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ENGINEER | PLAN | SURVEY | MANAGE

HORSESHOE DRAW FLOOD CONTROL, RESTORATION AND EROSION MITIGATION STUDY AND DESIGN PROJECT

VOLUME 6
FINAL DESIGN REPORT

COCHISE COUNTY, ARIZONA

Prepared for:

Hereford Natural Resource Conservation District
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January, 2017
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VOLUME 6
FINAL DESIGN REPORT

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1. INTRODUCTION

1.1. PROJECT DESRIPTION

This study has been prepared for the Hereford Natural Resource Conservation District (NRCD), who has identified the need for a project which will significantly reduce flooding, erosion and soil loss, as well as road and property damage in and adjacent to the ephemeral Horseshoe Draw (the Project). In order to complete such a project, the Hereford NRCD was awarded a grant from the Arizona Department of Water Resources (ADWR) through the Arizona Water Protection Fund Program. In turn, HILGARTWILSON has been contracted under the Water Protection Fund grant for professional engineering services.

1.2. LOCATION

The study area spans the border between the United States and Mexico roughly 7 miles west of Naco, Arizona/Sonora. The section of the study area located in the US lies within Township 24 South, Range 22 East of the Gila and Salt River Base and Meridian within the Upper San Pedro Basin in Cochise County, Arizona. The watershed of the Project originates in the Sierra San Jose mountains in Mexico and extends to the confluence of Horseshoe Draw and the San Pedro River, located just south of Highway 92. The Project's location is highlighted in Figure 1 (Vicinity Map) of Appendix A.

1.3. PURPOSE

The purpose of this report is to detail the proposed hydrologic and hydraulic conditions, as well as estimates for the sediment transport and groundwater recharge potential of various storm events to include the impoundment structure and basin design alternative selected in the *Volume 5, Remedial Design Alternatives Feasibility Study* (Volume 5) (HILGARTWILSON 2016). Previous reports submitted to the NRCD including; *Volume 1, Existing Conditions Hydrologic Study* (Volume 1) (HILGARTWILSON 2015a); *Volume 2, Existing Conditions Hydraulic Report* (Volume 2) (HILGARTWILSON 2015b); *Volume 3, Existing Conditions Sediment Transport Analysis* (Volume 3) (HILGARTWILSON 2015c); and *Volume 4, Existing Conditions Recharge Potential Analysis* (Volume 4) (HILGARTWILSON 2015d) are used as the baseline of comparison for the proposed hydrologic and hydraulic conditions, sediment transport, and groundwater recharge potential of the proposed embankment. This report shows that the impoundment structure effectively slows the rate of discharge to downstream waters by detaining surface water runoff and subsequently, increases groundwater recharge to the aquifer located within the Upper San Pedro Basin for typical, more regular storm events up to and including the theoretical 10-year design storm. Regulatory constraints which limit the practicable design capacity of the project also limit its effect in reducing flows for the larger, more extraordinary storm events.

1.4. REMEDIAL ALTERNATIVE SELECTION

Various alternatives were considered based on the effectiveness of remedial objectives (RO's) identified which would reduce road and property damage near

Horseshoe Draw by limiting flooding, erosion, and soil loss on the watershed resulting in sediment flows into the San Pedro River and increase groundwater recharge by slowing the rate of discharge to downstream waters. A combination embankment with an excavated detention basin below the downstream toe of the embankment was selected as the remedial alternative for the Project. The alternative of the embankment and detention basin was selected based on the effectiveness to reduce flooding and erosion during smaller storm events, limited regulatory requirements, modest construction efforts, and lower costs. Further justification for the alternative selection can be found in Volume 5.

2. HYDROLIGIC AND HYDRAULIC DESIGN BASIS

As discussed above, Volumes 1-4 have been prepared for the NRCD, detailing the hydrologic and hydraulic conditions, as well as estimates for the sediment transport and recharge potential of various storm events for the existing conditions. HEC-HMS (hydrologic) and HEC-RAS (hydraulic) models from previous reports, which were validated using various methods for comparison, have been updated to reflect the proposed embankment. An overview of the methodology for each analysis is described below. Specific methodology can be referenced from previous reports. Unless otherwise noted, parameters discussed below remained consistent between existing and proposed conditions models.

2.1. HYDROLOGIC MODELING METHOD DESCRIPTION

HEC-HMS Version 4.0 was used to model the hydrologic conditions of the Project. General parameters and input used in the analysis are discussed below.

2.1.1. WATERSHED DESCRIPTION

As mentioned above, the study area of the watershed for Horseshoe Draw extends from the Sierra San Jose Mountains in Sonora Mexico to Paloma Trail near the San Pedro River. The watershed was divided into 21 different sub basins. Sub basins were divided according to points of interest within the overall watershed, such as, junctions of the various wash branches. They were also separated at mountainous and low lying areas and were divided to be similar in area and flow path length.

Data for the delineation of the drainage sub basins was obtained from 2 sources. The first source was a flown topographical survey performed by Kenny Aerial Mapping in October, 2014. The second was a surface and corresponding image obtained from Google Earth. These sub basin boundaries are shown in the Hydrology Exhibit - Figure 2, Appendix A.

2.1.2. RAINFALL DATA

Site specific rainfall data for the Project was obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Hydrometeorological Design Studies Center. The 100-year, 6-hour and 100-year, 24-hour precipitation depths were originally used to compute peak flow rates in the HEC-HMS model. It was determined in Volume 2 that the 6-hour storm event produced the greatest amount of stormwater runoff and was therefore used as the design storm event. Precipitation values were entered into the HEC-HMS model at five minute intervals in order to match the time interval at which hydrograph values were calculated.

2.1.3. SOILS

Soil data and classifications for the site were gathered from the Natural Resources Conservation Services (NRCS) soil survey. The soil classifications found within the custom soil report for the area were used in in the HEC-HMS model while estimating infiltration losses. Further details regarding the soil near the Project can be found in Volume 1.

2.1.4. LOSS METHODS

Rainfall losses are a result of natural infiltration and surface retention. In the HEC-HMS modeling program, the SCS Curve Number loss method was used to estimate infiltration losses and determine sub basin runoff. The SCS Curve Number method is based off of several variables such as; soil type, hydraulic conductivity, vegetation type and coverage, and the time of concentration within each sub basin. Further details regarding SCS Curve Numbers used can be found in *Volume 1*.

A percolation rate of 6.1 cfs/acre was used in the groundwater recharge portion of the analysis comparing losses with and without infiltration. Justification for the percolation rate can be found in *Volume 3*.

2.1.5. TRANSFORM METHOD

The actual surface runoff calculations within the HEC-HMS model are performed by a transform method contained within the sub basin. The "Snyder Unit Hydrograph" transform method has been utilized while modeling runoff from the sub basins within the Horseshoe Draw watershed. The Snyder Unit Hydrograph transform method requires the user to enter two parameters into the model; these are the standard lag time and the peaking factor. Further discussion of the lag time and peaking factor can be found in Volume 1.

2.1.6. REACH ROUTING

Routing of hydrograph flows was modeled using the Lag routing method for all reaches in HEC-HMS with the exception of the groundwater recharge potential analysis. The Muskingum-Cunge method was used for the main wash of the hydrologic model in order to use percolation as an input parameter to estimate the amount of groundwater recharge occurring within the main channel of Horseshoe Draw. Further discussion of the routing and percolation can be found in Volume 4.

2.2. HYDRAULIC MODELING METHOD DESCRIPTION

Hydraulic analysis for this study was performed utilizing HEC-RAS version 4.1.0. General parameters and input for the analysis are discussed below.

2.2.1. VERTICAL DATUM

Cross sections within the model were exported from a digital terrain model (DTM) from AutoCAD Civil 3D. The DTM was built based on a topographic aerial survey performed by Kenny Aerial Mapping, Inc. in October, 2014. The aerial mapping contains detailed topography at 2-foot intervals using the North American Vertical Datum of 1988 (NAVD 88). A hydraulic exhibit has been included as Figure 3 of Appendix A, detailing the HEC-RAS cross sections and proposed embankment locations.

2.2.2. GENERAL HEC-RAS INPUT

Manning's roughness coefficients for Horseshoe Draw were estimated to be 0.030 and 0.035 for the channel and overbank areas respectively. The HEC-RAS expansion and contraction coefficients were assumed to be 0.1 and 0.3.

The most upstream and downstream cross sections were cut as closely as possible to the limits of the updated topography along horseshoe draw as to encompass the largest reach possible to be used in the future hydraulic design of the impoundment structure.

The hydraulic analysis focuses on the main wash of Horseshoe draw while taking into consideration the lateral inflows from the wash tributaries. The flow rates from these tributaries were also determined in the hydrologic study detailed in Volume 1. Flow changes have been added to cross sections directly downstream of these tributaries in order to reflect these conditions.

Many of the cross sections within the model span both the main channel of Horseshoe Draw as well as various tributaries. Consequently, these cross sections graphically display low points in the main wash as well as the tributaries. The levee option has been used within the model at these sections in order to continue directing flows in the main channel and not allowing flow to be shown in the tributaries. This has the effect of calculating the most conservative water surface elevations within the main channel while also keeping the delineated floodplain uniform rather than inaccurately displaying flow spits where these tributaries intersect the main wash. Further discussion regarding the HEC-RAS analysis can be found in Volume 2.

2.3. SEDIEMENT TRANSPORT ANALYSIS

Parameters required for the sediment transport analysis including upstream and downstream boundary conditions, soil properties and sediment data, the specified particle fall velocity method, and the specified sediment transport function which are discussed in detail in Volume 3.

The proposed conditions hydraulic model of the impoundment structure required the main reach to be spilt into two distinct models within HEC-RAS due to software limitations. Sediment transport in HEC-RAS requires a quasi-unsteady state simulation which subsequently does not allow flow reductions within the reach. Therefore, the reach was separated into two, split at the embankment location where the flow reduction occurs. The program does allow for an upstream mass loading boundary condition to be specified. Sediment loading at incremental time steps, copied from the upstream reaches last cross section, was entered in the downstream sediment data's upstream boundary condition.

2.4. GROUNDWATER RECHARGE ANALYSIS

The estimated increased volume of infiltration that may be observed within the main channel was calculated in HEC-HMS utilizing the percolation loss parameter function as mentioned in Section 2.1.4.

Identical to the analysis performed in Volume 4, the 2-year, 10-year, 25-year, 50-year, and 100-year storm events were modeled in HEC-HMS under two different scenarios; 1) without percolation losses which serves as a baseline for the analysis and 2) with percolation losses. The difference between the two flow hydrographs is then used to calculate the total recharge volume into the aquifer. The proposed results are then compared to the existing conditions infiltration results.

3. GEOTECHNICAL EVALUATION

Geotechnical analysis for the Project was prepared by Ninyo & Moore, in a report dated October 30, 2015 Geotechnical Evaluation, Horseshoe Draw Basin (Ninyo & Moore 2015). The purpose of the geotechnical evaluation was to assess the subsurface conditions at the project site in order to provide soil specification data to be used the sediment transport analysis as well as providing geotechnical recommendations for design and construction of the impoundment structure. The geotechnical evaluation included soil borings, shallow field infiltration tests, and laboratory testing evaluating the soil properties such as; moisture content, dry density, gradation, and Atterberg limits. The geotechnical report concluded the following:

- The near surface soils encountered at the project site are considered to be excavatable with conventional earth moving or excavation equipment. However, gravel, cobbles and possible boulders were encountered in borings at variable depths, resulting in slower excavation rates. The contractor should plan for such conditions.
- Based on the results of the field and laboratory evaluations, the proposed embankments can be founded on native soil deposits, subject to subgrade over excavation.
- It is anticipated that many of the site soils will be suitable for re-use as engineered fill. Imported and onsite soils that exhibit a relatively low plasticity and a very low to low expansive potential can generally be used for engineered fill. However, some isolated soils many not be suitable for reuse for the embankment construction without processing.
- It is estimated that native soils will have a shrinkage factor of 15 to 20 percent.

Further details regarding the recommended embankment material composition, foundation, and geometry can be found in the pertinent geotechnical report excerpts included as Appendix B.

4. EMBANKMENT AND DETENTION BASIN DESIGN

Construction documents detailing the physical description of the proposed embankment can be found in Appendix C. The general embankment layout can be seen in Figure 4 of Appendix A.

Table 1: Horseshoe Draw Basin and Embankment Data

Type of structure	Non-jurisdictional earthen embankment
Height of embankment above downstream toe	5.5 ft
Height of embankment above upstream basin	22 ft
Embankment slopes	6H:1V
Downstream Toe Elevation	4357.5 ft
Dead storage volume (below downstream ground surface)	61 ac-ft (20 million gallons)
Live storage volume (above downstream ground surface)	59 ac-ft (19 million gallons)
Top of dead storage basin elevation	4,363 ft
Primary Outlet	
Pipe	3-36" Coated CMP
Invert elevation	4,350 ft
Emergency Outlet	
Crest elevation	4,363 ft
Bottom Width	40 ft
Depth	9 ft
Side Slopes	2:1
Freeboard during 100-year design storm	1 ft
Maximum flow capacity	6,160 cfs

Storm Event	Peak Storage (ac-ft)	Inlfow (cfs)	Outflow (cfs)	Percent Reduction	Dewatering Duration (hrs)
2-Year	148	1,155	613	47%	10.6
10-Year	180	2,369	2,222	6%	11.6
25-Year	195	3,256	3,178	2%	11.9
50-Year	207	4,003	3,940	-	12.0
100-Year	217	4,821	4,781	-	12.2

4.1. EMBANKMENT CLASSIFICATION

The embankment will be classified as a non-jurisdictional structure as it does not meet the Arizona Department of Water Resources' (ADWR) definition of a jurisdictional dam being less than 6 feet high of the downstream toe. The basin will completely empty well under 24-hours exempting the embankment from water rights issues with ADWR. This structure is also exempt from Arizona Revised Statutes A.R.S 45-2631, prohibiting the construction or enlargement of new dams within the Gila River Maintenance Area as it is a flood control structure (B.1.a.) and therefore, the statute is not applicable.

As the site will be completely dry under normal operating conditions, implementation of a sand filter is recommended which is often utilized in the construction of embankments to prevent cracking and desiccation. However, it is understandable that due to the high cost associated with the construction of the embankment with a sand filter, the option is not feasible. Therefore, inspections and regular maintenance should be conducted to ensure the embankment functions as designed.

4.2. HYDRAULIC DESIGN

4.2.1. DETENTION BASIN

Stormwater is routed into the detention basin through a graded inlet approximately 700 feet upstream of the embankment. The opening, modeled as a 40-foot wide bottom width channel with 2:1 side slopes, has been dimensioned to accommodate 100-year peak flows. The basin emergency outlet has been modeled with an identical configuration. Toe protection provided at the inlet and outlet, have been sized based on methodology described in the Flood Control District of Maricopa County (FCDMC) Drainage Design Manual, Hydraulics (FCDMC 2013). The channel and scour protection calculations can be found in Appendix D.

4.2.2. EMBANKMENT OUTLETS

An elevation-storage-discharge relationship was required to determine how the main wash of Horseshoe Draw would function with the proposed embankment which included the storage component, primary culvert outlet, and the emergency outlet.

Various configurations of pipe quantities and sizes were considered to determine the inflow and outflow of the primary and emergency outlets for the given design storm events. Storage volumes at various elevations were determined within AutoCAD Civil 3D.

The 1987 Unites States Bureau of Reclamations' (USBR) Design of Small Dams (USBR 1987) was referenced to calculate the culvert spillway storage and discharge relationship for varying water surface elevations contained within the embankment using the equation below:

$$\frac{H}{D}+\frac{L}{D}\sin\theta-1.0=0.0252\left(1+K_e+\frac{29.1n^2L}{r^{4/3}}\right)\left(\frac{Q}{D^{5/2}}\right)^2 \qquad \text{USBR Eq. 33}$$

where:

H = hydraulic depth behind embankment to pipe invert (ft)

D = pipe diameter (ft)

L = pipe length (ft)

Θ = angle of pipe from upstream to downstream inverts (radians)

K_e = entrance loss coefficient

r = pipe inlet radius (squared or rounded) (ft)

Q = pipe discharge (cfs)

Rearranging and solving for Q yields:

$$Q = D^{5/2}\left[\frac{\left(\frac{H}{D}+\frac{L}{D}\sin\theta-1.0\right)}{0.0252\left(1+K_e+\frac{29.1n^2L}{r^{4/3}}\right)}\right]^{1/2}$$

The embankments emergency spillway was sized using the channel flow calculation within Hydraflow. As previously mentioned, the emergency outlet was sized similar to the inlet with a 40-foot wide bottom width, 9-feet deep, including one foot of freeboard. The outflow capacity of the spillway with freeboard is approximately 6,160 cfs and completely full, without freeboard, is 7,650 cfs. Supporting calculations for the elevation-storage-discharge relationship, inlet channel, and outlet channel can be found in Appendix D.

4.2.3. OUTLET ENERGY DISSIPATION

A riprap apron has been sized downstream of the primary culvert outlet to protect against scour, provide uniform spreading of flows, and decrease flow velocities. The apron was designed to accommodate calculated flows using a free outfall tail water condition, based on Figure 12-2 and Figure 12-3 in the 2003 Municipal Storm Water Management Manual, Second Edition by Debo and Reese.

Larger flows exiting the basin will be slowed within a 400-foot long channel corridor with a bottom width of 100-feet and a mild longitudinal slope of 0.1%. Flows exiting the corridor will be approximately 5 fps. The outlet channel Hydraflow calculation is included in Appendix D. Monitoring of the condition and performance of the toe of the inlet and embankment outlet will be critical in order to identify and repair erosional damage after storm events to ensure the basin and embankment continue to operate as designed.

5. RESULTS COMPARISON

Results comparing existing and proposed conditions of flows, sediment transport, and groundwater recharge potential for the main wash of Horseshoe Draw were performed and are summarized in the following sections.

5.1. HYDROLOGIC

As detailed in Table 1, the embankment is effective in reducing flows downstream of the structure for the 2-year and 10-year storm events but has little impact on the larger storms. A 47% reduction in flow is observed for the 2-year storm reducing the peak flow by approximately 550 cfs. Conversely, the 100-year storm reduction in flows is less than 1% as the majority of the runoff is bypassed through the emergency spillway. HEC-HMS output of the proposed conditions and comparison tables can be found in Appendix E.

5.2. SEDIMENT TRANSPORT

As discussed in Section 2.2.3, the sediment transport model for proposed conditions required dividing the wash into two separate models in order to account for the flow reduction from the embankment. Model results indicate that there is a reduction of sediment transport for all storm events shown in Table 2 below. Proposed conditions HEC-RAS output and results comparison tables can be found in Appendix F.

Table 2: Sediment Transport Comparison at Reach Outlet

Storm Event	Mass [tons]		
	Existing	Proposed	Sediment Reduction
2-Year	43,358	42,364	994
10-Year	90,528	68,590	21,938
25-Year	115,038	85,689	29,349
50-Year	129,804	97,032	32,772
100-Year	144,882	114,646	30,236

Based on the modeling methodology required for the proposed conditions, the results may be a poor indicator of the actual sediment transport reduction for the given storm events. Further study may be needed to adequately quantify the sediment transport downstream of the embankment. However, qualitatively, there is a direct correlation between flow and sediment transport. The reduced flows determined in the comparative hydrologic analysis indicate that there would also be a reduction in sediment transport. It can be anticipated that the sediment carried downstream will be reduced most significantly for the 2-year and 10-year storms as it shows the greatest flow reductions calculated. It would be expected that larger storm events resulting in larger peak flows would have similar quantities of sediment transported downstream.

5.3. GROUNDWATER RECHARGE POTENTIAL

HEC-HMS model results which included infiltration losses based on the estimated percolation rates observed at the site were compared for existing and proposed conditions. Results of the comparison can be seen in Table 3 below.

Table 3: Groundwater Recharge Potential Comparison			
Storm Event	Volume [acre-feet]		
	Existing	Proposed	Infiltration Increase
2-Year	243	423	180
10-Year	327	538	211
25-Year	368	594	226
50-Year	402	642	240
100-Year	480	722	242

Model results show that for the given storm events, there are considerable increases in the volumes of beneficial infiltration for the main reach of Horseshoe Draw. Proposed conditions HEC-HMS results and comparison tables can be found in Appendix G.

6. CONCLUSION

The Project will be subject to limited state, county, and federal review and regulations. As mentioned previously in Section 4.1, the impoundment structure will be classified as a non-jurisdictional structure as it does not meet the Arizona Department of Water Resources' (ADWR) definition of a jurisdictional dam being less than 6 feet high from the downstream toe. Because the impoundment structure is not considered jurisdictional, it will be exempt from a detailed ADWR review. Water retained by the basin will drain within 24-hours, exempting the impoundment structure from water rights issues with ADWR as well. Therefore, a permit to appropriate surface waters of the state will not be required. A comprehensive, supplementary report detailing the permits and agreements required to ensure compliance with all applicable local, state, and federal requirements has been included as Appendix H. The permitting and compliance report is also being submitted as a stand-alone document.

This study has been prepared in order to provide justification for the construction of an embankment and detention basin comparing existing and proposed conditions with respect to hydrologic and hydraulic analyses demonstrating resultant reduced flows, reduced sediment transport, and increased infiltration to help meet the Project RO's, especially for the smaller 2- and 10-year storm events. This report has also detailed the selected design features of the embankment and detention basin.

7. REFERENCES

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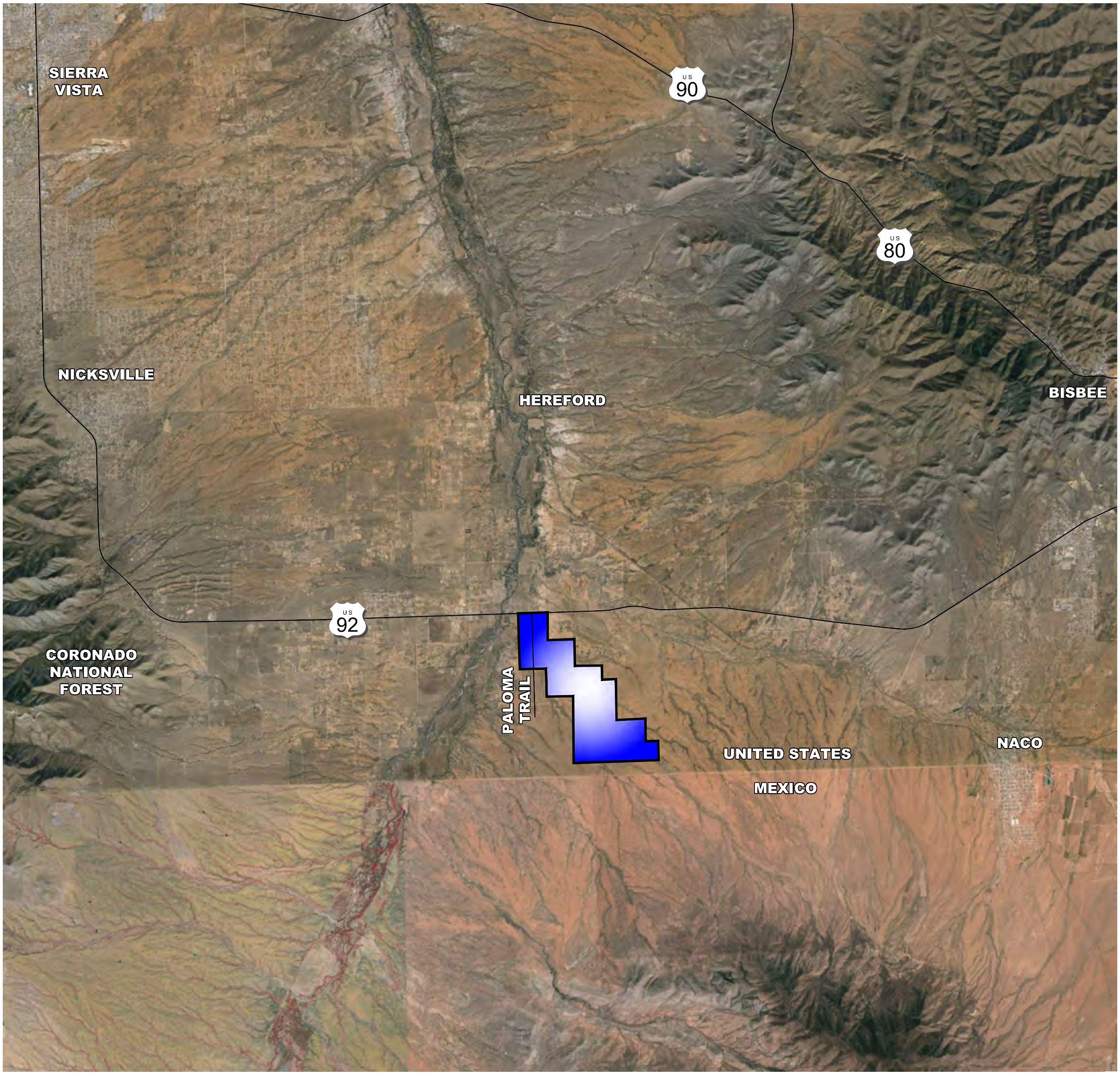
APPENDIX A
FIGURES



LEGEND

PROJECT LOCATION

N

PROJ.NO.:	1472
DATE:	MAR. 2016
SCALE:	1"=15,000'
DRAWN BY:	JPG
CHECKED BY:	AT

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

FIG 1: VICINITY MAP

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U:\1400\1472\REPORTS\DRAINAGE\Exhibits\1472 FIG 1 – Vicinity Map 15-1002.dwg 3/31/2016 1:49 PM

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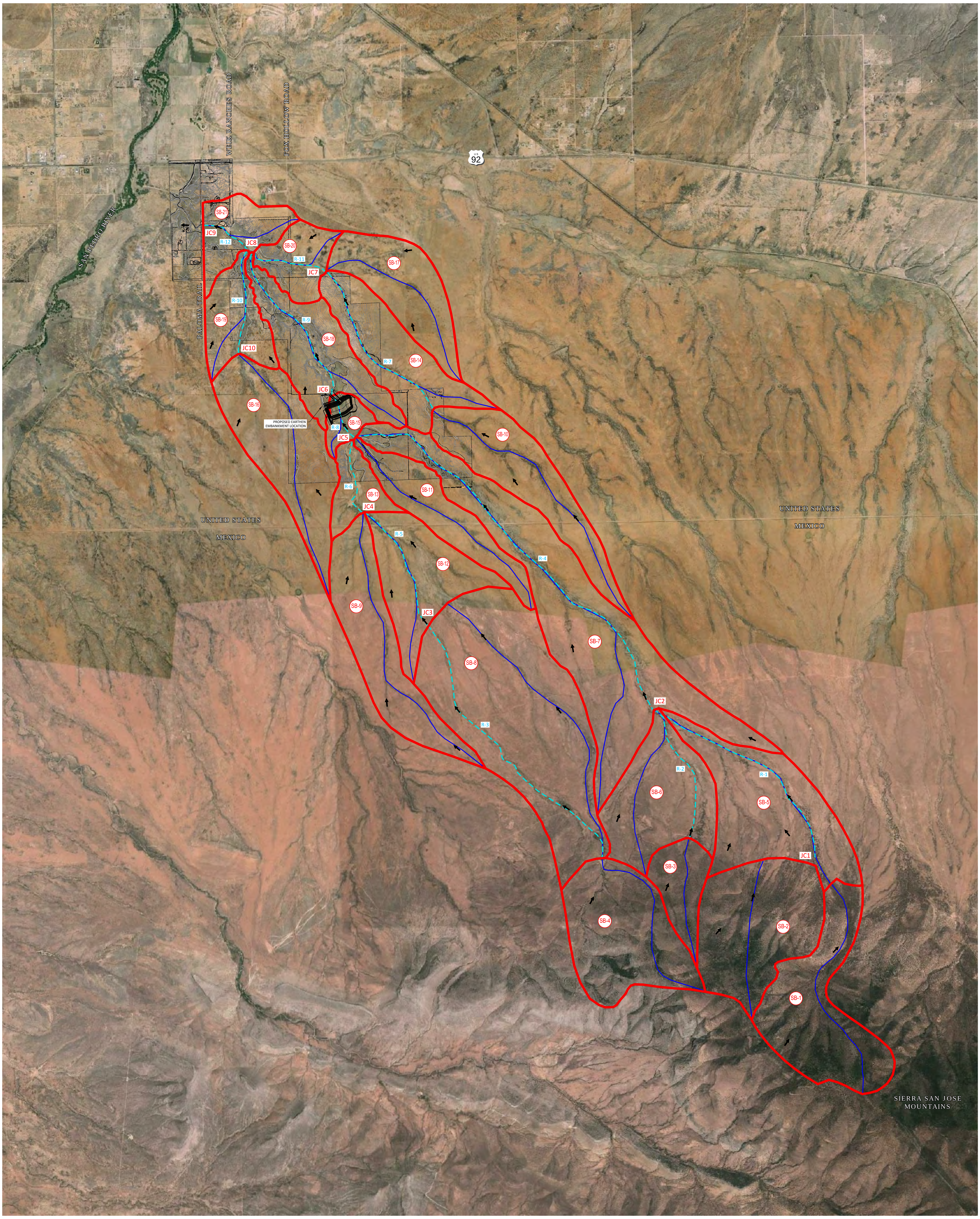

LEGEND

SUB BASIN BOUNDARY	
SUB BASIN LABEL	SB-4
LONGEST FLOW PATH	
ROUTING	R-11
FLOW ARROW	→
JUNCTION	JC7

N

2000 1000 0 2000 4000
SCALE FEET

HILGARTWILSON

PROJ NO.: 1472
DATE: DEC. 2016
SCALE: 1" = 2000'
DRAWN: HW
DESIGNED: HW
APPROVED: AT

DWG. NO.

SHT OF

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

FIG 2: HYDROLOGY HEC-HMS EXHIBIT

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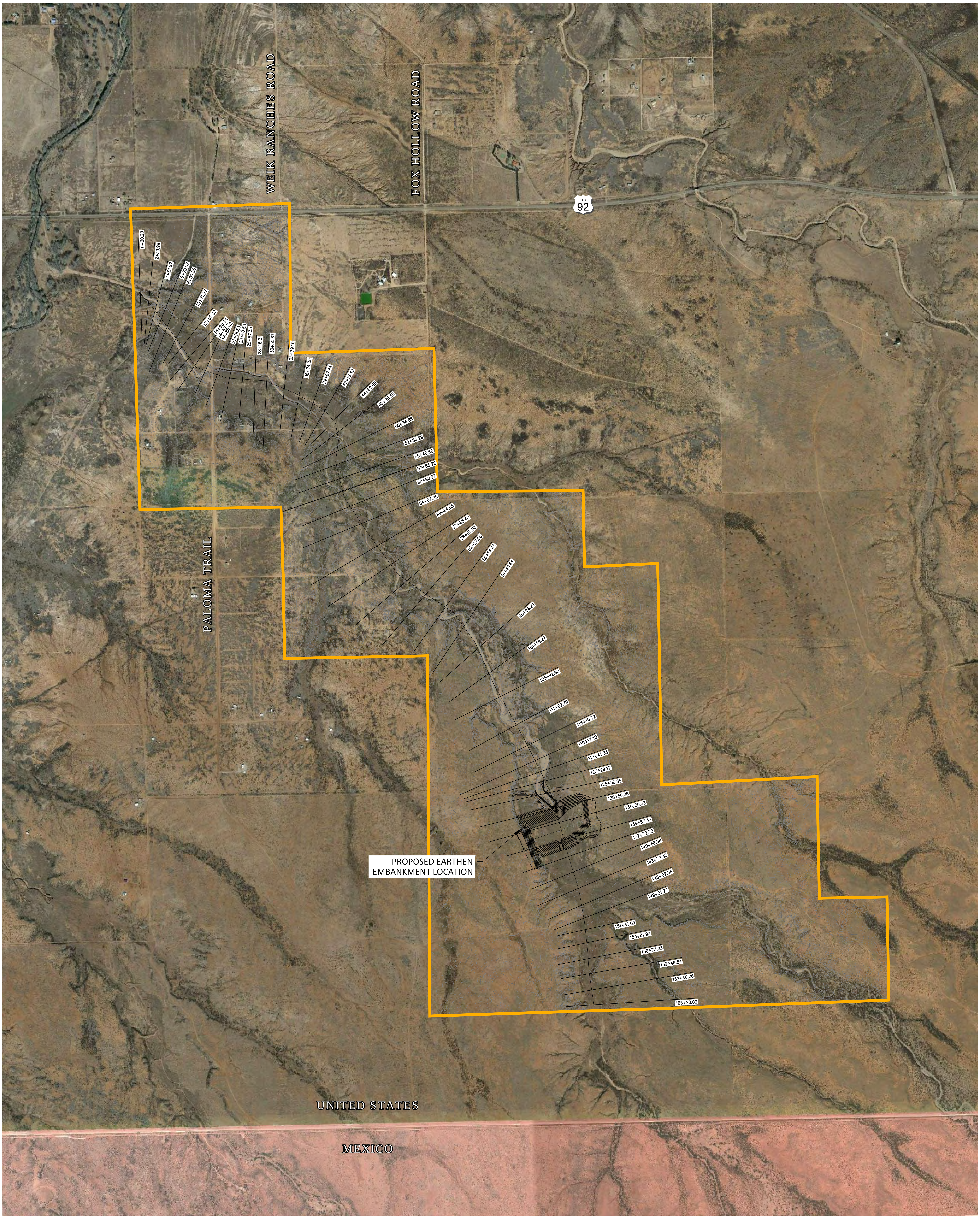

LEGEND

PROJECT BOUNDARY

N

800 400 0 800 1600
SCALE FEET

HILGARTWILSON

PROJ NO.:	1472
DATE:	OCT. 2016
SCALE:	1" = 800'
DRAWN:	HW
DESIGNED:	HW
APPROVED:	AT

SHT OF
DWG. NO.

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

FIG 3: HYDRAULIC HEC–RAS EXHIBIT

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COCHISE COUNTY, ARIZONA

FIG 4: EMBANKMENT LAYOUT

REV.:

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U:\1400\1472\REPORTS\DRAINAGE\Exhibits\1472 FIG 4 – Embankment Layout.dwg 12/16/2016 1:25 PM

APPENDIX B

GEOTECHNICAL EVALUATION EXCERPTS

GEOTECHNICAL EVALUATION
HORSESHOE DRAW BASIN
COCHISE COUNTY, ARIZONA

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October 30, 2015
Project No. 604915001

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Figures

Appendices

The soil samples collected from our drilling activities were transported to the Ninyo & Moore laboratory for geotechnical laboratory testing. The testing included in-situ moisture content and dry density, gradation, Atterberg limits, consolidation (response-to-wetting), and corrosivity characteristics (including pH, minimum electrical resistivity, and soluble sulfate and chloride contents). The results of the in-situ moisture content and dry density testing are presented on the excavation logs in Appendix A. A description of each laboratory test method and the remainder of the test results are presented in Appendix B.

In order to assist in obtaining percolation rate information, Ninyo & Moore conducted two shallow percolation tests within the proposed retention basin. The procedures utilized for the percolation test consisted of the insertion of an open-ended, 10-inch diameter casing into undisturbed soil, to a depth of about 5 feet, followed by pre-wetting of the soil. The test continued after the pre-wetting period by refilling the casing and monitoring the drop in water level as a function of time until steady-state conditions were achieved. The test locations are depicted on Figure 2, and the results of the tests are presented in Appendix C.

6. GEOLOGY AND SUBSURFACE CONDITIONS

The following sections describe the geologic conditions at the site.

6.1. Geologic Setting

The project site is located in the Southern San Pedro Valley Section of the Basin and Range physiographic province, which is typified by broad alluvial valleys separated by steep, discontinuous subparallel mountain ranges. The mountain ranges generally trend north-south and northwest-southeast. The basins consist of alluvium with thicknesses extending to several thousands of feet.

The basins and surrounding mountains were formed approximately 10 to 18 million years ago during the mid- to late-Tertiary. Extensional tectonics resulted in the formation of horsts (mountains) and grabens (basins) with vertical displacement along high-angle normal faults. Intermittent volcanic activity also occurred during this time. The surrounding basins filled with alluvium from the erosion of the surrounding mountains, as well as from deposition from rivers. Coarser-grained alluvial material was deposited at the margins of the basins near the mountains. The surface geology of the area is described as Quaternary alluvial fan and channel deposits. These deposits range from unconsolidated to strongly consolidated. The soils consist of sand, silt, clay and gravel (Arizona Bureau of Mines, 1959).

The surficial geology of the site is described as being Holocene-age (up to 100,000 years old) fluvial and alluvial deposits. The Web Soil Survey website by the United States Department of Agriculture Natural Resources Conservation Service indicates that the near-surface soils (upper 5 feet) consist of the Riveroad and Ubik soil complex consisting of loam, silt loam and fine sandy loam. Loam is an agricultural soil classification that refers to a soil comprised of a mixture of clay, silt, and sand.

6.2. Surface and Subsurface Conditions

Our knowledge of the subsurface conditions at the project site is based on our field exploration, laboratory testing, and our general understanding of the geology of the area. The following paragraph provides a generalized description of the materials encountered. More detailed stratigraphic information is presented on the boring logs in Appendix A. The boring logs contain our field and laboratory test results, as well as our interpretation of conditions believed to exist between actual samples retrieved. Therefore, these boring logs contain both factual and interpretive information. Lines delineating subsurface strata on the boring logs are intended to group soils having similar engineering properties and characteristics. They should be considered approximate, as the actual transition between soil types (strata) may be gradual. A key to the soil symbols and terms used on the boring logs is provided in Appendix A.

Alluvium was encountered in our borings, and extended to the boring termination depths. The alluvium generally consisted of loose to very dense clayey and silty sands and firm to hard sandy clays with varying amounts of gravel. Cobbles, boulders, and possible boulders should also be anticipated.

6.3. Groundwater

Groundwater was not encountered in our exploratory borings. Based on well data provided by the Arizona Department of Water Resources (ADWR), groundwater has been historically measured at a depth on the order of 100 feet bgs. However, it should be noted that groundwater levels near the site can fluctuate due to seasonal variations, flows in the Horseshoe Wash, irrigation, groundwater withdrawal or injection, and other factors. In general, groundwater is not expected to be a constraint to project design and construction.

7. GEOLOGIC HAZARDS

The following sections describe potential geologic hazards at the site, including land subsidence and earth fissures, and faulting.

7.1. Land Subsidence and Earth Fissures

Groundwater depletion, due to groundwater pumping, has caused land subsidence and earth fissures in numerous alluvial basins in southern Arizona. It has been estimated that subsidence has affected more than 3,000 square miles and has caused damage to a variety of engineered structures and agricultural land (Schumann and Genualdi, 1986). From 1948 to 1983, excessive groundwater withdrawal has been documented in several alluvial valleys where groundwater levels have been reportedly lowered by up to 500 feet. With such large depletions of groundwater, the alluvium has undergone consolidation resulting in large areas of land subsidence.

In Arizona, earth fissures are generally associated with land subsidence and pose an on-going geologic hazard. Earth fissures generally form near the margins of geomorphic basins where significant amounts of groundwater depletion have occurred. Reportedly, earth fissures have also formed due to tensional stress caused by differential subsidence of the unconsolidated alluvial materials over buried bedrock ridges and irregular bedrock surfaces (Schumann and Genualdi, 1986).

Active areas of ground surface subsidence have not been documented near the study area. Based upon our field reconnaissance and review of the referenced material, there are no known earth-fissures underlying or near the subject area. Therefore, ground subsidence and earth fissures are not expected to be a constraint to the project.

7.2. Faulting and Seismicity

The site lies within the Mexico Basin and Range zone, which is a relatively stable tectonic region located in southwestern Arizona, southeastern California, southern Nevada, and northern Mexico (Euge et al., 1992). This zone is characterized by sparse seismicity and few Quaternary faults. Based on our field observations, review of pertinent geologic data, and analysis of aerial photographs, faults are not located on or adjacent to the property.

The closest fault to the site is the Huachuca fault, located approximately 6 miles north-west of the site (Pearthree, 1996). The Huachuca fault is recognized by a low fault scarp trending north to northwest from near the US-Mexico Border to Arizona SR 90. Detailed surficial geologic mapping and morphologic fault scarp analysis indicate that the youngest fault rupture occurred 100,000 to 200,000 years ago. It is possible that faulting occurred in the early Quaternary as well. The slip-rate category of this fault is less than 0.2 millimeters per year (Pearthree, 1996). Seismic parameters recommended for the design of the proposed improvements are presented in Section 9.2.

8. CONCLUSIONS

Based on the results of our subsurface evaluation, laboratory testing, and data analysis, it is our opinion that the proposed construction is feasible from a geotechnical standpoint, provided that the recommendations of this report are incorporated into the design and construction of the proposed project, as appropriate. Geotechnical considerations include the following:

- In general, the near surface soils encountered at the project site are considered to be excavatable with conventional earth moving or excavation equipment in good working condition. However, gravel, cobbles, and possible boulders were encountered in our borings at variable depths and will result in slower excavation rates. The contractor should plan for such conditions.

- Based on the results of the field and laboratory evaluations, it is our opinion that the proposed embankments can be founded on native soil deposits, subject to the subgrade overexcavation.

- We anticipate that many of the site soils will be suitable for re-use as engineered fill. Imported and onsite soils that exhibit a relatively low plasticity and a very low to low expansive potential can generally be used for engineered fill. However, some isolated soils may not be suitable for reuse for the dam embankment construction without processing.

- We estimate an earthwork (shrinkage) factor of 15 to 25 percent for the native soils on this project. This estimate is based on the results of the in-situ dry density testing and an assumed maximum density.

- No known or reported geologic hazards are reported underlying, or immediately adjacent to, the site.

- Groundwater was not observed in our borings. Based on ADWR well data, the regional groundwater table has been historically measured at a depth on the order of 100 feet bgs. In general, groundwater is not expected to be a constraint to the design and construction of this project.

- Corrosivity test results indicate that the tested subgrade soils at the site may be corrosive to ferrous metals, and the sulfate content of the sampled tested presents a negligible sulfate exposure to concrete.

9. RECOMMENDATIONS

The following sections present our geotechnical recommendations for the proposed construction. If the proposed construction is changed from that discussed in this report, Ninyo & Moore should be contacted for additional recommendations.

9.1. Earthwork

The following sections provide our earthwork recommendations. In general, the earthwork specifications contained in the Maricopa Association of Governments (MAG), *Uniform Standard Specifications and Details for Public Works Construction,* or relevant grading ordinances having jurisdiction (e.g., City of Sierra Vista Development Code), and the project construction specifications should apply, except as noted in this report.

9.1.1. Site Preparation

Prior to performing grading operations, the site should be cleared of existing vegetation, surface obstructions, rubble and debris, and other deleterious materials. Existing utilities within the project limits, if encountered, should be re-routed or protected from damage by construction activities. Obstructions that extend below finished grade, if any, should be removed and the resulting voids filled with engineered fill. Materials generated from the clearing operations should be removed from the project site and either disposed of at a legal dumpsite or reused, if appropriate.

9.1.2. Excavations

Our evaluation of the excavation characteristics of the on-site materials is based on the results of the exploratory borings, our site observations, and our experience with similar materials. In our opinion, excavation of the alluvium soils can generally be achieved with heavy-duty earthmoving and excavation equipment. However, gravel, cobbles, and possible boulders were observed in our borings, which will be more difficult to excavate and will result in slower excavation rates. The contractor should be prepared for such conditions.

The proposed excavations are not anticipated to encounter significant groundwater (the possible exception of surface run-off or perched zones). However, relatively soft and/or loose materials may be encountered within or near the existing draw. Therefore, excavation bottom stabilization measures should be anticipated for this site during construction.

For temporary excavations in alluvium, the contractor should provide safely sloped excavations or an adequately constructed and braced shoring system, in compliance with Occupational Safety and Health Administration (OSHA) regulations, for employees working in an excavation that may expose them to the danger of moving ground. For planning purposes and according to OSHA soil classifications, a "Type C" soil should be considered for excavation in alluvial and/or fill soil for this project. In general, temporary slopes above the water table and excavations in competent "Type C" soil should be inclined no steeper than 1.5H:1V. These details apply to temporary open-trench excavations up to 20 feet deep. Trenches over 20 feet deep or in areas where seepage is encountered should be designed by the contractor's engineer based on project-specific geotechnical analyses.

Upon making the excavations, soil classification and excavation performance should be evaluated in the field by Ninyo & Moore in accordance with the OSHA regulations. Details for open-cut slopes and shoring based on soil type and groundwater conditions are provided in the latest amended OSHA regulations.

Temporary excavations that encounter groundwater seepage or surface runoff may need shoring or may be stabilized by placing sandbags or gravel along the base of the seepage zone. Excavations encountering groundwater seepage should be evaluated on a case-by-case basis. Flatter slopes or bracing should be used if sloughing or raveling is observed. If material is stored or equipment is operated near an excavation, stronger shoring should be used to resist the extra pressure due to superimposed loads.

9.1.3. Engineered Fill Placement, and Compaction

Soils generated from on-site excavation activities that exhibit a relatively low Plasticity Index ([PI] of less than 15, as evaluated by American Society for Testing and Materials [ASTM] D 4318) are generally suitable for re-use as engineered fill. Our Atterberg Limits tests indicated that the PI of the tested soils ranged from 7 to 15. Based on these results, many of the on-site soils will be suitable for re-use as engineered fill. Additional field sampling and laboratory testing should be conducted during construction by the contractor to better evaluate the suitability of on-site soils for re-use as engineered fill.

Engineered fill should be placed in lifts not exceeding 8 inches in loose thickness and compacted by appropriate mechanical methods to a relative compaction of 95 percent as evaluated by ASTM D 698 at a moisture content slightly above the laboratory optimum.

Suitable fill should not include organic material, construction debris, or other non-soil fill materials. Rock particles and clay lumps should not be larger than 6 inches in dimension. Unsuitable material should be disposed of off-site or in non-structural areas.

Imported fill, if utilized, should consist of granular material with a very low or low Expansion Index, and a PI of less than 18. Import material in contact with ferrous metals should preferably have low corrosion potential (minimum resistivity of 2,000 ohm-cm or more, chloride content less than 25 parts per million [ppm]). Import material in contact with concrete should preferably have a soluble sulfate content of less than 0.1 percent. In addition, imported fill should meet relevant requirements for the embankment construction, as detailed in Section 9.1.4. Ninyo & Moore should evaluate such materials and details of their placement prior to importation.

9.1.4. New Embankment

Based on the laboratory test results the near surface soils, and soils found near the foundation elevation of the new fill embankment exhibited a significant potential for collapse upon inundation with water. In addition, some of the subsurface soils demonstrated significant variation of relative densities within the anticipated foundation zone. Additionally, because this site could potentially contain buried channels creating lenses of highly permeable soils, the recommendations provided below are designed to reduce potential total and differential movements under proposed embankments and channels, and reduce hydraulic piping potential under engineered embankments.

We recommend that the new fill embankment be founded 5 feet below adjacent grade as measured from the center of the embankment, as measured from the existing ground surface. New embankment construction guidelines are presented on Figure 3.

Following the overexcavation as described above, and prior to the placement of new fill, the resulting exposed surface should be carefully evaluated by Ninyo & Moore. Based on this evaluation, additional remediation may be needed. This could include scarification of the exposed surface. This additional remediation, if needed, should be addressed by Ninyo & Moore during the earthwork operations. An earthwork (shrinkage) factor of about 15 to 25 percent for the on-site soils is estimated.

We recommend that the new embankment fill material gradation and plasticity meet the requirements presented below. Based on the results of our laboratory testing, some of the in-site soils may not meet these requirements. Blending with other soils obtained from the on-site excavations may result in acceptable material properties. Additional field sampling and laboratory testing should be conducted during construction to evaluate the suitability of on-site soils for the embankment construction.

Table 1 – New Embankment Fill

Sieve	Percent Passing
3 inch	100
No. 4	60-100
No. 8	55-100
No. 40	40-95
No. 200	20-60
PI	3-18

The new embankment fill should be placed in lifts the thickness of which will depend on the compaction equipment used, and should be re-compacted to 95 percent or more relative compaction, as evaluated by ASTM D 698 at a moisture content generally slightly above the optimum moisture.

Settlements of the new embankment fills as recommended above should be anticipated and can generally be estimated to be on the order of 1 to 1-½ percent of the fill height. Due to the generally unsaturated nature of the on-site soils majority of settlement is anticipated to occur during construction. No appreciable long-term settlements are anticipated.

Where new fill is to be placed on existing slopes, we recommend that horizontal benches angled slightly into the slope be cut into the native soils prior to placing fill. Benches should roughly parallel slope contours. These benches should extend 4 feet or more into competent material at vertical distances of approximately 4 feet. Bench recommendations may need revision during construction to account for field conditions.

9.1.5. Permanent Slopes and Erosion Protection

Based on our experience with similar projects, we recommend that permanent cut slopes within native soils (alluvium) be constructed no steeper than 2.5H:1V. Permanent fill embankment slopes should be no steeper than 3H:1V. In order to reduce the potential for erosion, for slopes steeper than 3H:1V, erosion control measures, such as vegetation with deep-rooted perennial grasses, or other appropriate measures should be considered.

Fill slopes should be constructed in a manner such that the degree of compaction is achieved to the finished slope face (e.g., overfilling and cutting to grade). We recommend that the overfill width be 12 inches or more; however, the overfill width may vary depending on the fill soil properties, compaction equipment used, and other factors.

9.1.6. Embankment Crest

We recommend that the new embankment crest be 10 or more feet wide in order to adequately maintain future operations of the facility. This width may be reduced if operation and maintenance activities are not needed on the embankment.

9.2. Seismic Design Considerations

Design of the proposed improvements should be performed in accordance with the requirements of the governing jurisdictions and applicable building codes. Table 2 presents the seismic design parameters for the site in accordance with the 2012 International Building Code (IBC) guidelines and adjusted maximum considered earthquake (MCE) spectral response acceleration parameters evaluated using the USGS, 2013 ground motion calculator (web-based).

Table 2 – 2012 International Building Code Seismic Design Criteria

Site Coefficients and Spectral Response Acceleration Parameters	Values
Site Class	D
Site Coefficient, F_a	1.6
Site Coefficient, F_v	2.4
Mapped Spectral Response Acceleration at 0.2-second Period, S_s	0.240 g
Mapped Spectral Response Acceleration at 1.0-second Period, S_1	0.70 g
Spectral Response Acceleration at 0.2-second Period Adjusted for Site	0.383 g
Spectral Response Acceleration at 1.0-second Period Adjusted for Site	0.168 g
Design Spectral Response Acceleration at 0.2-second Period, S_{DS}	0.256 g
Design Spectral Response Acceleration at 1.0-second Period, S_{D1}	0.112 g

9.3. Box and Pipe Culvert Foundations

We understand that a box or pipe culvert through the embankment (principal outlet) may be utilized for this project.

We recommend that culvert wing wall footings and the bottom slab (mat foundations) be supported on engineered fill extending 3 feet or more below the bottom of the footing, placed and compacted as described in Section 9.1.3. The overexcavation depth can be reduced to 2 feet for pipe culverts. Following the overexcavation as described above, and prior to the placement of new fill, the resulting exposed surface should be carefully evaluated by Ninyo & Moore. Based on this evaluation, additional remediation may be needed.

9.3.1. Footings

Continuous footings should have a width of 16 or more inches, and should be reinforced in accordance with the recommendations of the structural engineer. Footings may be designed using an allowable bearing pressure of up to 2,500 pounds per square foot (psf) for static conditions. The allowable soil bearing pressures may be increased by one-third when considering total loads, including loads of short duration such as wind or seismic forces.

Total and differential movements of up to about 1 inch and 1/2-inch, respectively, may occur under the footing foundations. Distortions of about 1/2-inch (vertical) over 20 feet (horizontal) are possible.

Foundations subject to lateral loadings may be designed using an ultimate coefficient of friction of 0.35 (total frictional resistance equals the coefficient of friction multiplied by the dead load). A passive resistance value of 300 psf of depth can be used. The lateral resistance can be taken as the sum of the frictional resistance and passive resistance, provided that the passive resistance does not exceed one-half of the total ultimate resistance. The passive resistance may be increased by one-third when considering loads of short duration such as wind or seismic forces. The foundations should preferably be proportioned such that the resultant force from loads, including lateral loading, falls within the kern (i.e., middle one-third of the footing base).

9.4. Lateral Earth Pressures

Earth pressures are calculated to compute the lateral forces acting on retaining structures and foundations. These pressures can be classified as at-rest, active, and passive. At-rest conditions exist when there is no movement, such as backfill pressure on a braced or rigid wall. The active pressures are exerted when the wall moves out or rotates slightly (typical for cantilever retaining walls) and the soil moves toward the wall away from the mass, thereby mobilizing the shear strength of the soil. The active pressures are typically mobilized at movements of less than about 0.1 percent of the wall height for granular soils. Passive pressures occur when the wall moves toward the soil mass.

Retaining walls that are not restrained from movement at the top and have a level granular backfill behind the wall may be designed using an "active" equivalent fluid unit weight of 37 pounds per cubic foot (pcf). This value assumes compaction within about 5 feet of the wall will be accomplished with relatively light compaction equipment, and that engineered granular fill will be placed behind the wall. Unrestrained retaining walls should also be designed to resist a surcharge pressure of 0.31q. The value for "q" represents the pressure induced by adjacent light loads, slab, or traffic loads plus any adjacent footing loads.

The "at-rest" earth pressure against walls that are restrained at the top or braced so that they cannot yield, and with level backfill, may be taken as equivalent to the pressure exerted by a fluid weighing 56 pcf. Restrained retaining walls should also be designed to resist a horizontal earth pressure of 0.47q. The value of q represents the vertical surcharge pressure induced by adjacent light loads, slab, or traffic loads plus any adjacent footing loads.

For "passive" resistance to lateral loads, we recommend that an ultimate equivalent fluid weight of 300 psf per foot of depth be used. This value assumes that the ground is horizontal for a distance of 10 feet or more in front the wall or three times the height generating the passive pressure, whichever is more. We recommend that the upper 12 inches of soil not protected by pavement or a concrete slab be neglected when calculating passive resistance. If passive and frictional resistances are to be used in combination, we recommend that the passive resistance be limited to one-half of the ultimate lateral resistance. The passive resistance values may be increased by one-third when considering loads of short duration such as wind or seismic forces.

Measures should be taken so that moisture does not build up behind retaining walls. Retaining walls should be backfilled with structure fill and provided with a drain. Drainpipes should outlet away from structures, and retaining walls should be waterproofed in accordance with the recommendations of the project civil engineer or architect. To reduce the potential for water- and sulfate/salt-related damage to the retaining walls, particular care should be taken in selection of the appropriate type of waterproofing material to be utilized and in the application of this material. For exterior retaining walls, weep holes may be used in lieu of drainage pipes.

9.5. Embankment Slope Surface Erosion

Surface erosion may occur on unprotected embankments from runoff during rain events, and from burrowing animals. This can result in features such as gullies, boils, and burrow holes. These features can ultimately reduce the embankments stability post construction, and after significant hydrologic events. We recommend the following:

- Provide rock mulch consisting of ¾-inch or greater aggregate applied to the surface of the embankment.
- Apply relatively dense shallow rooted vegetation to the surface of the embankment to prevent erosion.
- Implement an animal control strategy to prevent colonization of burrowing animals.

9.6. Slope Stability and Seepage Considerations

We understand that the new embankment slopes are planned to have a 3H:1V inclination with the height varying from nearly zero up to about 36 feet.

Based on this configuration, and the results of our field and laboratory tests, we anticipate that the new slopes will have sufficiently high safety factors for global (deep seated) stability for their operation during the service life. For the above reasons, we did not run a formal slope stability analysis for the basin. However, surficial slope stability may be affected by rain events and other factors as discussed in Section 9.5 above, which may result in shallow sloughing and erosion of unprotected slope faces.

Similarly, we did not perform a formal seepage analysis, due to the embankment configuration and the general soil types within the project area, which make the steady state seepage a highly remote condition.

9.7. Filter Diaphragm

We recommend that a filter diaphragm be designed for the pipe penetrations associated with this project in accordance with the National Engineering Handbook (NEH), Part 628, Dams, Chapter 45, Filter Diaphragms. The main purpose of a filter diaphragm is to intercept water that can flow through cracks that may occur in compacted fill surrounding conduits or water that may flow along the interface between the conduit and the surrounding fill. The gradation of the sands used in the filter diaphragms is important. ASTM C 33 sand usually meets requirements for many embankment base soils. However, the designer should perform design checks in accordance with NEH, Part 633, Chapter 26. Recommended minimum dimensions of a filter diaphragm are summarized on Figure 4. In some cases, the minimum recommended dimensions for a filter diaphragm may be reduced, for example when bedrock is encountered before the diaphragm dimensions are met.

9.8. Corrosion

The corrosion potential of the on-site materials was analyzed to evaluate its potential effect on the foundations and structures. Corrosion potential was evaluated using the results of laboratory testing of one sample obtained during our subsurface evaluation that was considered representative of soils at the subject site.

Laboratory testing consisted of pH, minimum electrical resistivity, and chloride and soluble sulfate contents. The pH and minimum electrical resistivity tests were performed in general accordance with Arizona Test 236c, while sulfate and chloride tests were performed in accordance with Arizona Test 733 and 736, respectively. The results of the corrosivity tests are presented in Appendix B.

The soil pH value of the sample tested was 7.7, which is considered to be alkaline. The minimum electrical resistivity value measured in the laboratory was about 600 ohm-cm, which is considered to be corrosive to ferrous materials. The chloride content of the sample tested was about 20 parts per million (ppm), which is not considered to be corrosive to ferrous materials. The soluble sulfate content of the soil sample tested was about 0.005 percent, which is considered to represent negligible potential for sulfate attack to concrete.

The results of the laboratory testing indicate that the on-site materials could be corrosive to ferrous materials. It is possible that soils with variable corrosivity characteristics may be encountered at the site and should be evaluated during construction. We recommend that special consideration be given to the use of heavy-gauge, corrosion-protected, underground steel pipe or culverts, if any are planned. As an alternative, plastic pipe or reinforced concrete pipe could be considered. A corrosion specialist should be consulted for further recommendations.

9.9. Concrete

Laboratory chemical tests performed on a selected sample of on-site soils indicated a sulfate content of about 0.005 percent by weight. Based on the following American Concrete Institute (ACI) table, the on-site soils should be considered to have a negligible sulfate exposure to concrete.

Notwithstanding the sulfate test result and due to the limited number of chemical tests performed, as well as our experience with similar soil conditions and local practice, we recommend the use of Type II cement for construction of concrete structures at this site. Due to potential uncertainties as to the use of reclaimed irrigation water, or topsoil that may contain higher sulfate contents, pozzolan or admixtures designed to increase sulfate resistance may be considered.

The concrete should have a water-cementitious materials ratio no more than 0.50 by weight for normal weight aggregate concrete. The structural engineer should select the concrete design strength based on the project specific loading conditions.

9.10. Pre-Construction Conference

We recommend that a pre-construction conference be held. Representatives of the owner, civil engineer, Ninyo & Moore, and the contractor should be in attendance to discuss the project plans and schedule. Our office should be notified if the project description included herein is incorrect, or if the project characteristics are significantly changed.

9.11. Construction Observation and Testing

During construction operations, we recommend that Ninyo & Moore perform observation and testing services for the project. These services should be performed to evaluate exposed subgrade conditions, including the extent and depth of overexcavation, to evaluate the suitability of proposed borrow materials for use as fill and to observe placement and test compaction of fill soils. If another geotechnical consultant is selected to perform observation and testing services for the project, we request that the selected consultant provide a letter to the owner, with a copy to Ninyo & Moore, indicating that they fully understand our recommendations and that they are in full agreement with the recommendations contained in this report. Qualified subcontractors utilizing appropriate techniques and construction materials should perform construction of the proposed improvements.

10. LIMITATIONS

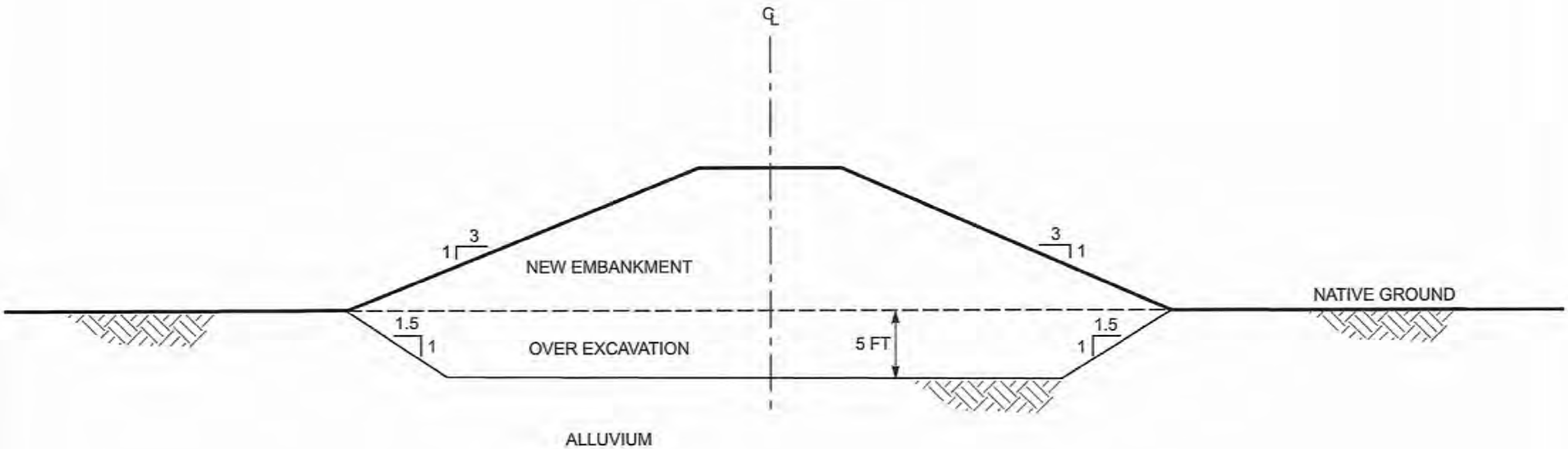
The field evaluation, laboratory testing, and geotechnical analyses presented in this geotechnical report have been conducted in general accordance with current practice and the standard of care exercised by geotechnical consultants performing similar tasks in the project area. No warranty, expressed or implied, is made regarding the conclusions, recommendations, and opinions presented in this report. There is no evaluation detailed enough to reveal every subsurface condition. Variations may exist and conditions not observed or described in this report may be encountered during construction. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation will be performed upon request. Please also note that our evaluation was limited to assessment of the geotechnical aspects of the project, and did not include evaluation of structural issues, environmental concerns, or the presence of hazardous materials.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. Ninyo & Moore should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

This report is intended for design purposes only. It does not provide sufficient data to prepare an accurate bid by contractors. It is suggested that the bidders and their geotechnical consultant perform an independent evaluation of the subsurface conditions in the project areas. The independent evaluations may include, but not be limited to, review of other geotechnical reports prepared for the adjacent areas, site reconnaissance, and additional exploration and laboratory testing.

Our conclusions, recommendations, and opinions are based on an analysis of the observed site conditions. If geotechnical conditions different from those described in this report are encountered, our office should be notified and additional recommendations, if warranted, will be provided upon request. It should be understood that the conditions of a site could change with time as a result of natural processes or the activities of man at the subject site or nearby sites. In addition, changes to the applicable laws, regulations, codes, and standards of practice may occur due to government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which Ninyo & Moore has no control.

This report is intended exclusively for use by the client. Any use or reuse of the findings, conclusions, and/or recommendations of this report by parties other than the client is undertaken at said parties' sole risk.



NOT TO SCALE

Note: Dimensions, directions, and locations are approximate.

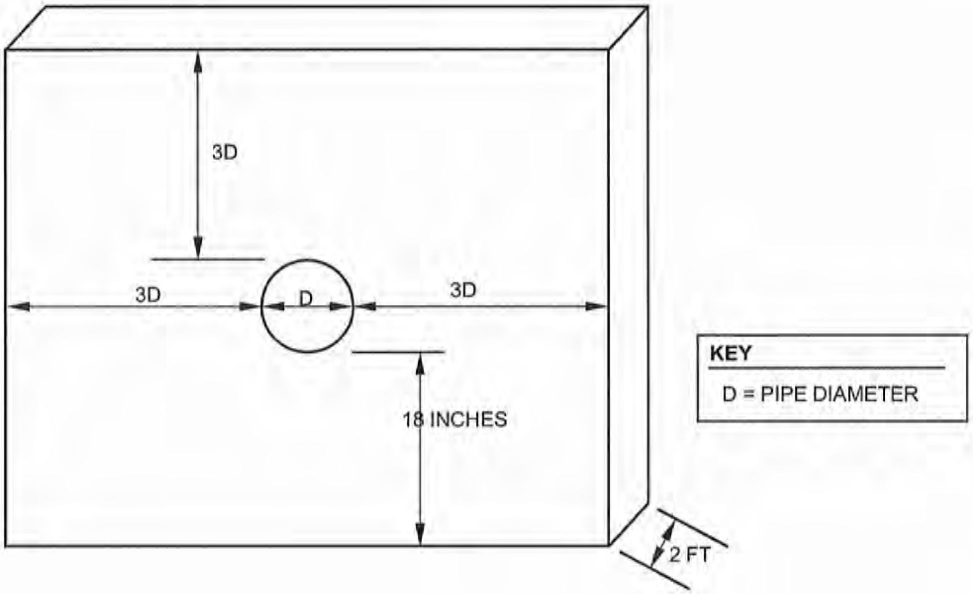
Ninyo & Moore

NEW EMBANKMENT CONSTRUCTION GUIDELINES

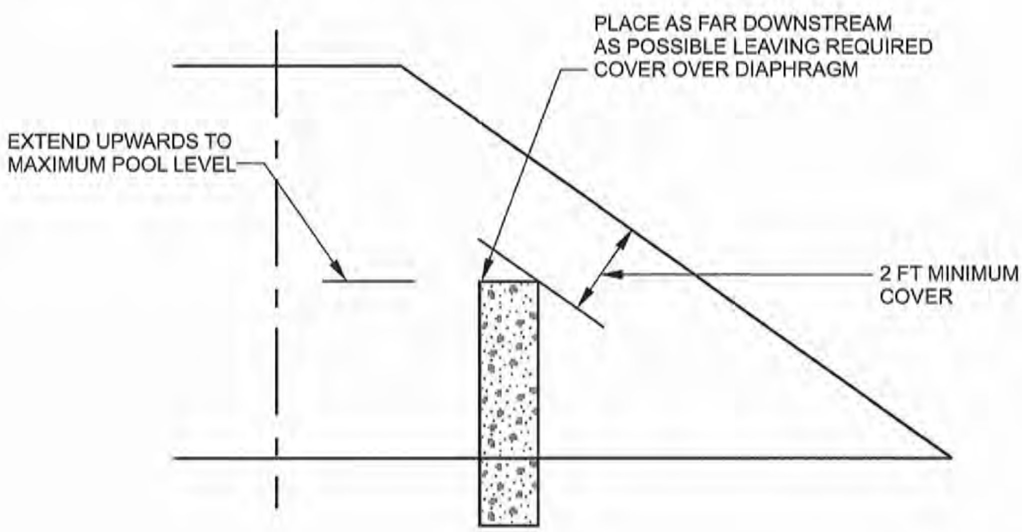
PROJECT NO:	DATE:		FIGURE
604915001	10/15	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	3

file no: 4915sec1015

FILTER DIAPHRAGM DIMENSIONS



LOCATION OF FILTER DIAPHRAGM IN EMBANKMENT



Note: Dimensions, directions and locations are approximate.

Ninyo & Moore		FILTER DIAPHRAGM DESIGN GUIDELINES	FIGURE
PROJECT NO: 604915001	DATE: 10/15	HORSESHOE DRAW BASIN COCHISE COUNTY, ARIZONA	4

file no: 4915filt1015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

APPENDIX C

CONSTRUCTION DOCUMENTS

Cochise County
Community Development
Highway and Floodplain Division
Public Programs…Personal Service
www.cochise.az.gov

FLOODPLAIN USE PERMIT NO. FP 17-01

A permit is hereby issued to the applicant for the purpose of: **Horseshoe Draw Earthen Embankment & Detention Plan**

Name Of Applicant:	**Aubrey Thomas – HilgartWilson, LLC**
Address Of Applicant:	**2141 E. Highland – Suite 250 – Phoenix, AZ 85016**
Telephone Number:	**602-490-0535**
Contractor / License:	**HilgartWilson, LLC**
Legal Descriptions:	**Township 24 S, Range 22 E. Section 11 & 14**
Location:	**104-62-002A & 104-62-003**
Date:	**January 23, 2017**

This permit is subject to the following conditions and/or restrictions.

1. Stabilization work will be limited to the area detailed on application/plans.
2. Excavation will be limited to the area detailed on application/plans.
3. No obstructions or equipment shall be left in the watercourses when work is not in progress.
4. Vegetation damaged shall be kept to a minimum outside of the construction envelope.
5. Any adverse impacts to adjacent properties due to the construction covered under this permit are the responsibility of the applicant, including Right of Way areas maintained by the County.
6. Storage of materials that are buoyant in time of flooding is prohibited.
7. This permit allows you to work along the channel bed upstream and downstream of Horseshow Draw.

All pertinent portions of the Cochise County Floodplain Regulations, January 2016, are incorporated herein by reference.

By accepting the Permit, the Permittee hereby agrees to faithfully abide by all the Covenants, Conditions and Restrictions contained or referred to herein.

APPROVED BY: Joaquin Solis ________________ DATE: January 23, 2017
Floodplain Engineer

Highway and Floodplain
1415 Melody Lane, Building F
Bisbee, Arizona 85603
520-432-9300
520-432-9337 fax
1-800-752-3745
highway@cochise.az.gov
floodplain@cochise.az.gov

Planning, Zoning and Building Safety
1415 Melody Lane, Building E
Bisbee, Arizona 85603
520-432-9300
520-432-9278 fax
1-877-777-7958
planningandzoning@cochise.az.gov

GRADING AND DRAINAGE PLANS
HORSESHOE DRAW:
EARTHEN EMBANKMENT
AND DETENTION BASIN PLAN
COCHISE COUNTY, ARIZONA

LOCATED IN TOWNSHIP 24 SOUTH, RANGE 22 EAST
OF THE GILA AND SALT RIVER MERIDIAN, COCHISE COUNTY, ARIZONA

HILGARTWILSON STANDARD ENGINEERING NOTES

1. THESE PLANS ARE SUBJECT TO THE INTERPRETATION OF INTENT BY THE ENGINEER. ALL QUESTIONS REGARDING THESE PLANS SHALL BE PRESENTED TO THE ENGINEER. ANYONE WHO TAKES IT UPON THEMSELF THE INTERPRETATION OF THE DRAWINGS OR MAKES REVISIONS TO THE SAME WITHOUT CONFERRING WITH THE DESIGN ENGINEER SHALL BE RESPONSIBLE FOR THE CONSEQUENCES THEREOF.

2. THE ESTIMATED QUANTITIES SHOWN ARE FOR INFORMATION PURPOSES ONLY. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE COMPLETENESS AND ACCURACY OF A DETAILED ESTIMATE BASED ON THESE PLANS, CURRENT CODES, AND SITE VISITATION.

3. ALL EARTHWORK CONSTRUCTION SHALL CONFORM TO THE LATEST MARICOPA ASSOCIATION OF GOVERNMENTS STANDARD DETAILS AND/OR SPECIFICATIONS INCLUDING ANY SUPPLEMENTS THERETO, AND ALL ADDENDA.

4. PRIOR TO BIDDING THE WORK, THE CONTRACTOR SHALL THOROUGHLY SATISFY HIMSELF AS TO THE ACTUAL CONDITIONS, REQUIREMENTS OF THE WORK AND EXCESS OR DEFICIENCY IN QUANTITIES. NO CLAIMS SHALL BE MADE AGAINST THE OWNER/DEVELOPER OR ENGINEER FOR ANY EXCESS OR DEFICIENCY THEREIN, ACTUAL OR RELATIVE.

5. THE ENGINEER SHALL NOT BE RESPONSIBLE FOR CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES, PROCEDURES OR SAFETY PRECAUTIONS OR PROGRAMS UTILIZED IN CONNECTION WITH THE WORK, AND WILL NOT BE RESPONSIBLE FOR THE CONTRACTOR'S FAILURE TO CARRY OUT THE WORK IN ACCORDANCE WITH THE CONTRACT DOCUMENTS.

6. THE ENGINEER SHALL NOT BE RESPONSIBLE FOR COORDINATING THE RELOCATION OF UTILITIES, POWER POLES, ETC.

7. THE CONTRACTOR SHALL MAKE NO CLAIM AGAINST THE OWNER OR THE SURVEYOR REGARDING ALLEGED INACCURACY OF CONSTRUCTION STAKES SET BY THE SURVEYOR UNLESS ALL SURVEY STAKES SET BY THE ENGINEER ARE MAINTAINED INTACT AND CAN BE VERIFIED AS TO THEIR ORIGIN. IF, IN THE OPINION OF THE SURVEYOR, THE STAKES ARE NOT MAINTAINED INTACT AND CANNOT BE VERIFIED AS TO THEIR ORIGIN, ANY REMEDIAL WORK REQUIRED TO CORRECT ANY ITEM OF IMPROPER CONSTRUCTION WORK SHALL BE PERFORMED AT THE SOLE EXPENSE OF THE RESPONSIBLE CONTRACTOR OR SUBCONTRACTOR.

8. THE SURVEYOR WILL MAKE FIELD AS-BUILT MEASUREMENTS OF THE WORK UPON NOTIFICATION BY THE CLIENT OR HIS REPRESENTATIVE THAT THE WORK IS COMPLETE AND READY FOR AS-BUILT SURVEY. FOR PIPE WORK, THE CONTRACTOR IS RESPONSIBLE FOR LEAVING TRENCHES OPEN SO THAT AS-BUILTS CAN BE PERFORMED TO COMPLY WITH THE AGENCY'S REQUIREMENTS. (IF THE TRENCHES ARE BACKFILLED AND OBSCURED TO THE POINT THAT AS-BUILT MEASUREMENTS CANNOT BE PERFORMED, IT WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO POTHOLE UTILITY TRENCHES AS NECESSARY TO COMPLETE AN AS-BUILT SURVEY.)

9. THE CONTRACTOR IS TO VERIFY THE LOCATION, ELEVATION, CONDITION, AND CROSS-SLOPE OF ALL EXISTING SURFACES AT POINTS OF TIE-IN AND MATCHING, PRIOR TO COMMENCEMENT OF GRADING OR OTHER SURFACE CONSTRUCTION. SHOULD EXISTING LOCATIONS, ELEVATIONS, CONDITIONS, OR CROSS-SLOPES DIFFER FROM THAT SHOWN ON THESE PLANS, RESULTING IN THE DESIGN INTENT REFLECTED ON THESE PLANS NOT BEING ABLE TO BE CONSTRUCTED, THE CONTRACTOR SHALL NOTIFY THE OWNER'S AGENT IMMEDIATELY FOR DIRECTION ON HOW TO PROCEED PRIOR TO COMMENCEMENT OF CONSTRUCTION. THE CONTRACTOR ACCEPTS RESPONSIBILITY FOR ALL COSTS ASSOCIATED WITH CORRECTIVE ACTION IF THESE PROCEDURES ARE NOT FOLLOWED.

10. EXISTING UTILITIES SHOWN ON THESE PLANS HAVE BEEN LOCATED ACCORDING TO INFORMATION PROVIDED BY THE AGENCY OPERATING EACH UTILITY. LOCATIONS SHOWN ARE APPROXIMATE ONLY, AND ARE NOT RELIABLE FOR CONSTRUCTION PURPOSES. CALL BLUE STAKE FOR FIELD LOCATION AT (602) 263-1100. THE CONTRACTOR SHALL PROTECT AND MAINTAIN ALL EXISTING UTILITIES ON THE SITE. ANY DAMAGE TO EXISTING UTILITIES, WHETHER SHOWN OR NOT ON THE DRAWING, SHALL BE REPAIRED/REPLACED AT THE CONTRACTOR'S EXPENSE. EXISTING SURFACE FEATURES AND FENCING SHALL BE REPLACED IN LIKE KIND.

11. PRIOR TO CONSTRUCTION, THE ENGINEER AND APPLICABLE AGENCY MUST APPROVE ANY ALTERATION, OR VARIANCE FROM THESE PLANS. ANY VARIATIONS FROM THESE PLANS SHALL BE PROPOSED ON CONSTRUCTION FIELD PRINTS AND TRANSMITTED TO THE ENGINEER.

12. ANY INSPECTION BY THE CITY, COUNTY, ENGINEER, OR OTHER JURISDICTIONAL AGENCY, SHALL NOT, IN ANY WAY, RELIEVE THE CONTRACTOR FROM ANY OBLIGATION TO PERFORM THE WORK IN STRICT COMPLIANCE WITH APPLICABLE CODES AND AGENCY REQUIREMENTS.

13. CONTRACTOR IS RESPONSIBLE FOR PROTECTING ALL STORM DRAIN PIPES, STORM WATER RETENTION PIPES AND DRAINAGE FACILITIES FROM DAMAGE DURING ALL STAGES OF CONSTRUCTION. THE DEPTH OF COVER ON THE STORM DRAIN PIPE IS DESIGNED FOR FINAL GRADE. THEREFORE, EXTRA CARE SUCH AS BERMING OVER PIPES, FLAGGING OR SIGNAGE SHOULD BE USED DURING CONSTRUCTION TO MAINTAIN COVER OR PROTECT THE PIPES.

14. THE ENGINEER MAKES NO REPRESENTATION OR GUARANTEE REGARDING EARTHWORK QUANTITIES OR THAT THE EARTHWORK FOR THIS PROJECT WILL BALANCE DUE TO THE VARYING FIELD CONDITIONS, CHANGING SOIL TYPES, ALLOWABLE CONSTRUCTION TOLERANCES AND CONSTRUCTION METHODS THAT ARE BEYOND THE CONTROL OF THE ENGINEER.

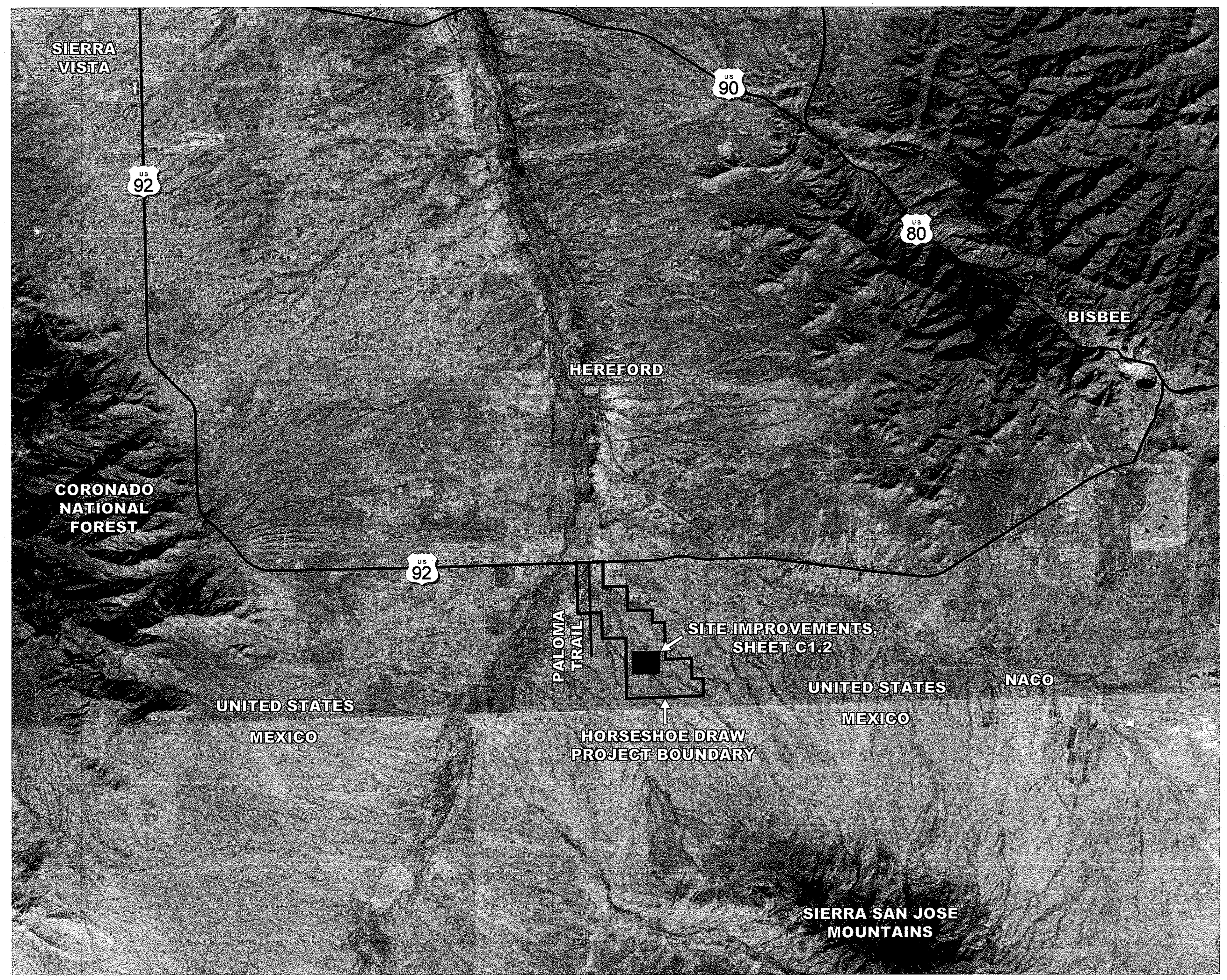
15. UNDERGROUND UTILITIES SHALL BE MARKED IN ACCORDANCE WITH SECTION 40-360 OF THE ARIZONA REVISED STATUTES AND LOCAL MUNICIPALITY REQUIREMENTS.

GEOTECHNICAL ENGINEERING NOTES

1. WITH THE EXCEPTION OF THOSE RECOMMENDATIONS SPECIFICALLY PERTAINING TO OVER EXCAVATION, THE CONTRACTOR IS TO FOLLOW THE RECOMMENDATIONS OF THE GEOTECHNICAL EVALUATION REPORT FOR HORSESHOE DRAW BASIN, AS PREPARED BY NINYO & MOORE, PROJECT NO. 604915001, DATED OCTOBER 30, 2015.

2. TYPICAL FREQUENCIES FOR COMPACTION TESTS WILL BE 1 PER 1000 FEET PER 8 INCH LIFT TO A RELATIVE COMPACTION OF 95%. INITIAL COMPACTION TESTS SHALL BE TAKEN MORE FREQUENTLY WITHIN 20 FEET OF THE EMBANKMENT EDGES EVERY 500 FEET (250 FEET ALTERNATING EDGES).

3. INSTALLATION OF PIPE AND PIPE TRENCH COMPACTION DENSITIES SHALL BE IN ACCORDANCE WITH SECTION 601.4.4 OF THE COCHISE COUNTY ROAD DESIGN AND CONSTRUCTION STANDARDS. MINIMUM COMPACTION FOR ALL TRENCHING SHALL BE 90%COMPACTION AS FOLLOWS: THE MATERIAL FROM SURFACE TO WITHIN 2 FEET BELOW SURFACE SHALL BE AGGREGATE BASE PER TABLE 702-1, COMPACTED TO 100% MAXIMUM DRY DENSITY. FROM 2 FEET BELOW SURFACE TO 1 FOOT ABOVE PIPE THE MATERIAL SHALL BE AGGREGATE BASE OR SELECT MATERIAL TYPE B PER TABLE 702-1 AND COMPACTED TO 100% MAXIMUM DRY DENSITY. FROM ONE FOOT ABOVE PIPE TO BOTTOM OF TRENCH THE MATERIAL SHALL BE TYPE B COMPACTED TO 95% ADDITIONAL NOTES ON C1.3.



VICINITY MAP
1" = 10,000'

SITE AREA
42.0 ACRES

DISTURBED AREA
40.6 ACRES

OWNER/DEVELOPER
HEREFORD NATURAL RESOURCE
CONSERVATION DISTRICT (NRCD)
P.O. BOX 336
SIERRA VISTA, AZ 85636

ENGINEER
HILGARTWILSON
2141 EAST HIGHLAND AVENUE SUITE 250
PHOENIX, AZ 85016
PH: 602.490.0535
CONTACT: AUBREY THOMAS, P.E.

BENCHMARK
BRASS CAP, ELEVATION: 4430.30 (NAVD '88 DATUM)
NGS MONUMENT
DESIGNATION: TIGER, PID: CG1159.

BASIS OF BEARING
BASIS OF BEARING IS N00°00'03"E ALONG THE WEST LINE OF THE SOUTHWEST QUARTER OF SECTION 3, TOWNSHIP 24 SOUTH, RANGE 22 EAST OF THE GILA AND SALT RIVER MERIDIAN, COCHISE COUNTY, ARIZONA. NORTHING AND EASTING COORDINATE SYSTEM IN NAD83 ARIZONA CENTRAL ZONE STATE PLANE (INTERNATIONAL FEET).

FLOODPLAIN DESIGNATION
ZONE A (NO BASE FLOOD ELEVATIONS DETERMINED):
THE 1% ANNUAL CHANCE 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 AREA IS THE AREA SUBJECT TO FLOODING BY THE 1% ANNUAL CHANCE FLOOD.

ZONE X (OTHER FLOOD AREAS):
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 1% ANNUAL CHANCE FLOOD.

SHEET INDEX

ENGINEER'S ESTIMATED EARTHWORK QUANTITIES

GROSS CUT	190,000 C.Y.
GROSS FILL	189,850 C.Y.
NET EARTHWORK QUANTITY (CUT)	**150 C.Y.**
STORM DRAIN PIPE (36" COATED CMP)	936 L.F.
EROSION REVETMENT D50=15"	166 S.Y.
4" CONCRETE (MAG SPEC CLS. A 3,000 PSI)	3,560 S.Y.
HEADWALL (MAG STD. DTL. 501-1 AND 501-2)	2 EA

NOTES:
EQUIVALENT SIZED FRACTURED CONCRETE MAY BE USED AS SUBSTITUTE FOR RIPRAP/REVETMENT.

EARTHWORK QUANTITIES ARE ESTIMATED VOLUMES BASED ON RAW VOLUMES. THE CONTRACTOR SHALL PREPARE HIS OWN EARTHWORK ANALYSIS FOR BIDDING PURPOSES.

DATA CERTIFICATION
I HEREBY CERTIFY THAT THIS DESIGN IS BASED ON ACCURATE FIELD DATA WHICH HAS BEEN CHECKED IN THE FIELD PRIOR TO FIRST SUBMISSION OF THESE PLANS TO THE CITY FOR APPROVAL.

BY DATE

Call at least two full working days before you begin excavation.
ARIZONA 811
Arizona Blue Stake, Inc.
Dial 8-1-1 or 1-800-STAKE-IT (782-5348)
In Maricopa County: (602) 263-1100

REV.:

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE
2141 E. HIGHLAND AVE., STE. 250 | P: 602.490.0535 / F: 602.368.2436
PHOENIX, AZ 85016 www.hilgartwilson.com

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO. 49011
AUBREY J. THOMAS
Date Signed 1/13/17
ARIZONA U.S.A.
Expires 12/31/2017

HORSESHOE DRAW
COCHISE COUNTY, ARIZONA
GRADING AND DRAINAGE PLAN COVER

HILGARTWILSON
PROJ NO.: 1472
DATE: JAN. 2017
SCALE: AS SHOWN
DRAWN: ARK
DESIGNED: HW
APPROVED: AT

DWG. NO.
C1.1
SHT. 1 OF 7

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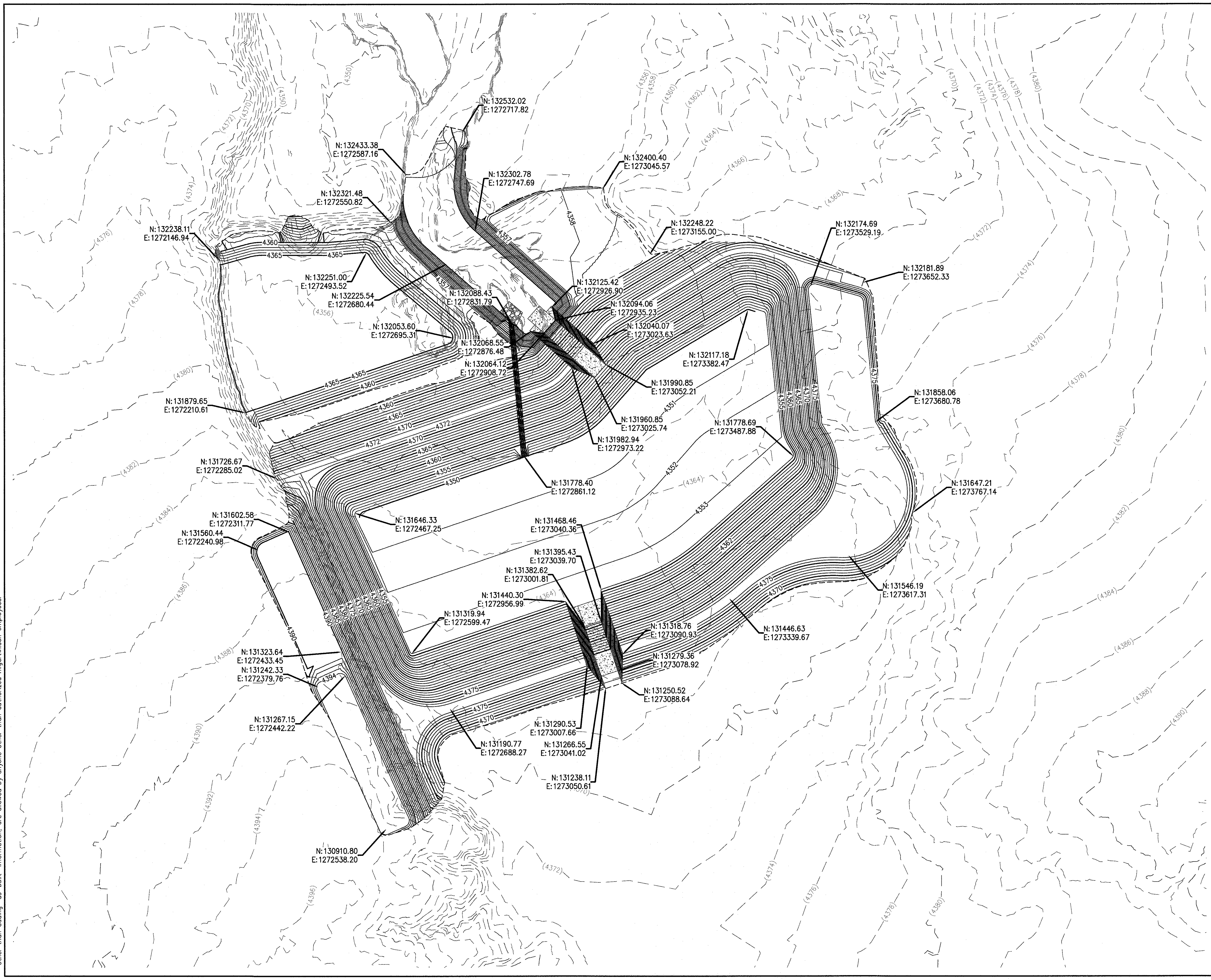

GRADING CONSTRUCTION NOTES

NORTHING AND EASTING COORDINATES IN NAD83 ARIZONA CENTRAL ZONE STATE PLANE (INTERNATIONAL FEET).

Call at least two full working days before you begin excavation.
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REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO. 49011
AUBREY J. THOMAS
ARIZONA U.S.A.
Expires 12/31/2017

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

NORTHINGS AND EASTINGS

PROJ. NO.	1472
DATE:	JAN. 2017
SCALE:	AS SHOWN

HILGARTWILSON

DESIGNED: HW | DRAWN: ARK | APPROVED: AT

REV.

DWG. NO.
C1.2

SHT. 2 OF 7

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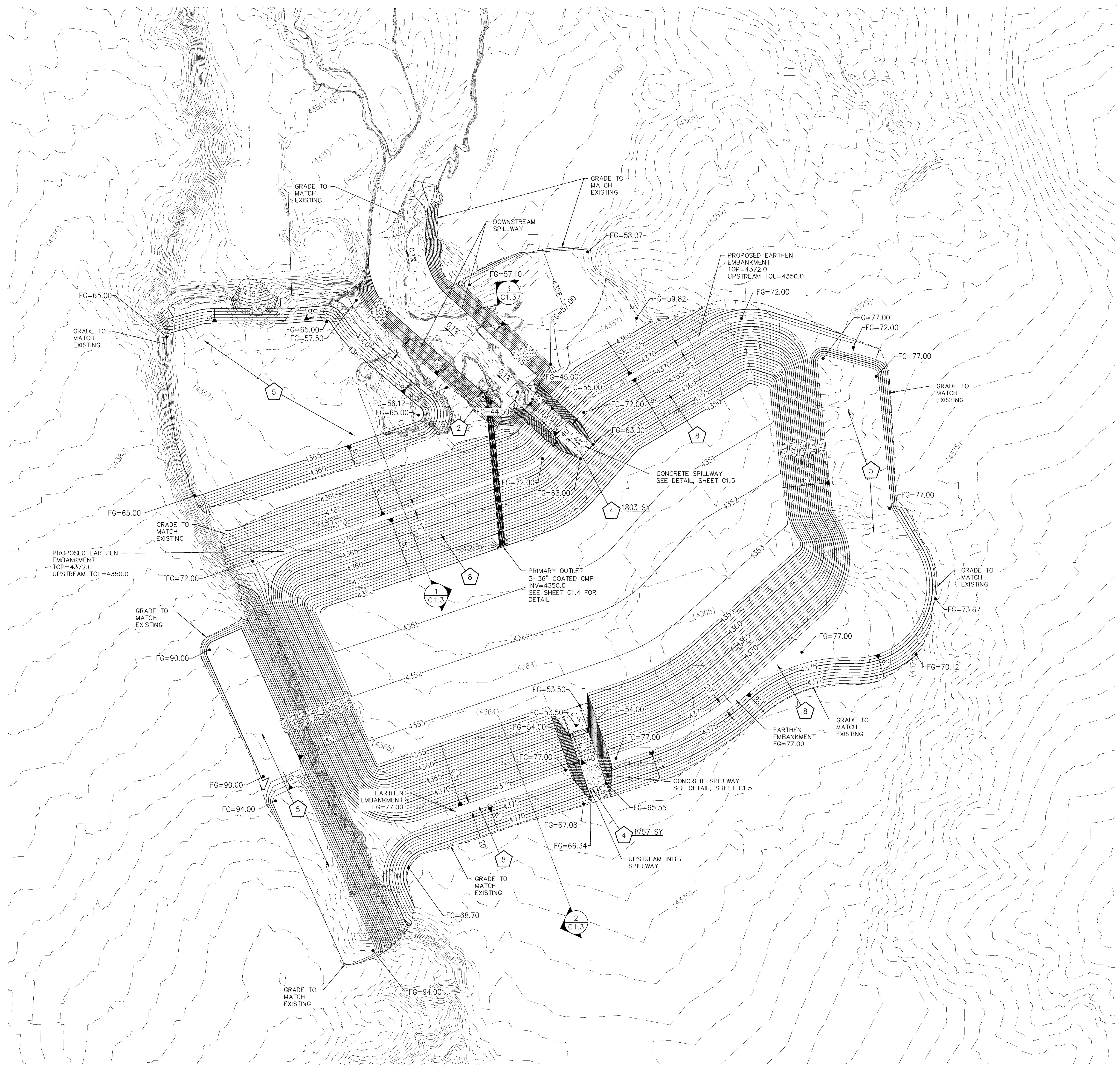
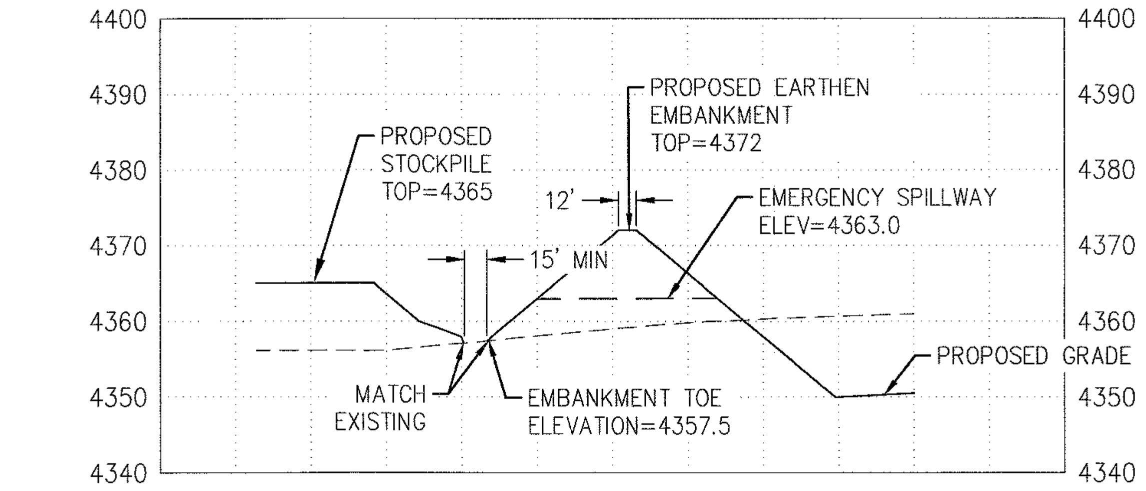
GRADING CONSTRUCTION NOTES

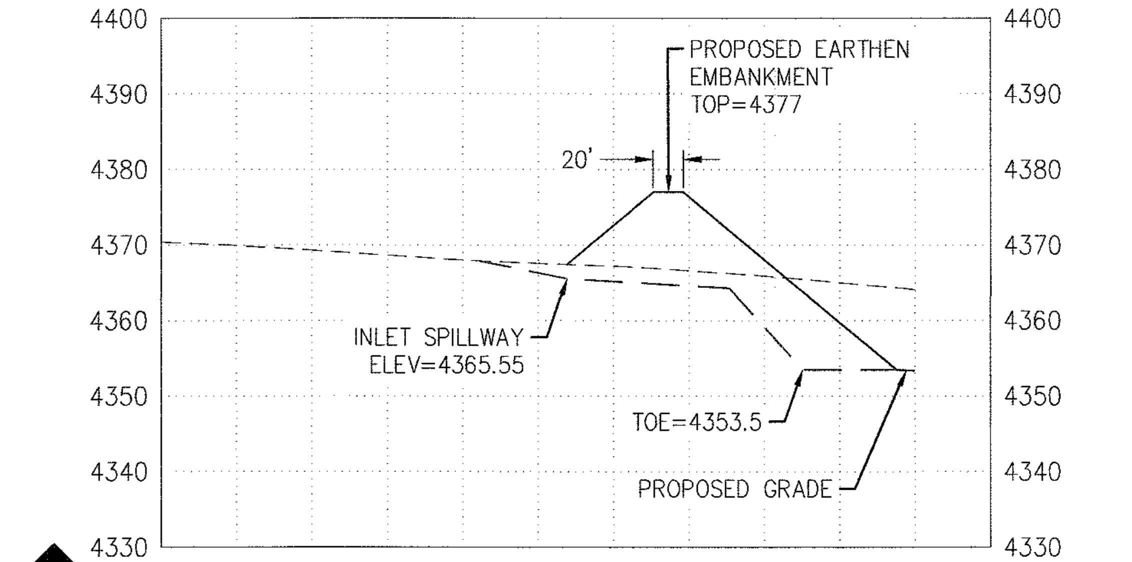
(2)	INSTALL LOOSE RIP-RAP, D50=15", (OR EQUIVALENT SIZED FRACTURED CONCRETE) WITH A DEPTH OF 24"	166 SY
(4)	CONSTRUCT CONCRETE SPILLWAY PER DETAILS ON SHEET C1.5	3560 SY
(5)	STOCKPILE AREA	
(8)	CONTRACTOR TO CONSTRUCT EARTHEN EMBANKMENT. LIFTS NOT TO EXCEED 8" AND TO BE COMPACTED BY APPROPRIATE MECHANICAL METHODS TO A RELATIVE COMPACTION OF 95% WITH A TEST FREQUENCY OF 1 PER 1000 FEET.	NPI





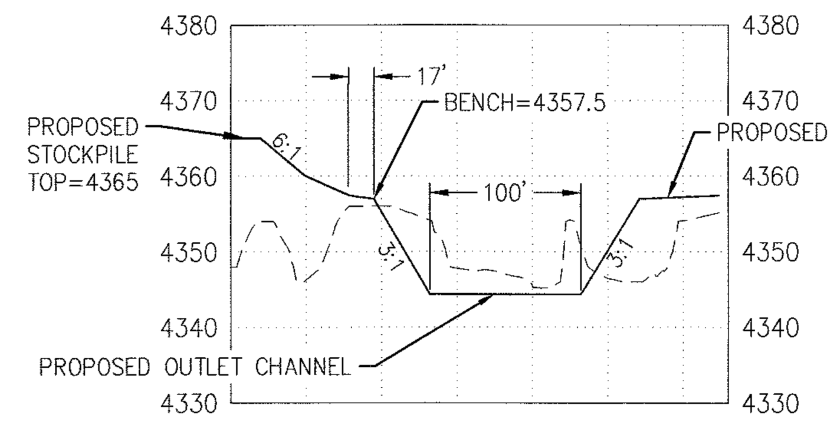
1 C1.3 EARTHEN EMBANKMENT AND DETENTION POND

PROFILE SCALE: HORIZ: 1" = 100' VERT: 1" = 20'



2 C1.3 EARTHEN EMBANKMENT AND DETENTION POND

PROFILE SCALE: HORIZ: 1" = 100' VERT: 1" = 20'



3 C1.3 OUTLET CHANNEL

PROFILE SCALE: HORIZ: 1" = 100' VERT: 1" = 20'

Call at least two full working days before you begin excavation. ARIZONA 811 Arizona Blue Stake, Inc. Dial 8-1-1 or 1-800-STAKE-IT (782-5348) In Maricopa County: (602) 263-1100

REGISTERED PROFESSIONAL CIVIL ENGINEER 49011 AUBREY J. THOMAS ARIZONA U.S.A. Expires 12/31/2017

SCALE 100 50 0 100 200 FEET

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

GRADING AND DRAINAGE PLAN

PROJ. NO.	1472
DATE:	JAN. 2017
SCALE:	AS SHOWN
DESIGNED: HW	DRAWN: ARK
APPROVED:	AT

HILGARTWILSON

REV. DWG. NO. C1.3

SHT. 3 OF 7

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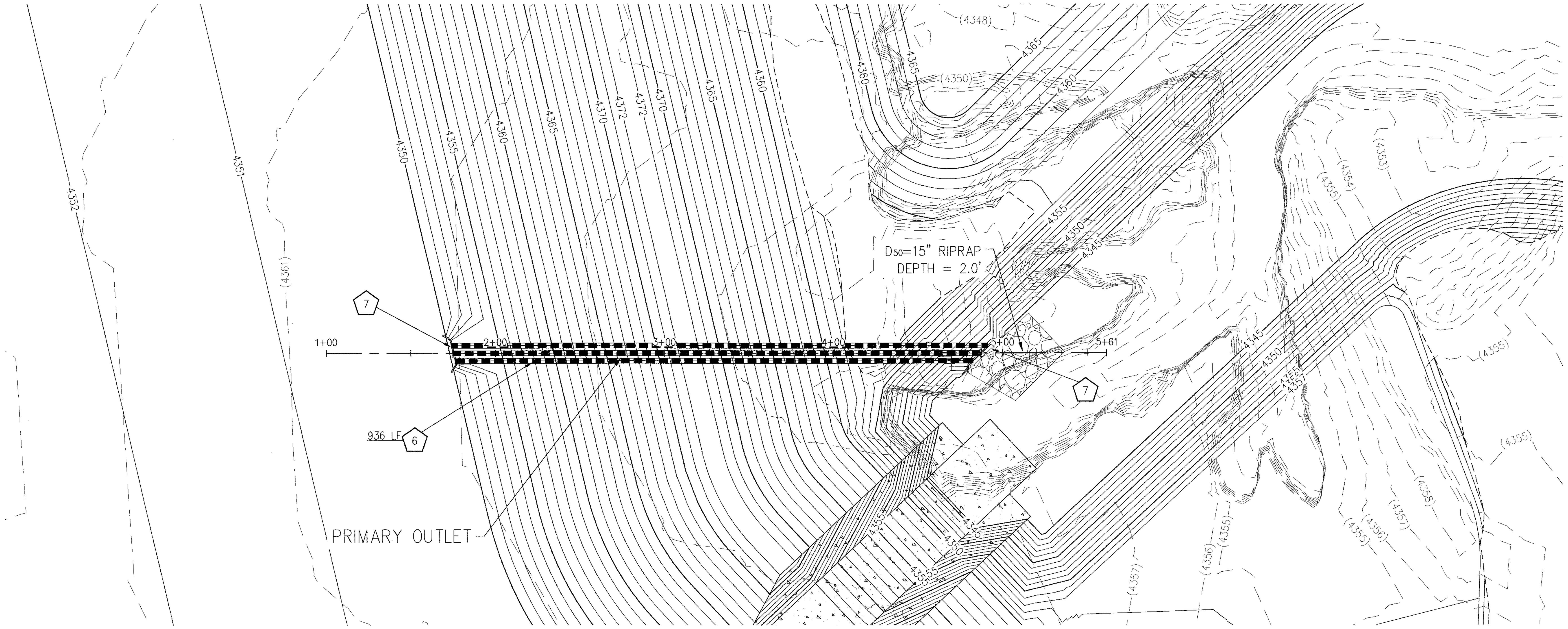
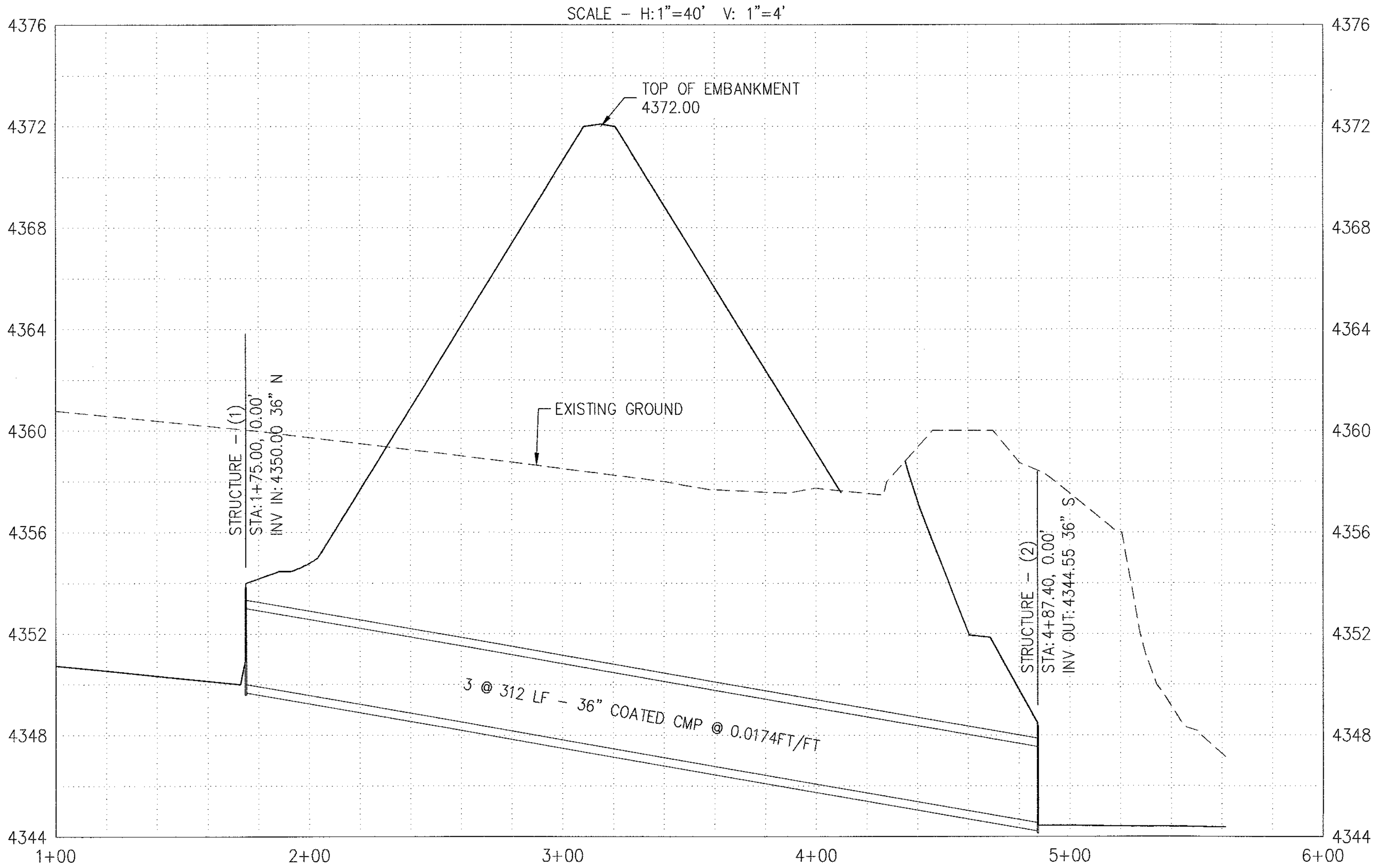
GRADING CONSTRUCTION NOTES

6	INSTALL 3-36" COATED CMP	936 LF
7	INSTALL HEADWALL PER MAG STD DTL 501-1, 501-2 (SEE DETAILS ON SHEET C1.5)	2 EA



PRIMARY OUTLET

SCALE – H:1"=40' V: 1"=4'



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40 20 0 40 80

SCALE FEET

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REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO. 49011
AUBREY J. THOMAS
Date Signed 1/13/17
ARIZONA U.S.A.
Expires 12/31/2017

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

STORM DRAIN PROFILE

PROJ. NO.	1472				
DATE:	JAN. 2017				
SCALE:	AS SHOWN	HILGARTWILSON			
DESIGNED:	HW	DRAWN:	ARK	APPROVED:	AT
REV.				DWG. NO.	C1.4
				SHT. 4 OF 7	

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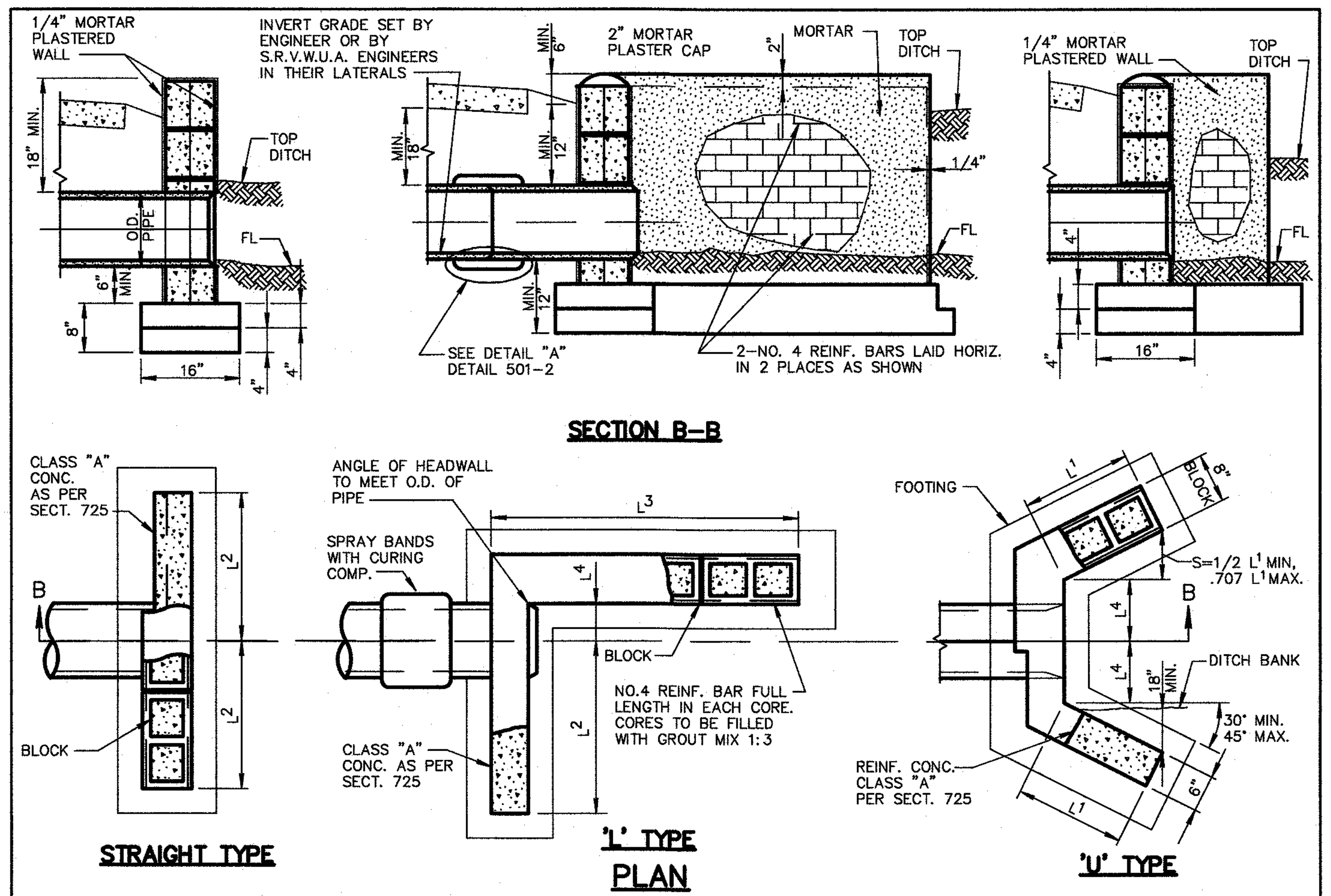
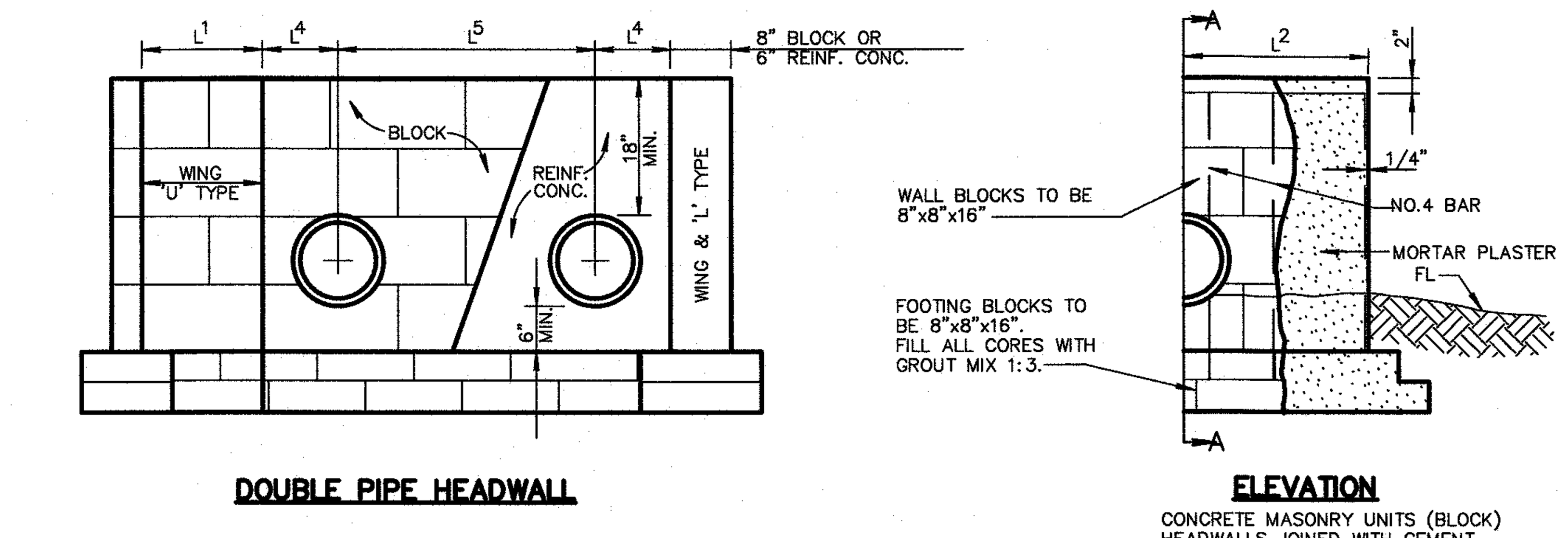


DETAIL NO.	MARICOPA ASSOCIATION of GOVERNMENTS — STANDARD DETAIL ENGLISH	HEADWALL	REVISED	DETAIL NO.
501-1			01-01-2012	501-1



CONCRETE MASONRY UNITS (BLOCK) HEADWALLS JOINED WITH CEMENT MORTAR PLASTERED BOTH SIDES OF WALL FULL HEIGHT AND SHALL BE CURED PER SECT. 726.

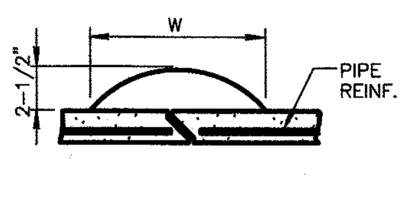
NOTES:

1. ALL CONCRETE SHALL BE CLASS 'A' PER SECT. 505 & 725.
2. CONCRETE MASONRY UNITS (BLOCK) PER SECT. 510, 775 & 776.
3. CONCRETE REINF. SHALL BE NO.4 BAR 12" O.C. BOTH WAYS.

HEADWALL DIMENSIONS

*NOMINAL PIPE SIZE	L^1	L^2	L^3	L^4	L^5
12"	1'-4"	2'-0"	3'-8"	0'-10"	2'-10"
15"	2'-0"	2'-8"	4'-0"	1'-0"	3'-0"
18"	2'-0"	3'-8"	4'-8"	1'-2"	3'-4"
21"	2'-8"	4'-0"	5'-4"	1'-3"	3'-8"
24"	2'-8"	4'-0"	5'-4"	1'-6"	3'-11"
30"	2'-8"	5'-4"	6'-8"	1'-10"	4'-7"
36"	3'-4"	6'-8"	8'-0"	1'-10"	5'-2"
42"	4'-0"	8'-0"	9-4"	2'-2"	5'-9"

* NOMINAL PIPE SIZE GIVEN FOR REINFORCED CONC. PIPE.



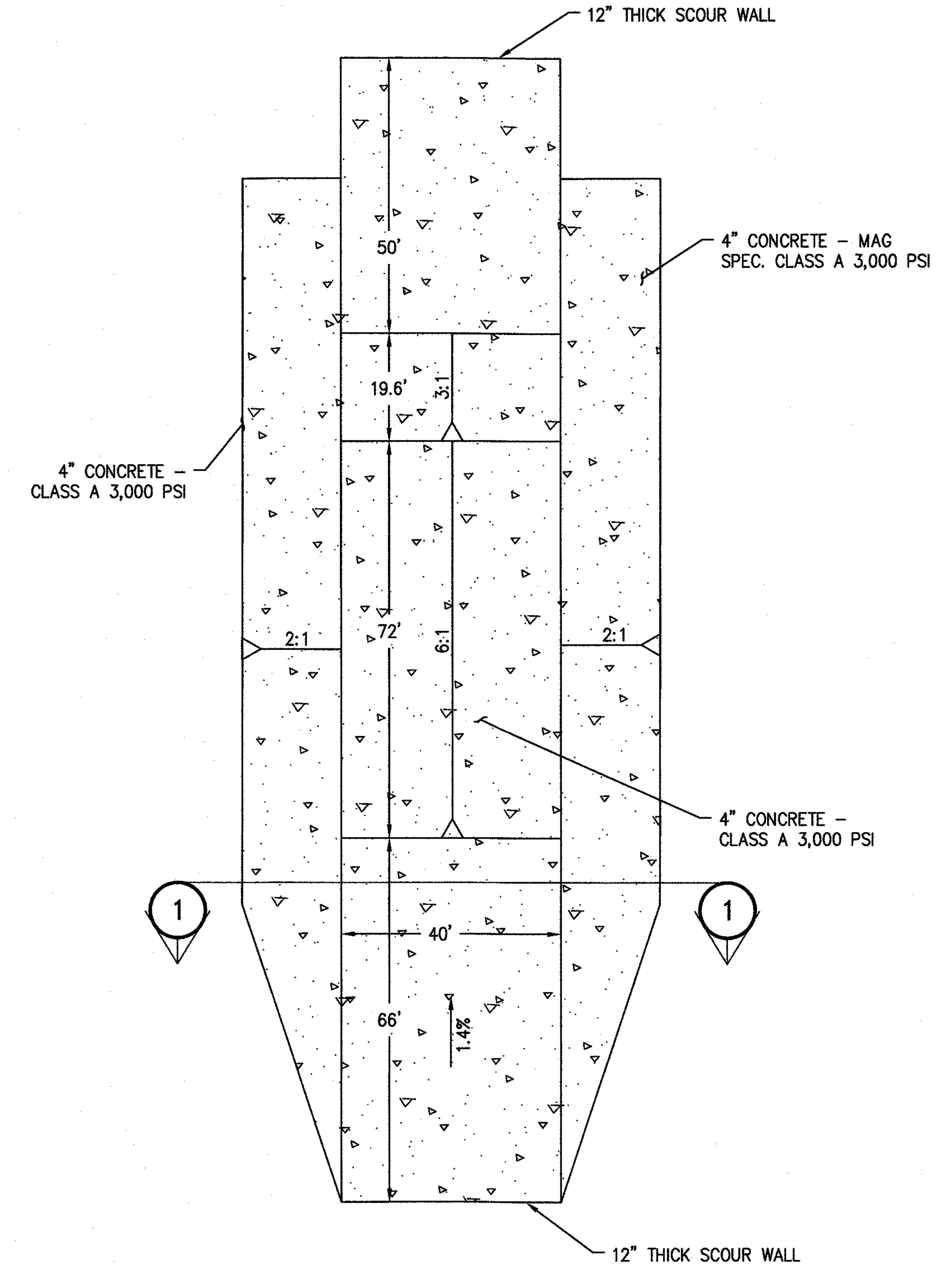
PIPE SIZE	W
12" - 21" INCL.	11"
24" - 42" INCL.	13"

DETAIL "A"

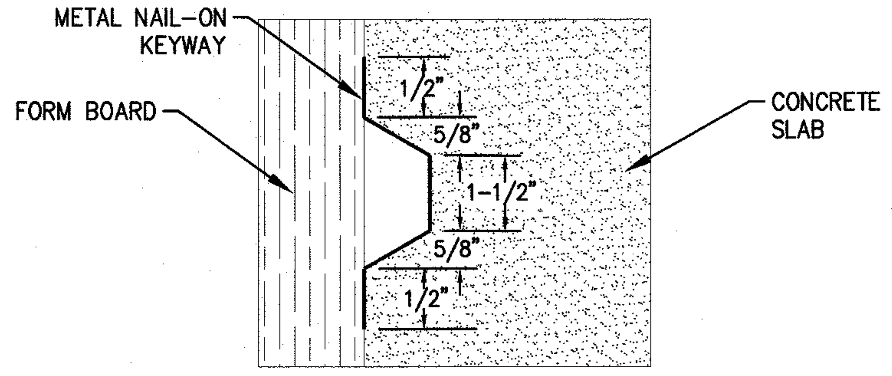
DETAIL NO.	MARICOPA ASSOCIATION of GOVERNMENTS — STANDARD DETAIL ENGLISH	HEADWALL	REVISED	DETAIL NO.
501-2			01-01-2012	501-2

CONSTRUCTION NOTES

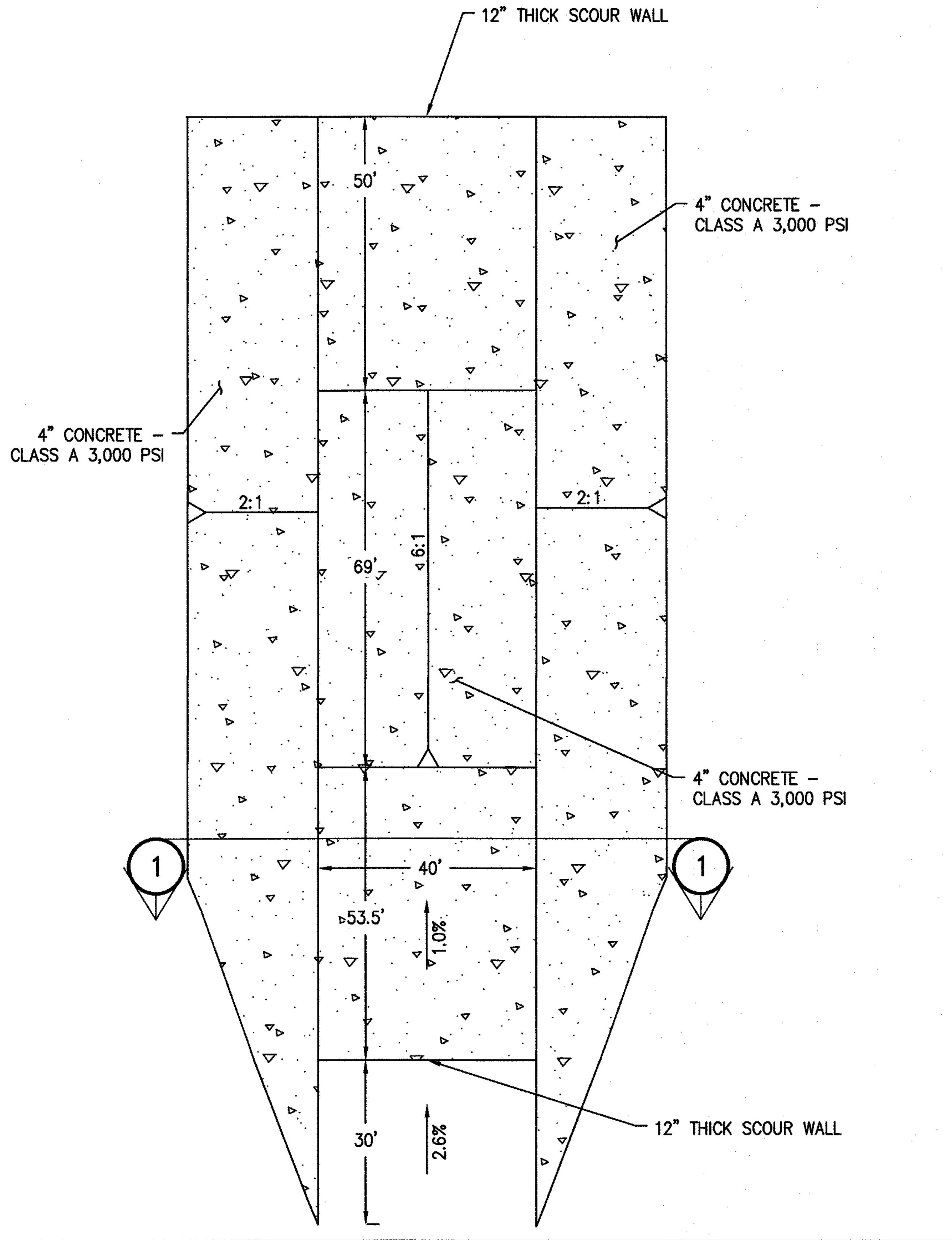
CONTROL JOINTS TO BE PLACED EVERY 10 FEET ON CENTER WITH 1/2" TOOLED JOINT.
KEYWAYS TO BE PLACED AT COLD JOINTS AND SPILLWAY FLOOR/ SIDE WALL INTERSECTIONS (SEE DETAIL 4)
CONCRETE COMPRESSION TESTING USING CYLINDER SPECIMENS SHALL BE MADE FOR EVERY 50 CY OR NOT LESS THAN EACH HALF DAYS PLACEMENT PER MAG SPEC 725.8.2.



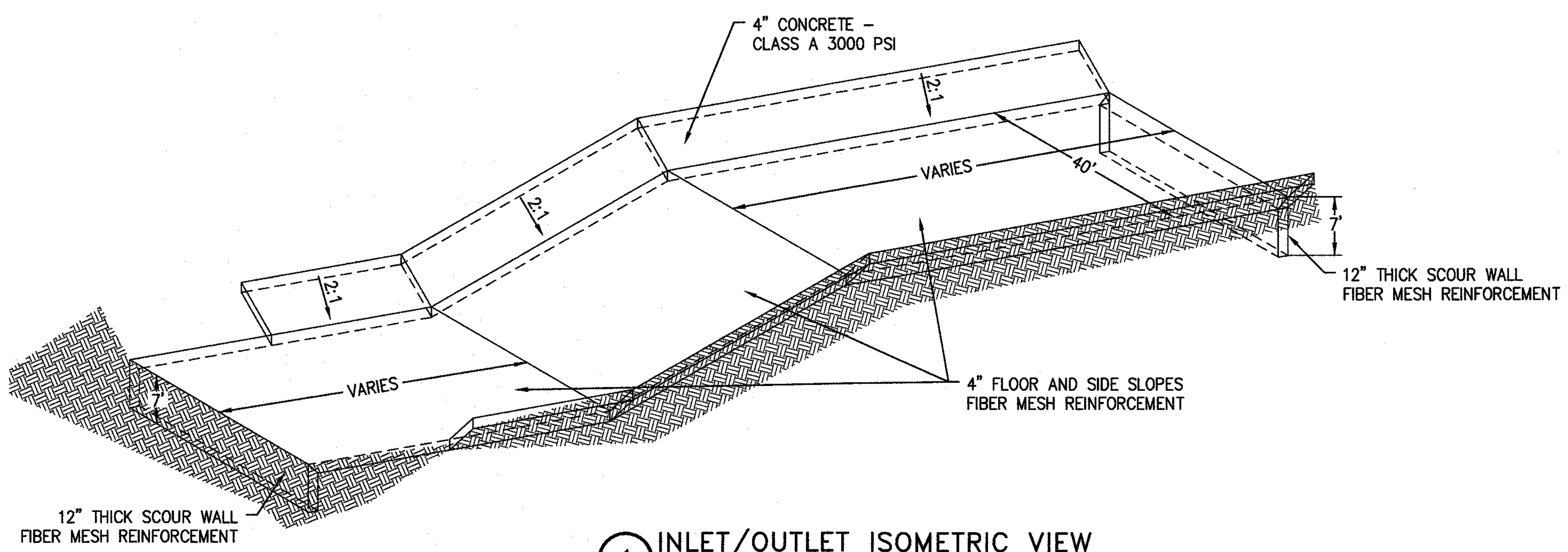
3 OUTLET PLAN VIEW
N.T.S.



4 KEYWAY DETAIL
N.T.S.



2 INLET PLAN VIEW
N.T.S.



1 INLET/OUTLET ISOMETRIC VIEW
N.T.S.

Call at least two full working days before you begin excavation.
ARIZONA 811
Arizona Blue Stake, Inc.
Dial 8-1-1 or 1-800-STAKE-IT (782-5348)
In Maricopa County: (602) 263-1100

REGISTERED PROFESSIONAL ENGINEER (CIVIL) CERTIFICATE NO. 49011 AUBREY J. THOMAS ARIZONA U.S.A. Expires 12/31/2017

HORSESHOE DRAW

COCHISE COUNTY, ARIZONA

DETAILS

PROJ. NO.	1472	HILGARTWILSON	
DATE:	JAN. 2017		
SCALE:	AS SHOWN		
DESIGNED: HW	DRAWN: ARK	APPROVED: AT	
REV.			DWG. NO. C1.5
			SHT. 5 OF 7

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HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

APPENDIX D

EMBANKMENT AND DETENTION BASIN SUPPORTING CALCULATIONS

Channel Report

Basin Inlet

Trapezoidal

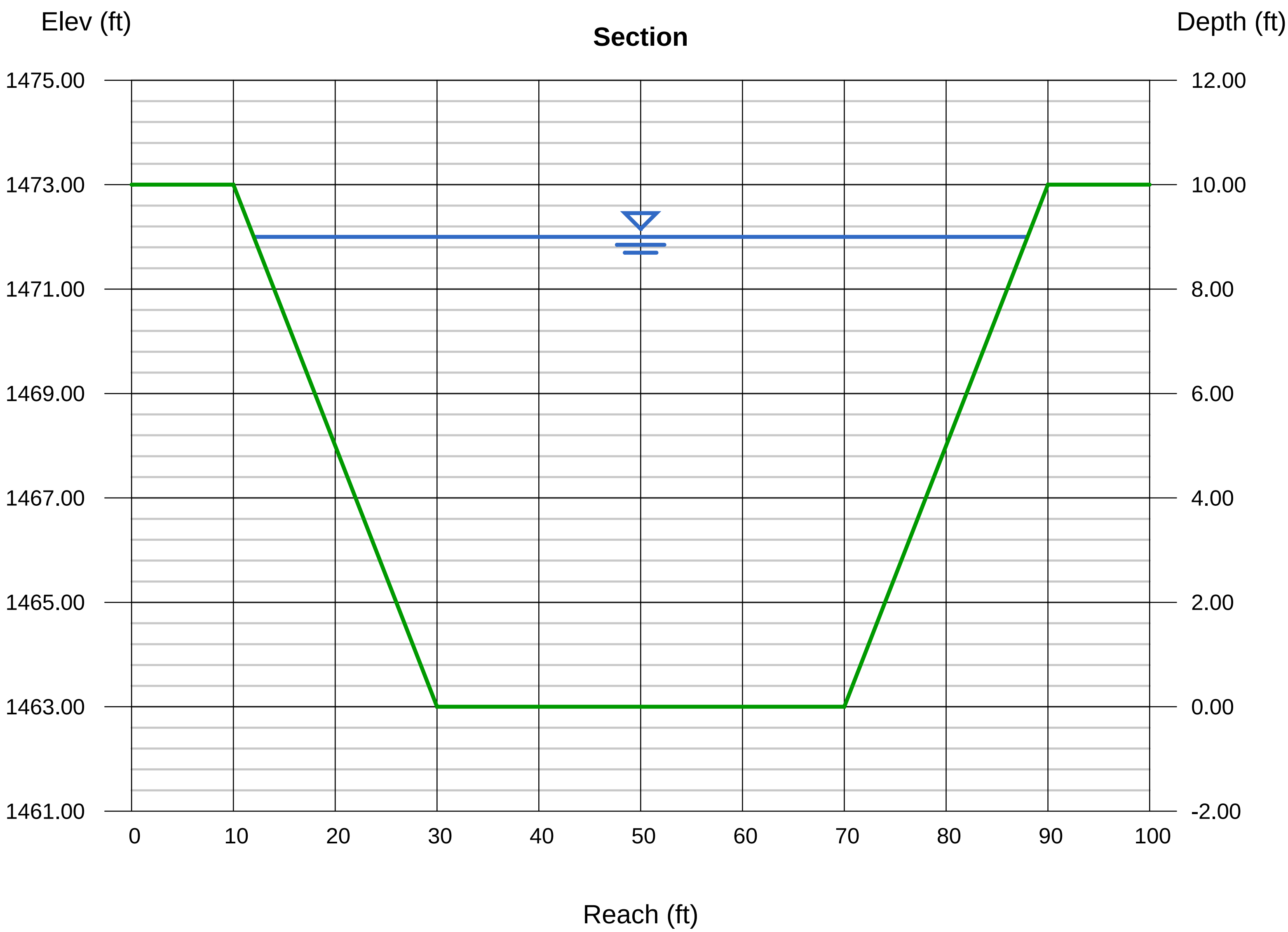
Bottom Width (ft)	=	40.00
Side Slopes (z:1)	=	2.00, 2.00
Total Depth (ft)	=	10.00
Invert Elev (ft)	=	1463.00
Slope (%)	=	0.50
N-Value	=	0.025

Calculations

Compute by:		Q vs Depth
No. Increments	=	10

Highlighted

Depth (ft)	=	9.00
Q (cfs)	=	7,650
Area (sqft)	=	522.00
Velocity (ft/s)	=	14.66
Wetted Perim (ft)	=	80.25
Crit Depth, Yc (ft)	=	8.93
Top Width (ft)	=	76.00
EGL (ft)	=	12.34



EMBANKMENT ELEVATION-STORAGE-DISCHARGE RELATIONSHIP

Project: Horseshoe Draw

Prepared by: HW

Date: December 2016

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Elevation	Storage [ac-ft]	Discharge [ft^3/s]		
		Primary Outlet(1)	Emergency(2)	Total
4371	238	292	6160	6452
4369	207	288	3665	3953
4367	178	271	1795	2066
4365	157	253	547	800
4363	131	235	0	235
4361	106	214	0	214
4359	71	191	0	191
4357	50	165	0	165
4355	30	134	0	134
4353	12	94	0	94
4351	2	17	0	17
4350	0	0	0	0

Notes:

(1) Calculations below are for the total flow from Primary outlet (3-36" CMPs).

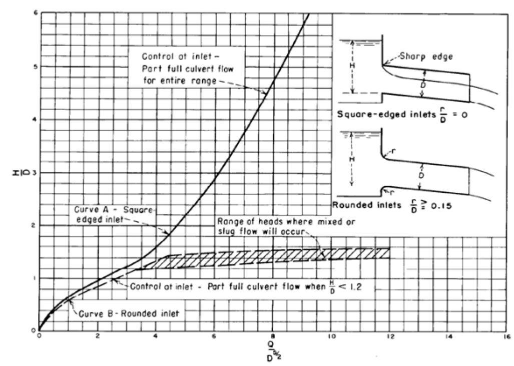
(2) Emergency Spillway outlet elevation-discharge calculated in Hydraflow.

USBR; Design of Small Dams, Equation 33

$$\frac{H}{D}+\frac{L}{D}\sin\theta-1.0=0.0252\left(1+K_e+\frac{29.1n^2L}{r^{4/3}}\right)\left(\frac{Q}{D^{5/2}}\right)^2$$

Rearange and solve for Q

$$Q=D^{5/2}\left[\frac{\left(\frac{H}{D}+\frac{L}{D}\sin\theta-1.0\right)}{0.0252\left(1+K_e+\frac{29.1n^2L}{r^{4/3}}\right)}\right]^{1/2}$$



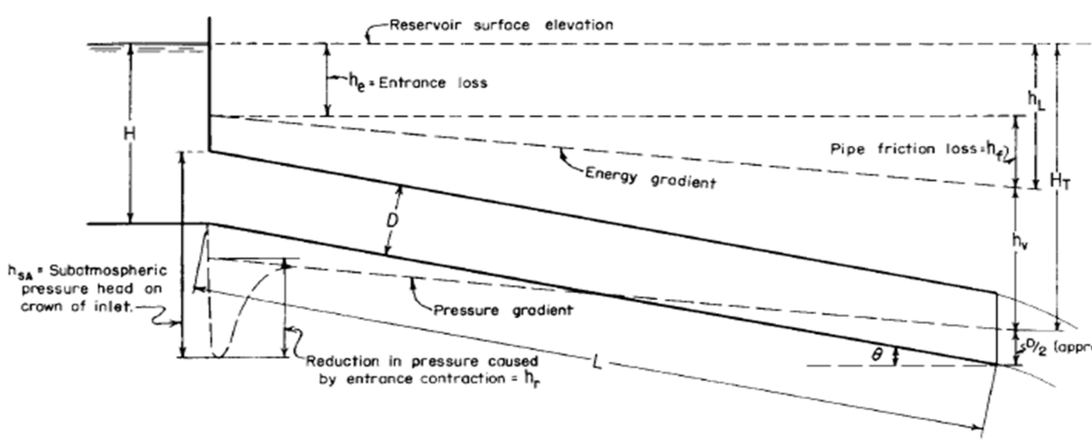


Figure 9-69.—Hydraulic characteristics of full pipe flow for culvert spillways. 288–D–2519.

CULVERT RIPRAP SIZING CALCULATION

Project: Horseshoe Draw

Prepared by: HW

Date: December 2016

HILGARTWILSON
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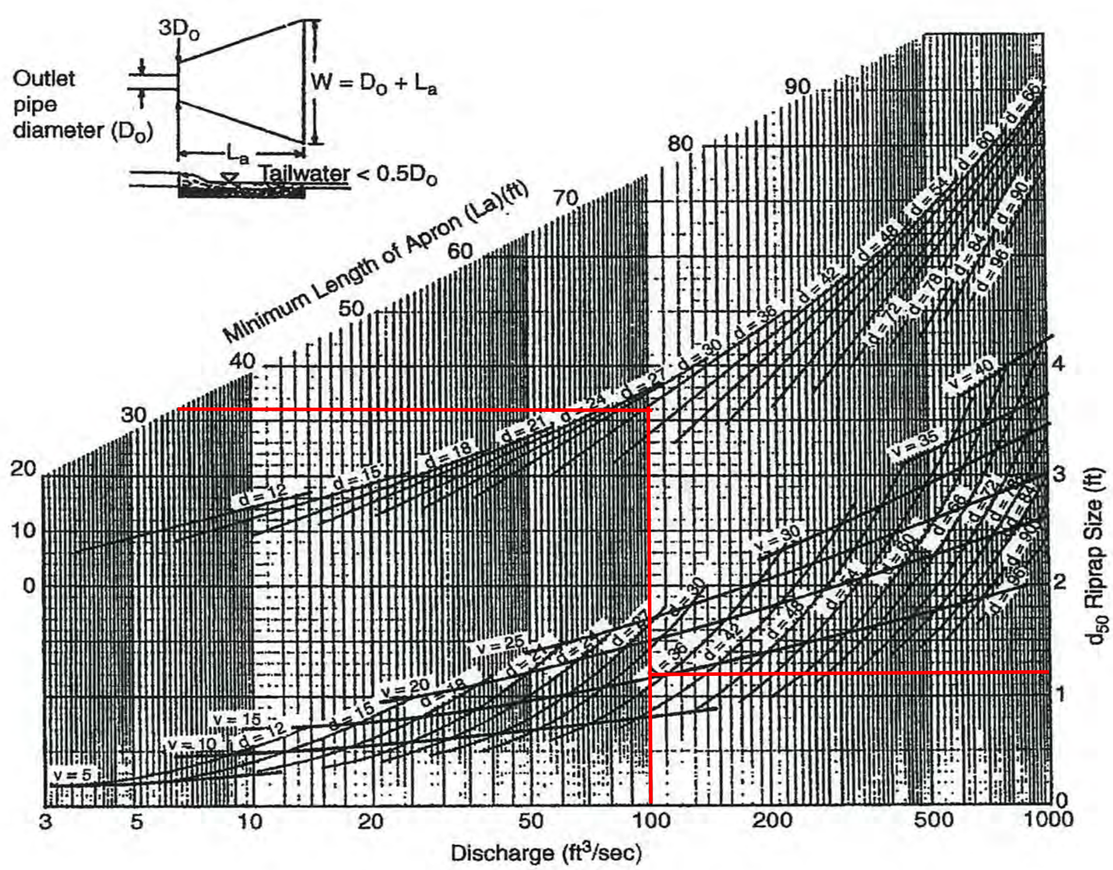
Outlet ID	Quantity	Pipe Water Height (in)	100 YR Discharge Flow(2) [Q] (cfs)	100 YR Velocity(2) [V] (ft/s)	Depth of Flow [d] (ft)	Width$_1$=3Do W_1 (ft)	Minimum Length of Apron [La] (ft)	Width$_2$ =Do+La W_2 (ft)	Minimum Riprap Size Required [d_{50}] (in)
Primary	3	36	97	14.0	3.0	27.0	32.0	41.0	15"

Notes

(1) **Source:** Thomas N. Debo, Andre J. Reese. *Municipal Stormwater Management* . Figure 12-3

(2) Flow and velocity obtained from *USBR Design of Small Dams* (USBR 1987), Equation 33 calculation.



Curves may not be extrapolated.

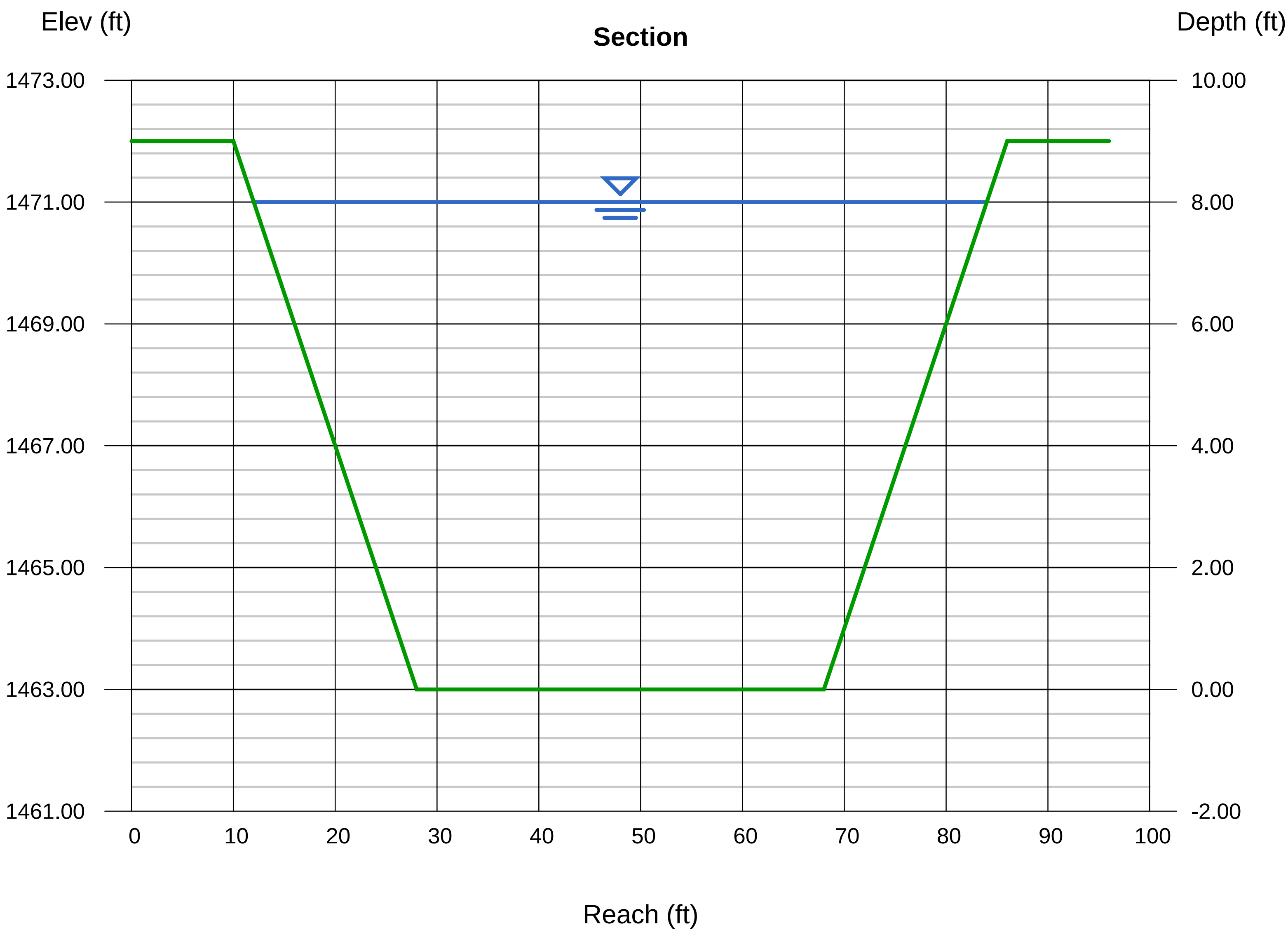
FIGURE 12-2
Riprap apron under minimum tailwater conditions. (From U.S. Department of Agriculture, Soil Conservation Service, Standards and Specifications for Soil Erosion and Sedimentation in Developing Areas, Washington, DC, 1975.)

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Dec 16 2016

Basin Emergency Outlet

Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 40.00	Depth (ft)	= 8.00
Side Slopes (z:1)	= 2.00, 2.00	Q (cfs)	= 6,160
Total Depth (ft)	= 9.00	Area (sqft)	= 448.00
Invert Elev (ft)	= 1463.00	Velocity (ft/s)	= 13.75
Slope (%)	= 0.50	Wetted Perim (ft)	= 75.78
N-Value	= 0.025	Crit Depth, Yc (ft)	= 7.87
		Top Width (ft)	= 72.00
Calculations		EGL (ft)	= 10.94
Compute by:	Q vs Depth		
No. Increments	= 9		

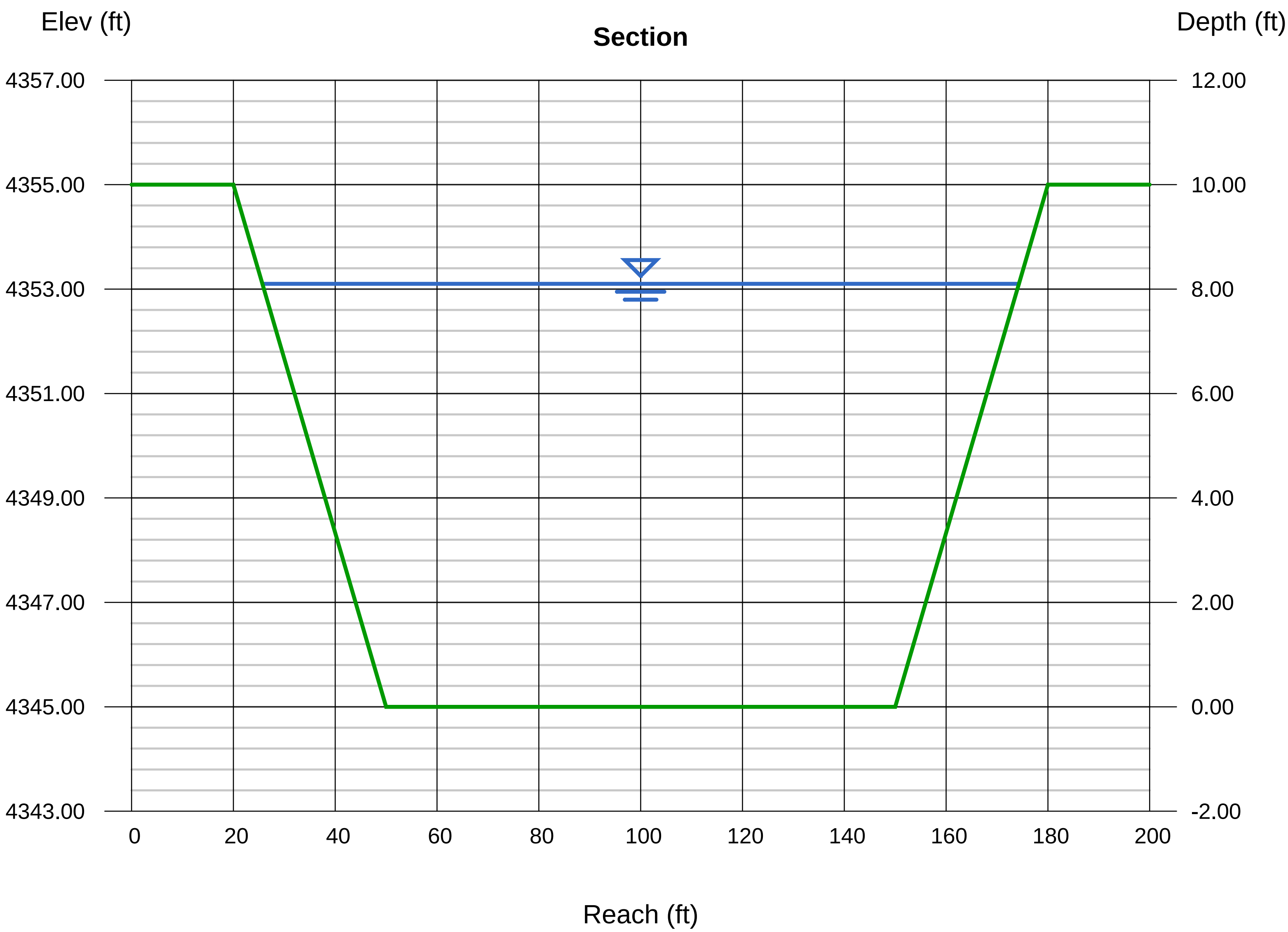


Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Friday, Dec 16 2016

Outlet Channel

Trapezoidal		Highlighted	
Bottom Width (ft)	= 100.00	Depth (ft)	= 8.10
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 4,781
Total Depth (ft)	= 10.00	Area (sqft)	= 1006.84
Invert Elev (ft)	= 4345.00	Velocity (ft/s)	= 4.75
Slope (%)	= 0.10	Wetted Perim (ft)	= 151.23
N-Value	= 0.035	Crit Depth, Yc (ft)	= 3.98
		Top Width (ft)	= 148.60
Calculations		EGL (ft)	= 8.45
Compute by:	Known Q		
Known Q (cfs)	= 4781.00		



SCOUR DEPTH CALCULATION

Project: Horseshoe Draw

Prepared by: HW

Date: December 2016

Flowrate: Peak flowrate values were taken from HEC-HMS analysis.

Flowrate 4821 **cfs**

General Scour- Regime Equations

1. Lacey's Equation

$$y_{gs} = k_l * 0.47 (Q / f)^{1/3}$$

where: y_{gs} = general scour depth (ft)
k_l = adjustment coefficient for Lacey's Equation (0.25 for straight reaches)
Q = design discharge, (ft^3/s)
f = Lacey's silt factor = $1.76(D_m)^{1/2}$
D_m = mean grain size of bed material, (mm)

D_m	f	Q	k_l	y_{gs}
0.1	0.5566	4821	0.25	**2.4**

2. Blench Equation

$$y_{gs} = k_b * [q_f^{2/3} / F_{b0}^{1/3}]$$

where: y_{gs} = general scour depth (ft)
k_b = adjustment coefficient for Blench's Equation (0.6)
q_f = design discharge per unit width ($ft^3/s/ft$)
F_{b0} = Blench's "zero bed factor" in ft/s^2 from *Chart for Estimating F_{b0}* (Pemberton and Lara, 1984)

k_b	q_f	F_{b0}	y_{gs}
0.6	44.23	1.05	**7.4**

Long Term Degradation

Arizona State Standard SSA 5-96 Level I (1996)

$$d_{lts} = 0.02 (Q_{100})^{0.6}$$

where: d_{lts} = long term scour depth, (ft)
Q_{100} = 100-year peak flowrate, (ft^3/s)

Q_{100}	d_{lts}
4821	**3.2**

Bedform Scour

Simons and Senturn (1992)

$$y_{bfs} = 0.5\ d_h$$

where:
- y_{bfs} = bedform scour depth, (ft)
- d_h = dune height for subcritical flow with $F_r < 0.7$, (ft)
  - $d_h = 0.066 * Y_h^{1.21}$
- d_h = dune height for supercritical flow with $F_r > 0.7$, (ft)
  - $d_h = 0.28 * \pi * Y_h * F_r^2$
- Y_h = hydraulic Depth of Flow (ft)
- F_r = Froude number

Y_h	F_r	d_h	y_{bfs}
1.26	4.52	22.64	**11.3**

Average General Scour Depth =	**4.9**	**ft**
Long Term Degradation Depth =	**3.2**	**ft**
Bedform Scour Depth =	**11.3**	**ft**
Low Flow Scour =	**1.5**	
Factor of Safety =	**1.3**	
Design Scour Depth =	**27.3**	**ft**

Note:

Extending the cutoff protection below the total theoretical scour depth is cost prohibitive. The proposed 7 foot scour wall will provide a significant level of protection to the portions of the spillway that are vulnerable to scour. These areas, along with all other portions of the project that are subject to concentrated flow will need to be inspected and maintained after large storm events.

APPENDIX E

HYDROLOGIC HEC-HMS RESULTS AND COMPARISON

HEC-HMS FLOW REDUCTION AND DEWATERING SUMMARY

Project: Horseshoe Draw

Prepared by: HW

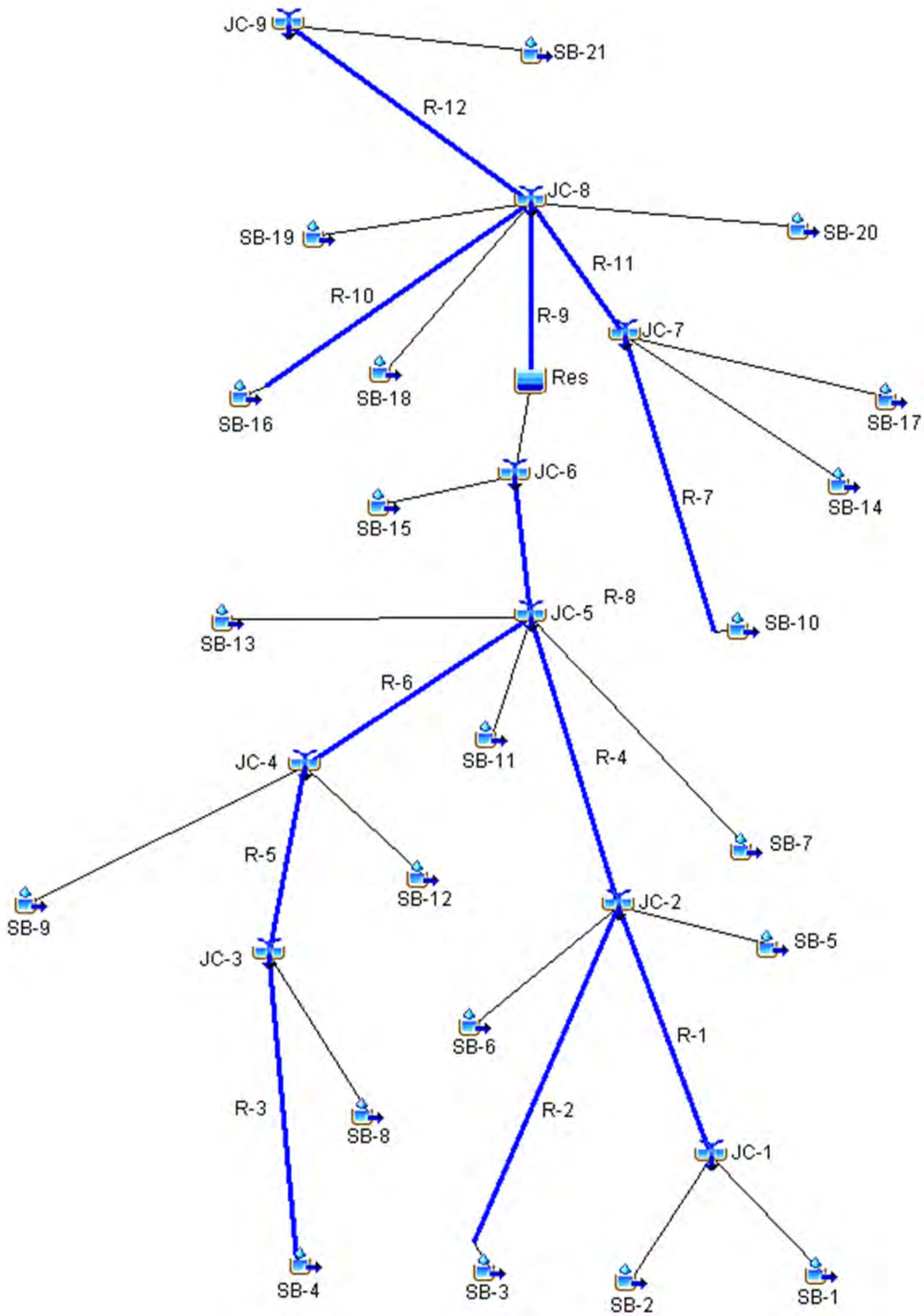
Date: December 2016

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Storm Event	Peak Storage [ac-ft]	Inlfow [cfs]	Outflow [cfs]	Percent Reduction	Dewatering Duration(1) [hrs]
2-Year	148	1155	613	47%	10.6
10-Year	180	2,369	2,222	6%	11.6
25-Year	195	3,256	3,178	2%	11.9
50-Year	207	4,003	3,940	-	12.0
100-Year	217	4,821	4,781	-	12.2

Notes:

(1) Dewatering duration based based on time of final inflow - time of final outflow.



JC-9
SB-21
R-12
JC-8
SB-19
SB-20
R-11
R-10
R-9
JC-7
Res
SB-16
SB-18
SB-17
JC-6
R-7
SB-15
SB-14
R-8
JC-5
SB-10
SB-13
R-6
JC-4
SB-11
R-4
SB-7
R-5
SB-12
SB-9
JC-2
SB-5
JC-3
SB-6
R-1
R-3
R-2
SB-8
JC-1
SB-4
SB-3
SB-2
SB-1

Project: HSD EMBANKMENT Simulation Run: Run 1

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 23:00	Meteorologic Model:	Met 1: 2-YR
Compute Time:	16Dec2016, 09:42:08	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	1.027	35.1	01Jan2016, 05:00	6.8
SB-2	1.064	34.9	01Jan2016, 04:50	7.0
JC-1	2.091	69.9	01Jan2016, 04:55	13.8
R-1	2.091	69.9	01Jan2016, 05:30	13.8
SB-3	0.323	10.5	01Jan2016, 05:00	2.1
R-2	0.323	10.5	01Jan2016, 05:20	2.1
SB-5	1.113	173.0	01Jan2016, 04:40	31.0
SB-6	0.854	126.8	01Jan2016, 04:40	23.8
JC-2	4.381	342.1	01Jan2016, 04:55	70.6
R-4	4.381	342.1	01Jan2016, 06:00	70.6
SB-7	2.093	323.8	01Jan2016, 04:40	58.2
SB-11	0.539	86.5	01Jan2016, 04:40	15.0
SB-4	1.003	33.5	01Jan2016, 04:55	6.6
R-3	1.003	33.5	01Jan2016, 05:40	6.6
SB-8	2.19	340.9	01Jan2016, 04:35	60.9
JC-3	3.193	341.9	01Jan2016, 04:40	67.5
R-5	3.193	341.9	01Jan2016, 05:00	67.5
SB-9	0.854	138.5	01Jan2016, 04:45	23.8
SB-12	0.73	117.4	01Jan2016, 04:45	20.3
JC-4	4.777	590.6	01Jan2016, 04:50	111.6
R-6	4.777	589.7	01Jan2016, 05:05	111.6
SB-13	0.249	19.3	01Jan2016, 04:45	3.7
JC-5	12.039	1147.0	01Jan2016, 05:20	259.0
R-8	12.039	1146.0	01Jan2016, 05:25	259.0
SB-15	0.141	10.5	01Jan2016, 04:45	2.1
JC-6	12.180	1154.5	01Jan2016, 05:25	261.1
Res	12.180	612.7	01Jan2016, 06:55	261.1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
R-9	12.180	612.4	01Jan2016, 07:20	261.1
SB-10	0.826	139.0	01Jan2016, 04:45	23.0
R-7	0.826	138.8	01Jan2016, 05:10	23.0
SB-14	0.733	63.3	01Jan2016, 04:55	10.8
SB-17	0.641	107.5	01Jan2016, 04:45	17.8
JC-7	2.200	297.5	01Jan2016, 05:00	51.6
R-11	2.200	297.4	01Jan2016, 05:15	51.6
SB-16	0.967	85.8	01Jan2016, 04:55	14.2
R-10	0.967	85.7	01Jan2016, 05:10	14.2
SB-18	0.738	62.9	01Jan2016, 04:50	10.9
SB-19	0.406	63.4	01Jan2016, 04:40	11.3
SB-20	0.316	47.9	01Jan2016, 04:40	8.8
JC-8	16.807	724.7	01Jan2016, 07:10	357.9
R-12	16.807	724.1	01Jan2016, 07:20	357.9
SB-21	0.036	5.3	01Jan2016, 04:35	1.0
JC-9	16.843	725.0	01Jan2016, 07:20	358.9

Project: HSD EMBANKMENT Simulation Run: Run 1

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 23:00	Meteorologic Model:	Met 1: 2-YR
Compute Time:	16Dec2016, 09:43:42	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	1.027	118.0	01Jan2016, 04:45	22.4
SB-2	1.064	117.2	01Jan2016, 04:45	23.2
JC-1	2.091	235.1	01Jan2016, 04:45	45.6
R-1	2.091	234.4	01Jan2016, 05:15	45.6
SB-3	0.323	35.3	01Jan2016, 04:45	7.0
R-2	0.323	35.3	01Jan2016, 05:05	7.0
SB-5	1.113	352.5	01Jan2016, 04:35	62.7
SB-6	0.854	258.6	01Jan2016, 04:30	48.1
JC-2	4.381	799.9	01Jan2016, 04:55	163.4
R-4	4.381	799.9	01Jan2016, 06:00	163.4
SB-7	2.093	659.9	01Jan2016, 04:35	117.9
SB-11	0.539	175.7	01Jan2016, 04:35	30.4
SB-4	1.003	112.6	01Jan2016, 04:45	21.9
R-3	1.003	112.5	01Jan2016, 05:30	21.9
SB-8	2.19	694.3	01Jan2016, 04:30	123.4
JC-3	3.193	714.3	01Jan2016, 04:45	145.2
R-5	3.193	714.3	01Jan2016, 05:05	145.2
SB-9	0.854	281.4	01Jan2016, 04:40	48.1
SB-12	0.73	238.6	01Jan2016, 04:40	41.1
JC-4	4.777	1204.1	01Jan2016, 04:50	234.5
R-6	4.777	1201.5	01Jan2016, 05:00	234.5
SB-13	0.249	48.1	01Jan2016, 04:35	9.1
JC-5	12.039	2349.9	01Jan2016, 05:20	555.3
R-8	12.039	2349.4	01Jan2016, 05:25	555.3
SB-15	0.141	26.3	01Jan2016, 04:35	5.1
JC-6	12.180	2368.9	01Jan2016, 05:25	560.4
Res	12.180	2221.7	01Jan2016, 05:55	560.4

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
R-9	12.180	2220.6	01Jan2016, 06:20	560.4
SB-10	0.826	281.7	01Jan2016, 04:40	46.5
R-7	0.826	280.7	01Jan2016, 05:05	46.5
SB-14	0.733	158.6	01Jan2016, 04:45	26.6
SB-17	0.641	217.6	01Jan2016, 04:40	36.1
JC-7	2.200	628.1	01Jan2016, 05:00	109.3
R-11	2.200	628.0	01Jan2016, 05:10	109.3
SB-16	0.967	214.2	01Jan2016, 04:50	35.2
R-10	0.967	214.1	01Jan2016, 05:05	35.2
SB-18	0.738	157.2	01Jan2016, 04:45	26.8
SB-19	0.406	129.0	01Jan2016, 04:35	22.9
SB-20	0.316	97.6	01Jan2016, 04:35	17.8
JC-8	16.807	2810.8	01Jan2016, 06:15	772.4
R-12	16.807	2808.9	01Jan2016, 06:20	772.4
SB-21	0.036	10.7	01Jan2016, 04:30	2.0
JC-9	16.843	2813.0	01Jan2016, 06:20	774.4

Project: HSD EMBANKMENT Simulation Run: Run 1

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 23:00	Meteorologic Model:	Met 1: 2-YR
Compute Time:	16Dec2016, 09:44:29	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	1.027	189.5	01Jan2016, 04:40	35.6
SB-2	1.064	187.8	01Jan2016, 04:35	36.9
JC-1	2.091	376.2	01Jan2016, 04:40	72.6
R-1	2.091	375.9	01Jan2016, 05:10	72.6
SB-3	0.323	56.6	01Jan2016, 04:40	11.2
R-2	0.323	56.6	01Jan2016, 05:00	11.2
SB-5	1.113	477.6	01Jan2016, 04:35	85.3
SB-6	0.854	350.8	01Jan2016, 04:30	65.5
JC-2	4.381	1151.7	01Jan2016, 04:55	234.6
R-4	4.381	1151.7	01Jan2016, 06:00	234.6
SB-7	2.093	894.2	01Jan2016, 04:30	160.5
SB-11	0.539	238.6	01Jan2016, 04:35	41.3
SB-4	1.003	180.6	01Jan2016, 04:35	34.8
R-3	1.003	180.2	01Jan2016, 05:20	34.8
SB-8	2.19	943.1	01Jan2016, 04:30	167.9
JC-3	3.193	990.0	01Jan2016, 04:45	202.7
R-5	3.193	990.0	01Jan2016, 05:05	202.7
SB-9	0.854	381.3	01Jan2016, 04:40	65.5
SB-12	0.73	323.3	01Jan2016, 04:35	56.0
JC-4	4.777	1641.3	01Jan2016, 04:50	324.1
R-6	4.777	1638.7	01Jan2016, 05:00	324.1
SB-13	0.249	70.5	01Jan2016, 04:35	13.2
JC-5	12.039	3231.3	01Jan2016, 05:20	773.7
R-8	12.039	3228.3	01Jan2016, 05:25	773.7
SB-15	0.141	38.5	01Jan2016, 04:35	7.5
JC-6	12.180	3256.2	01Jan2016, 05:25	781.2
Res	12.180	3178.7	01Jan2016, 05:45	781.2

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
R-9	12.180	3176.3	01Jan2016, 06:10	781.2
SB-10	0.826	382.1	01Jan2016, 04:40	63.3
R-7	0.826	381.5	01Jan2016, 05:05	63.3
SB-14	0.733	231.6	01Jan2016, 04:45	38.9
SB-17	0.641	295.5	01Jan2016, 04:40	49.1
JC-7	2.200	868.0	01Jan2016, 04:55	151.3
R-11	2.200	865.7	01Jan2016, 05:10	151.3
SB-16	0.967	313.1	01Jan2016, 04:45	51.3
R-10	0.967	312.4	01Jan2016, 05:00	51.3
SB-18	0.738	229.9	01Jan2016, 04:40	39.1
SB-19	0.406	175.0	01Jan2016, 04:35	31.1
SB-20	0.316	132.6	01Jan2016, 04:30	24.2
JC-8	16.807	4102.8	01Jan2016, 06:00	1078.3
R-12	16.807	4095.8	01Jan2016, 06:10	1078.3
SB-21	0.036	14.6	01Jan2016, 04:30	2.8
JC-9	16.843	4102.0	01Jan2016, 06:10	1081.0

Project: HSD EMBANKMENT Simulation Run: Run 1

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 23:00	Meteorologic Model:	Met 1: 2-YR
Compute Time:	16Dec2016, 09:44:50	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	1.027	254.4	01Jan2016, 04:40	47.6
SB-2	1.064	252.6	01Jan2016, 04:35	49.4
JC-1	2.091	506.3	01Jan2016, 04:35	97.0
R-1	2.091	505.5	01Jan2016, 05:10	97.0
SB-3	0.323	76.1	01Jan2016, 04:40	15.0
R-2	0.323	76.1	01Jan2016, 05:00	15.0
SB-5	1.113	583.4	01Jan2016, 04:30	104.3
SB-6	0.854	428.4	01Jan2016, 04:30	80.0
JC-2	4.381	1455.0	01Jan2016, 04:50	296.2
R-4	4.381	1455.0	01Jan2016, 05:55	296.2
SB-7	2.093	1092.4	01Jan2016, 04:30	196.1
SB-11	0.539	291.0	01Jan2016, 04:35	50.5
SB-4	1.003	243.0	01Jan2016, 04:35	46.5
R-3	1.003	242.5	01Jan2016, 05:20	46.5
SB-8	2.19	1151.5	01Jan2016, 04:30	205.2
JC-3	3.193	1221.5	01Jan2016, 04:45	251.7
R-5	3.193	1221.5	01Jan2016, 05:05	251.7
SB-9	0.854	465.3	01Jan2016, 04:35	80.0
SB-12	0.73	394.7	01Jan2016, 04:35	68.4
JC-4	4.777	2010.8	01Jan2016, 04:50	400.1
R-6	4.777	2007.9	01Jan2016, 05:00	400.1
SB-13	0.249	89.7	01Jan2016, 04:35	16.8
JC-5	12.039	3971.8	01Jan2016, 05:20	959.7
R-8	12.039	3969.8	01Jan2016, 05:30	959.7
SB-15	0.141	49.0	01Jan2016, 04:35	9.5
JC-6	12.180	4003.1	01Jan2016, 05:30	969.2
Res	12.180	3939.8	01Jan2016, 05:45	969.2

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
R-9	12.180	3938.9	01Jan2016, 06:10	969.2
SB-10	0.826	465.4	01Jan2016, 04:40	77.4
R-7	0.826	465.1	01Jan2016, 05:05	77.4
SB-14	0.733	294.8	01Jan2016, 04:40	49.5
SB-17	0.641	360.1	01Jan2016, 04:40	60.1
JC-7	2.200	1066.9	01Jan2016, 04:55	186.9
R-11	2.200	1064.3	01Jan2016, 05:05	186.9
SB-16	0.967	398.7	01Jan2016, 04:45	65.2
R-10	0.967	398.2	01Jan2016, 05:00	65.2
SB-18	0.738	293.2	01Jan2016, 04:40	49.8
SB-19	0.406	213.4	01Jan2016, 04:35	38.0
SB-20	0.316	161.9	01Jan2016, 04:30	29.6
JC-8	16.807	5123.9	01Jan2016, 05:55	1338.8
R-12	16.807	5120.1	01Jan2016, 06:00	1338.8
SB-21	0.036	17.8	01Jan2016, 04:30	3.4
JC-9	16.843	5128.4	01Jan2016, 06:00	1342.1

Project: HSD EMBANKMENT Simulation Run: Run 1

Start of Run:	01Jan2016, 00:00	Basin Model:	Basin 1
End of Run:	02Jan2016, 23:00	Meteorologic Model:	Met 1: 2-YR
Compute Time:	16Dec2016, 09:45:13	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
SB-1	1.027	328.3	01Jan2016, 04:35	61.3
SB-2	1.064	325.3	01Jan2016, 04:35	63.5
JC-1	2.091	653.6	01Jan2016, 04:35	124.9
R-1	2.091	651.4	01Jan2016, 05:10	124.9
SB-3	0.323	98.1	01Jan2016, 04:35	19.3
R-2	0.323	98.1	01Jan2016, 04:55	19.3
SB-5	1.113	696.4	01Jan2016, 04:30	124.8
SB-6	0.854	511.4	01Jan2016, 04:30	95.7
JC-2	4.381	1793.8	01Jan2016, 04:50	364.6
R-4	4.381	1793.8	01Jan2016, 05:55	364.6
SB-7	2.093	1304.1	01Jan2016, 04:30	234.6
SB-11	0.539	346.9	01Jan2016, 04:35	60.4
SB-4	1.003	313.2	01Jan2016, 04:35	59.9
R-3	1.003	313.0	01Jan2016, 05:20	59.9
SB-8	2.19	1374.2	01Jan2016, 04:30	245.5
JC-3	3.193	1475.8	01Jan2016, 04:45	305.4
R-5	3.193	1475.8	01Jan2016, 05:05	305.4
SB-9	0.854	555.2	01Jan2016, 04:35	95.7
SB-12	0.73	470.9	01Jan2016, 04:35	81.8
JC-4	4.777	2409.3	01Jan2016, 04:50	482.9
R-6	4.777	2405.8	01Jan2016, 05:00	482.9
SB-13	0.249	111.1	01Jan2016, 04:30	20.8
JC-5	12.039	4780.4	01Jan2016, 05:25	1163.4
R-8	12.039	4780.3	01Jan2016, 05:30	1163.4
SB-15	0.141	60.6	01Jan2016, 04:30	11.8
JC-6	12.180	4820.7	01Jan2016, 05:30	1175.1
Res	12.180	4780.7	01Jan2016, 05:40	1175.1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
R-9	12.180	4778.1	01Jan2016, 06:05	1175.1
SB-10	0.826	554.6	01Jan2016, 04:35	92.6
R-7	0.826	554.4	01Jan2016, 05:05	92.6
SB-14	0.733	364.9	01Jan2016, 04:40	61.2
SB-17	0.641	429.0	01Jan2016, 04:40	71.9
JC-7	2.200	1283.5	01Jan2016, 04:55	225.6
R-11	2.200	1281.6	01Jan2016, 05:05	225.6
SB-16	0.967	492.5	01Jan2016, 04:45	80.7
R-10	0.967	492.3	01Jan2016, 05:00	80.7
SB-18	0.738	362.4	01Jan2016, 04:40	61.6
SB-19	0.406	254.4	01Jan2016, 04:35	45.5
SB-20	0.316	193.3	01Jan2016, 04:30	35.4
JC-8	16.807	6267.8	01Jan2016, 05:50	1624.0
R-12	16.807	6263.3	01Jan2016, 05:55	1624.0
SB-21	0.036	21.2	01Jan2016, 04:30	4.0
JC-9	16.843	6273.6	01Jan2016, 05:55	1628.1

HILGARTWILSON
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APPENDIX F
HEC-RAS SEDIMENT TRANSPORT RESULTS AND COMPARISON

SEDIMENT TRANSPORT RESULTS COMPARISON SUMMARY

Project: Horseshoe Draw

Prepared by: HW

Date: Mar 2016

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Storm Event	Mass [tons]		
	Existing	Proposed	Reduction
2-Year	43,358	42,364	994
10-Year	90,528	68,590	21,938
25-Year	115,038	85,689	29,349
50-Year	129,804	97,032	32,772
100-Year	144,882	114,646	30,236

HEC-RAS SEDIMENT TRANSPORT

FLOW DATA

TIME SERIES AND FLOW CHANGE STATION LOCATION - 2-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0	0.0
2:05	0.0	0.0	0.0	0.0	0.0
2:10	0.0	0.0	0.0	0.0	0.0
2:15	0.0	0.0	0.0	0.0	0.0
2:20	0.0	0.0	0.0	0.0	0.0
2:25	0.0	0.0	0.0	0.0	0.0
2:30	0.0	0.0	0.0	0.0	0.0
2:35	0.0	0.0	0.0	0.0	0.0
2:40	0.0	0.0	0.0	0.0	0.0
2:45	0.0	0.0	0.0	0.0	0.0
2:50	0.0	0.0	0.0	0.0	0.0
2:55	0.0	0.0	0.0	0.0	0.0
3:00	0.0	0.0	0.0	0.0	0.0
3:05	0.0	0.0	0.0	0.0	0.0
3:10	0.0	0.0	0.0	0.0	0.0
3:15	0.0	0.0	0.1	0.0	0.0
3:20	0.2	0.1	0.7	0.0	0.2
3:25	0.9	0.4	2.4	0.0	0.7
3:30	2.4	1.0	6.0	0.0	1.8
3:35	5.4	1.3	13.4	0.0	3.9
3:40	11.9	1.9	27.2	0.1	8.3
3:45	23.5	3.5	50.3	0.5	16.0
3:50	42.1	6.7	84.1	1.2	28.1
3:55	69.7	12.4	128.2	2.3	45.9
4:00	109.1	21.9	180.8	3.8	70.5
4:05	160.7	36.2	237.6	5.3	102.0
4:10	222.4	52.0	292.3	6.7	139.6
4:15	291.0	64.9	340.5	8.0	182.7
4:20	362.1	81.6	378.7	9.0	229.4
4:25	429.9	102.2	405.6	9.6	277.7
4:30	488.0	126.5	423.1	10.0	326.0
4:35	533.6	140.2	433.4	10.3	372.6

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
4:40	565.5	147.4	441.1	10.5	415.9
4:45	583.8	155.5	449.6	10.5	453.8
4:50	590.6	164.2	461.6	10.5	485.4
4:55	589.0	171.3	477.5	10.3	509.4
5:00	583.1	178.2	497.8	10.1	525.7
5:05	574.6	185.4	522.6	10.0	534.3
5:10	563.0	192.7	547.4	9.6	535.5
5:15	548.5	198.8	566.7	9.1	530.0
5:20	532.3	205.0	579.4	8.8	518.9
5:25	514.2	211.2	585.4	8.4	503.4
5:30	493.3	217.1	585.7	8.0	484.8
5:35	470.5	222.6	583.2	7.7	464.4
5:40	447.1	228.1	580.4	7.4	442.8
5:45	424.3	233.4	577.4	7.1	420.8
5:50	403.0	246.5	573.4	6.9	398.8
5:55	383.5	262.5	567.3	6.7	377.3
6:00	365.1	277.7	557.8	6.4	356.7
6:05	347.8	292.0	545.5	6.1	336.9
6:10	331.5	305.4	530.4	5.8	317.7
6:15	314.9	316.0	511.7	5.4	299.0
6:20	298.0	323.0	488.8	5.0	280.7
6:25	281.2	329.5	463.8	4.7	262.8
6:30	263.3	335.5	439.4	4.3	245.3
6:35	244.7	340.9	415.7	4.0	228.4
6:40	226.4	345.7	393.6	3.7	211.9
6:45	208.6	350.0	372.5	3.5	195.9
6:50	192.0	353.7	351.6	3.2	180.5
6:55	177.4	357.0	332.0	3.0	165.6
7:00	163.7	359.7	314.3	2.8	151.5
7:05	151.0	362.0	297.5	2.6	138.1
7:10	139.3	396.1	281.3	2.4	125.6
7:15	128.1	415.7	265.5	2.2	114.0
7:20	117.5	423.6	249.1	2.1	103.3
7:25	107.8	423.0	232.8	1.9	93.5
7:30	98.9	415.9	217.4	1.8	84.7
7:35	90.7	404.0	202.7	1.7	76.7
7:40	83.2	388.9	188.9	1.5	69.5
7:45	76.3	371.5	175.5	1.4	63.0
7:50	70.0	361.5	162.3	1.3	57.1
7:55	64.2	360.4	149.8	1.2	51.7
8:00	58.9	359.1	138.1	1.2	46.8
8:05	54.0	357.5	127.3	1.1	42.4
8:10	49.5	355.7	117.4	1.0	38.4
8:15	45.4	353.8	108.2	0.9	34.8
8:20	41.7	351.7	99.8	0.9	31.6
8:25	38.2	349.4	92.0	0.8	28.6
8:30	35.0	347.1	84.8	0.7	25.9
8:35	32.1	344.6	78.2	0.7	23.3
8:40	29.3	342.0	72.1	0.6	21.0
8:45	26.8	339.3	66.3	0.6	18.8
8:50	24.4	336.5	61.2	0.6	16.7
8:55	22.2	333.7	56.3	0.5	14.8
9:00	20.1	330.8	51.7	0.5	13.0
9:05	18.2	327.8	47.4	0.4	11.4
9:10	16.5	324.8	43.5	0.4	9.9
9:15	14.8	321.8	39.8	0.4	8.5
9:20	13.3	318.7	36.4	0.4	7.4
9:25	11.9	315.6	33.2	0.3	6.4
9:30	10.6	312.0	30.4	0.3	5.4
9:35	9.3	306.9	27.7	0.3	4.6
9:40	8.1	301.7	25.3	0.3	3.9
9:45	7.2	296.5	23.2	0.2	3.3

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
9:50	6.3	291.4	21.2	0.2	2.8
9:55	5.5	286.3	19.4	0.2	2.4
10:00	4.9	281.3	17.7	0.2	2.0
10:05	4.3	276.3	16.1	0.2	1.8
10:10	3.8	271.3	14.7	0.1	1.4
10:15	3.3	266.4	13.3	0.1	1.3
10:20	2.9	261.5	12.0	0.1	1.1
10:25	2.6	256.7	10.8	0.1	0.8
10:30	2.3	252.0	9.8	0.1	0.7
10:35	2.0	247.3	8.8	0.1	0.6
10:40	1.8	242.7	7.9	0.1	0.4
10:45	1.6	238.1	7.1	0.1	0.4
10:50	1.4	234.6	6.2	0.0	0.3
10:55	1.2	233.2	5.6	0.0	0.2
11:00	1.1	231.9	4.9	0.0	0.2
11:05	0.9	230.5	4.4	0.0	0.1
11:10	0.8	229.2	4.0	0.0	0.1
11:15	0.7	227.8	3.5	0.0	0.0
11:20	0.6	226.5	3.1	0.0	0.0
11:25	0.5	225.2	2.8	0.0	0.1
11:30	0.4	223.8	2.5	0.0	0.0
11:35	0.3	222.5	2.2	0.0	0.0
11:40	0.2	221.2	2.0	0.0	0.0
11:45	0.2	219.9	1.8	0.0	0.0
11:50	0.2	218.6	1.5	0.0	0.0
11:55	0.2	217.3	1.3	0.0	0.0
12:00	0.1	216.0	1.1	0.0	0.0
12:05	0.1	214.7	0.9	0.0	0.0
12:10	0.1	213.4	0.8	0.0	0.0
12:15	0.1	212.0	0.7	0.0	0.0
12:20	0.1	210.6	0.6	0.0	0.0
12:25	0.1	209.2	0.4	0.0	0.0
12:30	0.1	207.8	0.4	0.0	0.0
12:35	0.0	206.5	0.3	0.0	0.0
12:40	0.0	205.1	0.2	0.0	0.0
12:45	0.0	203.8	0.3	0.0	0.0
12:50	0.0	202.4	0.2	0.0	0.0
12:55	0.0	201.1	0.2	0.0	0.0
13:00	0.0	199.8	0.2	0.0	0.0
13:05	0.0	198.5	0.1	0.0	0.0
13:10	0.0	197.2	0.1	0.0	0.0
13:15	0.0	195.9	0.1	0.0	0.0
13:20	0.0	194.6	0.1	0.0	0.0
13:25	0.0	193.3	0.0	0.0	0.0
13:30	0.0	192.0	0.0	0.0	0.0
13:35	0.0	190.5	0.0	0.0	0.0
13:40	0.0	189.0	0.0	0.0	0.0
13:45	0.0	187.4	0.0	0.0	0.0
13:50	0.0	185.9	0.0	0.0	0.0
13:55	0.0	184.4	0.0	0.0	0.0
14:00	0.0	182.9	0.0	0.0	0.0
14:05	0.0	181.4	0.0	0.0	0.0
14:10	0.0	180.0	0.0	0.0	0.0
14:15	0.0	178.5	0.0	0.0	0.0
14:20	0.0	177.0	0.0	0.0	0.0
14:25	0.0	175.6	0.0	0.0	0.0
14:30	0.0	174.2	0.0	0.0	0.0
14:35	0.0	172.8	0.0	0.0	0.0
14:40	0.0	171.4	0.0	0.0	0.0
14:45	0.0	170.0	0.0	0.0	0.0
14:50	0.0	168.6	0.0	0.0	0.0
14:55	0.0	167.2	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
15:00	0.0	165.8	0.0	0.0	0.0
15:05	0.0	163.9	0.0	0.0	0.0
15:10	0.0	162.1	0.0	0.0	0.0
15:15	0.0	160.2	0.0	0.0	0.0
15:20	0.0	158.4	0.0	0.0	0.0
15:25	0.0	156.6	0.0	0.0	0.0
15:30	0.0	154.8	0.0	0.0	0.0
15:35	0.0	153.0	0.0	0.0	0.0
15:40	0.0	151.3	0.0	0.0	0.0
15:45	0.0	149.6	0.0	0.0	0.0
15:50	0.0	147.9	0.0	0.0	0.0
15:55	0.0	146.2	0.0	0.0	0.0
16:00	0.0	144.5	0.0	0.0	0.0
16:05	0.0	142.8	0.0	0.0	0.0
16:10	0.0	141.2	0.0	0.0	0.0
16:15	0.0	139.6	0.0	0.0	0.0
16:20	0.0	138.0	0.0	0.0	0.0
16:25	0.0	136.4	0.0	0.0	0.0
16:30	0.0	131.2	0.0	0.0	0.0
16:35	0.0	124.7	0.0	0.0	0.0
16:40	0.0	118.6	0.0	0.0	0.0
16:45	0.0	112.7	0.0	0.0	0.0
16:50	0.0	107.2	0.0	0.0	0.0
16:55	0.0	101.9	0.0	0.0	0.0
17:00	0.0	96.9	0.0	0.0	0.0
17:05	0.0	92.1	0.0	0.0	0.0
17:10	0.0	87.6	0.0	0.0	0.0
17:15	0.0	83.3	0.0	0.0	0.0
17:20	0.0	79.1	0.0	0.0	0.0
17:25	0.0	75.3	0.0	0.0	0.0
17:30	0.0	71.5	0.0	0.0	0.0
17:35	0.0	68.0	0.0	0.0	0.0
17:40	0.0	64.7	0.0	0.0	0.0
17:45	0.0	61.5	0.0	0.0	0.0
17:50	0.0	58.5	0.0	0.0	0.0
17:55	0.0	55.6	0.0	0.0	0.0
18:00	0.0	52.8	0.0	0.0	0.0
18:05	0.0	50.2	0.0	0.0	0.0
18:10	0.0	47.5	0.0	0.0	0.0
18:15	0.0	42.6	0.0	0.0	0.0
18:20	0.0	38.3	0.0	0.0	0.0
18:25	0.0	34.4	0.0	0.0	0.0
18:30	0.0	30.8	0.0	0.0	0.0
18:35	0.0	27.7	0.0	0.0	0.0
18:40	0.0	24.8	0.0	0.0	0.0
18:45	0.0	22.3	0.0	0.0	0.0
18:50	0.0	20.0	0.0	0.0	0.0
18:55	0.0	18.0	0.0	0.0	0.0
19:00	0.0	16.1	0.0	0.0	0.0
19:05	0.0	14.5	0.0	0.0	0.0
19:10	0.0	13.0	0.0	0.0	0.0
19:15	0.0	11.7	0.0	0.0	0.0
19:20	0.0	10.5	0.0	0.0	0.0
19:25	0.0	9.4	0.0	0.0	0.0
19:30	0.0	8.4	0.0	0.0	0.0
19:35	0.0	7.6	0.0	0.0	0.0
19:40	0.0	6.8	0.0	0.0	0.0
19:45	0.0	6.1	0.0	0.0	0.0
19:50	0.0	5.5	0.0	0.0	0.0
19:55	0.0	4.9	0.0	0.0	0.0
20:00	0.0	4.4	0.0	0.0	0.0
20:05	0.0	4.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
20:10	0.0	3.6	0.0	0.0	0.0
20:15	0.0	3.2	0.0	0.0	0.0
20:20	0.0	2.9	0.0	0.0	0.0
20:25	0.0	2.6	0.0	0.0	0.0
20:30	0.0	2.3	0.0	0.0	0.0
20:35	0.0	2.1	0.0	0.0	0.0
20:40	0.0	1.9	0.0	0.0	0.0
20:45	0.0	1.7	0.0	0.0	0.0
20:50	0.0	1.5	0.0	0.0	0.0
20:55	0.0	1.3	0.0	0.0	0.0
21:00	0.0	1.2	0.0	0.0	0.0
21:05	0.0	1.1	0.0	0.0	0.0
21:10	0.0	0.6	0.0	0.0	0.0
21:15	0.0	0.0	0.0	0.0	0.0
21:20	0.0	0.0	0.0	0.0	0.0
21:25	0.0	0.0	0.0	0.0	0.0
21:30	0.0	0.0	0.0	0.0	0.0
21:35	0.0	0.0	0.0	0.0	0.0
21:40	0.0	0.0	0.0	0.0	0.0
21:45	0.0	0.0	0.0	0.0	0.0
21:50	0.0	0.0	0.0	0.0	0.0
21:55	0.0	0.0	0.0	0.0	0.0
22:00	0.0	0.0	0.0	0.0	0.0
22:05	0.0	0.0	0.0	0.0	0.0
22:10	0.0	0.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0	0.0

Notes:

*Lateral Inflow

TIME SERIES AND FLOW CHANGE STATION LOCATION - 10-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0	0.0
2:05	0.0	0.0	0.0	0.0	0.0
2:10	0.0	0.0	0.0	0.0	0.0
2:15	0.0	0.0	0.0	0.0	0.0
2:20	0.0	0.0	0.0	0.0	0.0
2:25	0.0	0.0	0.0	0.0	0.0
2:30	0.0	0.0	0.0	0.0	0.0
2:35	0.0	0.0	0.0	0.0	0.0
2:40	0.0	0.0	0.1	0.0	0.0
2:45	0.1	0.0	0.2	0.0	0.1
2:50	0.2	0.1	0.6	0.0	0.2
2:55	0.6	0.4	1.3	0.0	0.4
3:00	1.2	1.0	2.6	0.0	0.8
3:05	2.2	1.1	4.7	0.0	1.4
3:10	4.1	1.3	8.1	0.0	2.6
3:15	7.3	1.8	13.3	0.0	4.3
3:20	12.3	2.6	21.5	0.0	7.1
3:25	20.0	4.1	34.3	0.1	11.4
3:30	31.5	6.5	52.4	0.4	18.0
3:35	48.8	10.4	79.1	1.0	28.5
3:40	74.9	16.5	119.8	2.2	45.3
3:45	112.8	25.8	177.8	4.1	71.3
3:50	164.6	40.0	255.0	6.7	109.2
3:55	233.7	54.2	349.7	10.0	161.5
4:00	324.3	68.7	458.6	13.8	229.9
4:05	435.8	89.2	572.5	17.4	313.4
4:10	562.4	116.5	676.4	20.2	408.6
4:15	697.0	139.5	762.0	22.4	512.0
4:20	832.4	149.4	827.0	24.3	619.4
4:25	957.7	161.4	874.0	25.5	726.2
4:30	1058.7	172.6	906.4	26.0	828.4
4:35	1130.0	183.8	926.0	26.3	921.9

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
4:40	1174.4	195.5	938.8	26.1	1003.6
4:45	1197.6	206.4	954.7	25.9	1070.7
4:50	1204.1	217.8	977.6	25.5	1121.3
4:55	1198.0	229.0	1009.0	24.9	1155.3
5:00	1185.0	253.4	1049.0	24.4	1173.1
5:05	1169.1	292.3	1095.4	23.6	1175.5
5:10	1147.5	324.2	1140.3	22.6	1163.1
5:15	1118.4	348.1	1173.3	21.5	1138.3
5:20	1085.2	556.5	1193.8	20.5	1103.7
5:25	1047.9	975.8	1209.0	19.5	1062.0
5:30	1004.6	1297.9	1223.3	18.6	1015.5
5:35	957.1	1564.4	1236.2	17.8	966.2
5:40	908.1	1843.4	1245.3	17.0	915.8
5:45	861.1	2012.3	1246.8	16.3	865.6
5:50	817.7	2107.8	1241.0	15.7	816.4
5:55	776.7	2152.3	1229.5	15.0	768.9
6:00	738.4	2161.0	1210.8	14.5	724.1
6:05	703.0	2144.9	1184.9	13.8	681.5
6:10	668.0	2111.2	1150.9	13.0	640.8
6:15	632.8	2064.5	1107.3	12.1	601.3
6:20	598.2	2007.5	1056.6	11.2	563.0
6:25	563.6	1941.7	1003.6	10.4	525.9
6:30	527.8	1868.6	951.0	9.7	490.0
6:35	490.6	1790.0	900.9	9.0	455.2
6:40	453.5	1708.2	853.1	8.4	421.5
6:45	418.6	1625.1	806.0	7.8	388.9
6:50	386.7	1541.6	760.3	7.2	357.5
6:55	357.4	1474.5	717.1	6.7	327.6
7:00	330.6	1417.3	677.3	6.3	299.3
7:05	306.1	1355.3	640.5	5.8	272.6
7:10	282.9	1290.7	605.8	5.4	247.8
7:15	260.2	1225.5	571.1	5.0	224.7
7:20	238.9	1160.8	536.0	4.7	203.6
7:25	219.3	1097.1	501.7	4.3	184.3
7:30	201.3	1034.5	469.1	4.0	167.0
7:35	184.8	973.2	438.8	3.7	151.3
7:40	169.7	913.6	409.9	3.5	136.9
7:45	155.8	856.0	381.2	3.2	124.0
7:50	143.0	800.7	352.8	3.0	112.3
7:55	131.3	747.5	325.8	2.8	101.8
8:00	120.5	696.6	300.6	2.6	92.2
8:05	110.7	647.8	277.3	2.4	83.5
8:10	101.6	601.5	255.9	2.2	75.7
8:15	93.3	557.8	236.1	2.1	68.5
8:20	85.6	516.6	217.8	1.9	61.9
8:25	78.5	478.1	200.9	1.8	56.0
8:30	72.0	442.0	185.3	1.7	50.5
8:35	65.9	408.5	171.0	1.6	45.4
8:40	60.3	377.2	157.7	1.4	40.6
8:45	55.0	361.3	145.3	1.3	36.1
8:50	50.1	359.7	133.8	1.2	31.9
8:55	45.6	358.0	123.3	1.2	28.1
9:00	41.3	356.0	113.3	1.1	24.5
9:05	37.4	353.9	104.1	1.0	21.3
9:10	33.9	351.7	95.6	0.9	18.4
9:15	30.5	349.3	87.5	0.9	15.9
9:20	27.4	346.8	80.2	0.8	13.6
9:25	24.6	344.1	73.3	0.7	11.7
9:30	21.8	341.4	67.1	0.7	9.9
9:35	19.3	338.5	61.5	0.6	8.4
9:40	17.0	335.6	56.3	0.6	7.1
9:45	15.1	332.7	51.6	0.5	6.1

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
9:50	13.3	329.6	47.3	0.5	5.2
9:55	11.7	326.5	43.3	0.4	4.4
10:00	10.4	323.4	39.6	0.4	3.7
10:05	9.3	320.2	36.1	0.3	3.2
10:10	8.2	317.0	32.9	0.3	2.6
10:15	7.4	313.8	30.0	0.3	2.3
10:20	6.6	309.0	27.1	0.2	1.9
10:25	5.9	303.7	24.5	0.2	1.6
10:30	5.3	298.4	22.2	0.2	1.3
10:35	4.7	293.2	20.0	0.1	1.0
10:40	4.2	288.0	18.0	0.1	0.8
10:45	3.7	282.8	16.2	0.1	0.6
10:50	3.3	277.7	14.5	0.1	0.5
10:55	2.9	272.7	13.1	0.1	0.3
11:00	2.5	267.7	11.8	0.1	0.3
11:05	2.1	262.7	10.5	0.1	0.2
11:10	1.8	257.8	9.5	0.0	0.1
11:15	1.6	253.0	8.5	0.0	0.1
11:20	1.3	248.3	7.5	0.0	0.0
11:25	1.1	243.6	6.7	0.0	0.0
11:30	0.9	239.0	6.0	0.0	0.0
11:35	0.7	234.8	5.2	0.0	0.0
11:40	0.6	233.5	4.6	0.0	0.0
11:45	0.5	232.1	4.0	0.0	0.0
11:50	0.4	230.7	3.5	0.0	0.0
11:55	0.4	229.4	3.0	0.0	0.0
12:00	0.3	228.0	2.5	0.0	0.0
12:05	0.3	226.7	2.2	0.0	0.0
12:10	0.2	225.3	1.9	0.0	0.0
12:15	0.2	224.0	1.5	0.0	0.0
12:20	0.2	222.7	1.3	0.0	0.0
12:25	0.1	221.3	1.1	0.0	0.0
12:30	0.1	220.0	0.9	0.0	0.0
12:35	0.1	218.7	0.7	0.0	0.0
12:40	0.1	217.4	0.7	0.0	0.0
12:45	0.1	216.1	0.5	0.0	0.0
12:50	0.0	214.8	0.4	0.0	0.0
12:55	0.0	213.5	0.3	0.0	0.0
13:00	0.0	212.1	0.3	0.0	0.0
13:05	0.0	210.7	0.3	0.0	0.0
13:10	0.0	209.3	0.2	0.0	0.0
13:15	0.0	207.9	0.2	0.0	0.0
13:20	0.0	206.6	0.1	0.0	0.0
13:25	0.0	205.2	0.1	0.0	0.0
13:30	0.0	203.9	0.1	0.0	0.0
13:35	0.0	202.5	0.0	0.0	0.0
13:40	0.0	201.2	0.0	0.0	0.0
13:45	0.0	199.9	0.0	0.0	0.0
13:50	0.0	198.6	0.0	0.0	0.0
13:55	0.0	197.3	0.0	0.0	0.0
14:00	0.0	196.0	0.0	0.0	0.0
14:05	0.0	194.7	0.0	0.0	0.0
14:10	0.0	193.4	0.0	0.0	0.0
14:15	0.0	192.1	0.0	0.0	0.0
14:20	0.0	190.6	0.0	0.0	0.0
14:25	0.0	189.1	0.0	0.0	0.0
14:30	0.0	187.5	0.0	0.0	0.0
14:35	0.0	186.0	0.0	0.0	0.0
14:40	0.0	184.5	0.0	0.0	0.0
14:45	0.0	183.0	0.0	0.0	0.0
14:50	0.0	181.5	0.0	0.0	0.0
14:55	0.0	180.0	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
15:00	0.0	178.6	0.0	0.0	0.0
15:05	0.0	177.1	0.0	0.0	0.0
15:10	0.0	175.7	0.0	0.0	0.0
15:15	0.0	174.3	0.0	0.0	0.0
15:20	0.0	172.9	0.0	0.0	0.0
15:25	0.0	171.5	0.0	0.0	0.0
15:30	0.0	170.1	0.0	0.0	0.0
15:35	0.0	168.7	0.0	0.0	0.0
15:40	0.0	167.3	0.0	0.0	0.0
15:45	0.0	166.0	0.0	0.0	0.0
15:50	0.0	164.1	0.0	0.0	0.0
15:55	0.0	162.2	0.0	0.0	0.0
16:00	0.0	160.3	0.0	0.0	0.0
16:05	0.0	158.5	0.0	0.0	0.0
16:10	0.0	156.7	0.0	0.0	0.0
16:15	0.0	154.9	0.0	0.0	0.0
16:20	0.0	153.1	0.0	0.0	0.0
16:25	0.0	151.4	0.0	0.0	0.0
16:30	0.0	149.7	0.0	0.0	0.0
16:35	0.0	148.0	0.0	0.0	0.0
16:40	0.0	146.3	0.0	0.0	0.0
16:45	0.0	144.6	0.0	0.0	0.0
16:50	0.0	143.0	0.0	0.0	0.0
16:55	0.0	141.3	0.0	0.0	0.0
17:00	0.0	139.7	0.0	0.0	0.0
17:05	0.0	138.1	0.0	0.0	0.0
17:10	0.0	136.5	0.0	0.0	0.0
17:15	0.0	131.6	0.0	0.0	0.0
17:20	0.0	125.1	0.0	0.0	0.0
17:25	0.0	118.9	0.0	0.0	0.0
17:30	0.0	113.1	0.0	0.0	0.0
17:35	0.0	107.5	0.0	0.0	0.0
17:40	0.0	102.2	0.0	0.0	0.0
17:45	0.0	97.2	0.0	0.0	0.0
17:50	0.0	92.4	0.0	0.0	0.0
17:55	0.0	87.8	0.0	0.0	0.0
18:00	0.0	83.5	0.0	0.0	0.0
18:05	0.0	79.4	0.0	0.0	0.0
18:10	0.0	75.5	0.0	0.0	0.0
18:15	0.0	71.8	0.0	0.0	0.0
18:20	0.0	68.2	0.0	0.0	0.0
18:25	0.0	64.9	0.0	0.0	0.0
18:30	0.0	61.7	0.0	0.0	0.0
18:35	0.0	58.6	0.0	0.0	0.0
18:40	0.0	55.8	0.0	0.0	0.0
18:45	0.0	53.0	0.0	0.0	0.0
18:50	0.0	50.4	0.0	0.0	0.0
18:55	0.0	47.8	0.0	0.0	0.0
19:00	0.0	42.9	0.0	0.0	0.0
19:05	0.0	38.5	0.0	0.0	0.0
19:10	0.0	34.6	0.0	0.0	0.0
19:15	0.0	31.0	0.0	0.0	0.0
19:20	0.0	27.9	0.0	0.0	0.0
19:25	0.0	25.0	0.0	0.0	0.0
19:30	0.0	22.4	0.0	0.0	0.0
19:35	0.0	20.1	0.0	0.0	0.0
19:40	0.0	18.1	0.0	0.0	0.0
19:45	0.0	16.2	0.0	0.0	0.0
19:50	0.0	14.6	0.0	0.0	0.0
19:55	0.0	13.1	0.0	0.0	0.0
20:00	0.0	11.7	0.0	0.0	0.0
20:05	0.0	10.5	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
20:10	0.0	9.5	0.0	0.0	0.0
20:15	0.0	8.5	0.0	0.0	0.0
20:20	0.0	7.6	0.0	0.0	0.0
20:25	0.0	6.8	0.0	0.0	0.0
20:30	0.0	6.1	0.0	0.0	0.0
20:35	0.0	5.5	0.0	0.0	0.0
20:40	0.0	4.9	0.0	0.0	0.0
20:45	0.0	4.4	0.0	0.0	0.0
20:50	0.0	4.0	0.0	0.0	0.0
20:55	0.0	3.6	0.0	0.0	0.0
21:00	0.0	3.2	0.0	0.0	0.0
21:05	0.0	2.9	0.0	0.0	0.0
21:10	0.0	2.6	0.0	0.0	0.0
21:15	0.0	2.3	0.0	0.0	0.0
21:20	0.0	2.1	0.0	0.0	0.0
21:25	0.0	1.9	0.0	0.0	0.0
21:30	0.0	1.7	0.0	0.0	0.0
21:35	0.0	1.5	0.0	0.0	0.0
21:40	0.0	1.4	0.0	0.0	0.0
21:45	0.0	1.2	0.0	0.0	0.0
21:50	0.0	1.1	0.0	0.0	0.0
21:55	0.0	0.7	0.0	0.0	0.0
22:00	0.0	0.0	0.0	0.0	0.0
22:05	0.0	0.0	0.0	0.0	0.0
22:10	0.0	0.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0	0.0

Notes:
*Lateral Inflow

TIME SERIES AND FLOW CHANGE STATION LOCATION - 25-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0	0.0
2:05	0.0	0.0	0.0	0.0	0.0
2:10	0.0	0.0	0.0	0.0	0.0
2:15	0.0	0.0	0.0	0.0	0.0
2:20	0.1	0.0	0.2	0.0	0.1
2:25	0.2	0.1	0.5	0.0	0.1
2:30	0.4	0.3	1.1	0.0	0.3
2:35	0.9	0.8	2.0	0.0	0.6
2:40	1.6	1.0	3.3	0.0	1.0
2:45	2.8	1.2	5.0	0.0	1.6
2:50	4.4	1.5	7.0	0.0	2.3
2:55	6.6	1.9	9.5	0.0	3.3
3:00	9.4	2.6	12.6	0.0	4.5
3:05	13.2	3.6	17.1	0.0	6.3
3:10	18.4	5.0	24.4	0.0	9.1
3:15	25.4	7.0	34.9	0.1	13.1
3:20	35.1	9.9	49.7	0.3	18.9
3:25	49.0	14.0	70.3	0.7	27.3
3:30	69.1	19.9	98.5	1.4	39.7
3:35	97.6	28.2	139.5	2.7	58.4
3:40	137.9	39.8	200.6	4.9	87.6
3:45	193.9	52.1	286.4	8.1	130.8
3:50	269.1	63.8	397.7	12.1	191.6
3:55	368.1	80.8	530.6	16.9	272.8
4:00	495.9	104.6	679.0	22.3	375.9
4:05	650.7	136.2	830.6	27.4	499.0
4:10	823.8	145.7	966.9	31.2	636.6
4:15	1004.5	158.0	1078.4	34.1	783.7
4:20	1182.3	171.0	1161.3	36.4	933.8
4:25	1342.8	183.6	1218.1	37.6	1080.2
4:30	1469.5	196.9	1256.0	38.2	1218.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
4:35	1556.7	210.1	1279.4	38.5	1342.0
4:40	1609.1	223.7	1296.6	38.2	1447.9
4:45	1634.8	245.0	1318.2	37.6	1532.2
4:50	1641.3	294.5	1349.9	36.9	1593.2
4:55	1634.1	332.8	1393.5	36.0	1631.0
5:00	1619.1	409.3	1448.5	35.1	1646.8
5:05	1598.7	1023.1	1511.1	34.0	1642.1
5:10	1569.6	1513.7	1570.9	32.4	1618.1
5:15	1530.3	2116.9	1616.8	30.7	1577.9
5:20	1485.7	2517.5	1650.0	29.2	1525.0
5:25	1434.4	2782.0	1678.3	27.9	1463.6
5:30	1374.0	2953.0	1704.9	26.6	1396.6
5:35	1308.4	3059.3	1728.4	25.3	1326.4
5:40	1241.0	3120.5	1745.1	24.1	1254.8
5:45	1176.3	3149.2	1749.3	23.0	1183.6
5:50	1117.0	3151.7	1741.9	22.2	1114.4
5:55	1061.0	3131.3	1725.8	21.3	1048.2
6:00	1006.6	3091.4	1698.3	20.4	985.6
6:05	955.9	3035.8	1659.6	19.4	926.1
6:10	908.1	2967.4	1610.1	18.2	868.9
6:15	860.0	2888.2	1547.6	16.9	813.7
6:20	811.3	2798.9	1475.2	15.7	760.2
6:25	762.4	2700.0	1400.4	14.6	708.8
6:30	712.6	2593.0	1328.6	13.6	659.2
6:35	661.6	2480.2	1260.2	12.6	611.2
6:40	611.2	2364.6	1193.3	11.7	564.9
6:45	563.9	2247.9	1125.6	10.9	520.2
6:50	521.5	2130.8	1059.7	10.1	477.6
6:55	483.2	2013.4	999.4	9.4	437.1
7:00	447.4	1896.7	945.1	8.7	398.8
7:05	413.9	1783.2	893.9	8.1	362.9
7:10	382.3	1674.9	843.2	7.5	329.5
7:15	351.7	1572.5	792.6	7.0	298.8
7:20	323.0	1485.6	742.9	6.5	270.6
7:25	296.6	1423.7	696.2	6.1	245.1
7:30	272.4	1357.2	652.0	5.6	222.0
7:35	250.1	1288.1	609.7	5.2	201.0
7:40	229.7	1217.9	568.8	4.9	182.1
7:45	210.9	1147.9	528.5	4.5	164.9
7:50	193.7	1078.7	489.0	4.2	149.3
7:55	177.9	1010.9	451.7	3.9	135.3
8:00	163.4	944.8	416.9	3.6	122.5
8:05	150.0	880.9	384.7	3.4	110.9
8:10	137.8	819.7	355.0	3.1	100.5
8:15	126.5	761.4	327.6	2.9	91.0
8:20	116.1	706.3	302.3	2.7	82.3
8:25	106.5	654.4	279.0	2.5	74.2
8:30	97.7	605.8	257.4	2.3	66.8
8:35	89.5	560.3	237.5	2.2	59.9
8:40	81.8	517.9	219.1	2.0	53.5
8:45	74.7	478.4	201.9	1.9	47.5
8:50	68.0	441.7	186.1	1.7	41.8
8:55	61.8	407.5	171.4	1.6	36.6
9:00	56.0	375.8	157.6	1.5	32.0
9:05	50.8	361.2	144.8	1.4	27.7
9:10	46.1	359.6	132.9	1.3	23.9
9:15	41.5	357.8	121.8	1.2	20.5
9:20	37.2	355.8	111.6	1.1	17.5
9:25	33.4	353.6	102.1	1.0	15.0
9:30	29.7	351.3	93.7	1.0	12.8
9:35	26.3	348.8	85.8	0.9	10.8

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
9:40	23.2	346.2	78.5	0.8	9.3
9:45	20.6	343.5	72.1	0.8	7.8
9:50	18.2	340.7	66.0	0.7	6.5
9:55	16.1	337.8	60.5	0.6	5.5
10:00	14.4	334.9	55.3	0.5	4.7
10:05	12.8	331.8	50.5	0.5	4.0
10:10	11.4	328.8	46.0	0.4	3.4
10:15	10.3	325.6	41.9	0.3	2.8
10:20	9.2	322.5	38.0	0.3	2.4
10:25	8.2	319.3	34.4	0.3	1.9
10:30	7.4	316.0	31.2	0.2	1.7
10:35	6.6	312.6	28.2	0.2	1.3
10:40	5.8	307.3	25.4	0.2	1.0
10:45	5.2	301.9	22.9	0.1	0.8
10:50	4.6	296.7	20.6	0.1	0.6
10:55	4.1	291.4	18.6	0.1	0.4
11:00	3.5	286.2	16.8	0.1	0.3
11:05	3.0	281.0	15.1	0.1	0.2
11:10	2.6	275.9	13.5	0.1	0.2
11:15	2.2	270.8	12.0	0.1	0.1
11:20	1.8	265.8	10.7	0.0	0.1
11:25	1.5	260.9	9.5	0.0	0.0
11:30	1.2	256.0	8.4	0.0	0.1
11:35	1.0	251.2	7.4	0.0	0.0
11:40	0.8	246.5	6.5	0.0	0.0
11:45	0.7	241.8	5.5	0.0	0.0
11:50	0.6	237.2	4.7	0.0	0.0
11:55	0.5	234.3	4.0	0.0	0.0
12:00	0.4	232.9	3.6	0.0	0.0
12:05	0.4	231.5	3.1	0.0	0.0
12:10	0.3	230.2	2.5	0.0	0.0
12:15	0.3	228.8	2.1	0.0	0.0
12:20	0.2	227.4	1.8	0.0	0.0
12:25	0.2	226.1	1.5	0.0	0.0
12:30	0.2	224.8	1.2	0.0	0.0
12:35	0.1	223.4	1.1	0.0	0.0
12:40	0.1	222.1	0.9	0.0	0.0
12:45	0.1	220.8	0.7	0.0	0.0
12:50	0.1	219.4	0.6	0.0	0.0
12:55	0.0	218.1	0.5	0.0	0.0
13:00	0.0	216.8	0.4	0.0	0.0
13:05	0.0	215.5	0.4	0.0	0.0
13:10	0.0	214.2	0.3	0.0	0.0
13:15	0.0	212.8	0.2	0.0	0.0
13:20	0.0	211.4	0.2	0.0	0.0
13:25	0.0	210.1	0.1	0.0	0.0
13:30	0.0	208.7	0.1	0.0	0.0
13:35	0.0	207.3	0.1	0.0	0.0
13:40	0.0	205.9	0.0	0.0	0.0
13:45	0.0	204.6	0.0	0.0	0.0
13:50	0.0	203.3	0.0	0.0	0.0
13:55	0.0	201.9	0.0	0.0	0.0
14:00	0.0	200.6	0.0	0.0	0.0
14:05	0.0	199.3	0.0	0.0	0.0
14:10	0.0	198.0	0.0	0.0	0.0
14:15	0.0	196.7	0.0	0.0	0.0
14:20	0.0	195.4	0.0	0.0	0.0
14:25	0.0	194.1	0.0	0.0	0.0
14:30	0.0	192.8	0.0	0.0	0.0
14:35	0.0	191.4	0.0	0.0	0.0
14:40	0.0	189.9	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
14:45	0.0	188.4	0.0	0.0	0.0
14:50	0.0	186.8	0.0	0.0	0.0
14:55	0.0	185.3	0.0	0.0	0.0
15:00	0.0	183.8	0.0	0.0	0.0
15:05	0.0	182.3	0.0	0.0	0.0
15:10	0.0	180.8	0.0	0.0	0.0
15:15	0.0	179.4	0.0	0.0	0.0
15:20	0.0	177.9	0.0	0.0	0.0
15:25	0.0	176.5	0.0	0.0	0.0
15:30	0.0	175.1	0.0	0.0	0.0
15:35	0.0	173.6	0.0	0.0	0.0
15:40	0.0	172.2	0.0	0.0	0.0
15:45	0.0	170.8	0.0	0.0	0.0
15:50	0.0	169.4	0.0	0.0	0.0
15:55	0.0	168.1	0.0	0.0	0.0
16:00	0.0	166.7	0.0	0.0	0.0
16:05	0.0	165.1	0.0	0.0	0.0
16:10	0.0	163.2	0.0	0.0	0.0
16:15	0.0	161.3	0.0	0.0	0.0
16:20	0.0	159.5	0.0	0.0	0.0
16:25	0.0	157.7	0.0	0.0	0.0
16:30	0.0	155.9	0.0	0.0	0.0
16:35	0.0	154.1	0.0	0.0	0.0
16:40	0.0	152.3	0.0	0.0	0.0
16:45	0.0	150.6	0.0	0.0	0.0
16:50	0.0	148.9	0.0	0.0	0.0
16:55	0.0	147.2	0.0	0.0	0.0
17:00	0.0	145.5	0.0	0.0	0.0
17:05	0.0	143.9	0.0	0.0	0.0
17:10	0.0	142.2	0.0	0.0	0.0
17:15	0.0	140.6	0.0	0.0	0.0
17:20	0.0	139.0	0.0	0.0	0.0
17:25	0.0	137.4	0.0	0.0	0.0
17:30	0.0	135.3	0.0	0.0	0.0
17:35	0.0	128.6	0.0	0.0	0.0
17:40	0.0	122.3	0.0	0.0	0.0
17:45	0.0	116.2	0.0	0.0	0.0
17:50	0.0	110.5	0.0	0.0	0.0
17:55	0.0	105.1	0.0	0.0	0.0
18:00	0.0	99.9	0.0	0.0	0.0
18:05	0.0	95.0	0.0	0.0	0.0
18:10	0.0	90.3	0.0	0.0	0.0
18:15	0.0	85.8	0.0	0.0	0.0
18:20	0.0	81.6	0.0	0.0	0.0
18:25	0.0	77.6	0.0	0.0	0.0
18:30	0.0	73.8	0.0	0.0	0.0
18:35	0.0	70.1	0.0	0.0	0.0
18:40	0.0	66.7	0.0	0.0	0.0
18:45	0.0	63.4	0.0	0.0	0.0
18:50	0.0	60.3	0.0	0.0	0.0
18:55	0.0	57.3	0.0	0.0	0.0
19:00	0.0	54.5	0.0	0.0	0.0
19:05	0.0	51.8	0.0	0.0	0.0
19:10	0.0	49.2	0.0	0.0	0.0
19:15	0.0	45.5	0.0	0.0	0.0
19:20	0.0	40.9	0.0	0.0	0.0
19:25	0.0	36.7	0.0	0.0	0.0
19:30	0.0	32.9	0.0	0.0	0.0
19:35	0.0	29.6	0.0	0.0	0.0
19:40	0.0	26.5	0.0	0.0	0.0
19:45	0.0	23.8	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
19:50	0.0	21.4	0.0	0.0	0.0
19:55	0.0	19.2	0.0	0.0	0.0
20:00	0.0	17.2	0.0	0.0	0.0
20:05	0.0	15.5	0.0	0.0	0.0
20:10	0.0	13.9	0.0	0.0	0.0
20:15	0.0	12.5	0.0	0.0	0.0
20:20	0.0	11.2	0.0	0.0	0.0
20:25	0.0	10.0	0.0	0.0	0.0
20:30	0.0	9.0	0.0	0.0	0.0
20:35	0.0	8.1	0.0	0.0	0.0
20:40	0.0	7.3	0.0	0.0	0.0
20:45	0.0	6.5	0.0	0.0	0.0
20:50	0.0	5.8	0.0	0.0	0.0
20:55	0.0	5.2	0.0	0.0	0.0
21:00	0.0	4.7	0.0	0.0	0.0
21:05	0.0	4.2	0.0	0.0	0.0
21:10	0.0	3.8	0.0	0.0	0.0
21:15	0.0	3.4	0.0	0.0	0.0
21:20	0.0	3.1	0.0	0.0	0.0
21:25	0.0	2.7	0.0	0.0	0.0
21:30	0.0	2.5	0.0	0.0	0.0
21:35	0.0	2.2	0.0	0.0	0.0
21:40	0.0	2.0	0.0	0.0	0.0
21:45	0.0	1.8	0.0	0.0	0.0
21:50	0.0	1.6	0.0	0.0	0.0
21:55	0.0	1.4	0.0	0.0	0.0
22:00	0.0	1.3	0.0	0.0	0.0
22:05	0.0	1.2	0.0	0.0	0.0
22:10	0.0	1.0	0.0	0.0	0.0
22:15	0.0	0.0	0.0	0.0	0.0
22:20	0.0	0.0	0.0	0.0	0.0
22:25	0.0	0.0	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0	0.0

Notes:
*Lateral Inflow

TIME SERIES AND FLOW CHANGE STATION LOCATION - 50-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.0	0.0	0.0
1:55	0.0	0.0	0.0	0.0	0.0
2:00	0.0	0.0	0.0	0.0	0.0
2:05	0.1	0.0	0.2	0.0	0.1
2:10	0.2	0.1	0.6	0.0	0.2
2:15	0.5	0.4	1.3	0.0	0.4
2:20	1.0	0.9	2.3	0.0	0.7
2:25	1.9	1.1	3.8	0.0	1.2
2:30	3.2	1.2	5.7	0.0	1.8
2:35	5.0	1.6	7.8	0.0	2.6
2:40	7.3	2.1	10.1	0.0	3.6
2:45	10.2	2.9	12.9	0.0	4.8
2:50	13.7	4.0	16.3	0.0	6.3
2:55	17.8	5.4	20.6	0.0	8.2
3:00	22.6	7.3	26.1	0.0	10.6
3:05	28.7	9.7	33.4	0.1	13.9
3:10	36.7	12.8	43.6	0.2	18.4
3:15	47.2	16.8	57.7	0.4	24.4
3:20	61.2	22.1	77.7	0.9	33.3
3:25	80.6	29.0	106.5	1.7	46.4
3:30	107.3	38.2	145.9	2.8	65.2
3:35	144.3	49.4	201.3	4.7	92.8
3:40	196.9	57.7	281.5	7.8	134.3
3:45	270.3	69.7	391.1	12.1	193.9
3:50	367.0	86.7	529.2	17.2	274.9
3:55	491.2	110.4	689.6	23.1	380.3
4:00	649.0	137.5	865.7	29.7	511.6
4:05	838.0	147.3	1044.9	36.0	666.2
4:10	1046.3	160.1	1207.3	40.6	837.8
4:15	1259.9	173.2	1340.1	44.2	1020.1
4:20	1467.9	186.9	1438.9	46.9	1205.2
4:25	1655.9	201.0	1506.9	48.4	1384.5
4:30	1805.2	215.7	1552.0	48.9	1551.3
4:35	1908.7	231.0	1580.1	49.0	1699.9

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
4:40	1971.8	276.4	1600.6	48.5	1824.9
4:45	2003.6	326.0	1626.0	47.5	1922.5
4:50	2010.8	377.6	1663.3	46.4	1990.5
4:55	2000.1	1111.7	1713.3	45.2	2029.6
5:00	1980.1	1813.2	1776.1	44.0	2042.1
5:05	1953.9	2514.5	1850.2	42.6	2030.0
5:10	1917.0	2990.6	1925.7	40.8	1995.9
5:15	1868.9	3318.7	1990.3	38.8	1943.2
5:20	1815.3	3547.7	2040.0	36.8	1875.6
5:25	1754.7	3732.2	2080.3	34.9	1797.5
5:30	1683.2	3845.9	2115.8	33.3	1712.8
5:35	1604.8	3909.7	2146.3	31.7	1624.7
5:40	1523.3	3938.7	2170.0	30.1	1535.7
5:45	1442.1	3942.3	2178.1	28.9	1447.6
5:50	1365.2	3923.8	2167.9	27.6	1361.5
5:55	1294.0	3883.2	2143.8	26.3	1279.0
6:00	1228.1	3821.1	2106.8	25.3	1201.1
6:05	1166.8	3740.2	2058.3	24.2	1127.4
6:10	1107.1	3644.1	1998.2	22.6	1057.1
6:15	1047.0	3538.9	1923.0	21.1	989.3
6:20	988.0	3437.0	1834.6	19.6	923.9
6:25	928.9	3321.0	1741.3	18.2	860.7
6:30	868.9	3192.9	1649.8	16.9	800.0
6:35	807.6	3055.9	1563.1	15.7	741.5
6:40	746.2	2913.8	1480.4	14.6	685.3
6:45	689.3	2770.0	1398.6	13.6	631.2
6:50	637.7	2626.1	1318.8	12.6	579.4
6:55	589.5	2482.5	1242.6	11.7	530.2
7:00	545.8	2340.1	1170.5	10.9	483.8
7:05	506.2	2200.6	1105.4	10.1	440.5
7:10	468.0	2066.4	1043.8	9.4	400.1
7:15	430.7	1939.0	982.6	8.7	362.7
7:20	395.6	1818.7	922.0	8.1	328.6
7:25	363.3	1704.6	862.9	7.5	297.5
7:30	333.7	1595.7	806.8	7.0	269.5
7:35	306.5	1495.8	755.2	6.5	244.0
7:40	281.5	1430.9	705.9	6.1	221.0
7:45	258.6	1361.2	656.5	5.6	200.2
7:50	237.5	1289.0	607.8	5.2	181.3
7:55	218.2	1215.5	561.3	4.9	164.2
8:00	200.4	1141.9	518.1	4.5	148.7
8:05	184.1	1069.1	478.2	4.2	134.6
8:10	169.0	998.2	441.4	3.9	121.9
8:15	155.2	929.8	407.4	3.6	110.2
8:20	142.5	864.5	376.1	3.4	99.6
8:25	130.7	802.6	347.0	3.1	89.8
8:30	119.9	744.2	320.2	2.9	80.7
8:35	109.8	689.3	295.5	2.7	72.3
8:40	100.4	637.8	272.5	2.5	64.5
8:45	91.6	589.8	251.2	2.3	57.2
8:50	83.5	545.0	231.5	2.2	50.4
8:55	76.0	503.2	213.4	2.0	44.0
9:00	68.9	464.3	196.1	1.9	38.4
9:05	62.4	428.1	180.2	1.7	33.3
9:10	56.6	394.4	165.5	1.6	28.7
9:15	50.9	363.0	151.8	1.5	24.6
9:20	45.8	360.5	139.1	1.4	21.0
9:25	41.0	358.8	127.4	1.3	17.9
9:30	36.6	356.9	116.8	1.2	15.3
9:35	32.4	354.8	107.1	1.1	12.9
9:40	28.6	352.5	98.0	1.0	11.1
9:45	25.5	350.1	89.9	0.9	9.4

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
9:50	22.6	347.5	82.5	0.8	7.8
9:55	20.0	344.8	75.6	0.8	6.6
10:00	17.8	342.0	69.1	0.7	5.6
10:05	16.0	339.2	63.1	0.6	4.8
10:10	14.3	336.2	57.7	0.5	4.0
10:15	12.8	333.2	52.5	0.4	3.4
10:20	11.5	330.1	47.7	0.4	2.8
10:25	10.4	327.0	43.1	0.3	2.4
10:30	9.3	323.8	39.2	0.3	2.0
10:35	8.3	320.6	35.4	0.2	1.6
10:40	7.3	317.4	32.0	0.2	1.3
10:45	6.6	314.1	28.9	0.2	1.0
10:50	5.8	309.5	26.0	0.1	0.7
10:55	5.1	304.1	23.5	0.1	0.5
11:00	4.4	298.8	21.2	0.1	0.3
11:05	3.7	293.5	19.0	0.1	0.3
11:10	3.2	288.3	17.1	0.1	0.2
11:15	2.7	283.1	15.3	0.1	0.1
11:20	2.2	277.9	13.5	0.1	0.0
11:25	1.9	272.8	11.9	0.0	0.0
11:30	1.6	267.8	10.6	0.0	0.0
11:35	1.3	262.8	9.3	0.0	0.0
11:40	1.0	257.9	8.0	0.0	0.0
11:45	0.9	253.0	6.9	0.0	0.0
11:50	0.8	248.2	5.9	0.0	0.0
11:55	0.6	243.5	5.1	0.0	0.0
12:00	0.6	238.8	4.4	0.0	0.0
12:05	0.5	234.8	3.7	0.0	0.0
12:10	0.4	233.4	3.2	0.0	0.0
12:15	0.3	232.0	2.7	0.0	0.0
12:20	0.3	230.6	2.2	0.0	0.0
12:25	0.3	229.3	1.8	0.0	0.0
12:30	0.2	227.9	1.6	0.0	0.0
12:35	0.2	226.6	1.3	0.0	0.0
12:40	0.1	225.2	1.2	0.0	0.0
12:45	0.1	223.9	0.9	0.0	0.0
12:50	0.1	222.5	0.7	0.0	0.0
12:55	0.1	221.2	0.7	0.0	0.0
13:00	0.0	219.9	0.5	0.0	0.0
13:05	0.0	218.6	0.4	0.0	0.0
13:10	0.0	217.2	0.4	0.0	0.0
13:15	0.0	215.9	0.3	0.0	0.0
13:20	0.0	214.6	0.2	0.0	0.0
13:25	0.0	213.3	0.2	0.0	0.0
13:30	0.0	211.9	0.1	0.0	0.0
13:35	0.0	210.5	0.1	0.0	0.0
13:40	0.0	209.1	0.0	0.0	0.0
13:45	0.0	207.8	0.0	0.0	0.0
13:50	0.0	206.4	0.0	0.0	0.0
13:55	0.0	205.0	0.0	0.0	0.0
14:00	0.0	203.7	0.0	0.0	0.0
14:05	0.0	202.4	0.0	0.0	0.0
14:10	0.0	201.0	0.0	0.0	0.0
14:15	0.0	199.7	0.0	0.0	0.0
14:20	0.0	198.4	0.0	0.0	0.0
14:25	0.0	197.1	0.0	0.0	0.0
14:30	0.0	195.8	0.0	0.0	0.0
14:35	0.0	194.5	0.0	0.0	0.0
14:40	0.0	193.2	0.0	0.0	0.0
14:45	0.0	192.0	0.0	0.0	0.0
14:50	0.0	190.4	0.0	0.0	0.0
14:55	0.0	188.9	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
15:00	0.0	187.3	0.0	0.0	0.0
15:05	0.0	185.8	0.0	0.0	0.0
15:10	0.0	184.3	0.0	0.0	0.0
15:15	0.0	182.8	0.0	0.0	0.0
15:20	0.0	181.3	0.0	0.0	0.0
15:25	0.0	179.9	0.0	0.0	0.0
15:30	0.0	178.4	0.0	0.0	0.0
15:35	0.0	177.0	0.0	0.0	0.0
15:40	0.0	175.5	0.0	0.0	0.0
15:45	0.0	174.1	0.0	0.0	0.0
15:50	0.0	172.7	0.0	0.0	0.0
15:55	0.0	171.3	0.0	0.0	0.0
16:00	0.0	169.9	0.0	0.0	0.0
16:05	0.0	168.5	0.0	0.0	0.0
16:10	0.0	167.2	0.0	0.0	0.0
16:15	0.0	165.7	0.0	0.0	0.0
16:20	0.0	163.8	0.0	0.0	0.0
16:25	0.0	162.0	0.0	0.0	0.0
16:30	0.0	160.1	0.0	0.0	0.0
16:35	0.0	158.3	0.0	0.0	0.0
16:40	0.0	156.5	0.0	0.0	0.0
16:45	0.0	154.7	0.0	0.0	0.0
16:50	0.0	152.9	0.0	0.0	0.0
16:55	0.0	151.2	0.0	0.0	0.0
17:00	0.0	149.5	0.0	0.0	0.0
17:05	0.0	147.7	0.0	0.0	0.0
17:10	0.0	146.1	0.0	0.0	0.0
17:15	0.0	144.4	0.0	0.0	0.0
17:20	0.0	142.7	0.0	0.0	0.0
17:25	0.0	141.1	0.0	0.0	0.0
17:30	0.0	139.5	0.0	0.0	0.0
17:35	0.0	137.9	0.0	0.0	0.0
17:40	0.0	136.3	0.0	0.0	0.0
17:45	0.0	130.7	0.0	0.0	0.0
17:50	0.0	124.3	0.0	0.0	0.0
17:55	0.0	118.2	0.0	0.0	0.0
18:00	0.0	112.4	0.0	0.0	0.0
18:05	0.0	106.8	0.0	0.0	0.0
18:10	0.0	101.6	0.0	0.0	0.0
18:15	0.0	96.6	0.0	0.0	0.0
18:20	0.0	91.8	0.0	0.0	0.0
18:25	0.0	87.3	0.0	0.0	0.0
18:30	0.0	83.0	0.0	0.0	0.0
18:35	0.0	78.9	0.0	0.0	0.0
18:40	0.0	75.0	0.0	0.0	0.0
18:45	0.0	71.3	0.0	0.0	0.0
18:50	0.0	67.8	0.0	0.0	0.0
18:55	0.0	64.5	0.0	0.0	0.0
19:00	0.0	61.3	0.0	0.0	0.0
19:05	0.0	58.3	0.0	0.0	0.0
19:10	0.0	55.4	0.0	0.0	0.0
19:15	0.0	52.7	0.0	0.0	0.0
19:20	0.0	50.1	0.0	0.0	0.0
19:25	0.0	47.2	0.0	0.0	0.0
19:30	0.0	42.3	0.0	0.0	0.0
19:35	0.0	38.0	0.0	0.0	0.0
19:40	0.0	34.1	0.0	0.0	0.0
19:45	0.0	30.6	0.0	0.0	0.0
19:50	0.0	27.5	0.0	0.0	0.0
19:55	0.0	24.7	0.0	0.0	0.0
20:00	0.0	22.1	0.0	0.0	0.0
20:05	0.0	19.9	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
20:10	0.0	17.8	0.0	0.0	0.0
20:15	0.0	16.0	0.0	0.0	0.0
20:20	0.0	14.4	0.0	0.0	0.0
20:25	0.0	12.9	0.0	0.0	0.0
20:30	0.0	11.6	0.0	0.0	0.0
20:35	0.0	10.4	0.0	0.0	0.0
20:40	0.0	9.3	0.0	0.0	0.0
20:45	0.0	8.4	0.0	0.0	0.0
20:50	0.0	7.5	0.0	0.0	0.0
20:55	0.0	6.7	0.0	0.0	0.0
21:00	0.0	6.1	0.0	0.0	0.0
21:05	0.0	5.4	0.0	0.0	0.0
21:10	0.0	4.9	0.0	0.0	0.0
21:15	0.0	4.4	0.0	0.0	0.0
21:20	0.0	3.9	0.0	0.0	0.0
21:25	0.0	3.5	0.0	0.0	0.0
21:30	0.0	3.2	0.0	0.0	0.0
21:35	0.0	2.8	0.0	0.0	0.0
21:40	0.0	2.6	0.0	0.0	0.0
21:45	0.0	2.3	0.0	0.0	0.0
21:50	0.0	2.1	0.0	0.0	0.0
21:55	0.0	1.8	0.0	0.0	0.0
22:00	0.0	1.7	0.0	0.0	0.0
22:05	0.0	1.5	0.0	0.0	0.0
22:10	0.0	1.3	0.0	0.0	0.0
22:15	0.0	1.2	0.0	0.0	0.0
22:20	0.0	1.1	0.0	0.0	0.0
22:25	0.0	0.5	0.0	0.0	0.0
22:30	0.0	0.0	0.0	0.0	0.0
22:35	0.0	0.0	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0	0.0

Notes:

*Lateral Inflow

TIME SERIES AND FLOW CHANGE STATION LOCATION - 100-YEAR

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
0:00	0.0	0.0	0.0	0.0	0.0
0:05	0.0	0.0	0.0	0.0	0.0
0:10	0.0	0.0	0.0	0.0	0.0
0:15	0.0	0.0	0.0	0.0	0.0
0:20	0.0	0.0	0.0	0.0	0.0
0:25	0.0	0.0	0.0	0.0	0.0
0:30	0.0	0.0	0.0	0.0	0.0
0:35	0.0	0.0	0.0	0.0	0.0
0:40	0.0	0.0	0.0	0.0	0.0
0:45	0.0	0.0	0.0	0.0	0.0
0:50	0.0	0.0	0.0	0.0	0.0
0:55	0.0	0.0	0.0	0.0	0.0
1:00	0.0	0.0	0.0	0.0	0.0
1:05	0.0	0.0	0.0	0.0	0.0
1:10	0.0	0.0	0.0	0.0	0.0
1:15	0.0	0.0	0.0	0.0	0.0
1:20	0.0	0.0	0.0	0.0	0.0
1:25	0.0	0.0	0.0	0.0	0.0
1:30	0.0	0.0	0.0	0.0	0.0
1:35	0.0	0.0	0.0	0.0	0.0
1:40	0.0	0.0	0.0	0.0	0.0
1:45	0.0	0.0	0.0	0.0	0.0
1:50	0.0	0.0	0.1	0.0	0.0
1:55	0.1	0.0	0.3	0.0	0.1
2:00	0.3	0.2	0.9	0.0	0.2
2:05	0.7	0.5	1.8	0.0	0.5
2:10	1.4	1.0	3.3	0.0	1.0
2:15	2.6	1.1	5.2	0.0	1.6
2:20	4.3	1.4	7.4	0.0	2.5
2:25	6.7	1.9	10.1	0.0	3.5
2:30	9.7	2.6	13.1	0.0	4.6
2:35	13.4	3.7	16.5	0.0	6.2
2:40	17.6	5.1	20.6	0.0	8.0
2:45	22.4	7.0	25.2	0.0	10.2
2:50	27.8	9.3	30.3	0.0	12.8
2:55	34.0	12.3	35.9	0.1	15.8
3:00	41.3	15.9	42.9	0.1	19.6
3:05	50.1	20.2	52.9	0.3	24.6
3:10	60.7	25.5	67.3	0.6	31.4
3:15	74.2	31.9	87.2	1.1	40.9
3:20	92.3	40.1	114.9	1.8	54.3
3:25	117.5	49.2	153.1	3.0	73.3
3:30	152.1	55.8	203.1	4.6	99.6
3:35	199.6	64.7	272.2	7.1	137.2
3:40	266.4	76.9	371.5	11.2	192.0
3:45	357.3	93.5	506.1	16.7	268.8
3:50	475.0	116.3	673.4	23.0	371.7
3:55	625.5	138.6	866.2	30.3	504.0
4:00	816.0	148.3	1076.4	38.5	667.4
4:05	1042.5	161.1	1288.2	45.9	857.8
4:10	1289.6	174.1	1477.5	51.3	1067.3
4:15	1541.6	188.5	1629.9	55.4	1287.8
4:20	1785.9	203.1	1742.7	58.5	1510.1
4:25	2004.7	218.9	1820.9	60.1	1724.0
4:30	2176.3	237.3	1873.0	60.6	1921.3
4:35	2293.1	298.5	1904.3	60.6	2095.3

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
4:40	2364.0	344.2	1926.4	59.7	2239.9
4:45	2400.6	840.7	1956.2	58.4	2350.6
4:50	2409.3	1647.7	2001.7	57.1	2425.8
4:55	2397.2	2594.4	2063.1	55.6	2466.5
5:00	2374.1	3246.9	2141.0	54.1	2475.6
5:05	2343.7	3728.2	2232.1	52.2	2455.6
5:10	2300.6	4098.3	2323.8	49.8	2409.2
5:15	2243.0	4346.9	2401.3	47.2	2340.6
5:20	2177.8	4518.7	2462.5	44.8	2254.9
5:25	2103.3	4636.5	2514.4	42.5	2157.5
5:30	2014.9	4712.8	2562.0	40.4	2052.8
5:35	1918.2	4756.1	2604.6	38.5	1944.3
5:40	1818.6	4773.8	2636.0	36.6	1835.2
5:45	1721.2	4769.6	2646.7	35.1	1727.9
5:50	1630.5	4742.8	2635.8	33.7	1624.0
5:55	1546.5	4691.0	2609.0	32.2	1525.0
6:00	1468.2	4614.6	2565.4	30.9	1431.7
6:05	1396.1	4516.9	2505.0	29.3	1343.5
6:10	1325.5	4401.6	2428.3	27.4	1259.1
6:15	1253.6	4271.6	2332.6	25.5	1177.9
6:20	1181.9	4128.5	2222.7	23.7	1099.6
6:25	1109.9	3973.0	2109.6	22.0	1024.3
6:30	1036.5	3806.4	1999.4	20.5	951.8
6:35	962.1	3632.2	1894.2	19.0	881.8
6:40	889.5	3469.0	1792.9	17.7	814.6
6:45	822.0	3311.4	1692.3	16.4	749.9
6:50	761.2	3147.1	1594.9	15.3	688.0
6:55	705.0	2979.1	1503.3	14.2	629.2
7:00	653.0	2810.5	1418.0	13.2	573.9
7:05	605.3	2644.9	1338.4	12.3	522.1
7:10	559.3	2485.4	1262.6	11.4	474.1
7:15	514.7	2333.6	1187.9	10.6	429.8
7:20	472.8	2189.6	1114.6	9.8	389.2
7:25	434.3	2052.5	1044.8	9.1	352.5
7:30	399.0	1921.7	978.1	8.5	319.2
7:35	366.5	1796.5	915.5	7.9	289.1
7:40	336.7	1677.2	855.0	7.3	261.7
7:45	309.3	1563.8	794.6	6.8	237.0
7:50	284.2	1473.3	735.4	6.3	214.7
7:55	261.1	1403.4	679.2	5.9	194.4
8:00	239.8	1329.0	627.1	5.5	176.0
8:05	220.3	1252.4	578.9	5.1	159.3
8:10	202.3	1175.4	534.4	4.7	144.1
8:15	185.8	1099.5	493.3	4.4	130.3
8:20	170.6	1025.9	455.3	4.1	117.8
8:25	156.5	955.1	420.3	3.8	106.2
8:30	143.6	887.7	387.8	3.5	95.4
8:35	131.5	823.8	357.9	3.3	85.3
8:40	120.2	763.6	330.1	3.0	76.0
8:45	109.8	707.0	304.3	2.8	67.4
8:50	100.0	654.0	280.6	2.6	59.2
8:55	90.9	604.5	258.4	2.4	51.7
9:00	82.5	558.2	237.7	2.3	45.0
9:05	74.8	515.1	218.4	2.1	39.0
9:10	67.8	474.8	200.6	2.0	33.6
9:15	61.1	437.2	184.0	1.8	28.8
9:20	54.9	402.2	168.7	1.7	24.5
9:25	49.2	369.6	154.5	1.6	20.9
9:30	43.9	360.8	141.8	1.4	17.8
9:35	38.9	359.1	130.0	1.3	15.1
9:40	34.4	357.2	119.1	1.2	12.8
9:45	30.7	355.1	109.3	1.1	10.8

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
9:50	27.3	352.8	100.2	1.0	9.1
9:55	24.2	350.4	91.8	0.9	7.7
10:00	21.6	347.8	84.1	0.8	6.5
10:05	19.3	345.1	76.8	0.7	5.5
10:10	17.3	342.3	70.1	0.6	4.7
10:15	15.6	339.5	63.9	0.5	3.9
10:20	14.0	336.5	58.0	0.4	3.3
10:25	12.6	333.5	52.5	0.4	2.8
10:30	11.3	330.4	47.7	0.3	2.3
10:35	10.1	327.3	43.2	0.3	1.8
10:40	8.9	324.1	39.1	0.2	1.5
10:45	8.0	320.9	35.3	0.2	1.1
10:50	7.1	317.6	31.9	0.2	0.8
10:55	6.2	314.4	28.7	0.1	0.6
11:00	5.3	309.9	26.0	0.1	0.4
11:05	4.5	304.5	23.3	0.1	0.3
11:10	3.9	299.2	20.9	0.1	0.2
11:15	3.3	293.9	18.7	0.1	0.1
11:20	2.7	288.6	16.5	0.1	0.1
11:25	2.3	283.4	14.6	0.1	0.0
11:30	1.9	278.2	12.8	0.0	0.0
11:35	1.5	273.1	11.2	0.0	0.0
11:40	1.3	268.0	9.8	0.0	0.0
11:45	1.1	263.0	8.4	0.0	0.0
11:50	0.9	258.0	7.1	0.0	0.0
11:55	0.8	253.1	6.1	0.0	0.0
12:00	0.7	248.3	5.3	0.0	0.0
12:05	0.5	243.6	4.5	0.0	0.0
12:10	0.5	238.9	3.8	0.0	0.0
12:15	0.4	234.8	3.2	0.0	0.0
12:20	0.4	233.4	2.7	0.0	0.0
12:25	0.3	232.0	2.3	0.0	0.0
12:30	0.3	230.6	1.9	0.0	0.0
12:35	0.2	229.3	1.6	0.0	0.0
12:40	0.2	227.9	1.3	0.0	0.0
12:45	0.1	226.6	1.1	0.0	0.0
12:50	0.1	225.2	0.9	0.0	0.0
12:55	0.1	223.9	0.7	0.0	0.0
13:00	0.0	222.5	0.7	0.0	0.0
13:05	0.0	221.2	0.5	0.0	0.0
13:10	0.0	219.9	0.5	0.0	0.0
13:15	0.0	218.5	0.4	0.0	0.0
13:20	0.0	217.2	0.3	0.0	0.0
13:25	0.0	215.9	0.2	0.0	0.0
13:30	0.0	214.6	0.1	0.0	0.0
13:35	0.0	213.3	0.1	0.0	0.0
13:40	0.0	211.9	0.0	0.0	0.0
13:45	0.0	210.5	0.0	0.0	0.0
13:50	0.0	209.1	0.0	0.0	0.0
13:55	0.0	207.7	0.0	0.0	0.0
14:00	0.0	206.4	0.0	0.0	0.0
14:05	0.0	205.0	0.0	0.0	0.0
14:10	0.0	203.7	0.0	0.0	0.0
14:15	0.0	202.3	0.0	0.0	0.0
14:20	0.0	201.0	0.0	0.0	0.0
14:25	0.0	199.7	0.0	0.0	0.0
14:30	0.0	198.4	0.0	0.0	0.0
14:35	0.0	197.1	0.0	0.0	0.0
14:40	0.0	195.8	0.0	0.0	0.0
14:45	0.0	194.5	0.0	0.0	0.0
14:50	0.0	193.2	0.0	0.0	0.0
14:55	0.0	191.9	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
15:00	0.0	190.4	0.0	0.0	0.0
15:05	0.0	188.8	0.0	0.0	0.0
15:10	0.0	187.3	0.0	0.0	0.0
15:15	0.0	185.8	0.0	0.0	0.0
15:20	0.0	184.3	0.0	0.0	0.0
15:25	0.0	182.8	0.0	0.0	0.0
15:30	0.0	181.3	0.0	0.0	0.0
15:35	0.0	179.8	0.0	0.0	0.0
15:40	0.0	178.4	0.0	0.0	0.0
15:45	0.0	176.9	0.0	0.0	0.0
15:50	0.0	175.5	0.0	0.0	0.0
15:55	0.0	174.1	0.0	0.0	0.0
16:00	0.0	172.7	0.0	0.0	0.0
16:05	0.0	171.3	0.0	0.0	0.0
16:10	0.0	169.9	0.0	0.0	0.0
16:15	0.0	168.5	0.0	0.0	0.0
16:20	0.0	167.1	0.0	0.0	0.0
16:25	0.0	165.7	0.0	0.0	0.0
16:30	0.0	163.8	0.0	0.0	0.0
16:35	0.0	161.9	0.0	0.0	0.0
16:40	0.0	160.1	0.0	0.0	0.0
16:45	0.0	158.3	0.0	0.0	0.0
16:50	0.0	156.5	0.0	0.0	0.0
16:55	0.0	154.7	0.0	0.0	0.0
17:00	0.0	152.9	0.0	0.0	0.0
17:05	0.0	151.2	0.0	0.0	0.0
17:10	0.0	149.4	0.0	0.0	0.0
17:15	0.0	147.7	0.0	0.0	0.0
17:20	0.0	146.0	0.0	0.0	0.0
17:25	0.0	144.4	0.0	0.0	0.0
17:30	0.0	142.7	0.0	0.0	0.0
17:35	0.0	141.1	0.0	0.0	0.0
17:40	0.0	139.5	0.0	0.0	0.0
17:45	0.0	137.9	0.0	0.0	0.0
17:50	0.0	136.3	0.0	0.0	0.0
17:55	0.0	130.7	0.0	0.0	0.0
18:00	0.0	124.2	0.0	0.0	0.0
18:05	0.0	118.1	0.0	0.0	0.0
18:10	0.0	112.3	0.0	0.0	0.0
18:15	0.0	106.8	0.0	0.0	0.0
18:20	0.0	101.5	0.0	0.0	0.0
18:25	0.0	96.5	0.0	0.0	0.0
18:30	0.0	91.8	0.0	0.0	0.0
18:35	0.0	87.2	0.0	0.0	0.0
18:40	0.0	82.9	0.0	0.0	0.0
18:45	0.0	78.9	0.0	0.0	0.0
18:50	0.0	75.0	0.0	0.0	0.0
18:55	0.0	71.3	0.0	0.0	0.0
19:00	0.0	67.8	0.0	0.0	0.0
19:05	0.0	64.4	0.0	0.0	0.0
19:10	0.0	61.3	0.0	0.0	0.0
19:15	0.0	58.2	0.0	0.0	0.0
19:20	0.0	55.4	0.0	0.0	0.0
19:25	0.0	52.6	0.0	0.0	0.0
19:30	0.0	50.0	0.0	0.0	0.0
19:35	0.0	47.1	0.0	0.0	0.0
19:40	0.0	42.3	0.0	0.0	0.0
19:45	0.0	38.0	0.0	0.0	0.0
19:50	0.0	34.1	0.0	0.0	0.0
19:55	0.0	30.6	0.0	0.0	0.0
20:00	0.0	27.5	0.0	0.0	0.0
20:05	0.0	24.6	0.0	0.0	0.0

Elapsed Time [Min]	Flow [CFS]				
	JC-4 for US Flow	RES For DS Flow	JC-5 - R-6	SB-15	JC-8 - R-9
	165+20.00	123+29.17	146+92.54*	125+56.85*	44+62.68*
20:10	0.0	22.1	0.0	0.0	0.0
20:15	0.0	19.9	0.0	0.0	0.0
20:20	0.0	17.8	0.0	0.0	0.0
20:25	0.0	16.0	0.0	0.0	0.0
20:30	0.0	14.4	0.0	0.0	0.0
20:35	0.0	12.9	0.0	0.0	0.0
20:40	0.0	11.6	0.0	0.0	0.0
20:45	0.0	10.4	0.0	0.0	0.0
20:50	0.0	9.3	0.0	0.0	0.0
20:55	0.0	8.4	0.0	0.0	0.0
21:00	0.0	7.5	0.0	0.0	0.0
21:05	0.0	6.7	0.0	0.0	0.0
21:10	0.0	6.1	0.0	0.0	0.0
21:15	0.0	5.4	0.0	0.0	0.0
21:20	0.0	4.9	0.0	0.0	0.0
21:25	0.0	4.4	0.0	0.0	0.0
21:30	0.0	3.9	0.0	0.0	0.0
21:35	0.0	3.5	0.0	0.0	0.0
21:40	0.0	3.2	0.0	0.0	0.0
21:45	0.0	2.8	0.0	0.0	0.0
21:50	0.0	2.5	0.0	0.0	0.0
21:55	0.0	2.3	0.0	0.0	0.0
22:00	0.0	2.1	0.0	0.0	0.0
22:05	0.0	1.8	0.0	0.0	0.0
22:10	0.0	1.7	0.0	0.0	0.0
22:15	0.0	1.5	0.0	0.0	0.0
22:20	0.0	1.3	0.0	0.0	0.0
22:25	0.0	1.2	0.0	0.0	0.0
22:30	0.0	1.1	0.0	0.0	0.0
22:35	0.0	0.5	0.0	0.0	0.0
22:40	0.0	0.0	0.0	0.0	0.0
22:45	0.0	0.0	0.0	0.0	0.0
22:50	0.0	0.0	0.0	0.0	0.0
22:55	0.0	0.0	0.0	0.0	0.0
23:00	0.0	0.0	0.0	0.0	0.0

Notes:

*Lateral Inflow

CUMULATIVE SEDIMENT MASS FOR 2-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Mar 2016

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

River Station	Cumulative Sediment Mass [TONS]		
	Existing	Proposed	Difference
16520.00	1682	1,682	0
16246.06	4468	4,482	14
15946.84	4377	4,407	30
15673.03	7410	7,468	58
15381.93	9042	9,112	71
15141.09	9202	9,310	108
14931.77	12382	12,505	123
14692.54	15587	15,552	-34
14379.42	16214	16,346	132
14066.58	23953	24,160	208
13772.72	27086	27,516	431
13457.43	26382	27,095	712
13130.33	30121	30,706	586
12856.26	34515	34,597	82
12556.85*	31668	30,032	-1,637
12329.17	29722	27,675	-2,046
12141.33	27506	10,797	-16,709
11917.10	28178	12,854	-15,324
11610.72	30746	13,458	-17,288
11182.79	32487	15,439	-17,049
10592.60	28953	16,715	-12,238
10118.27	27971	17,781	-10,190
9624.29	33051	21,549	-11,502
9149.64	36602	23,620	-12,982
8654.43	38369	25,169	-13,201
8227.06	37484	25,862	-11,622
7805.03	32561	25,400	-7,161
7385.40	35905	25,124	-10,781
6964.05	39136	24,874	-14,262
6467.25	40667	23,021	-17,646
6090.97	40031	22,022	-18,010
5785.22	38195	21,172	-17,024
5546.66	35338	20,149	-15,189
5283.29	38129	21,427	-16,702
5034.86	38370	22,925	-15,445
4695.55	36889	23,413	-13,476
4462.68	37192	24,241	-12,951
4219.43	37364	25,104	-12,259
3967.44	37457	25,599	-11,857
3674.39	37954	25,828	-12,126
3379.10	39028	26,248	-12,780
3030.67	38829	25,316	-13,514
2816.21	39071	24,373	-14,699
2587.35	40381	23,552	-16,828
2350.58	41551	23,195	-18,357
2118.63	42407	24,712	-17,695
1888.92	40887	27,036	-13,851
1668.12	40222	27,901	-12,321
1490.38	39845	29,578	-10,267
1255.37	40042	31,755	-8,287
1071.27	42156	33,860	-8,296
800.36	44048	37,239	-6,809
623.07	44738	38,709	-6,028
432.97	41308	38,924	-2,383
239.99	42193	41,009	-1,183
20.29	43358	42,364	-994

NOTES:
Station totals are cumulative sum of sediment going out of control volume at each cross-section
*Location of proposed impoundment structure

CUMULATIVE SEDIMENT MASS FOR 10-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Mar 2016

River Station	Cumulative Sediment Mass [TONS]		
	Existing	Proposed	Difference
16520.00	2854	2,855	1
16246.06	8388	8,405	17
15946.84	9781	9,806	25
15673.03	13805	13,829	24
15381.93	15703	15,729	26
15141.09	16003	16,031	28
14931.77	22286	22,285	0
14692.54	28272	28,257	-15
14379.42	31651	31,625	-26
14066.58	41322	41,239	-83
13772.72	47276	47,305	29
13457.43	47887	47,115	-772
13130.33	52098	52,355	257
12856.26	57015	57,563	548
12556.85*	52701	51,161	-1,540
12329.17	48892	47,613	-1,280
12141.33	45537	24,732	-20,805
11917.10	48374	20,689	-27,685
11610.72	53697	20,958	-32,739
11182.79	53951	21,944	-32,006
10592.60	54285	23,345	-30,939
10118.27	56082	25,249	-30,833
9624.29	62415	28,992	-33,424
9149.64	68197	33,337	-34,859
8654.43	78664	37,278	-41,387
8227.06	79247	38,803	-40,444
7805.03	78840	39,063	-39,777
7385.40	79541	39,013	-40,528
6964.05	82711	40,712	-42,000
6467.25	80168	40,805	-39,363
6090.97	78234	40,723	-37,511
5785.22	74866	41,065	-33,801
5546.66	70879	41,432	-29,447
5283.29	79914	43,966	-35,948
5034.86	79764	45,651	-34,113
4695.55	75181	47,489	-27,692
4462.68	77978	48,303	-29,675
4219.43	80637	49,123	-31,514
3967.44	82579	49,846	-32,733
3674.39	84689	50,557	-34,132
3379.10	86998	53,127	-33,871
3030.67	87711	53,735	-33,976
2816.21	88452	54,148	-34,305
2587.35	89158	54,854	-34,304
2350.58	89477	55,606	-33,871
2118.63	88951	56,554	-32,397
1888.92	82886	55,237	-27,649
1668.12	83482	55,353	-28,129
1490.38	85699	56,649	-29,049
1255.37	88363	58,496	-29,867
1071.27	91389	60,325	-31,065
800.36	94304	63,601	-30,703
623.07	95359	65,191	-30,168
432.97	91588	64,970	-26,618
239.99	91063	67,351	-23,713
20.29	90528	68,590	-21,938

NOTES:
Station totals are cumulative sum of sediment going out of control volume at each cross-section
*Location of proposed impoundment structure

CUMULATIVE SEDIMENT MASS FOR 25-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Mar 2016

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

River Station	Cumulative Sediment Mass [TONS]		
	Existing	Proposed	Difference
16520.00	3592	3,597	6
16246.06	10993	11,017	24
15946.84	13620	13,636	17
15673.03	18921	19,060	139
15381.93	21372	21,406	34
15141.09	22681	22,696	15
14931.77	30791	30,898	107
14692.54	36199	36,259	60
14379.42	43601	43,794	192
14066.58	56008	56,685	677
13772.72	62669	63,736	1,066
13457.43	63314	64,708	1,394
13130.33	64041	66,413	2,371
12856.26	63652	66,759	3,107
12556.85*	60853	60,669	-184
12329.17	57437	57,282	-155
12141.33	52624	32,548	-20,076
11917.10	56823	26,926	-29,897
11610.72	67607	26,734	-40,873
11182.79	76409	28,898	-47,511
10592.60	76104	30,568	-45,535
10118.27	76908	31,711	-45,197
9624.29	84092	35,837	-48,255
9149.64	90659	39,068	-51,591
8654.43	98126	41,721	-56,405
8227.06	96744	44,322	-52,422
7805.03	94345	45,532	-48,814
7385.40	98260	44,878	-53,383
6964.05	101486	50,246	-51,240
6467.25	97493	51,517	-45,976
6090.97	99324	51,760	-47,563
5785.22	100456	51,903	-48,553
5546.66	99595	52,236	-47,359
5283.29	99511	54,675	-44,836
5034.86	99207	55,093	-44,114
4695.55	97389	55,667	-41,722
4462.68	99496	55,298	-44,198
4219.43	101174	56,919	-44,255
3967.44	104238	58,990	-45,249
3674.39	108581	61,327	-47,254
3379.10	109209	65,530	-43,680
3030.67	109271	68,150	-41,121
2816.21	108082	69,689	-38,393
2587.35	108393	70,366	-38,027
2350.58	108696	71,291	-37,405
2118.63	108696	71,579	-37,117
1888.92	102105	68,952	-33,153
1668.12	101655	68,893	-32,762
1490.38	104390	70,054	-34,336
1255.37	107261	72,084	-35,177
1071.27	110818	74,677	-36,140
800.36	114796	77,495	-37,301
623.07	116267	79,047	-37,220
432.97	114715	81,961	-32,754
239.99	114958	84,499	-30,459
20.29	115038	85,689	-29,349

NOTES:
Station totals are cumulative sum of sediment going out of control volume at each cross-section
*Location of proposed impoundment structure

CUMULATIVE SEDIMENT MASS FOR 50-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Nov 2015

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

River Station	Cumulative Sediment Mass [TONS]		
	Existing	Proposed	Difference
16520.00	4,170	4,214	45
16246.06	13,047	13,028	-19
15946.84	16,605	16,826	222
15673.03	23,862	24,748	886
15381.93	26,086	26,535	449
15141.09	28,060	28,621	561
14931.77	37,223	37,890	668
14692.54	43,103	43,635	532
14379.42	52,824	53,072	248
14066.58	67,594	67,360	-233
13772.72	74,616	74,193	-424
13457.43	75,562	75,112	-451
13130.33	77,383	75,371	-2,012
12856.26	72,905	71,770	-1,135
12556.85*	67,888	66,062	-1,826
12329.17	63,256	62,525	-731
12141.33	59,292	39,449	-19,842
11917.10	63,315	33,093	-30,222
11610.72	71,670	32,094	-39,575
11182.79	72,519	31,954	-40,565
10592.60	71,876	34,084	-37,792
10118.27	73,503	36,406	-37,097
9624.29	80,805	41,746	-39,058
9149.64	94,655	48,757	-45,898
8654.43	107,191	52,118	-55,074
8227.06	108,507	54,612	-53,895
7805.03	112,535	55,214	-57,321
7385.40	111,405	53,009	-58,396
6964.05	114,099	55,250	-58,850
6467.25	116,572	57,073	-59,499
6090.97	112,754	58,846	-53,908
5785.22	107,438	61,121	-46,317
5546.66	103,131	62,179	-40,952
5283.29	116,758	66,460	-50,298
5034.86	116,497	65,161	-51,337
4695.55	110,393	64,182	-46,211
4462.68	111,754	64,032	-47,721
4219.43	116,362	65,589	-50,773
3967.44	123,849	68,669	-55,180
3674.39	130,819	71,297	-59,522
3379.10	130,241	75,063	-55,177
3030.67	129,813	77,880	-51,933
2816.21	130,077	80,016	-50,061
2587.35	135,873	85,335	-50,538
2350.58	136,642	85,767	-50,875
2118.63	136,461	86,212	-50,249
1888.92	127,732	83,692	-44,040
1668.12	127,763	83,995	-43,768
1490.38	129,428	85,340	-44,088
1255.37	131,553	87,330	-44,223
1071.27	133,992	89,809	-44,183
800.36	136,865	93,206	-43,660
623.07	137,751	94,378	-43,374
432.97	129,587	94,948	-34,639
239.99	129,456	96,337	-33,118
20.29	129,804	97,032	-32,772

NOTES:

Station totals are cumulative sum of sediment going out of control volume at each cross-section

*Location of proposed impoundment structure

CUMULATIVE SEDIMENT MASS FOR 100-YEAR, DESIGN STORM EVENT

Project: Horseshoe Draw

Prepared by: HW

Date: Mar 2016

HILGARTWILSON
ENGINEER | PLAN | SURVEY | MANAGE

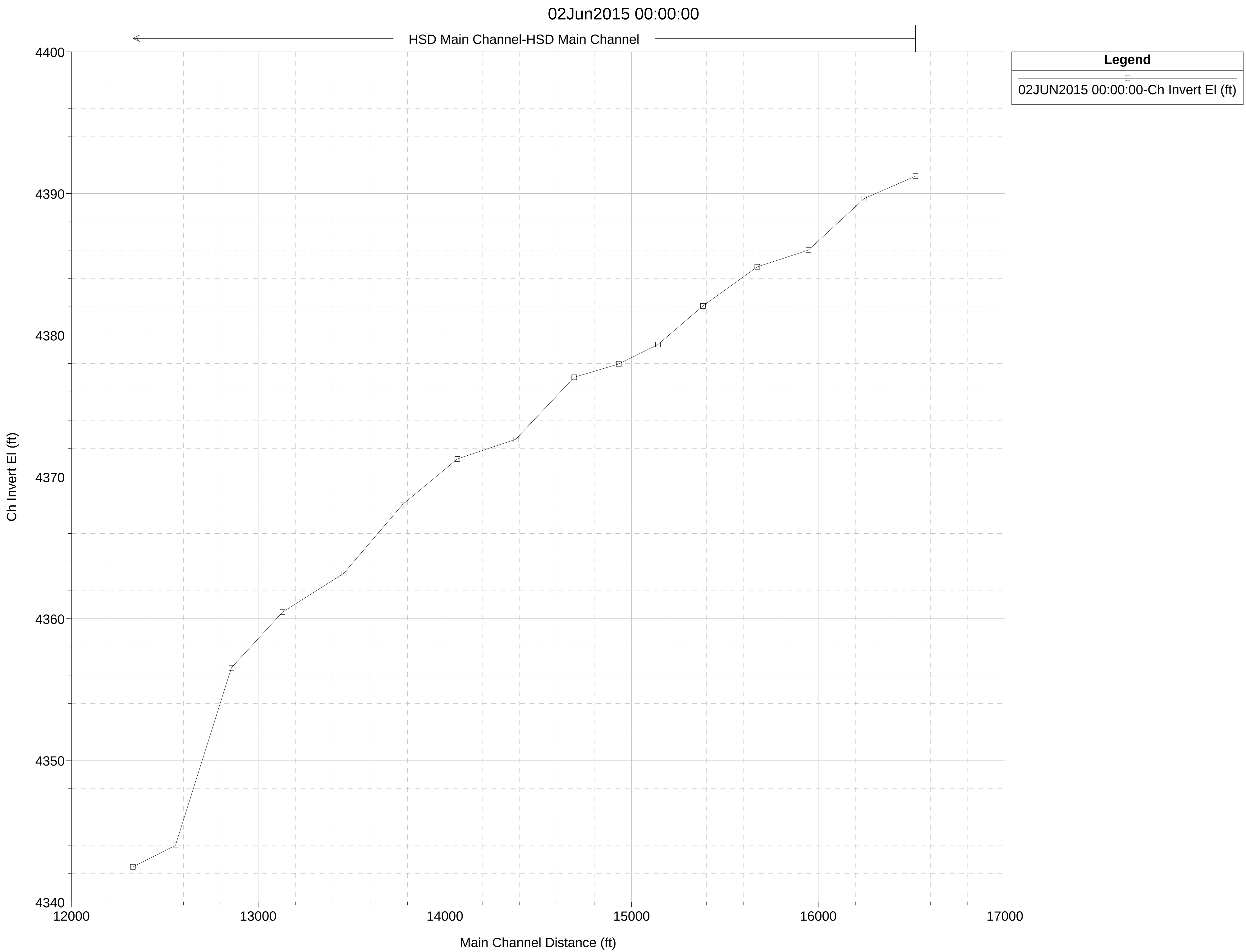
River Station	Cumulative Sediment Mass [TONS]		
	Existing	Proposed	Difference
16520.00	4763	4,752	-11
16246.06	15292	15,040	-252
15946.84	20074	19,527	-547
15673.03	29069	28,018	-1,050
15381.93	29674	28,682	-992
15141.09	27847	26,738	-1,109
14931.77	32193	30,938	-1,255
14692.54	37961	36,931	-1,030
14379.42	51089	49,695	-1,394
14066.58	70074	68,718	-1,356
13772.72	82399	79,161	-3,238
13457.43	87057	85,020	-2,037
13130.33	91578	90,894	-684
12856.26	86908	86,439	-469
12556.85*	80326	79,245	-1,081
12329.17	74700	75,086	386
12141.33	76006	42,969	-33,037
11917.10	78970	39,380	-39,590
11610.72	85729	39,006	-46,723
11182.79	86463	39,411	-47,052
10592.60	85613	42,303	-43,310
10118.27	86710	45,187	-41,523
9624.29	94584	51,475	-43,109
9149.64	111484	59,639	-51,845
8654.43	126154	63,088	-63,066
8227.06	128495	64,940	-63,556
7805.03	131559	67,295	-64,264
7385.40	138259	72,445	-65,814
6964.05	140258	81,959	-58,299
6467.25	136028	81,318	-54,710
6090.97	132592	82,402	-50,189
5785.22	125943	83,732	-42,211
5546.66	120400	83,886	-36,514
5283.29	120776	84,552	-36,225
5034.86	125503	82,333	-43,170
4695.55	123678	77,844	-45,833
4462.68	127190	77,755	-49,435
4219.43	132668	78,878	-53,790
3967.44	141072	84,901	-56,171
3674.39	149220	88,769	-60,451
3379.10	148372	92,408	-55,964
3030.67	147661	94,709	-52,953
2816.21	146764	96,870	-49,894
2587.35	145883	103,234	-42,649
2350.58	155560	103,610	-51,950
2118.63	155409	103,939	-51,470
1888.92	144754	101,050	-43,704
1668.12	145392	100,901	-44,490
1490.38	147139	101,846	-45,293
1255.37	149102	103,612	-45,490
1071.27	151144	106,055	-45,089
800.36	153709	109,927	-43,782
623.07	154487	111,567	-42,920
432.97	144746	111,045	-33,701
239.99	144577	113,291	-31,287
20.29	144882	114,646	-30,236

NOTES:
Station totals are cumulative sum of sediment going out of control volume at each cross-section
*Location of proposed impoundment structure

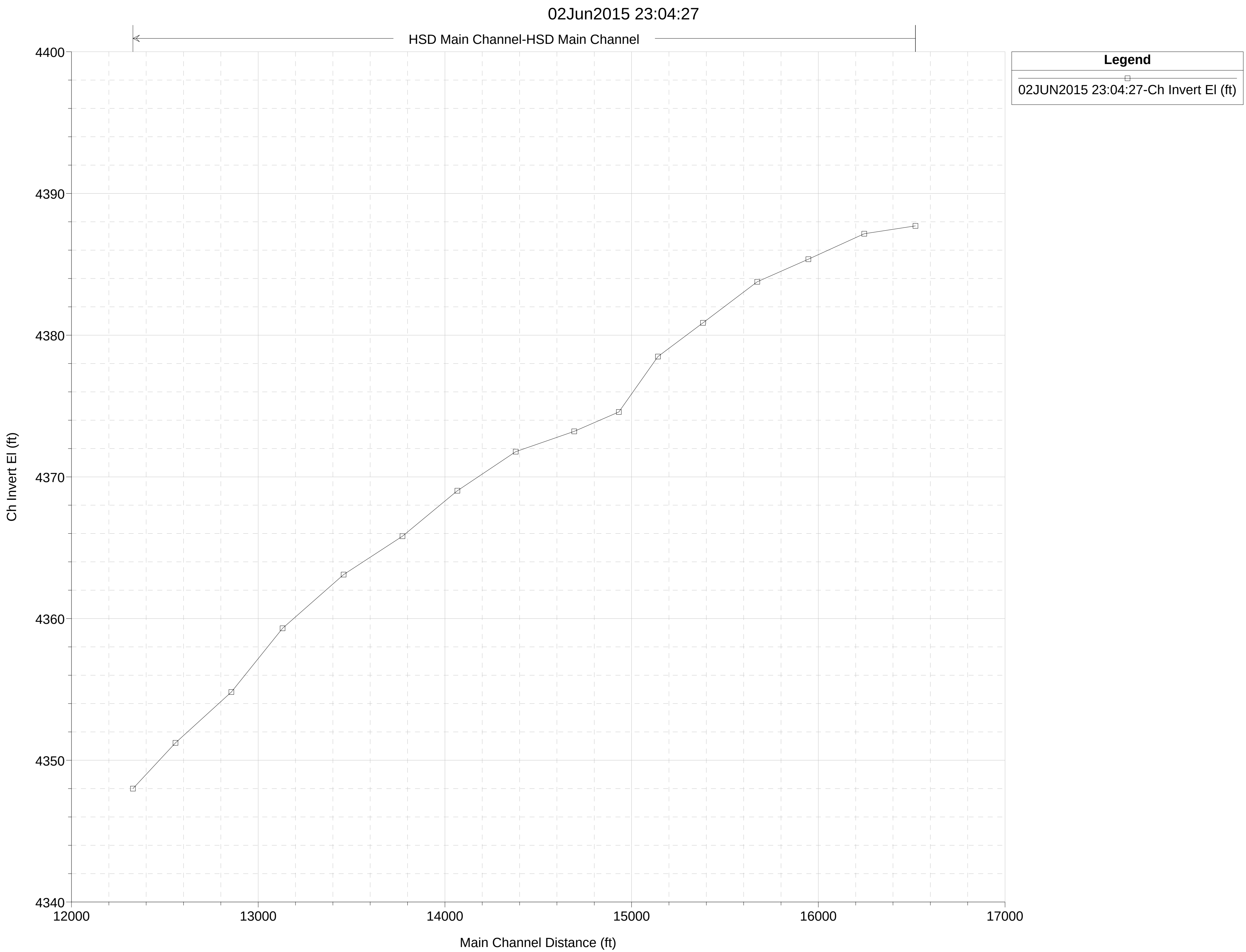
HEC-RAS SEDIMENT TRANSPORT RESULTS

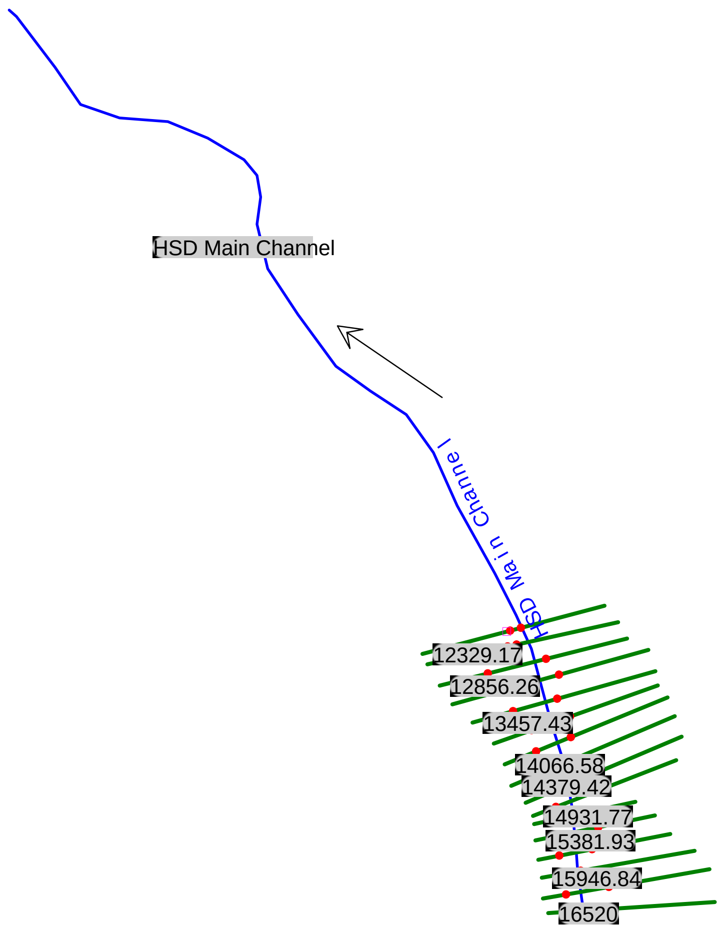
HEC-RAS SEDIMENT TRANSPORT

UPSTREAM



02Jun2015 00:00:00
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 00:00:00-Ch Invert El (ft)
Ch Invert El (ft)
4400
4390
4380
4370
4360
4350
4340
12000
13000
14000
15000
16000
17000
Main Channel Distance (ft)


02Jun2015 23:04:27
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 23:04:27-Ch Invert El (ft)
Ch Invert El (ft)
4400
4390
4380
4370
4360
4350
4340
12000
13000
14000
15000
16000
17000
Main Channel Distance (ft)


HSD Main Channel
HSD Main Channel
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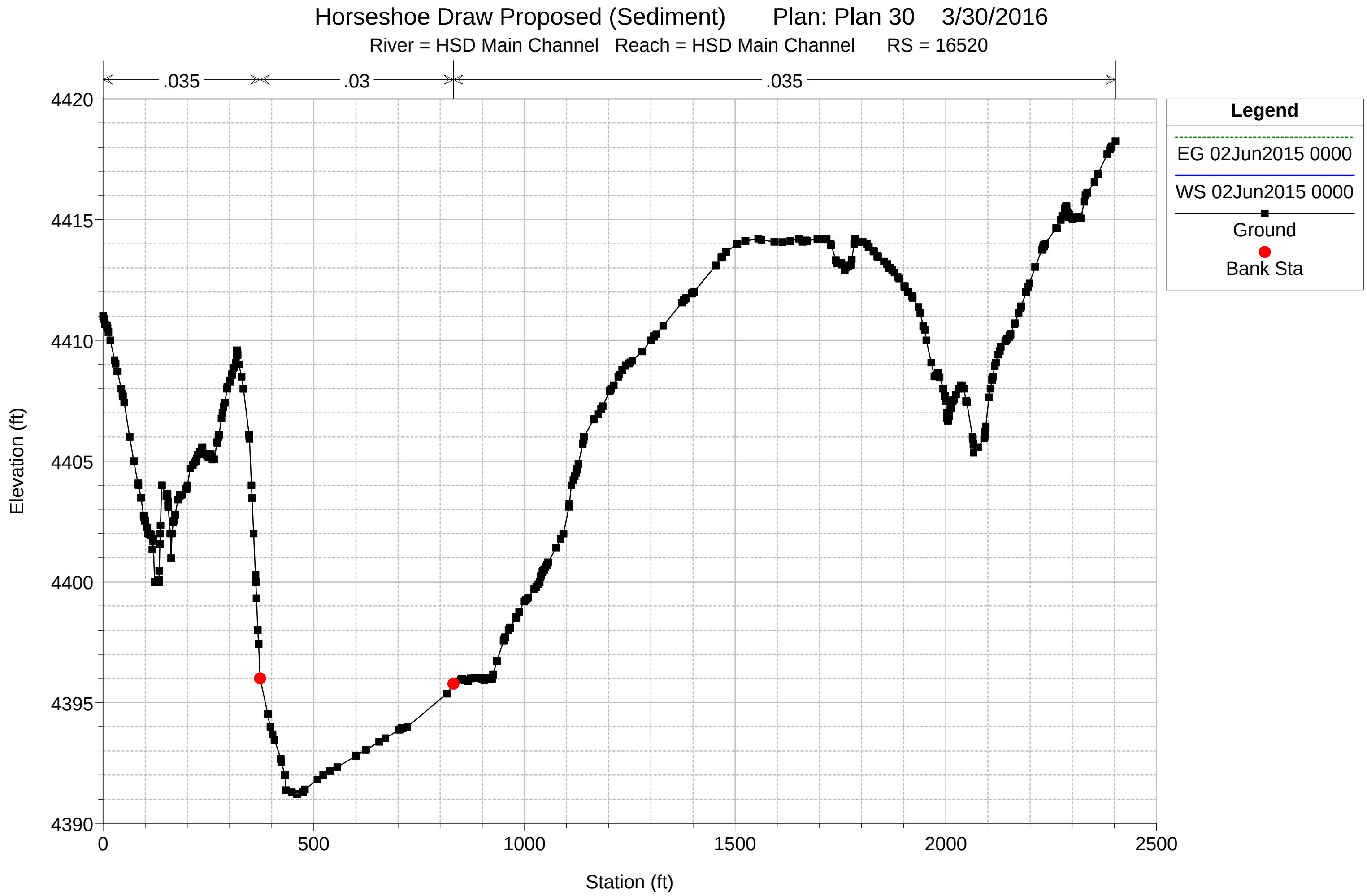
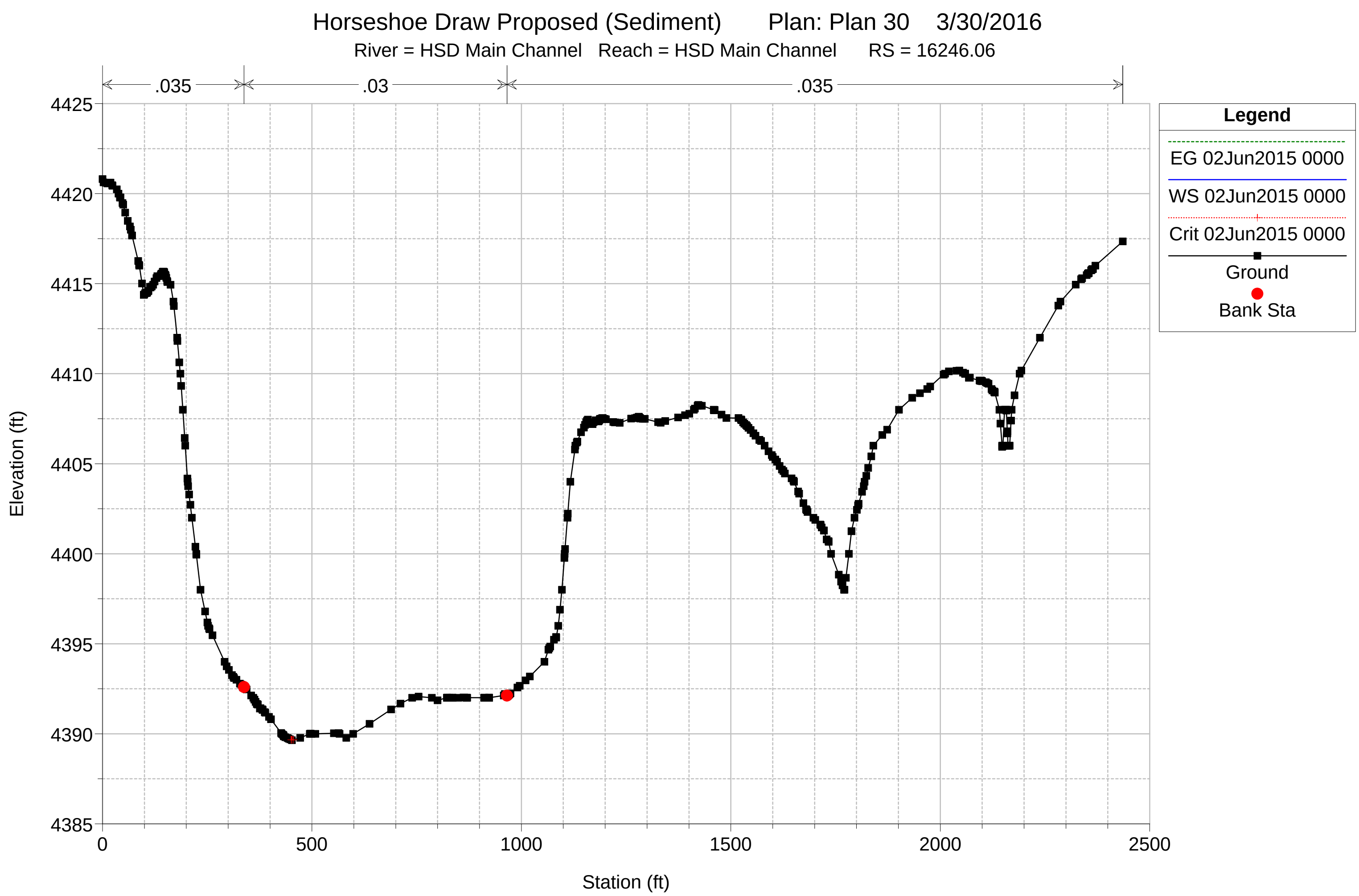
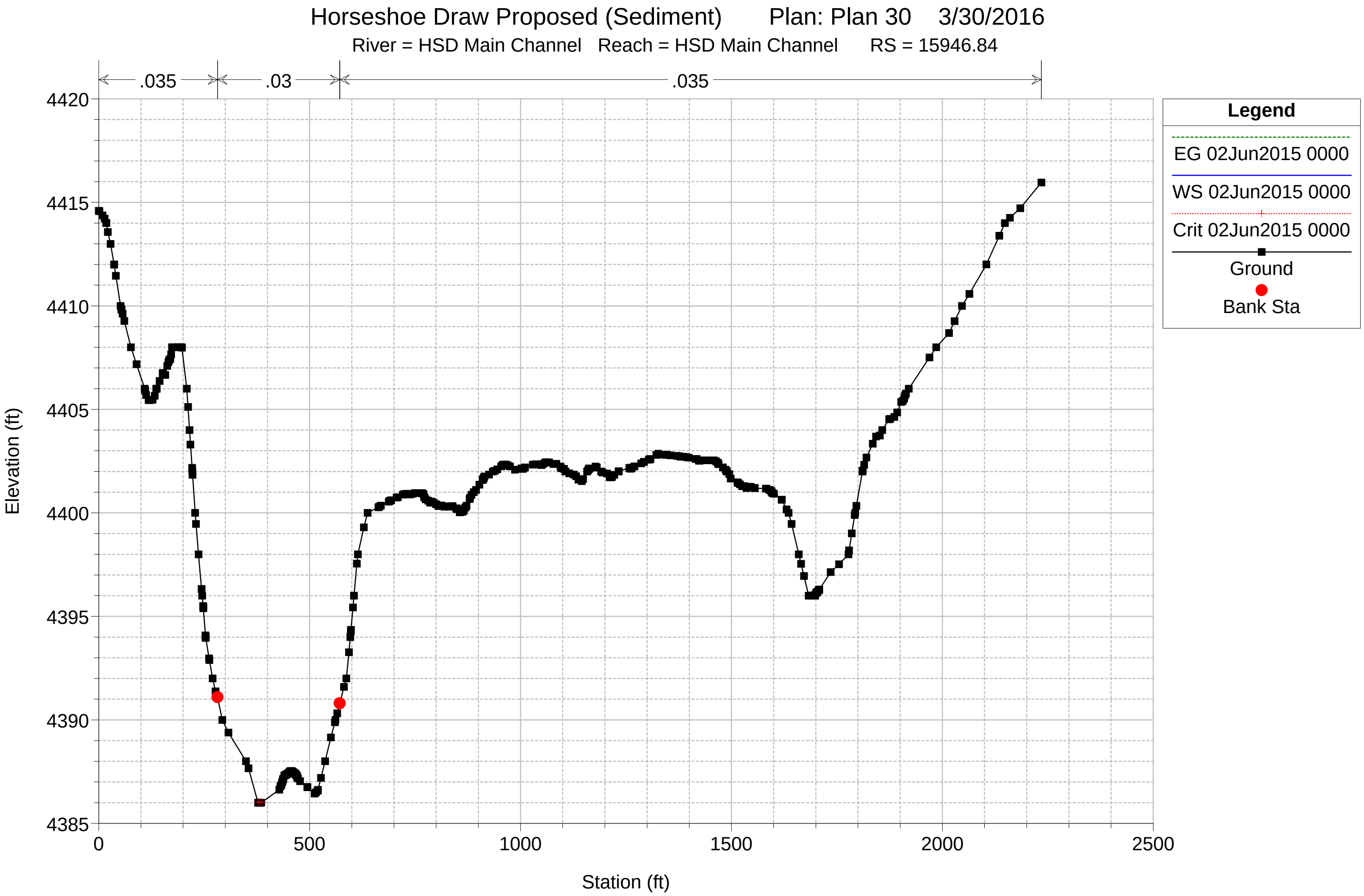
13457.43
14066.58
14379.42
14931.77
15381.93
15946.84
16520



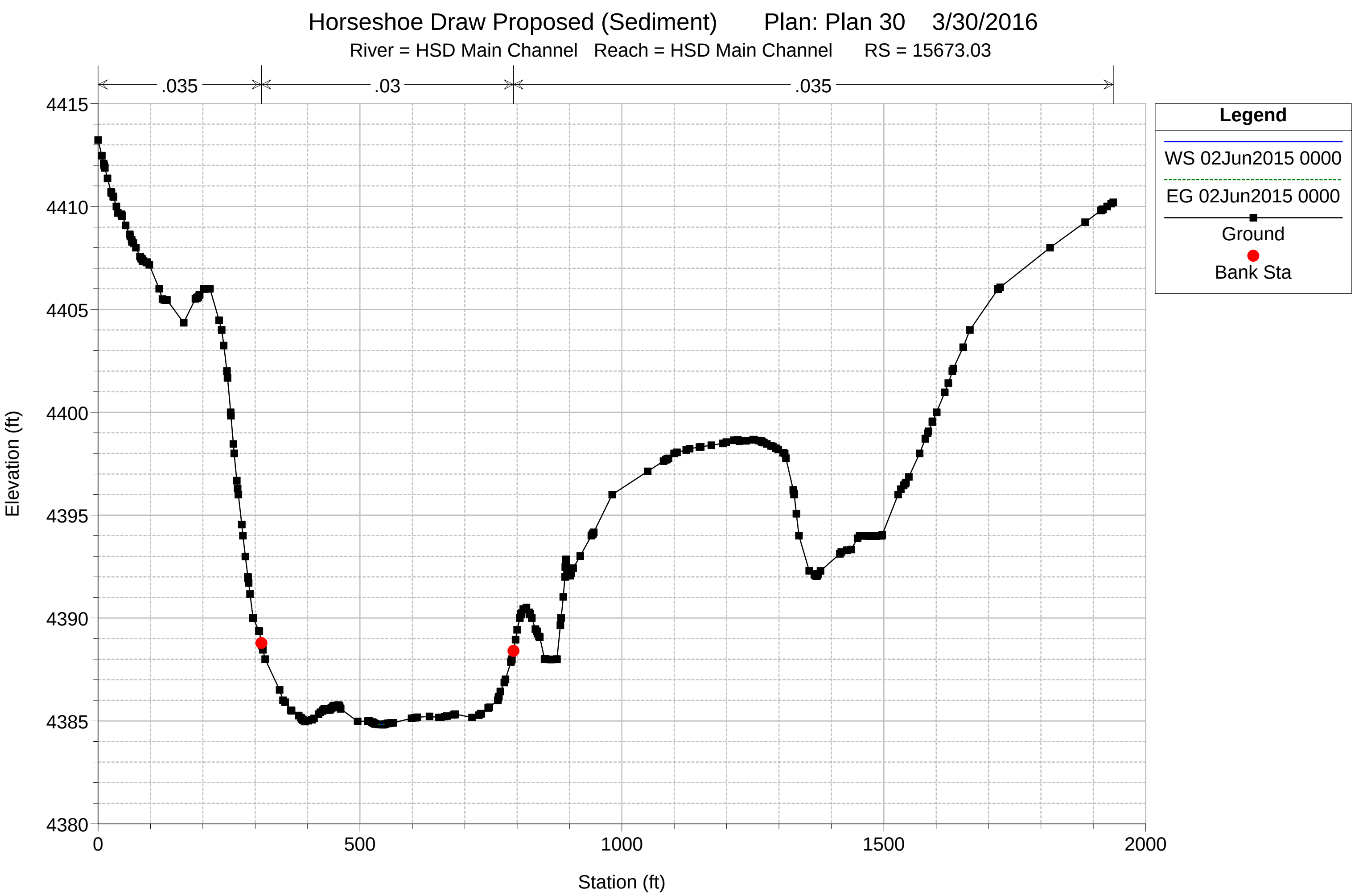
Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 16520
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
4420
4415
4410
4405
4400
4395
4390
0
500
1000
1500
2000
2500
Station (ft)



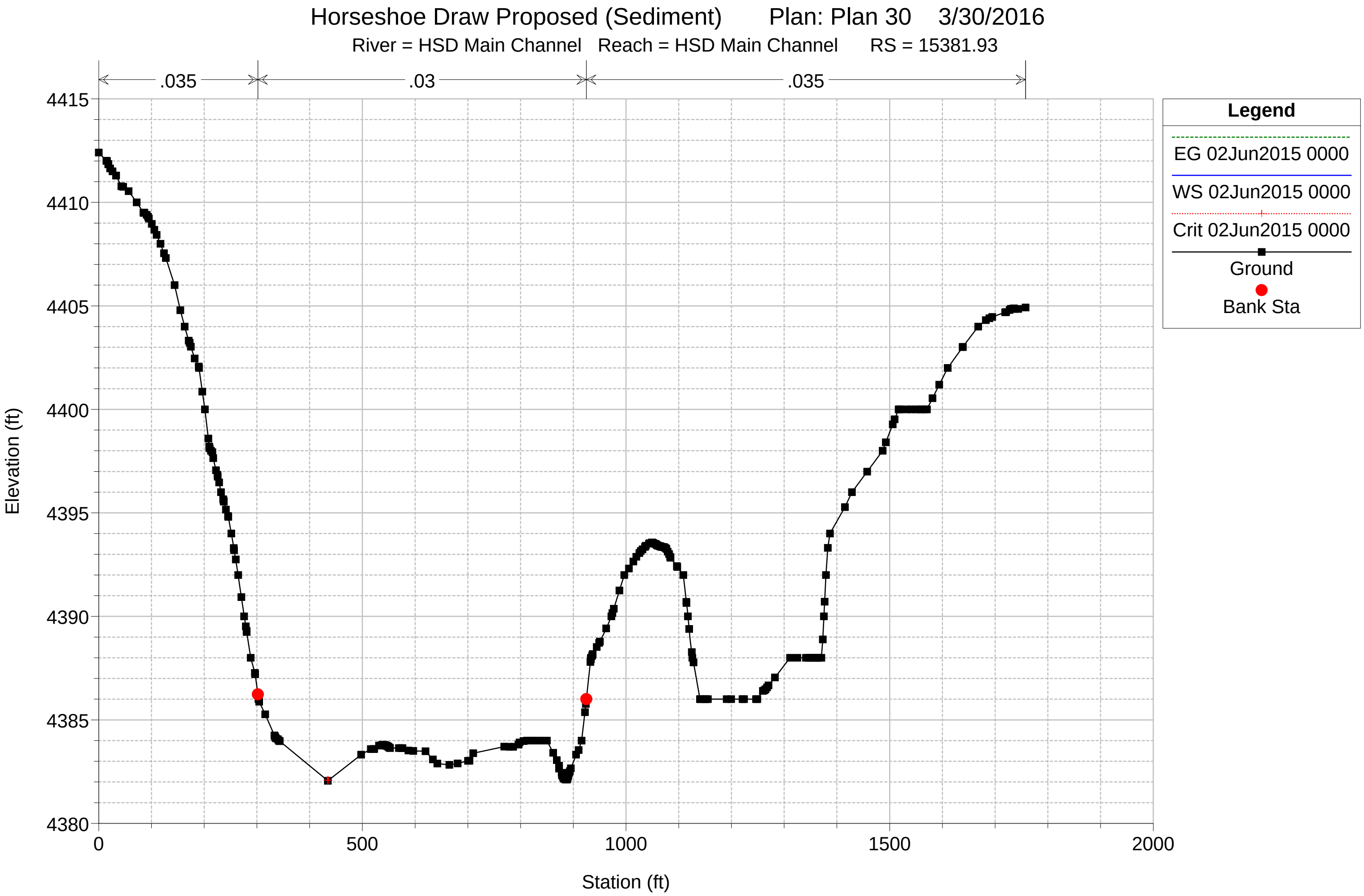
Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 16246.06
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
4425
4420
4415
4410
4405
4400
4395
4390
4385
0
500
1000
1500
2000
2500
Station (ft)

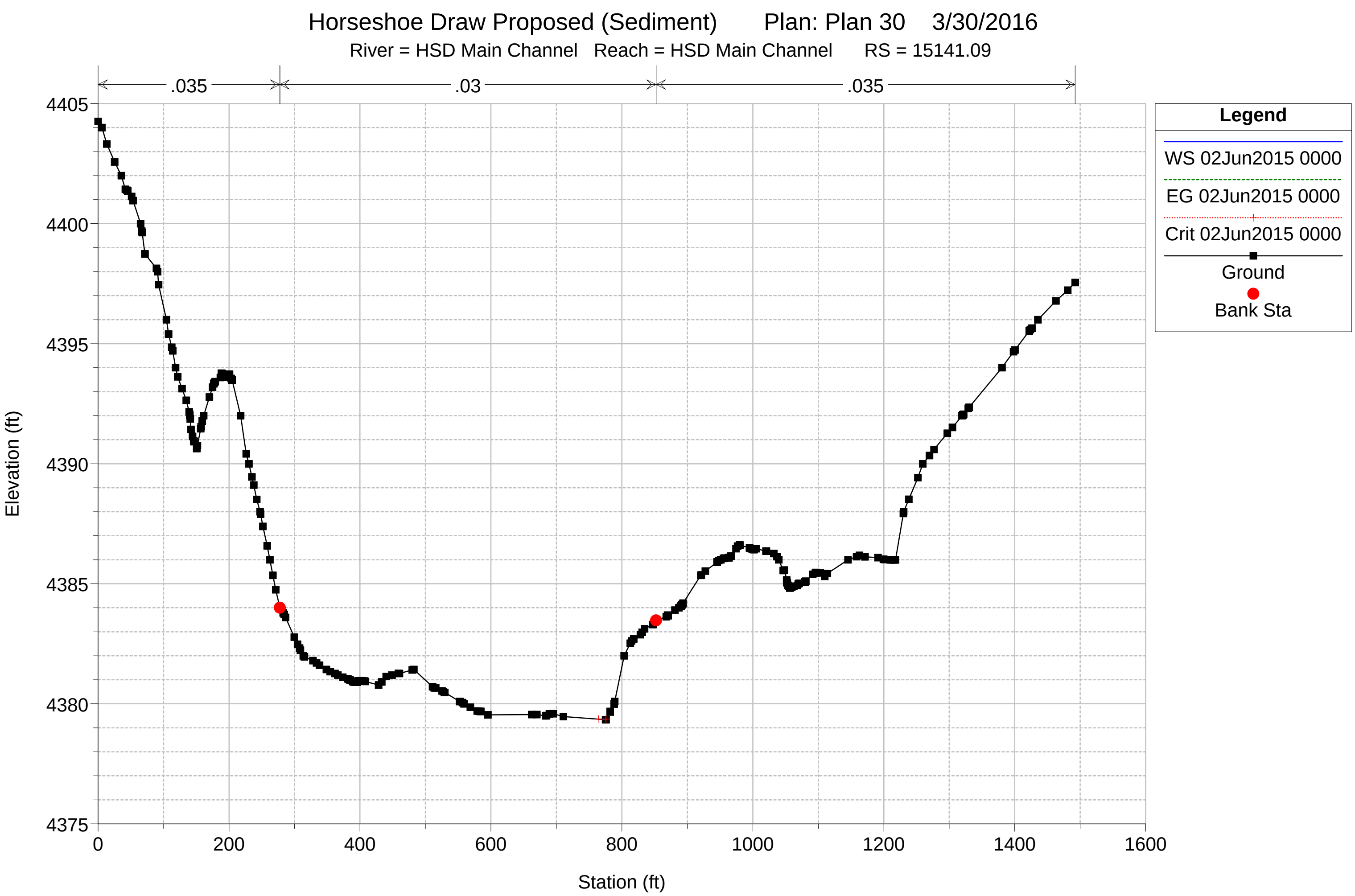


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 15946.84
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4420
4415
4410
4405
4400
4395
4390
4385
0
500
1000
1500
2000
2500



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 15673.03
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4415
4410
4405
4400
4395
4390
4385
4380
0
500
1000
1500
2000


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 15381.93
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4415
4410
4405
4400
4395
4390
4385
4380
0
500
1000
1500
2000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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
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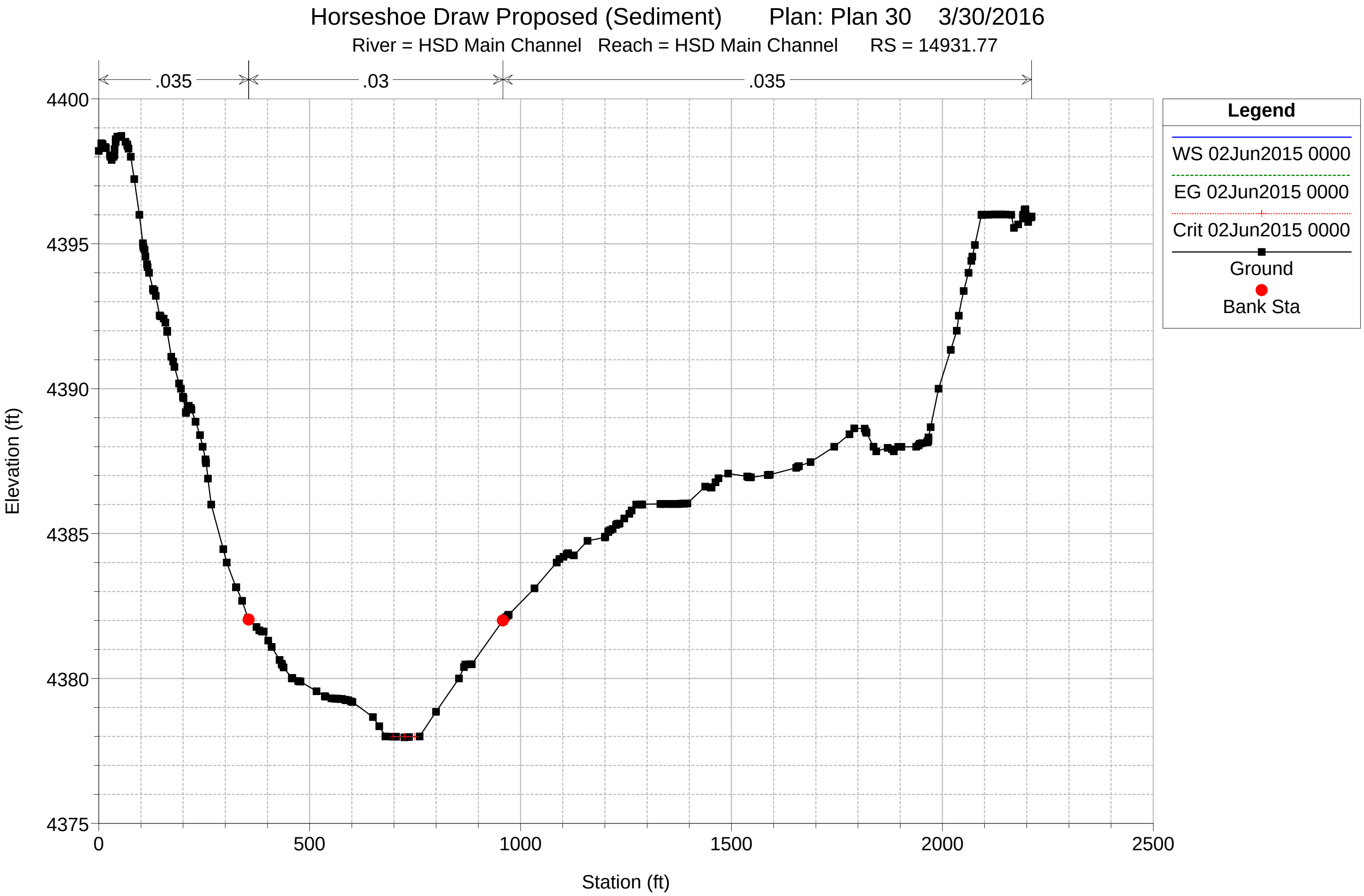
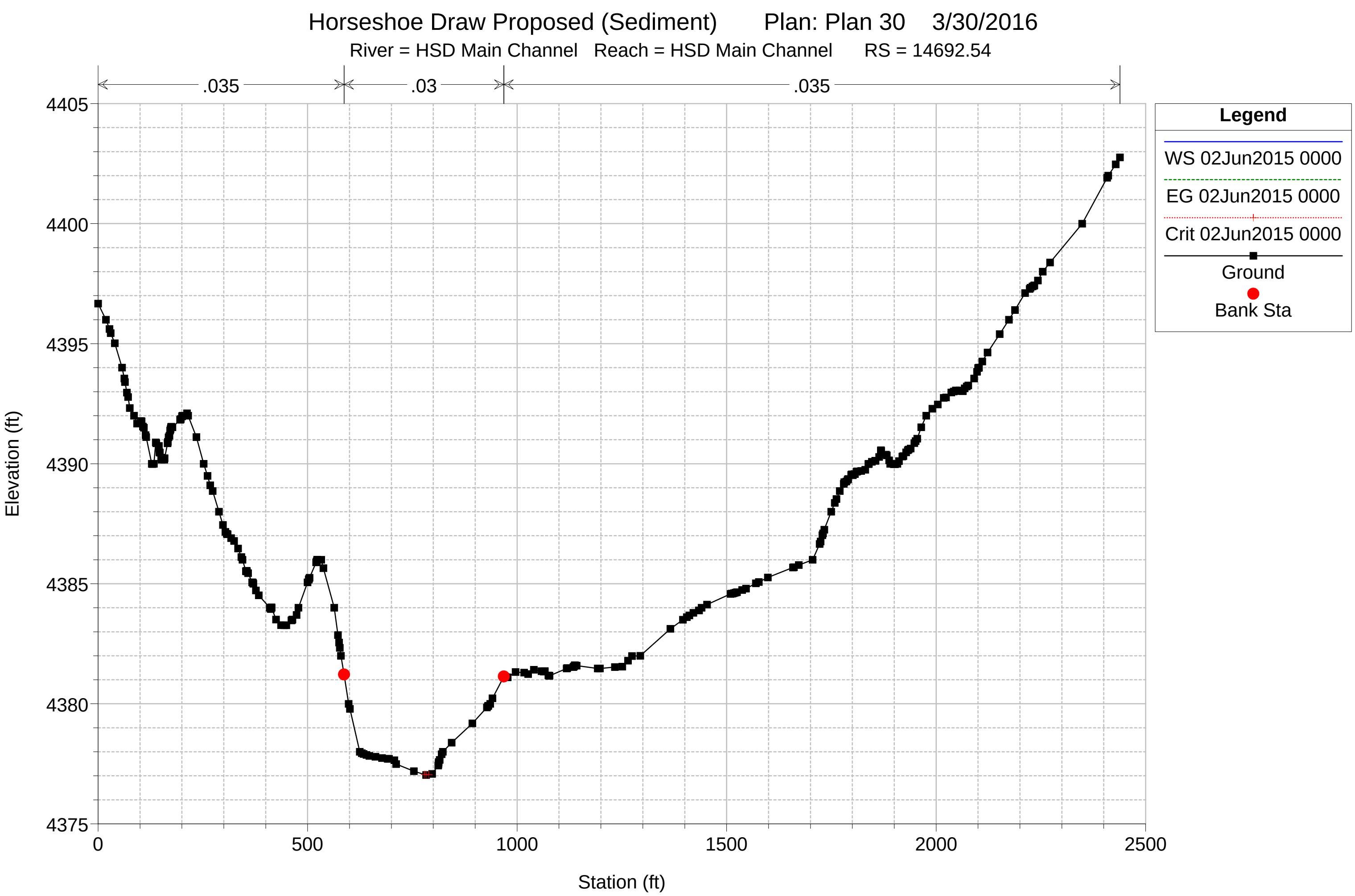
4395
4390
4385
4380
4375
0
200
400
600
800
1000
1200
1400
1600



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 14931.77
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4375
4380
4385
4390
4395
4400
0
500
1000
1500
2000
2500



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
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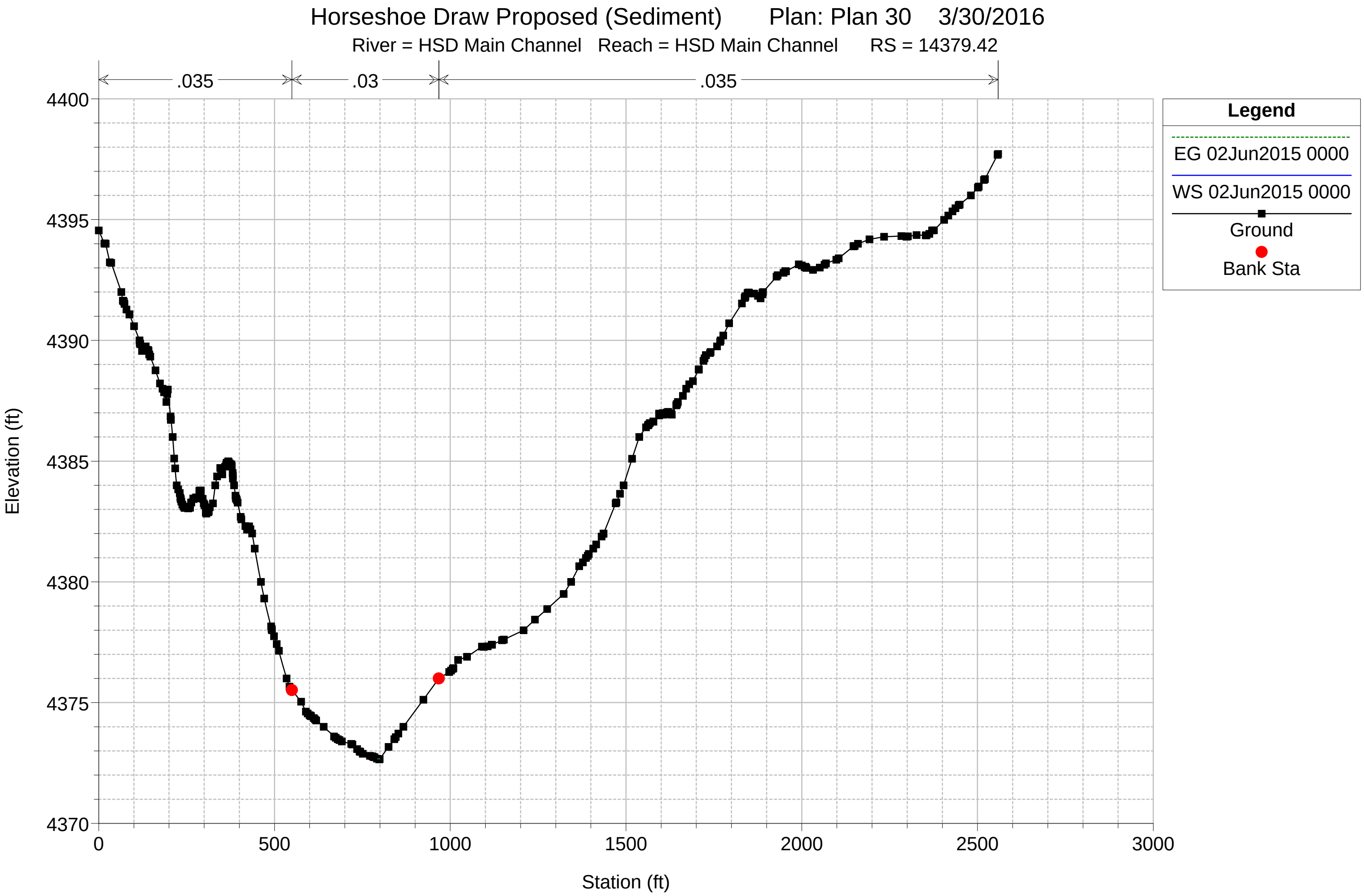
4380
4385
4390
4395
4400
4405
0
500
1000
1500
2000
2500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.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
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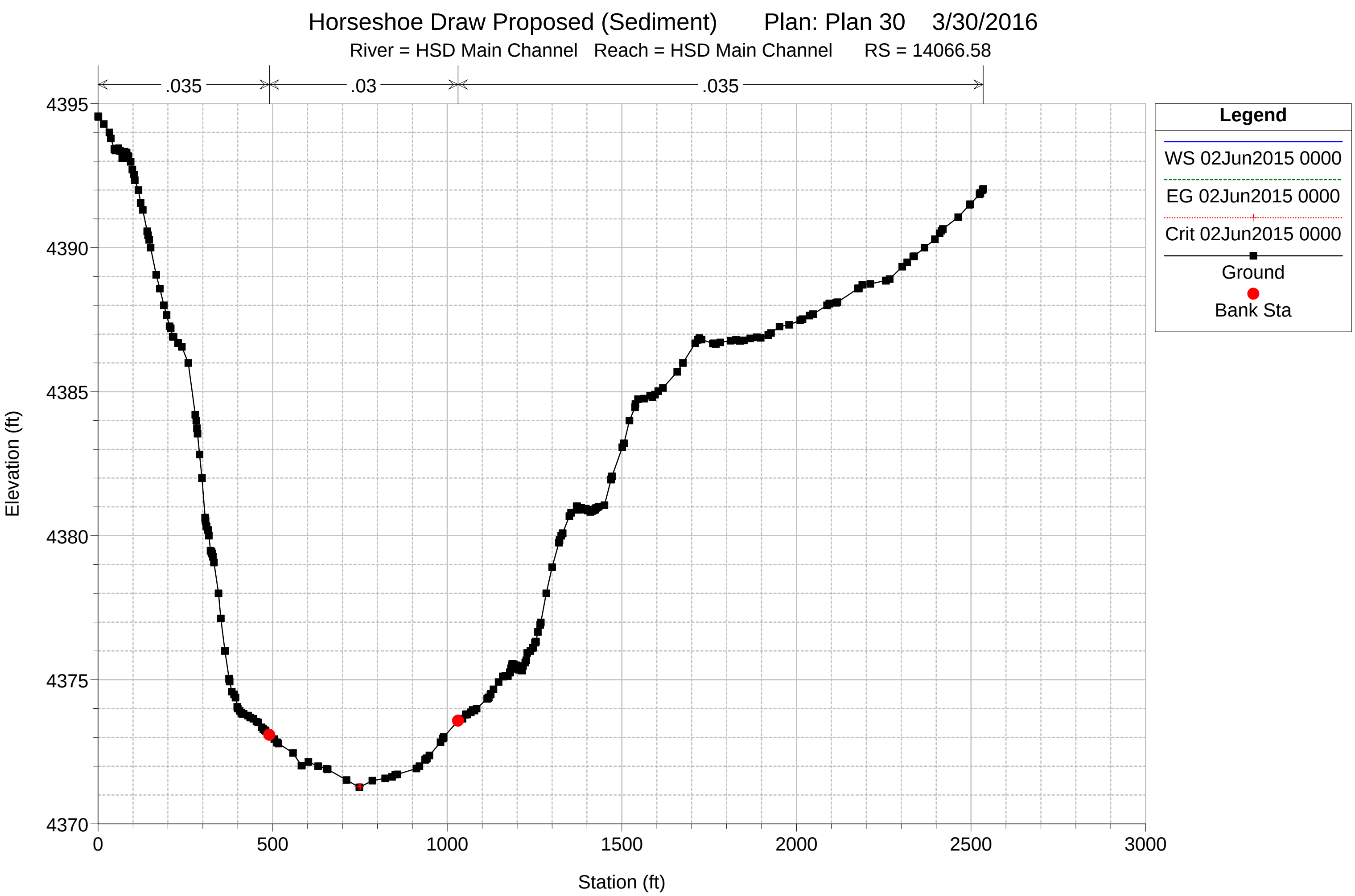
4395
4390
4385
4380
4375
4370
0
500
1000
1500
2000
2500
3000
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 14066.58
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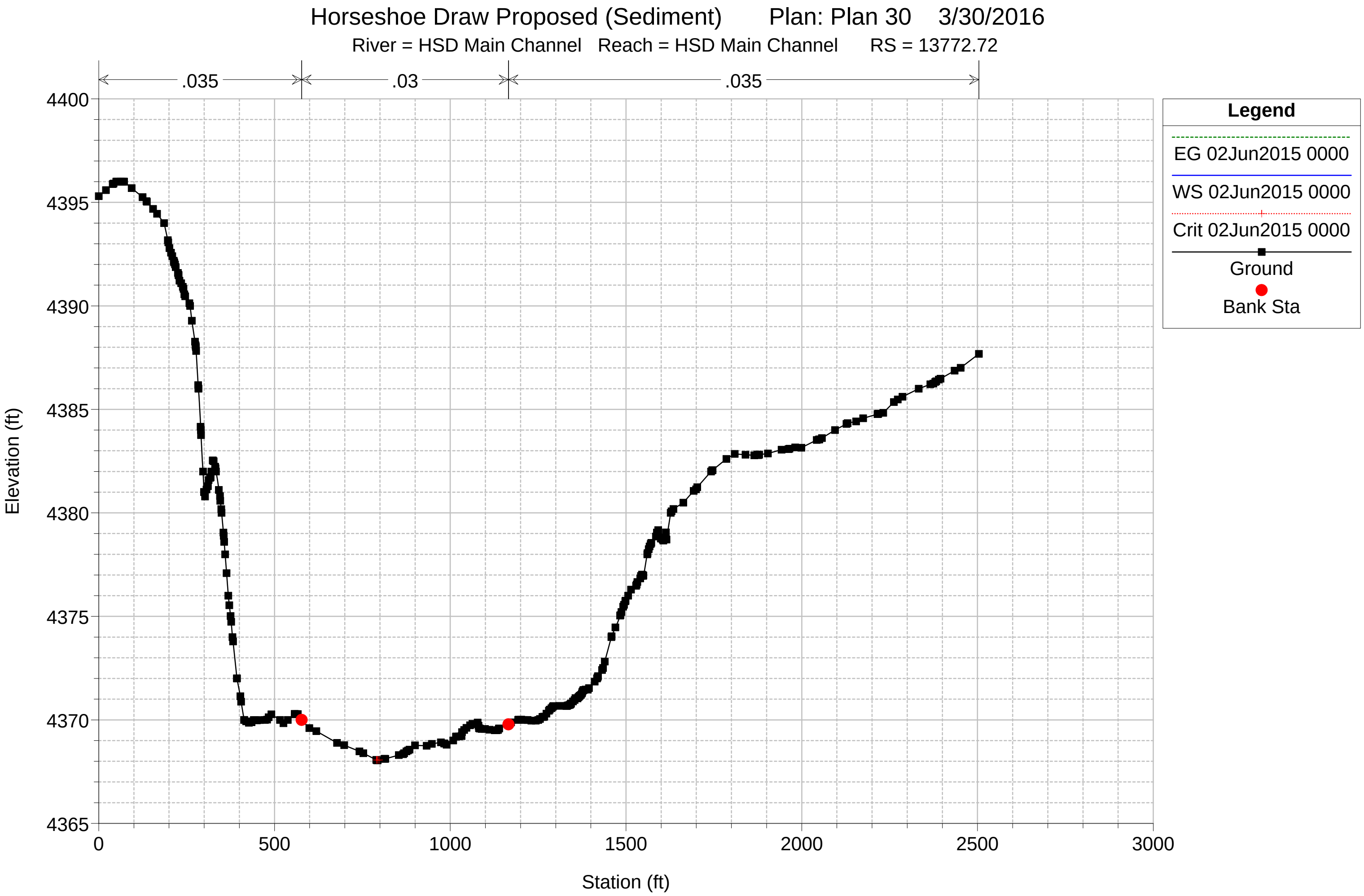
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
4395
4390
4385
4380
4375
4370
0
500
1000
1500
2000
2500
3000
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 13772.72
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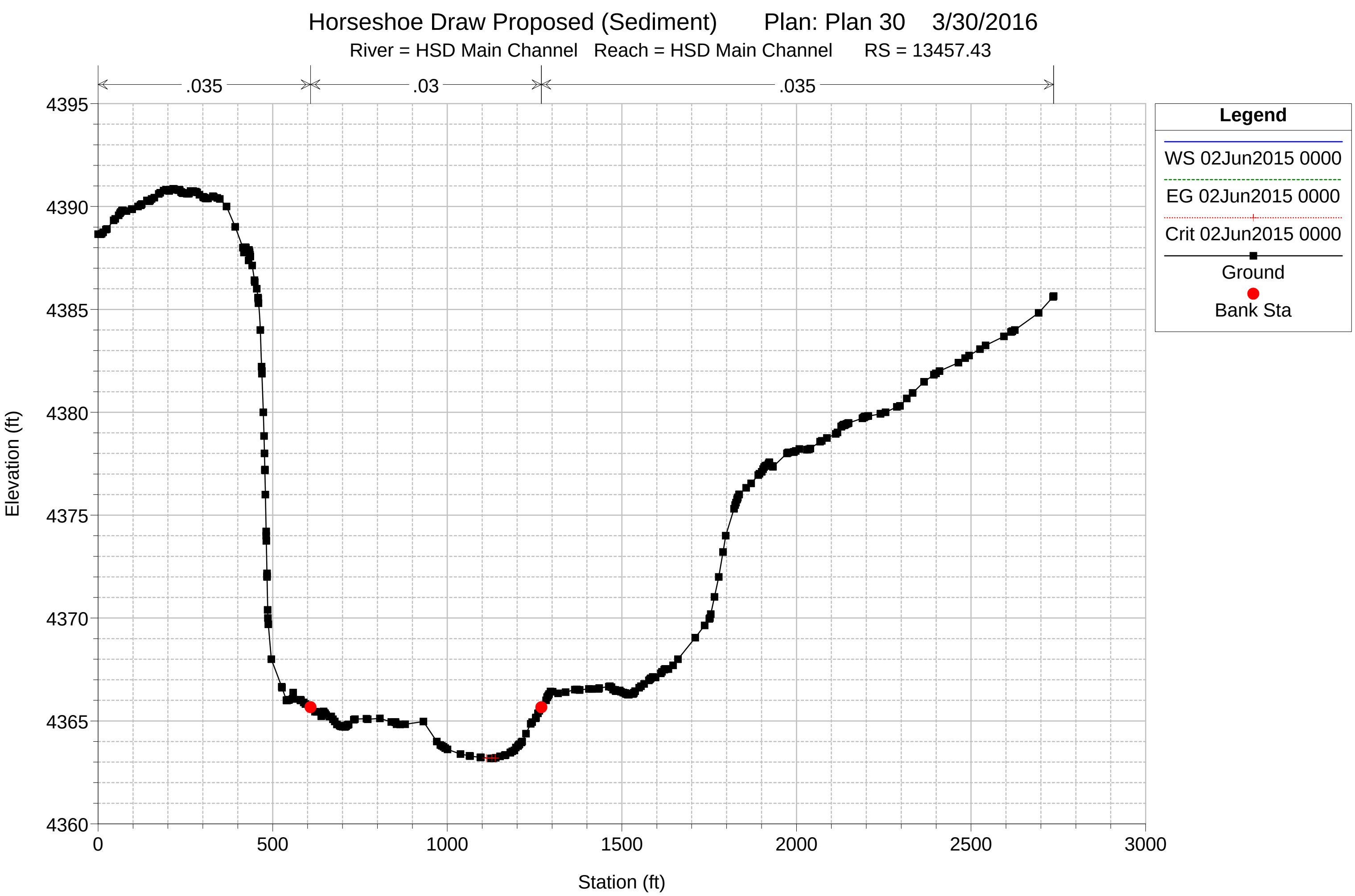
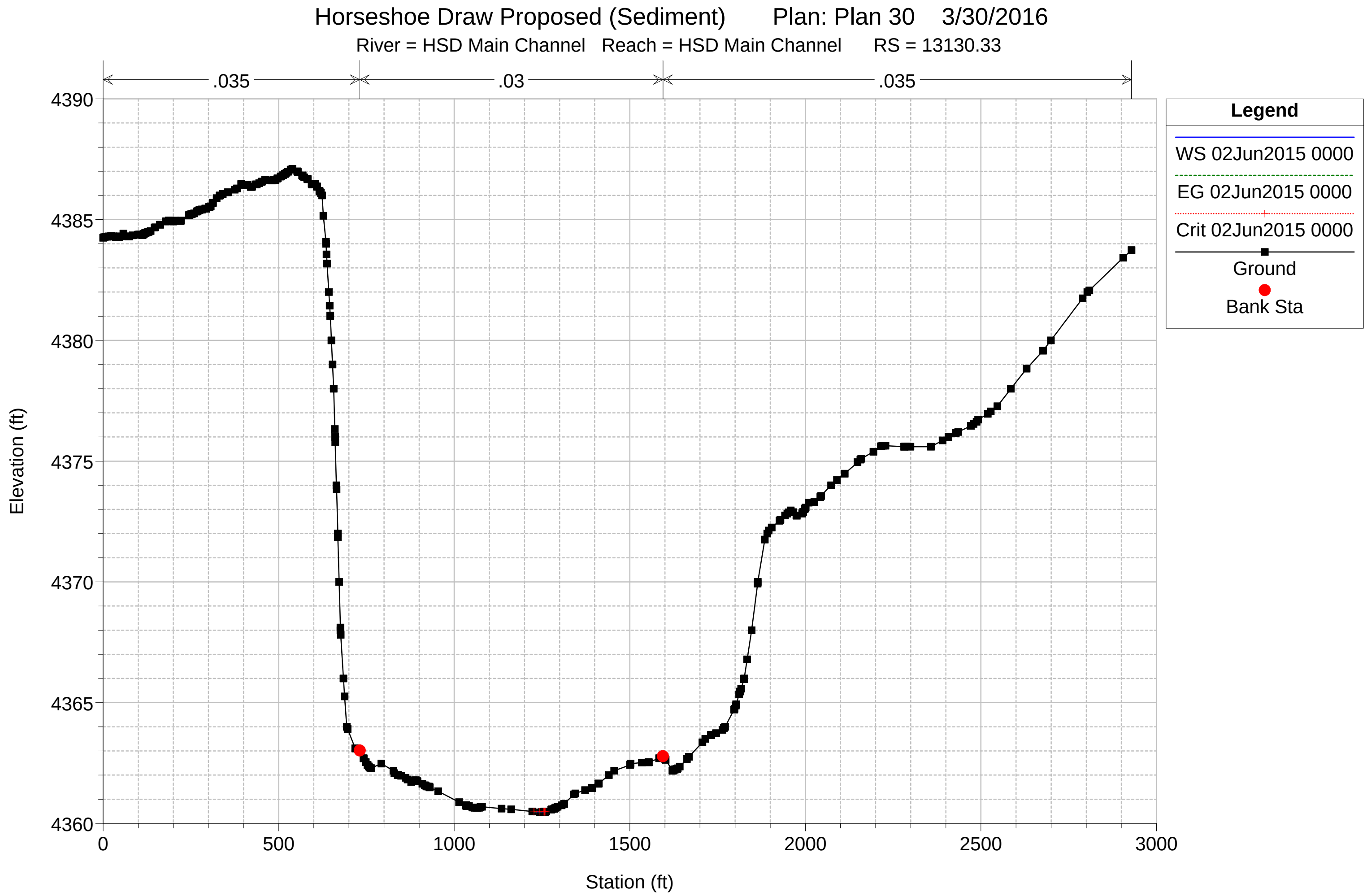
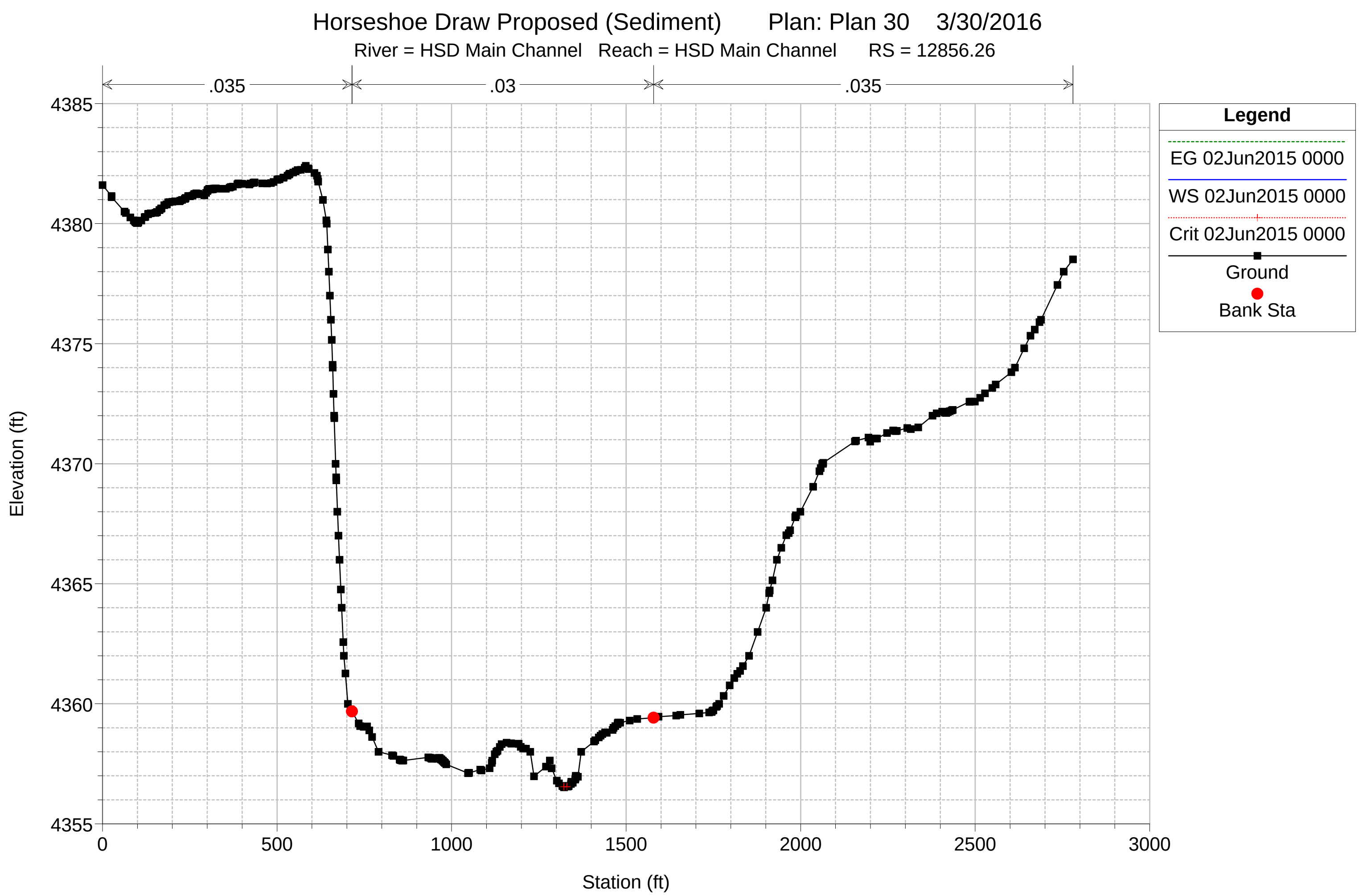
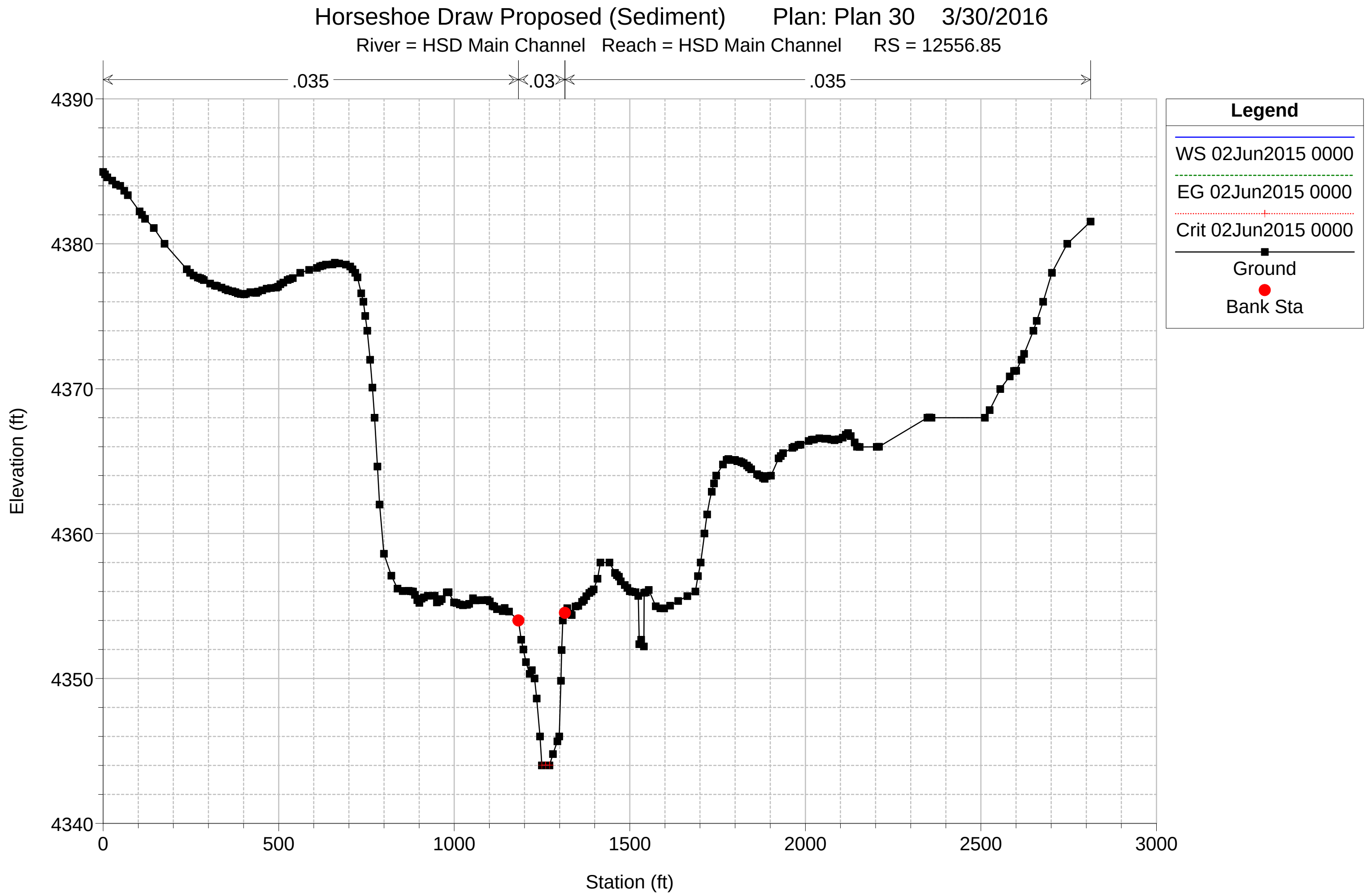
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)



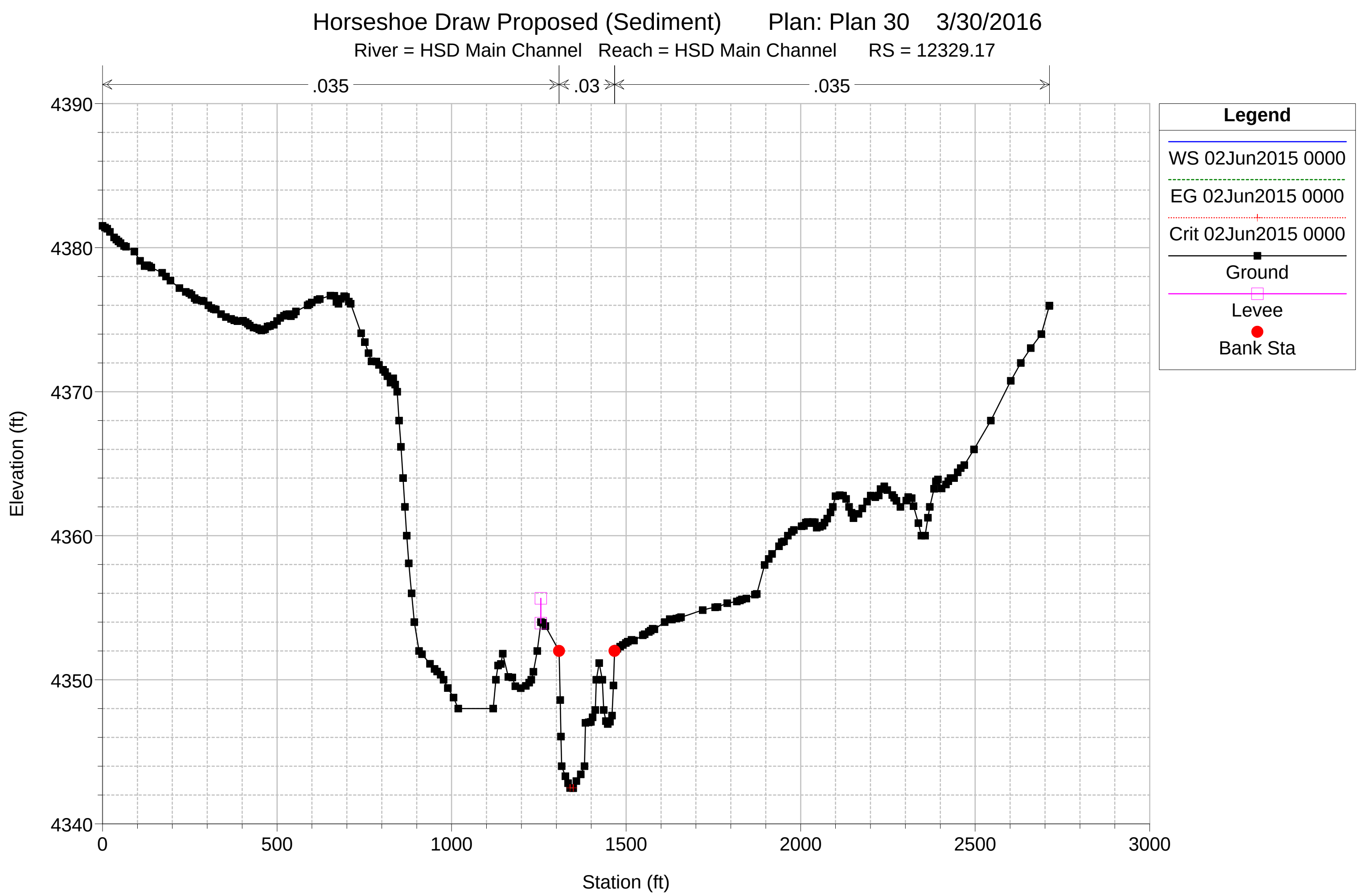
Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 13457.43
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 13130.33
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4390
4385
4380
4375
4370
4365
4360
0
500
1000
1500
2000
2500
3000


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 12856.26
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4385
4380
4375
4370
4365
4360
4355
0
500
1000
1500
2000
2500
3000



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 12556.85
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 12329.17
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta

HEC-RAS Version 4.0.0 March 2008
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
            X     X  XXXXXX   XXXX        XXXX      XX      XXXX
            X     X  X       X    X       X   X    X  X    X
            X     X  X       X            X   X   X    X   X
            XXXXXXX  XXXX    X       XXX  XXXX    XXXXXX    XXXX
            X     X  X       X            X  X    X    X        X
            X     X  X       X    X       X   X   X    X        X
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PROJECT DATA
Project Title: Horseshoe Draw Proposed (Sediment)
Project File : HorseshoeDrawProp.prj
Run Date and Time: 3/30/2016 10:28:47 AM

Project in English units

PLAN DATA

Plan Title: Plan 30
Plan File : u:\1400\1472\REPORTS\DRAINAGE\HEC-RAS\Proposed Conditions\Sediment Transport\Split Geo - US\HorseshoeDrawProp.p30

Geometry Title: Horseshoe Draw Existing Conditions
Geometry File : u:\1400\1472\REPORTS\DRAINAGE\HEC-RAS\Proposed Conditions\Sediment Transport\Split Geo - US\HorseshoeDrawProp.g01

Flow Title :
Flow File :

Plan Summary Information:

Number of:				
	Cross Sections =	16	Multiple Openings =	0
	Culverts =	0	Inline Structures =	0
	Bridges =	0	Lateral Structures =	0

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Mixed Flow

FLOW DATA

Flow Title:
Flow File :

Flow Data (cfs)

River	Reach	RS	PF 1

Boundary Conditions

River	Reach	Profile	Upstream	Downstream

SUMMARY OF MANNING'S N VALUES

River:HSD Main Channel

Reach	River Sta.	n1	n2	n3
HSD Main Channel	16520	.035	.03	.035
HSD Main Channel	16246.06	.035	.03	.035
HSD Main Channel	15946.84	.035	.03	.035
HSD Main Channel	15673.03	.035	.03	.035
HSD Main Channel	15381.93	.035	.03	.035
HSD Main Channel	15141.09	.035	.03	.035

HSD Main Channel	14931.77	.035	.03	.035
HSD Main Channel	14692.54	.035	.03	.035
HSD Main Channel	14379.42	.035	.03	.035
HSD Main Channel	14066.58	.035	.03	.035
HSD Main Channel	13772.72	.035	.03	.035
HSD Main Channel	13457.43	.035	.03	.035
HSD Main Channel	13130.33	.035	.03	.035
HSD Main Channel	12856.26	.035	.03	.035
HSD Main Channel	12556.85	.035	.03	.035
HSD Main Channel	12329.17	.035	.03	.035

SUMMARY OF REACH LENGTHS

River: HSD Main Channel

Reach	River Sta.	Left	Channel	Right
HSD Main Channel	16520	273.94	273.94	273.94
HSD Main Channel	16246.06	299.22	299.22	299.22
HSD Main Channel	15946.84	273.81	273.81	273.81
HSD Main Channel	15673.03	291.1	291.1	291.1
HSD Main Channel	15381.93	240.84	240.84	240.84
HSD Main Channel	15141.09	209.32	209.32	209.32
HSD Main Channel	14931.77	239.23	239.23	239.23
HSD Main Channel	14692.54	313.12	313.12	313.12
HSD Main Channel	14379.42	312.84	312.84	312.84
HSD Main Channel	14066.58	293.86	293.86	293.86
HSD Main Channel	13772.72	315.29	315.29	315.29
HSD Main Channel	13457.43	327.1	327.1	327.1
HSD Main Channel	13130.33	274.07	274.07	274.07
HSD Main Channel	12856.26	299.41	299.41	299.41
HSD Main Channel	12556.85	227.68	227.68	227.68
HSD Main Channel	12329.17	187.84	187.84	187.84

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: HSD Main Channel

Reach	River Sta.	Contr.	Expan.
HSD Main Channel	16520	.1	.3
HSD Main Channel	16246.06	.1	.3
HSD Main Channel	15946.84	.1	.3
HSD Main Channel	15673.03	.1	.3
HSD Main Channel	15381.93	.1	.3
HSD Main Channel	15141.09	.1	.3
HSD Main Channel	14931.77	.1	.3
HSD Main Channel	14692.54	.1	.3
HSD Main Channel	14379.42	.1	.3
HSD Main Channel	14066.58	.1	.3
HSD Main Channel	13772.72	.1	.3
HSD Main Channel	13457.43	.1	.3
HSD Main Channel	13130.33	.1	.3
HSD Main Channel	12856.26	.1	.3
HSD Main Channel	12556.85	.1	.3
HSD Main Channel	12329.17	.1	.3

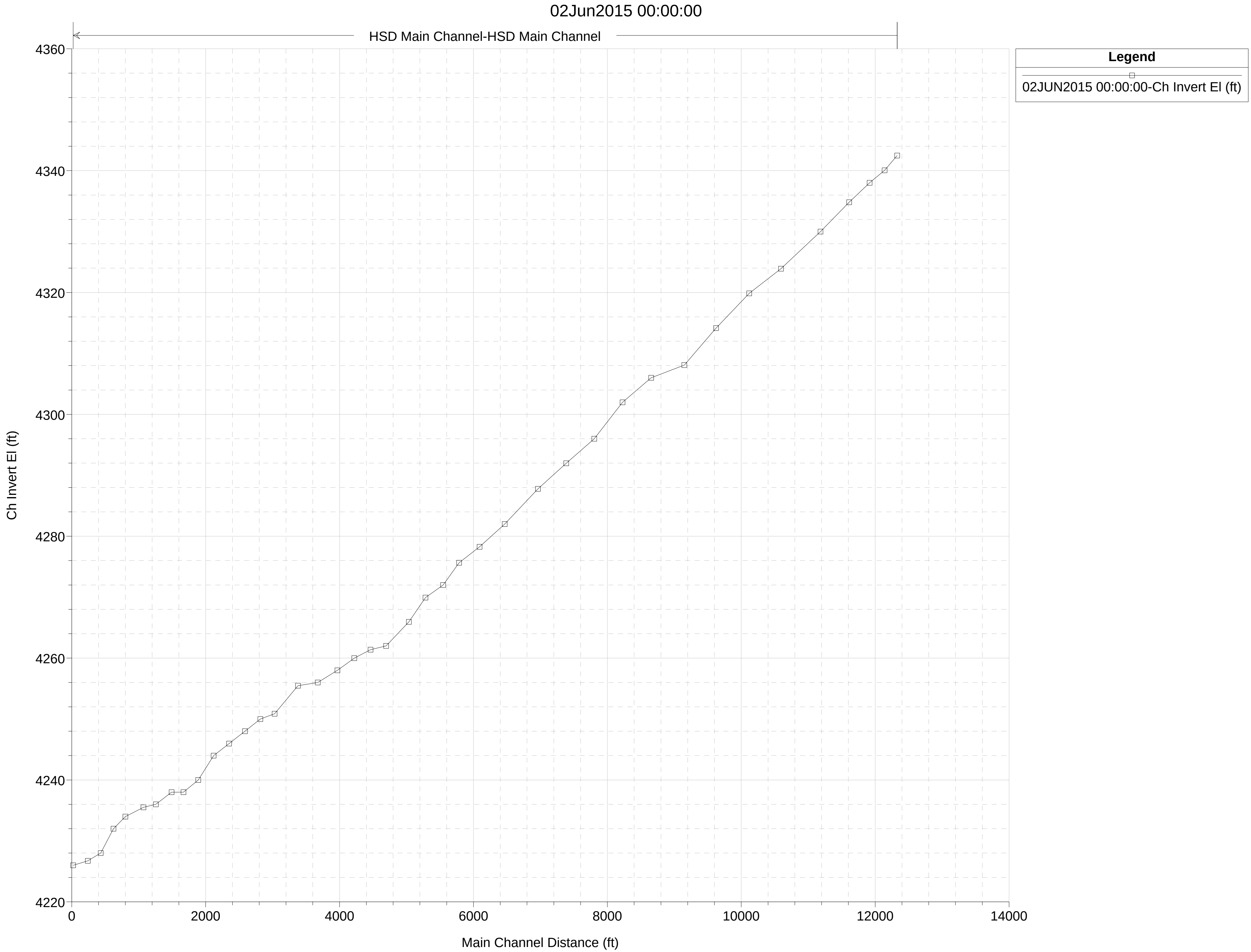
Profile Output Table - Standard Table 1

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
HSD Main Channel	16520	02Jun2015 0000	0.01	4391.22	4391.24		4391.24	0.018879	0.26	0.04	5.05	0.53
HSD Main Channel	16246.06	02Jun2015 0000	0.01	4389.64	4389.67	4389.67	4389.67	0.002736	0.14	0.07	5.65	0.22
HSD Main Channel	15946.84	02Jun2015 0000	0.01	4386.00	4386.02	4386.02	4386.03	0.000152	0.05	0.21	9.47	0.06
HSD Main Channel	15673.03	02Jun2015 0000	0.01	4384.82	4384.83		4384.83	0.006310	0.14	0.07	10.47	0.30
HSD Main Channel	15381.93	02Jun2015 0000	0.01	4382.06	4382.09	4382.09	4382.09	0.015609	0.33	0.03	2.43	0.52
HSD Main Channel	15141.09	02Jun2015 0000	0.01	4379.34	4379.36	4379.36	4379.36	0.000878	0.07	0.13	11.81	0.12
HSD Main Channel	14931.77	02Jun2015 0000	0.01	4377.97	4377.99	4377.99	4377.99	0.000129	0.02	0.43	50.92	0.04
HSD Main Channel	14692.54	02Jun2015 0000	0.01	4377.03	4377.05	4377.05	4377.05	0.001135	0.08	0.12	10.56	0.14
HSD Main Channel	14379.42	02Jun2015 0000	0.01	4372.65	4372.67		4372.67	0.005706	0.18	0.06	5.63	0.31
HSD Main Channel	14066.58	02Jun2015 0000	0.01	4371.27	4371.29	4371.29	4371.29	0.003513				

	0.14	0.07	6.57		0.24					
HSD Main Channel	13772.72		02Jun2015 0000	0.01	4368.04	4368.06	4368.06	4368.06	0.003444	
	0.14	0.07	7.07		0.24					
HSD Main Channel	13457.43		02Jun2015 0000	0.01	4363.18	4363.20	4363.20	4363.20	0.000085	
	0.03	0.37	25.58		0.04					
HSD Main Channel	13130.33		02Jun2015 0000	0.01	4360.46	4360.48	4360.48	4360.48	0.000139	
	0.03	0.35	32.07		0.05					
HSD Main Channel	12856.26		02Jun2015 0000	0.01	4356.52	4356.54	4356.54	4356.54	0.001662	
	0.10	0.10	9.01		0.17					
HSD Main Channel	12556.85		02Jun2015 0000	0.01	4344.00	4344.03	4344.03	4344.03	0.000018	
	0.02	0.56	21.94		0.02					
HSD Main Channel	12329.17		02Jun2015 0000	0.01	4342.48	4342.50	4342.50	4342.50	0.000542	
	0.07	0.14	9.34		0.10					

HEC-RAS SEDIMENT TRANSPORT

DOWNSTREAM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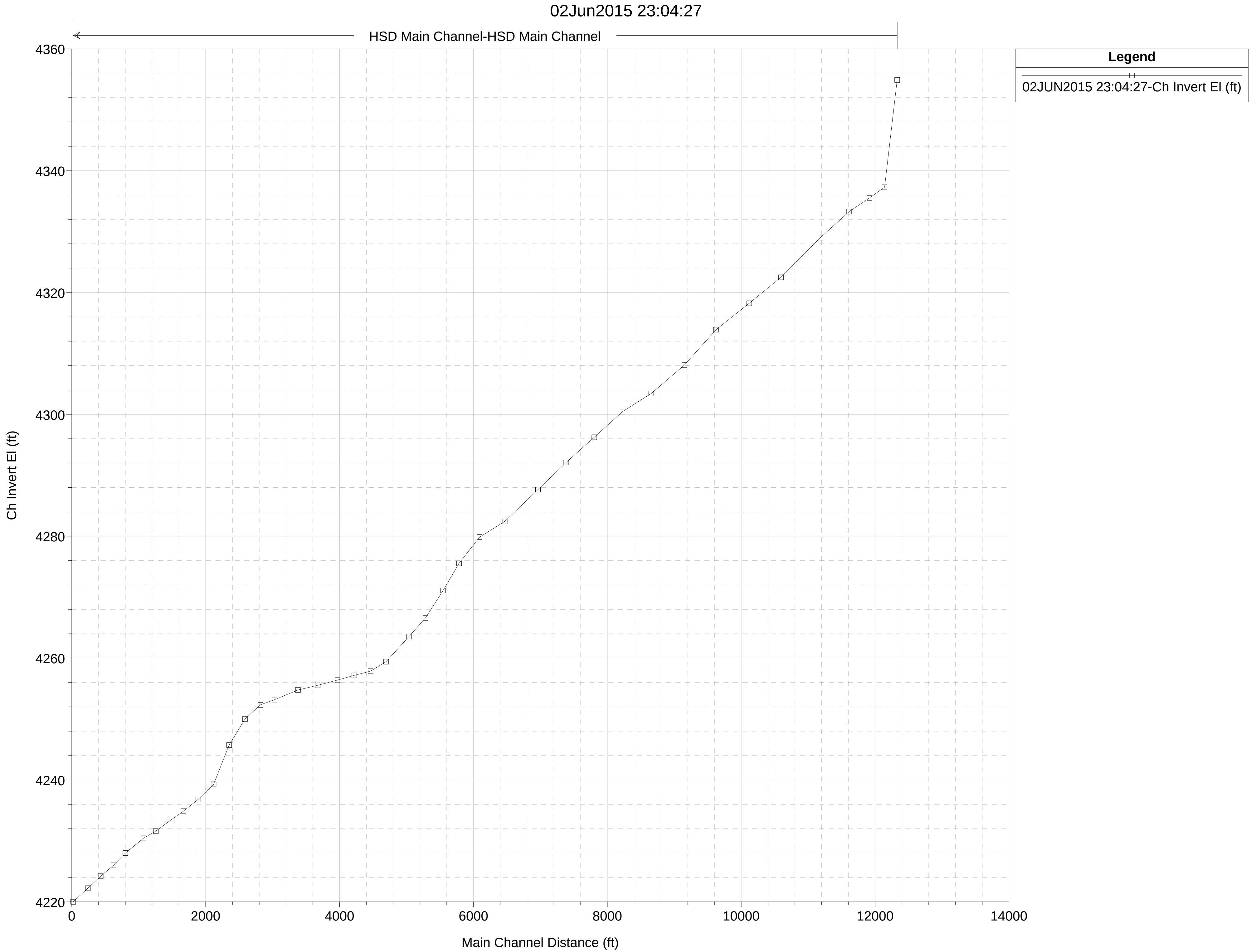
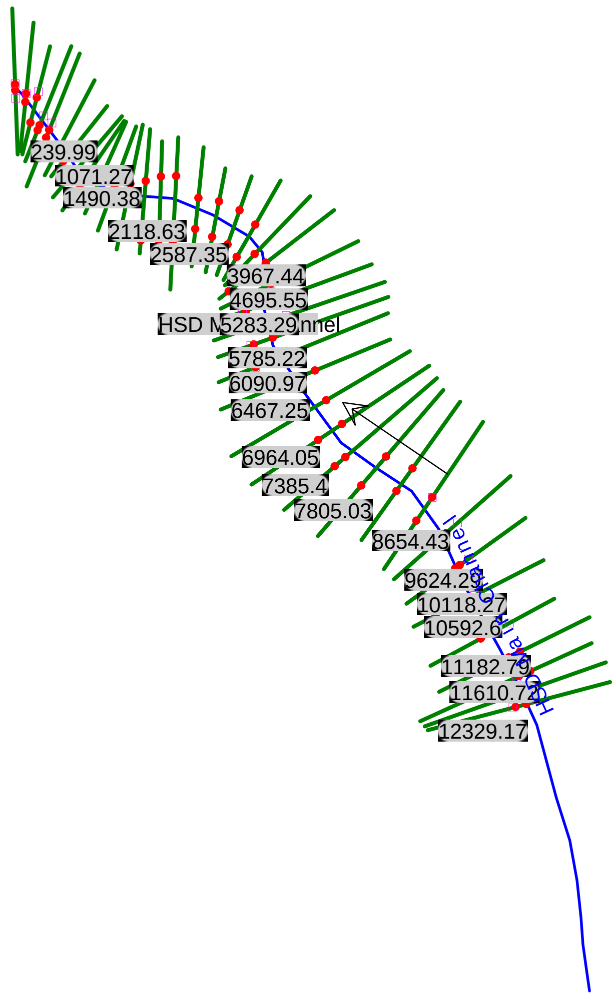
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 00:00:00-Ch Invert El (ft)
Ch Invert El (ft)
4360
4340
4320
4300
4280
4260
4240
4220
0
2000
4000
6000
8000
10000
12000
14000
Main Channel Distance (ft)


02Jun2015 23:04:27
HSD Main Channel-HSD Main Channel
Legend
02JUN2015 23:04:27-Ch Invert El (ft)
Ch Invert El (ft)
4360
4340
4320
4300
4280
4260
4240
4220
0
2000
4000
6000
8000
10000
12000
14000
Main Channel Distance (ft)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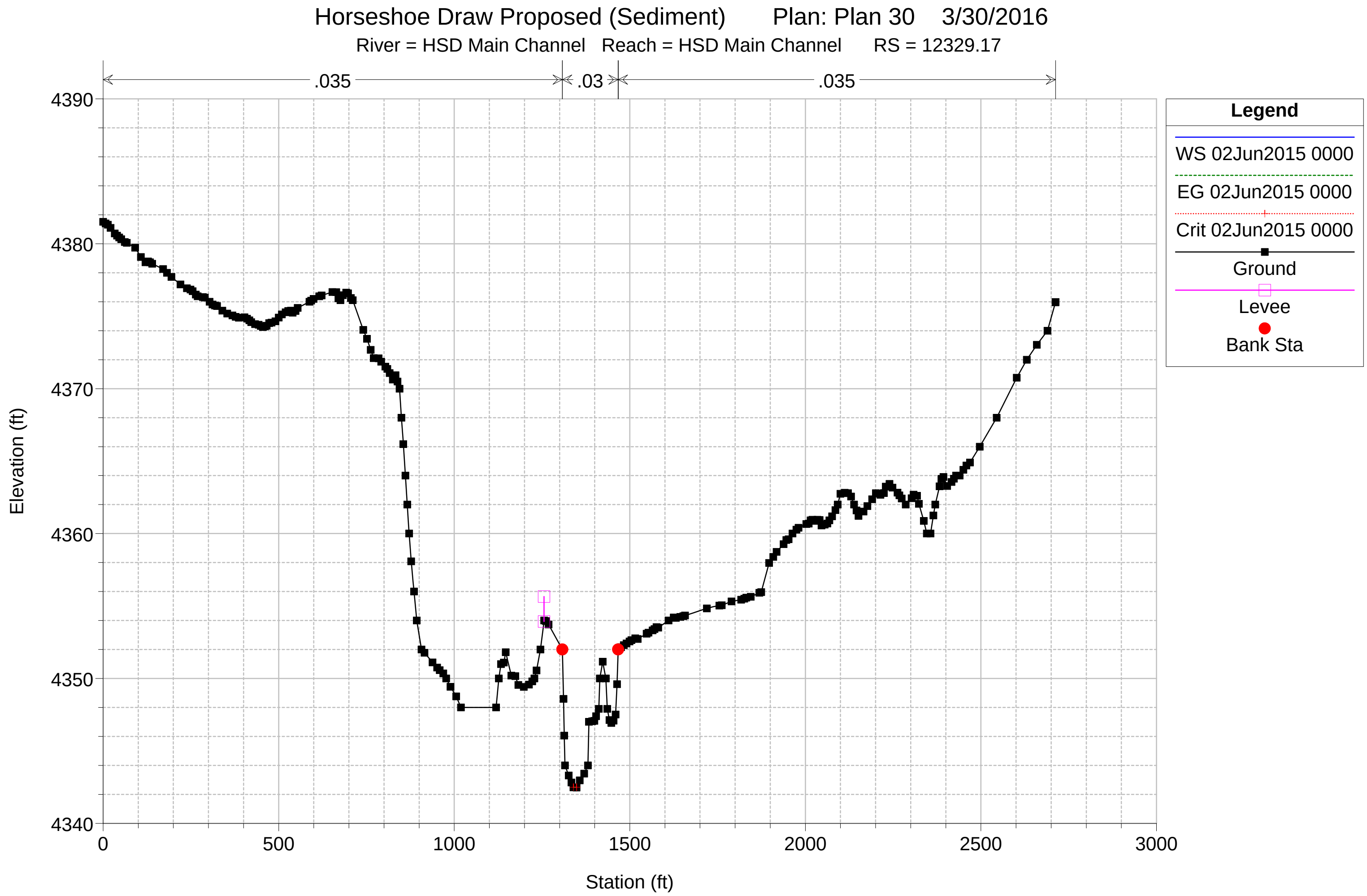
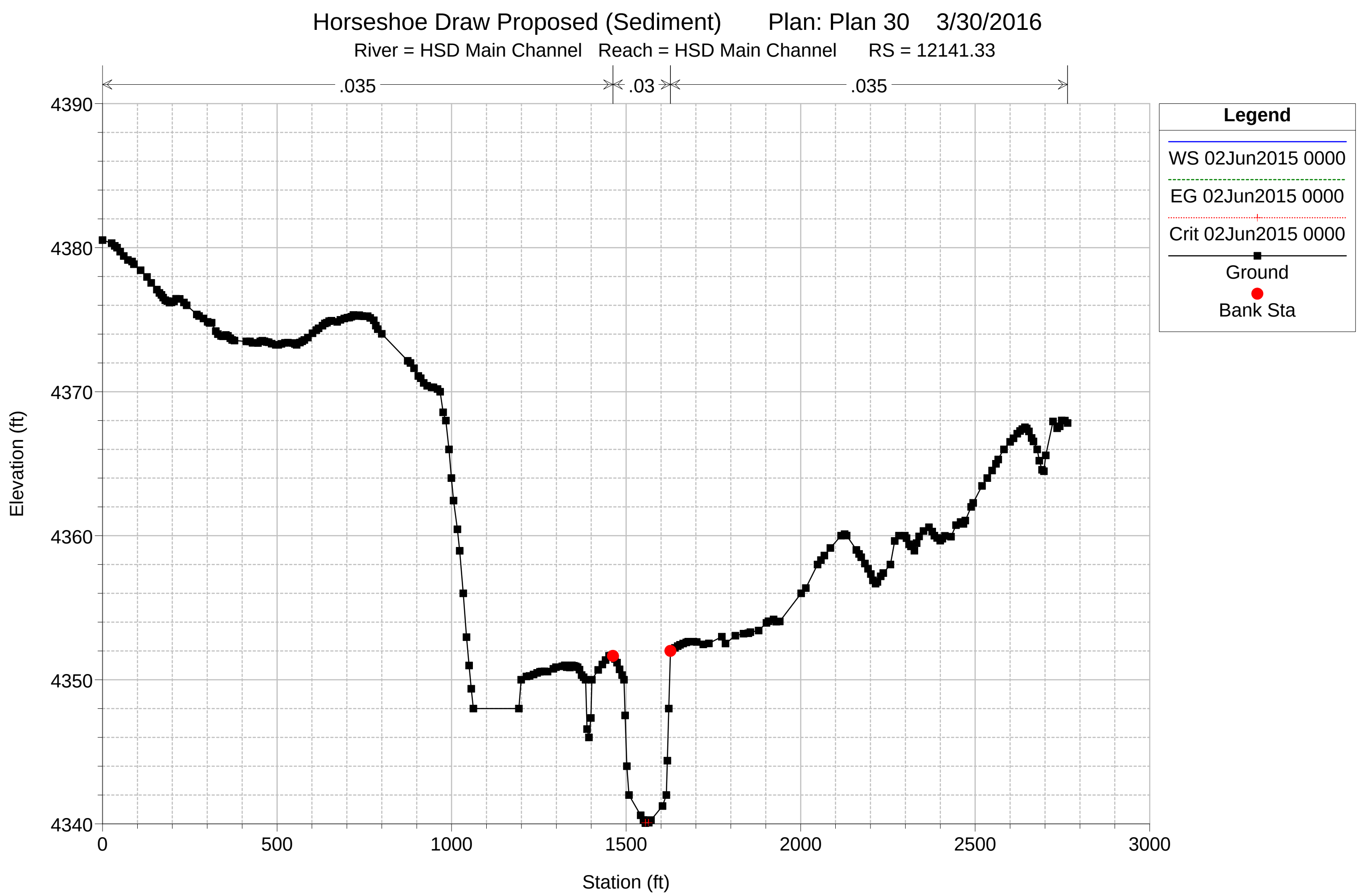
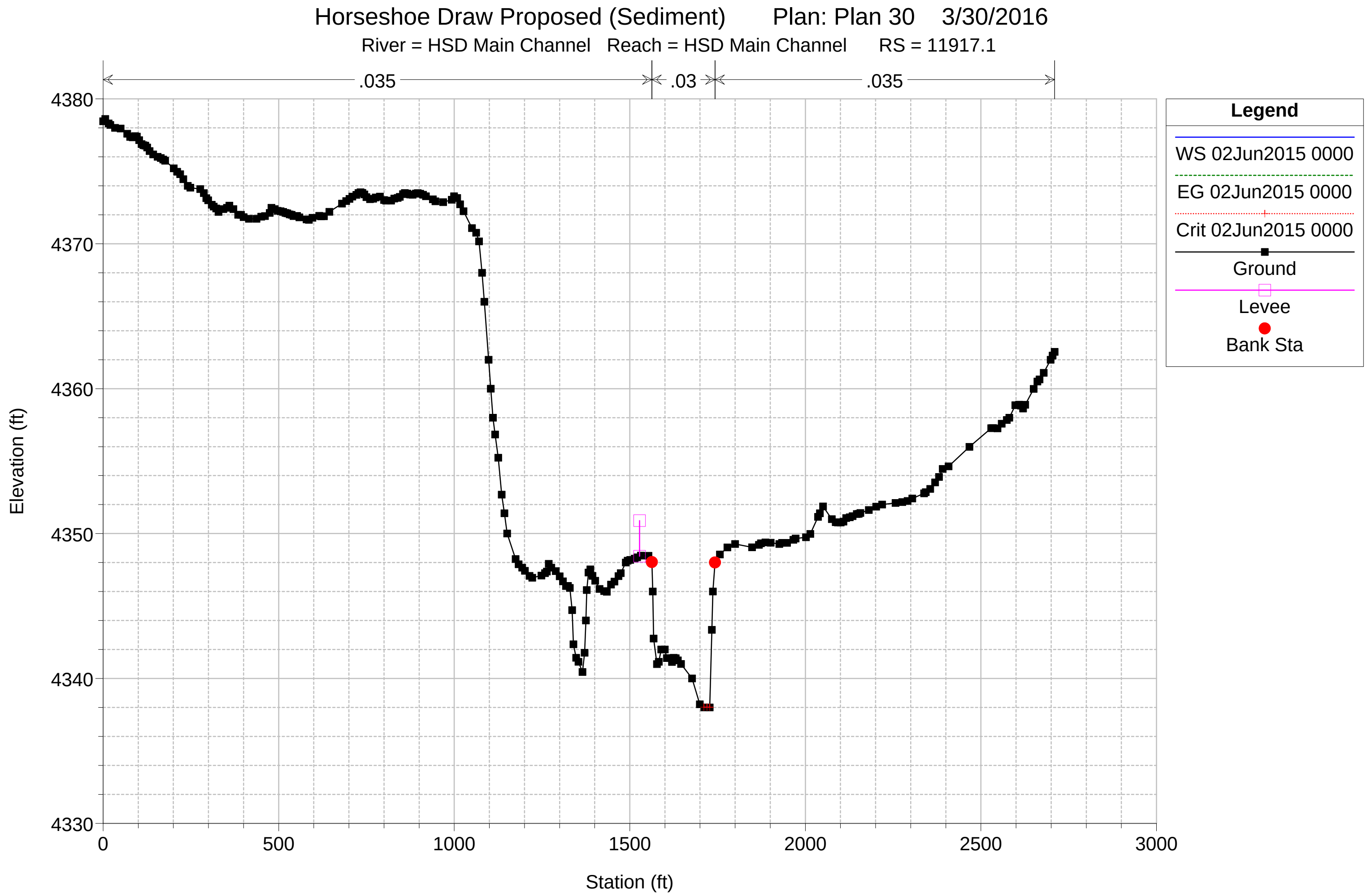
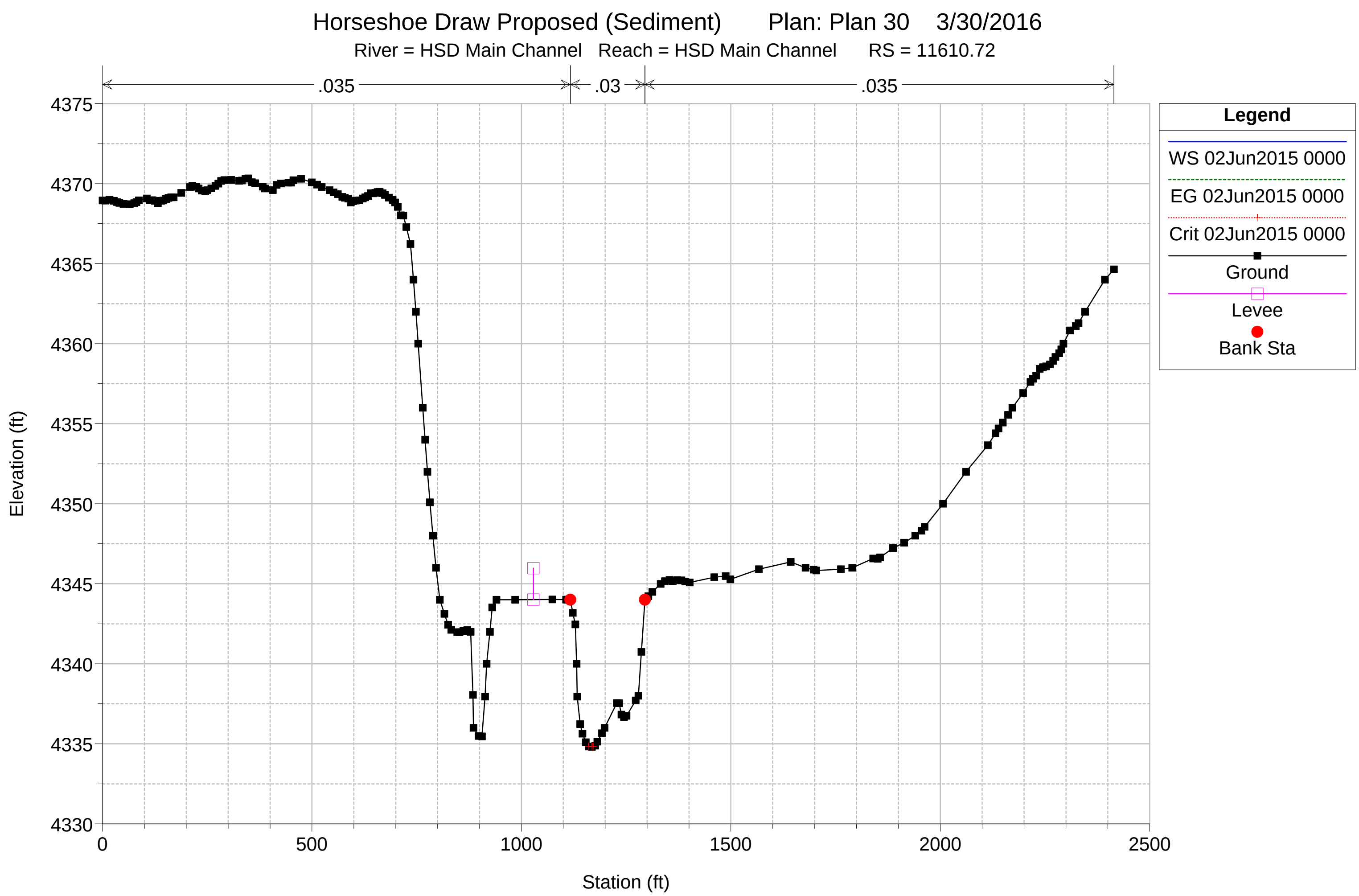
1071.27
1490.38
2118.63
2587.35
3967.44
4695.55
5283.29
5785.22
6090.97
6467.25
6964.05
7385.4
7805.03
8654.43
9624.29
10118.27
10592.6
11182.79
11610.72
12329.17


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 12329.17
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
4390
4380
4370
4360
4350
4340
0
500
1000
1500
2000
2500
3000


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 12141.33
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4390
4380
4370
4360
4350
4340
0
500
1000
1500
2000
2500
3000



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 11917.1
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
4380
4370
4360
4350
4340
4330
0
500
1000
1500
2000
2500
3000



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River = HSD Main Channel Reach = HSD Main Channel RS = 11610.72
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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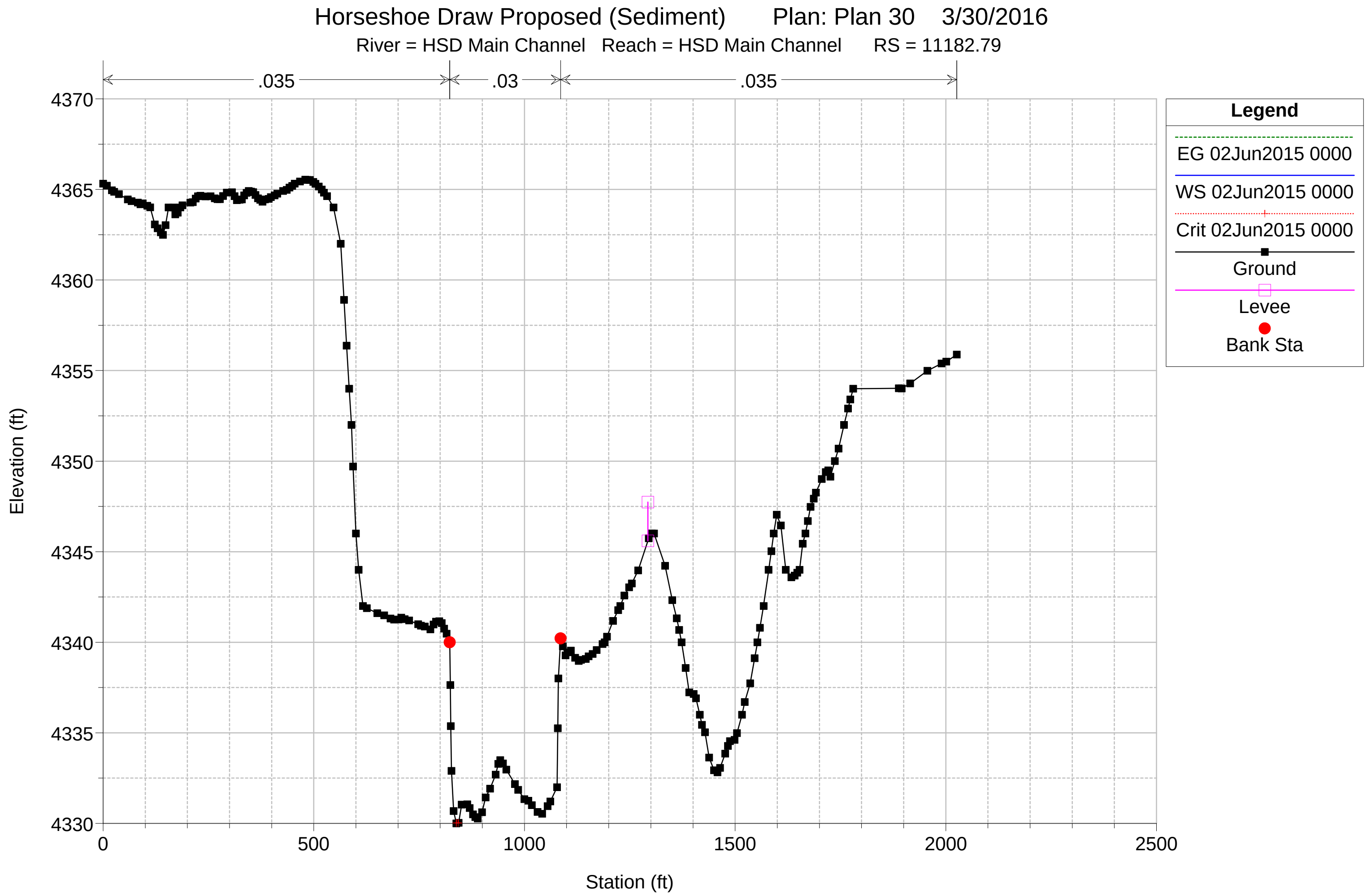
4370
4365
4360
4355
4350
4345
4340
4335
4330
0
500
1000
1500
2000
2500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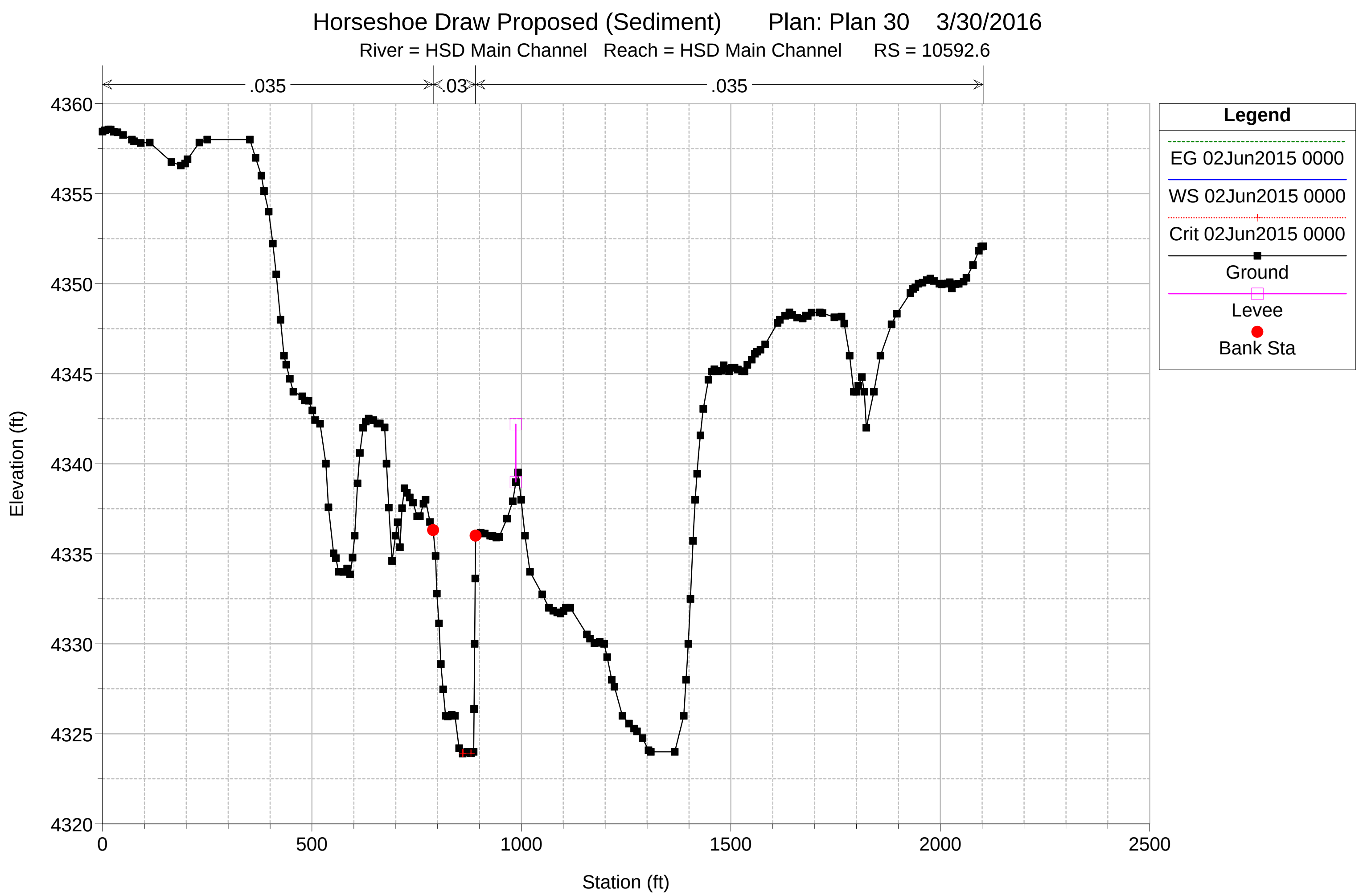
River = HSD Main Channel Reach = HSD Main Channel RS = 11182.79
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
4370
4365
4360
4355
4350
4345
4340
4335
4330
0
500
1000
1500
2000
2500
Station (ft)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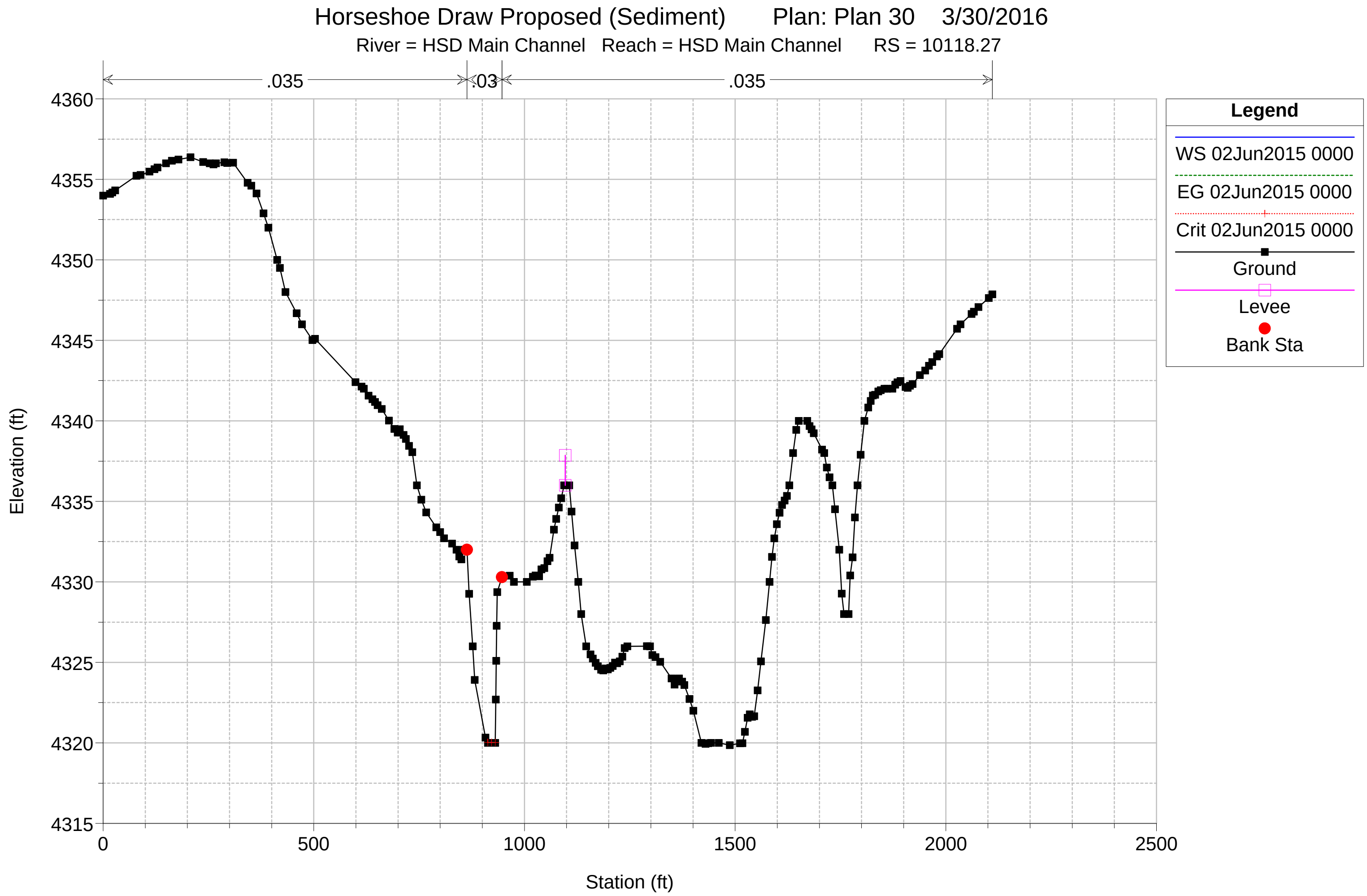
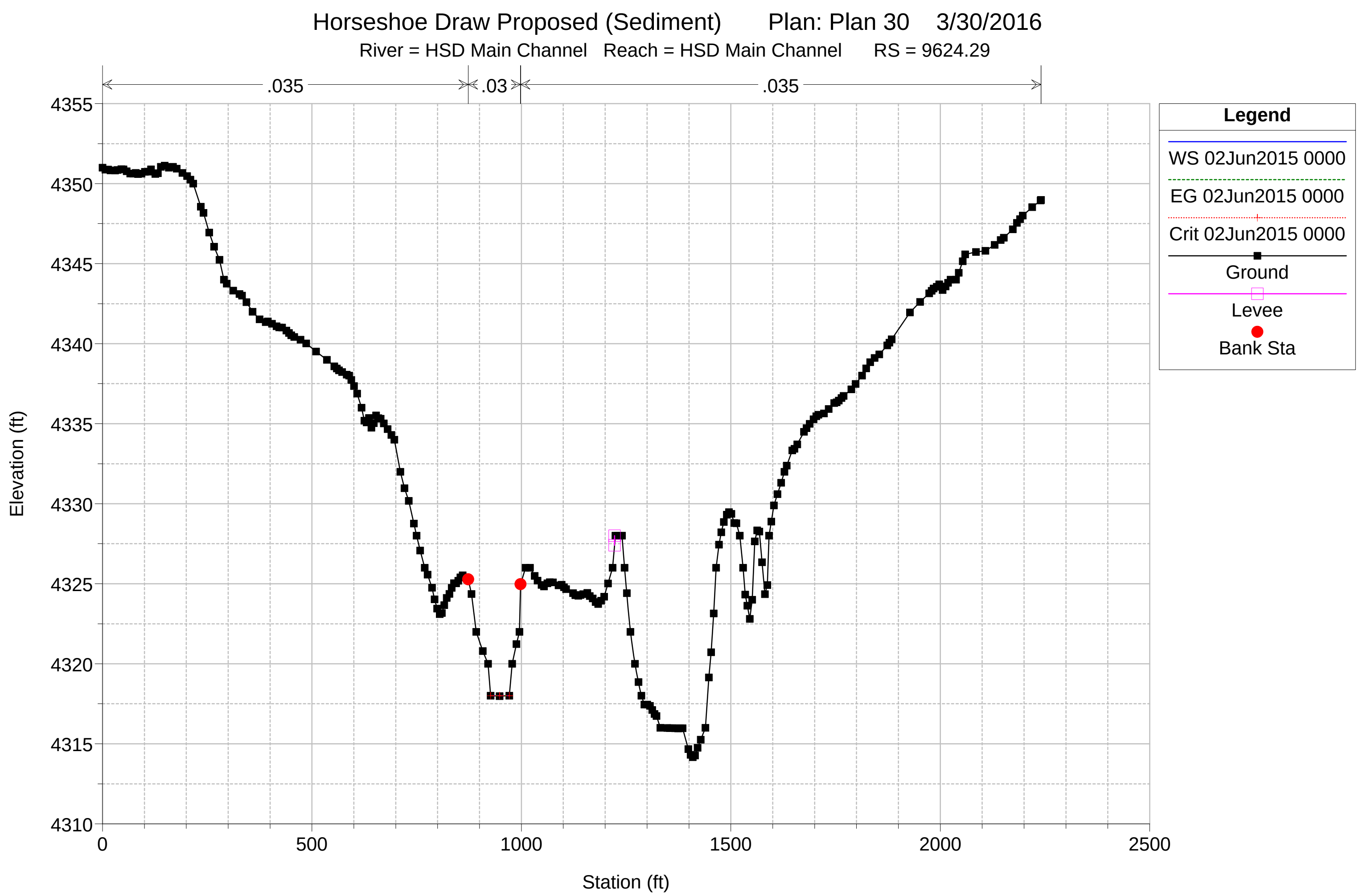
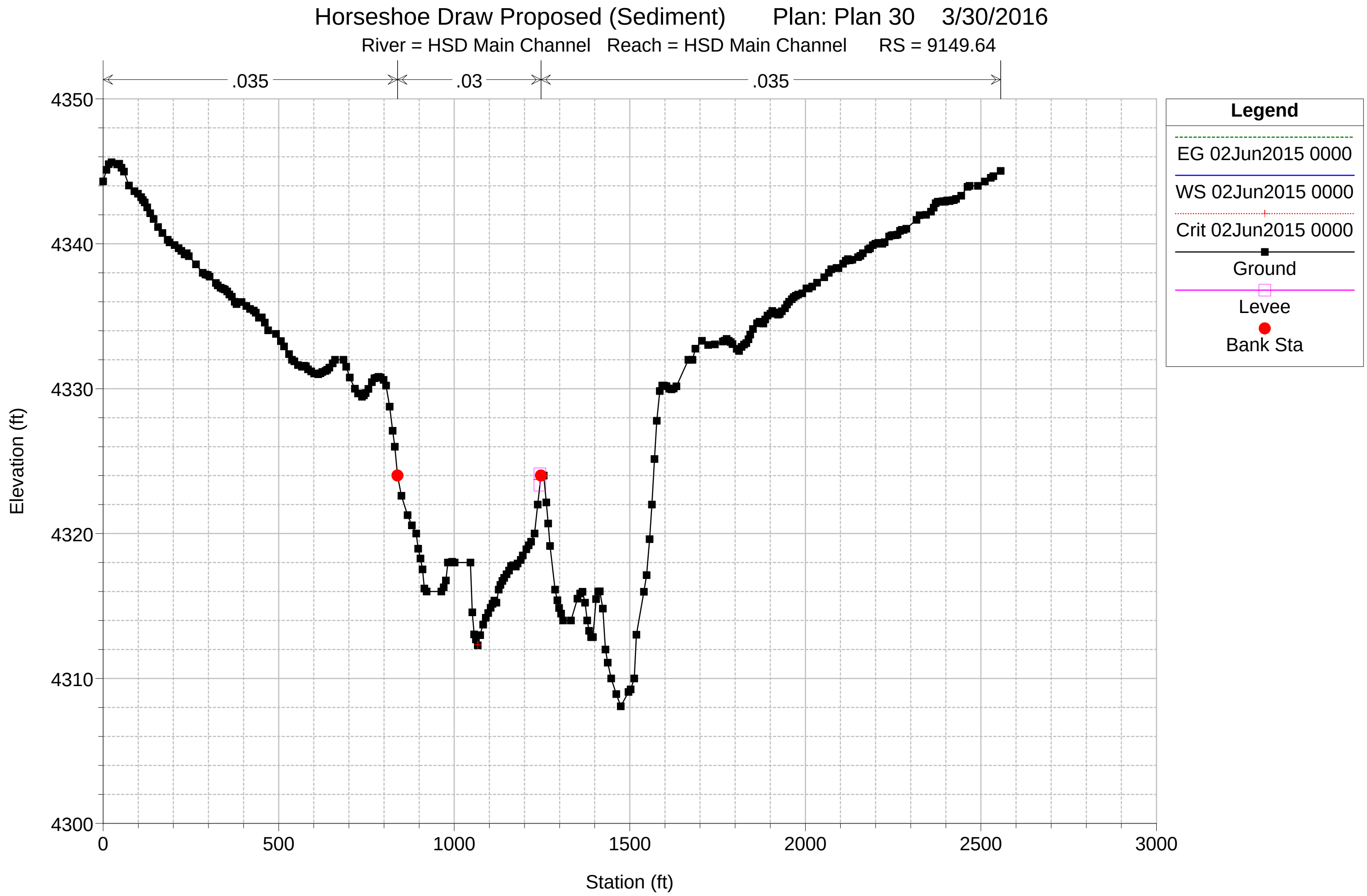
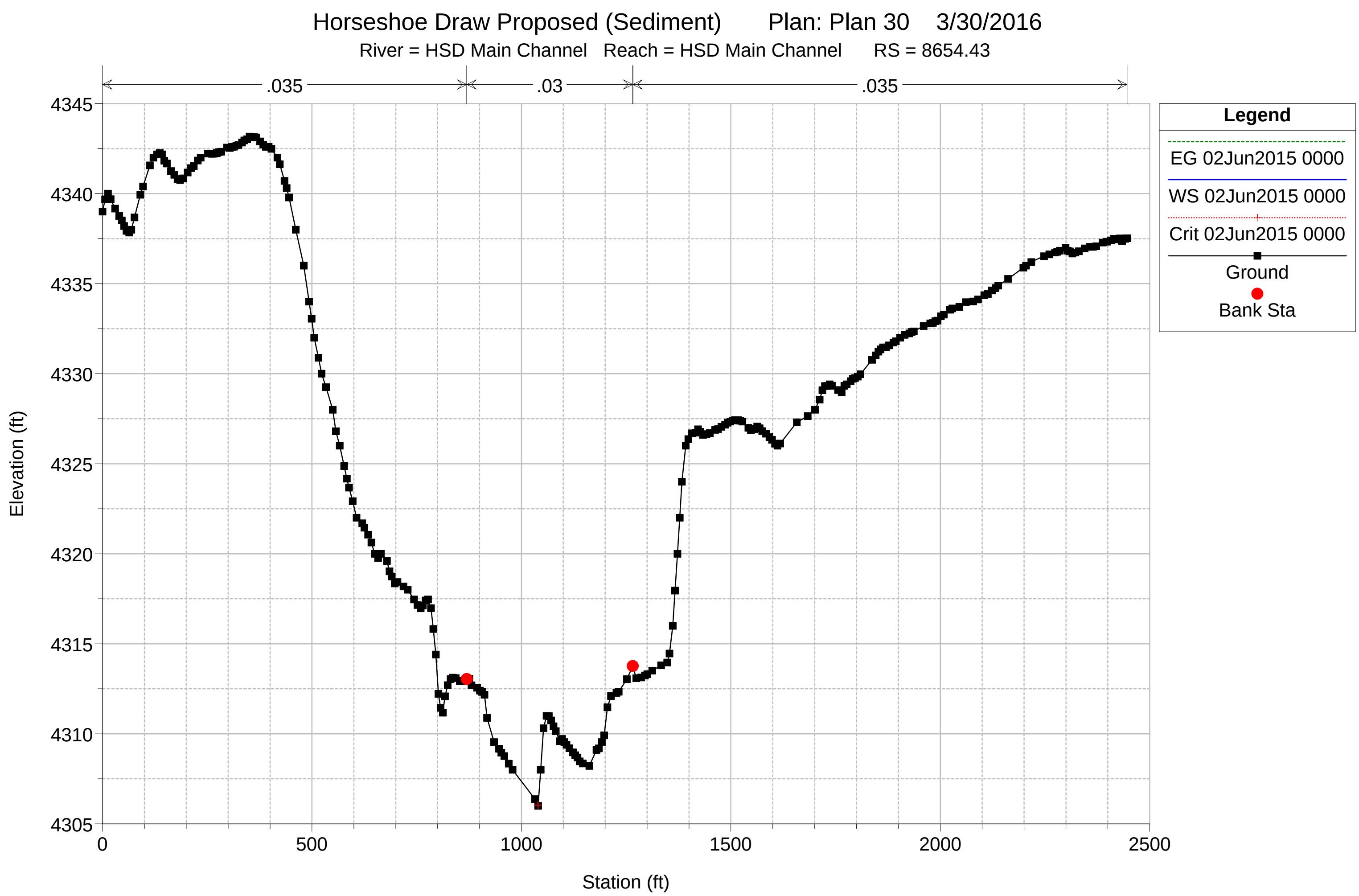
River = HSD Main Channel Reach = HSD Main Channel RS = 10592.6
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
4360
4355
4350
4345
4340
4335
4330
4325
4320
0
500
1000
1500
2000
2500
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 10118.27
.035
.03
.035
Elevation (ft)
Station (ft)
4360
4355
4350
4345
4340
4335
4330
4325
4320
4315
0
500
1000
1500
2000
2500
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 9624.29
.035
.03
.035
Elevation (ft)
Station (ft)
4355
4350
4345
4340
4335
4330
4325
4320
4315
4310
0
500
1000
1500
2000
2500
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 9149.64
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta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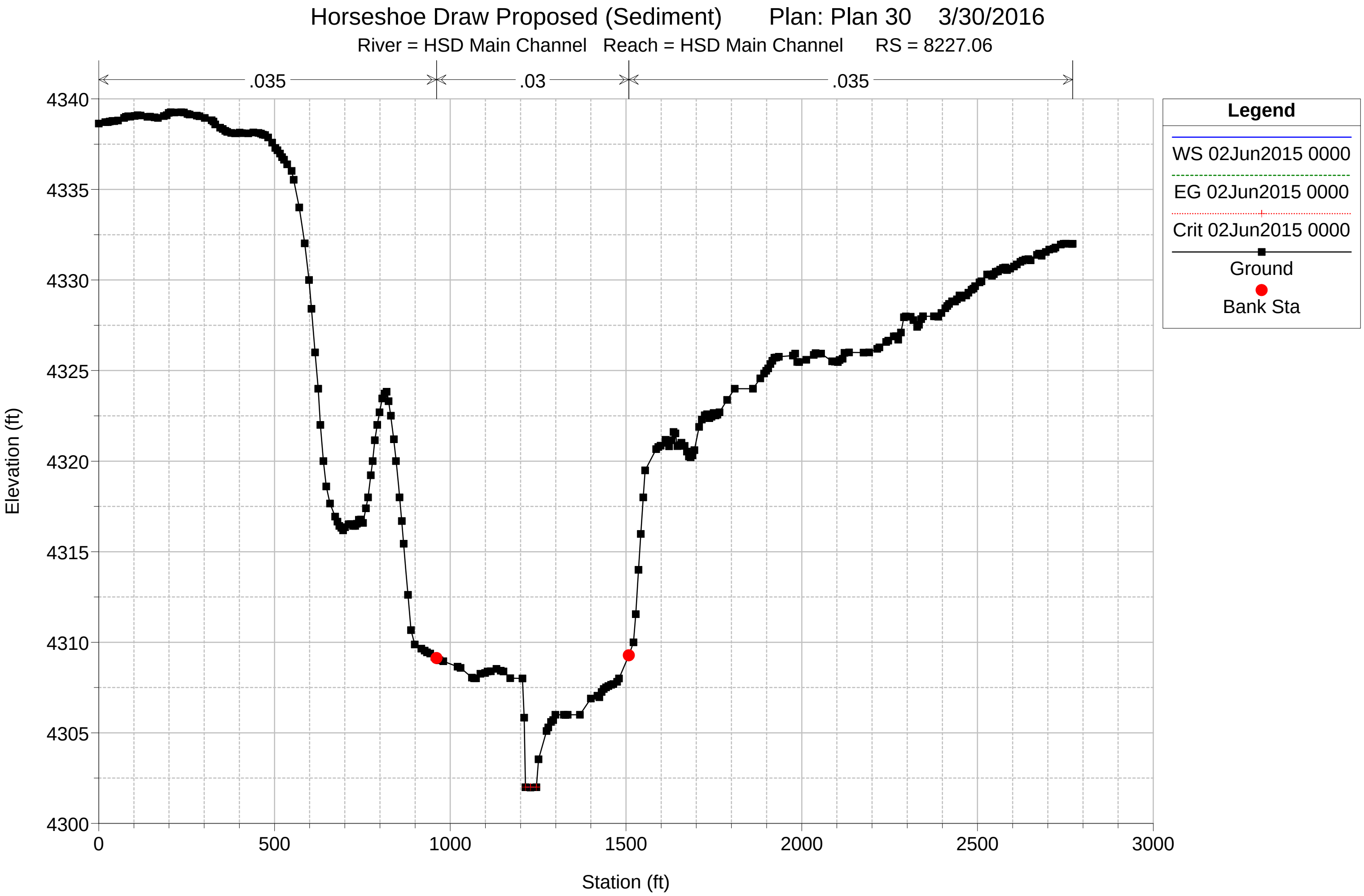
River = HSD Main Channel Reach = HSD Main Channel RS = 8654.43
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta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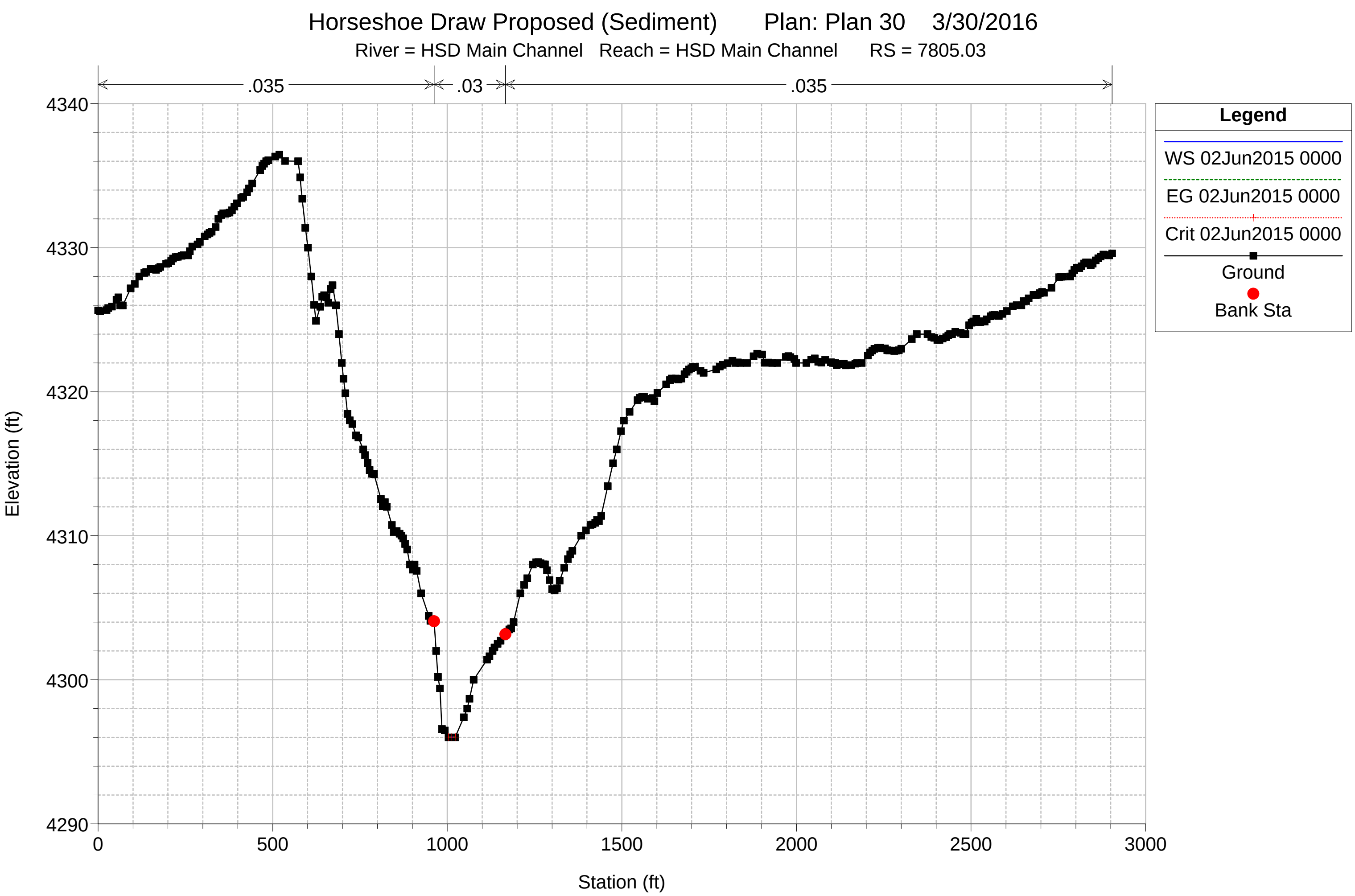
River = HSD Main Channel Reach = HSD Main Channel RS = 8227.06
.035
.03
.035
Elevation (ft)
4340
4335
4330
4325
4320
4315
4310
4305
4300
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta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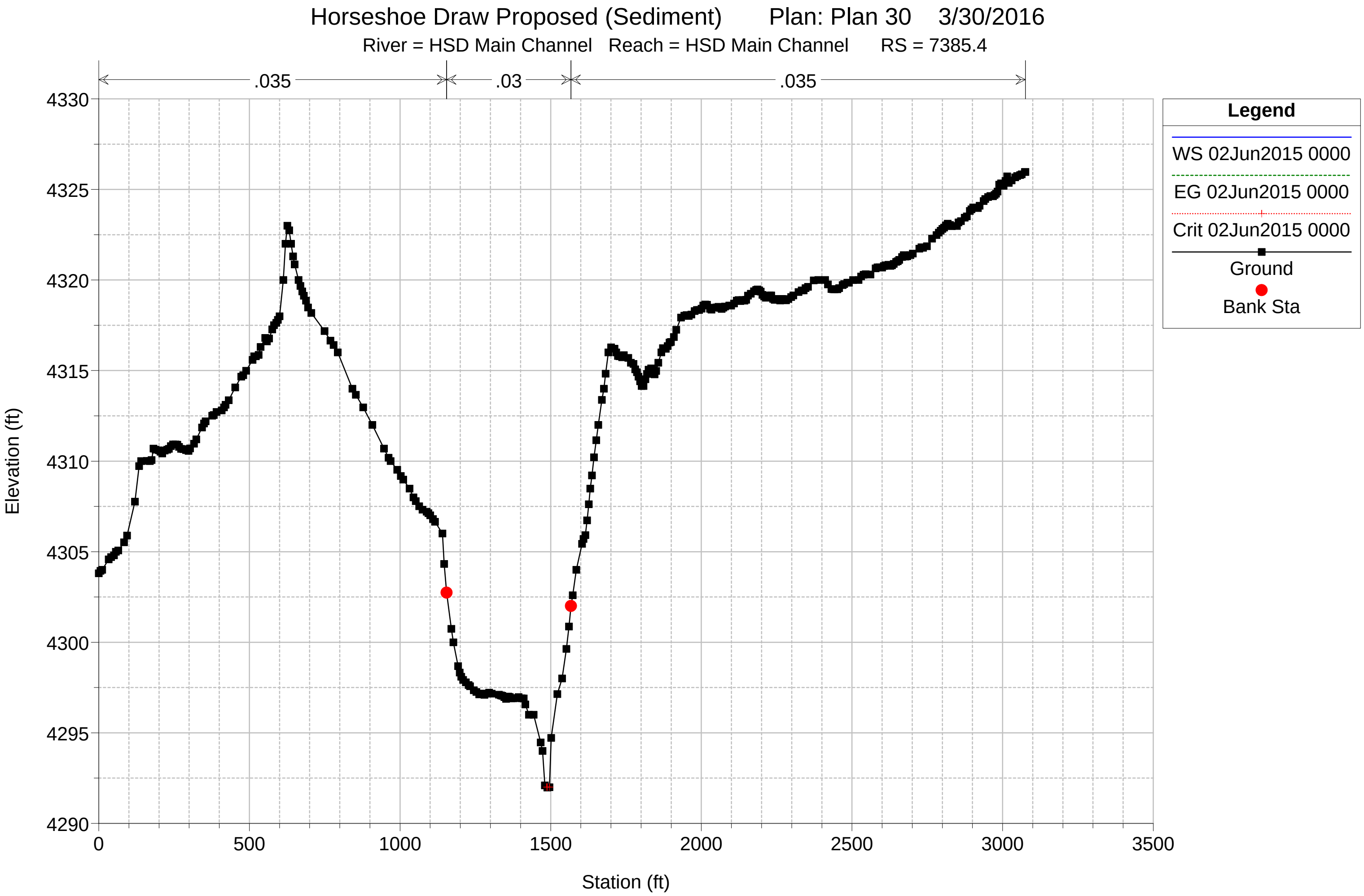
River = HSD Main Channel Reach = HSD Main Channel RS = 7805.03
.035
.03
.035
Elevation (ft)
4340
4330
4320
4310
4300
4290
0
500
1000
1500
2000
2500
3000
Station (ft)
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta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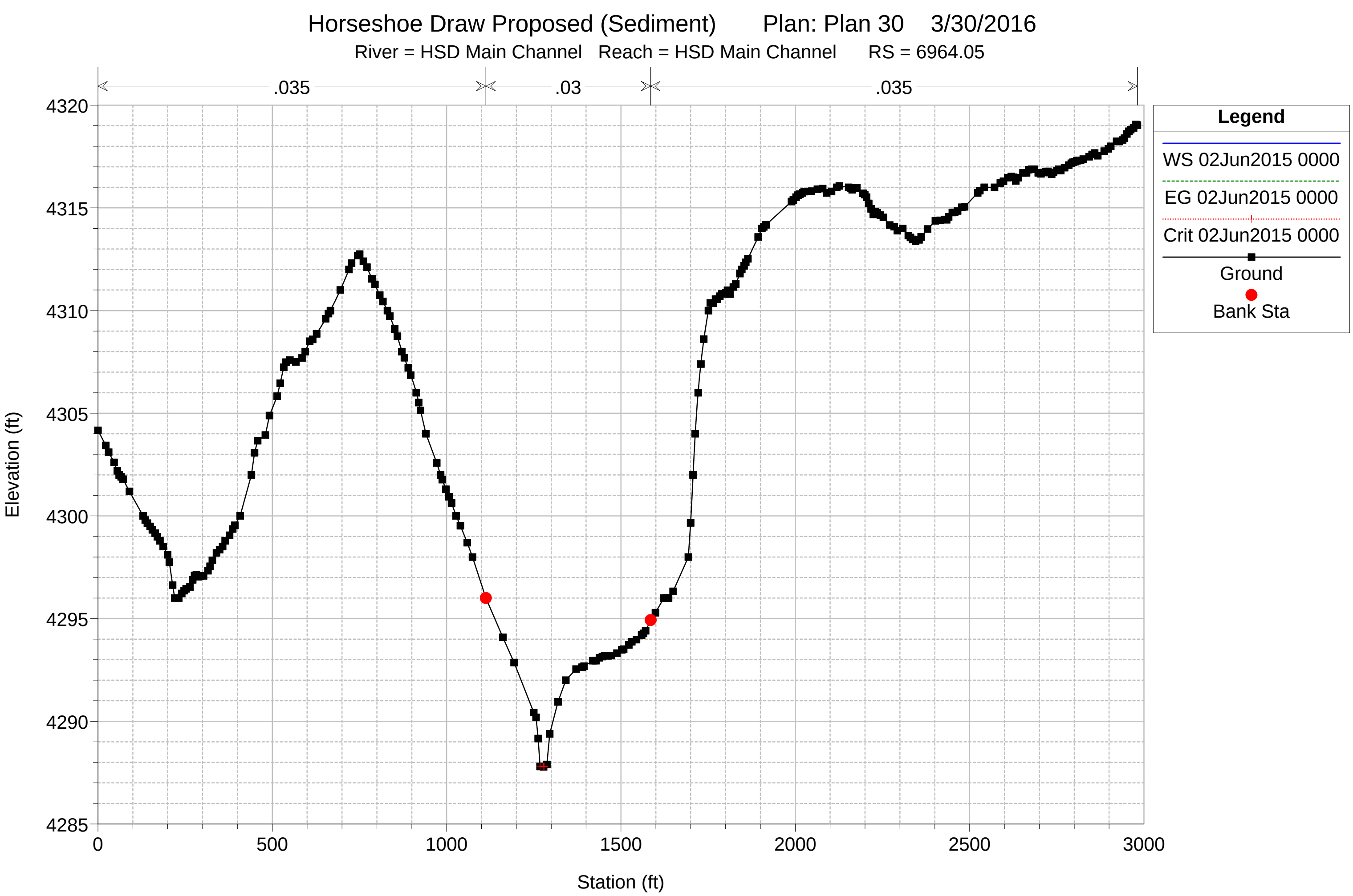
River = HSD Main Channel   Reach = HSD Main Channel   RS = 7385.4
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4330
4325
4320
4315
4310
4305
4300
4295
4290
0
500
1000
1500
2000
2500
3000
3500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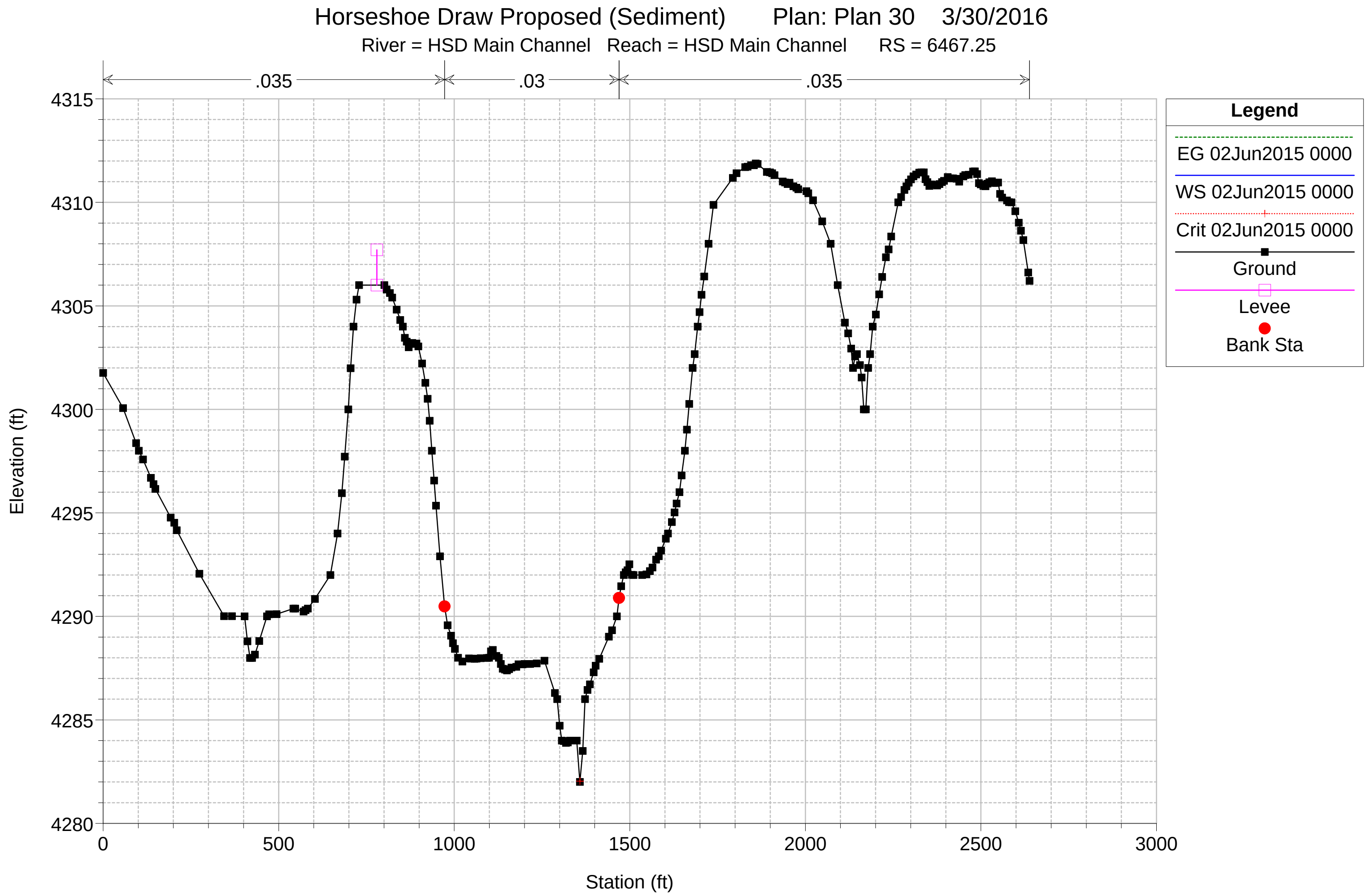
River = HSD Main Channel   Reach = HSD Main Channel   RS = 6964.05
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4320
4315
4310
4305
4300
4295
4290
4285
0
500
1000
1500
2000
2500
3000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River = HSD Main Channel Reach = HSD Main Channel RS = 6467.25
.035
.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
4315
4310
4305
4300
4295
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4285
4280
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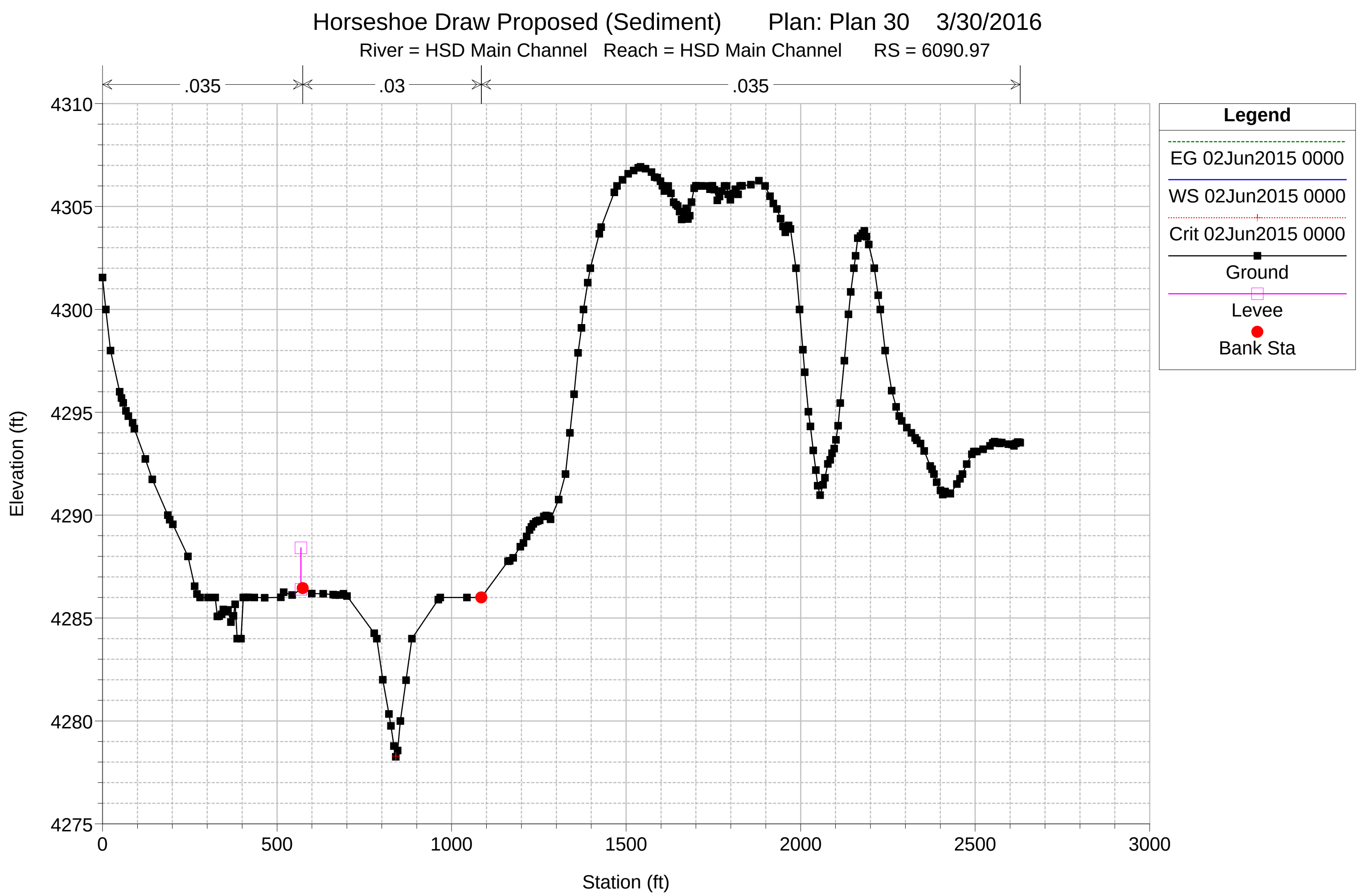
1500
2000
2500
3000


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 6090.97
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.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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1000
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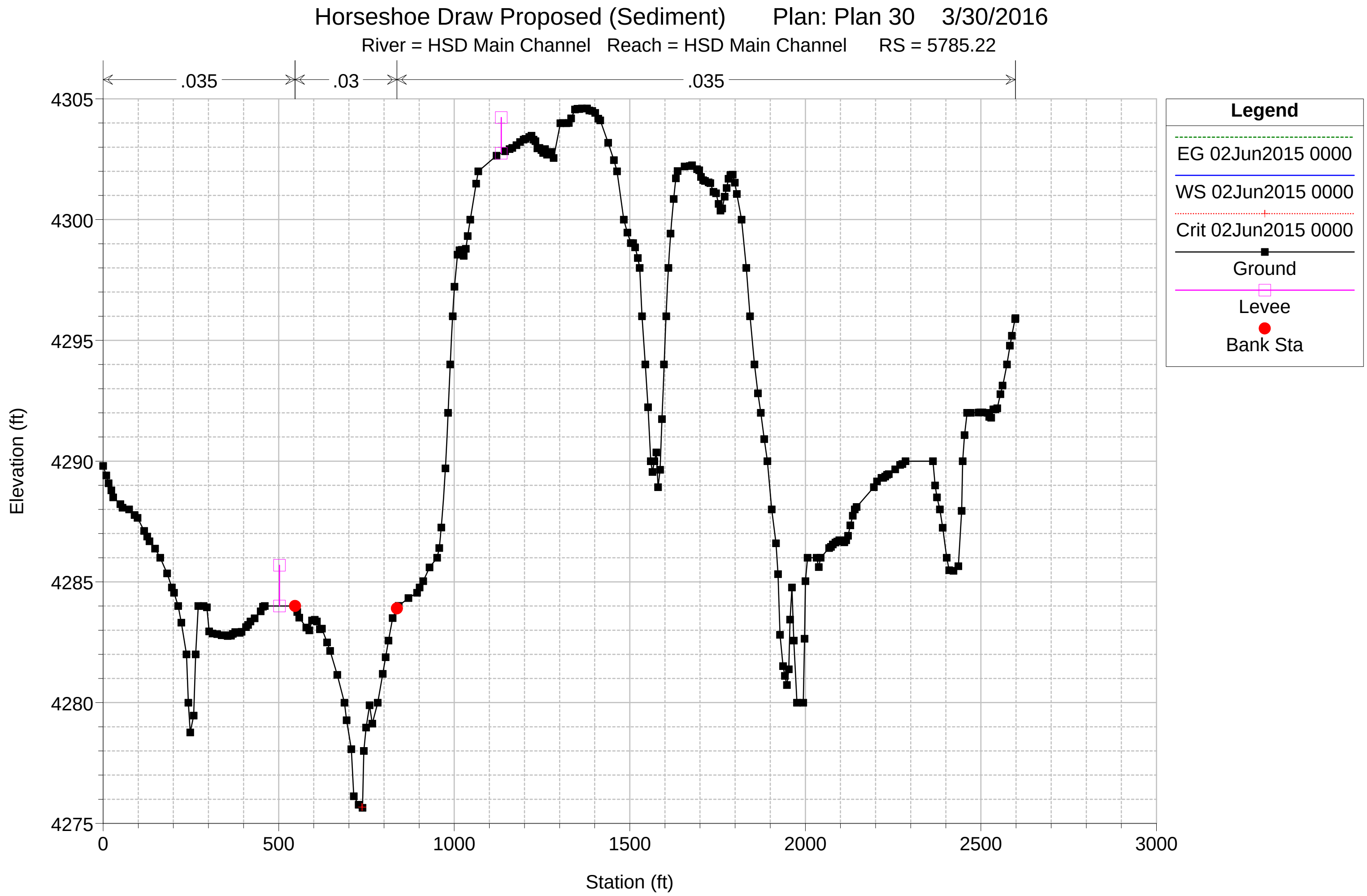
Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 5785.22
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.03
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Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
4305
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4290
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1500
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2500
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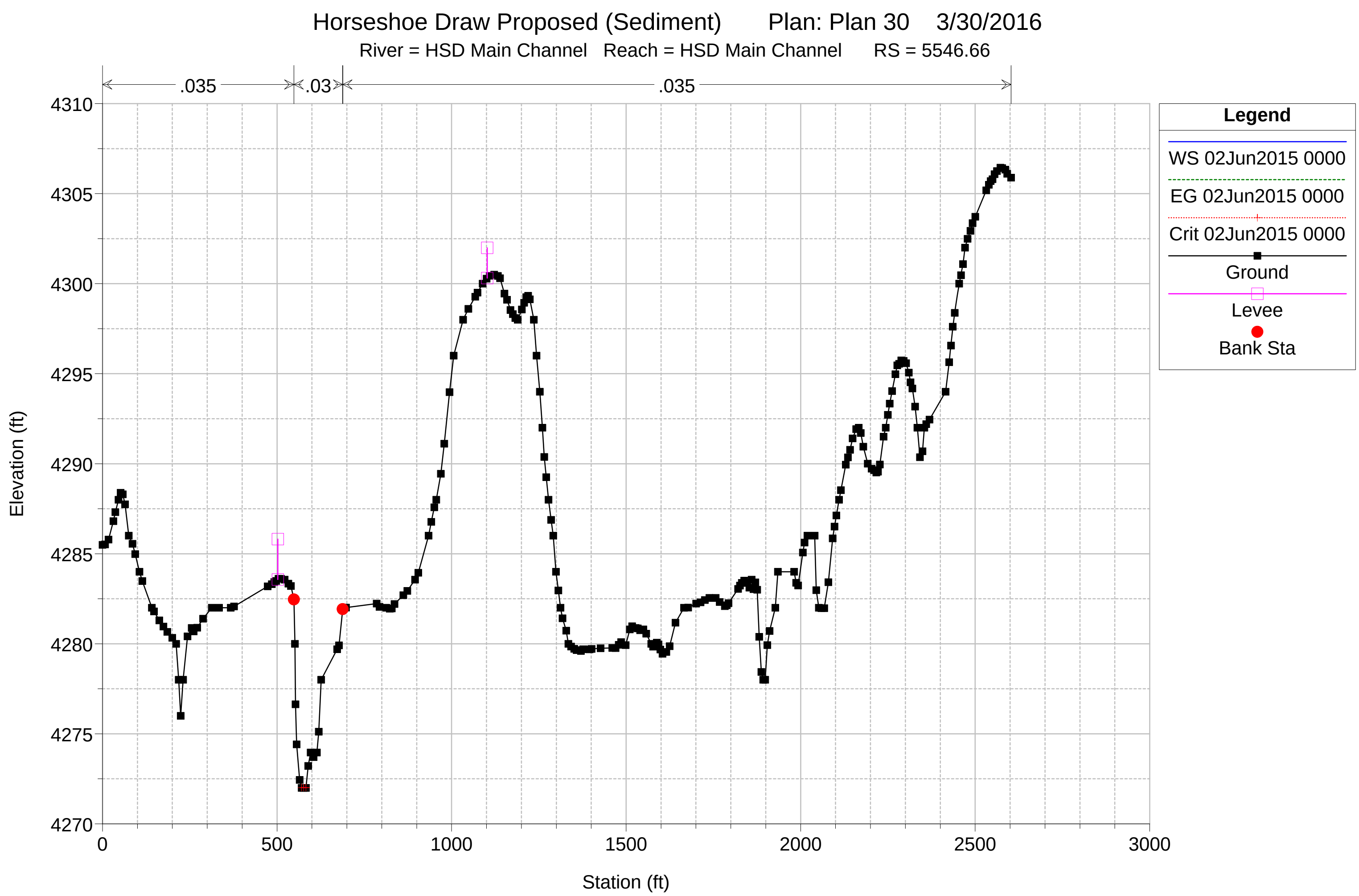
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 5546.66
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
4310
4305
4300
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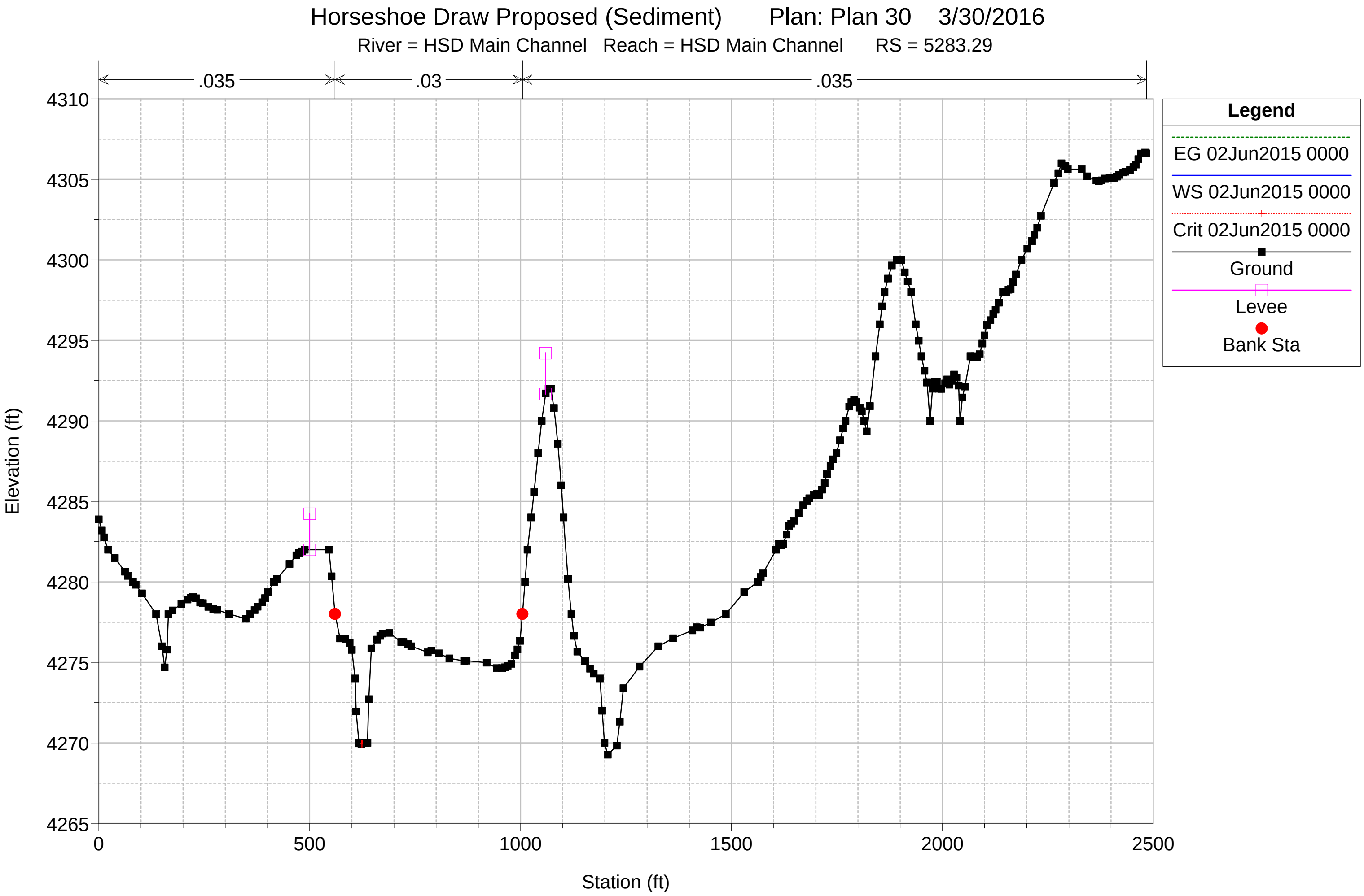
1000
1500
2000
2500
3000
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 5283.29
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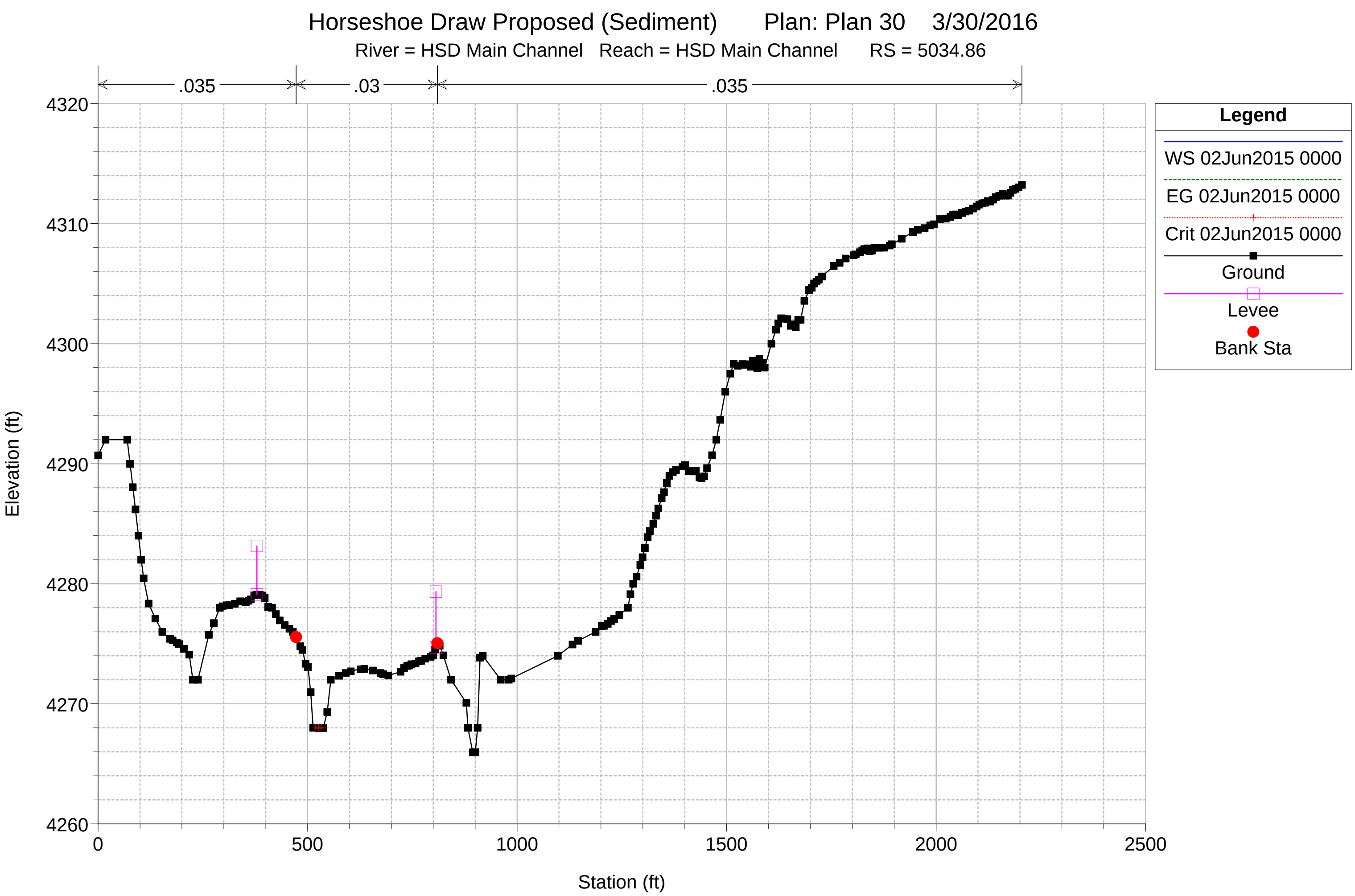
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 5034.86
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Legend
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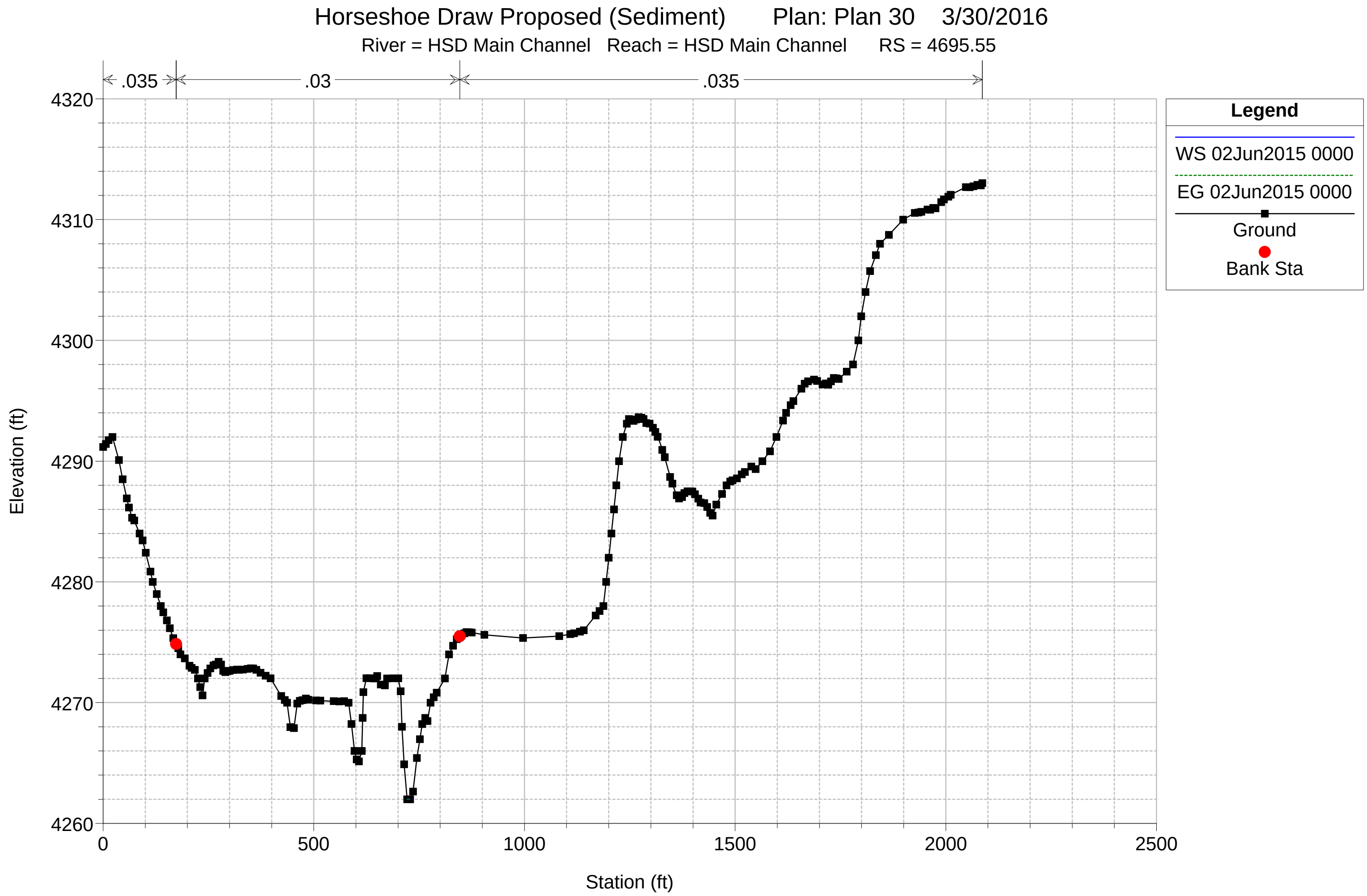
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 4695.55
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
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4300
4290
4280
4270
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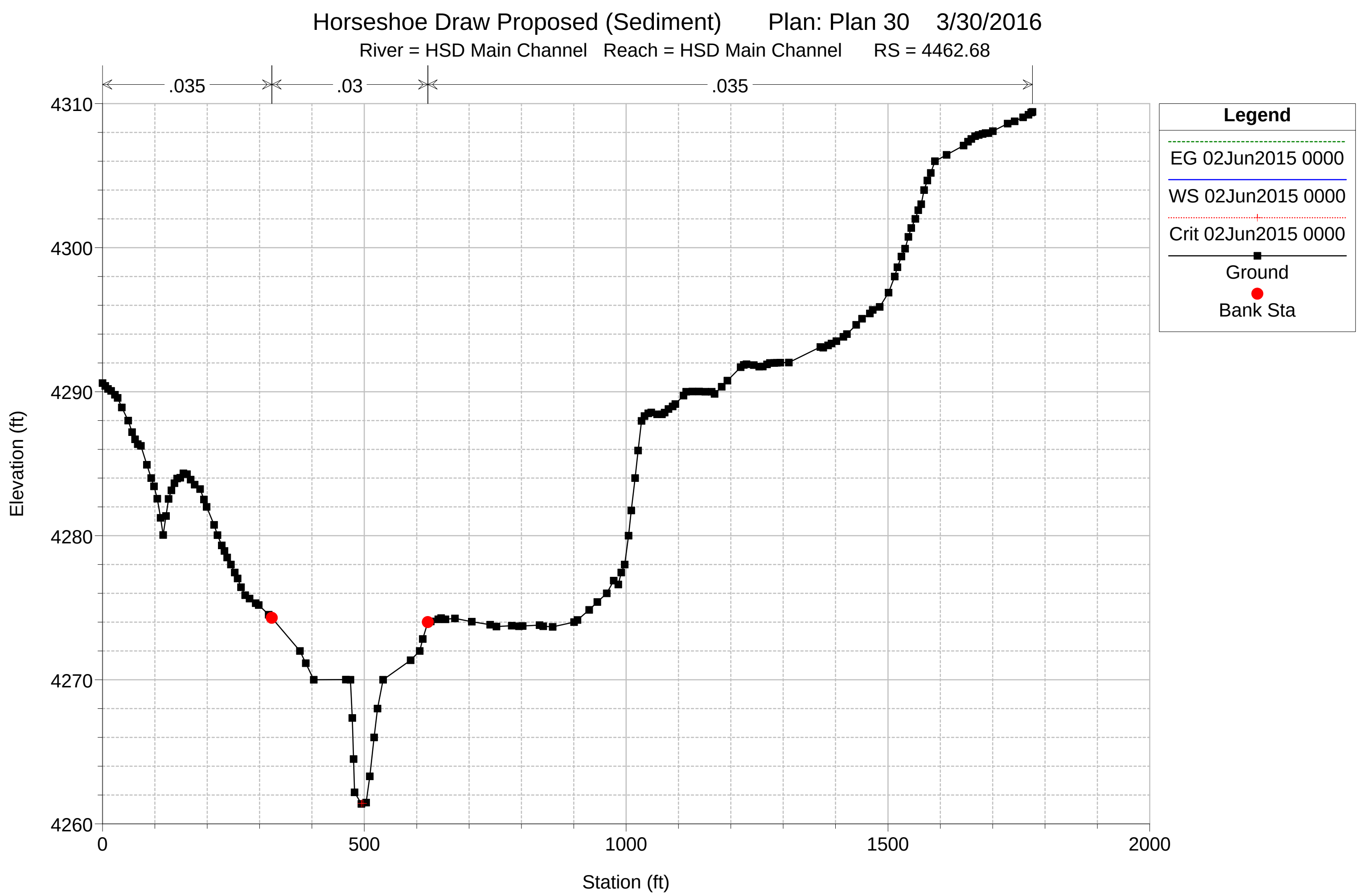
0
500
1000
1500
2000
2500
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 4462.68
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.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
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4300
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4260
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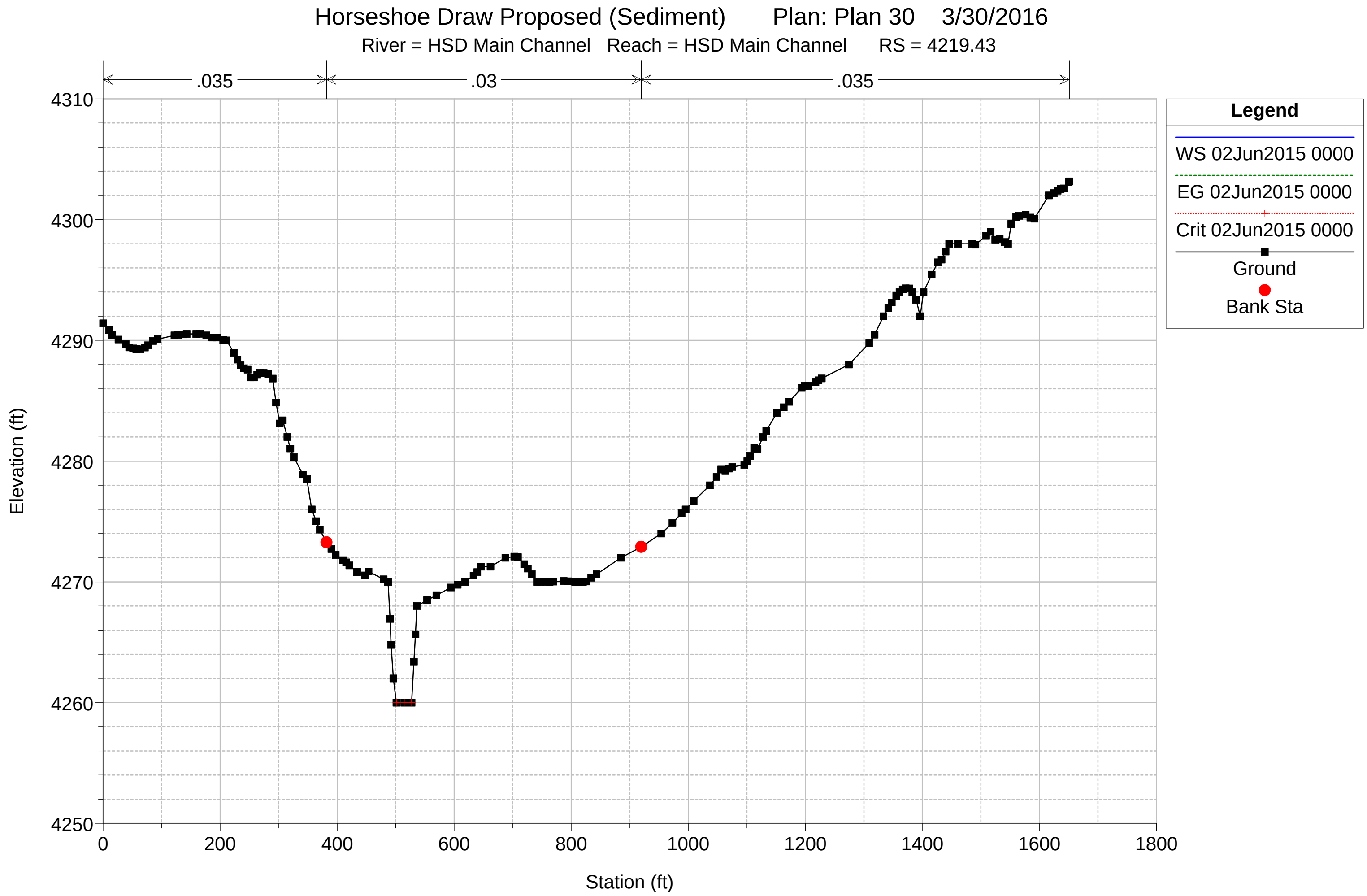
1000
1500
2000
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 4219.43
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
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600
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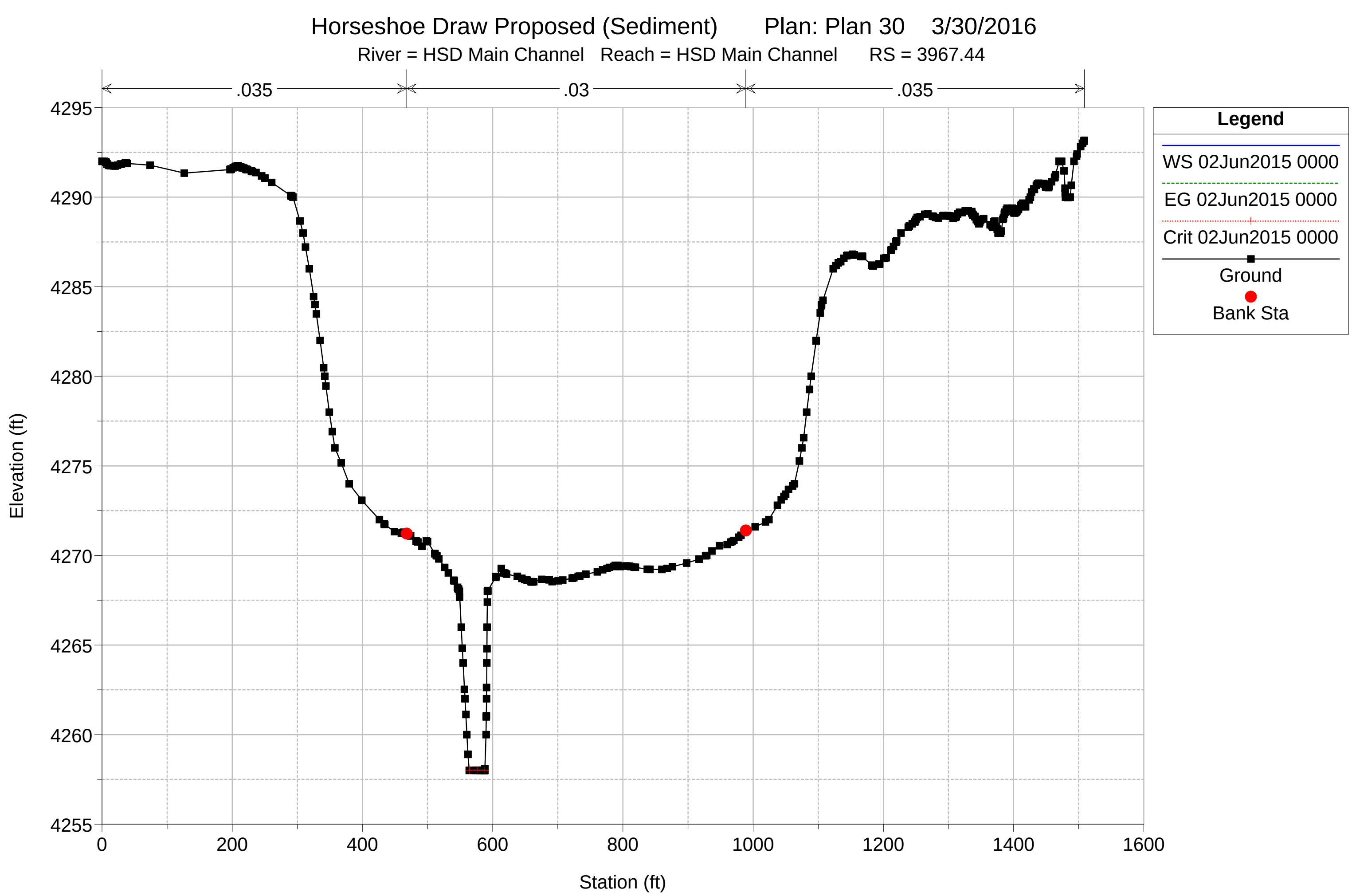
1600
1800


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 3967.44
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4295
4290
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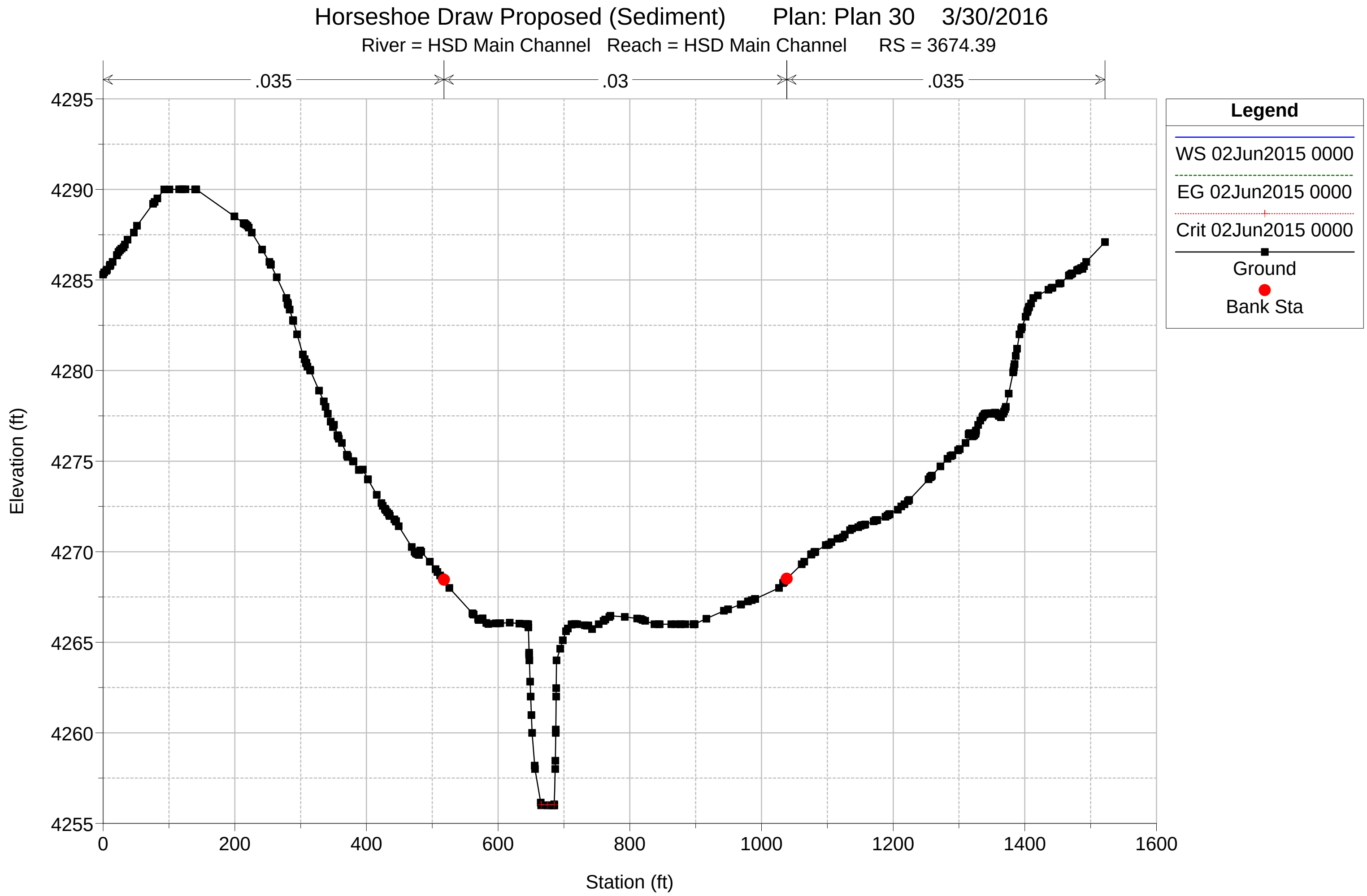
Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 3674.39
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.03
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Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
4295
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4270
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1400
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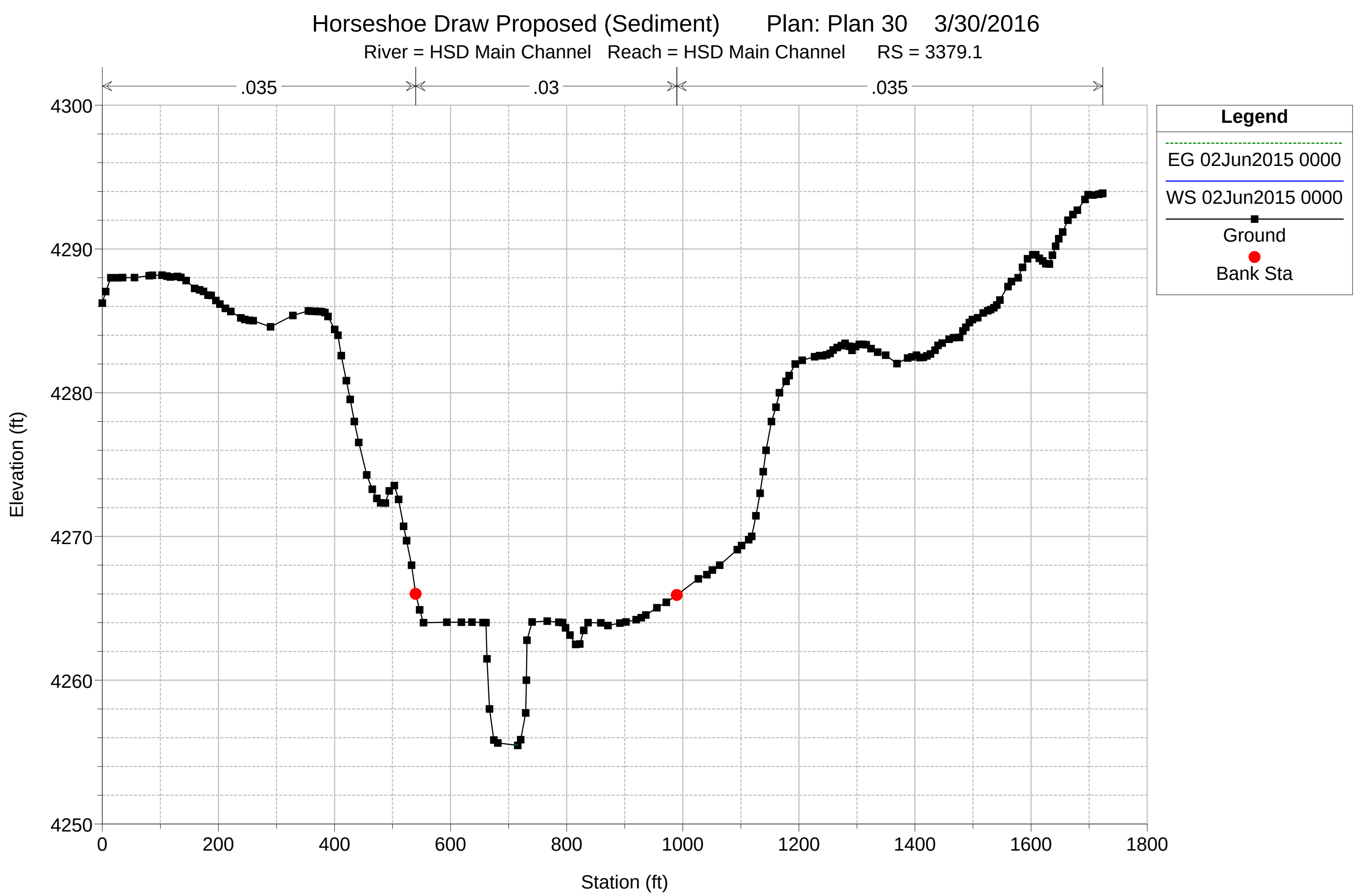
Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 3379.1
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.03
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Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
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4270
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800
1000
1200
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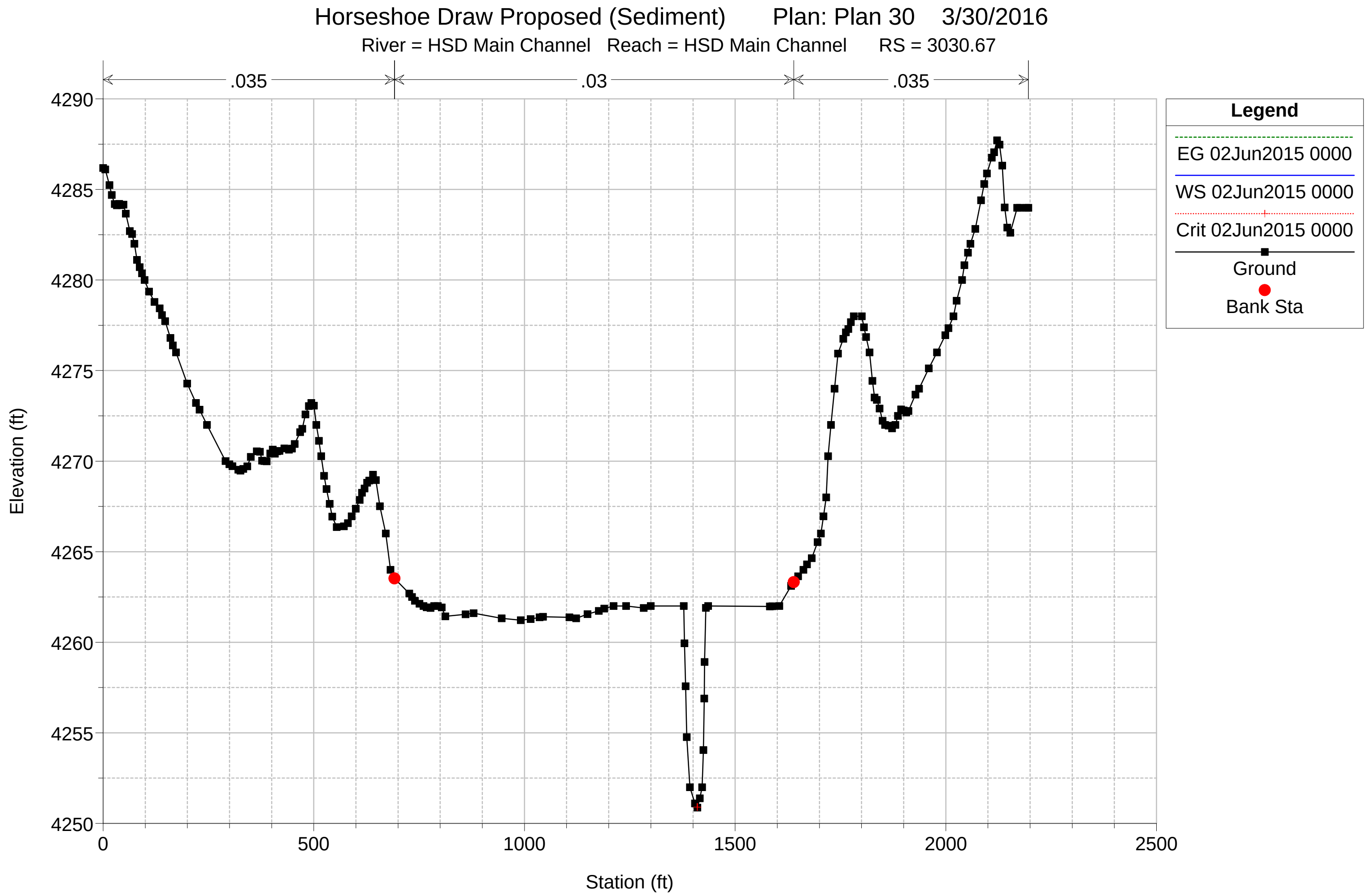
1600
1800


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 3030.67
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.03
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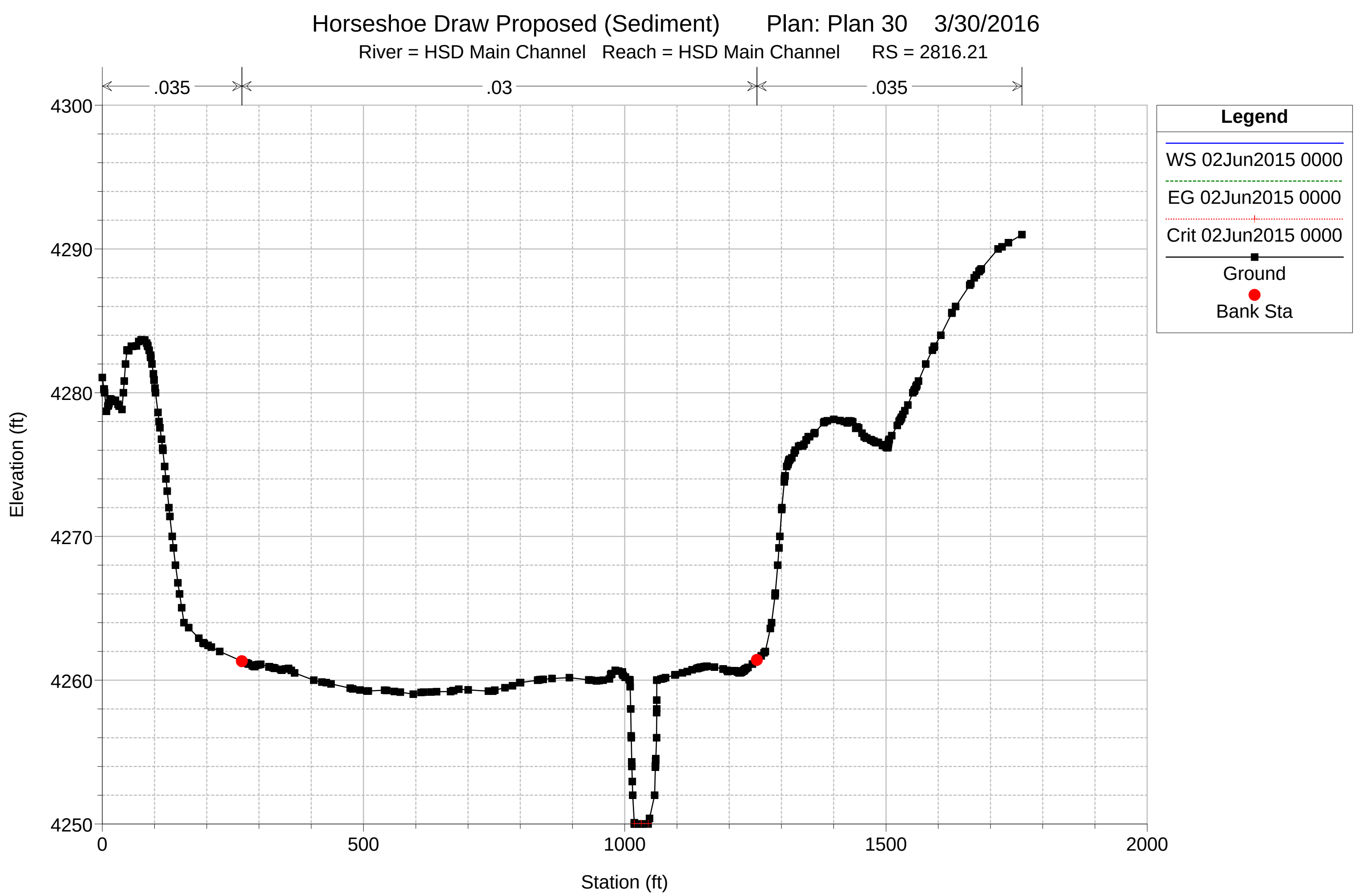
Elevation (ft)
Station (ft)
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 2816.21
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Elevation (ft)
Station (ft)
Legend
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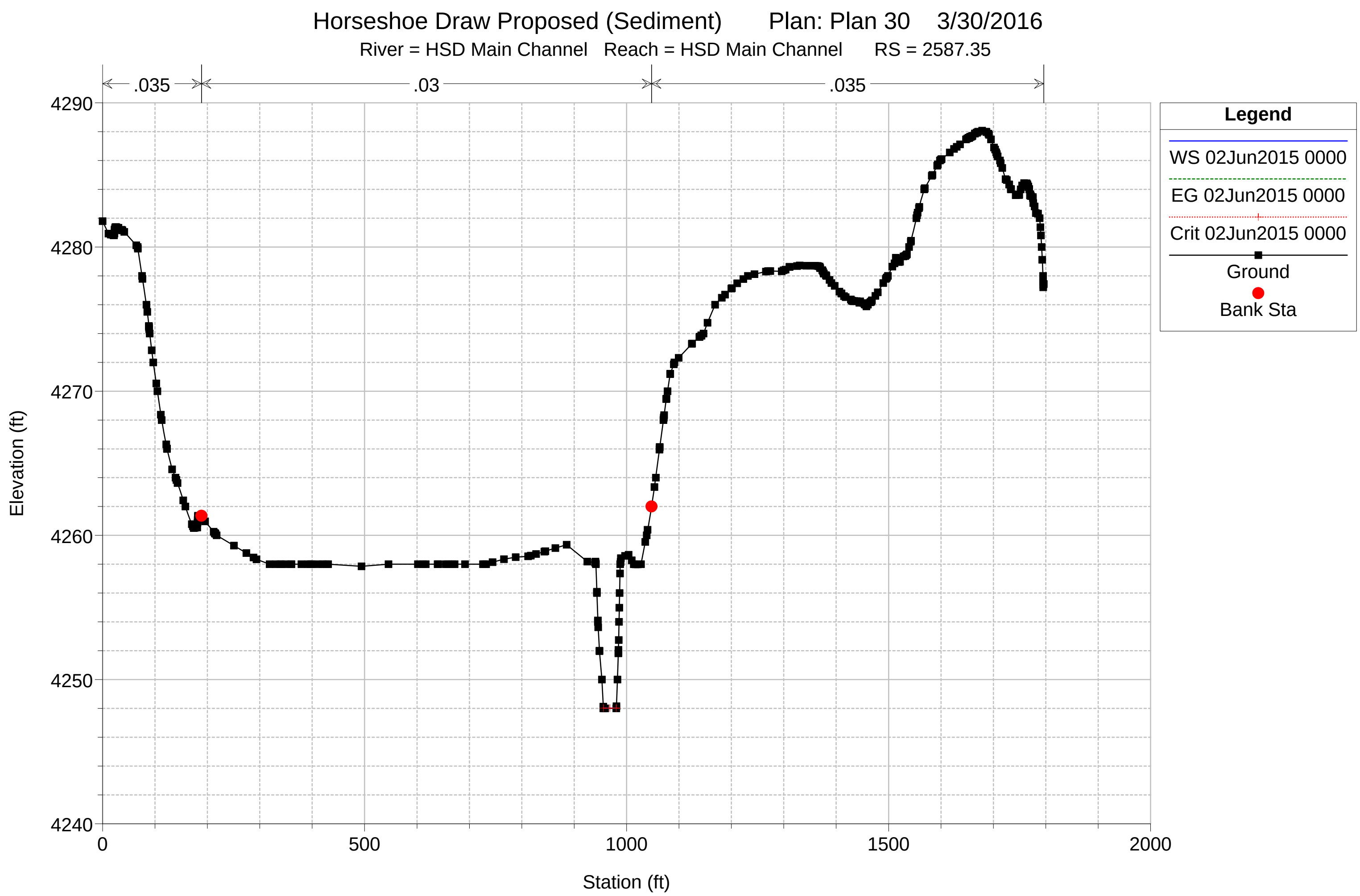
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 2587.35
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
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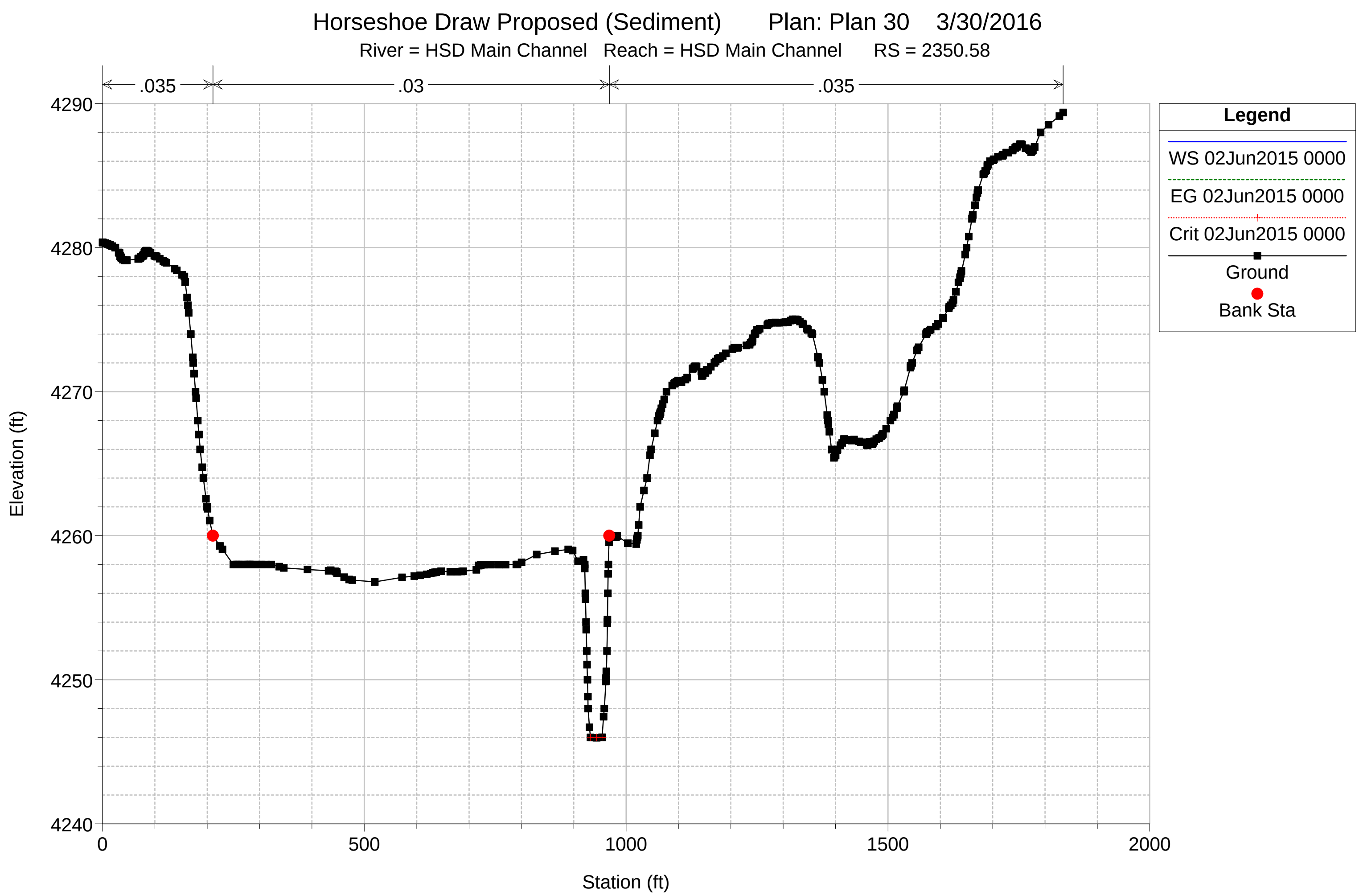
1000
1500
2000
Station (ft)


Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 2350.58
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.03
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Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
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1000
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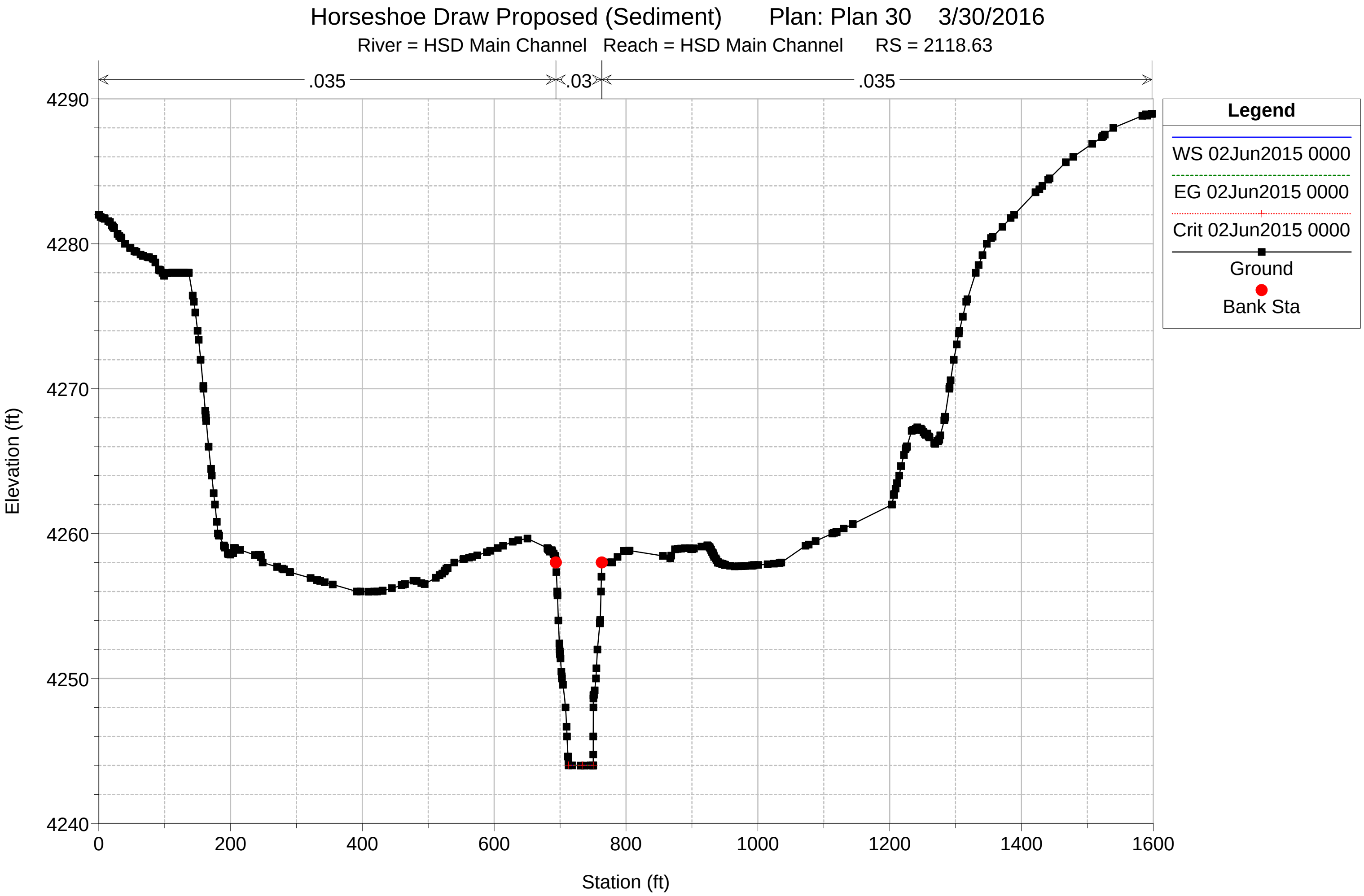
2000
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 2118.63
.035
.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
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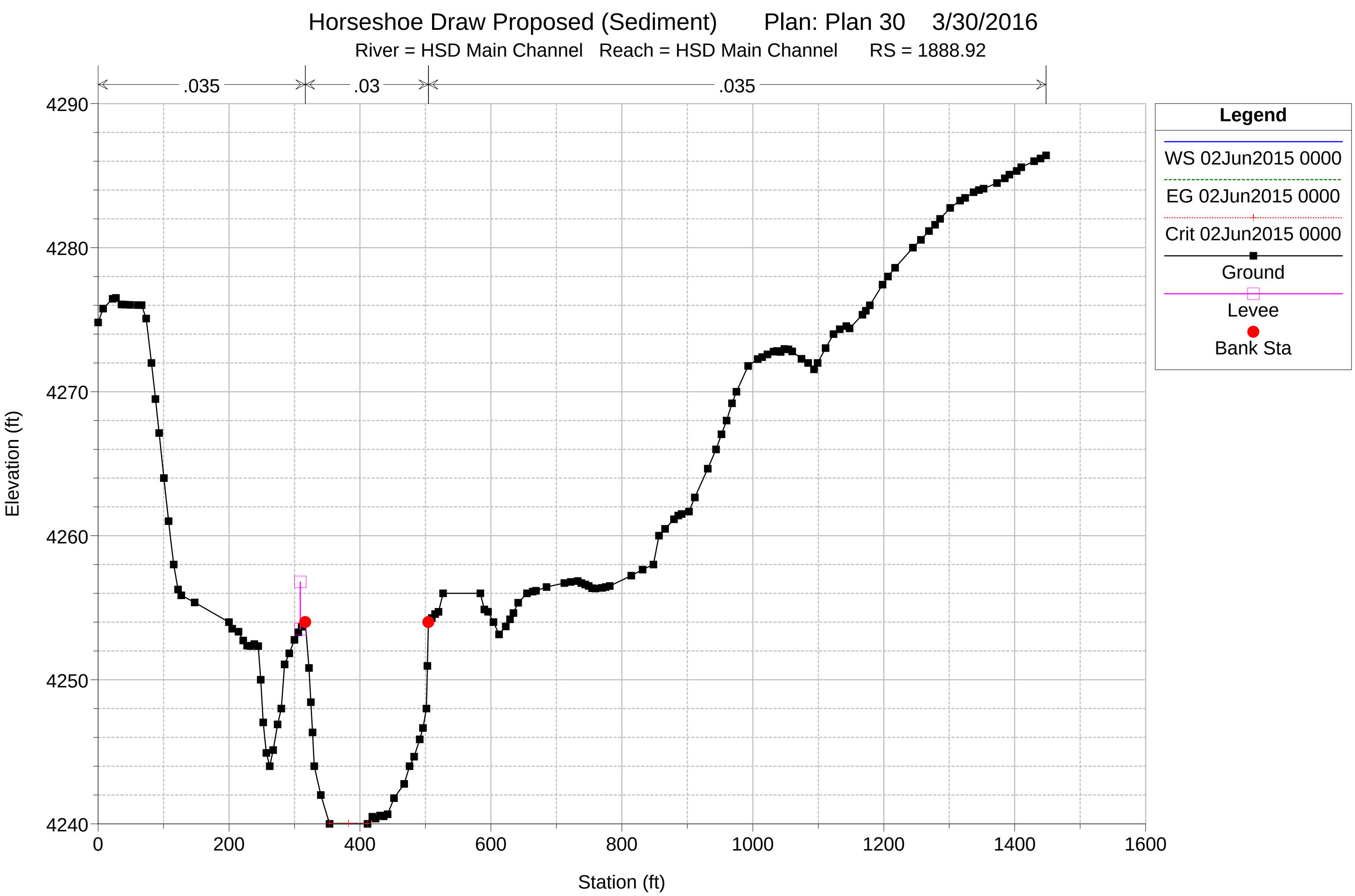
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 1888.92
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
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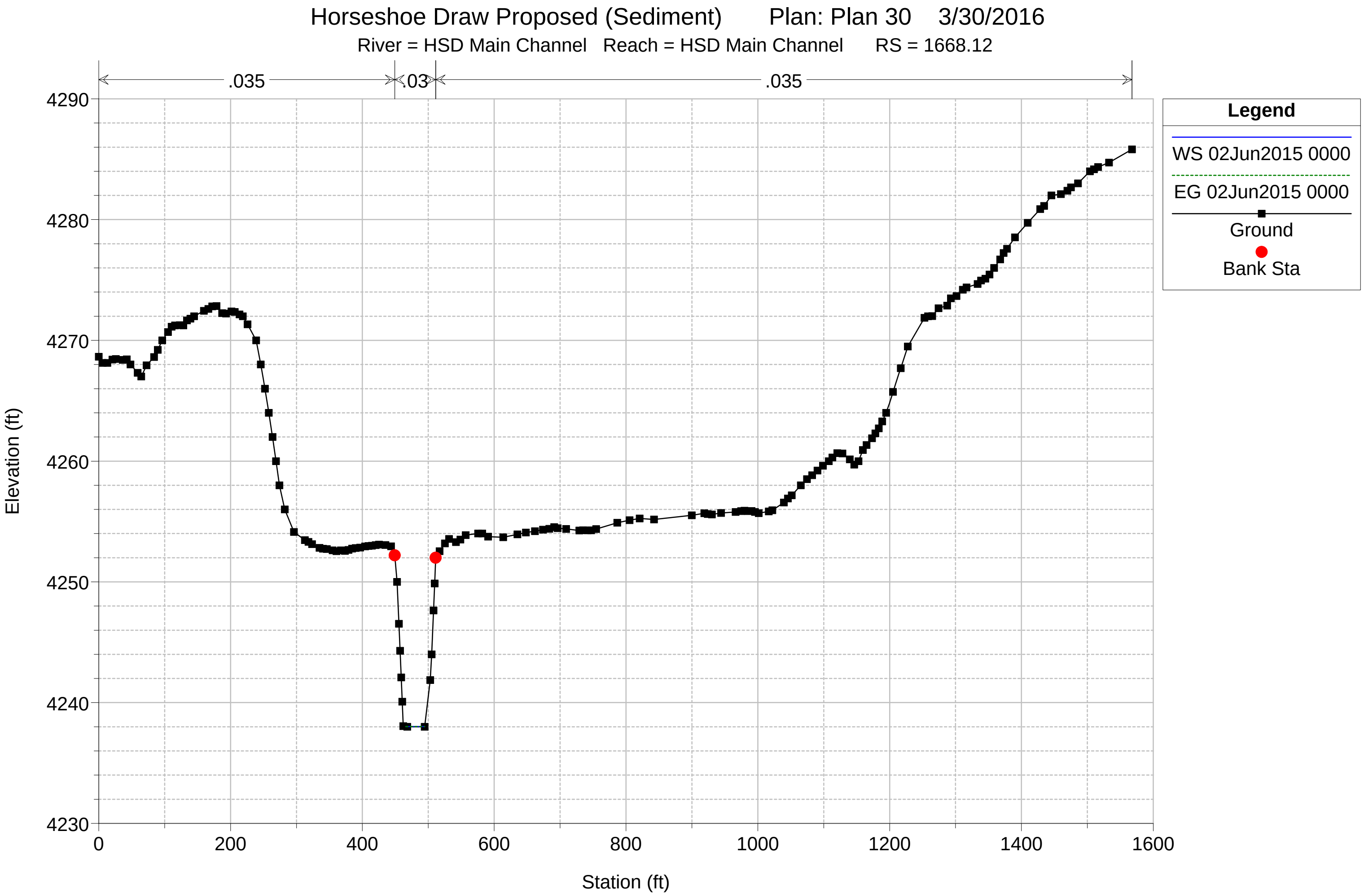
400
600
800
1000
1200
1400
1600
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 1668.12
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
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4260
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4280
4290
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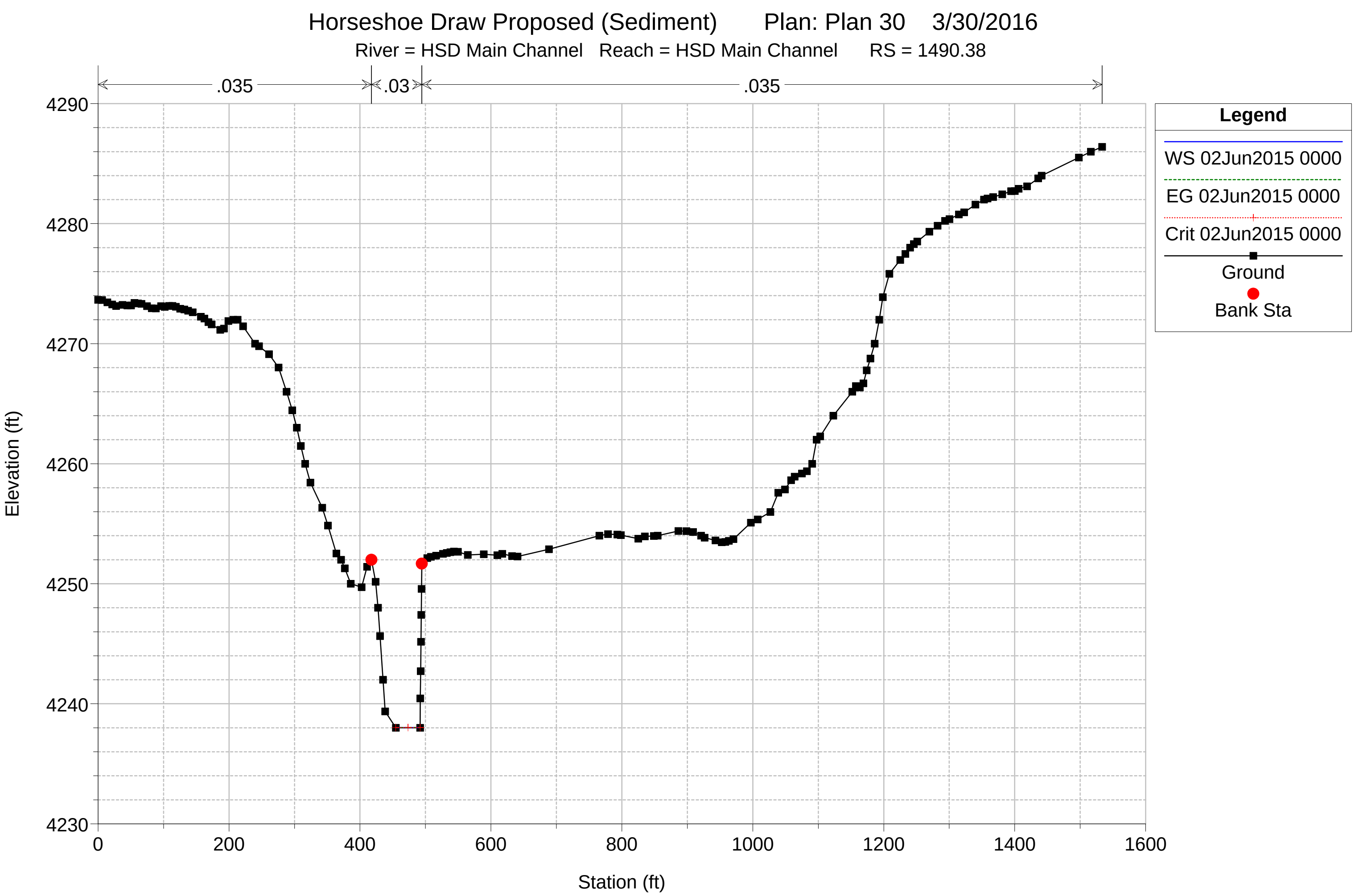
1000
1200
1400
1600



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 1490.38
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
Station (ft)
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4260
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600
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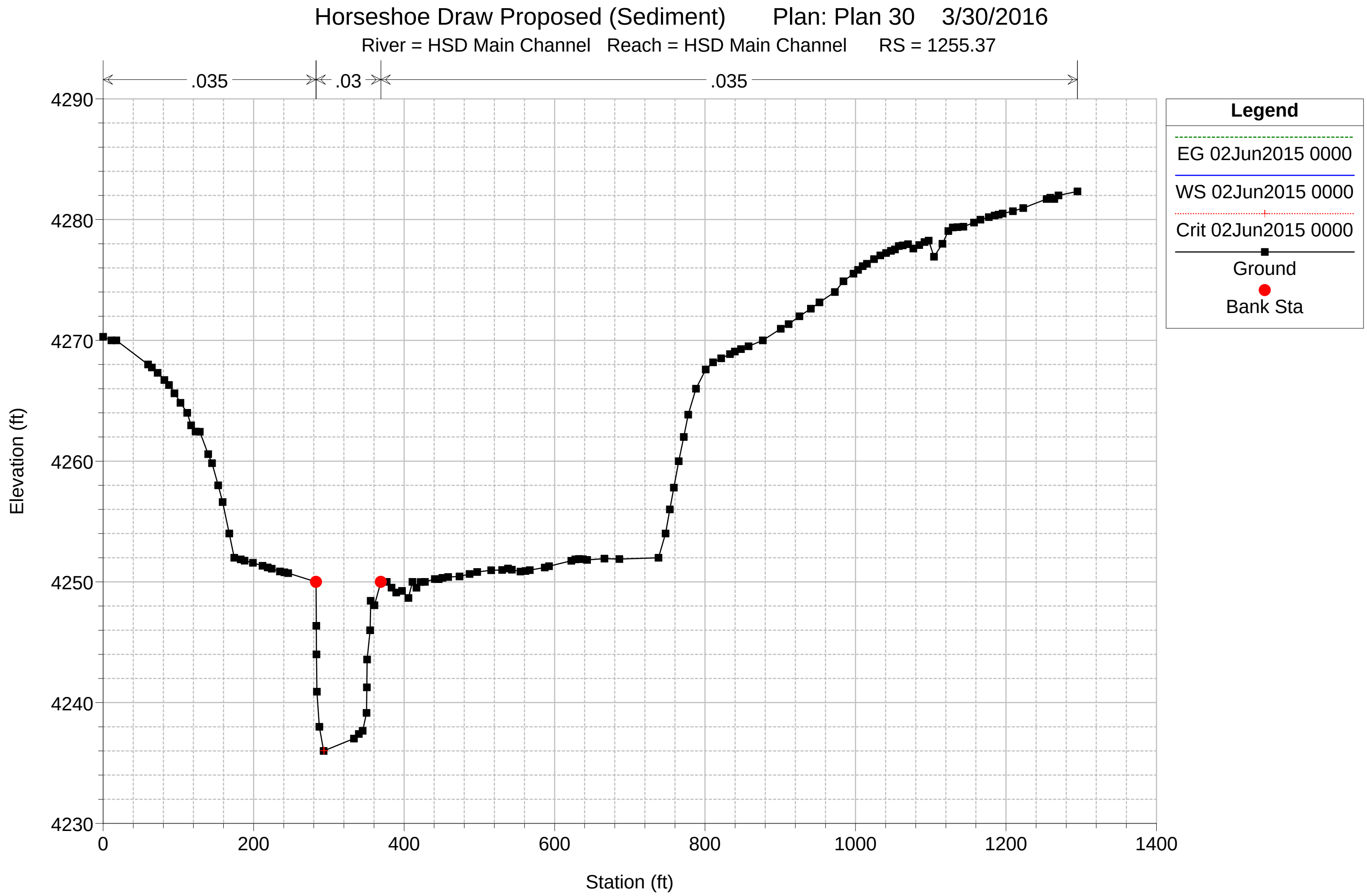
1000
1200
1400
1600



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 1255.37
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.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Bank Sta
Elevation (ft)
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4250
4240
4230
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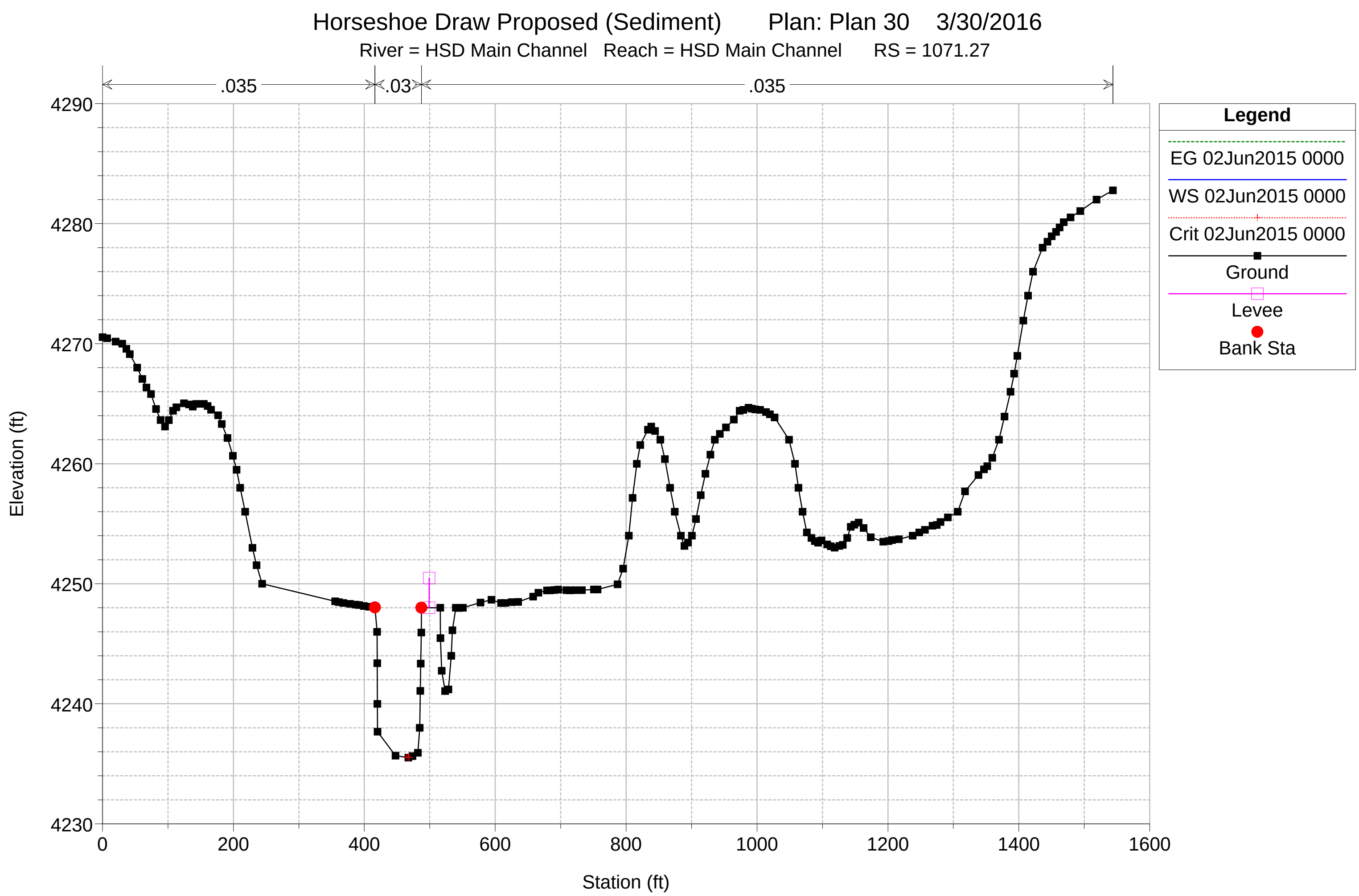
200
400
600
800
1000
1200
1400
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 1071.27
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.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
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4240
4230
0
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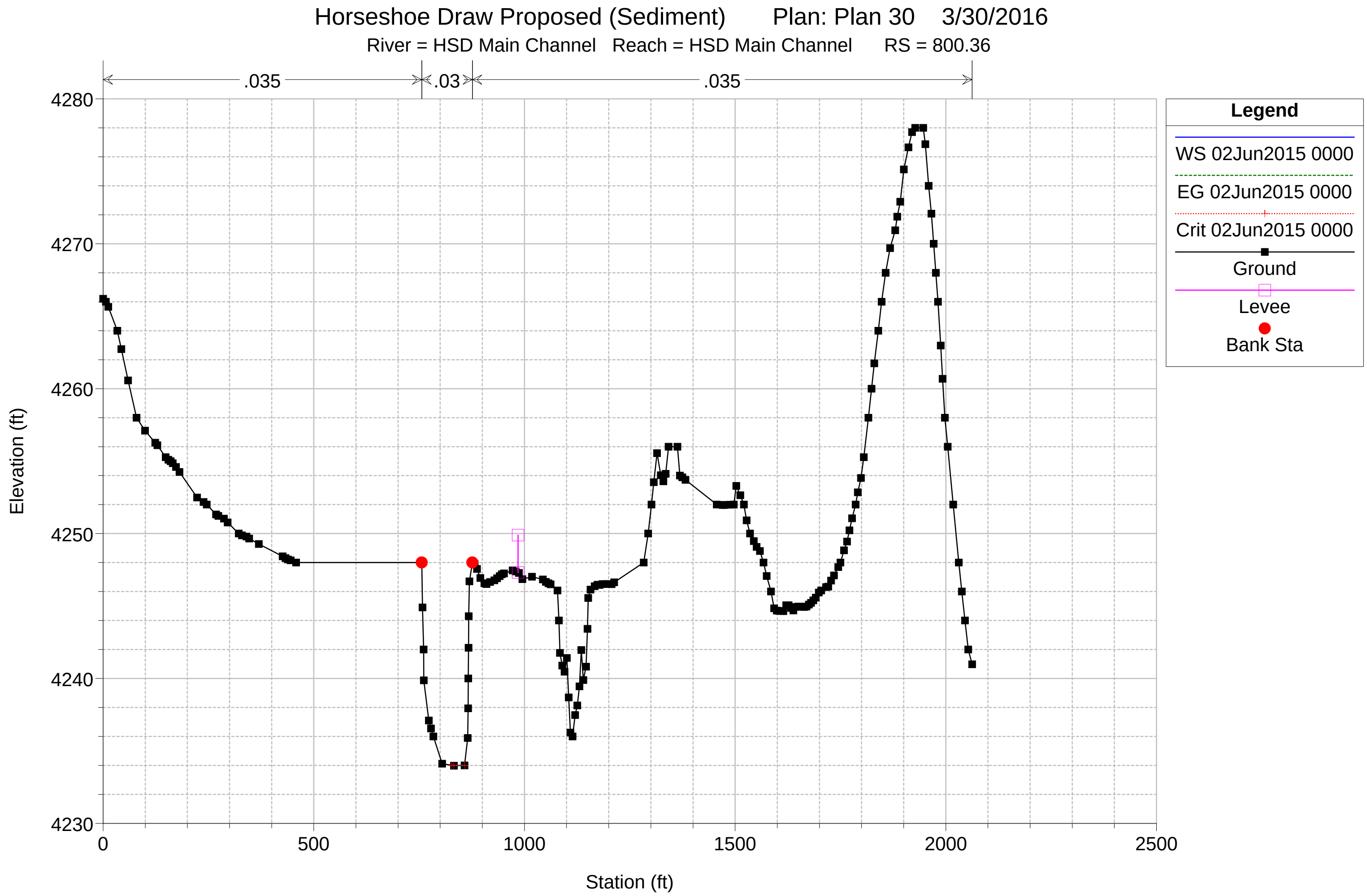
600
800
1000
1200
1400
1600
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 800.36
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
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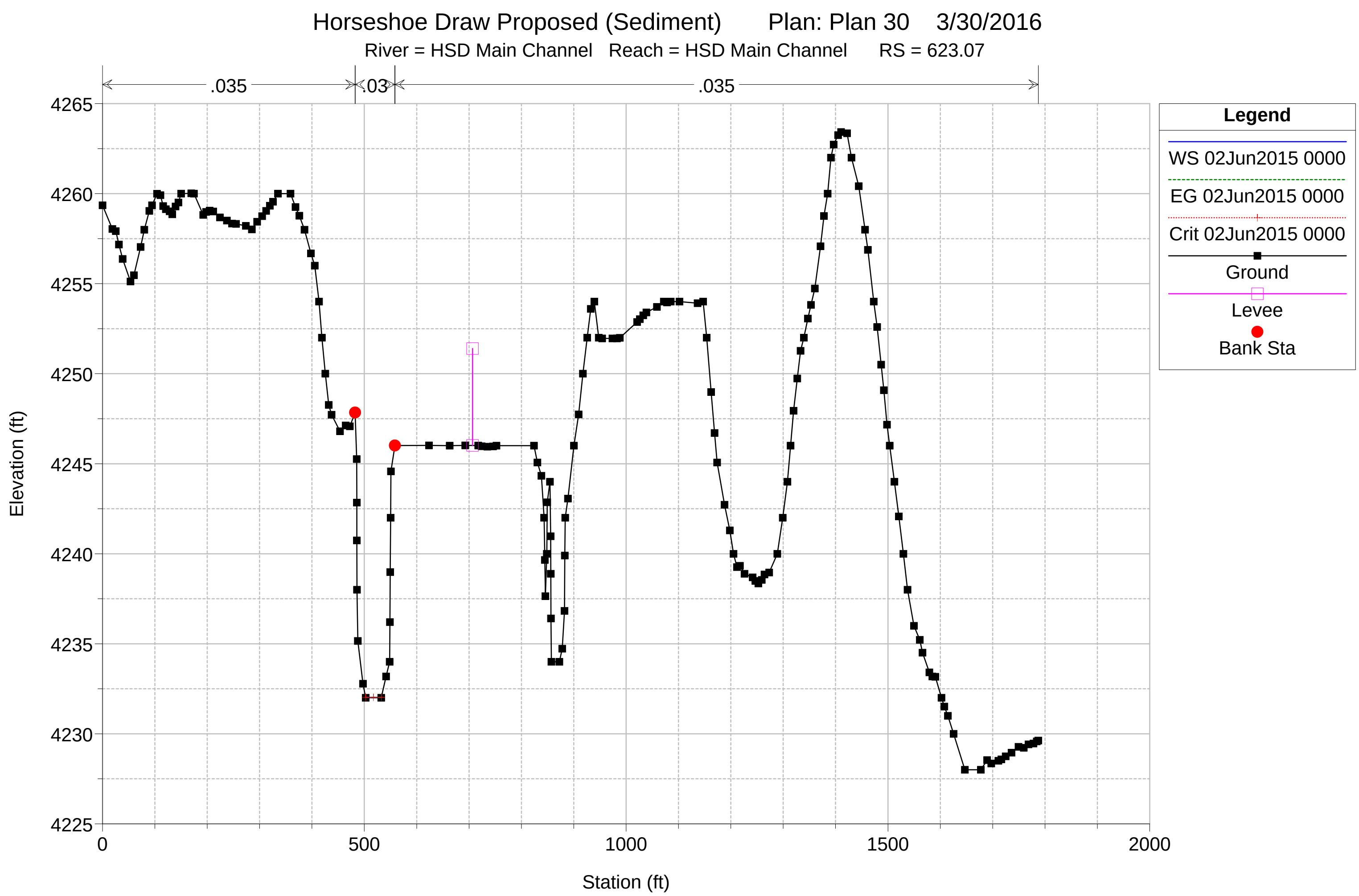
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 623.07
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
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4225
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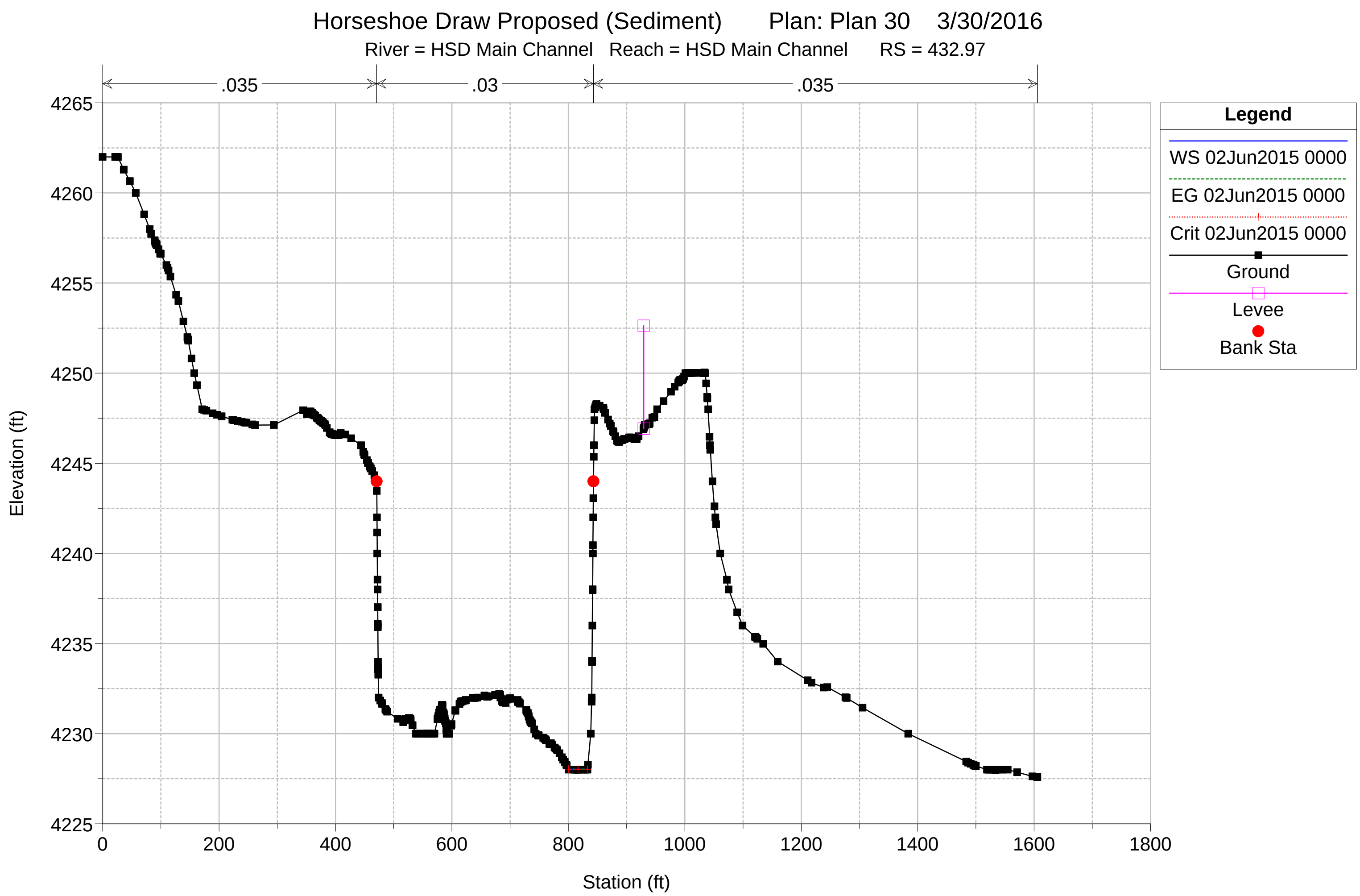
1000
1500
2000
Station (ft)



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 432.97
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
4265
4260
4255
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4245
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4235
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4225
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1200
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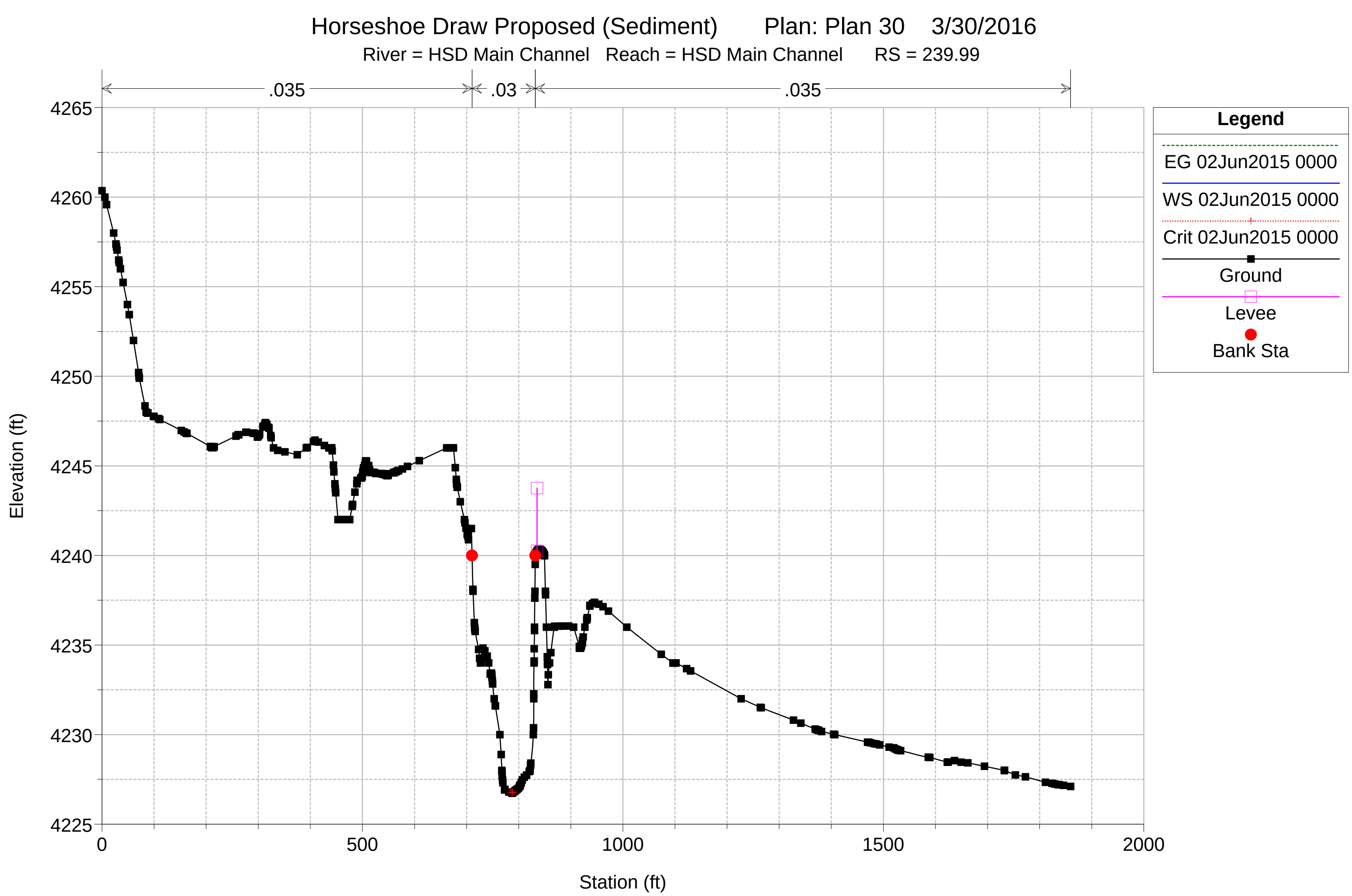
1600
1800



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 239.99
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.03
.035
Legend
EG 02Jun2015 0000
WS 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
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4255
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4230
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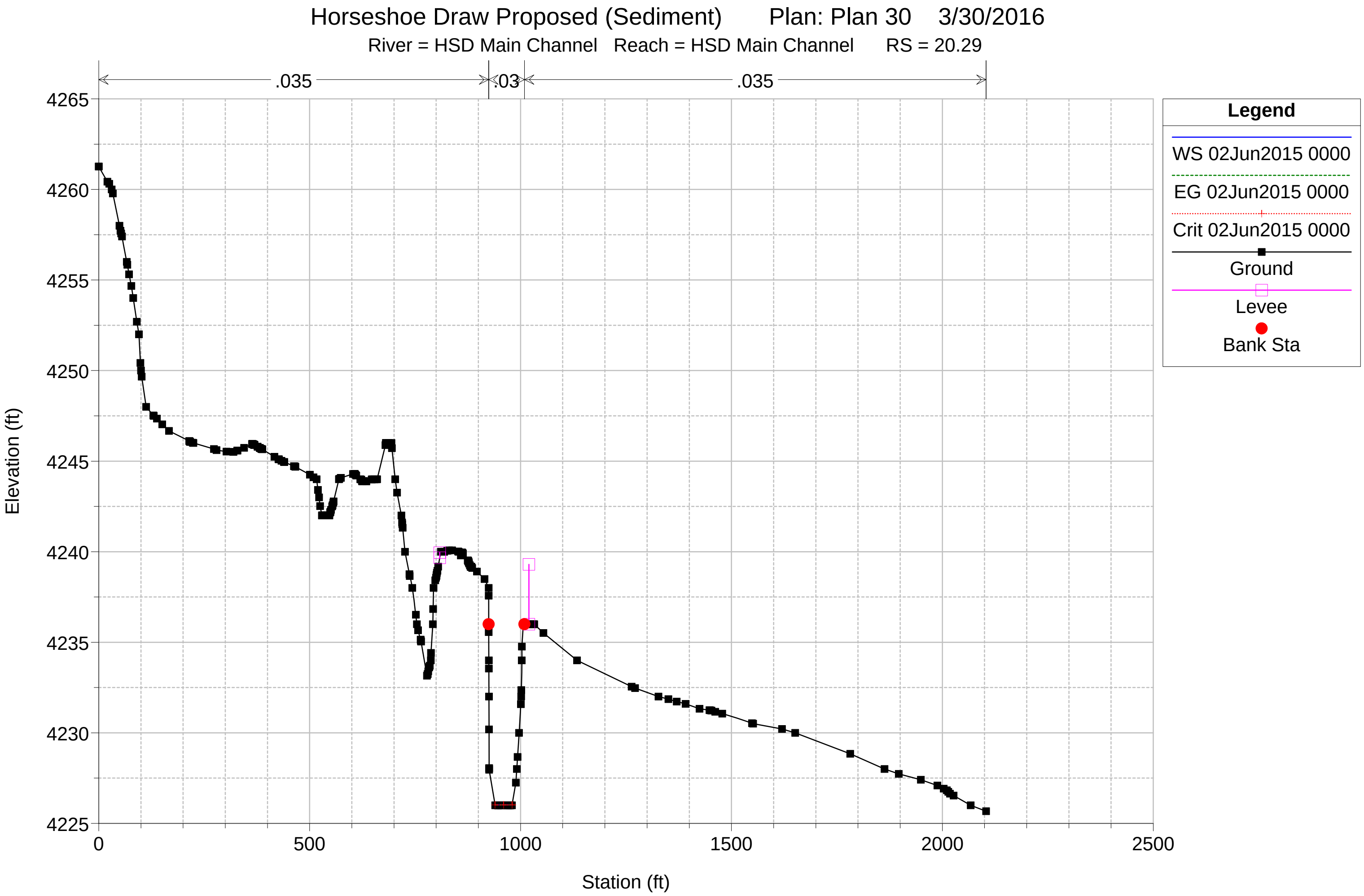
1000
1500
2000



Horseshoe Draw Proposed (Sediment) Plan: Plan 30 3/30/2016
River = HSD Main Channel Reach = HSD Main Channel RS = 20.29
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.03
.035
Legend
WS 02Jun2015 0000
EG 02Jun2015 0000
Crit 02Jun2015 0000
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
4265
4260
4255
4250
4245
4240
4235
4230
4225
0
500
1000
1500
2000
2500

```
                        HEC-RAS Version 4.0.0 March 2008
                          U.S. Army Corps of Engineers
                         Hydrologic Engineering Center
                               609 Second Street
                               Davis, California


            X     X  XXXXXX    XXXX        XXXX       XX      XXXX
            X     X  X        X    X       X   X     X  X    X
            X     X  X        X            X   X    X    X   X
            XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
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PROJECT DATA
Project Title: Horseshoe Draw Proposed (Sediment)
Project File : HorseshoeDrawProp.prj
Run Date and Time: 3/30/2016 12:21:44 PM

Project in English units

PLAN DATA

Plan Title: Plan 30
Plan File : u:\1400\1472\REPORTS\DRAINAGE\HEC-RAS\Proposed Conditions\Sediment Transport\Split Geo - DS\HorseshoeDrawProp.p30

Geometry Title: Horseshoe Draw Existing Conditions
Geometry File : u:\1400\1472\REPORTS\DRAINAGE\HEC-RAS\Proposed Conditions\Sediment Transport\Split Geo - DS\HorseshoeDrawProp.g01

Flow Title :
Flow File :

```
Plan Summary Information:
Number of:  Cross Sections =   41    Multiple Openings  =    0
            Culverts       =    0    Inline Structures  =    0
            Bridges        =    0    Lateral Structures =    0

Computational Information
    Water surface calculation tolerance  =  0.01
    Critical depth calculation tolerance =  0.01
    Maximum number of iterations         =  20
    Maximum difference tolerance         =  0.3
    Flow tolerance factor                =  0.001

Computation Options
    Critical depth computed only where necessary
    Conveyance Calculation Method: At breaks in n values only
    Friction Slope Method:         Average Conveyance
    Computational Flow Regime:     Mixed Flow
```

FLOW DATA

Flow Title:
Flow File :

Flow Data (cfs)

River	Reach	RS	PF 1

Boundary Conditions

River	Reach	Profile	Upstream	Downstream

SUMMARY OF MANNING'S N VALUES

River:HSD Main Channel

Reach	River Sta.	n1	n2	n3
HSD Main Channel	12329.17	.035	.03	.035
HSD Main Channel	12141.33	.035	.03	.035
HSD Main Channel	11917.1	.035	.03	.035
HSD Main Channel	11610.72	.035	.03	.035
HSD Main Channel	11182.79	.035	.03	.035
HSD Main Channel	10592.6	.035	.03	.035

HSD Main Channel	10118.27	.035	.03	.035
HSD Main Channel	9624.29	.035	.03	.035
HSD Main Channel	9149.64	.035	.03	.035
HSD Main Channel	8654.43	.035	.03	.035
HSD Main Channel	8227.06	.035	.03	.035
HSD Main Channel	7805.03	.035	.03	.035
HSD Main Channel	7385.4	.035	.03	.035
HSD Main Channel	6964.05	.035	.03	.035
HSD Main Channel	6467.25	.035	.03	.035
HSD Main Channel	6090.97	.035	.03	.035
HSD Main Channel	5785.22	.035	.03	.035
HSD Main Channel	5546.66	.035	.03	.035
HSD Main Channel	5283.29	.035	.03	.035
HSD Main Channel	5034.86	.035	.03	.035
HSD Main Channel	4695.55	.035	.03	.035
HSD Main Channel	4462.68	.035	.03	.035
HSD Main Channel	4219.43	.035	.03	.035
HSD Main Channel	3967.44	.035	.03	.035
HSD Main Channel	3674.39	.035	.03	.035
HSD Main Channel	3379.1	.035	.03	.035
HSD Main Channel	3030.67	.035	.03	.035
HSD Main Channel	2816.21	.035	.03	.035
HSD Main Channel	2587.35	.035	.03	.035
HSD Main Channel	2350.58	.035	.03	.035
HSD Main Channel	2118.63	.035	.03	.035
HSD Main Channel	1888.92	.035	.03	.035
HSD Main Channel	1668.12	.035	.03	.035
HSD Main Channel	1490.38	.035	.03	.035
HSD Main Channel	1255.37	.035	.03	.035
HSD Main Channel	1071.27	.035	.03	.035
HSD Main Channel	800.36	.035	.03	.035
HSD Main Channel	623.07	.035	.03	.035
HSD Main Channel	432.97	.035	.03	.035
HSD Main Channel	239.99	.035	.03	.035
HSD Main Channel	20.29	.035	.03	.035

SUMMARY OF REACH LENGTHS

River: HSD Main Channel

Reach	River Sta.	Left	Channel	Right
HSD Main Channel	12329.17	187.84	187.84	187.84
HSD Main Channel	12141.33	224.23	224.23	224.23
HSD Main Channel	11917.1	306.38	306.38	306.38
HSD Main Channel	11610.72	427.93	427.93	427.93
HSD Main Channel	11182.79	590.19	590.19	590.19
HSD Main Channel	10592.6	474.33	474.33	474.33
HSD Main Channel	10118.27	493.98	493.98	493.98
HSD Main Channel	9624.29	474.65	474.65	474.65
HSD Main Channel	9149.64	495.21	495.21	495.21
HSD Main Channel	8654.43	427.37	427.37	427.37
HSD Main Channel	8227.06	422.03	422.03	422.03
HSD Main Channel	7805.03	419.63	419.63	419.63
HSD Main Channel	7385.4	421.35	421.35	421.35
HSD Main Channel	6964.05	496.8	496.8	496.8
HSD Main Channel	6467.25	376.28	376.28	376.28
HSD Main Channel	6090.97	305.75	305.75	305.75
HSD Main Channel	5785.22	238.56	238.56	238.56
HSD Main Channel	5546.66	263.37	263.37	263.37
HSD Main Channel	5283.29	248.43	248.43	248.43
HSD Main Channel	5034.86	339.31	339.31	339.31
HSD Main Channel	4695.55	232.87	232.87	232.87
HSD Main Channel	4462.68	243.25	243.25	243.25
HSD Main Channel	4219.43	251.99	251.99	251.99
HSD Main Channel	3967.44	293.05	293.05	293.05
HSD Main Channel	3674.39	295.29	295.29	295.29
HSD Main Channel	3379.1	348.43	348.43	348.43
HSD Main Channel	3030.67	214.46	214.46	214.46
HSD Main Channel	2816.21	228.86	228.86	228.86
HSD Main Channel	2587.35	236.77	236.77	236.77
HSD Main Channel	2350.58	231.95	231.95	231.95
HSD Main Channel	2118.63	229.71	229.71	229.71
HSD Main Channel	1888.92	220.8	220.8	220.8
HSD Main Channel	1668.12	177.74	177.74	177.74
HSD Main Channel	1490.38	235.01	235.01	235.01
HSD Main Channel	1255.37	184.1	184.1	184.1
HSD Main Channel	1071.27	270.91	270.91	270.91
HSD Main Channel	800.36	177.29	177.29	177.29
HSD Main Channel	623.07	190.1	190.1	190.1
HSD Main Channel	432.97	192.98	192.98	192.98
HSD Main Channel	239.99	219.7	219.7	219.7
HSD Main Channel	20.29			

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: HSD Main Channel

Reach	River Sta.	Contr.	Expan.
HSD Main Channel	12329.17	.1	.3
HSD Main Channel	12141.33	.1	.3
HSD Main Channel	11917.1	.1	.3
HSD Main Channel	11610.72	.1	.3
HSD Main Channel	11182.79	.1	.3
HSD Main Channel	10592.6	.1	.3
HSD Main Channel	10118.27	.1	.3
HSD Main Channel	9624.29	.1	.3
HSD Main Channel	9149.64	.1	.3
HSD Main Channel	8654.43	.1	.3
HSD Main Channel	8227.06	.1	.3
HSD Main Channel	7805.03	.1	.3
HSD Main Channel	7385.4	.1	.3
HSD Main Channel	6964.05	.1	.3
HSD Main Channel	6467.25	.1	.3
HSD Main Channel	6090.97	.1	.3
HSD Main Channel	5785.22	.1	.3
HSD Main Channel	5546.66	.1	.3
HSD Main Channel	5283.29	.1	.3
HSD Main Channel	5034.86	.1	.3
HSD Main Channel	4695.55	.1	.3
HSD Main Channel	4462.68	.1	.3
HSD Main Channel	4219.43	.1	.3
HSD Main Channel	3967.44	.1	.3
HSD Main Channel	3674.39	.1	.3
HSD Main Channel	3379.1	.1	.3
HSD Main Channel	3030.67	.1	.3
HSD Main Channel	2816.21	.1	.3
HSD Main Channel	2587.35	.1	.3
HSD Main Channel	2350.58	.1	.3
HSD Main Channel	2118.63	.1	.3
HSD Main Channel	1888.92	.1	.3
HSD Main Channel	1668.12	.1	.3
HSD Main Channel	1490.38	.1	.3
HSD Main Channel	1255.37	.1	.3
HSD Main Channel	1071.27	.1	.3
HSD Main Channel	800.36	.1	.3
HSD Main Channel	623.07	.1	.3
HSD Main Channel	432.97	.1	.3
HSD Main Channel	239.99	.1	.3
HSD Main Channel	20.29	.1	.3

Profile Output Table - Standard Table 1

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
HSD Main Channel	12329.17	02Jun2015 0000	0.01	4342.48	4342.50	4342.50	4342.50	0.000542	0.07	0.14	9.34	0.10
HSD Main Channel	12141.33	02Jun2015 0000	0.01	4340.05	4340.08	4340.08	4340.08	0.000646	0.07	0.14	9.69	0.11
HSD Main Channel	11917.1	02Jun2015 0000	0.01	4338.00	4338.02	4338.02	4338.02	0.000060	0.03	0.35	16.73	0.04
HSD Main Channel	11610.72	02Jun2015 0000	0.01	4334.81	4334.84	4334.84	4334.84	0.000338	0.06	0.17	10.70	0.08
HSD Main Channel	11182.79	02Jun2015 0000	0.01	4330.00	4330.02	4330.02	4330.02	0.004871	0.18	0.06	4.65	0.29
HSD Main Channel	10592.6	02Jun2015 0000	0.01	4323.90	4323.92	4323.92	4323.93	0.014527	0.28	0.04	3.64	0.49
HSD Main Channel	10118.27	02Jun2015 0000	0.01	4320.00	4320.02	4320.02	4320.02	0.000033	0.02	0.43	17.91	0.03
HSD Main Channel	9624.29	02Jun2015 0000	0.01	4317.98	4318.00	4318.00	4318.00	0.000029	0.02	0.64	44.65	0.02
HSD Main Channel	9149.64	02Jun2015 0000	0.01	4312.29	4312.34	4312.33	4312.34	0.005606	0.33	0.03	1.18	0.35
HSD Main Channel	8654.43	02Jun2015 0000	0.01	4306.00	4306.03	4306.03	4306.04	0.051934	0.74	0.01	0.79	1.00
HSD Main Channel	8227.06	02Jun2015 0000	0.01	4301.98	4302.00	4302.00	4302.00	0.000137	0.03	0.35	30.96	0.05
HSD Main Channel	7805.03	02Jun2015 0000	0.01	4296.00	4296.02	4296.02	4296.02	0.000043	0.02	0.41	19.78	0.03
HSD Main Channel	7385.4	02Jun2015 0000	0.01	4291.98	4292.01	4292.01	4292.01	0.000582	0.07	0.14	9.07	0.10
HSD Main Channel	6964.05	02Jun2015 0000	0.01	4287.78	4287.80	4287.80	4287.80	0.000961	0.08	0.13	11.82	0.13
HSD Main Channel	6467.25	02Jun2015 0000	0.01	4282.00	4282.06	4282.05	4282.06	0.020003	0.64	0.02	0.55	0.67
HSD Main Channel	6090.97	02Jun2015 0000	0.01	4278.26	4278.31	4278.29	4278.31	0.005955	0.31	0.03	1.35	0.36
HSD Main Channel	5785.22	02Jun2015 0000	0.01	4275.65	4275.68	4275.68	4275.68	0.013521	0.32	0.03	2.43	0.49
HSD Main Channel	5546.66	02Jun2015 0000	0.01	4271.99	4272.01	4272.01	4272.01	0.000167	0.04	0.23	12.59	0.06

HSD Main Channel	5283.29	02Jun2015 0000	0.01	4269.93	4269.95	4269.95	4269.95	0.005404	0.17	0.06	5.72	0.30
HSD Main Channel	5034.86	02Jun2015 0000	0.01	4267.96	4267.99	4267.99	4267.99	0.000477	0.05	0.18	15.96	0.09
HSD Main Channel	4695.55	02Jun2015 0000	0.01	4262.00	4262.01		4262.01	0.001643	0.11	0.09	7.37	0.17
HSD Main Channel	4462.68	02Jun2015 0000	0.01	4261.39	4261.42	4261.42	4261.42	0.004359	0.20	0.05	3.41	0.29
HSD Main Channel	4219.43	02Jun2015 0000	0.01	4259.99	4260.01	4260.01	4260.01	0.000072	0.03	0.39	25.92	0.04
HSD Main Channel	3967.44	02Jun2015 0000	0.01	4258.00	4258.02	4258.02	4258.02	0.000031	0.02	0.49	24.02	0.03
HSD Main Channel	3674.39	02Jun2015 0000	0.01	4256.00	4256.03	4256.03	4256.03	0.000013	0.02	0.59	19.97	0.02
HSD Main Channel	3379.1	02Jun2015 0000	0.01	4255.47	4255.49		4255.49	0.006076	0.19	0.05	4.92	0.32
HSD Main Channel	3030.67	02Jun2015 0000	0.01	4250.87	4250.90	4250.90	4250.91	0.046918	0.64	0.02	1.05	0.93
HSD Main Channel	2816.21	02Jun2015 0000	0.01	4250.00	4250.03	4250.03	4250.03	0.000009	0.01	0.74	26.69	0.01
HSD Main Channel	2587.35	02Jun2015 0000	0.01	4248.00	4248.02	4248.02	4248.02	0.000028	0.02	0.51	24.83	0.02
HSD Main Channel	2350.58	02Jun2015 0000	0.01	4245.98	4246.00	4246.00	4246.00	0.000187	0.04	0.28	22.20	0.06
HSD Main Channel	2118.63	02Jun2015 0000	0.01	4243.99	4244.01	4244.01	4244.01	0.000031	0.02	0.58	37.37	0.02
HSD Main Channel	1888.92	02Jun2015 0000	0.01	4240.00	4240.03	4240.03	4240.03	0.000003	0.01	1.45	58.44	0.01
HSD Main Channel	1668.12	02Jun2015 0000	0.01	4238.00	4238.02		4238.02	0.000016	0.02	0.64	28.74	0.02
HSD Main Channel	1490.38	02Jun2015 0000	0.01	4238.00	4238.02	4238.02	4238.02	0.000012	0.01	0.77	37.15	0.02
HSD Main Channel	1255.37	02Jun2015 0000	0.01	4236.00	4236.05	4236.02	4236.05	0.001585	0.17	0.06	2.21	0.19
HSD Main Channel	1071.27	02Jun2015 0000	0.01	4235.51	4235.54	4235.54	4235.54	0.006306	0.21	0.05	3.93	0.33
HSD Main Channel	800.36	02Jun2015 0000	0.01	4233.98	4234.01	4234.01	4234.01	0.000056	0.02	0.45	30.40	0.03
HSD Main Channel	623.07	02Jun2015 0000	0.01	4232.00	4232.03	4232.03	4232.03	0.000009	0.01	0.78	30.16	0.01
HSD Main Channel	432.97	02Jun2015 0000	0.01	4228.00	4228.03	4228.03	4228.03	0.000007	0.01	0.85	32.67	0.01
HSD Main Channel	239.99	02Jun2015 0000	0.01	4226.73	4226.76	4226.76	4226.76	0.005509	0.20	0.05	3.85	0.31
HSD Main Channel	20.29	02Jun2015 0000	0.01	4226.00	4226.02	4226.02	4226.02	0.000009	0.01	0.86	40.39	0.01

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APPENDIX G

HEC-HMS RECHARGE POTENTIAL RESULTS AND COMPARISON

GROUNDWATER RECHARGE POTENTIAL HEC-HMS COMPARISON

Project: Horseshoe Draw

Prepared by: HW

Date: December 2016

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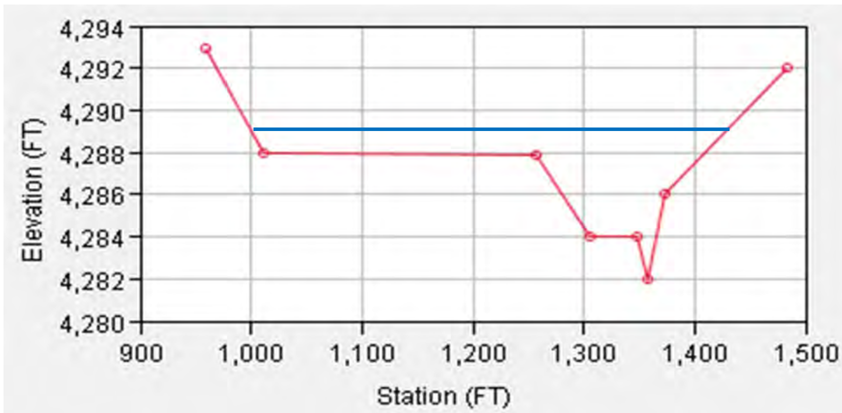
Storm Event	HEC-HMS Reach	HEC-RAS Reach Cross-Section Span	Existing		Proposed		Volumetric Increase [acre-feet]
			Volume [acre-feet]	Total Volume [acre-feet]	Volume [acre-feet]	Total Volume [acre-feet]	
2-Year	Basin	--	--	**243**	89	**423**	**180**
	R-9	123+29.17-46+95.55	119		157		
	R-12	44+62.68-21+18.63	124		176		
10-Year	Basin	--	--	**327**	117	**538**	**211**
	R-9	123+29.17-46+95.55	160		198		
	R-12	44+62.68-21+18.63	167		222		
25-Year	Basin	--	--	**368**	129	**594**	**226**
	R-9	123+29.17-46+95.55	181		219		
	R-12	44+62.68-21+18.63	188		246		
50-Year	Basin	--	--	**402**	139	**642**	**240**
	R-9	123+29.17-46+95.55	197		234		
	R-12	44+62.68-21+18.63	205		270		
100-Year	Basin	--	--	**480**	147	**722**	**242**
	R-9	123+29.17-46+95.55	235		267		
	R-12	44+62.68-21+18.63	245		308		

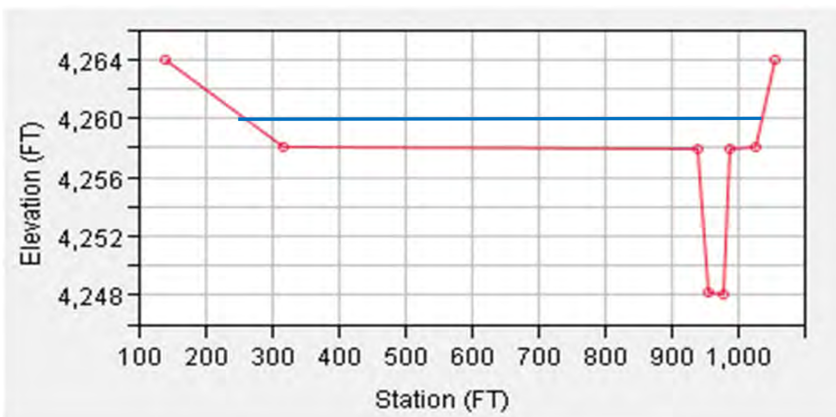
Notes:

Percolation rate = 0.5 $ft^3/hr/ft^2$ = 6.1 cfs/acre

R-9


4,294
4,292
4,290
4,288
4,286
4,284
4,282
4,280
Elevation (FT)
900
1,000
1,100
1,200
1,300
1,400
1,500
Station (FT)

R-12


4,264
4,260
4,256
4,252
4,248
Elevation (FT)
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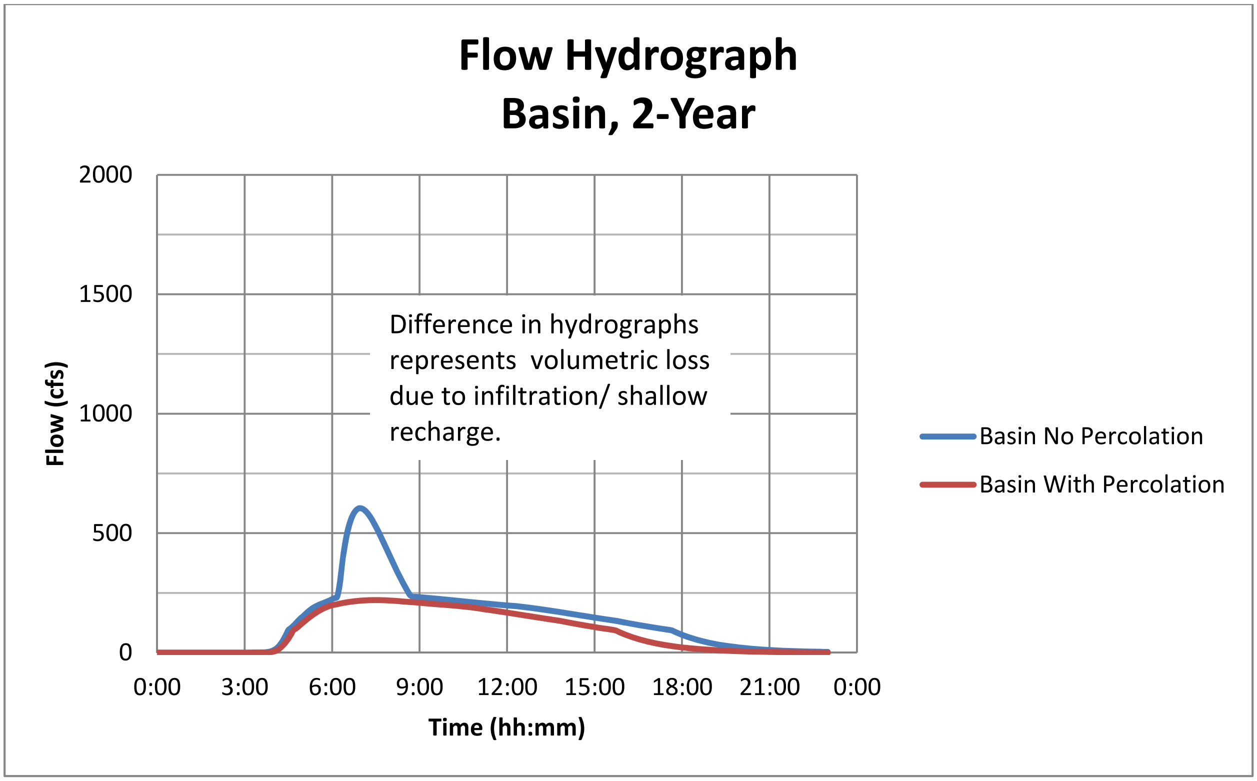
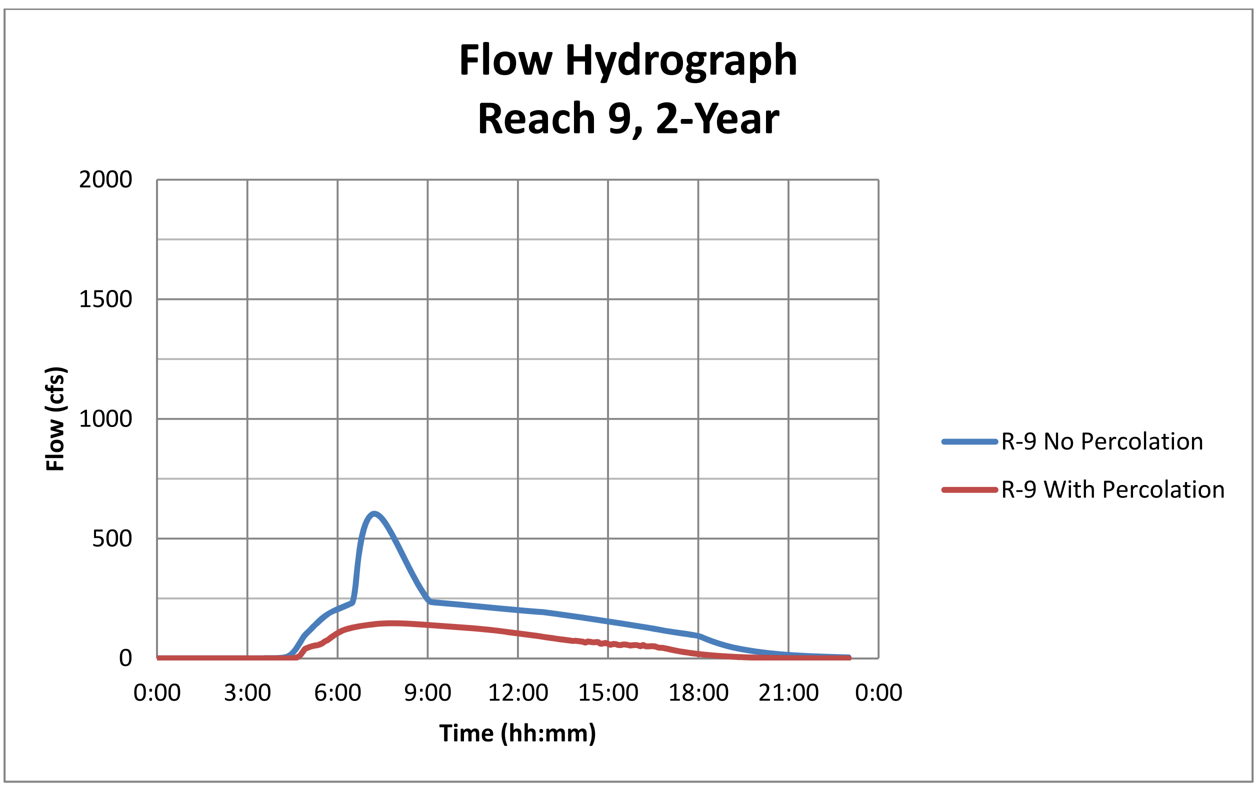
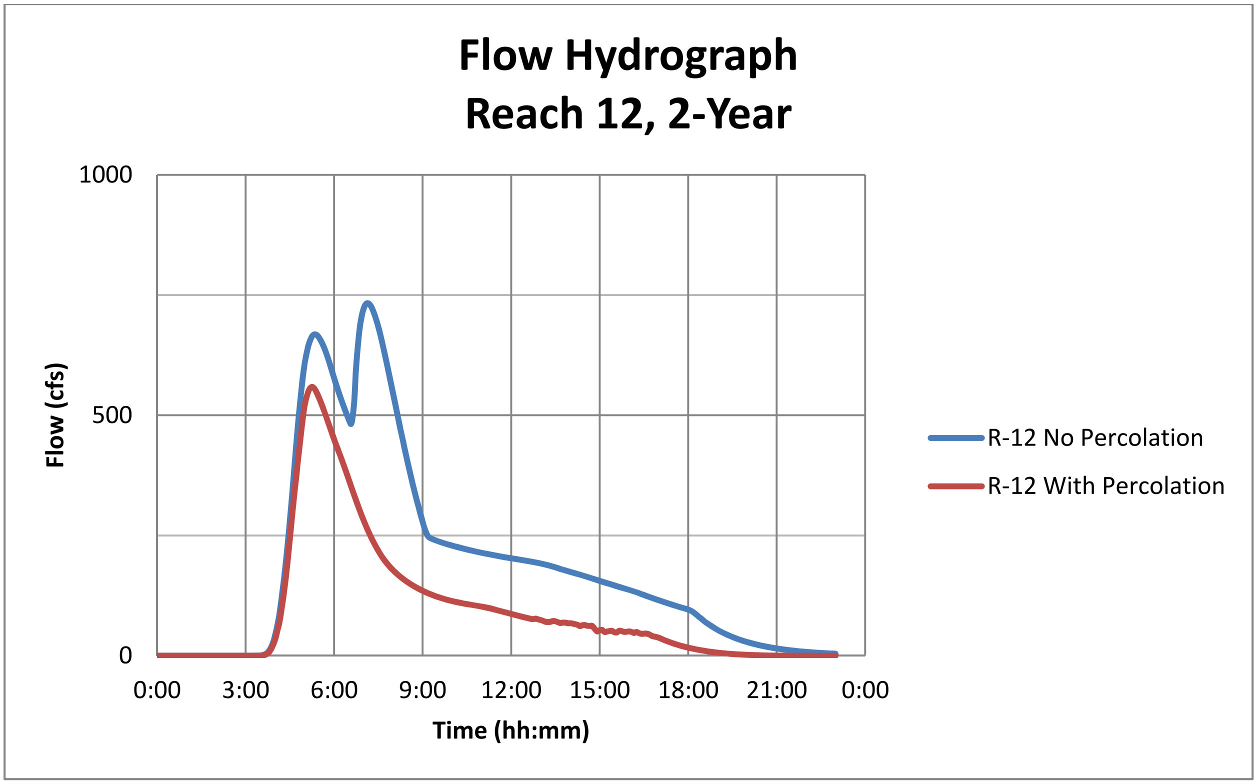
200
300
400
500
600
700
800
900
1,000
Station (FT)

Horseshoe Draw HEC-HMS Model Flow Output

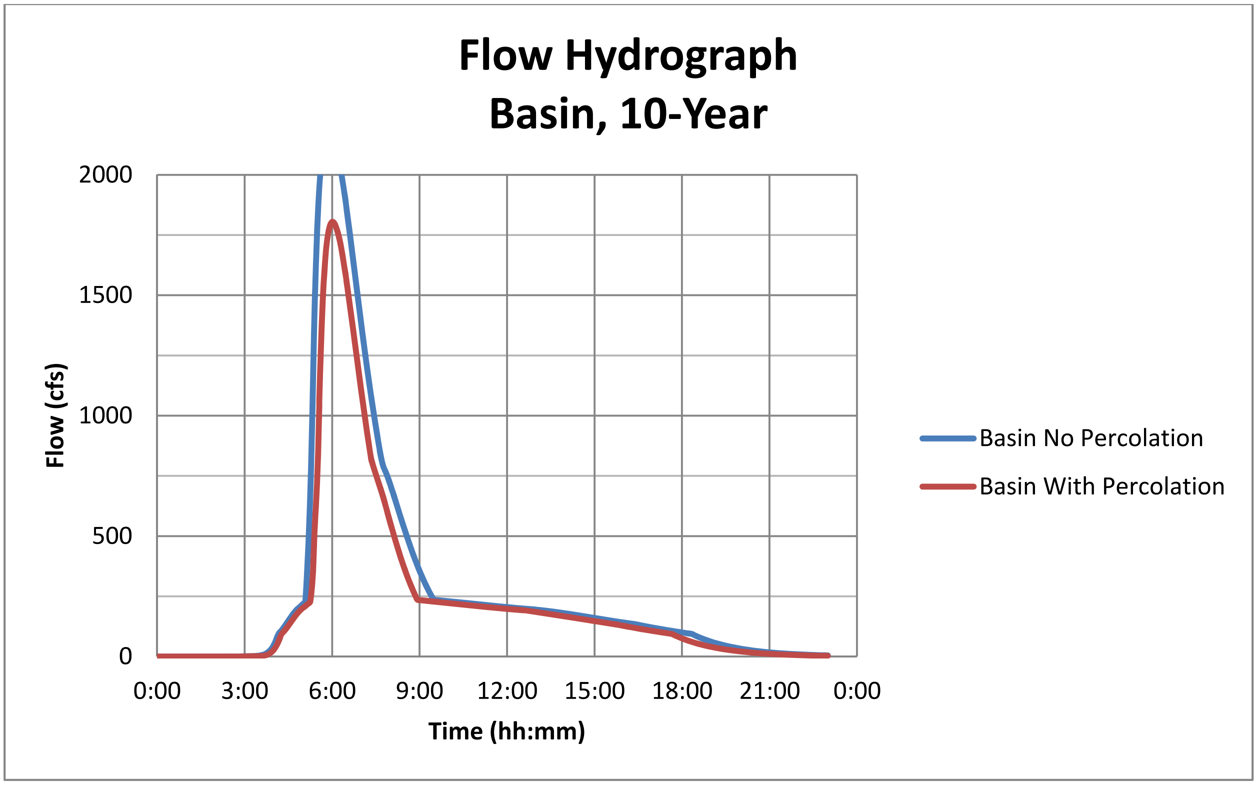


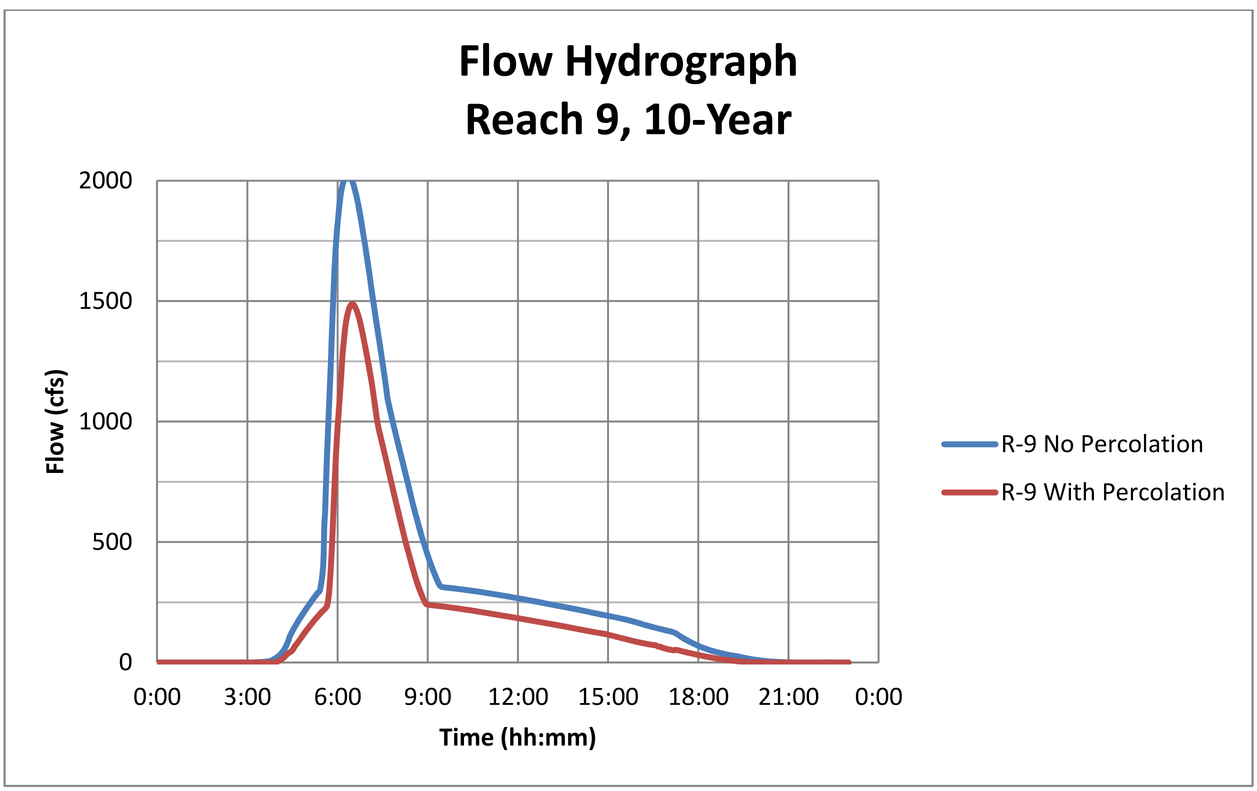


Horseshoe Draw HEC-HMS Model Flow Output

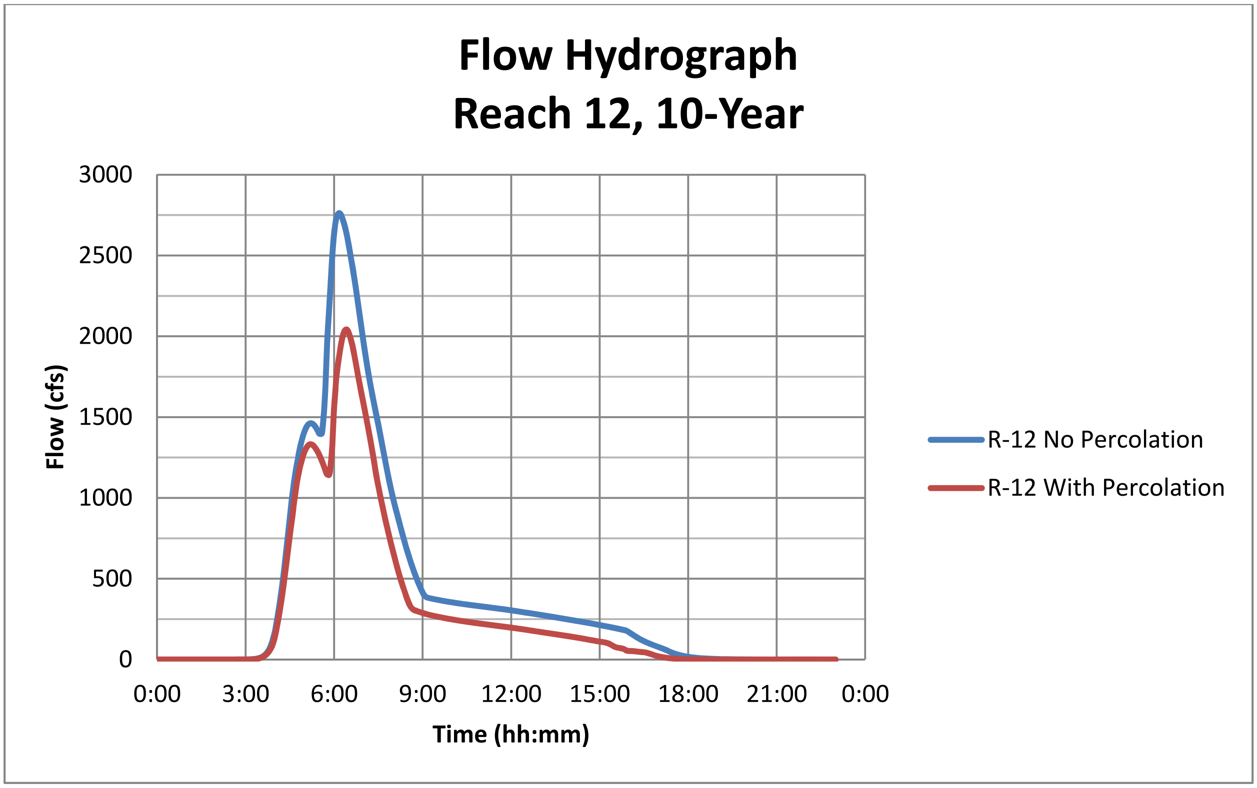


Horseshoe Draw HEC-HMS Model Flow Output

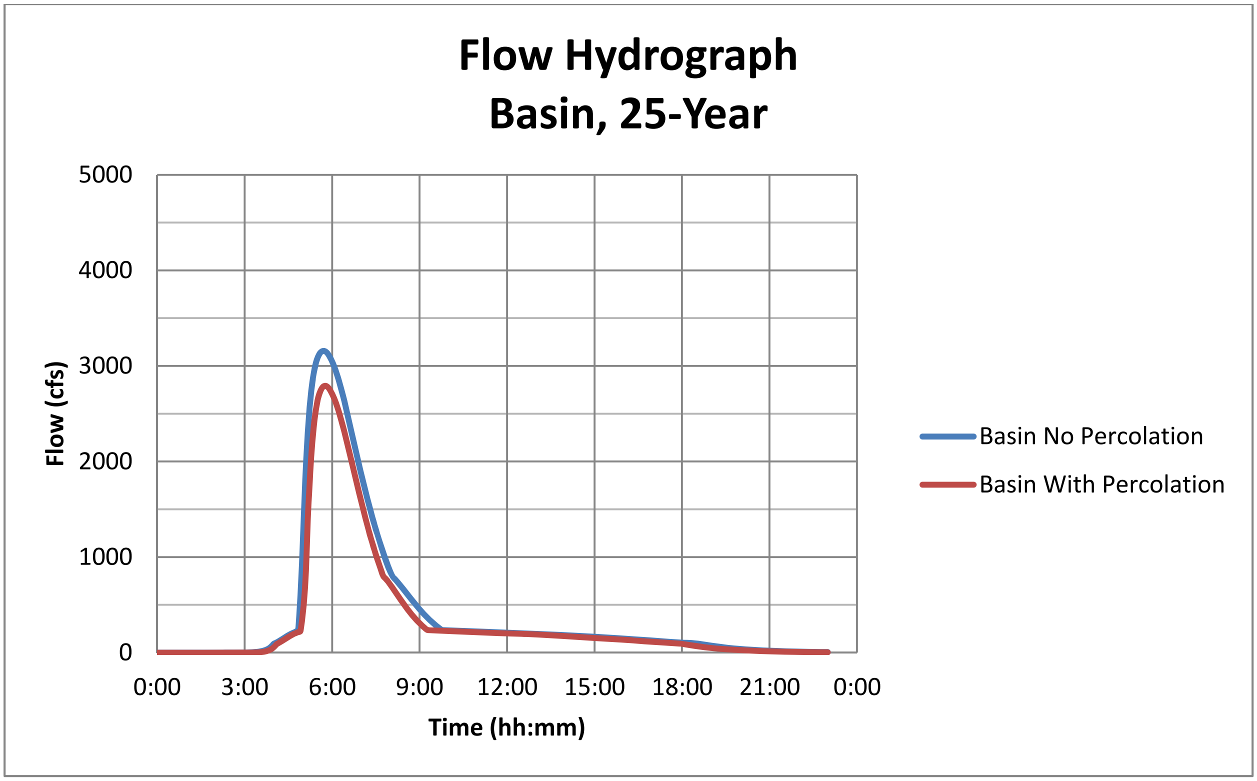


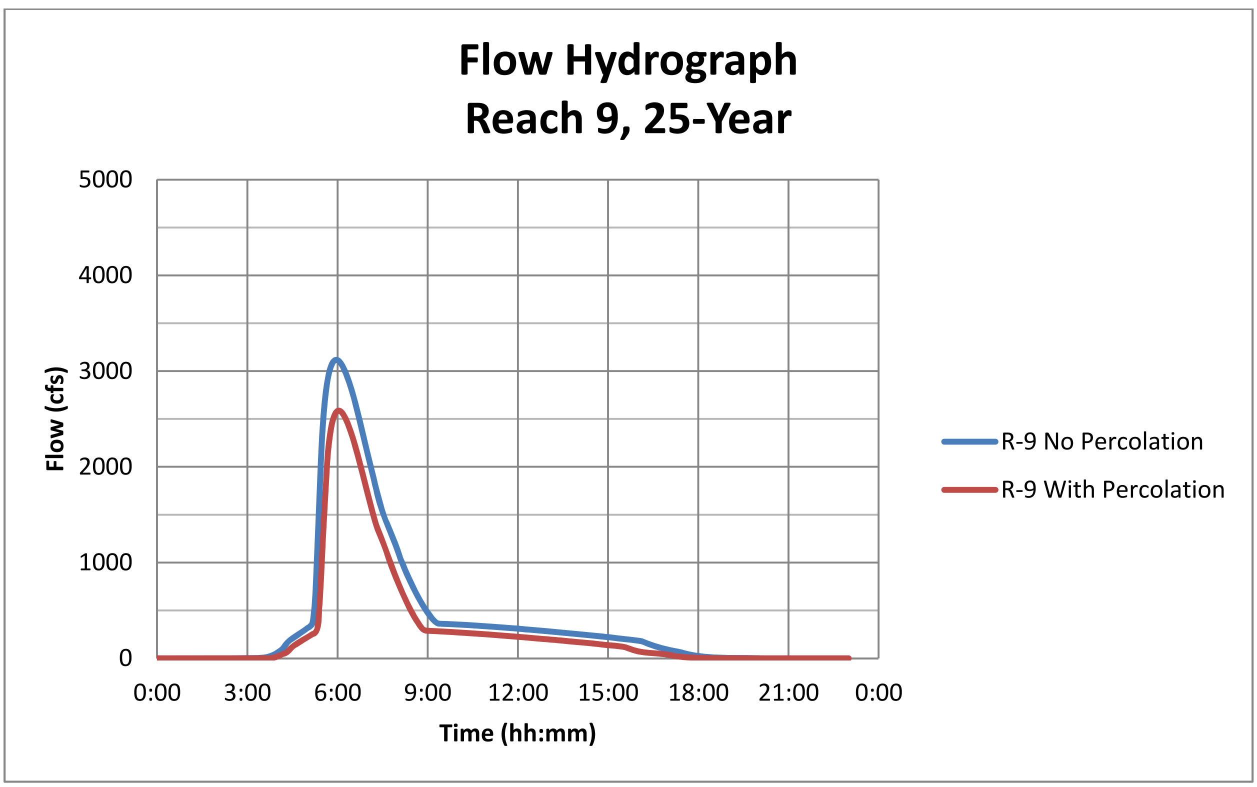


Horseshoe Draw HEC-HMS Model Flow Output

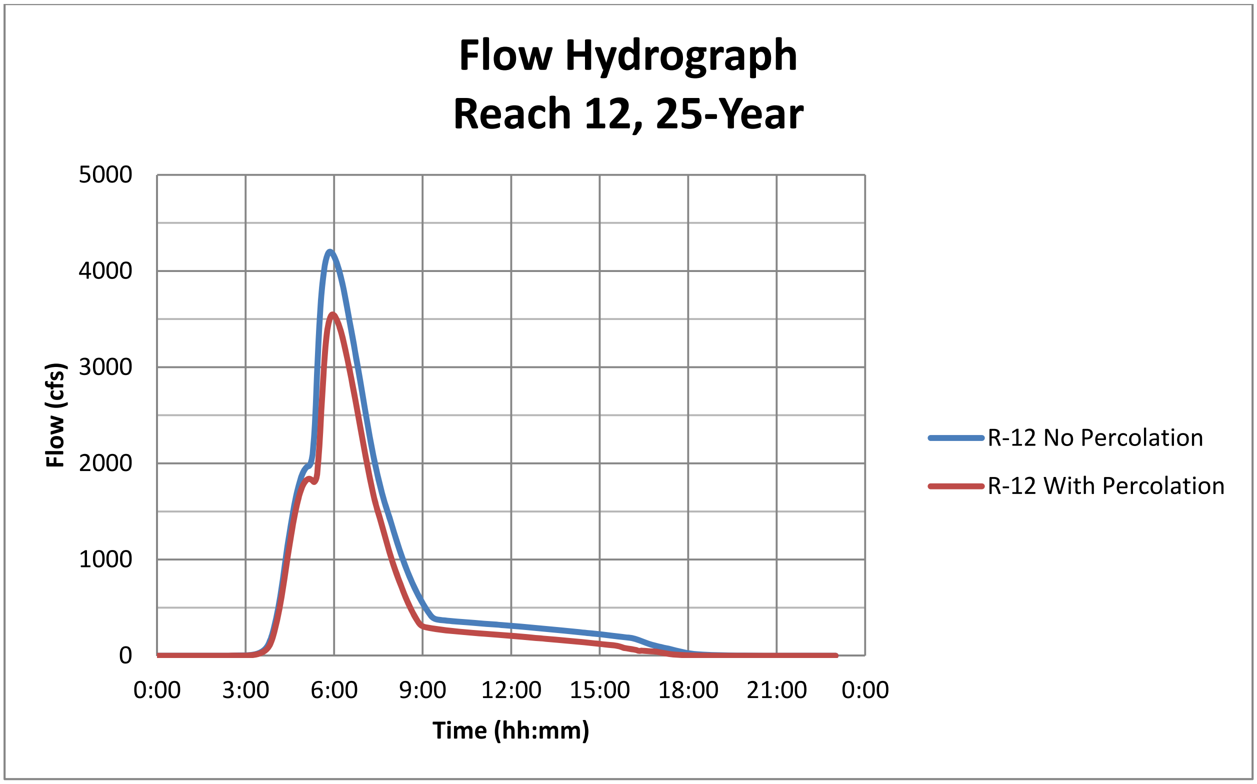


Horseshoe Draw HEC-HMS Model Flow Output

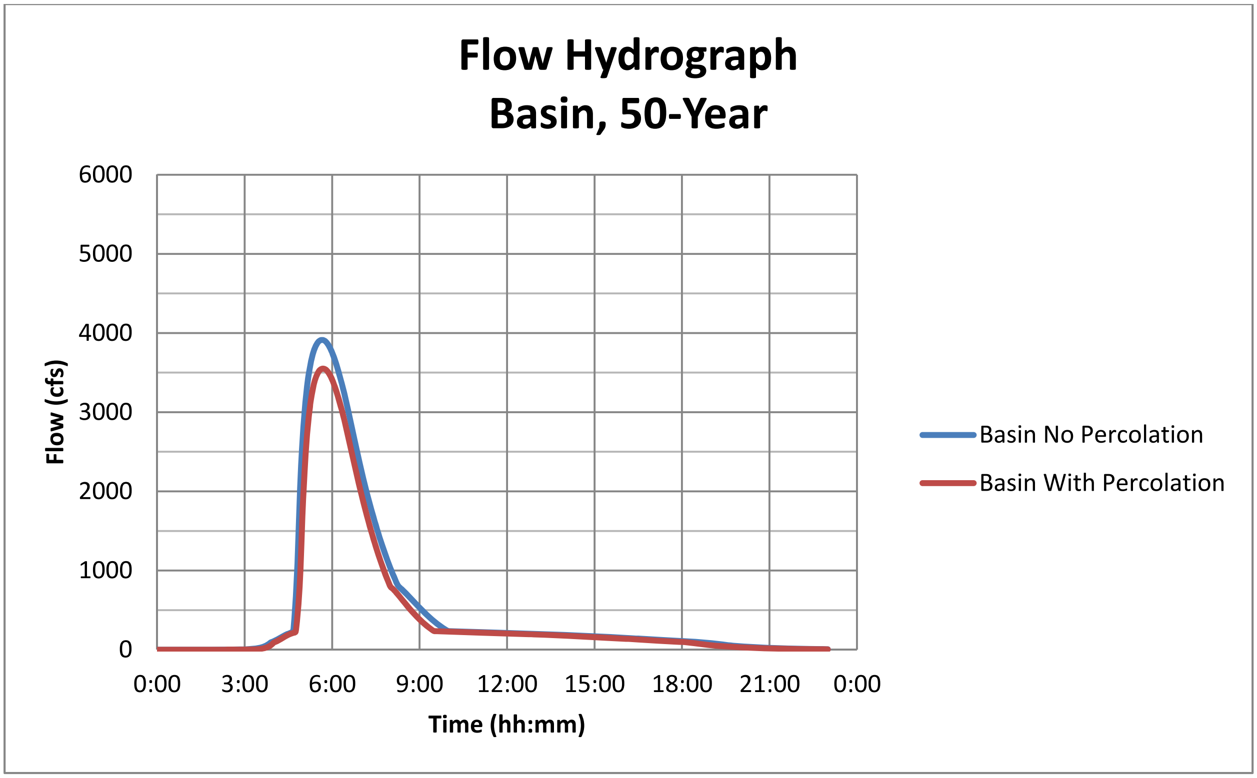


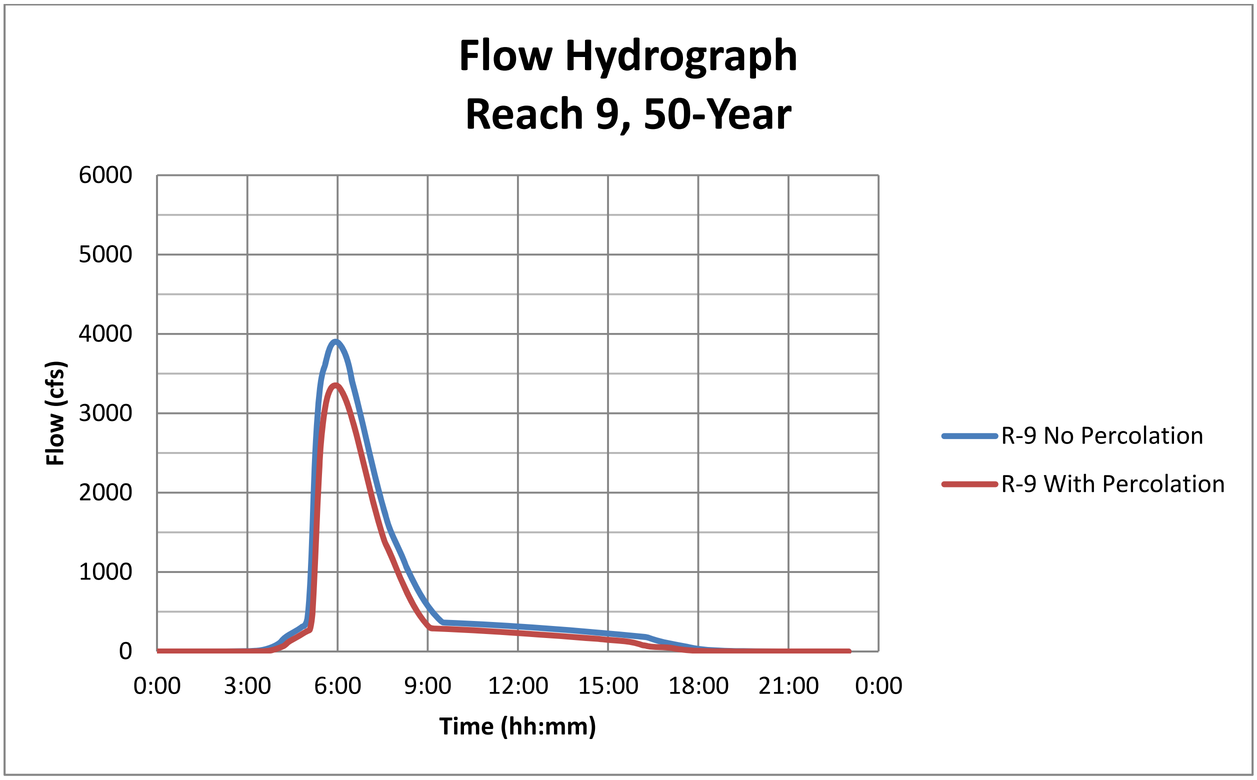


Horseshoe Draw HEC-HMS Model Flow Output

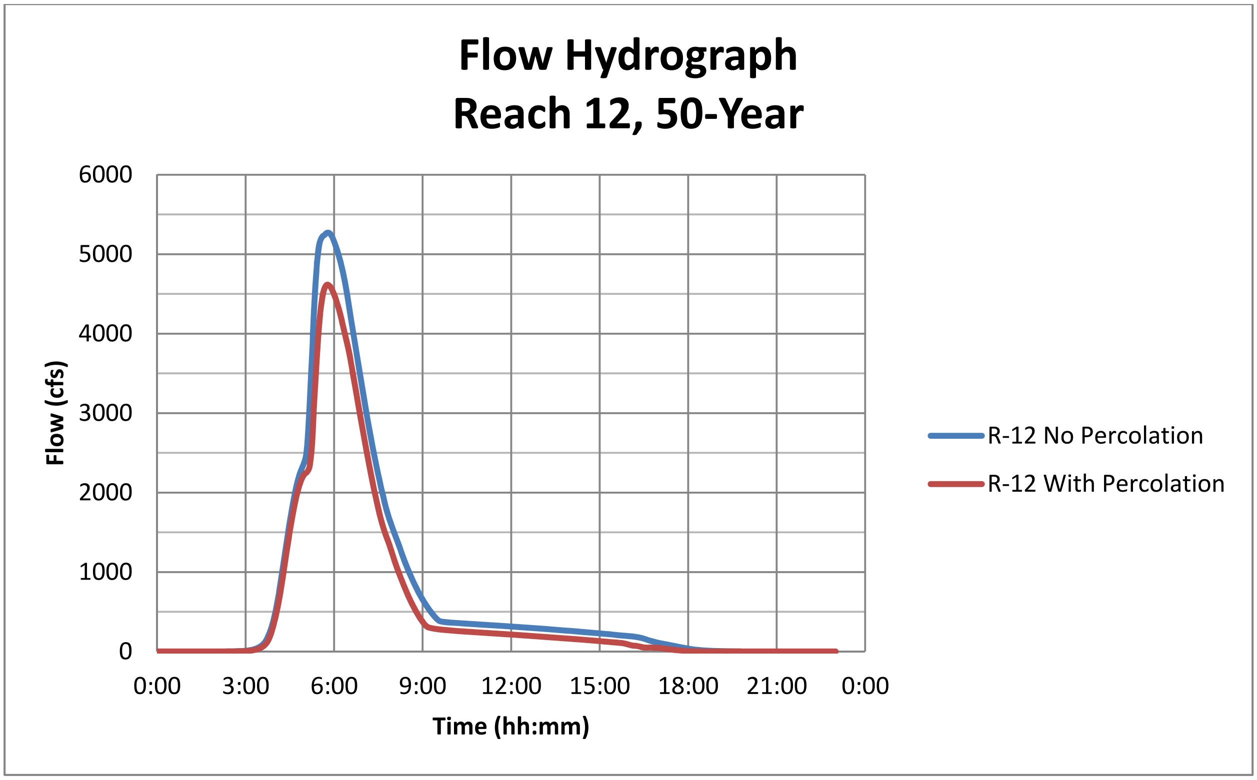


Horseshoe Draw HEC-HMS Model Flow Output

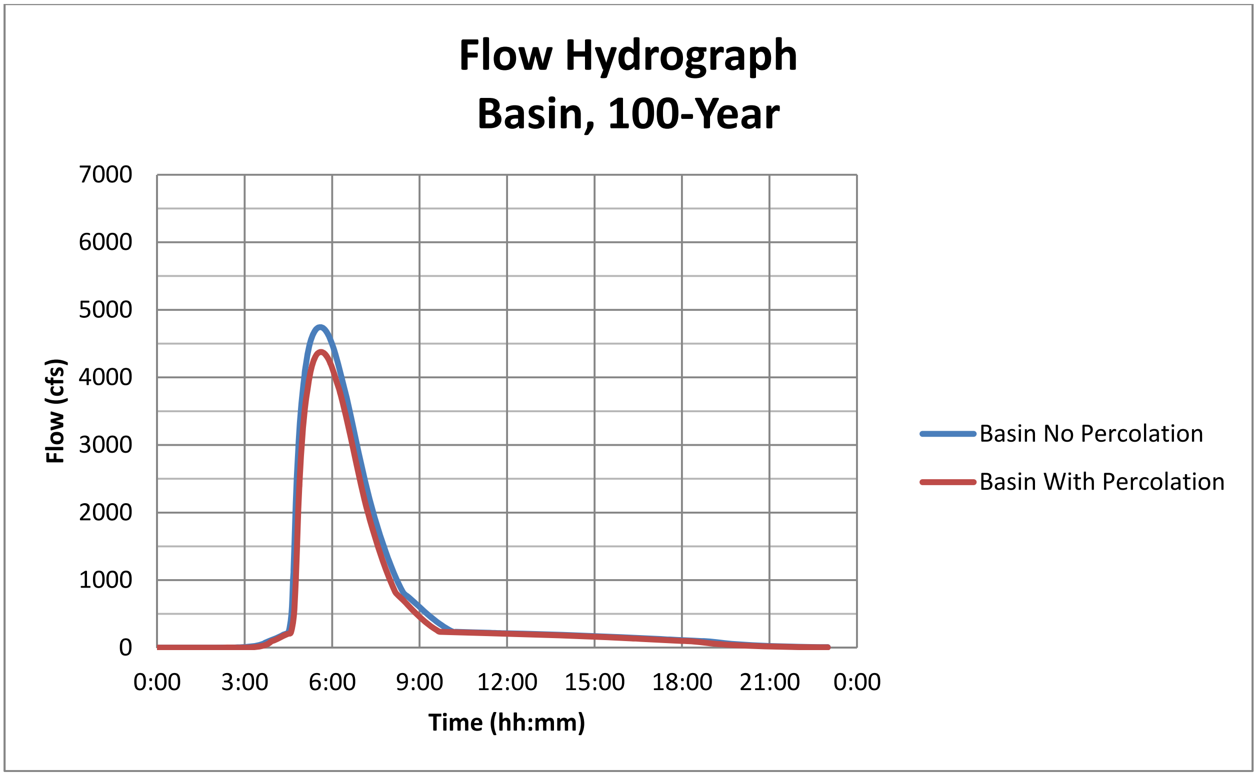


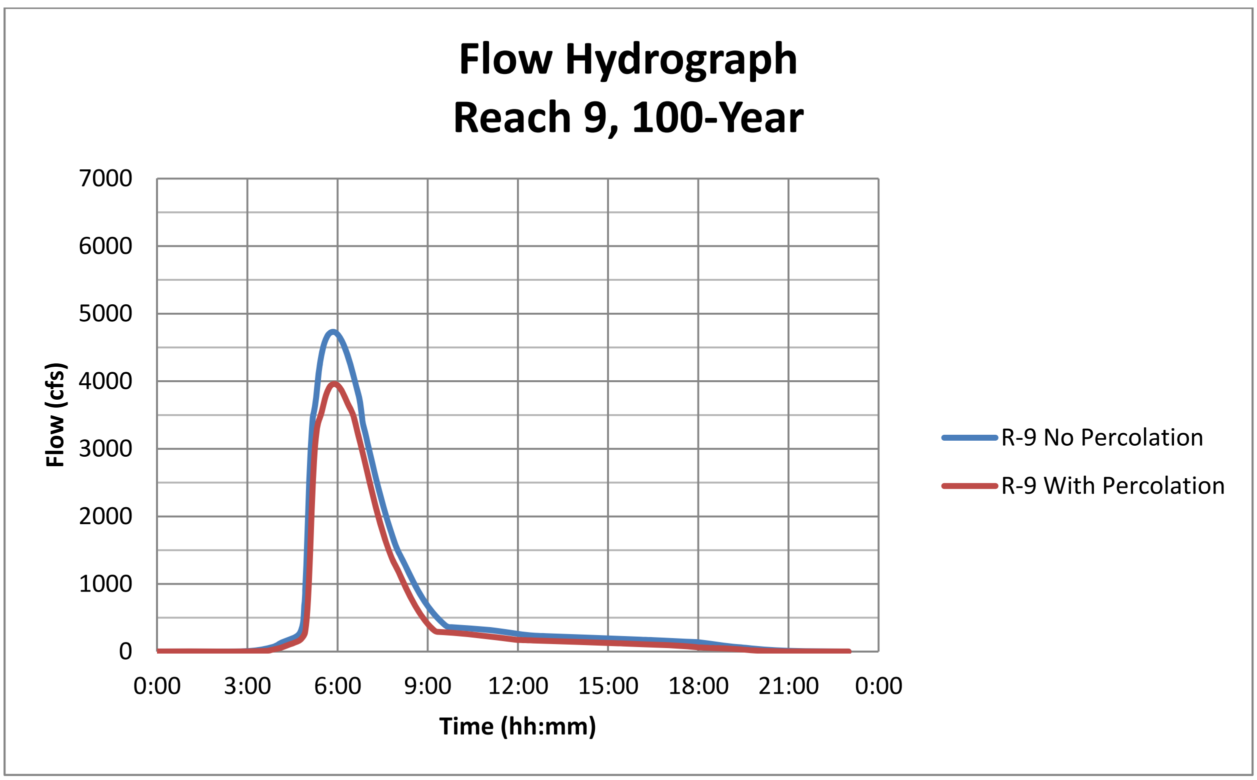


Horseshoe Draw HEC-HMS Model Flow Output

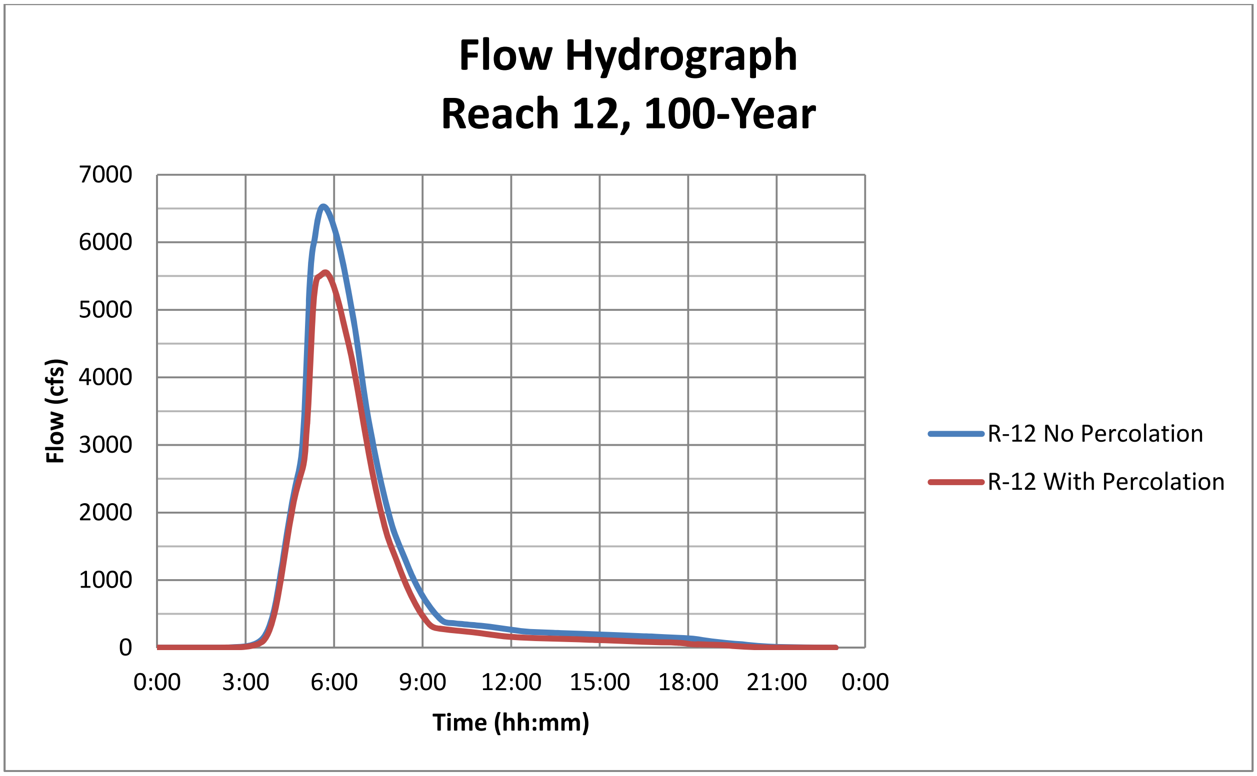


Horseshoe Draw HEC-HMS Model Flow Output





Horseshoe Draw HEC-HMS Model Flow Output



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APPENDIX H
PROJECT PERMITTING AND COMPLIANCE

HORSESHOE DRAW FLOOD CONTROL, RESTORATION AND EROSION MITIGATION STUDY AND DESIGN PROJECT

VOLUME 1A

PROJECT PERMITTING AND COMPLIANCE

COCHISE COUNTY, ARIZONA

Prepared for:

Hereford Natural Resource
Conservation District
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Huachuca City, AZ 85616

Prepared by:

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October 2016
HilgartWilson Project No. 1472

VOLUME 1A
PROJECT PERMITTING AND COMPLIANCE

TABLE OF CONTENTS

TABLES

1. INTRODUCTION

1.1. PROJECT DESCRIPTION, LOCATION, AND PURPOSE

This study has been prepared for the Hereford Natural Resource Conservation District (NRCD), who has identified the need for a project which will substantially reduce flooding, erosion and soil loss, as well as road and property damage in and adjacent to the ephemeral Horseshoe Draw (the Project). The study area spans the border between the United States and Mexico roughly 7 miles west of Naco, Arizona/Sonora in Cochise County.

The purpose of this supplementary report is to summarize the necessary permits and agreements prior to and during construction of the proposed embankment and detention basin (impoundment structure) that will ensure compliance with the applicable local, state, and federal requirements. Details of the proposed Project found in previously submitted reports provide justification for the permitting (and exemptions) pertaining to the construction of the impoundment structure and are discussed below.

Previous reports under this study submitted to the NRCD include; *Volume 1, Existing Conditions Hydrologic Study* (Volume 1) (HILGARTWILSON 2015a); *Volume 2, Existing Conditions Hydraulic Report* (Volume 2) (HILGARTWILSON 2015b); *Volume 3, Existing Conditions Sediment Transport Analysis* (Volume 3) (HILGARTWILSON 2015c); and *Volume 4, Existing Conditions Recharge Potential Analysis* (Volume 4) (HILGARTWILSON 2015d) which detail existing conditions used for comparison of the impoundment structure with respect to hydrologic and hydraulic conditions, sediment transport, and groundwater recharge potential. The recommended remedial alternative was selected in *Volume 5, Remedial Design Alternatives Feasibility Study* (Volume 5) (HILGARTWILSON 2016a) and the resulting impacts and design specifications of the proposed alternative are detailed in *Volume 6, Final Design Report* (Volume 6) (HILGARTWILSON 2016b).

2. IMPOUNDMENT STRUCTURE CLASSIFICATION AND EXEMPTIONS

The impoundment structure will be classified as a non-jurisdictional structure as it does not meet the Arizona Department of Water Resources' (ADWR) definition of a jurisdictional dam being less than 6 feet high from the downstream toe. Because the impoundment structure is not considered jurisdictional, it will be exempt from ADWR review. Water retained by the basin will drain within 24-hours, exempting the impoundment structure from water rights issues with ADWR as well. Therefore, a permit to appropriate surface waters of the state will not be required.

In addition, the Project is located on privately held land; thus the Arizona State Land Department (ASLD) or Bureau of Land Management (BLM) do not have jurisdiction.

While portions of the Project are located within the Gila River Maintenance Area, designated by the ADWR, the impoundment structure is exempt from the prohibitions listed under ARS 45-2631, which do not allow construction or enlargement of new dams within this designated area. The Project is exempt because it falls within the definition of a flood control structure pursuant to ARS 45-2631(B)(1)(a).

3. REQUIRED PERMITTING

The Project would be subject to limited state, county, and federal review and regulations, as discussed herein. Table 1 summarizes the anticipated permitting for the Project; a discussion of the permits and supporting documentation required is provided subsequently.

Table 1: Horseshoe Draw Permitting	
Regulator	**Permit**
U.S. Army Corps of Engineers	Approved Jurisdictional Determination (demonstrating there are no "waters of the U.S." in the project area pursuant to CWA Section 404)
U.S. Fish and Wildlife Service	Endangered Species Act
Arizona Water Protection Fund	Arizona Historic Preservation Act
ADEQ	CWA Section 402 Arizona Pollutant Discharge Elimination System Permit (AZPDES)
	Stormwater Construction General Permit
	Notice of Intent (NOI)
	Stormwater Pollution Prevention Plan (SWPPP)
Cochise County	Floodplain Use Permit - Non-Residential
	Building/Use Permit
	Clearing Permit

3.1. U.S. ARMY CORPS OF ENGINEERS

The U.S. Army Corps of Engineers (Corps) administers CWA Section 404, including the identification of "waters of the U.S." via a jurisdictional determination and permitting for the discharge of dredged or fill materials into waters of the U.S.

3.1.1. JURISDICTIONAL DETERMINATION

Pursuant to the *U.S. Army Corps of Engineers Jurisdictional Determination Form Instructional Guidebook* prepared jointly by the Corps and the Environmental Protection Agency (EPA; Corps and EPA 2007), as revised per the memorandum dated December 2, 2008, entitled *Clean Water Act Jurisdiction Following the U.S. Supreme Court's Decision in Rapanos v. United States & Carabell v. United States* (Corps and EPA 2008), an approved jurisdictional determination (JD) seeks to define the limits of "waters of the U.S.," that are present (or absent) on a particular site.

In the arid southwest (and for the Horseshow Draw project), a significant nexus analysis will be used to assess the flow characteristics and functions of drainage feature(s) and wetlands in the project area to determine if they significantly affect the chemical, physical, and biological integrity of the downstream “traditional navigable water.” Significant nexus includes consideration of hydrologic factors including the following:

- volume, duration, and frequency of flow, including consideration of certain physical characteristics of the tributary
- proximity to the traditionally navigable water (TNW)
- size of the watershed
- average annual rainfall
- potential of tributaries to carry pollutants and flood waters to traditional navigable waters
- provision of aquatic habitat that supports a traditional navigable water
- potential of wetlands to trap and filter pollutants or store flood waters
- maintenance of water quality in traditional navigable waters

It is anticipated that the drainage features in the project area will not be found to have a significant nexus with a downstream TNW, and thus, the Corps will determine that there are no waters of the U.S. in the project area. Review and processing times may vary depending on the Corps Project Managers’ work load and other factors, but would be expected within 4 to 6 months.

3.1.2. SECTION 404 PERMIT

Because it is not expected that the Corps will identify waters of the U.S. in the project area, a Section 404 permit is not anticipated.

3.2. ENDANGERED SPECIES ACT

The purpose of the Endangered Species Act (ESA) is to protect and recover imperiled species and the ecosystems upon which they depend. The ESA makes it unlawful for a person to take a listed animal without a permit. Take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.” Through regulations, the term “harm” is defined as “an act which actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.” Listed plants are not protected from take, although it is illegal to collect or maliciously harm them on Federal land.

Information on threatened and endangered species and designated critical habitat can be obtained from the U.S. Fish and Wildlife Service (FWS) website at http://www.fws.gov/ipac.

Section 7(a)(2) of the ESA requires cooperation and consultation with the FWS to ensure that federal actions are not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. Without a nexus to another federal permit, compliance with Section

7 of the ESA is not needed for this project. However, HILGARTWILSON conducted the ESA screening analysis and is summarized in a memo included as Attachment 1. The analysis found no potentials for occurrence of any endangered species other than the Jaguar which was deemed unlikely to occur near the Project.

3.3. ARIZONA WATER PROTECTION FUND

3.3.1. ARIZONA HISTORIC PRESERVATION ACT

Pursuant to the *Arizona Water Protection Fund* (AWPF) *Commission Grant Application Manual* (AWPF 2015),

> …it is understood that recipients of state funds are required to comply with [the Arizona Historic Preservation Act (AHPA)] throughout the project period. All projects that affect the ground-surface that are funded by AWPF require [State Historic Preservation Officer] SHPO clearance, including those on private and federal lands.
>
> The State Historic Preservation Office (SHPO) must review each grant application recommended for funding in order to determine the effect, if any, a proposed project may have on archaeological or cultural resources.

The AHPA (Arizona Revised Statutes [ARS] 41-861 *et seq.)* provides that the SHPO review and comment on plans which involve property eligible for listing on the Arizona register of historic places. The AWPF project must include measures coordinated with the SHPO to ensure that the prehistorical, historical, architectural or culturally significant values will be preserved or enhanced.[1] A Class III archaeological survey is currently being conducted and is not expected to yield any significant findings based on previous surveys.

3.4. ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY/ ARIZONA POLLUTANT DISCHARGE ELIMINATION SYSTEM GENERAL PERMIT

The Arizona Department of Environmental Quality (ADEQ) has primacy to administer the Arizona Pollutant Discharge Elimination System (AZPDES) Permit program pursuant to Section 402 of the CWA. Under this program, facilities with the potential to discharge pollutants are required to obtain coverage under an AZPDES permit. A Construction General Permit (CGP) is available for construction activities, which would likely apply to the construction of the impoundment structure.

To obtain authorization for discharges of stormwater associated with construction activity, the applicant must comply with the requirements of the CGP and submit a Notice of Intent (NOI). A Stormwater Pollution Prevention Plan (SWPPP) would be required to be maintained on the project site during construction. The SWPPP would identify best management practices, such as erosion control measures (waddles, straw bales, etc.) to prevent stormwater pollution.

[1] As with Section 7 of the ESA, without a nexus to another federal permit, compliance with Section 106 of the National Historic Preservation Act (NHPA) is not required for this Project.

3.5. COCHISE COUNTY

The following sections discuss the permitting required to construct the proposed Project within Cochise County (the County). Review and processing times may vary but will take a minimum of 4-weeks per permit application.

3.5.1. FLOODPLAIN USE PERMIT

A Floodplain Use Permit is required prior to building, grading, filling, or installing a structure within the floodplain. The Floodplain Use Permit would be issued by the Cochise County (County) Flood Control District. A completed form found on the County's website will need to be signed and submitted with pertinent project information.

3.5.2. BUILDING/USE PERMIT

A Building/Use Permit is required to erect, construct, reconstruct, alter or use any structure in the County disturbing one acre of land or more. A Building/Use Permit by contacting the Cochise County Planning and Zoning Department.

3.5.3. CLEARING PERMIT

A Clearing Permit is required if the proposed clearing is in conjunction with construction, structures, or improvements. Information regarding dust and erosion control measures, area to be cleared, and acreage must be included. A completed signed form found on the County's website will need to be submitted with pertinent project information and should be submitted with the Building/Use Permit.

4. CONCLUSION

This report summarizes the permits and compliance that is anticipated for the Project. The identified permits would need to be approved prior to construction activities.

5. REFERENCES

AWFP, 2015. *Arizona Water Protection Fund Commission Grant Application Manual.* (http://www.azwpf.gov/Pubs/documents/FY2015GrantApplicationManualFINAL.pdf)

HILGARTWILSON, 2015a. *Horseshoe Draw Flood Control, Restoration and Erosion Mitigation Study and Design Project, Volume 1, Existing Conditions Hydrologic Study.* May 2015. Phoenix, Arizona.

HILGARTWILSON, 2015b. *Horseshoe Draw Flood Control, Restoration and Erosion Mitigation Study and Design Project, Volume 2, Existing Conditions Hydraulic Report.* October 2015. Phoenix, Arizona.

HILGARTWILSON, 2015c. *Horseshoe Draw Flood Control, Restoration and Erosion Mitigation Study and Design Project, Volume 3, Existing Conditions Sediment Transport Report.* November 2015. Phoenix, Arizona.

HILGARTWILSON, 2015d. *Horseshoe Draw Flood Control, Restoration and Erosion Mitigation Study and Design Project, Volume 4, Existing Conditions Recharge Potential Analysis.* December 2015. Phoenix, Arizona.

HILGARTWILSON, 2016a. *Horseshoe Draw Flood Control, Restoration and Erosion Mitigation Study and Design Project, Volume 5, Remedial Design Alternatives Feasibility Study.* January 2016. Phoenix, Arizona.

HILGARTWILSON, 2016b. *Horseshoe Draw Flood Control, Restoration and Erosion Mitigation Study and Design Project, Volume 6, Final Design Report.* March 2016. Phoenix, Arizona.

USACE, 2012. *2012 Nationwide Permits, Conditions, District Engineer's Decision, Further Information, and Definitions (with corrections).* September 12, 2012.

ATTACHEMENT 1

ENDANGERED SPECIES SCREENING ANALYSIS

TECHNICAL MEMORANDUM

Date: June 21st, 2016

RE: Horseshoe Draw Endangered Species Screening Analysis

Project No.: 1472

Introduction and Background

HILGARTWILSON, LLC (HW) conducted the following screening analysis for endangered species, pursuant to Section 7 of the Endangered Species Act for the Horseshoe Draw project area (Project Area).

The project area encompasses the headwaters of Horseshoe Draw, a tributary to the upper San Pedro River in Cochise County, southeast of Palominas, Arizona. The project area is characterized by a broad alluvial plain of desert scrub and semi-desert grassland, dissected by headcutting of the Horseshow Draw tributary. Vegetation on the project area includes mesquite (*Prosopis* spp.), tarbush (*Flourensia cernua*), sacaton (*Sporobolus* spp.), seep willow, (*Baccharis salicifolia*), desert broom (*Baccharis sarothroides*), desert hackberry (*Celtis pallida*), and desert willow (*Chilopsis linearis*). There are no special aquatic habitats or riparian areas.

Screening Analysis for Federally Listed Species

Species Identification—HW conducted an official query of the U.S. Fish and Wildlife Service Information (USFWS) for Planning and Conservation (IPaC) online database to identify federally listed species that have the potential to occur within the project area (Table 1). Species range and habitat data was obtained from information provided by the USFWS and the Arizona Game and Fish Department (AGFD) Heritage Database Management System (HDMS). Natural history for each of these species was reviewed to determine habitat and life history requirements and to assess potential habitat on the project area.

Habitat Assessment—Background research information, previous studies, site photography, and maps depicting the ecoregion were used to characterize the habitat features and vegetation communities that occur in the project area and vicinity. This information was used to evaluate the project area's potential to support federally listed species identified by the IPaC.

Potential for Occurrence—Results from the species identification and habitat assessment described above were used to facilitate the screening analysis and determine the potential for federally listed species to occur on or near the project area. Individual species were eliminated from detailed evaluation if the project area occurred outside their known range or if habitat requirements were not present at or near the project area. In addition, the presence or absence of proposed or designated critical habitat was reviewed for the federally listed species. The potential for each species to occur within or near the project area was then evaluated and designated one of the following four categories:

Known to occur—The species is documented to occur in the project area or vicinity.

May occur—The project area is within the species' currently known range or distribution, and vegetation communities, habitat, soils, or other biotic and abiotic indicators resemble those known to support the lifecycle and/or natural history requirements of the species.

Unlikely to occur—The project area is within the species' currently known range or distribution, but vegetation communities, soils, and other biotic and abiotic indicators do not resemble those known to support the lifecycle and/or natural history requirements of the species.

Does not occur—The project area is not within the species' known range or distribution and other biotic and abiotic indicators do not resemble those known to support the lifecycle and/or natural history requirements of the species.

Table 1 provides the list of federally listed species identified in the IPaC, and their potential for occurrence. There are no critical habitats in the project area.

Table 1 – Screening Analysis for Federally Listed Species in the Project Area

Common Name (*Species Name*)	**Status***	**Habitat Requirements**	**Potential for Occurrence in Project Area**
Amphibians			
Arizona Treefrog (*Hyla wrightorum*)	C	**Range:** The species range spans from near Williams, Arizona, southeast along Mogollon Rim into mountains of western New Mexico. Treefrog populations also are found in the Sierra Ancha Mountains of central Arizona, the Huachuca Mountains and Canelo Hills of southeastern Arizona, and the Sierra Madre Occidental of northern Mexico. **Habitat:** Habitat includes streams, ponds, cienegas and wet meadows in oak, pine and fir forests. Frogs can be found in shallow pools, on damp ground in monsoon rains. Elevation: Above 5,000 feet	**Does not occur.** The project area is too low in elevation, and does not have any suitable habitat of conifer forests or riparian areas.

Common Name (*Species Name*)	Status*	Habitat Requirements	Potential for Occurrence in Project Area
Chiricahua leopard frog (*Lithobates chiricahuensis)*	T	**Range:** U.S. range includes west-central and southwestern New Mexico, and central and southeastern Arizona. Critical habitat is designated for 10,346 acres in Apache, Cochise, Gila, Graham, Greenlee, Pima, Santa Cruz, and Yavapai counties in Arizona. **Habitat:** Habitat includes ponds, tanks, cienegas (wet meadows), and small streams that provide permanent water. Habitats with a variety of plants, depths, in-water structure, and other complexities are desired. Currently restricted to springs, livestock tanks, and streams in upper portion of watersheds with few non-native predators. **Elevation:** 3,200-8,900 feet	**Does not occur**. No suitable riparian habitat in the project area.
Birds			
Mexican Spotted owl (*Strix occidentalis lucida*)	T	**Range.** The Mexican spotted owl occurs in isolated areas in forested mountains and canyon lands in the U.S. Southwest and Mexico. Within the U.S., its range includes portions of the states of Utah, Colorado, New Mexico, and west Texas. **Habitat**: Most common in mature to old-growth mixed-conifer forests dominated by Douglas fir and or white fir and forested canyons. They also occur in ponderosa pine-Gambel oak habitats, typically where the understory vegetation is well developed; nesting and roosting habitat within closed canopy forest or rocky canyons. **Elevation**: 5,820 to 9,100 feet (Meyer 2007; USFWS 2012).	**Does not occur**. No suitable nesting or roosting forest habitat exists in the project area.

Common Name (*Species Name*)	Status*	Habitat Requirements	Potential for Occurrence in Project Area
Northern aplomado falcon (*Falco femoralis septentrionalis*)	EXPN	**Range**: Species ranges from southwestern United States through Mexico and Central America to Argentina and Chile. Currently very rare in the United States and extremely uncommon in northern Mexico. Prior to 1890, a fairly common summer or permanent resident in southweatern AZ, then virtually extirpated from the state, and there have been only two credible sightings in AZ since 1910. Under Section 10(j) of the endangered species Act, reintroduction of these birds has begun in Texas and New Mexico. The Nonessential/Experimental range includes southeastern Arizona. The State of Arizona is supportive of having falcons re-established, but does not wish to conduct reintroductions, and thus far, no individuals or breeding pairs have established in Arizona. **Habitat**: In the U.S., this species prefers open Chihuahuan Desert grassland areas with relatively low ground cover and scattered trees suitable for nesting platforms. Habitat suitability declines rapidly with an increase in woody vegetation. **Elevation**: 3,500-9,000 feet	**Does not occur**. No individuals or breeding pairs of this species have established in Arizona.
Southwestern Willow flycatcher (*Empidonax traillii extimus*)	E	**Range**: A neotropical migrant that winters in Mexico and Central America. Known to breed throughout the southwest United States. The species breeds locally along Colorado River in Grand Canyon and Little Colorado River headwaters, very locally along the middle Gila, Salt, and Verde rivers; middle to lower San Pedro River; and upper San Francisco River near Alpine. **Habitat**: The species occurs in dense riparian habitats along streams, rivers, and other wetlands where cottonwood, willow, boxelder, tamarisk, Russian olive, buttonbush, and arrowweed are present. Nests are found in thickets of trees and shrubs that are primarily 13 to 23 feet tall, among dense, homogeneous foliage. The species prefers dense canopy cover, a large volume of foliage, and surface water during midsummer. **Elevation**: 75–9,180 feet in AZ	**Does not occur**. Vegetation found within the project area has none of the documented and required habitat elements for this species. Lack of suitable riparian habitat necessary for breeding and foraging.

Common Name (*Species Name*)	Status*	Habitat Requirements	Potential for Occurrence in Project Area
Yellow-Billed Cuckoo (*Coccyzus americanus*)	T	**Range:** The Yellow-billed cuckoo ranges from Canada to South America, and may be found in southern, central, and northeastern Arizona. The highest concentrations in Arizona are along the Agua Fria, San Pedro, upper Santa Cruz, and Verde river drainages, and Cienega and Sonoita creeks. **Habitat:** The species prefers habitats of streamside cottonwood, willow groves, and mesquite bosques for migrating and breeding. Dense understory foliage appears to be an important factor in nest site selection. **Elevation:** 90 to 6,710 feet in AZ	**Does not occur.** Vegetation found within the project area has none of the documented and required habitat elements for this species. Lack of suitable riparian habitat necessary for breeding and foraging
Flowering Plants			
Huachuca water-umbel (*Lilaeopsis schaffneriana var. recurva*)	E	**Range:** The species' range includes southwestern New Mexico to southeastern Arizona and adjacent Sonora, Mexico. Within Arizona, disjunct populations are located in Cochise and Santa Cruz counties in the Huachuca Mountains, San Pedro area, and San Bernardino Valley/Black Draw, and in Santa Cruz County in the Canelo Hills/Turkey Creek, Sonoita Creek and San Rafael Valley. **Habitat:** Cienegas or marshy wetlands in Sonoran desertscrub, grassland or oak woodland, and conifer forest. The species requires perennial water with gentle stream gradients. **Elevation:** 2,000 to 6,000 feet	**Does not occur.** No suitable riparian habitat in the project area.
Wright's Marsh thistle (*Cirsium wrightii*)	C	**Range:** Currently occurs in New Mexico; however, it has been extirpated from all previously known locations in Arizona. Historically from San Bernardino Cienega on what is now the U.S. Fish and Wildlife Service, San Bernardino National Wildlife Refuge, Cochise County. **Habitat:** Wet, alkaline soils in spring seeps, cienegas, and marshy edges of streams and ponds, in otherwise semi-arid to arid areas. **Elevation:** 3,450 - 8,500 feet	**Does not occur.** The species is considered to be extirpated from AZ, and no suitable riparian habitat in the project area.

Common Name (*Species Name*)	Status*	Habitat Requirements	Potential for Occurrence in Project Area
Mammals			
Jaguar (*Panthera onca*)	E	**Range.** Historically, the jaguar's range extended from southern Brazil and Argentina north through South and Central America, then along the coasts and the western mountains of Mexico into the southwestern United States as far north as the Grand Canyon (AGFD 2013). Isolated jaguars have been reported in southeastern Arizona, and these sightings led to the designation of critical habitat for the species in Pima, Santa Cruz, and Cochise counties in Arizona (79 FR 12571). **Habitat.** In Arizona and New Mexico, jaguars are known to have occurred in habitats ranging from desert grassland to montane-conifer forest. Their movement corridors in the American Southwest and northern Mexico are not well known but probably include a variety of upland habitats that connect some of the isolated, rugged mountains, foothills, and ridges in this region.	**Unlikely to occur.** Isolated jaguars have been reported in southeastern Arizona; these jaguars are considered to be part of populations in Mexico.
Lesser Long-Nosed bat (*Leptonycteris curasoae yerbabuenae*)	E	**Range:** Migrates from central Mexico and arrives in Arizona, New Mexico, and adjoining portions of Sonora, Mexico in April. Move from the southwestern part of the state to the southeastern part over the summer, and returns to central Mexico by September. **Habitat**: Requires caves and mines for roost sites (maternity, male-only, late-summer, and night roosts are used differently) and access to healthy stands of saguaro cactus and paniculate agaves for foraging. **Elevation**: <3,500 feet but may range up to 7,320 feet	**Does not occur.** No suitable roosting or foraging habitat in project vicinity.
Ocelot (*Leopardus (=felis) pardalis*)	E	**Range:** Southern Texas and southern Arizona, through Central and South America into northern Argentina and Uruguay. Listed endangered throughout its range in the western hemisphere. Habitat: Species prefers dense cover or vegetation of forests or thorscrub with high prey populations and generally avoid open areas. Elevation: below 4,000 feet	**Does not occur.** The species is very rare in Arizona, and the project area does not have any dense, forested habitat.

Common Name (*Species Name*)	Status*	Habitat Requirements	Potential for Occurrence in Project Area
Reptiles			
Northern Mexican gartersnake (*Thamnophis eques megalops*)	T	**Range:** Current range includes fragmented populations within the middle and upper Verde River drainage, middle and lower Tonto Creek, and the upper Santa Cruz River, as well as in a small number of isolated wetland habitats in southeastern Arizona. Status in New Mexico is uncertain; however, it is likely extirpated. **Habitat**: Strongly associated with permanent water with vegetation, including stock tanks, ponds, lakes, cienegas, cienegas, streams, and riparian woods. In New Mexico, this snake is known from the lower Gila River basin, along Duck and Mule creeks in Grant County. **Elevation**: 3,000-5,000 feet; up to 8,500 feet.	**Does not occur**. No suitable riparian habitat exists in the project area.

*USFWS Status Definitions:

E = Endangered. The ESA specifically prohibits the take of a species listed as endangered. Take is defined by the ESA as: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to engage in any such conduct.

T = Threatened. The ESA specifically prohibits the take of a species listed as threatened. Take is defined by the ESA as: to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to engage in any such conduct.

PT = Proposed Threatened. Species in this category are currently in the process of being listed as threatened species under the ESA. Due to the pending uplisting, these species are treated as though listed as threatened.

C = Candidate. Candidate species are those for which USFWS has sufficient information on biological vulnerability and threats to support proposals to list as endangered or threatened under the ESA. However, proposed rules have not yet been issued because they are precluded by other listing activity that is a higher priority. This listing category has no legal protection, but some federal agencies have developed guidelines and measures to reduce impacts to candidate species.

EXPN = Experimental Non-essential Population. A species listed as experimental and non-essential. Experimental, nonessential populations of endangered species are treated as threatened species on public land for consultation purposes and as species proposed for listing on private land.