

Flood Relief Alternatives for Carson River Downstream from Lahontan Reservoir Churchill County, Nevada

Feasibility Engineering Study - Final

June 8, 2015

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Feasibility Engineering Study (Final Report)

June 8, 2015

Prepared For:

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Prepared By:

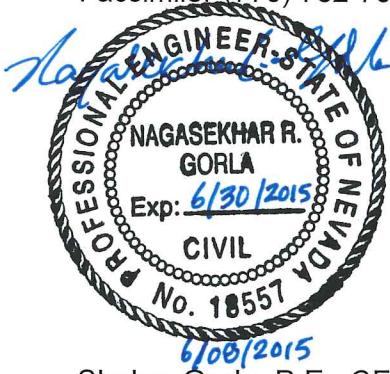
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Shaker Gorla, P.E., CFM

A handwritten signature in blue ink that reads "Robert O. Anderson".

Reviewed By:
Robert O. Anderson, P.E., CFM, WRS

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1 Executive Summary

The City of Fallon and unincorporated Churchill County are located downstream from Lahontan Reservoir. During periods when Lahontan Reservoir is near capacity and a significant hydrologic event occurs simultaneously in the Carson River watershed, flooding occurs downstream from Lahontan Dam as a result of flood water releases necessary to protect the structure. R.O. Anderson Engineering, Inc. (ROA) was retained by the Carson Water Subconservancy District (CWSD) to investigate the technical and economic feasibility of mitigating flood risk for flood prone residential and agricultural areas by diverting sufficient flood flows from the Carson River downstream of Lahontan Reservoir and overland toward Sheckler Reservoir through uninhabited Churchill County lands, BLM lands, and potentially U.S. Navy properties.

The following tasks were included in the scope of services:

- Collect available topographic data for the study area.
- Use the collected topographic data to identify at least two potential routes for diverting flood flows during flood events on the Carson River below Lahontan Reservoir.
- Develop feasibility-level designs for conveying flood flows along the identified routes.
- Provide an engineer's estimate of probable construction cost for each of the identified alternatives.
- Prepare a draft report with supporting exhibits for CWSD's, and other public agencies' (stakeholders) review and comment.
- Participate in and present the results of this study at the Carson River Coalition River Corridor Working Group Meeting and one general public meeting.
- Address comments and feedback received from stakeholders and the public and finalize the report.

This feasibility study was initiated with a field reconnaissance survey followed by data collection efforts which resulted in the production of a series of base maps. The base maps show the general topography of the project area overlaid on ortho-rectified satellite images. Using these base maps, four potential routes were identified to divert and convey floodwater from the Carson River toward Sheckler Reservoir. In addition to these alternative routes, an additional "Do-Nothing" alternative was also considered to demonstrate the advantages of

diverting floodwaters away from downstream infrastructure, homes and properties. These alternatives were further examined and ranked based on the feasibility, constructability, and cost effectiveness. The result of this effort is the identification of a Preferred Alternative that meets the goals and objectives of stakeholders.

Section 2 of this report includes a brief discussion of the Carson River's journey from its headwaters to final destination, as well as a background and goals of this project. Section 3 of the report includes a brief discussion of the identified alternative routes to divert floodwater to Sheckler Reservoir. Section 4 of the report includes a detailed discussion of the alternatives considered, a comparison of the alternatives, along with the presentation of the engineer's estimate of probable construction costs. Section 5 of the report contains the findings and conclusions of this study.

2 Background

The 184-mile Carson River drains the approximately 3,966 square mile watershed. In its upper watershed region, the river includes two major forks: 74-mile long East Fork reach and 40-mile long West Fork reach (*Figure 1 - Project Vicinity Map*). The West Fork reach joins the East Fork reach about 1 mile southeast of Genoa. The combined Carson River then flows north 18 miles to the end of the upper watershed at Mexican Dam just southeast of Carson City. Downstream of Mexican Dam, the middle watershed of the river runs generally northeast from Carson City past Dayton through portions of unincorporated Lyon County. The middle watershed ends in western Churchill County at Lahontan Dam, where the river flows are augmented by flows from the Truckee Canal (USGSⁱ).

Downstream of Lahontan Dam, river flows are regulated by the Carson River Diversion Dam, which is located approximately five miles below Lahontan Dam. The Carson River Diversion Dam is 241-feet long with a 225-foot long, 31-foot high concrete control section that functions to divert water into two main canals (V-Line and T-Line canals) that together irrigate hundreds of farms within the Newlands Project Area. During the irrigation season, Truckee Carson Irrigation District (TCID) diverts a flow of 660 cfs and 150 cfs into the V-Line Canal and T-Line Canal, respectively, and 550 cfs is released downstream of the diversion dam that flows toward ultimate destination - Carson Sink. Existing plan of operations at the Carson River Diversion Dam are graphically shown on *Figure 3 – Existing Flow Diversion Plan at Carson River Diversion Dam*.

Flooding problems in unincorporated Churchill County and the City of Fallon are primarily due to the overflow of the Carson River. Most recently high runoff events occurred in 1983, 1986, 1996, and 1997, respectively. (FEMAⁱⁱ) These high runoff events have filled Lahontan Reservoir and Carson River Diversion Dam upstream of the City of Fallon and the resultant releases, as well as spillway flows, have caused damage to County roads, private properties, and residences. In order to alleviate and minimize flood-related damages in the Carson River floodplains downstream from the diversion dam, CWSD contemplated the possibility of diverting additional flood flows overland to Sheckler Reservoir through uninhabited Churchill County lands, BLM lands, and possibly through US Navy property (*Figure 2 – Project Location Map*).

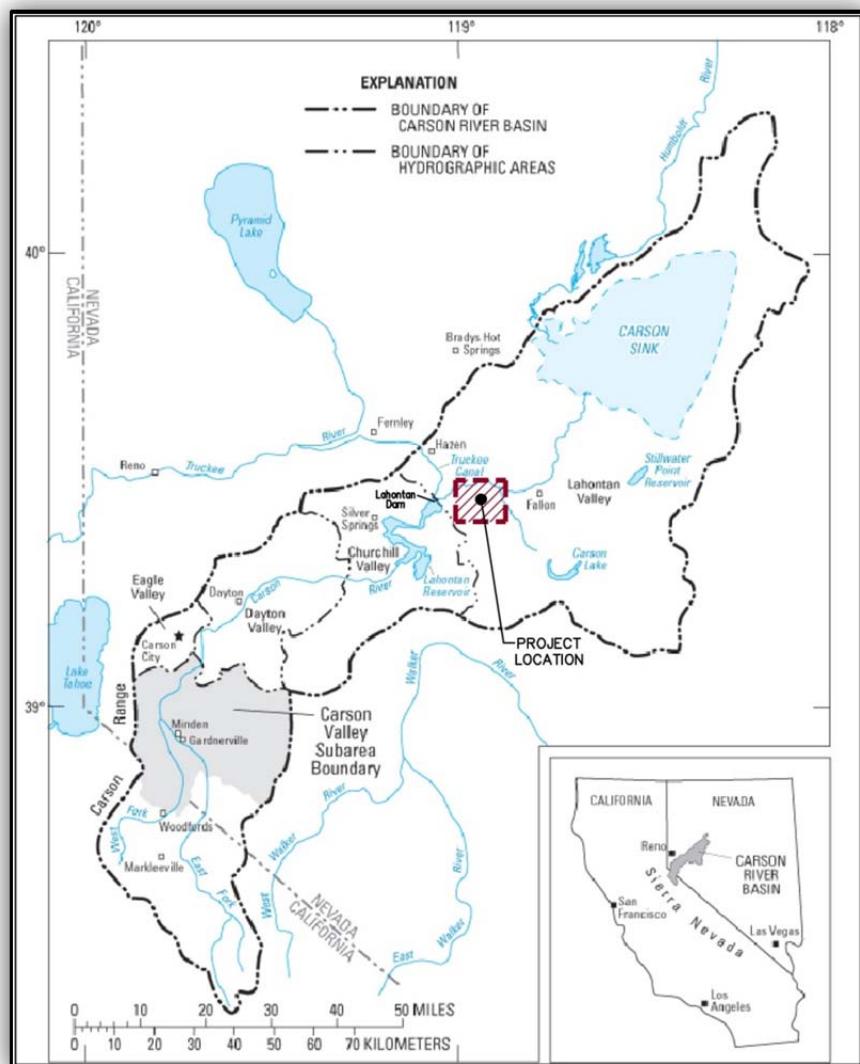


Figure 1 - Project Vicinity Map

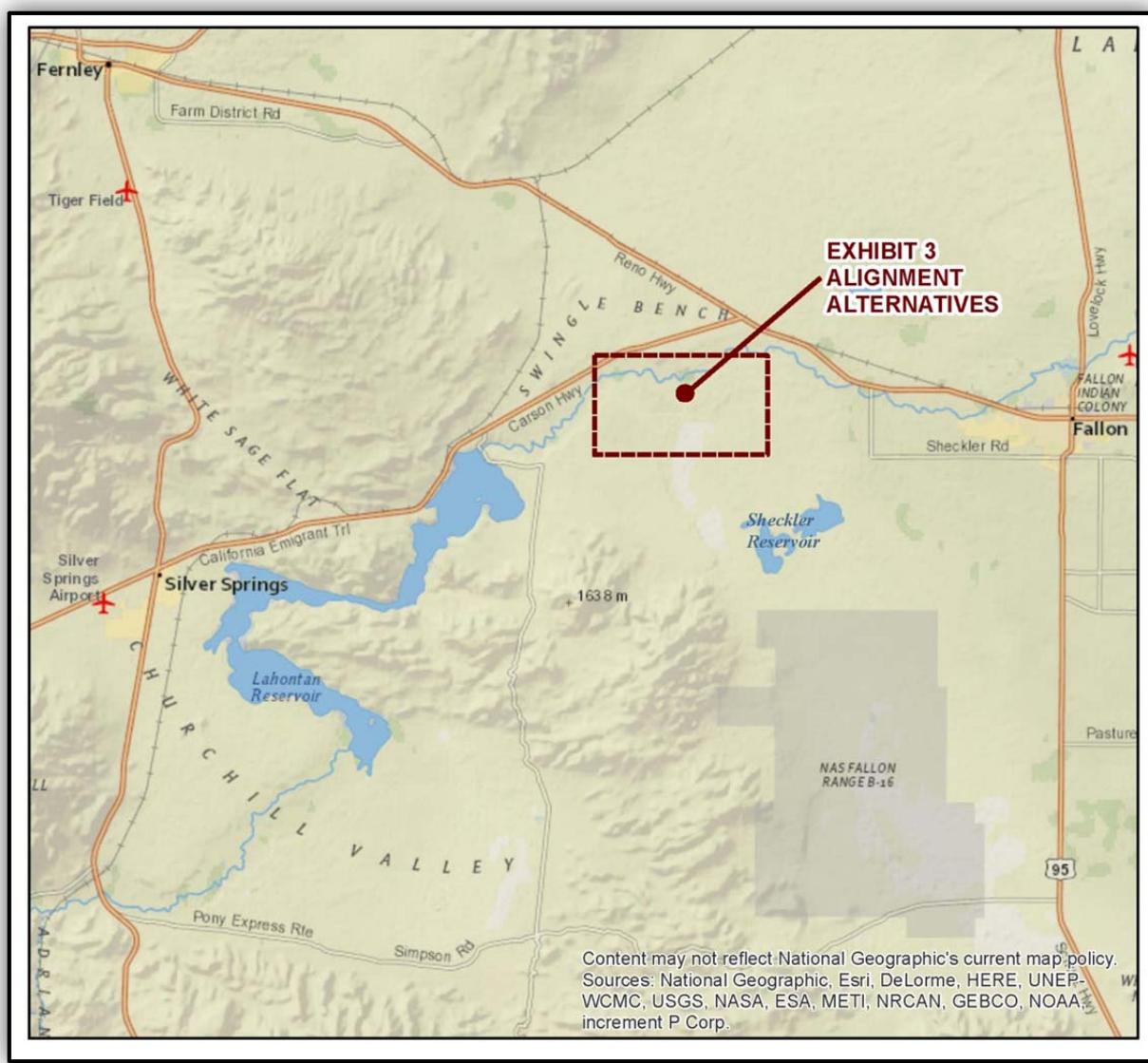


Figure 2 – Project Location Map

Peak discharges for this reach of the Carson River are documented in the hydrologic analysis study performed by the U.S. Army Corps of Engineers (USCAE)ⁱⁱⁱ. That study lists 1-percent annual chance of recurrence floodflow in the study reach at 3,100 cubic feet per second (cfs). During discussions with the stakeholders, it was decided that, at a minimum, 1,200 cfs of additional floodflow needs to be diverted from the Carson River to Sheckler Reservoir during the 1-percent annual chance flood.

ROA personnel performed an initial field reconnaissance survey on December 17, 2014 to assess the existing topography and explore potential alternative routes to divert additional

floodwaters from the Carson River to Scheckler Reservoir. Another field visit was performed on April 17, 2015 to identify another less expensive alternative. The photographs taken during the field visit are included in the Appendix 1 and 2.

Immediately after the field visit, available LiDAR data covering the project area were obtained from Churchill County Planning Division^{iv} and the base maps were prepared showing the general topography of the project site. The LiDAR data provided by Churchill County included 1-meter Digital Elevation Models (DEMs) and 1-foot interval contour data. Data supplied by the County is sufficient for feasibility level investigations and detailed field surveys are not warranted. After the base maps were prepared, ROA personnel began the process of considering and developing alternatives to divert flood flows from Carson River to Scheckler Reservoir.



Figure 3 – Existing Flow Diversion Plan at Carson River Diversion Dam

3 Alternatives Evaluated

The draft report submitted on March 31st 2015 identified four different alternatives of diverting floodwater away from the Carson River. The stakeholders, specifically Churchill County was concerned about the feasibility of obtaining several million dollars in funding to construct identified alternatives, and requested to look into other feasible low-cost alternatives. Subsequently ROA personnel identified another less expensive alternative that contemplates constructing lateral weirs on existing V-Line Canal to divert flood flows and utilize existing channels downstream of the proposed lateral weirs to safely carry flood flows toward Sheckler Reservoir. Accordingly, the more expensive alternatives identified previously were removed from further consideration and only recently identified alternative is included in this final report. A Do-Nothing alternative was also considered, the analysis of which serves as a baseline to demonstrate the benefits of diverting floodwaters away from the flood prone neighborhoods downstream of Carson River Diversion Dam.

Alternative 1: This alternative will utilize the existing V-Line Canal as a flood diversion channel, and does not require construction of expensive inline structure to impound floodwaters to divert flood flows to Sheckler Reservoir. Instead, this alternative contemplates building two new lateral weirs along the right bank of the existing V-Line Canal, approximately 2.3 miles downstream from the Carson River Diversions Dam. The crest of the proposed lateral weirs will be set such that only flows over 660 cfs are spilled over the lateral weirs and discharge into the existing earthen channels downstream. These existing channels have enough capacity to carry expected flood flows downstream to a sufficient distance, and then flow overland toward Sheckler Reservoir. A detailed hydraulic analysis was performed to assess the capacity of the existing channels and the results of that hydraulic analysis are included in the next section of this report. The proposed centerline alignment of this alternative route is shown on Figures 4-5 in Appendix 3.

Alternative 2: This is the “Do-Nothing” alternative that leaves the system as is and affords no additional flood protection for those facilities located in or adjacent to the Carson River floodplain downstream of the Diversion Dam. The flood flows reaching the Diversion Dam split between the V-Line Canal, the T-Line Canal and the Carson River and are directed downstream in the Carson River floodplain just as it does today. During the occurrence of a significant hydrologic event, overwhelming flood flows will be released from the diversion structure into the Carson River, and the flood flows will eventually spill over the banks of the

Carson River resulting in damage to County and City roads, public infrastructure, property losses and risk to life.

4 Alternatives Analysis

4.1 Alternative 1

This alternative consists of utilizing the existing V-Line Canal in conjunction with proposed two lateral diversion weirs to divert flood flows in excess of 660 cfs toward Sheckler Reservoir. Two new lateral weirs will be built along the right bank of the existing V-Line Canal, approximately 2.3 miles downstream from the Carson River Diversions Dam. The crest of the proposed lateral weirs will be set such that only flows above 660 cfs exit the V-Line Canal and spill over the lateral weirs and discharge into the existing earthen channels. During normal conditions flows will be contained within V-Line Canal and the diverted flow from the Carson River will be available for agricultural purposes as intended.

A HEC-RAS model was built that included proposed lateral weirs and steady flow simulations were performed using built-in flow optimization techniques. The initial split flow optimization estimates were iteratively changed until flow convergence was achieved. Detailed hydraulic simulation results are included in Appendix 4 of the report. Based on HEC-RAS simulation results, it is estimated that two 120-foot lateral weirs with relatively flat side slopes (maximum of 8H:1V) are needed to divert approximately 1,200 cfs flow away from the V-Line Canal during the flood events.

Another HEC-RAS model was built to analyze the capacity of the existing channels downstream of the proposed lateral weirs. The results of the HEC-RAS modeling confirmed that the existing channels have enough capacity to carry expected additional flood flows. The detailed output of the HEC-RAS simulations is included in Appendix 4 of this report.

The proposed lateral weirs will be constructed using recycled asphalt materials or cement treated base (CTB). During the flooding events, it is expected that the flow over the proposed lateral weirs will be turbulent enough to cause soil erosion downstream of the weir structures, requiring some kind of energy dissipating mechanism or riprap lining of the downstream channel. Although the existing channels downstream of the proposed lateral weirs have enough capacity to carry flood flows, the side slopes of these channels are

relatively steep and susceptible for bank erosion. Therefore, it is recommended that the banks of these channels for a limited distance downstream be improved with mild side slopes (<2H:1V), and stabilized using rock riprap for a distance downstream to reduce potential for bank erosion.

The preliminary estimate of probable construction cost for this alternative is about \$680,000, and the breakdown of costs is shown on *Table 1 - Engineer's Preliminary Estimate of Costs – Alternative 1*. This amount includes an allowance for contingencies of 25% of the estimated construction costs. A schematic sketch of this alternative route is shown on Figures 4-5 in Appendix 3 and a preliminary cross section through the proposed lateral weirs along with typical cross sections through the existing earthen channels downstream of the proposed lateral weirs are shown on Figures 6-11 in Appendix 3.

If implemented, the improvements contemplated under Alternative 1 would achieve the project's objectives and significantly reduce risk to flooding downstream of Lahontan Reservoir within the City of Fallon and unincorporated areas of Churchill County.

Table 1 - Engineer's Preliminary Estimate of Costs – Alternative 1

DIVISION 1 - GENERAL REQUIREMENTS				
ITEM	DESCRIPTION	QUANTITY	UNIT COST	TOTAL
1	Mobilization	1	Lump Sum	2.00% /%
2	Demobilization	1	Lump Sum	2.00% /%
3	Bonds & Insurance	1	Lump Sum	5.00% /%
4	Testing	1	Lump Sum	5.00% /%
5	Construct Lateral Weirs w/ Recycled Asphalt Millings/CTB	2	Lump Sum	\$40,000 /LS
6	Construct Riprap Outlet Protection and Energy Dissipators	2	Lump Sum	\$100,000 /LS
7	Channel Grading	2	Lump Sum	\$25,000 /LS
8	Land Acquisition	1	Lump Sum	\$30,000 /LS
9	Erosion and Sediment Control / Revegetation	1	Lump Sum	\$15,000 /LS
CONSTRUCTION SUB TOTAL				\$429,000
CONTINGENCY AT 25% ¹				\$107,250
Engineer's Preliminary Estimate of Construction Costs				\$536,250

¹Contingency is for unknowns since a full design has not been completed.

Engineering Design, Permitting, and Services During Construction

ITEM	DESCRIPTION	QUANTITY	UNIT COST	TOTAL
1	Design	1	%	10 /LS
2	Permitting	1	%	10 /LS
3	Special Inspections, Material Testing	1	%	2 /LS
4	Services During Construction	1	%	5 /LS
Engineer's Preliminary Estimate of Design, Permitting, and Services During Construction Costs				\$146,000

Engineer's Preliminary Estimate of Probable Project Costs **\$682,250**

Note: Total Project Cost Excludes Financing Charges.

4.2 Alternative 2

This is the “Do-Nothing” alternative that leaves the system as is. The flood flows reaching the Carson River Diversion Dam split to V-Line and T-Line according to the existing plans of operations and much of the floodflow will pass through the diversion dam spillway and continue downstream in the Carson River. During the occurrence of a significant hydrologic event, overwhelming flood flows will be released from the diversion structure into the Carson River, and the flood flows will eventually spill over the banks of the Carson River resulting in the potential of significant damage to County and City roads, as well as property loss and risk of life. Adopting this alternative will have direct and appreciable financial consequences to each stakeholder after each significant flood event, the dates of which are not knowable. Such an approach results in unplanned expenses stressing adopted budgets and financial plans. In addition, land owners and businesses within affected areas will continue to be required to maintain flood insurance and potential for new development in flood prone areas is restricted.

There are no identified capital costs associated with the Do Nothing alternative; however, this alternative also does not achieve the project’s objectives of providing flood relief to those areas and the public infrastructure located downstream of Lahontan Reservoir.

5 Findings and Conclusions

Portions of the City of Fallon and unincorporated Churchill County experience flooding during the periods when Lahontan Reservoir is near capacity and a significant hydrologic event occurs simultaneously in the Carson River Watershed. This conceptual study evaluated possibilities of diverting excess floodwaters (~1,200 cfs) downstream of Lahontan Dam away from the Carson River floodplain toward Sheckler Reservoir such that downstream flooding risks are minimized.

During the initial phase of this study four alternative means of conveying these excess flows were identified, and probable construction cost estimates for each alternative were prepared and a draft report was submitted to the stakeholders for review and comment. One of the stakeholders, Churchill County expressed concerns about the feasibility of obtaining required funding to construct suggested alternatives, and directed ROA personnel to identify another less expensive alternative to convey flood flows away from the Carson River.

Subsequently, ROA personnel revisited the project site, and identified another economical alternative that would utilize the existing V-Line Canal in conjunction with two new lateral weirs built on the right banks of the V-Line Canal to divert flood flows toward Sheckler Reservoir. The engineer's probable construction cost for the newly identified flood diversion alternative is approximately \$682,250, which includes a 25% contingency. In addition, a "Do Nothing" alternative was also considered to demonstrate the positive impacts of the proposed improvements that alleviate the flooding problems downstream.

Further studies are necessary to assess cultural, environmental impacts of proposed improvements, in addition to performing soil borings, associated material testing, and detailed hydraulic analyses. Furthermore, it is necessary to investigate need for right-of-way of acquisition, easement agreements, and be cognizant of federal, state, and local regulatory requirements.

ⁱ U.S. Department of the Interior, Geologic Survey, Water Resources Data for Nevada

ⁱⁱ Federal Emergency Management Agency (2008). Flood Insurance Study Churchill County, Nevada and Incorporated Areas

ⁱⁱⁱ U.S. Army Corps of Engineers, Flood Frequency Analysis for Lahontan Dam Outflow, August 1997

^{iv} Churchill County Planning Division – LiDAR Dataset

6 Appendices

Appendix 1: December 17, 2014 Site Visit Photo log

Appendix 2: April 17, 2015 Site Visit Photo log

Appendix 3: Exhibits

Appendix 4: HEC-RAS Modeling Results

Appendix 5: Channel Capacity Calculations

**APPENDIX 1
DECEMBER 17, 2014 SITE VISIT PHOTOGRAPHS**



Title:	File: L1120706.JPG	Date: 12/17/2014 13:32
Desc:		Slide: 1

Carson River Diversion Dam.



Title:	File: L1120707.JPG	Date: 12/17/2014 13:32
Desc:		Slide: 2

V-Line Ditch looking south-east from the Carson River Diversion Dam.



Title:		File:	L1120708.JPG	Date:	12/17/2014 13:43
Desc:				Slide:	3

Carson River just upstream of Carson River Diversion Dam.



Title:		File:	L1120709.JPG	Date:	12/17/2014 13:43
Desc:				Slide:	4

Another picture of Carson River just upstream of Carson River Diversion Dam.



Title:		File:	L1120710.JPG	Date:	12/17/2014 13:43
Desc:				Slide:	5

Another picture of Carson River just upstream of Carson River Diversion Dam.



Title:		File:	L1120711.JPG	Date:	12/17/2014 13:53
Desc:				Slide:	6

Carson River Diversion Dam. The spillway and woodboards that control flow into the V-Line ditch can be seen in the foreground.



Title:	File: L1120712.JPG	Date: 12/17/2014 13:53
Desc:		Slide: 7

Carson River Diversion Dam. The spillway and woodboards that control flow into the V-Line ditch can be seen in the foreground.



Title:	File: L1120713.JPG	Date: 12/17/2014 14:03
Desc:		Slide: 8

Approximately 2000 feet upstream from the Carson River Diversion Dam - One of the contemplated floodwater diversion locations.



Title:		File:	L1120714.JPG	Date:	12/17/2014 14:08
Desc:				Slide:	9



Title:		File:	L1120715.JPG	Date:	12/17/2014 14:08
Desc:				Slide:	10

View of the terrain in the vicinity of contemplated new diversion location upstream from the existing Carson River Diversion Dam.



Title:	File:	Date:
Desc:	L1120716.JPG	12/17/2014 14:08

View of the terrain in the vicinity of contemplated new diversion location upstream from the existing Carson River Diversion Dam.



Title:	File:	Date:
Desc:	L1120717.JPG	12/17/2014 14:15

View of Carson River looking east approximately 2000 feet upstream from Carson River Diversion Dam.



Title:	File: L1120718.JPG	Date: 12/17/2014 14:15
Desc:		Slide: 13

View of Carson River looking west approximately 2000 feet upstream from Carson River Diversion Dam.



Title:	File: L1120719.JPG	Date: 12/17/2014 14:33
Desc:		Slide: 14

V-Line Ditch approximately 2 miles downstream from Carson River Diversion Structure.



Title:		File:	L1120720.JPG	Date:	12/17/2014 14:34
Desc:				Slide:	15

Looking south-west from V-Line Ditch.



Title:		File:	L1120721.JPG	Date:	12/17/2014 14:34
Desc:				Slide:	16

V-Line ditch looking upstream.



Title:	File: L1120722.JPG	Date: 12/17/2014 14:34
Desc:		Slide: 17

V-Line ditch looking downstream.



Title:	File: L1120723.JPG	Date: 12/17/2014 14:37
Desc:		Slide: 18

Another view of V-Line ditch looking downstream.



Title:	File: L1120724.JPG	Date: 12/17/2014 14:37
Desc:		Slide: 19

Looking south-west at V-Line Ditch



Title:	File: L1120725.JPG	Date: 12/17/2014 14:37
Desc:		Slide: 20

Looking west at V-line Ditch.

**APPENDIX 2
APRIL 17, 2015 SITE VISIT PHOTOGRAPHS**



Title:	File:	2015-04-17 14.30.37.jpg	Date:	4/17/2015 14:30
Desc:			Slide:	1

Carson River Diversion Dam - V-Line Canal Spillway



Title:	File:	2015-04-17 14.31.41.jpg	Date:	4/17/2015 14:31
Desc:			Slide:	2

Another view of Carson River Diversion Dam - V-Line Canal Spillway



Title:		File:	2015-04-17 14.58.14.jpg	Date:	4/17/2015 14:58
Desc:				Slide:	3



Title:		File:	2015-04-17 14.58.25.jpg	Date:	4/17/2015 14:58
Desc:				Slide:	4

Existing drainage channels downstream of the proposed lateral weirs - West Channel



Title:	File:	Date:
Desc:	2015-04-17 14.58.34.jpg	4/17/2015 14:58

Existing drainage channels downstream of the proposed lateral weirs



Title:	File:	Date:
Desc:	2015-04-17 15.01.35.jpg	4/17/2015 15:01

Existing drainage channels downstream of the proposed lateral weirs - East Channel



Title:		File:	2015-04-17 15.02.23.jpg	Date:	4/17/2015 15:02
Desc:				Slide:	7

Existing drainage channels downstream of the proposed lateral weirs - East Channel



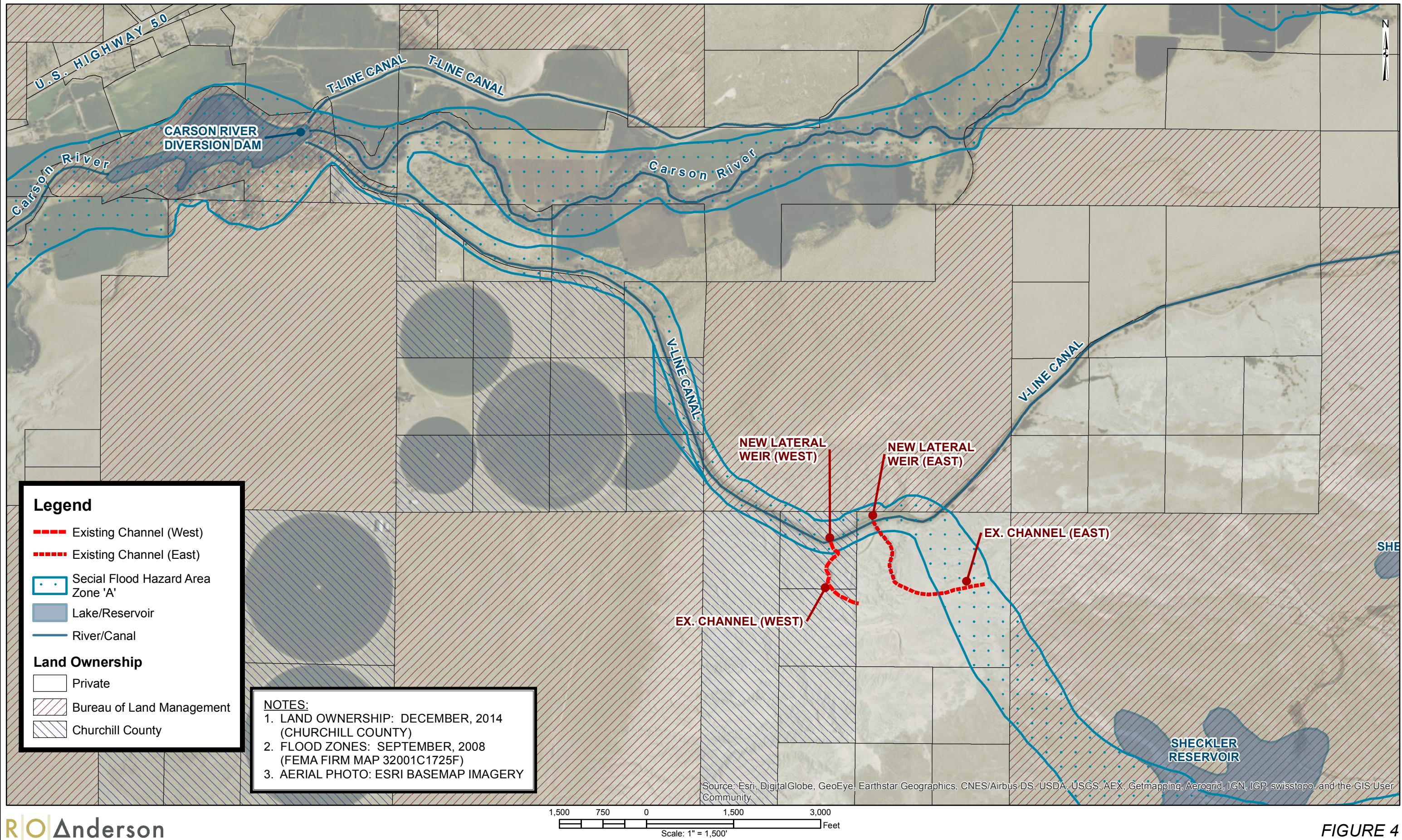
Title:		File:	2015-04-17 15.02.36.jpg	Date:	4/17/2015 15:02
Desc:				Slide:	8

Existing drainage channels downstream of the proposed lateral weirs - East Channel

**APPENDIX 3
EXHIBITS**

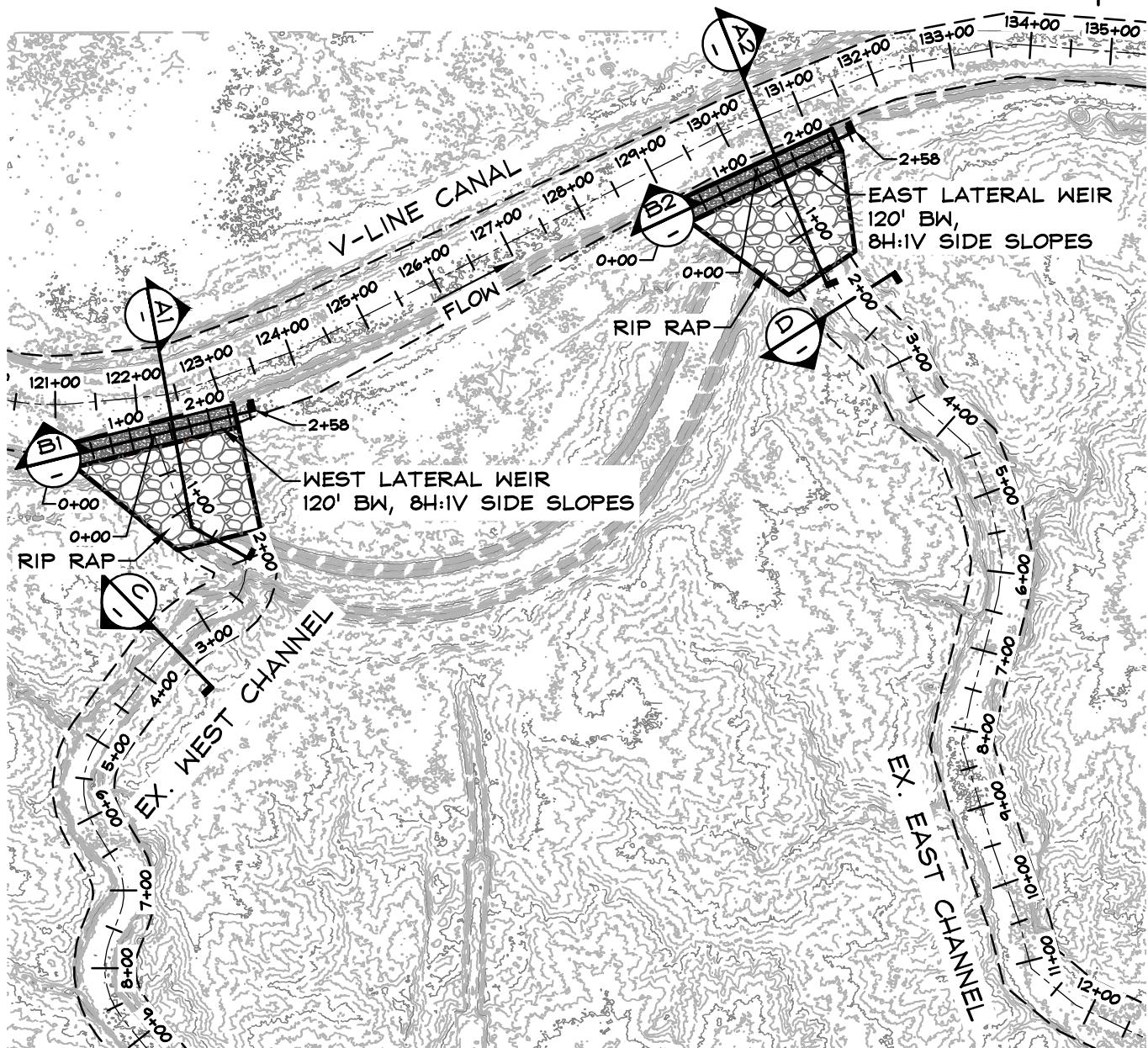
Flood Relief Alternatives for Carson River Downstream from Lahontan Reservoir, Churchill County, Nevada – Feasibility Engineering Study

FIGURE 4: ALIGNMENT ALTERNATIVES



PRELIMINARY
NOT FOR CONSTRUCTION

SCALE: 1" = 200'



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FIGURE 5 - ALTERNATIVE 1
PLAN VIEW EXHIBIT
CARSON RIVER FLOOD RELIEF ALTERNATIVES
V-LINE CANAL LATERAL WEIRS
0713-005 05/15/15

R|O|Anderson FIGURE 6 – SECTION A1
CARSON RIVER FLOOD RELIEF ALTERNATIVES
WEST LATERAL WEIR

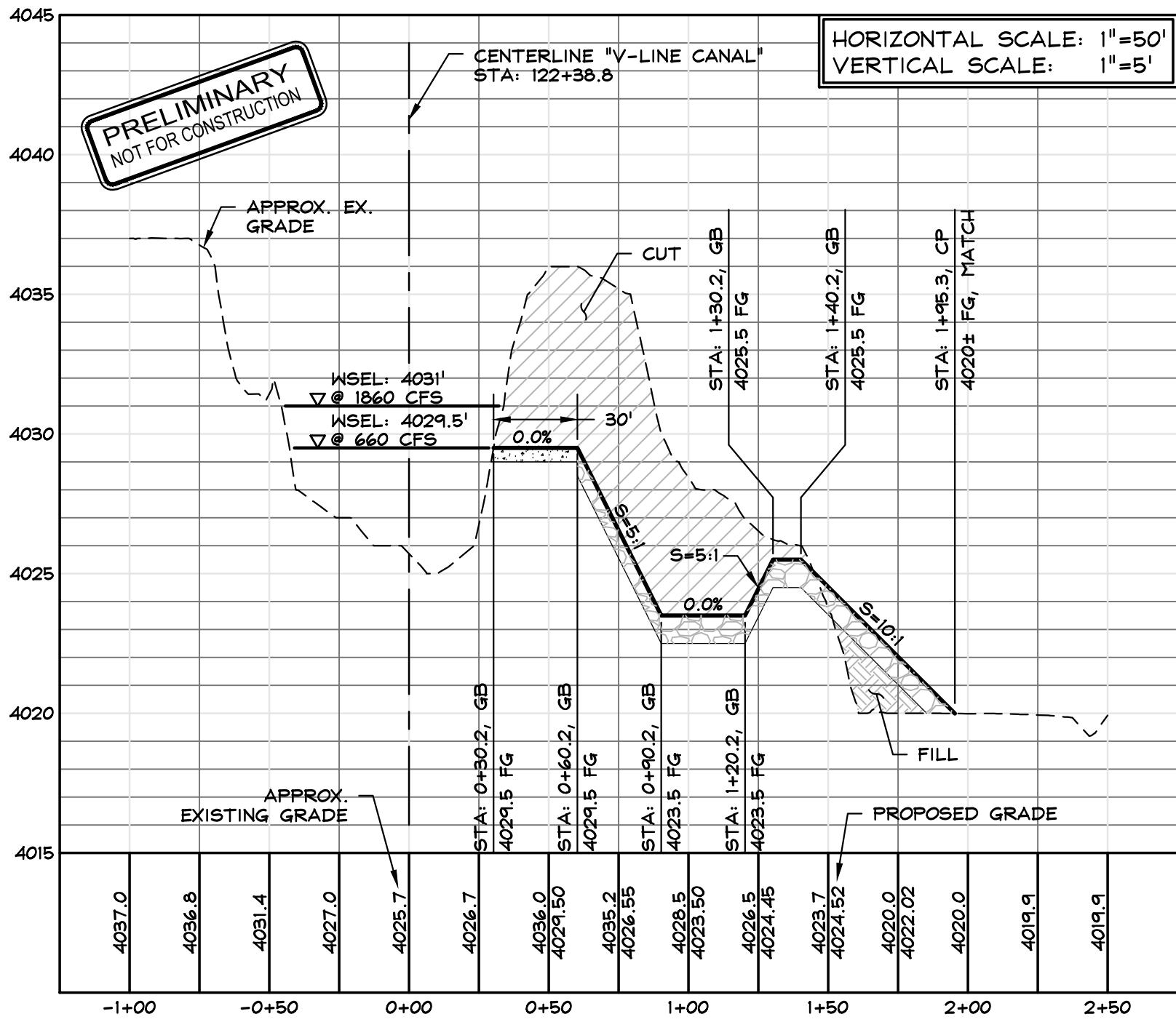
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FIGURE 6 – SECTION A1

HORIZONTAL SCALE: 1"=50'
 VERTICAL SCALE: 1"=5'



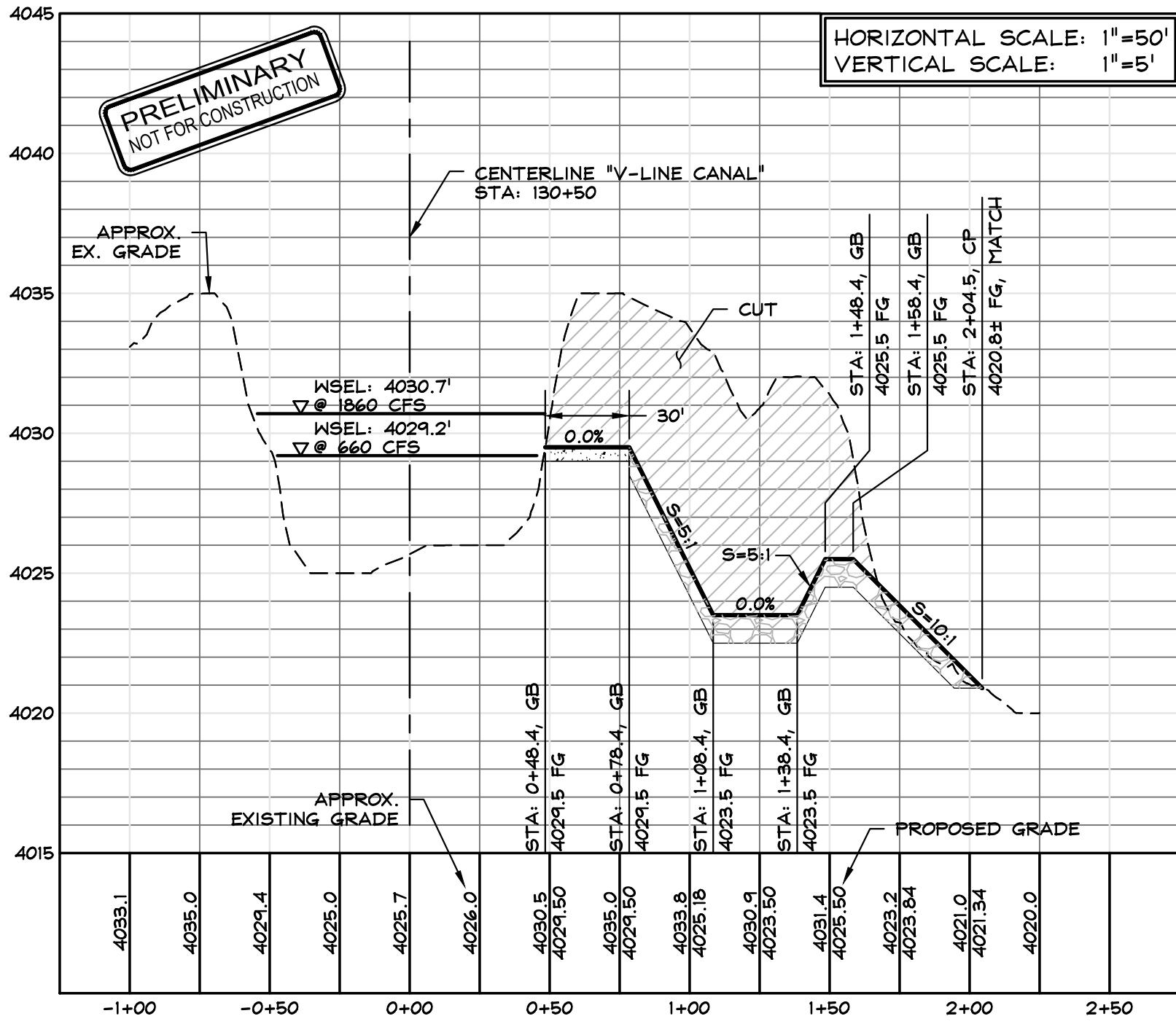
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FIGURE 7 – SECTION A2
 CARSON RIVER FLOOD RELIEF ALTERNATIVES
 EAST LATERAL WEIR

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R|O Anderson | **FIGURE 8 – SECTION B1**
CARSON RIVER FLOOD RELIEF ALTERNATIVES
WEST LATERAL WEIR

05/15/15

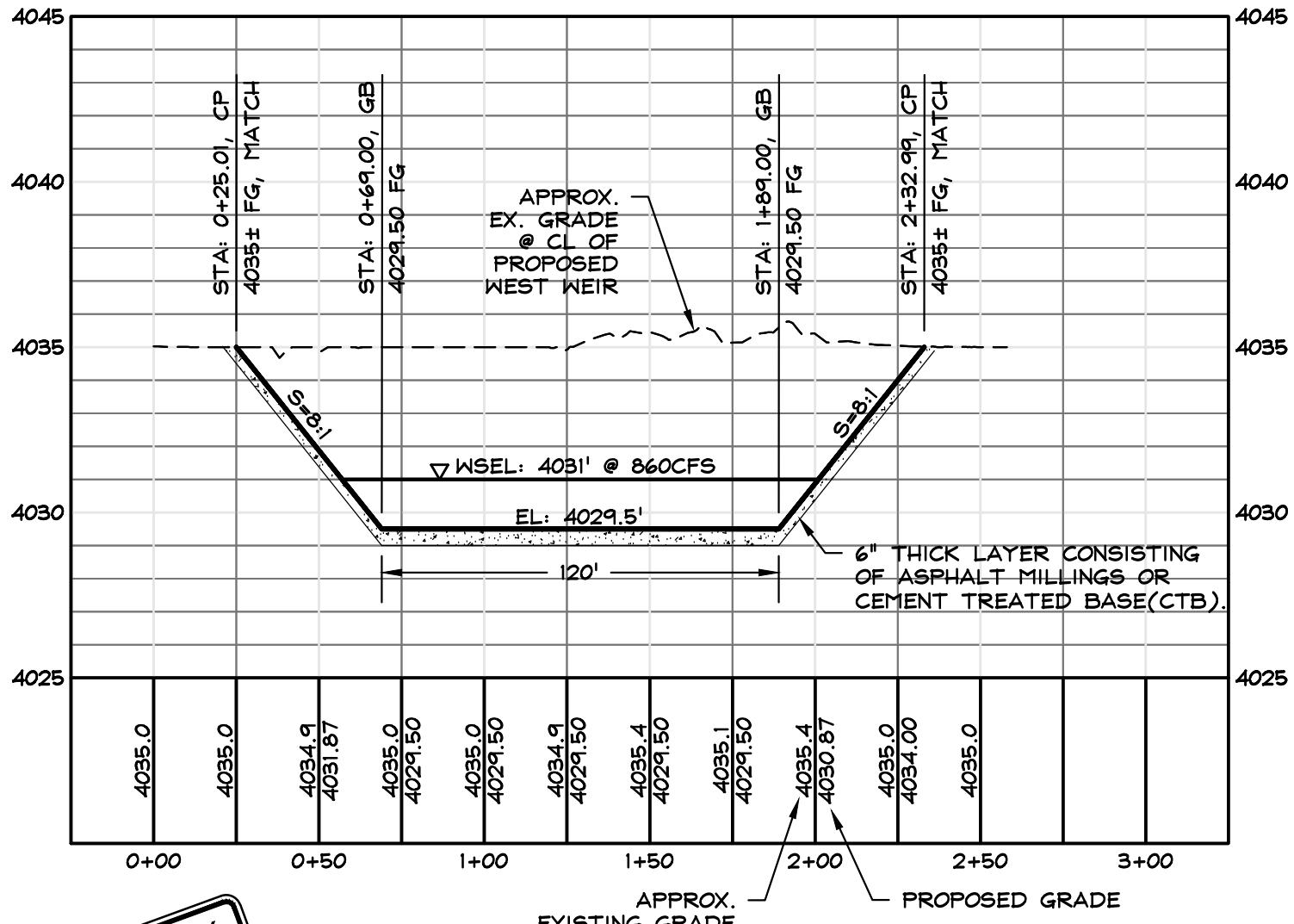
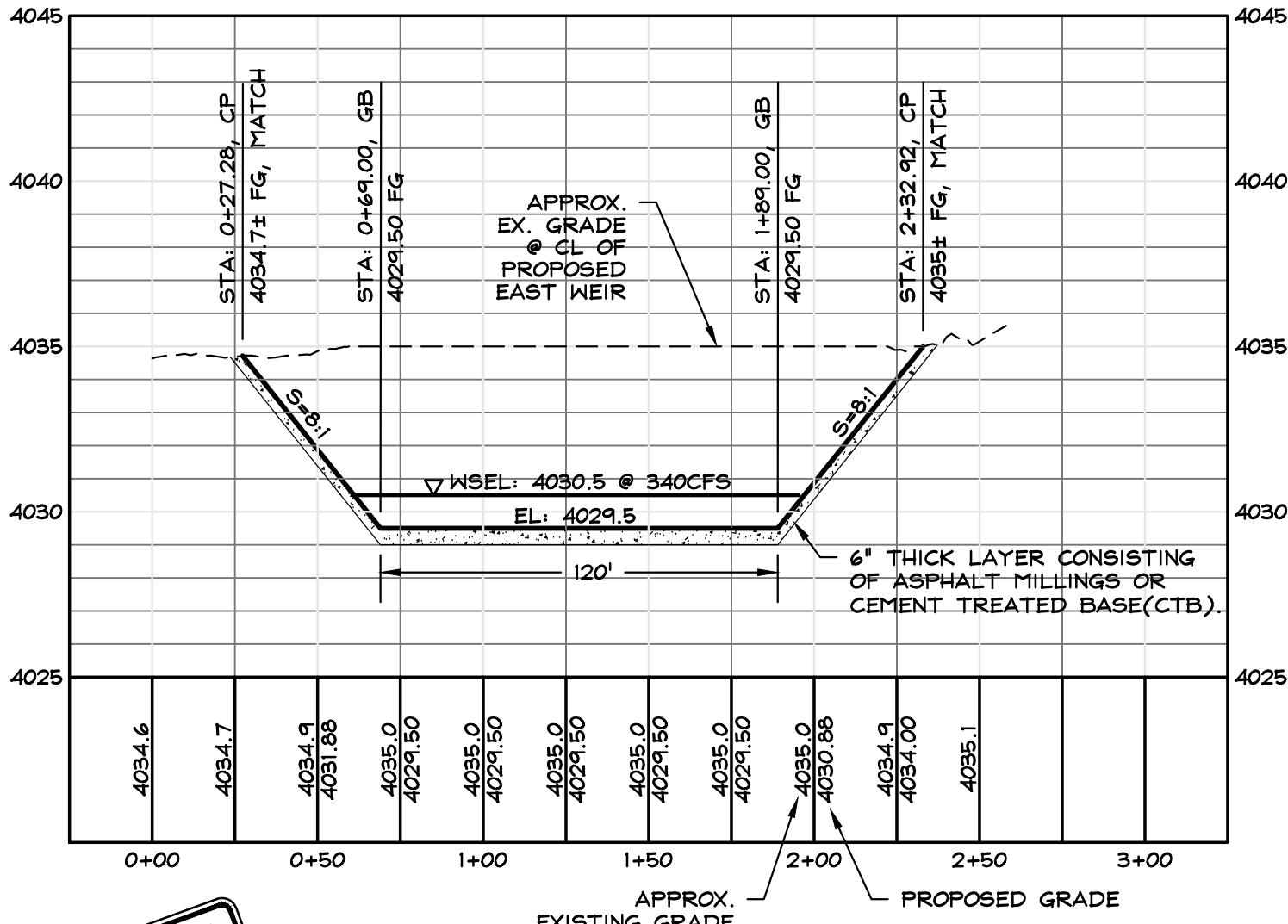
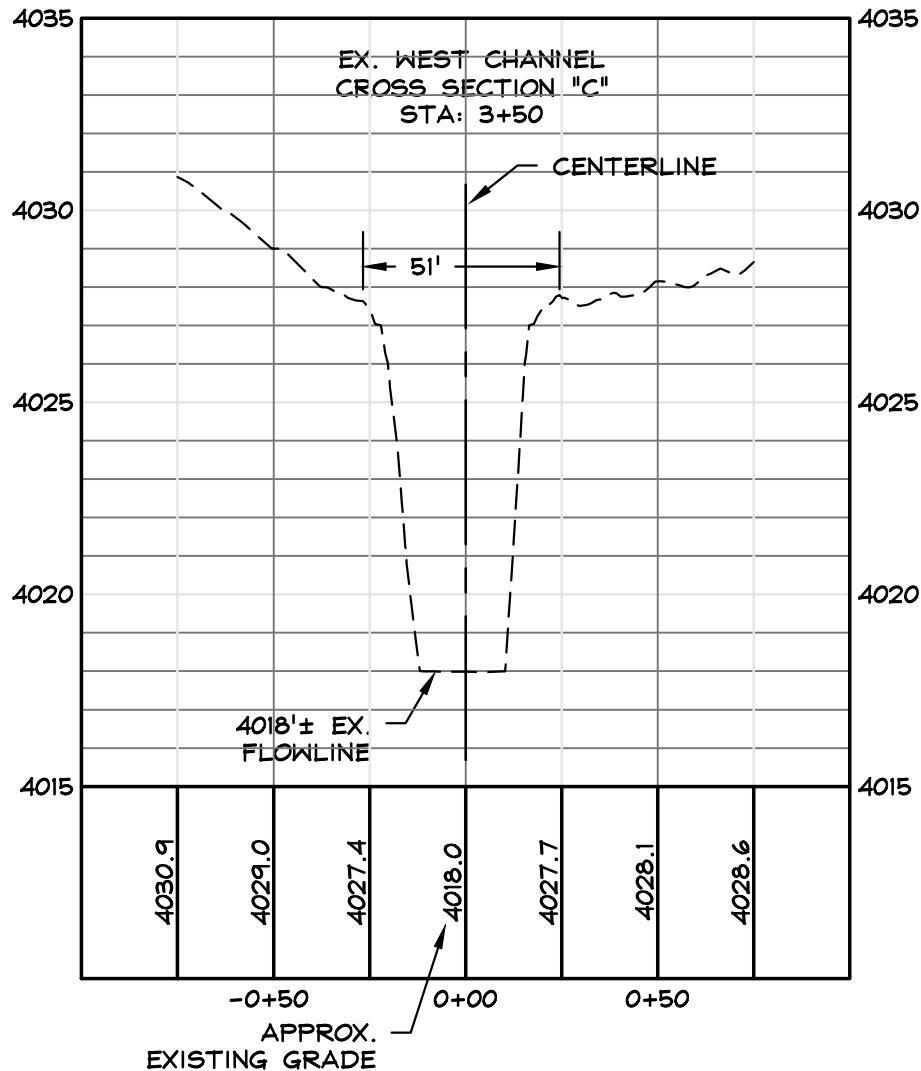


FIGURE 9 - SECTION B2
CARSON RIVER FLOOD RELIEF ALTERNATIVES
EAST LATERAL WEIR

05/15/15



PRELIMINARY
NOT FOR CONSTRUCTION



HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=5'

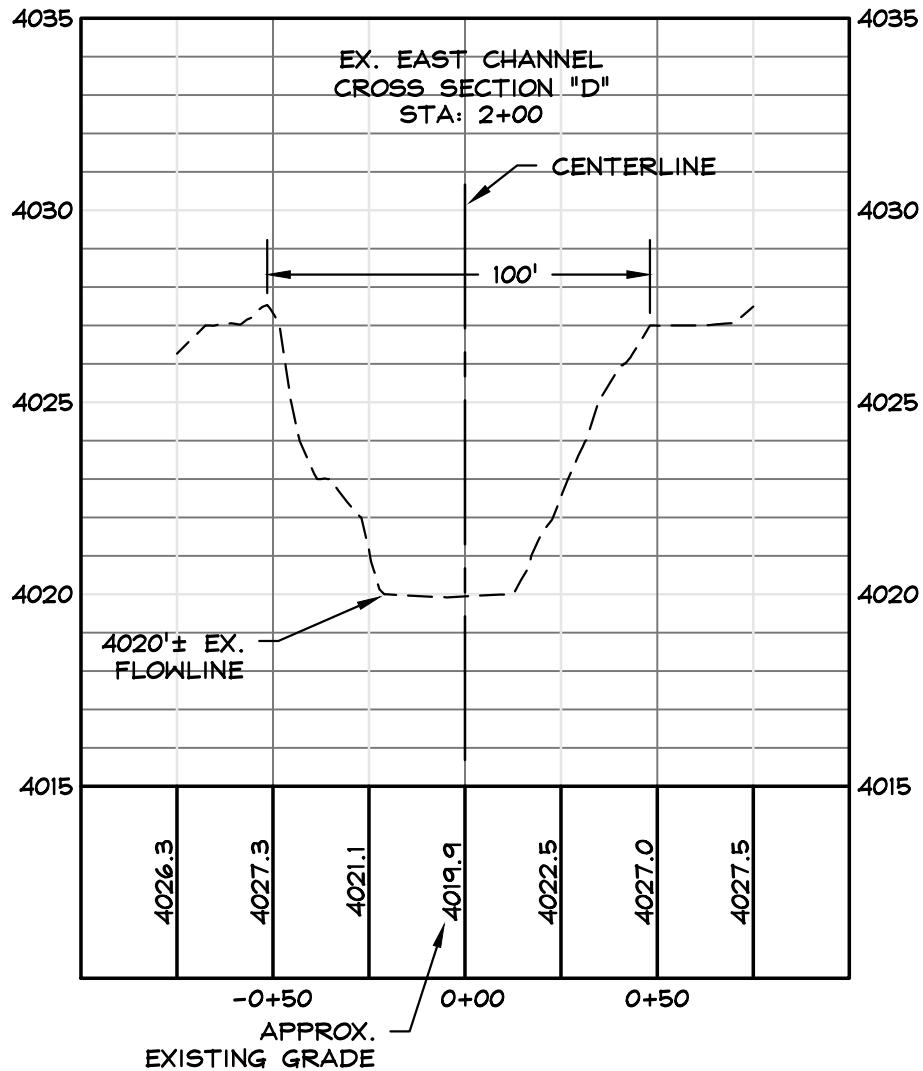
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FIGURE 10 - SECTION C
CARSON RIVER FLOOD RELIEF ALTERNATIVES
EXISTING WEST CHANNEL

0713-005
05/15/15

PRELIMINARY
NOT FOR CONSTRUCTION



HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=5'

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p 775.782.2322
f 775.782.7084

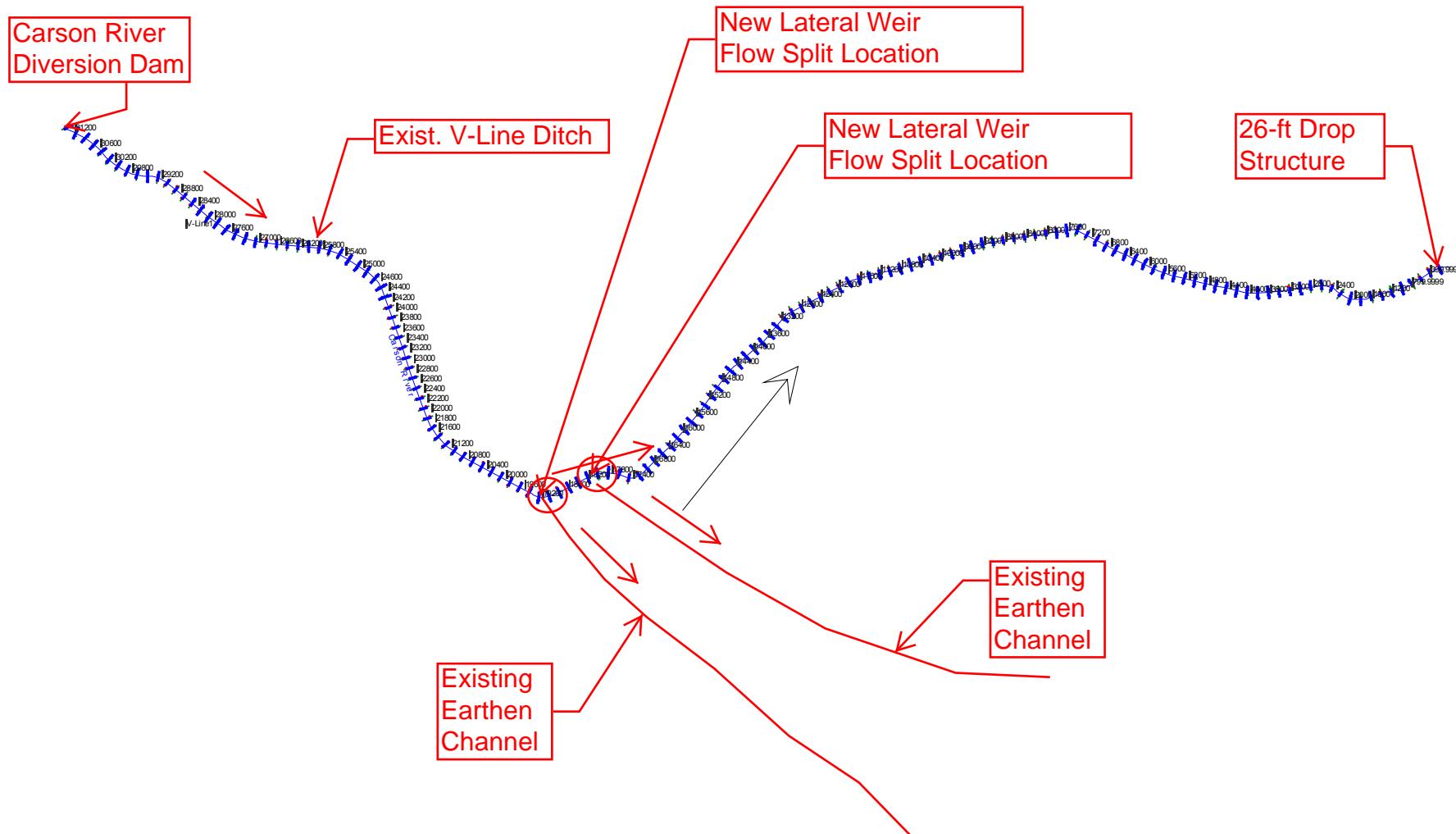
FIGURE 11 - SECTION D

CARSON RIVER FLOOD RELIEF ALTERNATIVES

EXISTING EAST CHANNEL

05/15/15

**APPENDIX 4
HEC-RAS MODELING RESULTS**



Reach	River Sta	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
V-Line1	31200	1860	4023.9	4034.9	4027.59	4035	0.00018	2.97034	626.19	84.91	0.17
V-Line1	31000	1860	4023.38	4034.8	4028.22	4035	0.00022	3.18396	584.18	101.71	0.2
V-Line1	30800	1860	4024.62	4034.8	4028.38	4034.9	0.00018	2.86697	648.77	120.37	0.18
V-Line1	30600	1860	4024.75	4034.8	4028.6	4034.9	0.0002	2.90942	639.3	100.17	0.18
V-Line1	30400	1860	4023.08	4034.7	4027.57	4034.9	0.00017	2.7901	666.64	107.78	0.17
V-Line1	30200	1860	4024.68	4034.7	4028.37	4034.8	0.00018	2.74657	677.21	108.83	0.18
V-Line1	30000	1860	4024.6	4034.7	4028.38	4034.8	0.00019	2.94736	631.07	110.26	0.18
V-Line1	29800	1860	4024.78	4034.6	4028.59	4034.8	0.00018	2.74039	678.74	118.45	0.17
V-Line1	29600	1860	4023.74	4034.6	4028.05	4034.7	0.00015	2.54192	731.73	107.9	0.16
V-Line1	29400	1860	4024.65	4034.6	4028.48	4034.7	0.00014	2.14158	868.52	148.91	0.15
V-Line1	29200	1860	4024.5	4034.5	4028.44	4034.6	0.00021	3.01052	617.83	117.79	0.19
V-Line1	29000	1860	4023.46	4034.4		4034.6	0.00021	3.03234	613.39	76.69	0.19
V-Line1	28800	1860	4023.83	4034.4		4034.6	0.00021	3.03296	613.26	77.59	0.19
V-Line1	28600	1860	4023.83	4034.4		4034.5	0.00017	2.81229	661.38	79.65	0.17
V-Line1	28400	1860	4024.13	4034.3	4027.95	4034.5	0.00018	2.88374	645	78.23	0.18
V-Line1	28200	1860	4024.04	4034.3	4027.8	4034.4	0.0002	3.03612	612.62	89.81	0.18
V-Line1	28000	1860	4024.33	4034.2	4028.06	4034.4	0.00021	3.04457	610.92	122.19	0.19
V-Line1	27800	1860	4024.53	4034.2	4028.44	4034.3	0.00023	3.12032	596.09	131.09	0.2
V-Line1	27600	1860	4024.21	4034.1	4028.13	4034.3	0.00022	3.11684	596.76	113.22	0.19
V-Line1	27400	1860	4024.39	4034.1	4028.42	4034.3	0.00025	3.19882	581.47	102.81	0.2
V-Line1	27200	1860	4024.23	4034.1	4028.24	4034.2	0.00023	3.1373	592.87	88.45	0.2
V-Line1	27000	1860	4024.46	4034	4028.19	4034.2	0.00023	3.13155	593.96	77.45	0.2
V-Line1	26800	1860	4024.34	4034		4034.1	0.00024	3.13008	594.23	79.03	0.2
V-Line1	26600	1860	4024.22	4033.9		4034.1	0.00023	3.0841	603.09	79.99	0.2
V-Line1	26400	1860	4024.76	4033.8	4028.6	4034	0.00031	3.47783	534.82	72.37	0.23
V-Line1	26200	1860	4025.17	4033.8	4028.39	4033.9	0.00024	3.11128	597.82	89.7	0.2
V-Line1	26000	1860	4024.68	4033.7	4028.55	4033.9	0.00032	3.54417	524.81	98.87	0.23
V-Line1	25800	1860	4024.19	4033.6	4028.2	4033.8	0.00032	3.59909	516.8	108.83	0.23
V-Line1	25600	1860	4023.7	4033.5	4028.07	4033.7	0.00033	3.65605	508.75	79.83	0.23
V-Line1	25400	1860	4023.65	4033.5	4028.15	4033.7	0.00034	3.65874	508.37	99.09	0.24
V-Line1	25200	1860	4023.46	4033.3	4028.4	4033.6	0.00049	4.22705	440.02	106.6	0.28
V-Line1	25000	1860	4023.78	4033.3	4028.22	4033.5	0.0004	3.88198	479.14	119.3	0.26
V-Line1	24800	1860	4023.91	4033.2	4028.21	4033.4	0.00039	3.8353	484.97	137.31	0.25
V-Line1	24600	1860	4024.11	4033.1	4028.26	4033.3	0.00035	3.60119	516.5	131.76	0.24
V-Line1	24400	1860	4023.56	4033	4028.46	4033.2	0.00045	3.94295	471.73	138.57	0.27
V-Line1	24200	1860	4024.18	4032.9	4028.32	4033.2	0.0004	3.7078	501.64	94.27	0.26
V-Line1	24000	1860	4024.18	4032.9		4033.1	0.00034	3.5587	522.66	76.07	0.24
V-Line1	23800	1860	4024.16	4032.8		4033	0.00038	3.69739	503.06	75	0.25
V-Line1	23600	1860	4024.22	4032.7		4032.9	0.00034	3.44419	540.04	82.4	0.24
V-Line1	23400	1860	4024.05	4032.7		4032.8	0.00033	3.35034	555.17	87.57	0.23
V-Line1	23200	1860	4024.25	4032.6		4032.8	0.00032	3.33531	557.67	86.59	0.23
V-Line1	23000	1860	4024.54	4032.6		4032.7	0.00029	3.16908	586.92	91.87	0.22
V-Line1	22800	1860	4024.57	4032.5		4032.7	0.00031	3.26799	569.16	89.68	0.23
V-Line1	22600	1860	4024.61	4032.4		4032.6	0.00035	3.41641	544.43	87.17	0.24
V-Line1	22400	1860	4024.03	4032.3		4032.5	0.00035	3.49383	532.37	81.66	0.24
V-Line1	22200	1860	4024.71	4032.3		4032.4	0.00037	3.45084	539	89.42	0.25
V-Line1	22000	1860	4025.05	4032.2		4032.4	0.00043	3.56568	521.64	91.06	0.26
V-Line1	21800	1860	4025.59	4032.1		4032.3	0.00045	3.5062	530.49	99.07	0.27
V-Line1	21600	1860	4025.59	4032		4032.2	0.00041	3.28297	566.56	110.61	0.26
V-Line1	21400	1860	4024.77	4031.9		4032.1	0.00041	3.19738	581.73	117.78	0.25
V-Line1	21200	1860	4025.18	4031.8		4032	0.00045	3.3279	558.91	114.18	0.27
V-Line1	21000	1860	4025.21	4031.7		4031.9	0.00059	3.54651	524.46	119.78	0.3

Reach	River Sta	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
V-Line1	20800	1860	4025.17	4031.6		4031.8	0.00054	3.31287	561.45	132.44	0.28
V-Line1	20600	1860	4025.26	4031.5		4031.7	0.00057	3.35142	554.99	133.4	0.29
V-Line1	20400	1860	4025.25	4031.4		4031.6	0.00055	3.32968	558.61	133.46	0.29
V-Line1	20200	1860	4025.24	4031.3		4031.4	0.00056	3.41898	544.02	125.93	0.29
V-Line1	20000	1860	4025.41	4031.1		4031.3	0.00057	3.47207	535.7	122.76	0.29
V-Line1	19800	1860	4025.49	4031		4031.2	0.00058	3.4497	539.18	125.51	0.29
V-Line1	19600	1860	4025.54	4030.9		4031.1	0.00074	3.68825	504.3	127.91	0.33
V-Line1	19400	1860	4025.49	4030.6		4030.9	0.00105	4.26296	436.32	115.8	0.39
V-Line1	19200	1860	4025.56	4030.4	4028.46	4030.7	0.00099	4.25839	436.78	111.22	0.38
V-Line1	19100 Lat Struct										
V-Line1	19000	988.43	4025.04	4030.3	4028.12	4030.5	0.0007	3.45749	285.88	83.48	0.32
V-Line1	18800	988.43	4024.7	4030.2	4027.64	4030.4	0.00054	3.14787	314	79.11	0.28
V-Line1	18600	988.43	4025.12	4030.1	4027.37	4030.3	0.00045	2.80619	352.23	92.92	0.25
V-Line1	18400	988.43	4025	4030.1	4027.22	4030.2	0.00036	2.66837	370.43	89.21	0.23
V-Line1	18300 Lat Struct										
V-Line1	18200	668.64	4024.85	4030.1	4026.85	4030.1	0.00014	1.62969	410.29	102.78	0.14
V-Line1	18000	668.64	4024.71	4030	4026.76	4030.1	0.00014	1.65509	403.99	100.48	0.15
V-Line1	17800	668.64	4024.27	4030	4026.54	4030	0.00016	1.77996	375.65	87.93	0.15
V-Line1	17600	668.64	4024.25	4030	4026.37	4030	0.00015	1.69906	393.53	94.64	0.15
V-Line1	17400	668.64	4023.93	4029.9		4030	0.00012	1.70822	391.43	81.38	0.14
V-Line1	17200	668.64	4023.77	4029.9	4026.16	4030	0.00018	1.93618	345.34	78.08	0.16
V-Line1	17000	668.64	4022.79	4029.9	4025.53	4029.9	0.00016	1.99115	335.81	70.32	0.16
V-Line1	16800	668.64	4023.21	4029.8	4025.52	4029.9	0.00012	1.72667	387.24	87.75	0.14
V-Line1	16600	668.64	4023.3	4029.8	4025.25	4029.9	0.00009	1.53444	435.76	90.37	0.12
V-Line1	16400	668.64	4023.2	4029.8	4025.2	4029.8	0.00011	1.69745	393.91	73.99	0.13
V-Line1	16200	668.64	4022.72	4029.8	4025.03	4029.8	0.00011	1.7739	376.93	69.21	0.13
V-Line1	16000	668.64	4022.58	4029.8	4024.79	4029.8	0.0001	1.65157	404.85	72.95	0.12
V-Line1	15800	668.64	4021.96	4029.7	4024.59	4029.8	0.0001	1.7553	380.93	78.04	0.13
V-Line1	15600	668.64	4021.93	4029.7	4024.11	4029.8	0.00008	1.5873	421.25	81.67	0.11
V-Line1	15400	668.64	4021.4	4029.7	4024.11	4029.7	0.00008	1.59189	420.03	75.82	0.11
V-Line1	15200	668.64	4021.79	4029.7	4024.05	4029.7	0.00008	1.61324	414.47	69.51	0.11
V-Line1	15000	668.64	4021.44	4029.7	4024.02	4029.7	0.00009	1.74285	383.65	86.37	0.12
V-Line1	14800	668.64	4021.65	4029.6	4024.15	4029.7	0.00011	1.86558	358.41	78.47	0.13
V-Line1	14600	668.64	4021.56	4029.6	4024.09	4029.7	0.0001	1.75916	380.09	82.71	0.12
V-Line1	14400	668.64	4021.63	4029.6	4024.2	4029.6	0.00011	1.83157	365.06	85.24	0.13
V-Line1	14200	668.64	4021.38	4029.6	4024.09	4029.6	0.00009	1.70006	393.31	82.55	0.12
V-Line1	14000	668.64	4021.49	4029.5	4024.3	4029.6	0.00013	1.9587	341.37	74.62	0.14
V-Line1	13800	668.64	4021.57	4029.5	4024.34	4029.6	0.00013	1.97694	338.22	80.6	0.14
V-Line1	13600	668.64	4021.47	4029.5	4024.4	4029.5	0.00015	2.09098	319.77	118.64	0.15
V-Line1	13400	668.64	4021.41	4029.4	4024.29	4029.5	0.00014	2.0496	326.23	78.84	0.15
V-Line1	13200	668.64	4021.92	4029.4	4024.54	4029.5	0.00014	1.98502	336.84	68.4	0.15
V-Line1	13000	668.64	4021.91	4029.4	4024.57	4029.5	0.00014	1.9827	337.24	75.41	0.15
V-Line1	12800	668.64	4022.12	4029.4		4029.4	0.00016	2.06477	323.83	60.58	0.16
V-Line1	12600	668.64	4021.49	4029.3	4024.24	4029.4	0.00014	2.03406	328.72	76.75	0.15
V-Line1	12400	668.64	4021	4029.3	4023.88	4029.4	0.00011	1.82988	365.4	61.09	0.13
V-Line1	12200	668.64	4021.18	4029.3	4023.98	4029.3	0.00013	1.97219	339.03	58.23	0.14
V-Line1	12000	668.64	4021.28	4029.2	4024.16	4029.3	0.00015	2.04411	327.11	57.56	0.15
V-Line1	11800	668.64	4022.21	4029.2	4024.61	4029.3	0.00014	1.93263	345.97	76.16	0.15
V-Line1	11600	668.64	4022.04	4029.2	4024.5	4029.3	0.00014	1.9412	344.45	74.13	0.15
V-Line1	11400	668.64	4021.84	4029.2	4024.39	4029.2	0.00013	1.89847	352.2	65.74	0.14
V-Line1	11200	668.64	4021.87	4029.1	4024.32	4029.2	0.00012	1.8059	370.25	75.02	0.14
V-Line1	11000	668.64	4021.64	4029.1	4024.31	4029.2	0.00015	1.9381	345	66.39	0.15
V-Line1	10800	668.64	4021.62	4029.1		4029.1	0.00012	1.81686	368.02	68.18	0.14

Reach	River Sta	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
V-Line1	10600	668.64	4022.06	4029.1		4029.1	0.00012	1.83341	364.7	67.96	0.14
V-Line1	10400	668.64	4022.19	4029		4029.1	0.00012	1.81592	368.21	68.21	0.14
V-Line1	10200	668.64	4021.62	4029		4029.1	0.00012	1.86146	359.2	65.11	0.14
V-Line1	10000	668.64	4020.96	4029		4029	0.00013	1.96102	340.97	58.7	0.14
V-Line1	9800	668.64	4021.4	4028.9	4024.27	4029	0.00017	2.11706	315.83	63.85	0.16
V-Line1	9600	668.64	4022.05	4028.9	4024.57	4029	0.00014	1.83922	363.55	93.48	0.14
V-Line1	9400	668.64	4022.11	4028.9	4024.46	4028.9	0.00014	1.91962	348.32	83.81	0.15
V-Line1	9200	668.64	4022.34	4028.9	4024.54	4028.9	0.00013	1.81871	367.65	72.42	0.14
V-Line1	9000	668.64	4022.19	4028.8	4024.62	4028.9	0.00014	1.87572	356.47	71.15	0.15
V-Line1	8800	668.64	4022.27	4028.8		4028.9	0.00014	1.90844	350.36	68.41	0.15
V-Line1	8600	668.64	4021.84	4028.8		4028.8	0.00017	2.08007	321.45	61.14	0.16
V-Line1	8400	668.64	4021.66	4028.7		4028.8	0.00016	2.03262	328.96	63.28	0.16
V-Line1	8200	668.64	4021.79	4028.7		4028.8	0.00019	2.22767	300.15	56.98	0.17
V-Line1	8000	668.64	4022.48	4028.7		4028.7	0.00019	2.14109	312.29	63.87	0.17
V-Line1	7800	668.64	4022.51	4028.6	4024.81	4028.7	0.0002	2.15709	309.97	66.59	0.17
V-Line1	7600	668.64	4022.37	4028.6	4024.62	4028.6	0.00016	1.95228	342.49	73.05	0.16
V-Line1	7400	668.64	4021.73	4028.6	4024.27	4028.6	0.00014	1.88161	355.36	71.67	0.15
V-Line1	7200	668.64	4019.95	4028.5		4028.6	0.00018	2.01811	331.32	69.77	0.16
V-Line1	7000	668.64	4020.7	4028.5		4028.5	0.00015	2.04803	326.48	58.96	0.15
V-Line1	6800	668.64	4021.9	4028.4	4024.53	4028.5	0.00023	2.33406	286.47	69.97	0.19
V-Line1	6600	668.64	4022.3	4028.4	4024.78	4028.5	0.00026	2.42111	276.17	69.24	0.2
V-Line1	6400	668.64	4022.16	4028.3	4024.83	4028.4	0.00029	2.50625	266.79	65	0.21
V-Line1	6200	668.64	4021.96	4028.3	4024.58	4028.3	0.00027	2.45217	272.67	108.95	0.2
V-Line1	6000	668.64	4022.29	4028.2	4024.79	4028.3	0.0003	2.49603	267.88	83.67	0.21
V-Line1	5800	668.64	4022.38	4028.1	4024.73	4028.2	0.00028	2.43429	274.68	62.42	0.2
V-Line1	5600	668.64	4022.28	4028.1	4024.69	4028.2	0.00028	2.42074	276.21	62.57	0.2
V-Line1	5400	668.64	4022.03	4028	4024.44	4028.1	0.00025	2.34987	284.54	62.85	0.19
V-Line1	5200	668.64	4021.84	4028	4024.24	4028.1	0.00025	2.39208	279.52	70.17	0.19
V-Line1	5000	668.64	4021.77	4027.9	4024.41	4028	0.00029	2.50842	266.56	67.49	0.21
V-Line1	4800	668.64	4021.68	4027.8	4024.46	4028	0.00032	2.60973	256.21	63.79	0.22
V-Line1	4600	668.64	4021.51	4027.8	4024.2	4027.9	0.00028	2.50396	267.03	64.36	0.21
V-Line1	4400	668.64	4021.45	4027.7	4024.29	4027.8	0.00033	2.65822	251.54	55.38	0.22
V-Line1	4200	668.64	4022.13	4027.7	4024.48	4027.8	0.00032	2.54419	262.81	61.86	0.22
V-Line1	4000	668.64	4022.03	4027.6	4024.39	4027.7	0.0003	2.44866	273.06	66.27	0.21
V-Line1	3800	668.64	4022.02	4027.5	4024.41	4027.6	0.00029	2.39301	279.41	70.77	0.21
V-Line1	3600	668.64	4021.7	4027.5	4024.23	4027.6	0.00034	2.65024	252.29	75.91	0.22
V-Line1	3400	668.64	4020.98	4027.4	4023.82	4027.5	0.00034	2.74142	243.9	52.16	0.22
V-Line1	3200	668.64	4021.2	4027.3	4023.95	4027.4	0.00035	2.72747	245.15	54.44	0.23
V-Line1	3000	668.64	4020.86	4027.3	4023.62	4027.4	0.00031	2.66675	250.73	52.41	0.21
V-Line1	2800	668.64	4021.01	4027.2	4023.79	4027.3	0.00035	2.724	245.46	54.42	0.23
V-Line1	2600	668.64	4021.81	4027.1	4024.42	4027.2	0.00055	3.17216	210.78	52.62	0.28
V-Line1	2400	668.64	4021.35	4026.9		4027.1	0.00072	3.20316	208.74	63.4	0.31
V-Line1	2200	668.64	4020.53	4026.8	4023.76	4027	0.00042	2.88011	232.16	55.07	0.25
V-Line1	2000	668.64	4021.26	4026.7	4023.93	4026.9	0.00049	3.03183	220.54	54.33	0.27
V-Line1	1800	668.64	4021.63	4026.6	4024.03	4026.8	0.00053	3.09289	216.19	65.6	0.27
V-Line1	1600	668.64	4020.69	4026.5	4023.72	4026.7	0.0005	3.03199	220.53	54.77	0.27
V-Line1	1400	668.64	4021.13	4026.3	4024.11	4026.5	0.00078	3.57807	186.87	57.37	0.33
V-Line1	1200	668.64	4021.43	4026.1	4024.36	4026.3	0.00123	4.18727	159.68	67.48	0.41
V-Line1	1000	668.64	4021.42	4025.7	4024.39	4026	0.00172	4.66319	143.39	90.34	0.47
V-Line1	800	668.64	4019.95	4025.5	4023.35	4025.8	0.001	4.1124	162.59	53.35	0.37

Lateral Structure Output

File		Type	Options	Help	Lat Struct	Profile: PF1
River:	Carson River	Reach:	V-Line1	RS:	19100	Plan: 041515_W026FT
Plan: 041515_W026FT Carson River V-Line1 RS: 19100 Lat Struct Profile: PF1						
E.G. US. (ft)	4030.69	Weir Sta US (ft)	0.00			
W.S. US. (ft)	4030.41	Weir Sta DS (ft)	206.18			
E.G. DS (ft)	4030.49	Min El Weir Flow (ft)	4029.00			
W.S. DS (ft)	4030.31	Wr Top Wdth (ft)	143.86			
Q US (cfs)	1860.00	Weir Max Depth (ft)	1.65			
Q Leaving Total (cfs)	857.54	Weir Avg Depth (ft)	1.46			
Q DS (cfs)	988.43	Weir Flow Area (sq ft)	209.83			
Perc Q Leaving	46.86	Weir Coef (ft ^{1/2})	3.300			
Q Weir (cfs)	857.54	Weir Submerg	0.00			
Q Gates (cfs)		Q Gate Group (cfs)				
Q Culv (cfs)	0.00	Gate Open Ht (ft)				
Q Lat RC (cfs)		Gate #Open				
Q Breach (cfs)		Gate Area (sq ft)				
Breach Avg Velocity (ft/s)		Gate Submerg				
Breach Flow Area (sq ft)		Gate Invert (ft)				
		Gate Weir Coef				

Errors, Warnings and Notes

Warning: Divided flow computed for this cross-section.

Warning: The cross-section end points had to be extended vertically for the computed water surface.

Note: Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.

Enter to move to next downstream river station location

Lateral Structure Output

File		Type	Options	Help	Lat Struct	Profile: PF1
River:	Carson River	Reach:	V-Line1	RS:	18300	Plan: 041515_W026FT
Plan: 041515_W026FT Carson River V-Line1 RS: 18300 Lat Struct Profile: PF1						
E.G. US. (ft)	4030.17	Weir Sta US (ft)	0.00			
W.S. US. (ft)	4030.06	Weir Sta DS (ft)	186.52			
E.G. DS (ft)	4030.10	Min El Weir Flow (ft)	4029.30			
W.S. DS (ft)	4030.06	Wr Top Wdth (ft)	133.14			
Q US (cfs)	988.43	Weir Max Depth (ft)	0.85			
Q Leaving Total (cfs)	323.17	Weir Avg Depth (ft)	0.79			
Q DS (cfs)	668.64	Weir Flow Area (sq ft)	105.30			
Perc Q Leaving	32.35	Weir Coef (ft ^{1/2})	3.400			
Q Weir (cfs)	323.17	Weir Submerg	0.00			
Q Gates (cfs)		Q Gate Group (cfs)				
Q Culv (cfs)	0.00	Gate Open Ht (ft)				
Q Lat RC (cfs)		Gate #Open				
Q Breach (cfs)		Gate Area (sq ft)				
Breach Avg Velocity (ft/s)		Gate Submerg				
Breach Flow Area (sq ft)		Gate Invert (ft)				
		Gate Weir Coef				

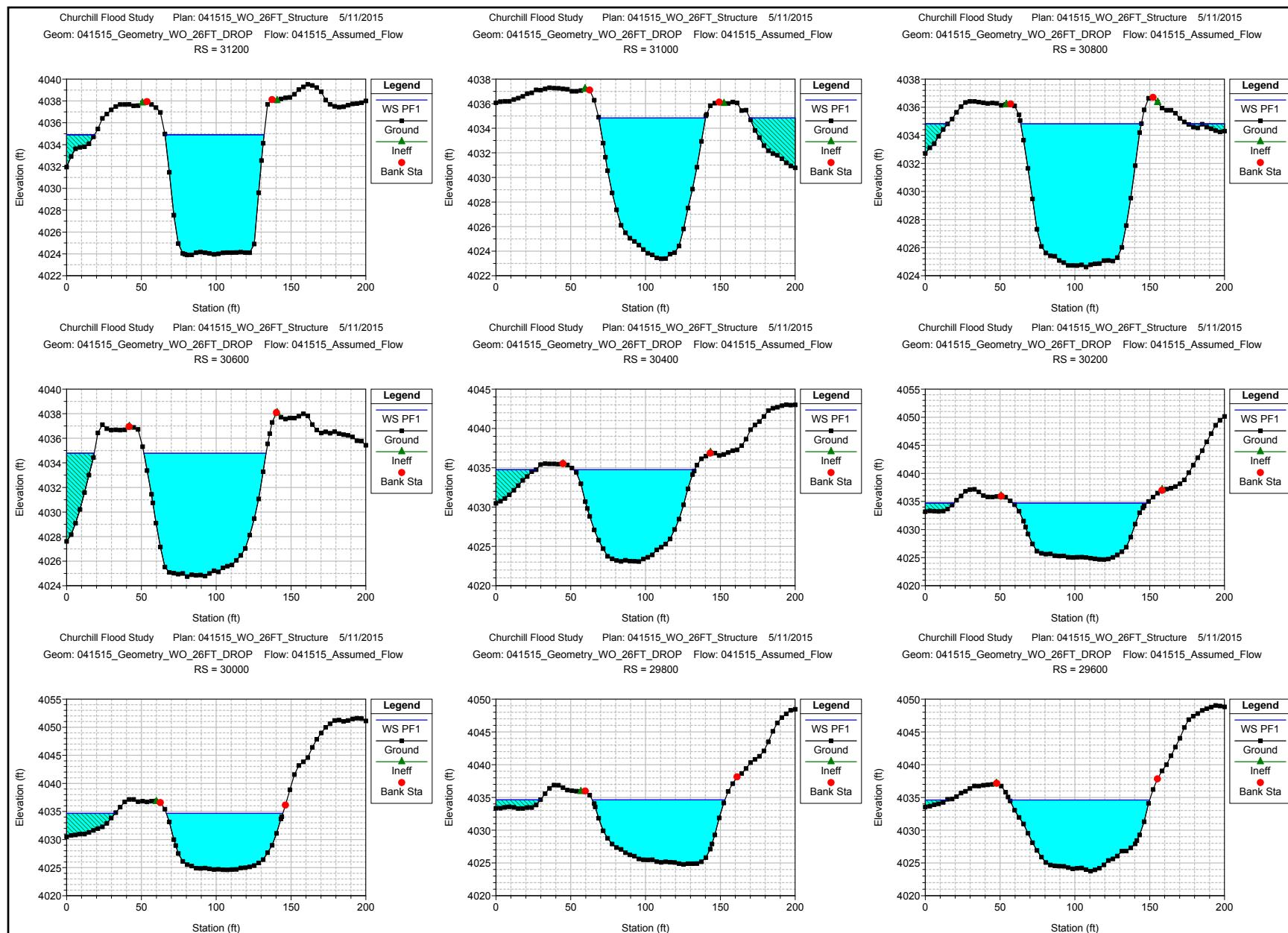
Errors, Warnings and Notes

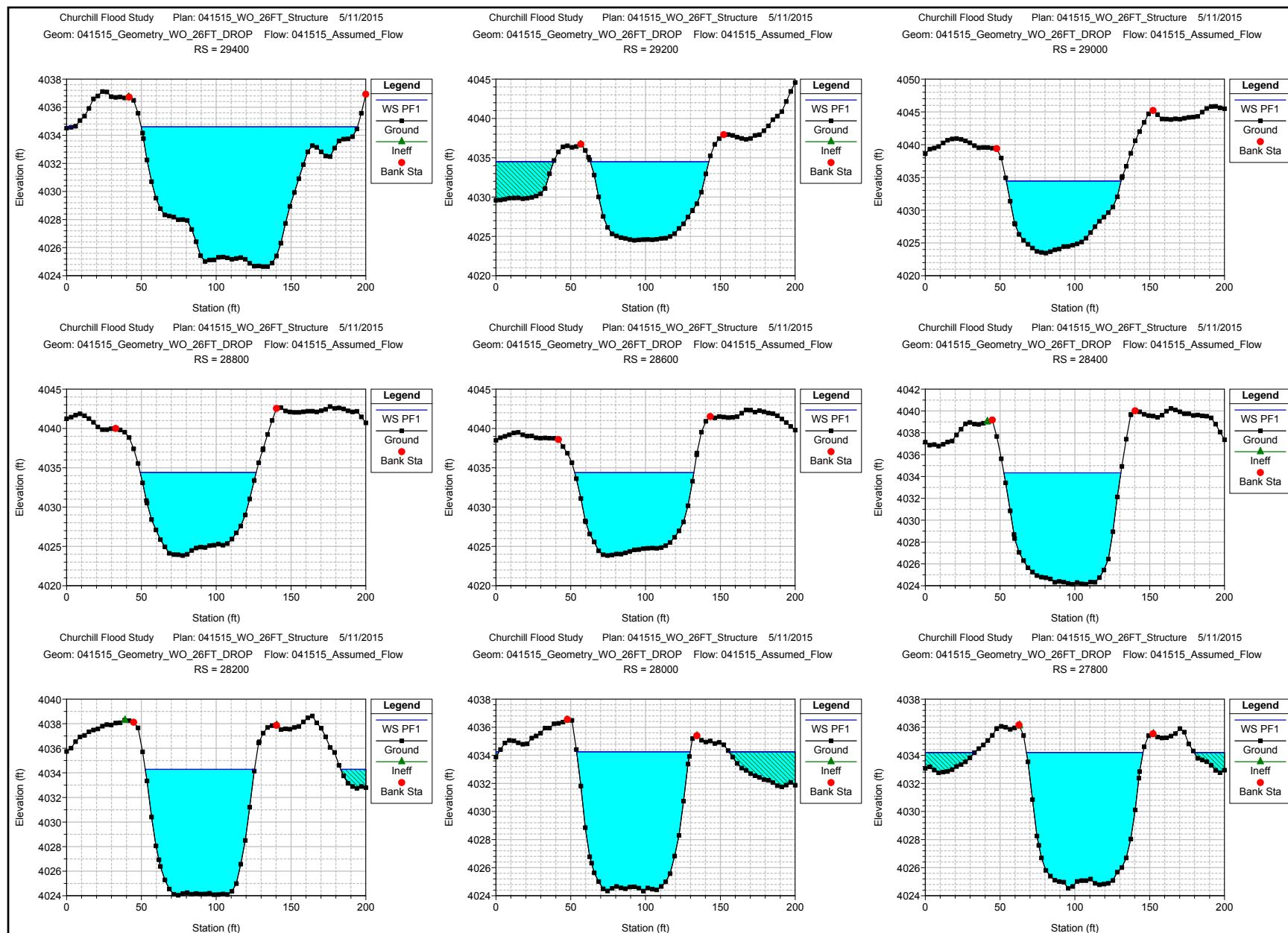
Warning: Divided flow computed for this cross-section.

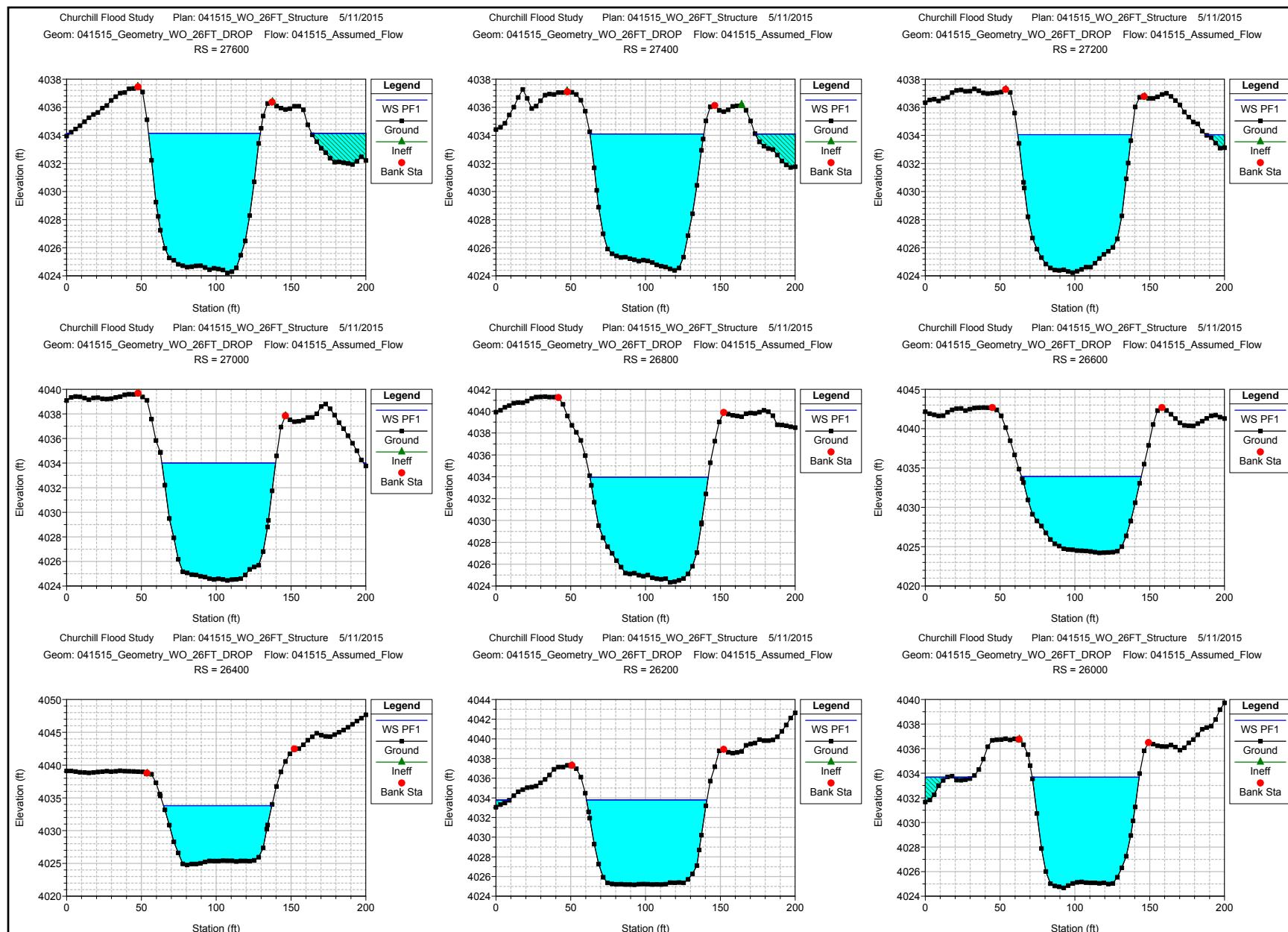
Warning: The cross-section end points had to be extended vertically for the computed water surface.

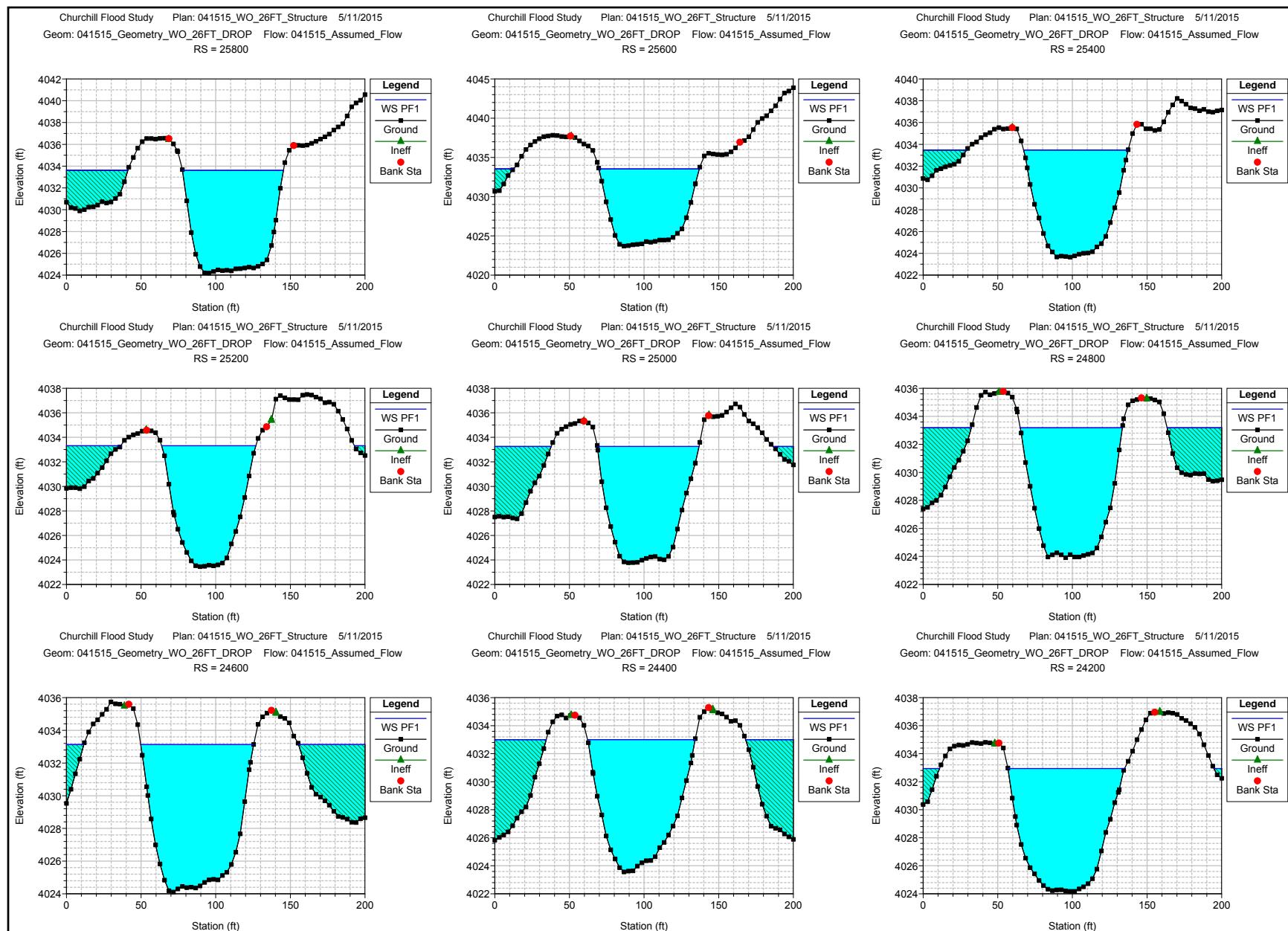
Note: Multiple critical depths were found at this location. The critical depth with the lowest, valid, energy was used.

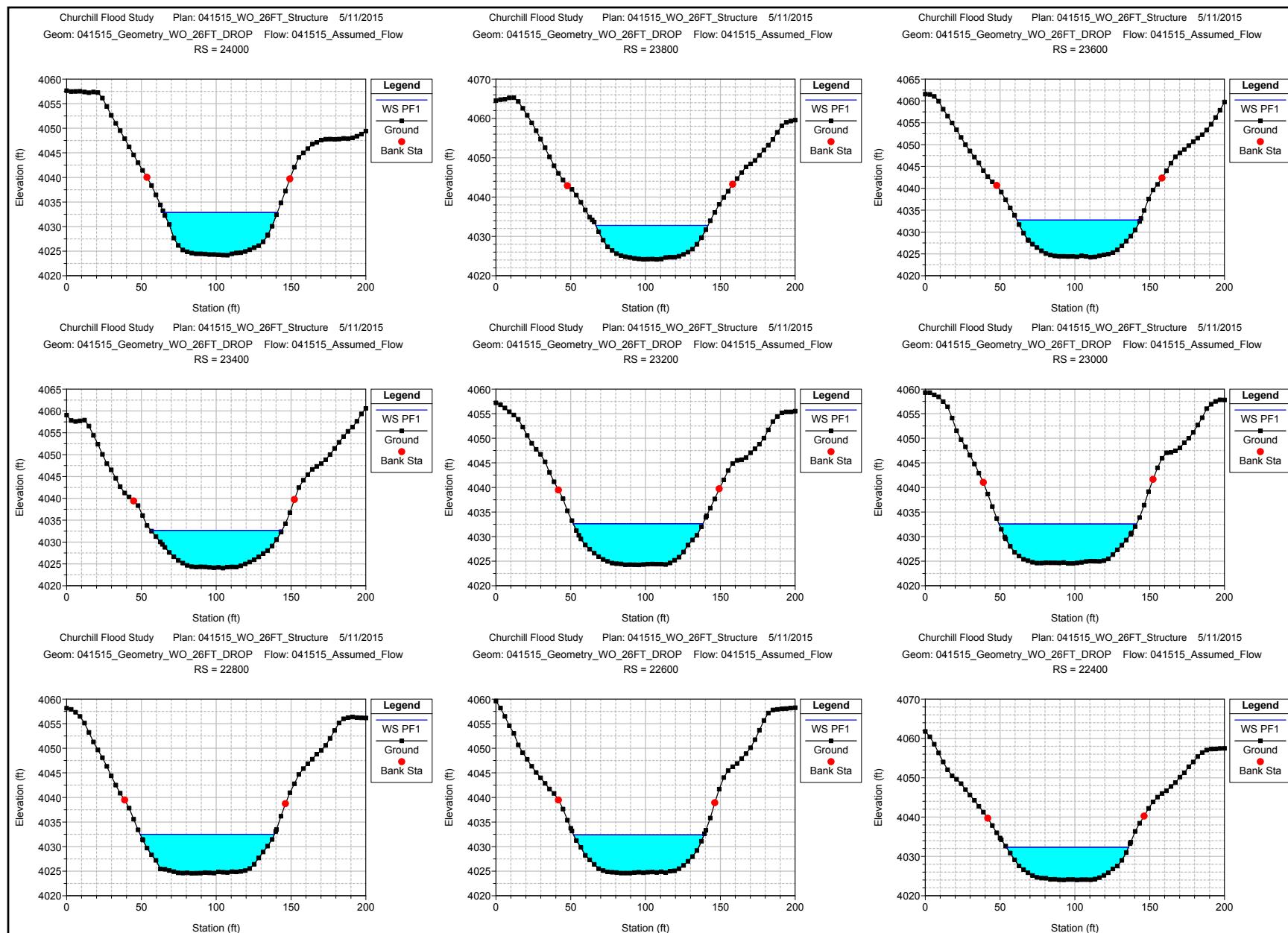
Enter to move to next downstream river station location

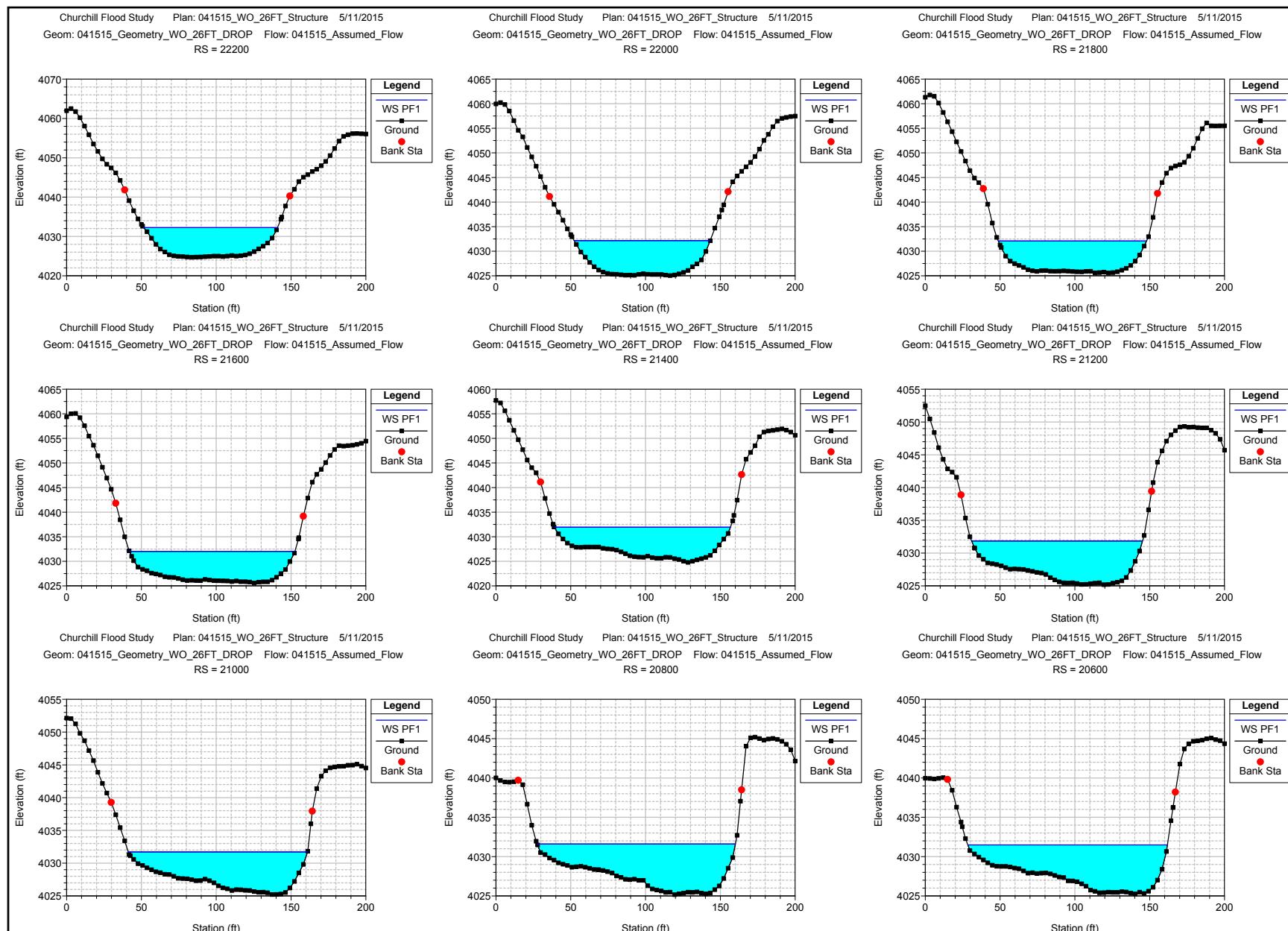


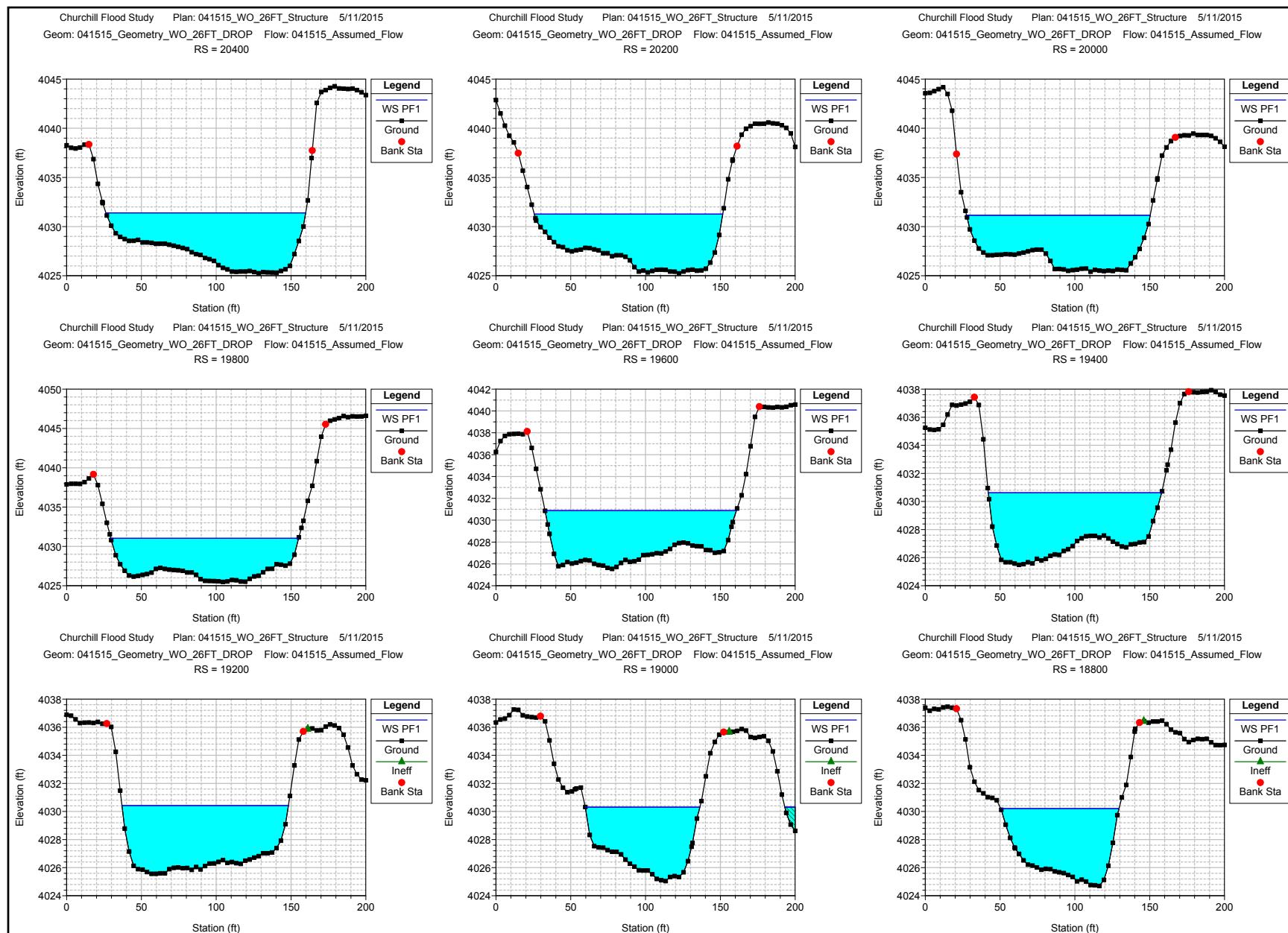


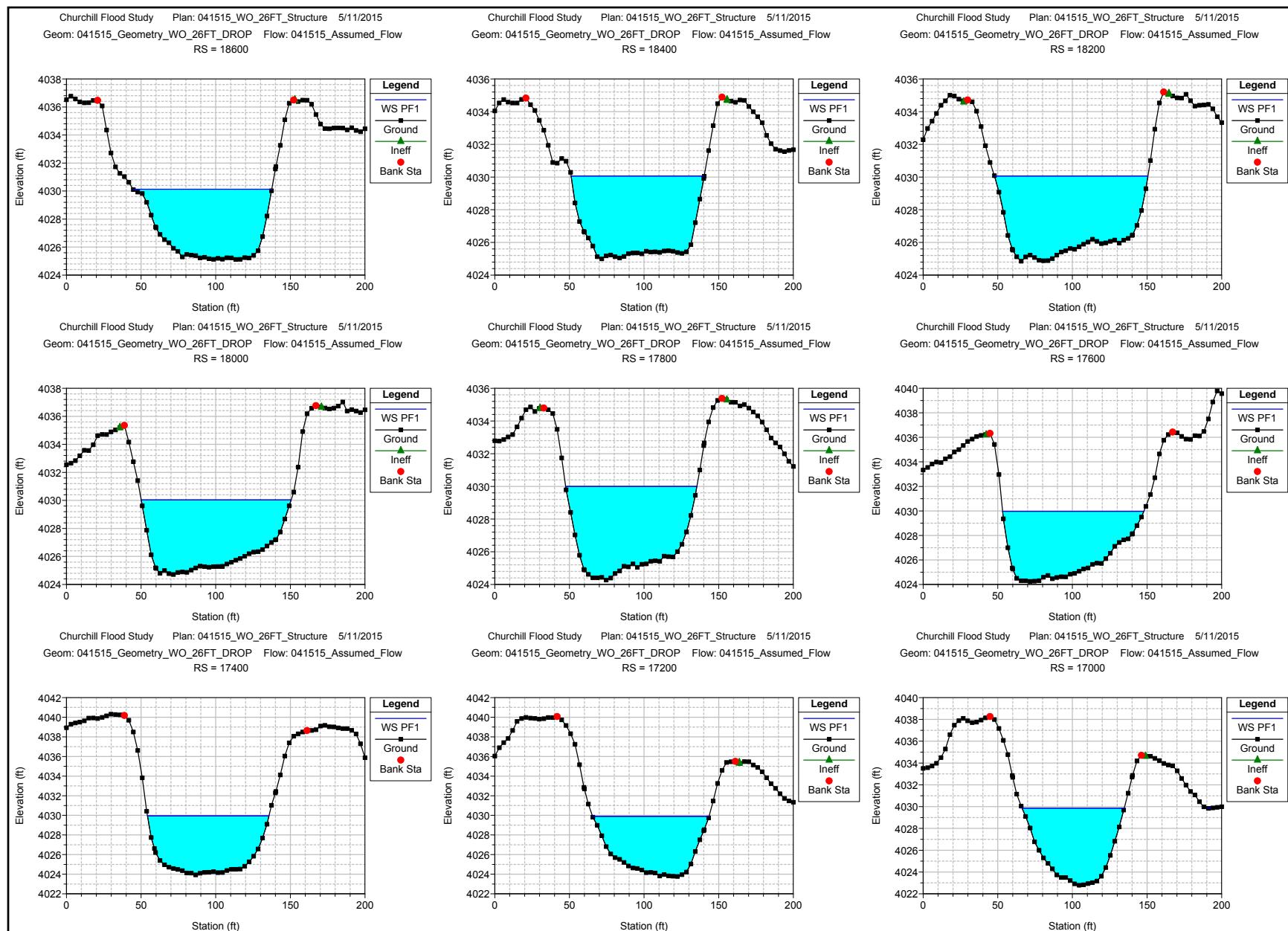


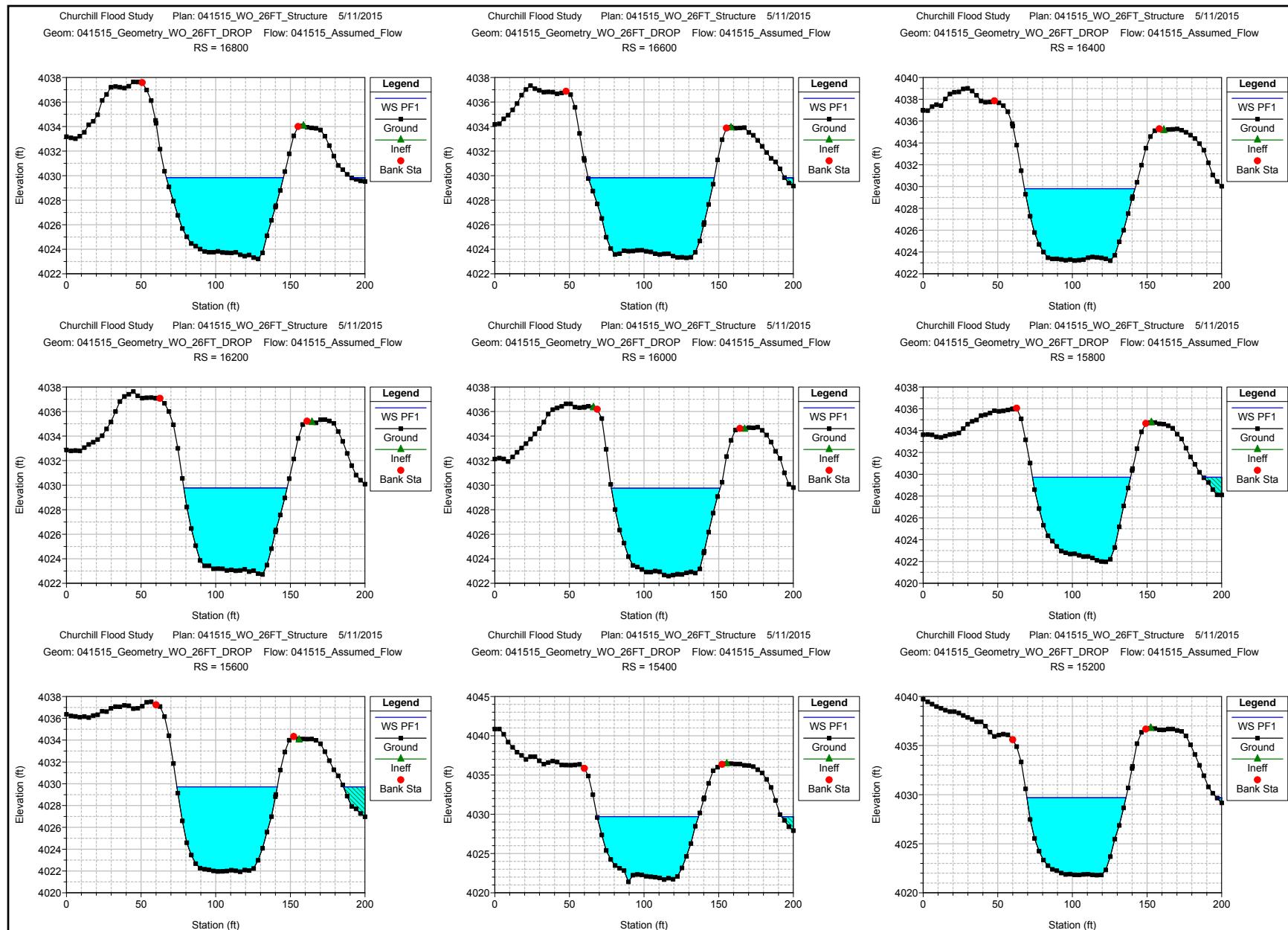


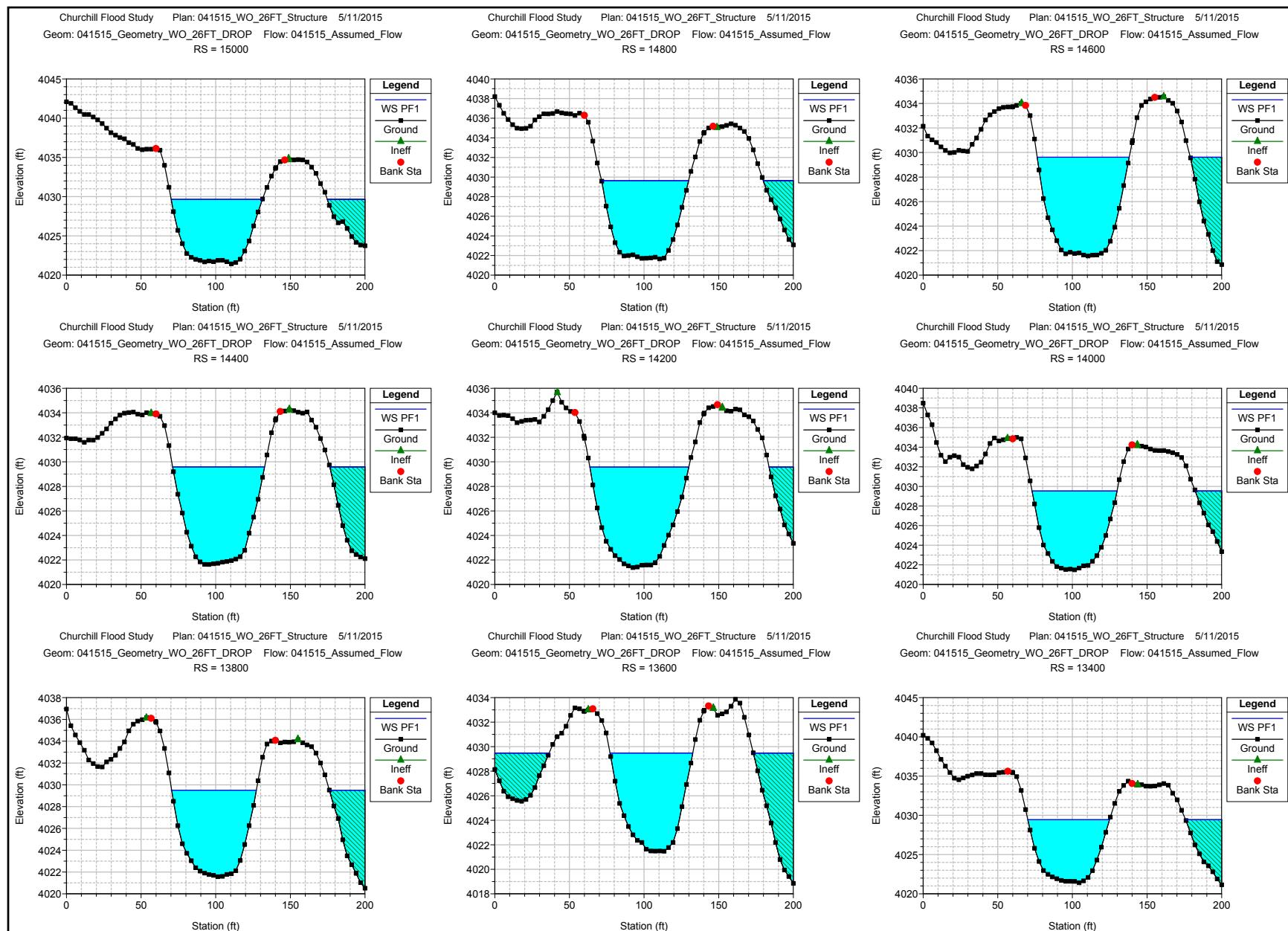


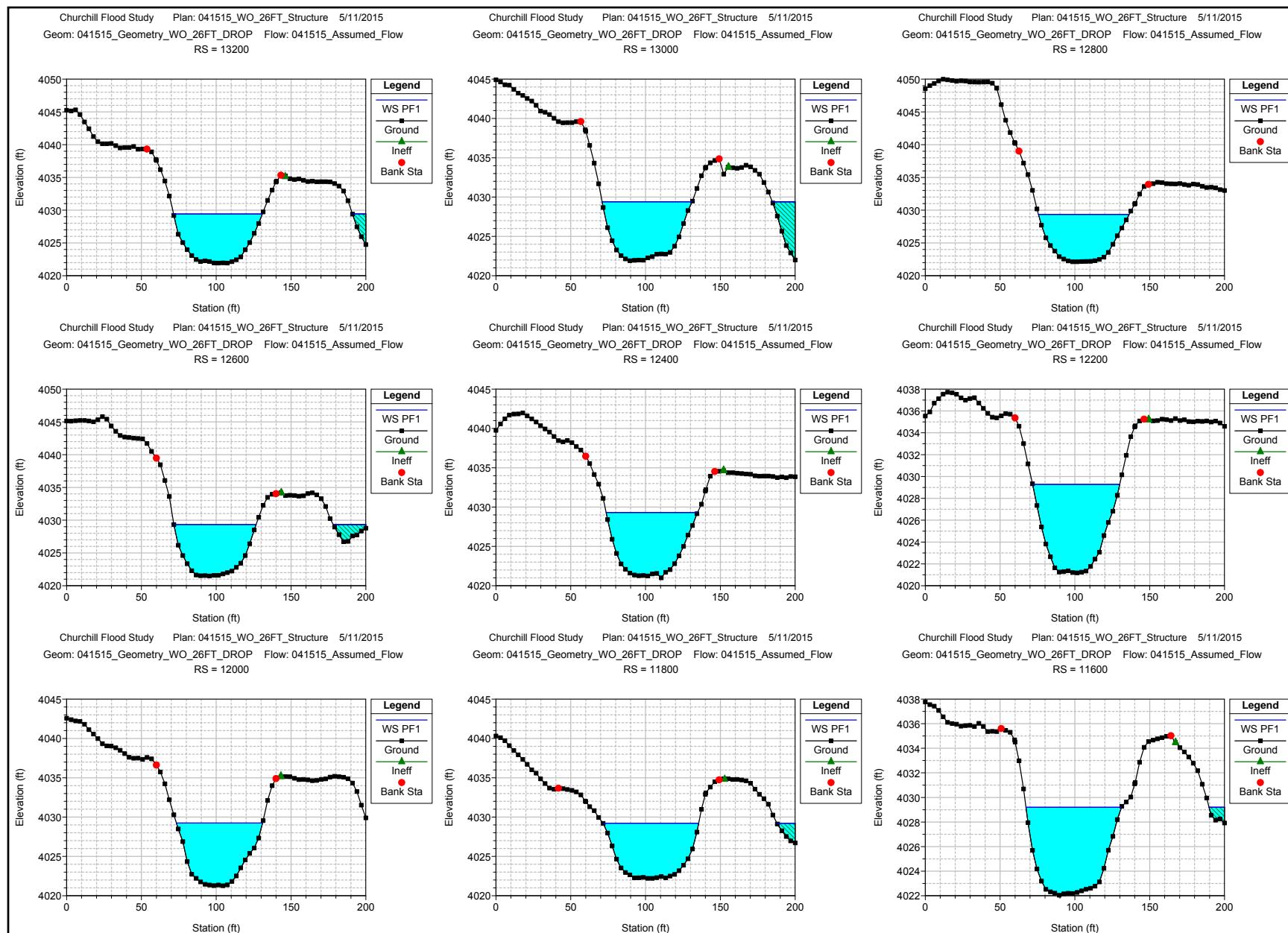


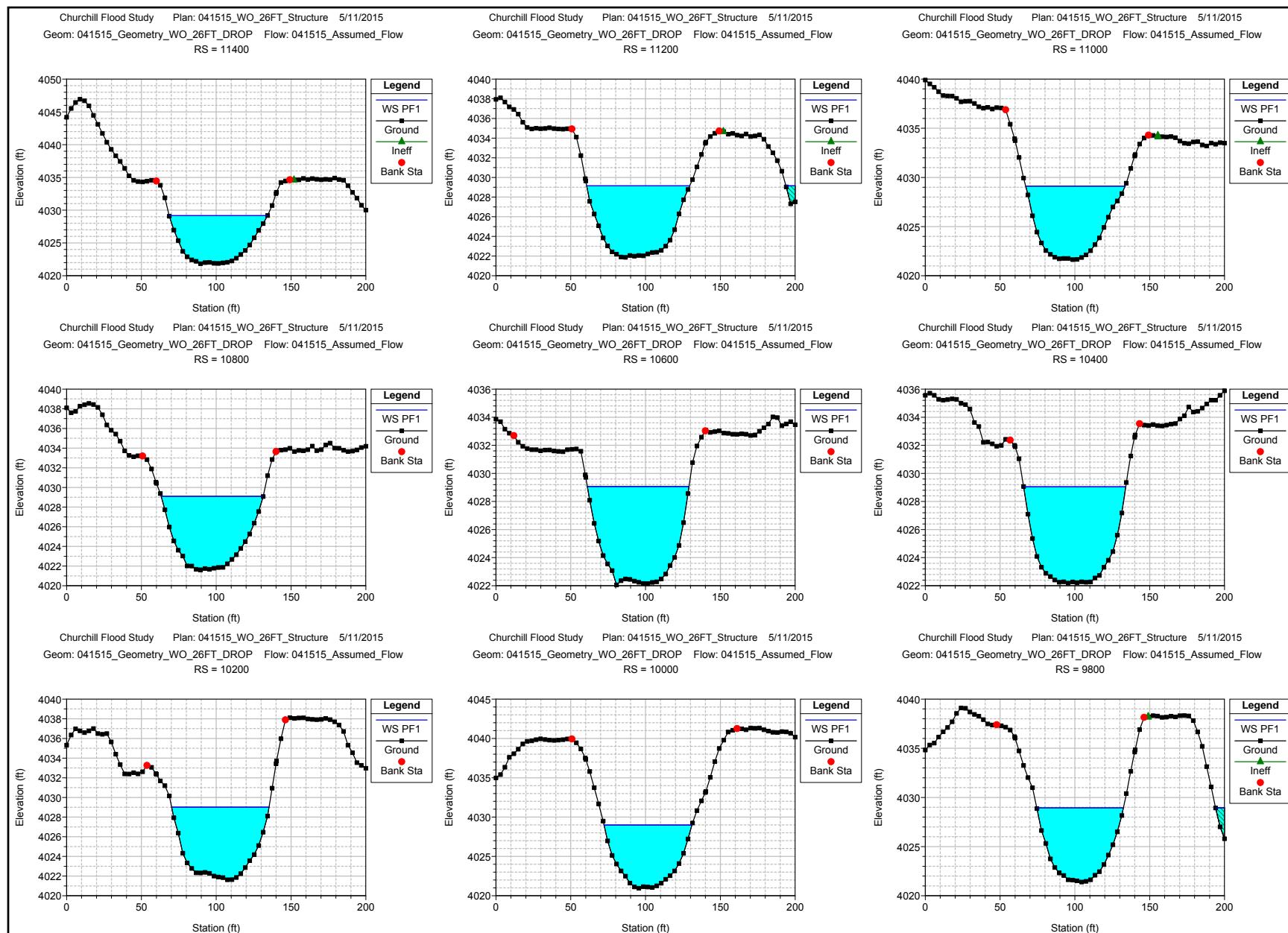


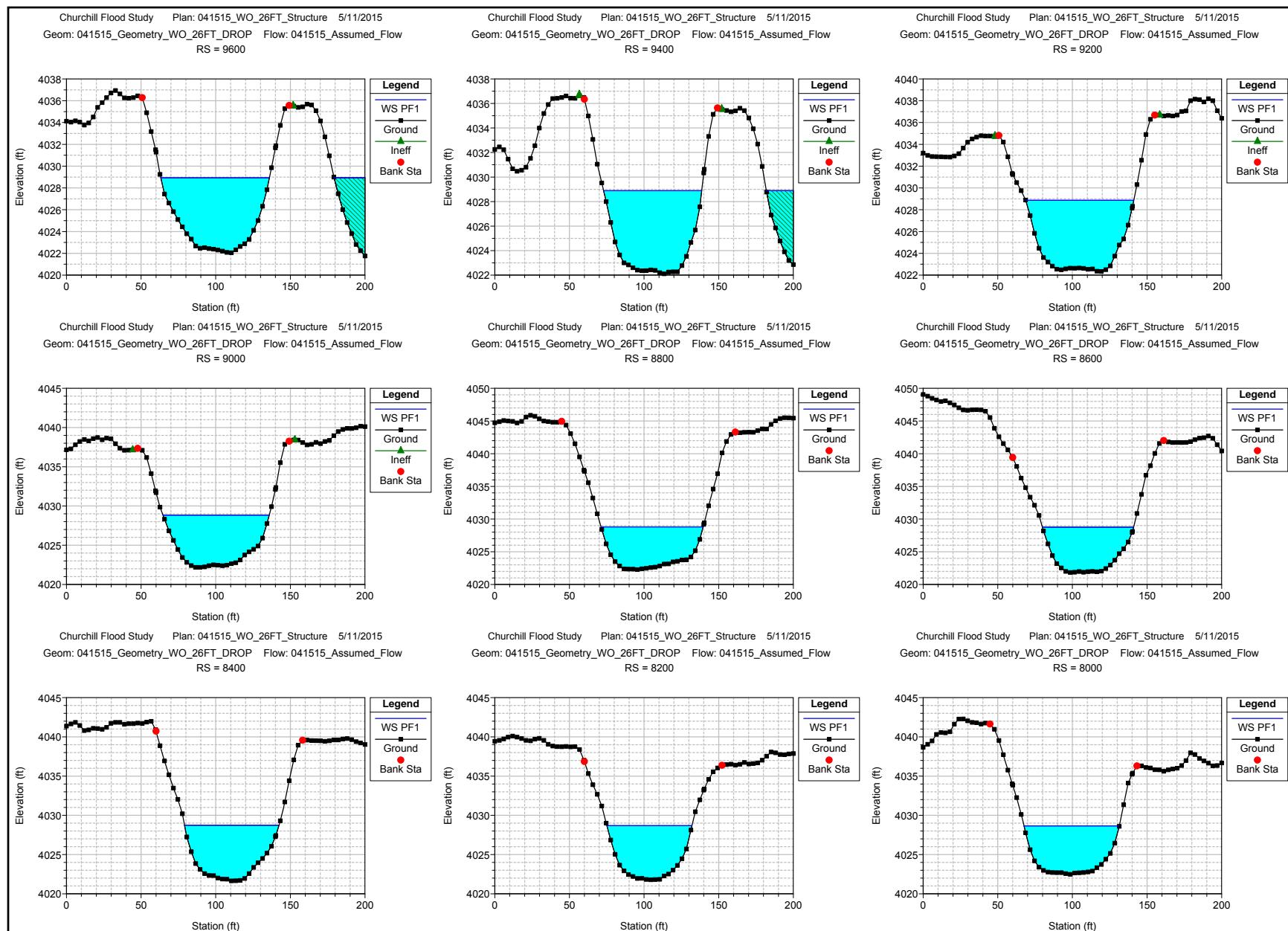


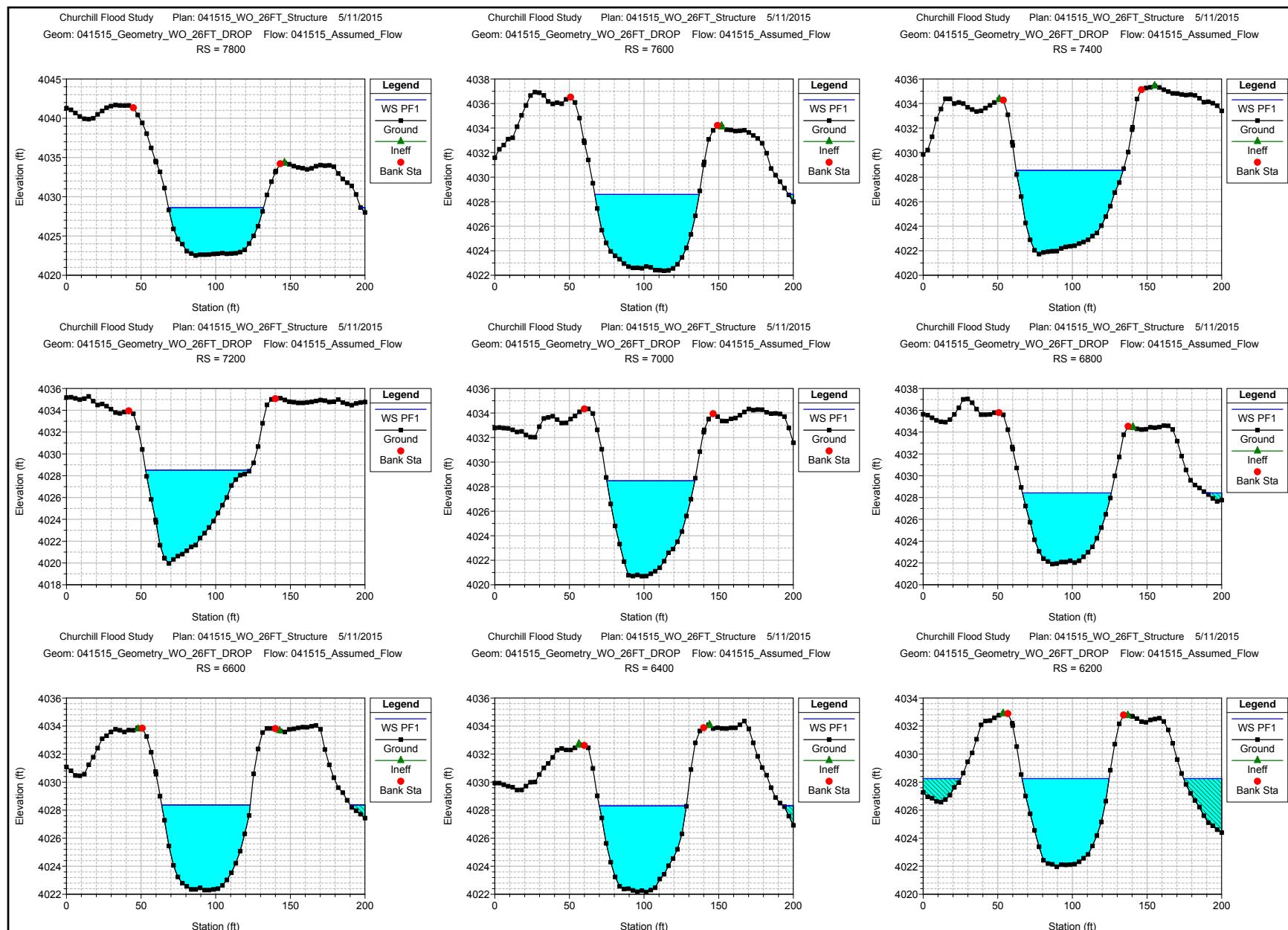


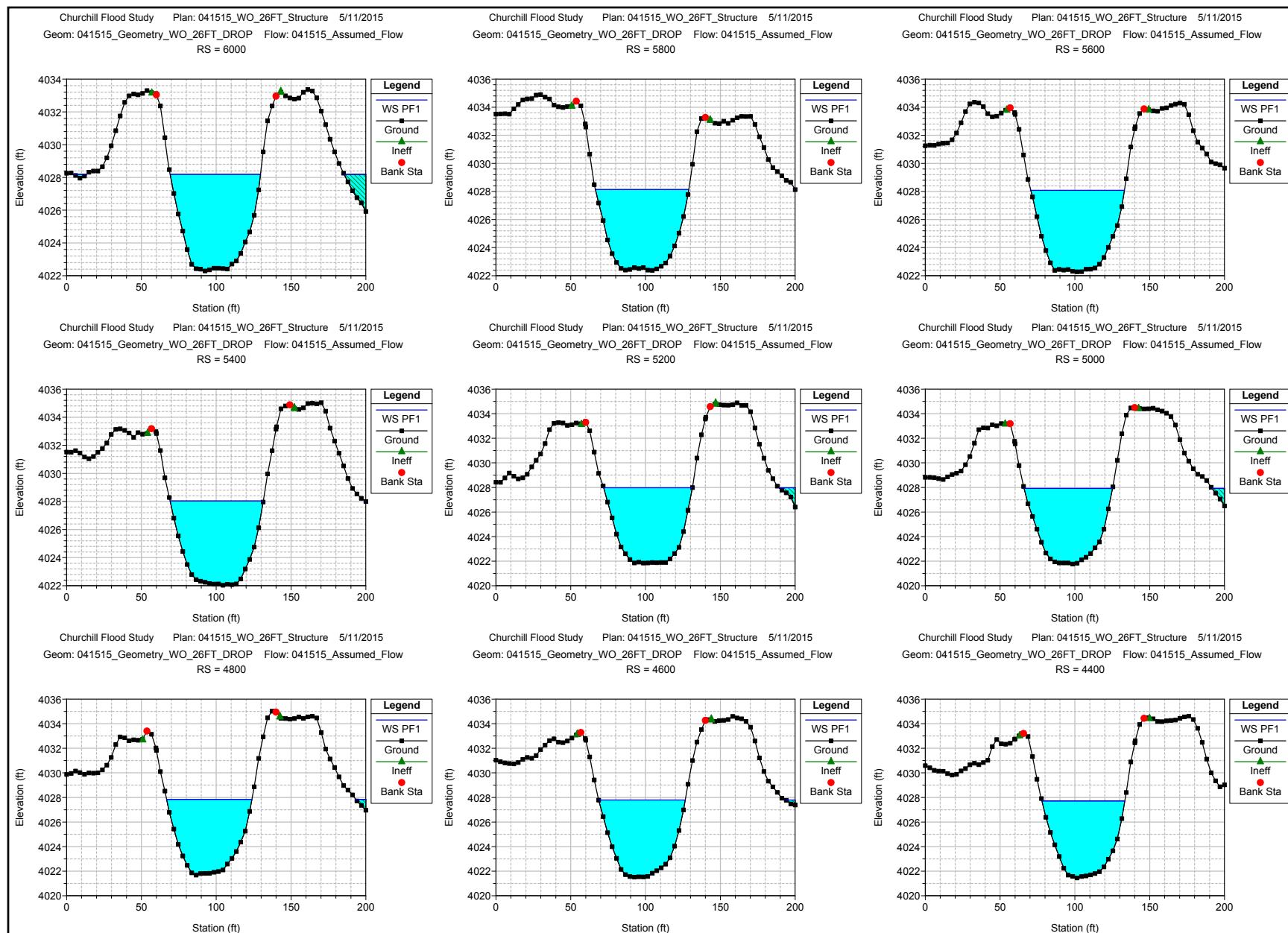


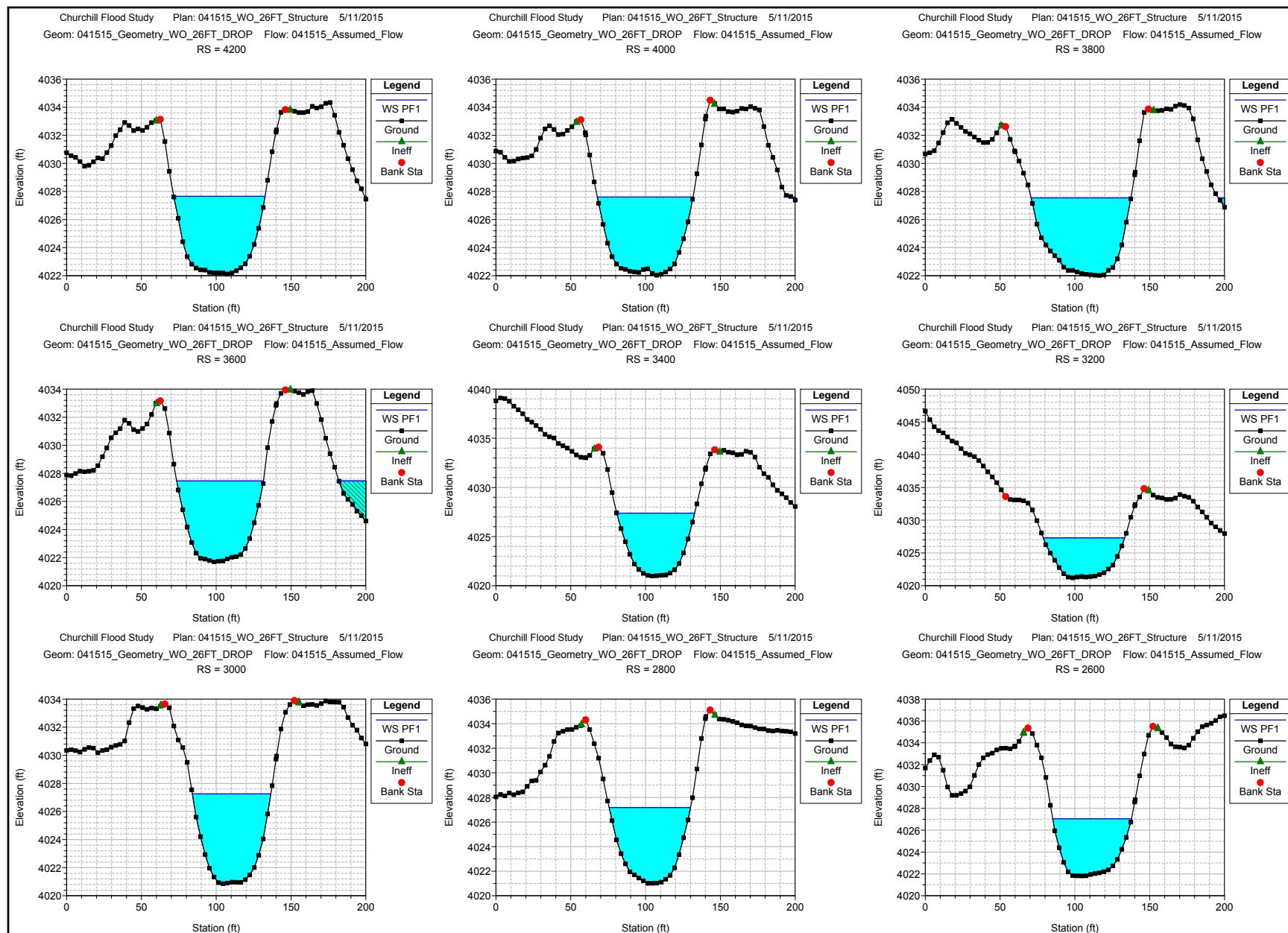


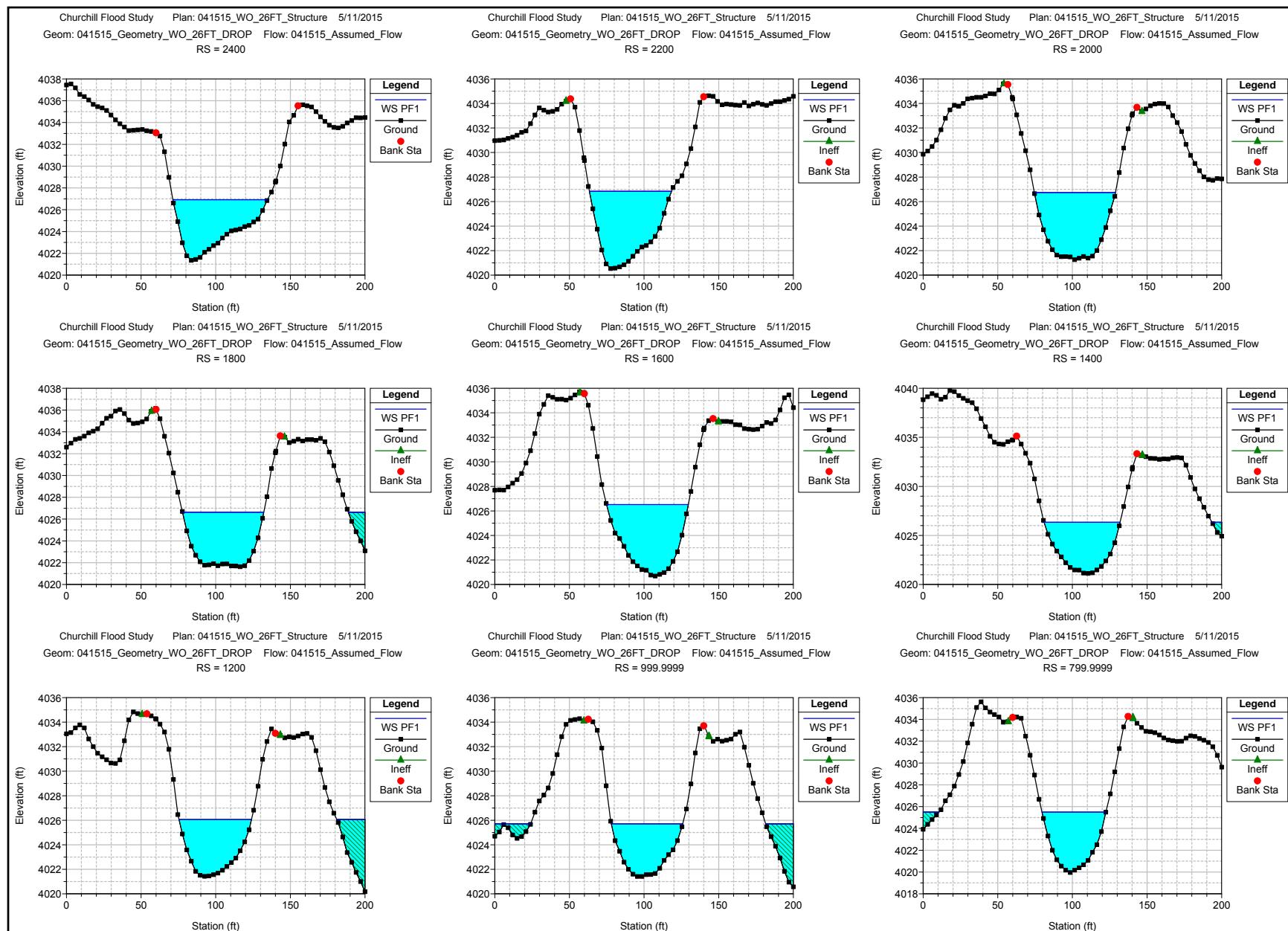


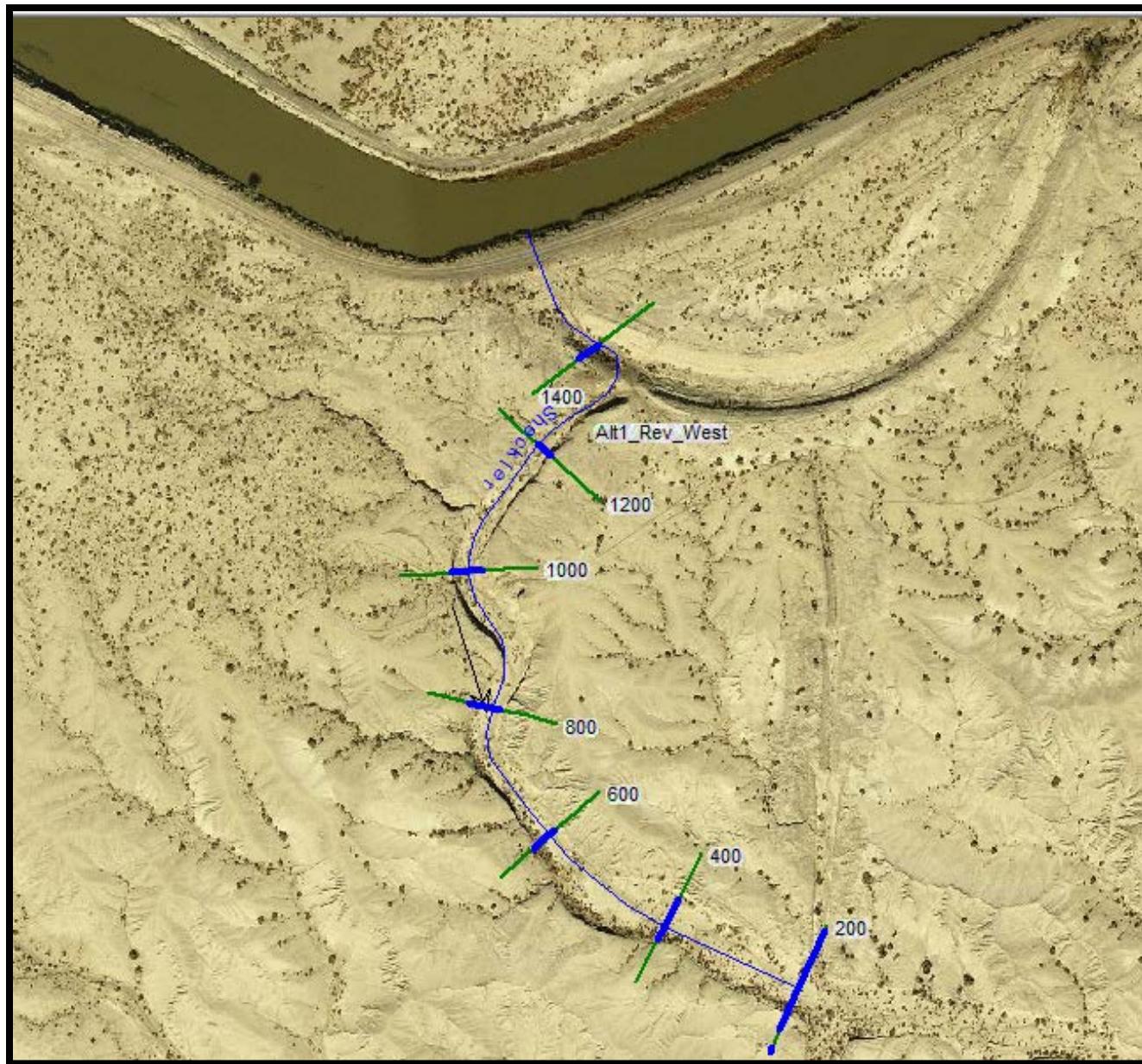


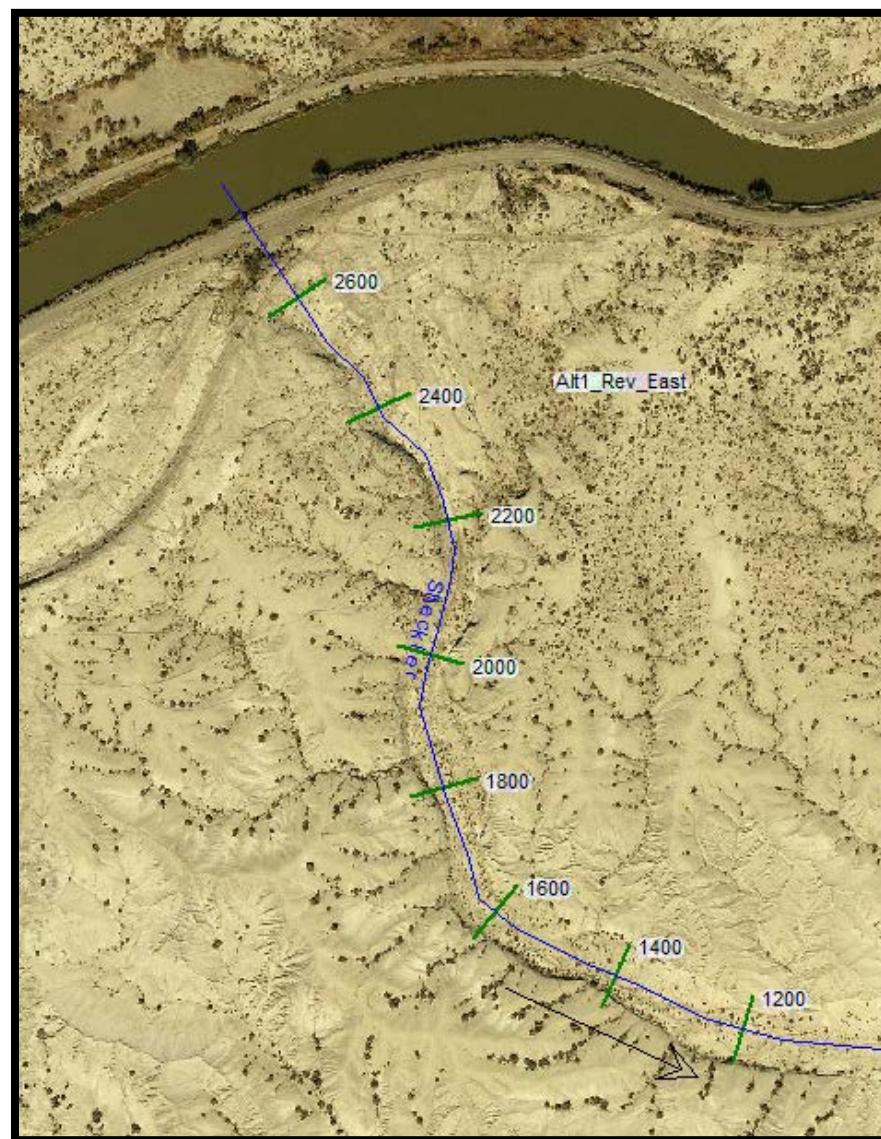




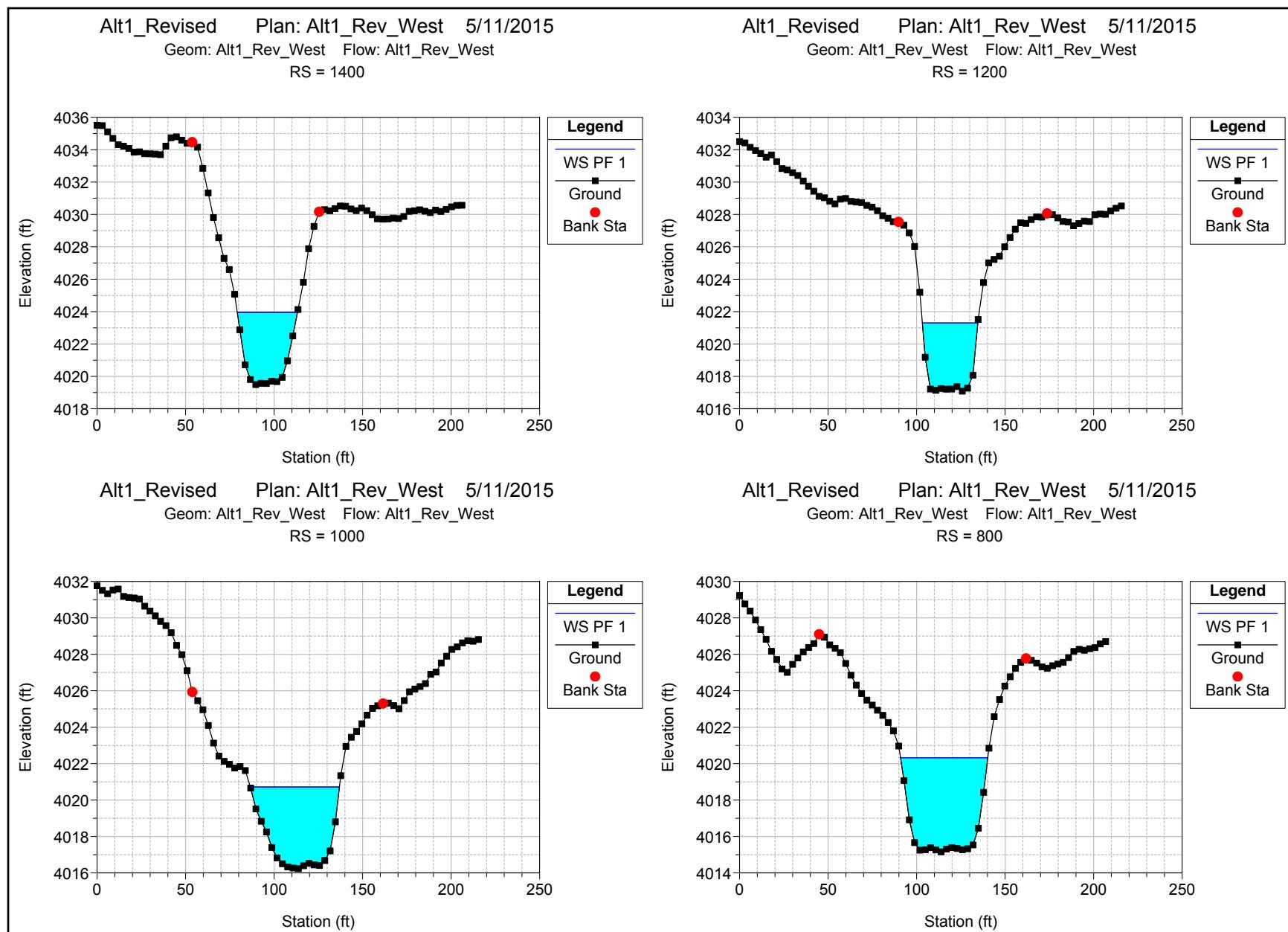


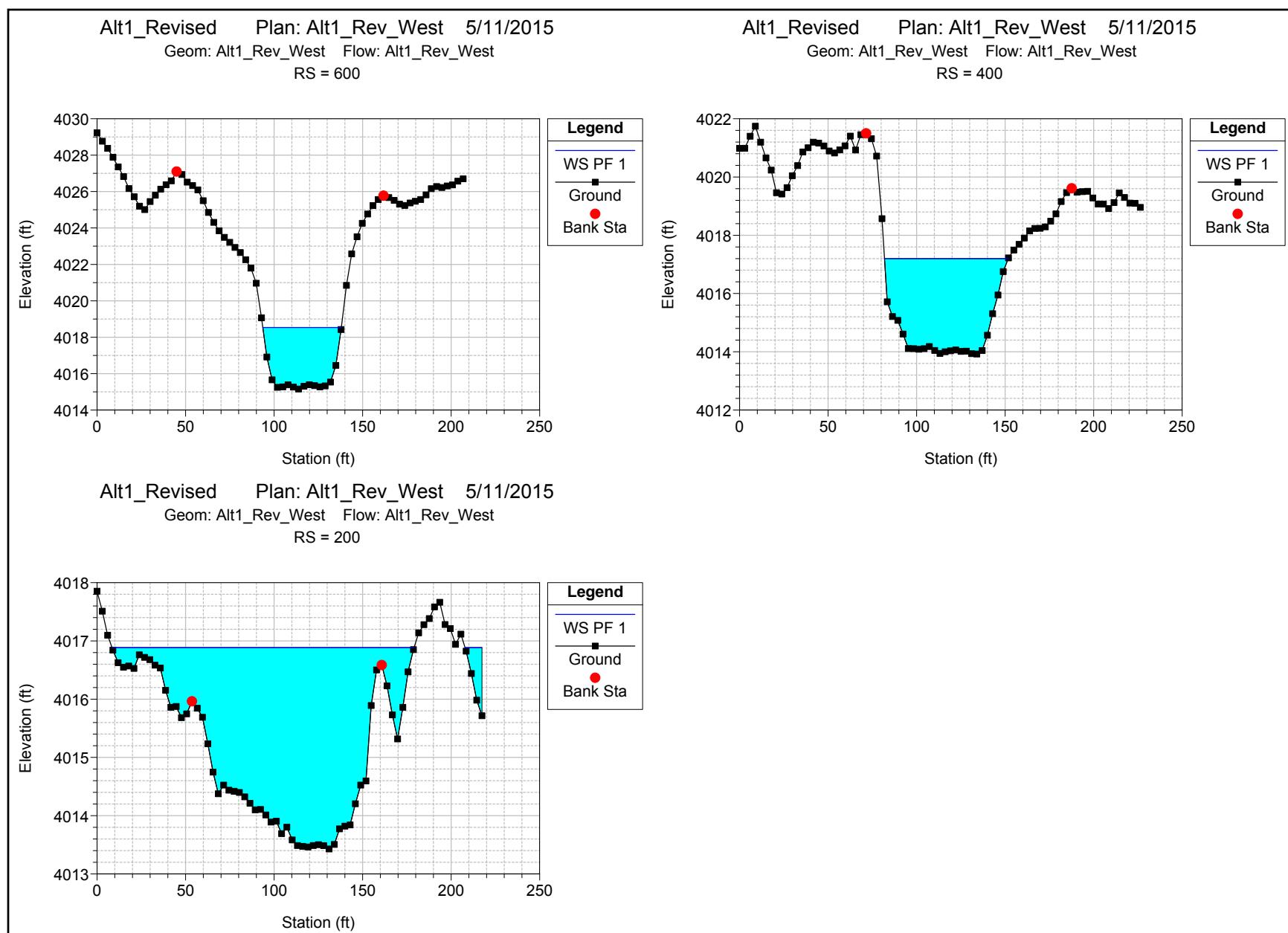


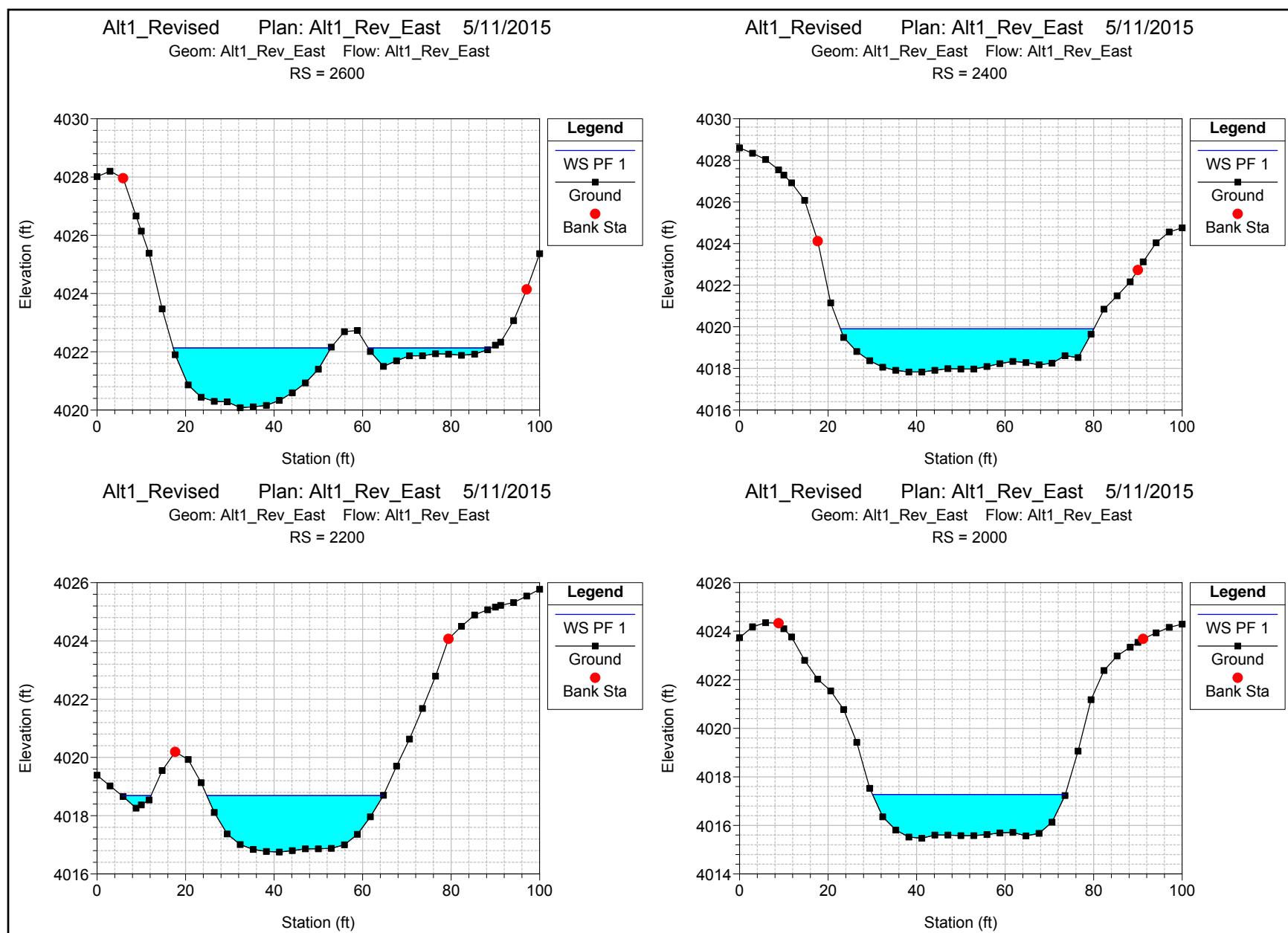


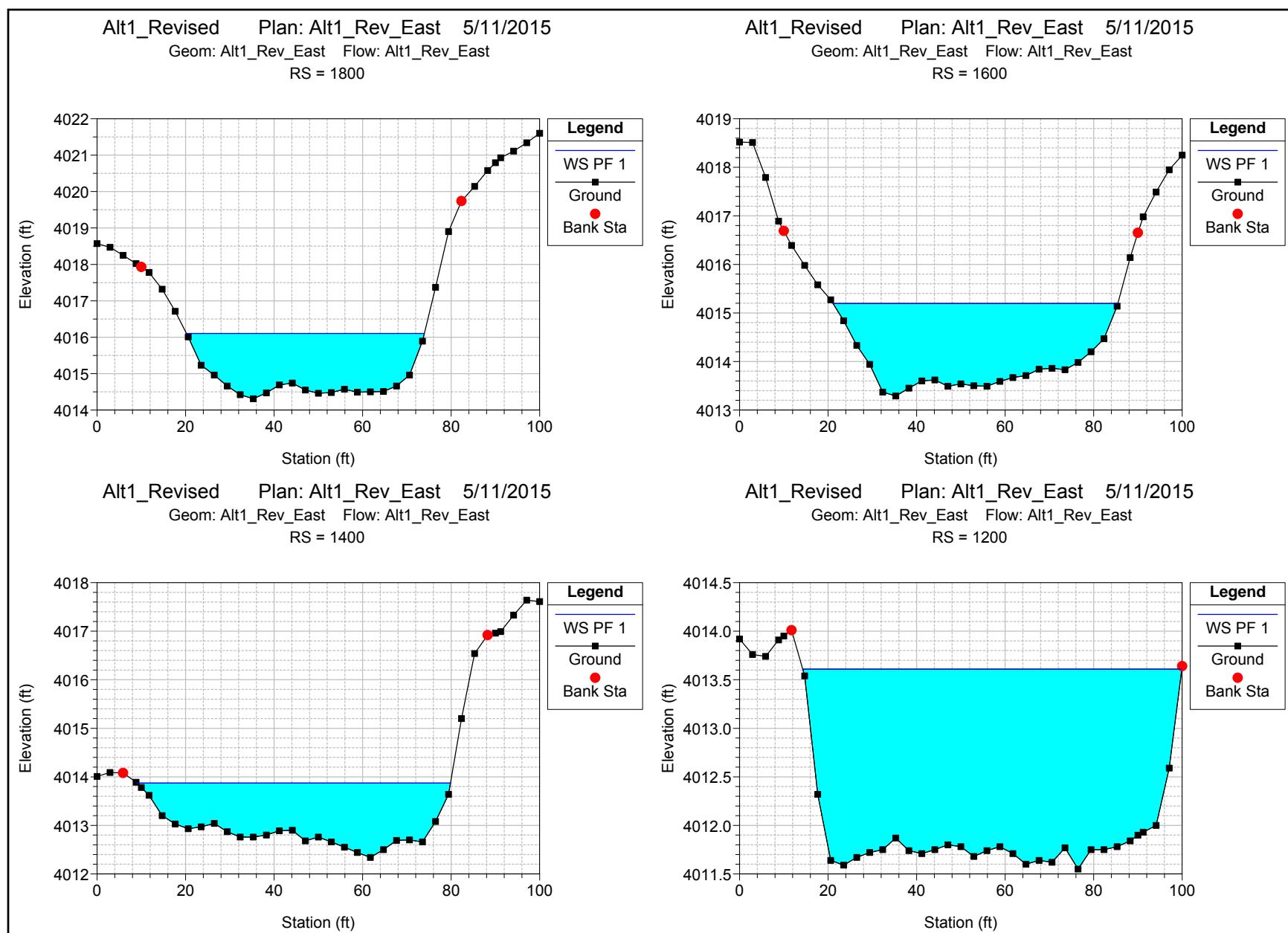


Reach	Plan	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Alt1_Rev_West	Alt1_Rev_West	1400	PF 1	1200	4019.49	4024.0	4024.0	4025.7	10.47	114.62	34.01	1.00
Alt1_Rev_West	Alt1_Rev_West	1200	PF 1	1200	4017.09	4021.3	4021.3	4023.1	10.73	111.86	31.34	1.00
Alt1_Rev_West	Alt1_Rev_West	1000	PF 1	1200	4016.23	4020.7		4021.5	7.08	169.53	50.31	0.68
Alt1_Rev_West	Alt1_Rev_West	800	PF 1	1200	4015.16	4020.3		4020.8	5.74	209.09	49.29	0.49
Alt1_Rev_West	Alt1_Rev_West	600	PF 1	1200	4015.16	4018.5	4018.5	4020.0	9.58	125.20	44.34	1.01
Alt1_Rev_West	Alt1_Rev_West	400	PF 1	1200	4013.92	4017.2		4017.9	6.57	182.77	69.89	0.72
Alt1_Rev_West	Alt1_Rev_West	200	PF 1	1200	4013.43	4016.9	4015.8	4017.1	4.17	322.31	180.15	0.46
Alt1_Rev_East	Alt1_Rev_East	2600	PF 1	340	4020.08	4022.1	4022.1	4022.6	5.58	60.94	63.30	1.00
Alt1_Rev_East	Alt1_Rev_East	2400	PF 1	340	4017.83	4019.9		4020.1	3.67	92.74	57.23	0.51
Alt1_Rev_East	Alt1_Rev_East	2200	PF 1	340	4016.75	4018.7	4018.5	4019.2	5.67	61.27	46.47	0.82
Alt1_Rev_East	Alt1_Rev_East	2000	PF 1	340	4015.47	4017.3		4017.7	5.30	64.21	43.54	0.77
Alt1_Rev_East	Alt1_Rev_East	1800	PF 1	340	4014.31	4016.1		4016.4	4.57	74.37	53.76	0.69
Alt1_Rev_East	Alt1_Rev_East	1600	PF 1	340	4013.29	4015.2		4015.4	3.92	86.70	64.35	0.60
Alt1_Rev_East	Alt1_Rev_East	1400	PF 1	340	4012.34	4013.9		4014.2	4.75	71.63	70.84	0.83
Alt1_Rev_East	Alt1_Rev_East	1200	PF 1	340	4011.55	4013.6	4012.6	4013.7	2.27	150.04	85.64	0.30









**APPENDIX 5
CHANNEL CAPACITY CALCULATIONS**

Cross Section for Trapezoidal Channel - 0.1% Longitudinal Slope

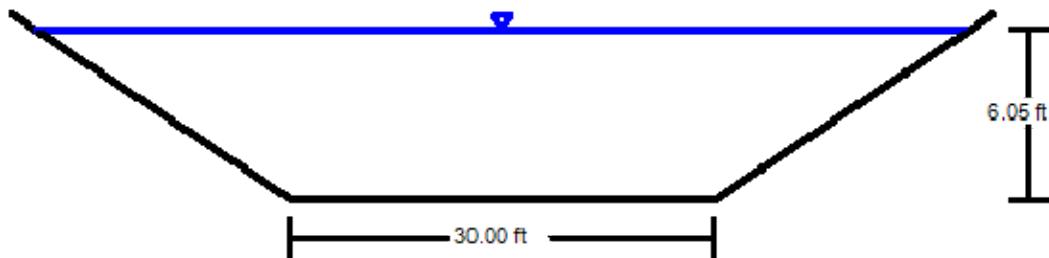
Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.10000 %
Normal Depth	6.05 ft
Left Side Slope	3.00 ft/ft (H:V)
Right Side Slope	3.00 ft/ft (H:V)
Bottom Width	30.00 ft
Discharge	1200.00 ft³/s

Cross Section Image



V: 2 H: 1

Trapezoidal Channel - 0.1% Longitudinal Slope

Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.10000 %
Left Side Slope	3.00 ft/ft (H:V)
Right Side Slope	3.00 ft/ft (H:V)
Bottom Width	30.00 ft
Discharge	1200.00 ft³/s

Results

Normal Depth	6.05 ft
Flow Area	291.23 ft²
Wetted Perimeter	68.26 ft
Hydraulic Radius	4.27 ft
Top Width	66.29 ft
Critical Depth	3.28 ft
Critical Slope	0.00978 ft/ft
Velocity	4.12 ft/s
Velocity Head	0.26 ft
Specific Energy	6.31 ft
Froude Number	0.35
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	6.05 ft
Critical Depth	3.28 ft
Channel Slope	0.10000 %

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Trapezoidal Channel - 0.1% Longitudinal Slope

GVF Output Data

Critical Slope

0.00978 ft/ft

Cross Section for Copy of Trapezoidal Channel - 0.2% Longitudinal

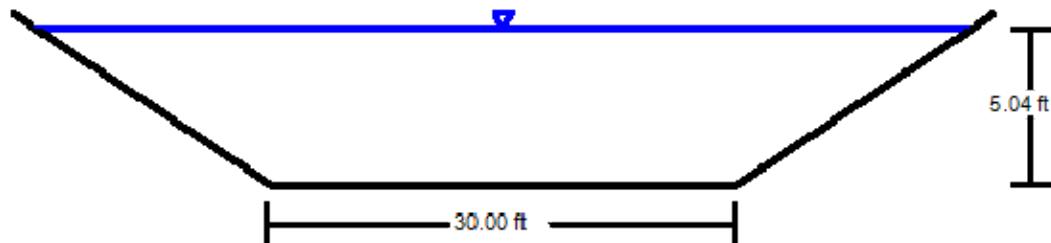
Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.20000 %
Normal Depth	5.04 ft
Left Side Slope	3.00 ft/ft (H:V)
Right Side Slope	3.00 ft/ft (H:V)
Bottom Width	30.00 ft
Discharge	1200.00 ft³/s

Cross Section Image



V: 2 H: 1

Trapezoidal Channel - 0.2% Longitudinal Slope

Project Description

Friction Method Manning Formula

Solve For Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.20000 %
Left Side Slope	3.00 ft/ft (H:V)
Right Side Slope	3.00 ft/ft (H:V)
Bottom Width	30.00 ft
Discharge	1200.00 ft³/s

Results

Normal Depth	5.04 ft
Flow Area	227.46 ft²
Wetted Perimeter	61.88 ft
Hydraulic Radius	3.68 ft
Top Width	60.25 ft
Critical Depth	3.28 ft
Critical Slope	0.00978 ft/ft
Velocity	5.28 ft/s
Velocity Head	0.43 ft
Specific Energy	5.47 ft
Froude Number	0.48
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	5.04 ft
Critical Depth	3.28 ft
Channel Slope	0.20000 %

R.O. Anderson Engineering, Inc.

Trapezoidal Channel - 0.2% Longitudinal Slope

GVF Output Data

Critical Slope	0.00978 ft/ft
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Cross Section for Trapezoidal Channel - 0.3% Longitudinal Slope

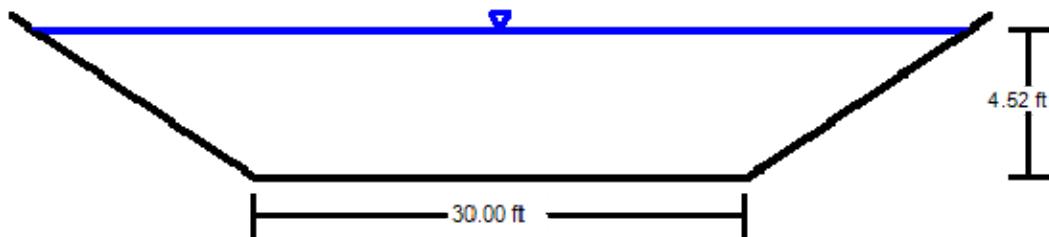
Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.30000 %
Normal Depth	4.52 ft
Left Side Slope	3.00 ft/ft (H:V)
Right Side Slope	3.00 ft/ft (H:V)
Bottom Width	30.00 ft
Discharge	1200.00 ft³/s

Cross Section Image



V: 2 H: 1

Trapezoidal Channel - 0.3% Longitudinal Slope

Project Description

Friction Method Manning Formula
Solve For Normal Depth

Input Data

Roughness Coefficient	0.030
Channel Slope	0.30000 %
Left Side Slope	3.00 ft/ft (H:V)
Right Side Slope	3.00 ft/ft (H:V)
Bottom Width	30.00 ft
Discharge	1200.00 ft³/s

Results

Normal Depth	4.52 ft
Flow Area	197.07 ft²
Wetted Perimeter	58.61 ft
Hydraulic Radius	3.36 ft
Top Width	57.14 ft
Critical Depth	3.28 ft
Critical Slope	0.00978 ft/ft
Velocity	6.09 ft/s
Velocity Head	0.58 ft
Specific Energy	5.10 ft
Froude Number	0.58
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.00 ft
Length	0.00 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.00 ft
Profile Description	
Profile Headloss	0.00 ft
Downstream Velocity	Infinity ft/s
Upstream Velocity	Infinity ft/s
Normal Depth	4.52 ft
Critical Depth	3.28 ft
Channel Slope	0.30000 %

R.O. Anderson Engineering, Inc.

Trapezoidal Channel - 0.3% Longitudinal Slope

GVF Output Data

Critical Slope	0.00978 ft/ft
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