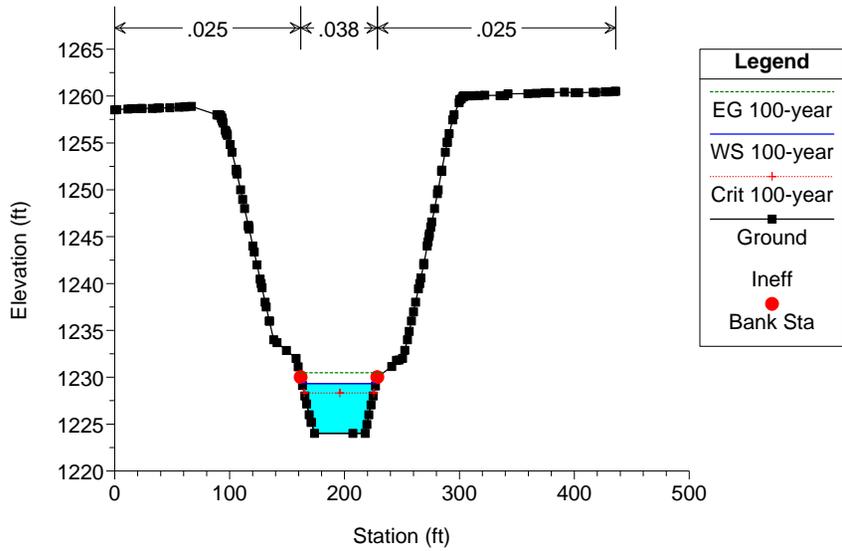
Sand CreekProposed Plan: Proposed Condition 12/10/2012



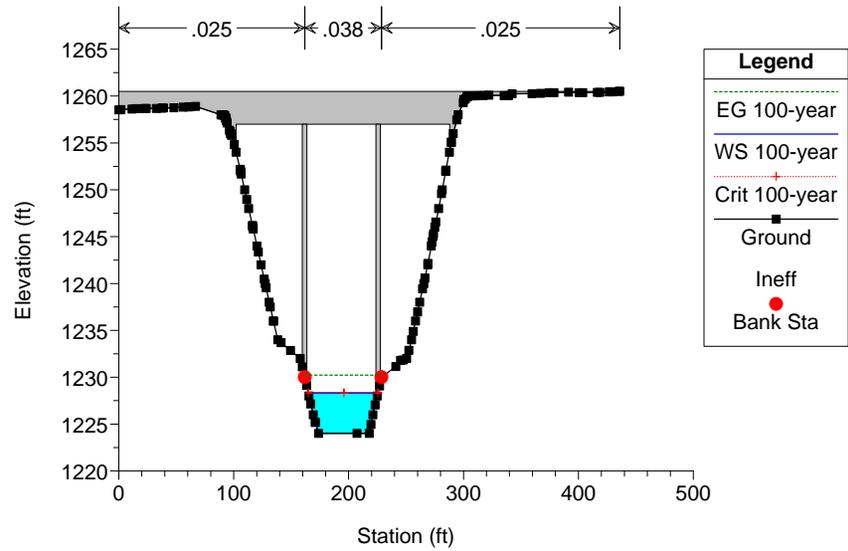
Sand CreekProposed Plan: Proposed Condition 12/10/2012



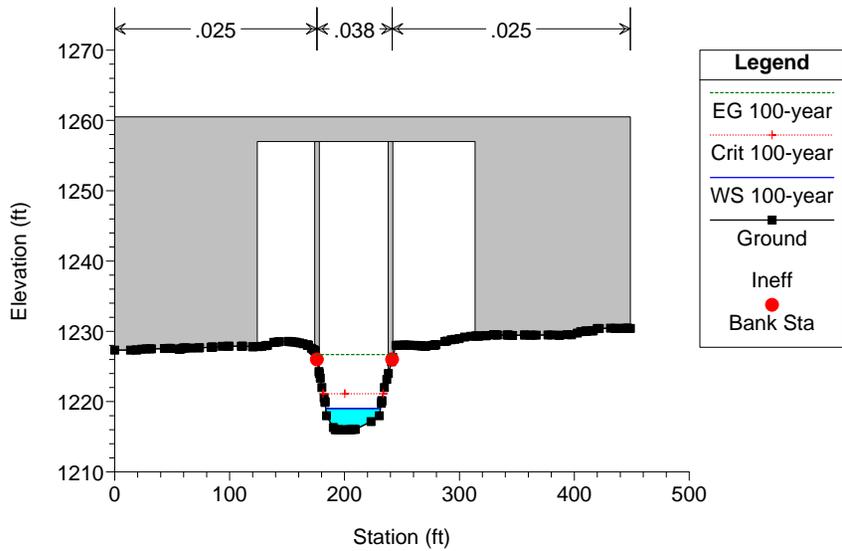
Sand CreekProposed Plan: Proposed Condition 12/10/2012



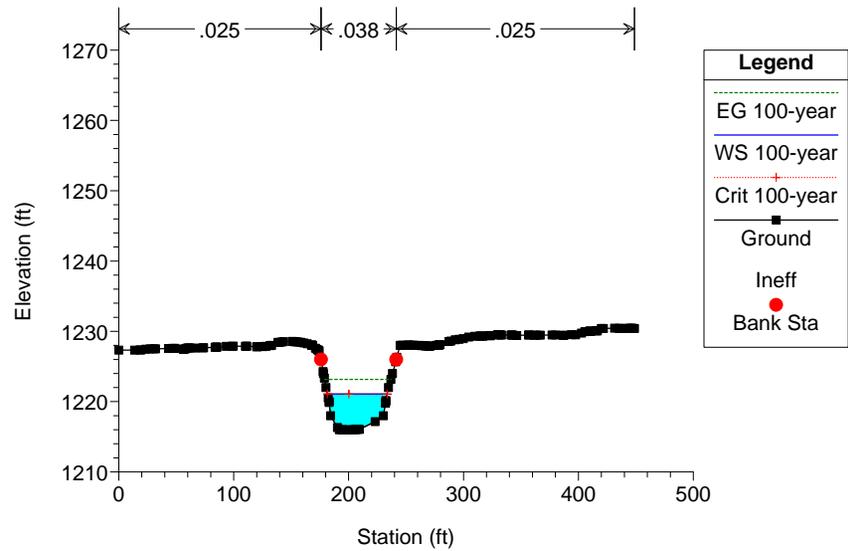
Sand CreekProposed Plan: Proposed Condition 12/10/2012



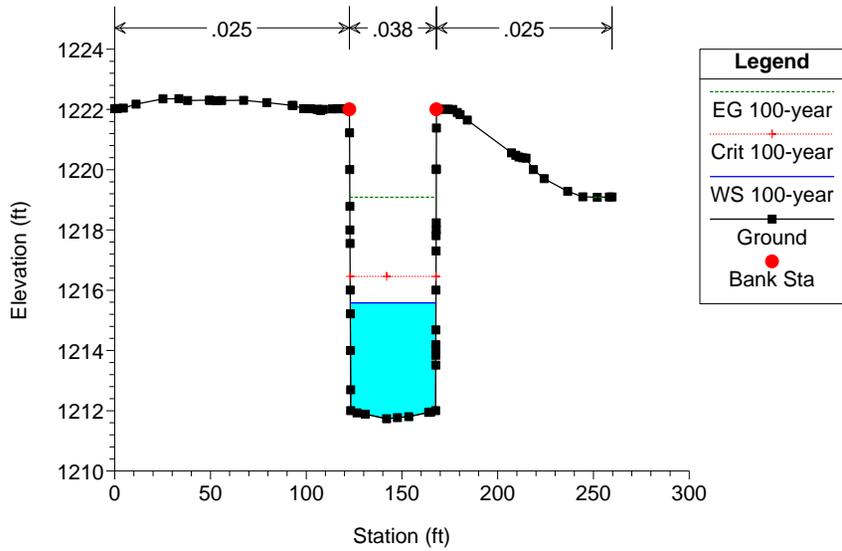
Sand CreekProposed Plan: Proposed Condition 12/10/2012



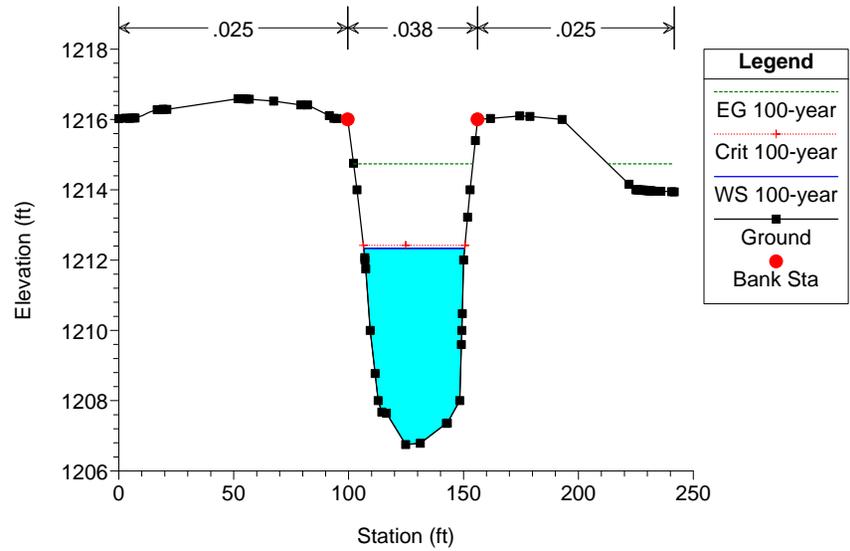
Sand CreekProposed Plan: Proposed Condition 12/10/2012



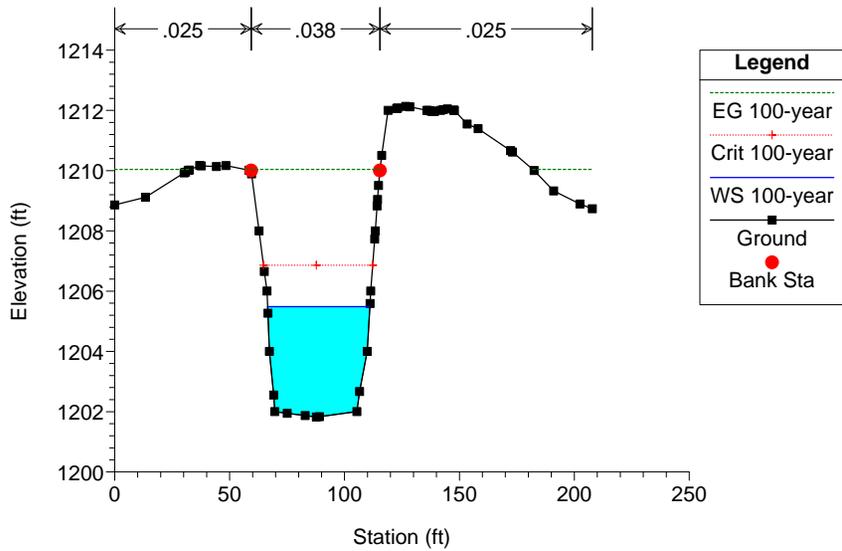
Sand CreekProposed Plan: Proposed Condition 12/10/2012



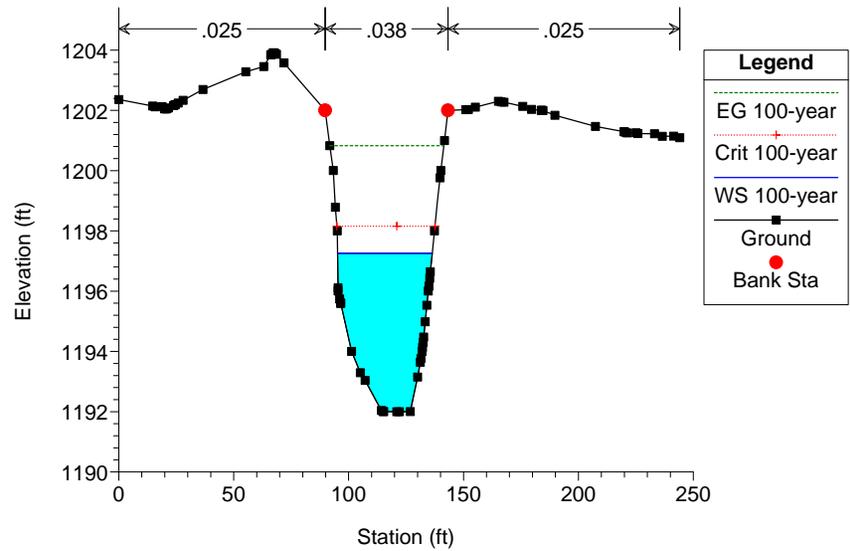
Sand CreekProposed Plan: Proposed Condition 12/10/2012



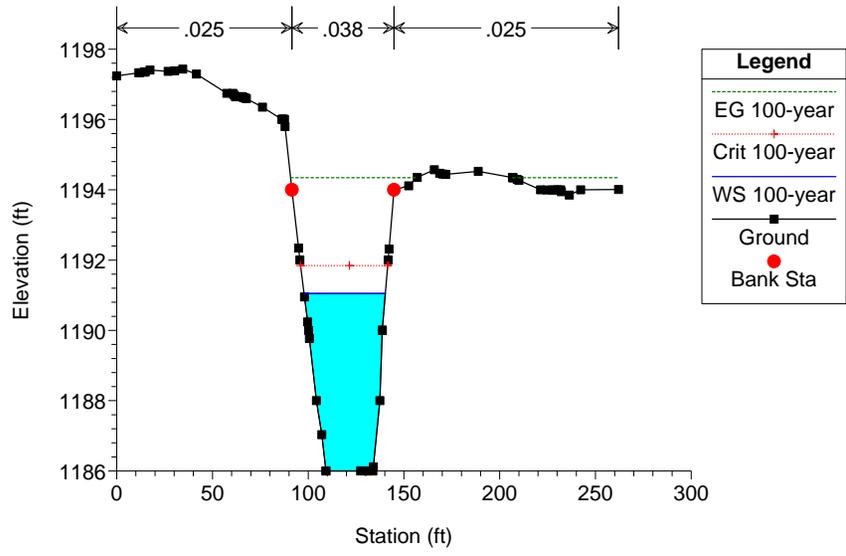
Sand CreekProposed Plan: Proposed Condition 12/10/2012



Sand CreekProposed Plan: Proposed Condition 12/10/2012



Sand Creek Proposed Plan: Proposed Condition 12/10/2012



HEC-RAS Plan: Prop Plan River: Sand Creek Reach: 1 Profile: 100-year

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)	
1	19	100-year	2496.00	1270.00	1285.47	1272.27	1285.47	0.000007	0.57	4343.95	333.62	0.03
1	18	100-year	2496.00	1278.91	1283.23	1283.23	1285.26	0.002396	11.45	217.93	54.06	1.01
1	17	100-year	2496.00	1266.00	1268.50	1271.72	1283.71	0.029547	31.30	79.75	33.87	3.49
1	16.5		Culvert									
1	16	100-year	2496.00	1259.38	1262.28	1265.37	1275.80	0.155939	29.51	84.58	38.37	3.20
1	15	100-year	2496.00	1253.64	1257.85	1259.04	1261.93	0.034284	16.21	153.98	42.95	1.51
1	14	100-year	2496.00	1248.00	1252.43	1253.54	1256.36	0.030789	15.90	156.96	41.61	1.44
1	13	100-year	2496.00	1238.00	1242.36	1243.97	1247.52	0.043107	18.23	136.95	38.08	1.69
1	12	100-year	2496.00	1233.85	1239.03	1240.07	1242.82	0.027700	15.62	159.75	40.21	1.38
1	11	100-year	2496.00	1230.00	1235.22	1236.38	1239.25	0.030495	16.11	154.89	39.90	1.44
1	10	100-year	2496.00	1229.57	1236.41	1234.61	1237.28	0.004203	7.50	333.57	66.09	0.57
1	9.5		Bridge									
1	9	100-year	2496.00	1225.65	1230.27	1230.27	1232.22	0.014234	11.22	222.48	57.44	1.00
1	8	100-year	2496.00	1224.00	1227.79	1228.78	1231.24	0.032001	14.89	167.58	52.26	1.47
1	7	100-year	2496.00	1224.00	1229.33	1228.33	1230.49	0.006900	8.62	289.54	64.32	0.72
1	6.5		Bridge									
1	6	100-year	2496.00	1215.98	1221.08	1221.08	1223.17	0.014331	11.60	215.19	52.14	1.01
1	5	100-year	2496.00	1211.73	1215.58	1216.46	1219.09	0.030971	15.03	166.10	44.70	1.37
1	4	100-year	2496.00	1206.75	1212.33	1212.42	1214.74	0.015131	12.44	200.59	43.92	1.03
1	3	100-year	2496.00	1201.82	1205.48	1206.86	1210.04	0.042873	17.13	145.68	44.51	1.67
1	2	100-year	2496.00	1192.00	1197.26	1198.15	1200.83	0.026034	15.17	164.59	41.19	1.34
1	1	100-year	2496.00	1186.00	1191.05	1191.85	1194.35	0.023663	14.57	171.34	42.45	1.28