



Preliminary Hydrologic and
Hydraulic Analyses
Arkansas River Low Water Dams

Prepared by:
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**PRELIMINARY
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INTRODUCTION

The Arkansas River begins near Leadville, Colorado and flows generally southeast to its confluence with the Mississippi River near Greenville, Mississippi. The Arkansas River drains approximately 75,700 square miles upstream of the Tulsa, Oklahoma vicinity, of which nearly 50,000 square miles actually contribute to flows at Tulsa. The basin upstream of Tulsa is about 650 miles long and averages 150 miles wide. An overview of the Arkansas River basin above Tulsa is illustrated in Figure 1.

The Arkansas River Corridor Master Plan study includes the hydraulic analyses of the impacts of 4 proposed low water dams on the Arkansas River at Sand Springs, Updated Zink, Jenks and Bixby, Oklahoma. The portion of the Arkansas River covered in this study includes approximately 41 river miles and flows through 3 counties. A map of the Arkansas River Corridor Master Plan study area is shown in Figure 2.

The purpose of this project was to further analyze three of the proposed low water dams. The Zink location was previously analyzed in greater detail during a 2009 study. This project brought the other three locations (Sand Springs, South Tulsa/Jenks, and Bixby) up to the general design level as the Zink structure. The hydraulic analysis for the structures was updated with detailed topography around the dams as well as a more refined gate layout for the dams. The locations of the proposed and existing low water dams are shown in Figure 3.

GENERAL

Bixby Low Water Dam

The Bixby Low Water Dam would be located about 4,000 feet downstream of the Memorial Drive Bridge on the Arkansas River in south Tulsa County. At the proposed dam location, the river width is approximately 2,100-ft and the total dam length is approximately 2,530 ft. The main dam is anticipated to be a concrete gravity dam with a crest elevation of 583.5 ft. For conditions of “no flow” on the Arkansas River, the water surface will be ponded upstream of the dam to elevation 583.0 ft. Two arching spillways will be placed near each bank of the river, with a radius of 88-ft and crest elevation of 583.0 ft. Additionally, six 50-ft wide x 4-ft high Obermeyer pneumatic bladder gates will be placed along the dam with crest elevation of 583.0 ft. and bottom sill elevation of 579.0 ft.



FIGURE 1. ARKANSAS RIVER WATERSHED ABOVE STUDY AREA

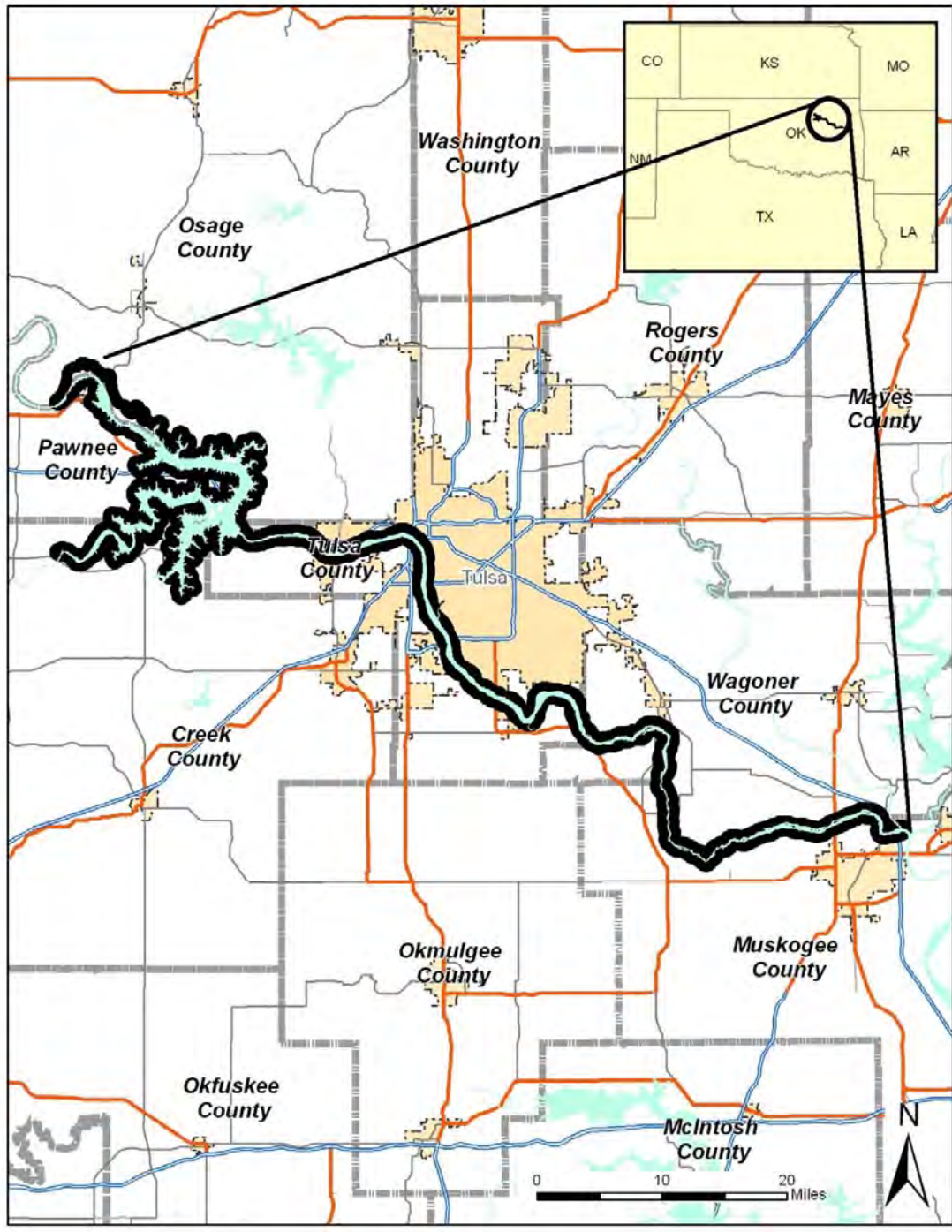


FIGURE 2. ARKANSAS RIVER CORRIDOR MASTER PLAN STUDY AREA



Figure 3. PROPOSED LOW WATER DAM LOCATIONS

South Tulsa/Jenks Low Water Dam

The proposed low water dam at South Tulsa/Jenks would have a permanent pool at elevation 597.0 and would inundate an area of about 502 acres. The static pool would be nearly 4 miles long and would average 4-6 feet in depth. The low water dam will also have a pedestrian bridge that will span from bank to bank. This structure is modeled as a bridge just downstream of the low water dam. In addition to the low water dam, a seawall is shown in the model on the west bank. This wall is elevated to the elevation produced by the 1986 Flood flowrate.

Zink Low Water Dam

The existing Zink low water dam is used in the existing model with updated cross sections from the previous study that more accurately reflects the channel and floodplain geometry in the vicinity of the Zink Dam project. The same proposed model is used from the previous study “Meshek Zink Narrative Nov 12 2012”. Due to the current changes that are happening with the Gathering Place construction, this proposed structure will need to be modified during final design to reflect the final grading in the area.

Sand Springs Low Water Dam

The proposed Sand Springs low water dam will have a crest elevation of 638. This location would also act as a re-regulation dam during times when there is no generation flows from Keystone Dam. The pool would be allowed to drop to an elevation of 635 through a controlled release of a minimum flow during those times. At elevation 638.0, the static pool would cover an area of close to 1,420 acres, would be about 8.7 miles long, and would average 4-7 feet in depth. In addition to the low water dam, a pedestrian bridge is also proposed above the dam spanning the river and providing pedestrian access to both banks.

DESIGN FLOWS/HYDROLOGY

Overall Hydrology

The existing FEMA flows developed for the current effective DFIRMs, as well as other pertinent flows, were used in this analysis. Those flows include:

	Arkansas River Flow (cfs)
One Hydropower Unit Operating	6,000
Two Hydropower Units Operating	12,000
10% Chance (10-yr) flood	90,000
2% Chance (50-yr) flood	155,000
1% Chance (100-yr) flood	205,000
October 1986 flood event	300,000
USACE Levee Design Flood	350,000
0.2% Chance (500-yr) flood	490,000

HYDRAULIC ANALYSES

HEC-RAS version 4.1.0 was used to determine the backwater elevations and velocities for all hydraulic modeling. The flow regime is generally subcritical, except where flows will be flowing over the weir sections.

The Arkansas River is fairly uniform through the study area. The channel banks have some brush and vegetation, while the channel bottom is mainly sand.

The Arkansas River was previously studied by the US Army Corps of Engineers (Tulsa District) in 2002 as part of the Tulsa County Flood Study. The HEC-RAS model used in that analysis was also used in this study, with certain modifications. Cross sections used in this study within the Tulsa City limits are based on 2010 topographic information produced for the City of Tulsa. Also, additional cross sections were added in the vicinity and just upstream of the proposed low water dams to more accurately reflect proposed conditions versus existing conditions. The channel and bank portions of the cross sections in the immediate vicinity of the proposed low water dam are based on new topographic surveys conducted by Meshek & Associates, PLC. Generally, Manning's roughness "n" values used in the 2002 study were used in this analysis, except for some minor changes around the proposed low water dam locations.

Existing Corrected Effective Model

The effective model for the area is the USACE's 2002 Arkansas River HEC-RAS model. This model was modified to create a corrected effective model. The changes included updating the cross sections to reflect the 2010 topography as well as the new detail topography at each of the proposed dam locations. Also additional cross sections were added in the vicinity of the low water dams. Minor modifications to the Manning's n-values were made around the work areas.

Proposed Model

The corrected effective model has been modified to include a more detailed design of each dam location as well as a refined gate layout. The dams include a stair-stepped anti-roller section downstream of the weir. Also for two of the locations, a pedestrian bridge was input just downstream of the weir.

Bixby Low Water Dam

The Bixby structure is the furthest downstream low water dam. The location of the structure is approximately 4200 feet downstream of Highway 64 (Memorial Drive) and just upstream of an old Fry Creek Tributary channel remnant.

The sill elevation of the proposed structure is set at an elevation of 679. The existing location at two deeper channels on the north and south banks of the river with a fairly high sand bar that covers most of the middle section of the river. The curved fixed weir sections are located at each end of the dam. The six 50-foot x 4-foot gates are equally spaced between the curvilinear weirs.

Additional channel excavation and bank shaping was included in the modeling as well. This removed some of the downstream sand bars, providing additional conveyance areas. The proposed grading areas are shown on Figure 4.

Figure 6 shows the proposed gates and fixed height dam layout. Table 1 shows the results of the backwater analyses for the proposed conditions in comparison to the existing conditions. The no-rise criteria is met at this location with the proposed structure in place.

The Bixby Low Water Dam is in the model output located in Appendix A as an inline structure at Cross Section 263777.

TABLE 1

Bixby Dam Model Analysis at Cross Section 263812

	1% Chance (100-year) 205,000 cfs	0.2% Chance (500-year) 490,000 cfs	USACE Levee Design 350,000 cfs
Existing	600.04	607.14	604.87
Proposed	599.82	606.94	604.66

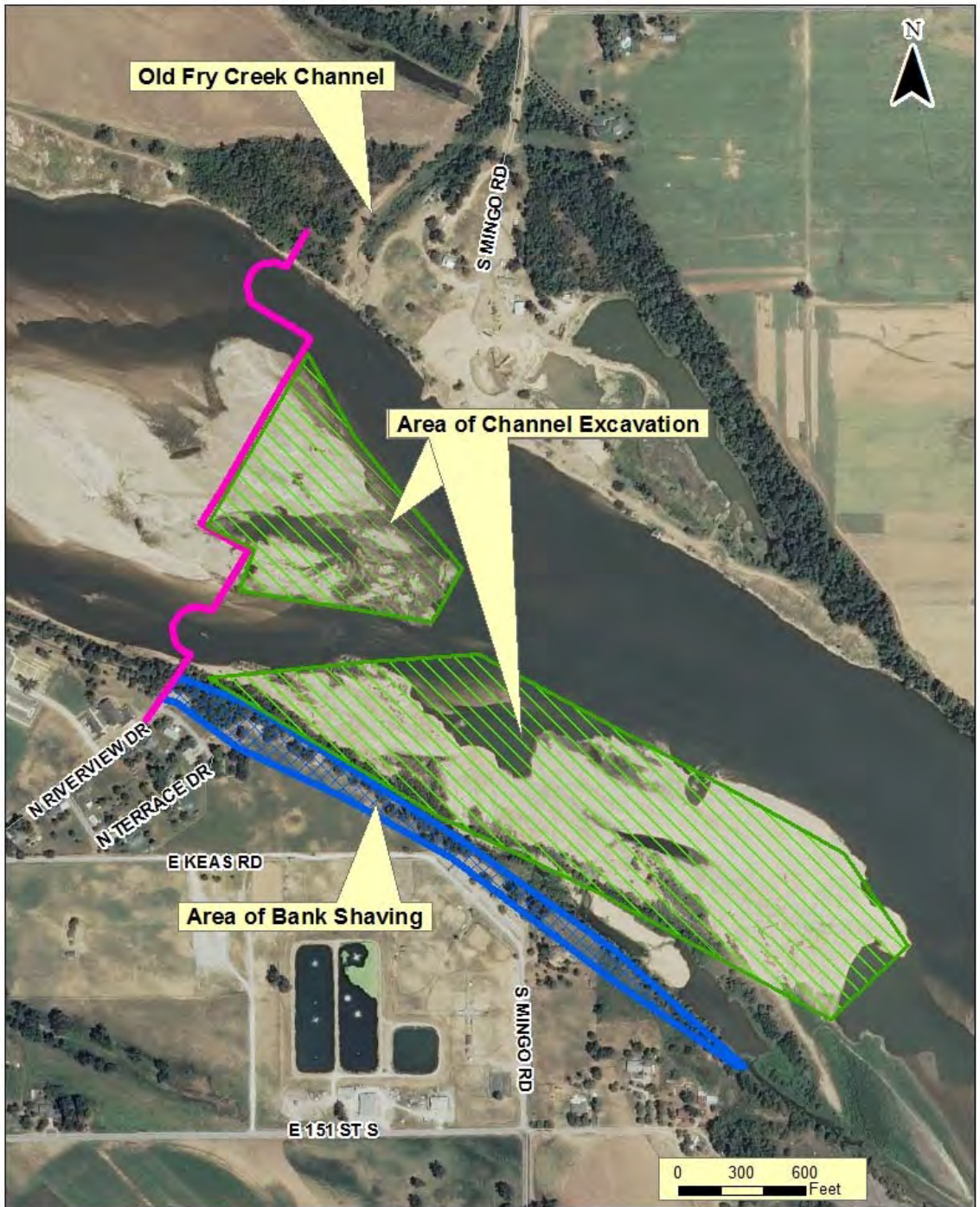


FIGURE 4. BIXBY LOW WATER DAM CHANNEL EXCAVATION AND BANK SHAVING



Figure 5. BIXBY LOW WATER DAM POOL INUNDATION LOCATION

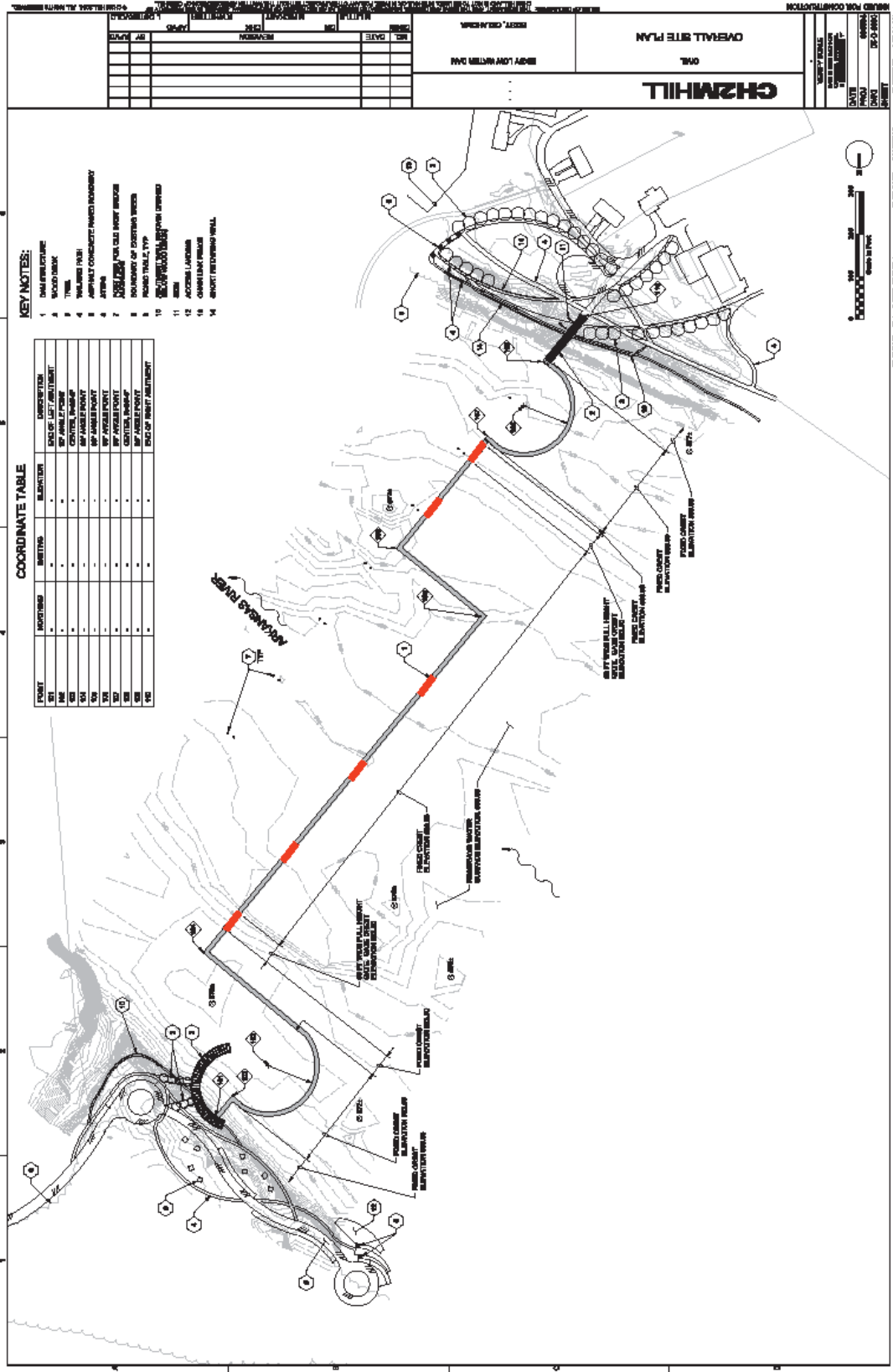


Figure 6. BIXBY GATE LAYOUT

South Tulsa/Jenks Low Water Dam

The proposed South Tulsa/Jenks low water dam is located 2,060 feet downstream of the Creek Turnpike. The gate layout is a mixture of 7 foot gates to regulate higher flows and 3 foot gates to regulate the pool elevation. The sill elevation is at 590 with 504 feet of 7 foot gates controlling high flows and 720 feet of 3 foot high crest gates to control the pool elevation at 534 feet long at an elevation of 594. The piers between the gates will have 4 foot width and the pedestrian bridge will have 2.5 foot round piers. The pedestrian bridge is set at above the levee design flow of 350,000 cfs and will span from bank to bank in 100 feet span increments and will be connected to the ground at the end of the span location. The cross sections downstream of the dam and under the pedestrian bridge are adjusted to match the roller design.

Additionally with the dam location, the proposed River District development location has been included into the modeling as a blocked obstruction in the location for future development shown in Figure 7.

Figure 7 shows the proposed location and with the future development location. Table 2 shows the results of the backwater analyses for the proposed conditions in comparison to the existing conditions. The no-rise criteria has not been met and appears to be localized and the final design will attempt to remove any rise in the location.

The South Tulsa/Jenks low water dam is in the model output located in Appendix A as an inline structure at Cross Section 297136.

TABLE 2

South Tulsa/Jenks Dam Model Analysis at Cross Section Station 297137

	1% Chance (100-year) 205,000 cfs	0.2% Chance (500-year) 490,000 cfs	USACE Levee Design 350,000 cfs
Existing	611.29	621.23	617.38
Proposed	611.62	621.70	617.76

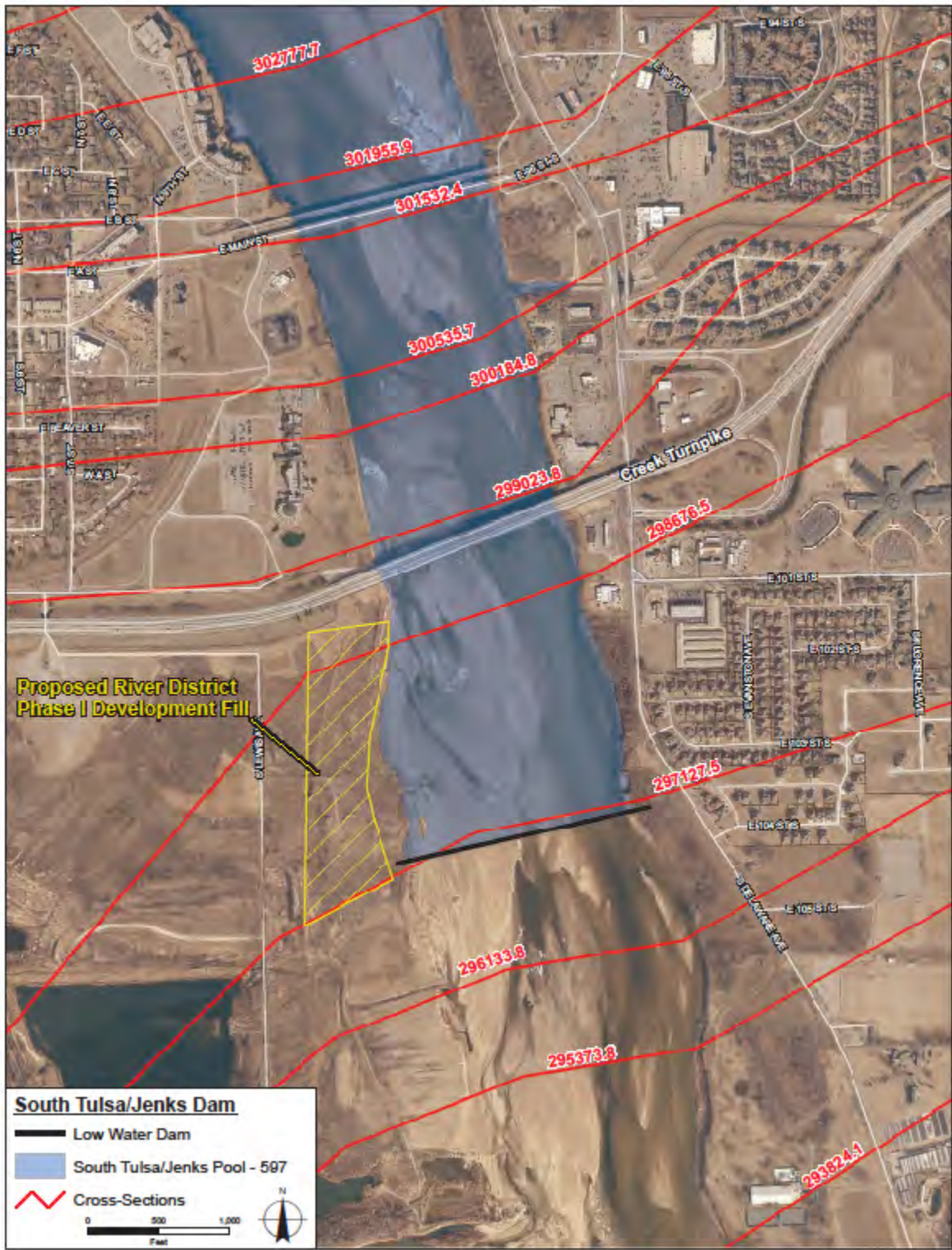


Figure 7. SOUTH TULSA/JENKS LOW WATER DAM AND DEVELOPMENT LOCATION

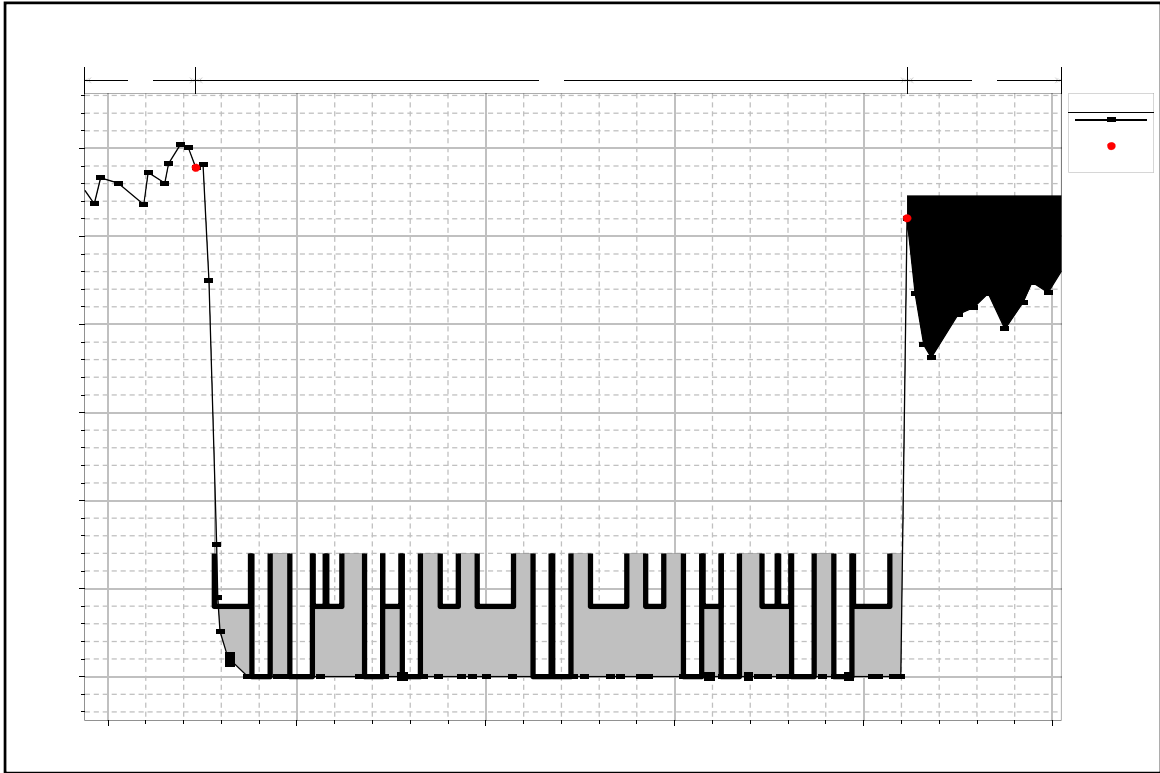


Figure 8. SOUTH TULSA/ JENKS GATE LAYOUT LOOKING DOWNSTREAM

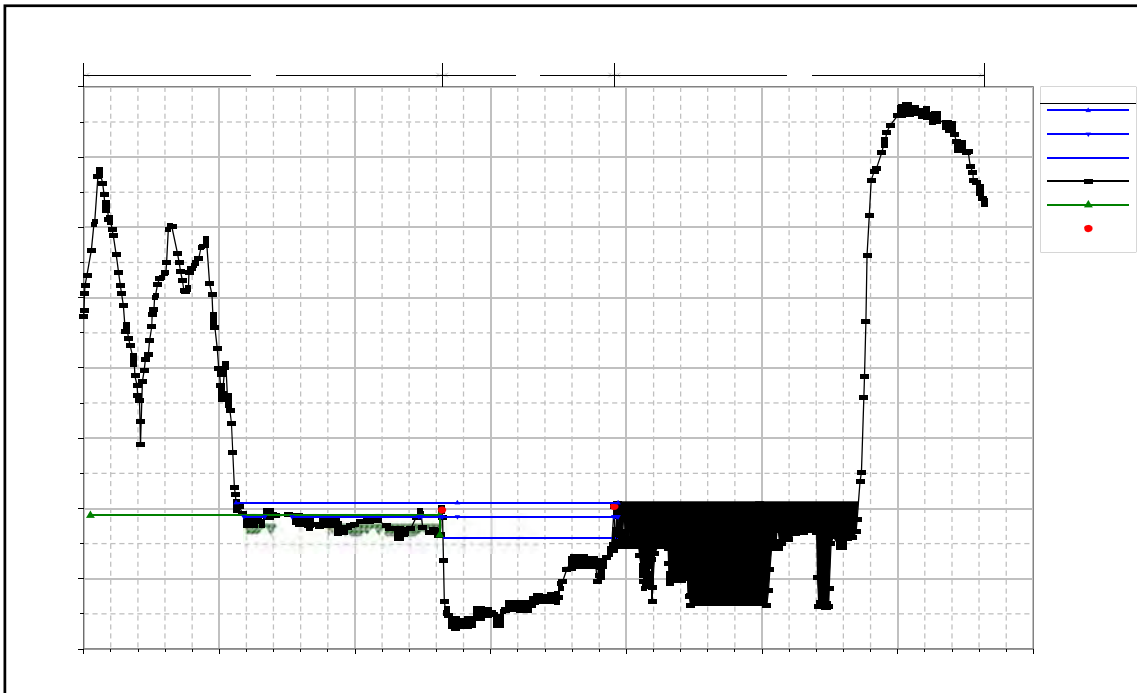


Figure 9. RIVER DISTRICT DEVELOPMENT AT CROSS SECTION 297087



Figure 10. SOUTH TULSA/JENKS POOL INUNDATION MAP

Zink Low Water Dam

In 2012, the preliminary design (PD) was completed for the Zink Dam and recreational flume project. The design details and project description are not repeated in this document. However, several modifications will be required to the initial design as a result of modifications to the east bank area that are being made as part of the Gathering Place project. These modifications include the creation of a “bench” area along the east bank that provides for flume access and safety. As a result, the island will need to be moved further away from the bank to provide space for the actual flume. This will also result in moving one of the big water gates and adding another 16-foot-length of full-height gate to compensate for the loss of three crest gate sections.

The proposed Pool inundation is shown on Figure 11. The Zink low water dam is in the model output located in Appendix A as an inline structure at Cross Section 339449.



Figure 11. ZINK POOL INUNDATION MAP

Sand Springs Low Water Dam

The proposed Sand Springs low water dam has a gate layout of a mixture of 10 foot gates to regulate higher flows and 3 foot gates to regulate the pool elevation. The sill elevation is at 628 feet with the top of all gates at 638 feet and the fixed crest elevation at 638.5 feet. The total dam length is 1900 feet long. The full gates will have a distance of 608 feet, the crest gates have 704 feet and the fixed crest will have 588 feet. The piers between the gates will have a 4 foot width and the pedestrian bridge will have 2.5 foot round piers. The pedestrian bridge is set at the levee design flow of 350,000 cfs and will have 100 foot spans between each pier and span 100 feet past each bank to connect to the ground. The cross sections downstream of the dam will mimic the anti-roller sections.

The proposed dam does have an increase in the 100 year storm event. Several alternatives were analyzed to try to reduce or eliminate the increased water surface. Several different gate configurations were used, as well as additional grading on the banks and channel. However, these changes did not produce much change in the proposed water surface. Some bank excavation on the north bank is included in the final scenario shown in figure 13. The excavation includes the lower tiered bank on the north for approximately 200 feet downstream of the dam. Table 3 shows the results of the current analysis.

The Sand Springs low water dam is in the model output located in Appendix A as an inline structure at Cross Section 382868.

TABLE 3
Sand Springs Dam Model Analysis at Cross Section Station 382868

	1% Chance (100-year) 205,000 cfs	0.2% Chance (500-year) 490,000 cfs	USACE Levee Design 350,000 cfs
Existing	649.02	662.85	657.36
Proposed	649.15	663.13	657.43

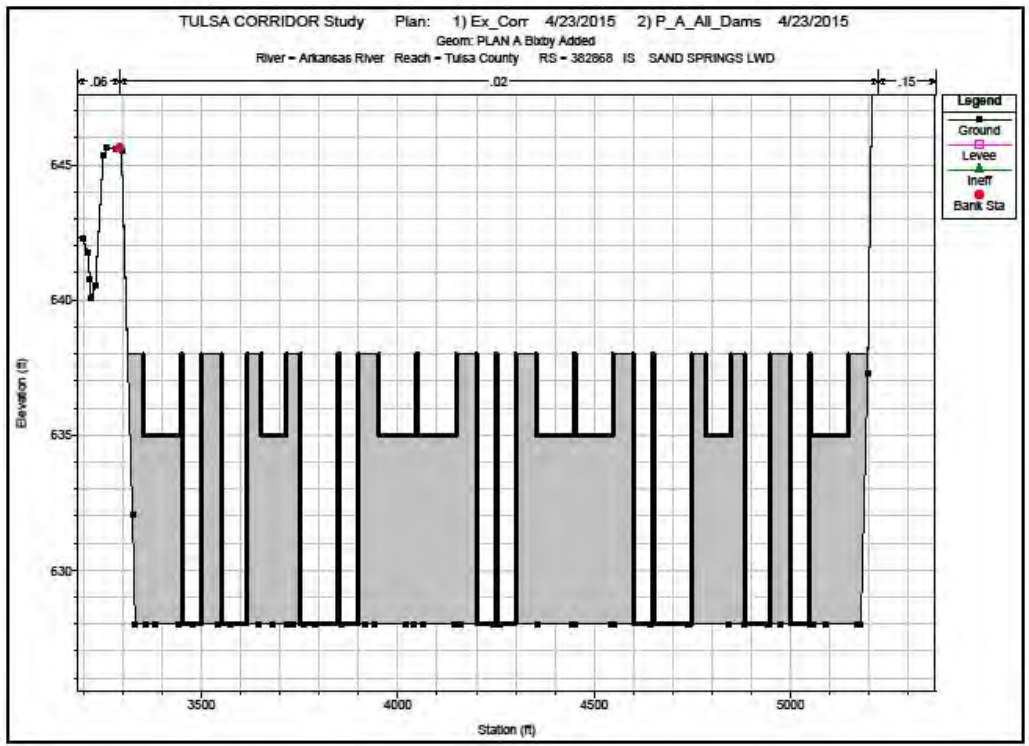


Figure 12. SAND SPRINGS GATE LAYOUT LOOKING DOWNSTREAM

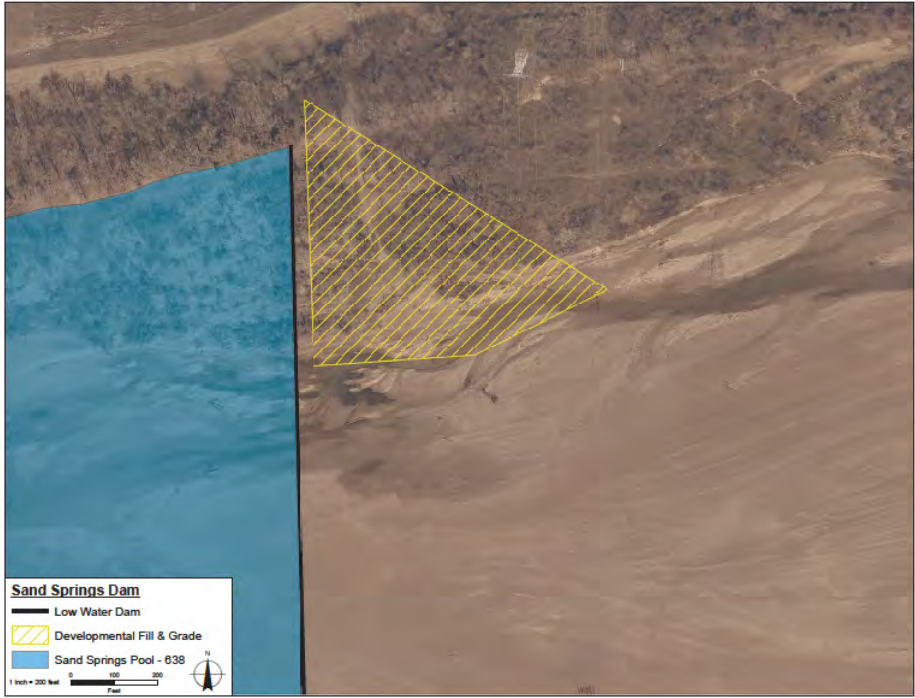


Figure 13. SAND SPRINGS GRADING PLAN

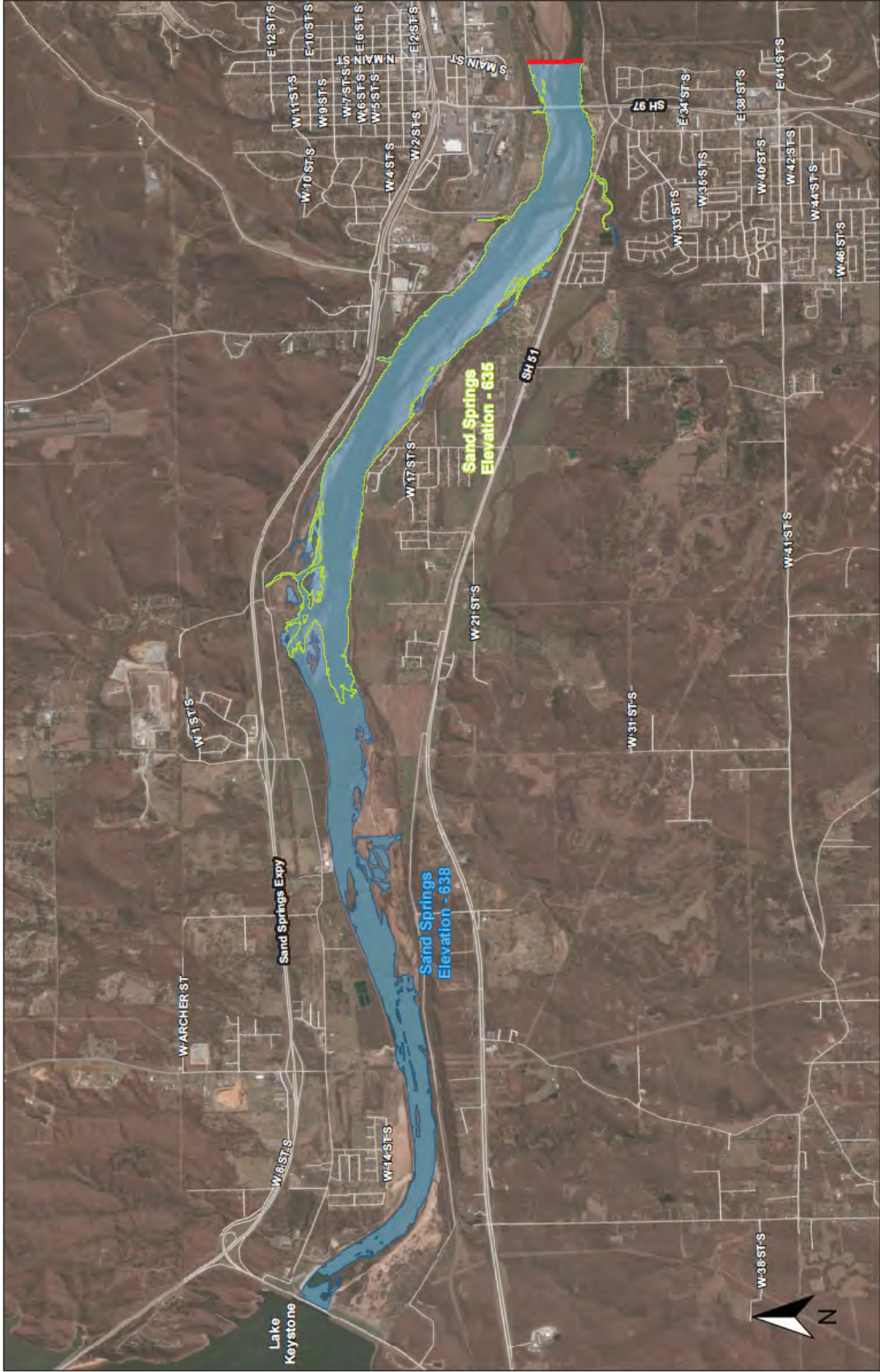


Figure 14. SAND SPRINGS POOL INUNDATION MAP

CONCLUSION





The primary focus of this analysis was to determine if the construction of the low water dams would cause and adverse impact to the surround properties as it is related to the larger flood flows in the Arkansas River. The outcome of the analysis had mixed results.

For two of the locations, the recommended plan reduces the water surface elevation around the dam. The Bixby and Zink locations have a small reduction in water surface elevation. The other two locations, Sand Springs and South Tulsa/Jenks, have small increases. The impacts appear to be minimal if not negligible. However, they are present and additional alternatives will be analyzed during the final design to reduce or eliminate the increases.

If any increases are not mitigated, the impacted regulatory entities will be notified and the proper steps will be followed to work through the permitting process. The following figures show the dams, the inundation area, 1 percent annual chance (100-Year) floodplain, and levee locations. This information shows that the levees will not be impacted by the small increases in the Base Flood Elevation and the most of the 100-year floodplain is contained in the channel and no structures are impacted.

FIGURE 15. South Tulsa/Jenks - Levee Proximity



-  Low Water Dam
-  Low Water Pool - 638 ft
-  Levee
-  100 yr Floodplain

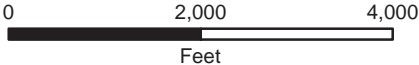
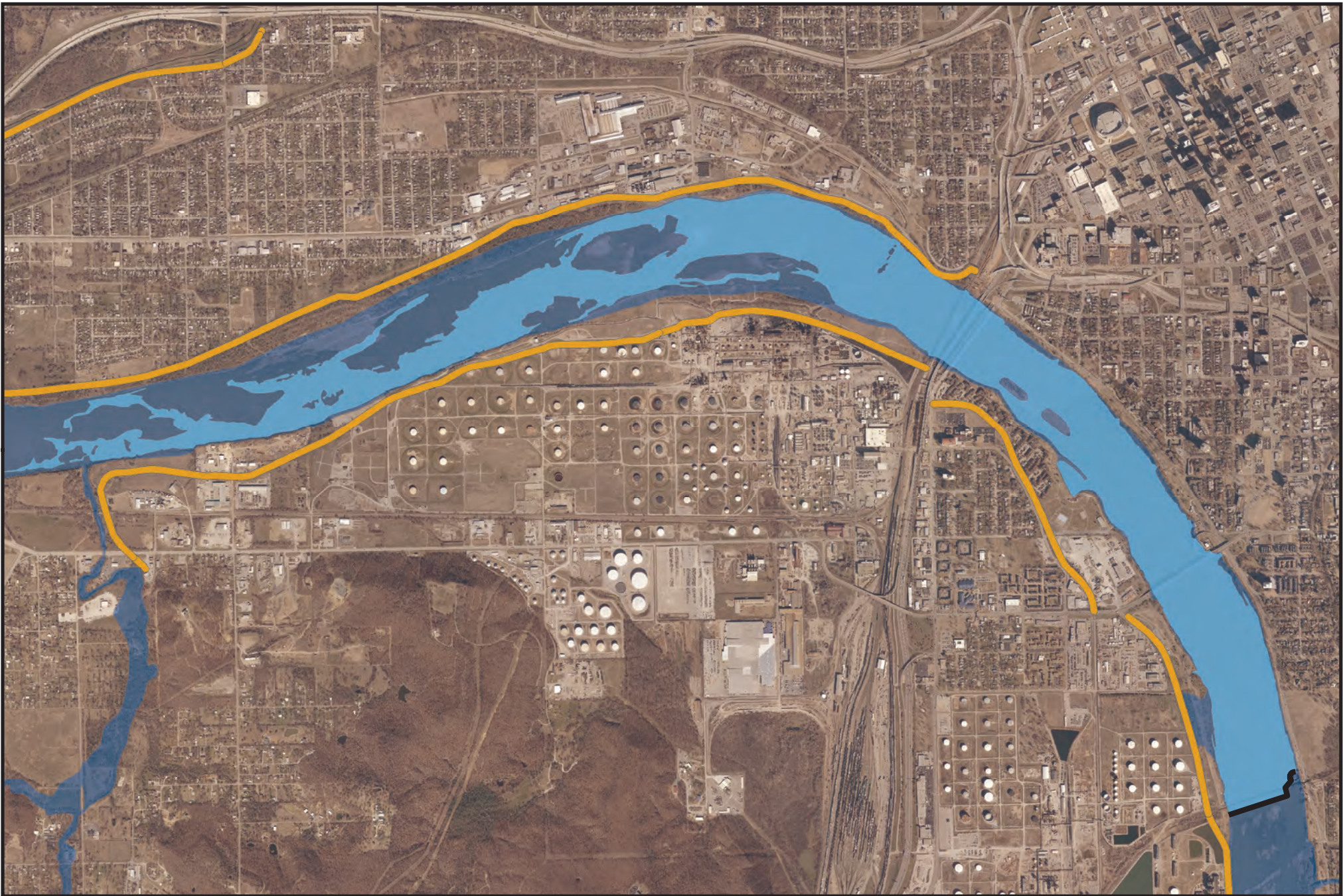






FIGURE 16. Sand Springs Dam - Levee Proximity





CH2MHILL

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& ASSOCIATES, P.L.C.

-  Low Water Dam
-  Zink Pool - 620
-  Levee
-  100 yr Floodplain

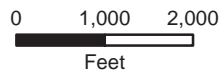
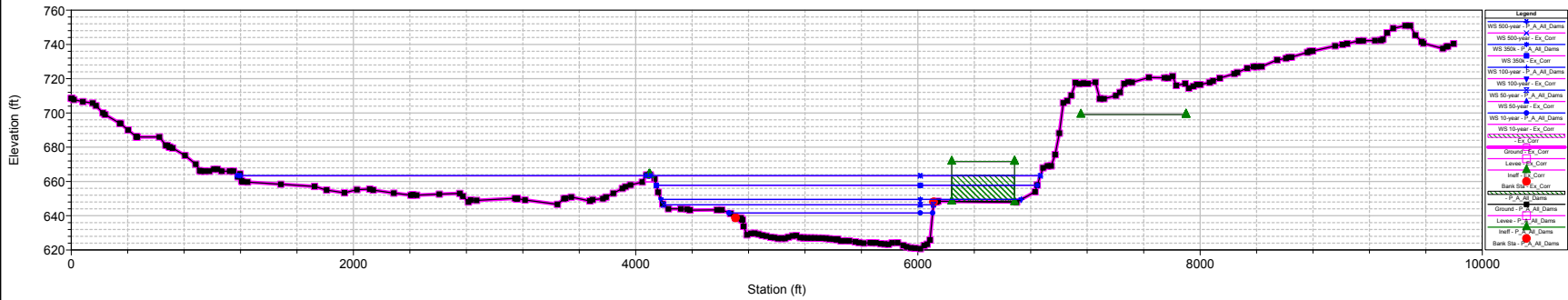


FIGURE 17. Zink Dam -

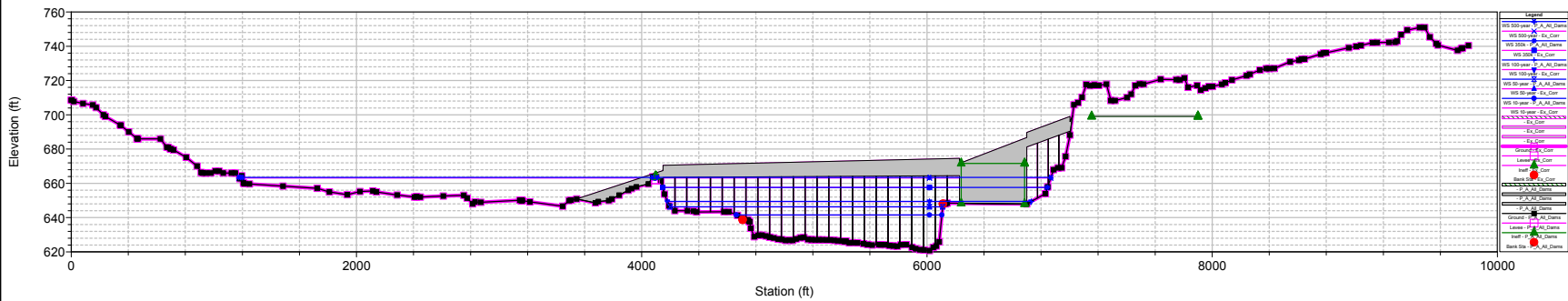
Levee Proximity

APPENDIX A
HYDRAULIC MODEL

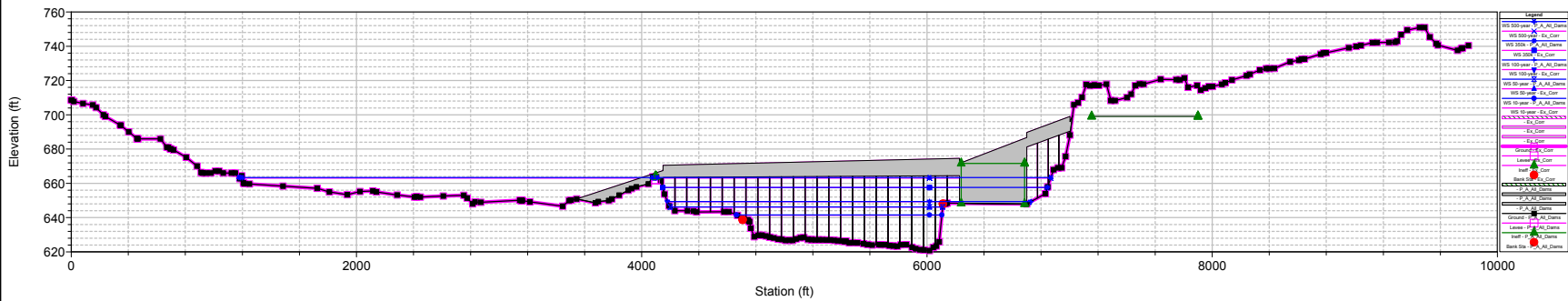
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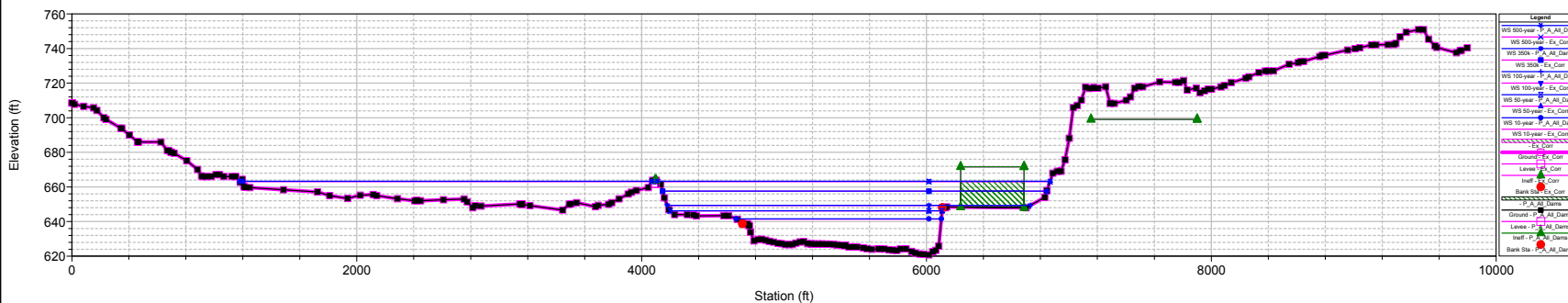
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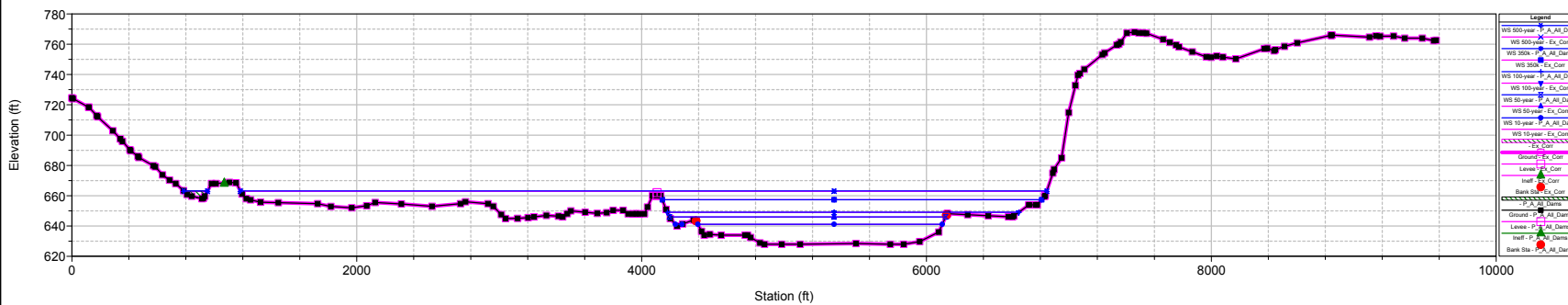
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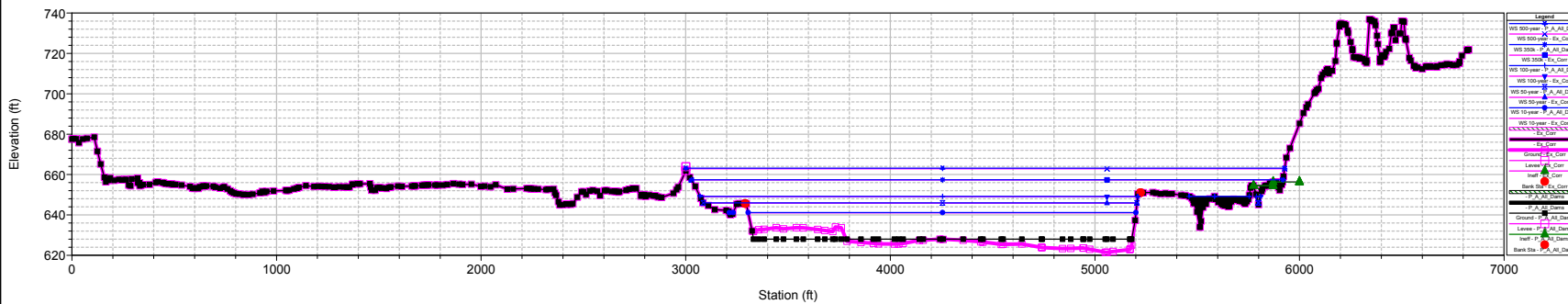
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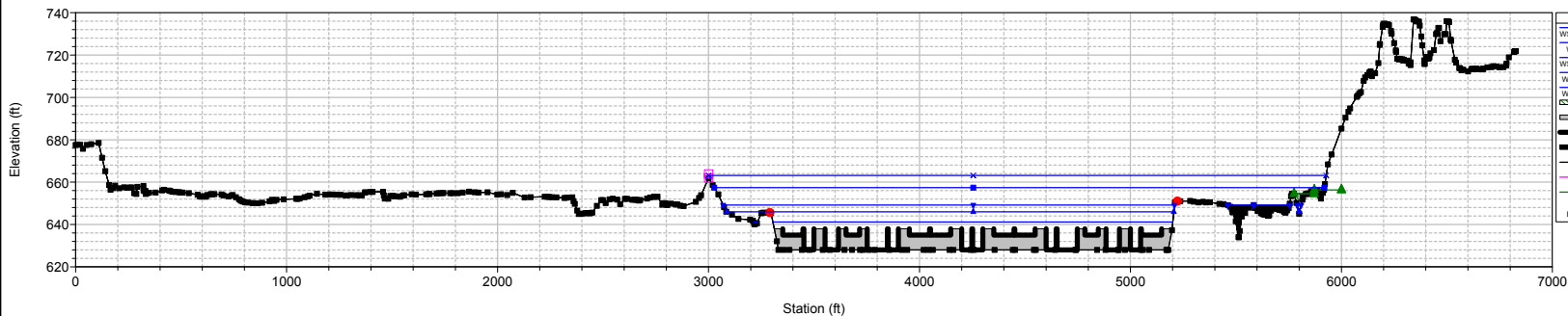
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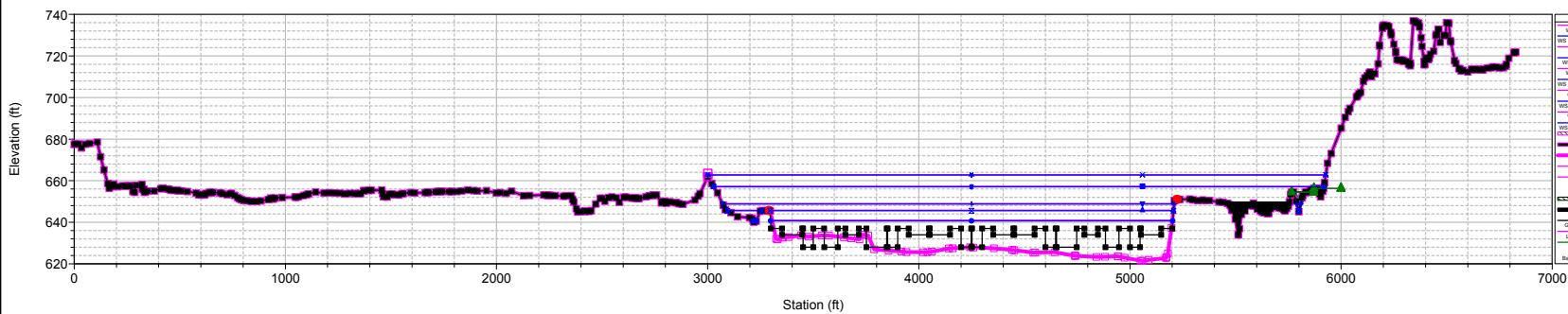
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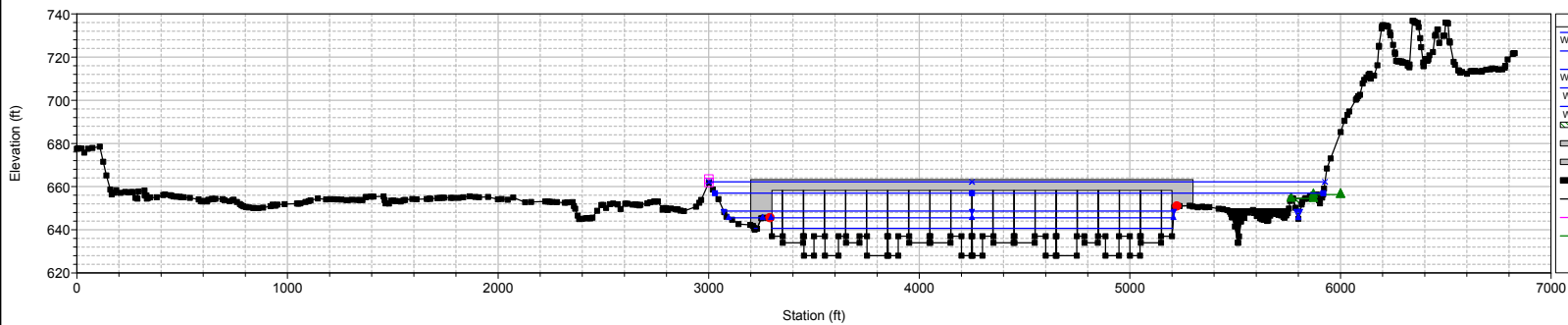
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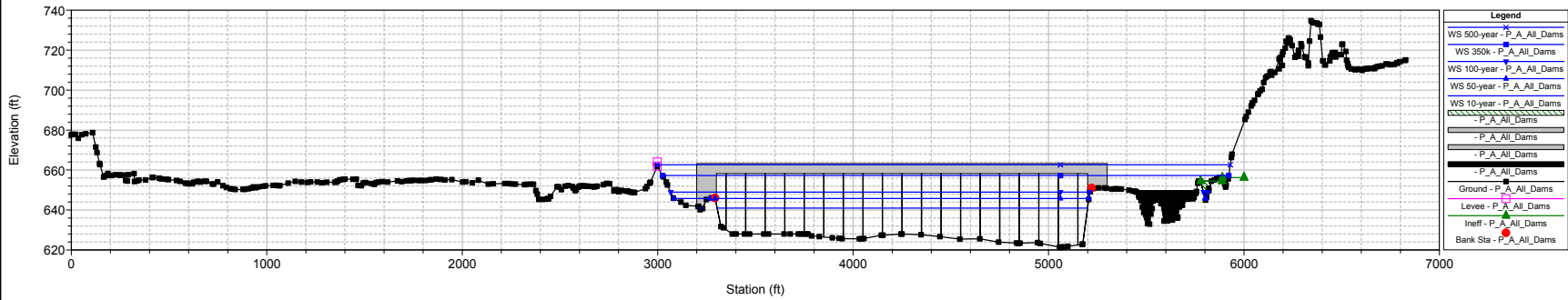
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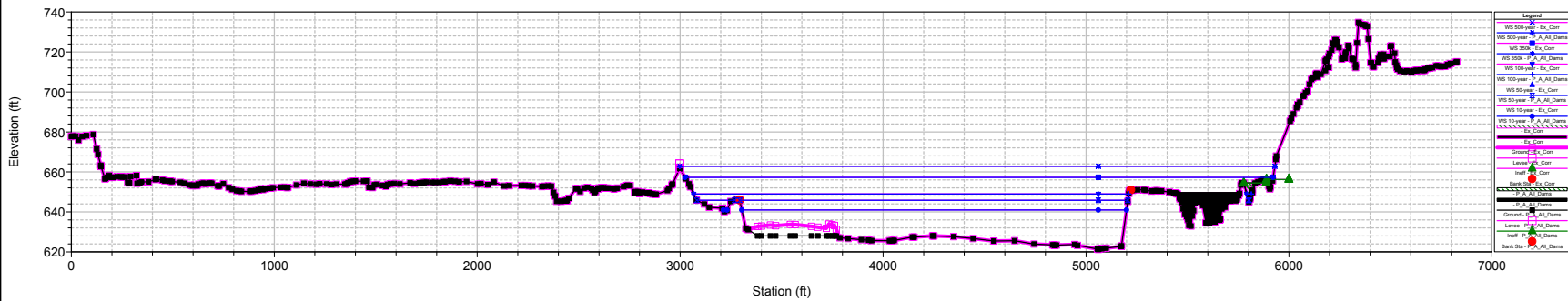
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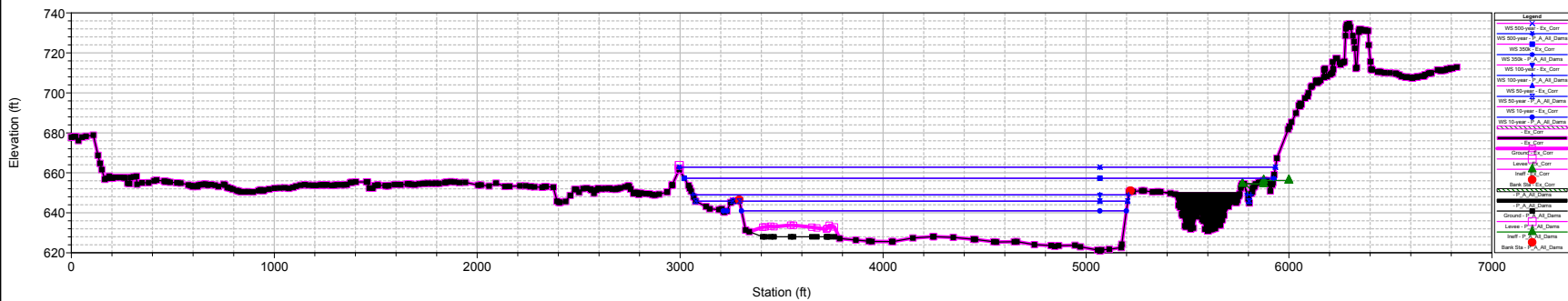
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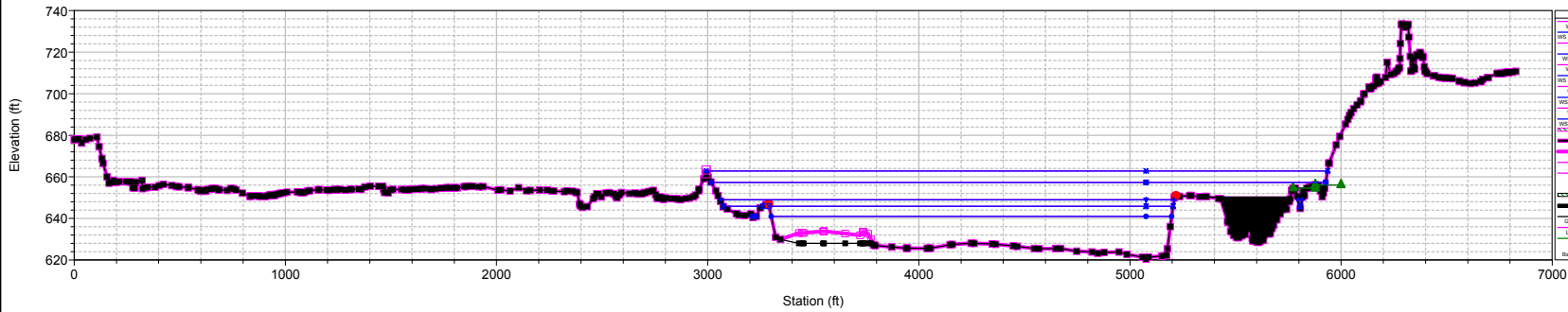
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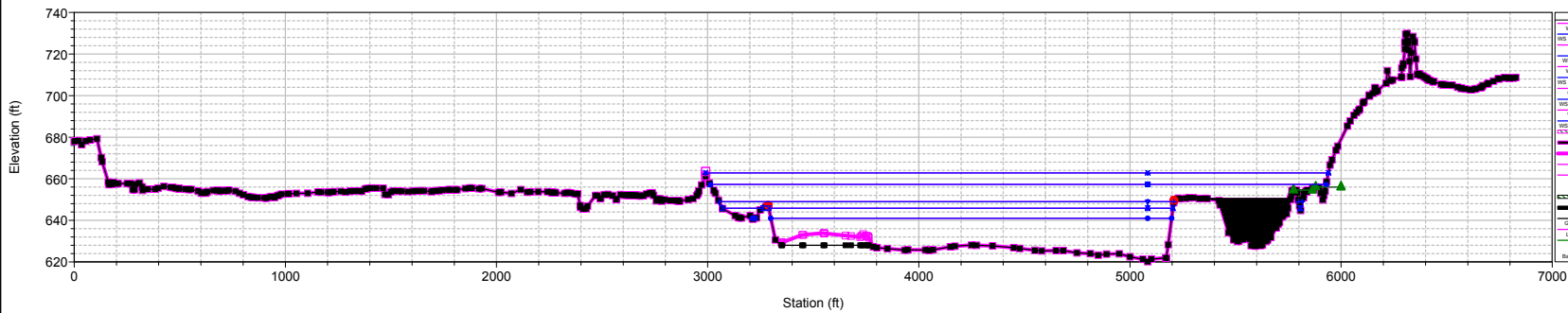
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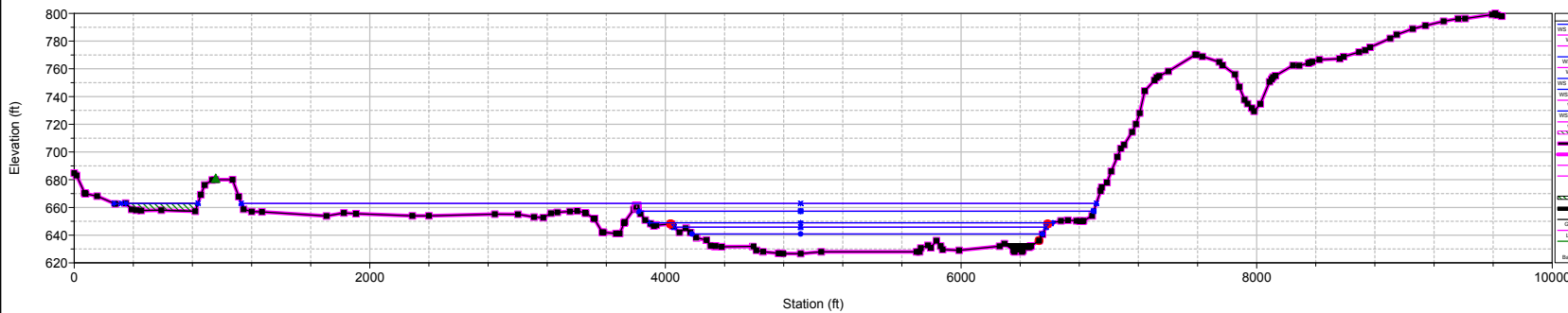
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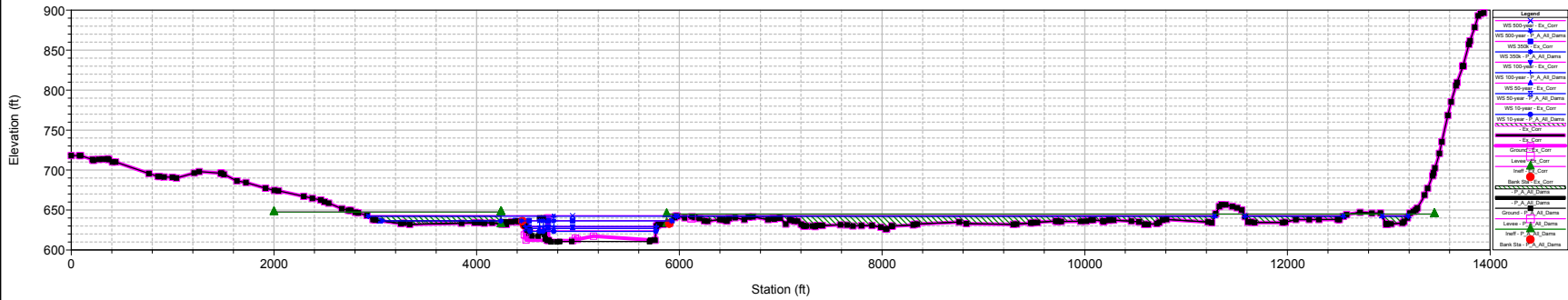
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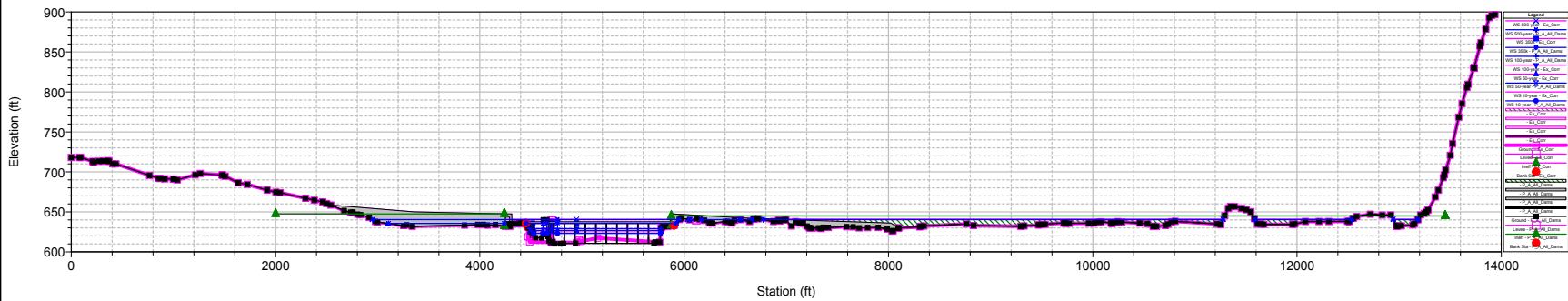
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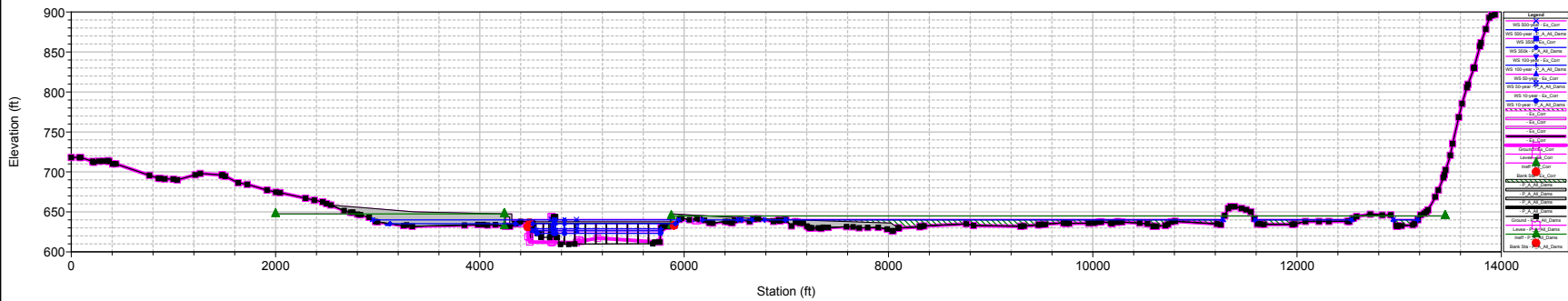
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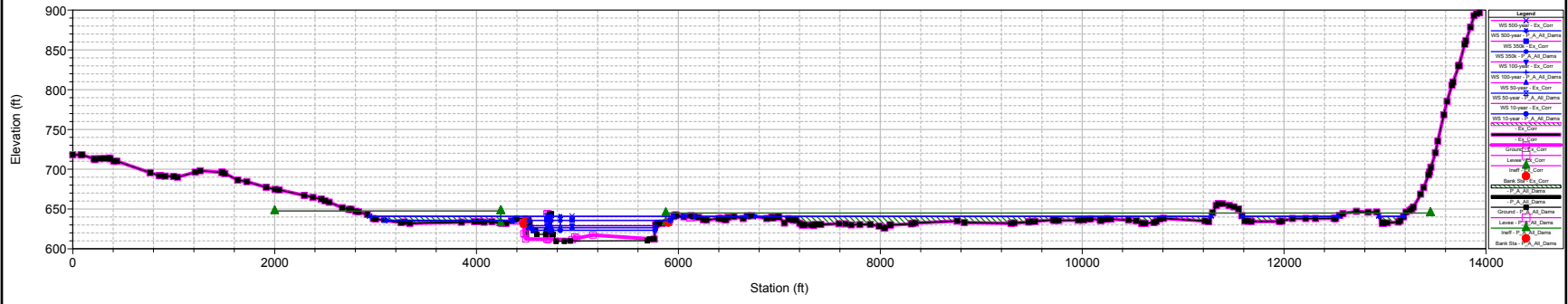
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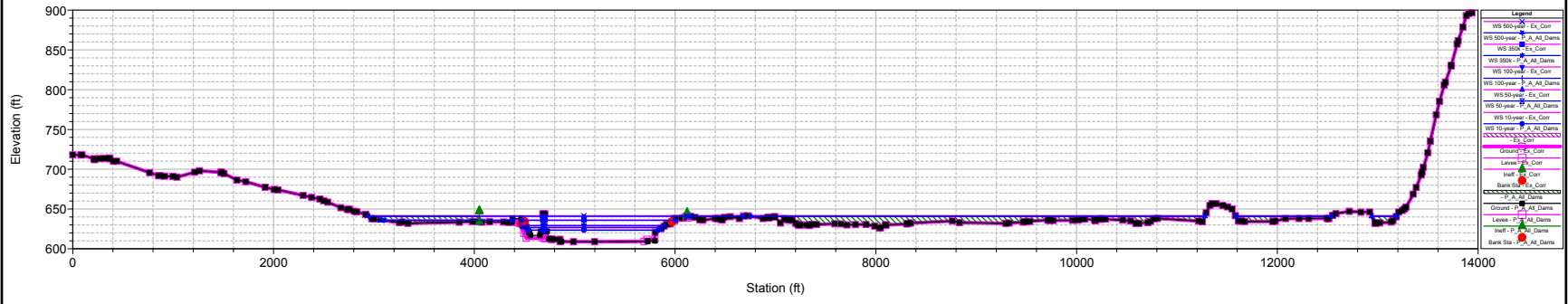
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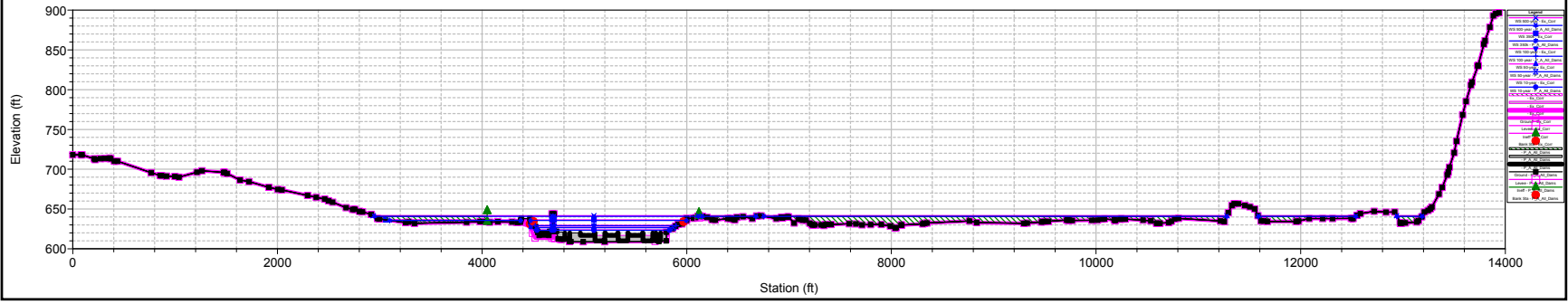
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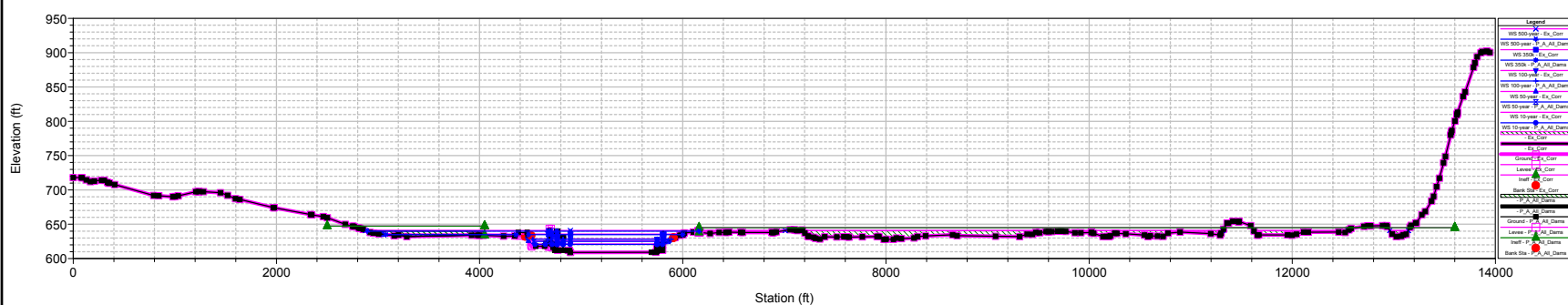
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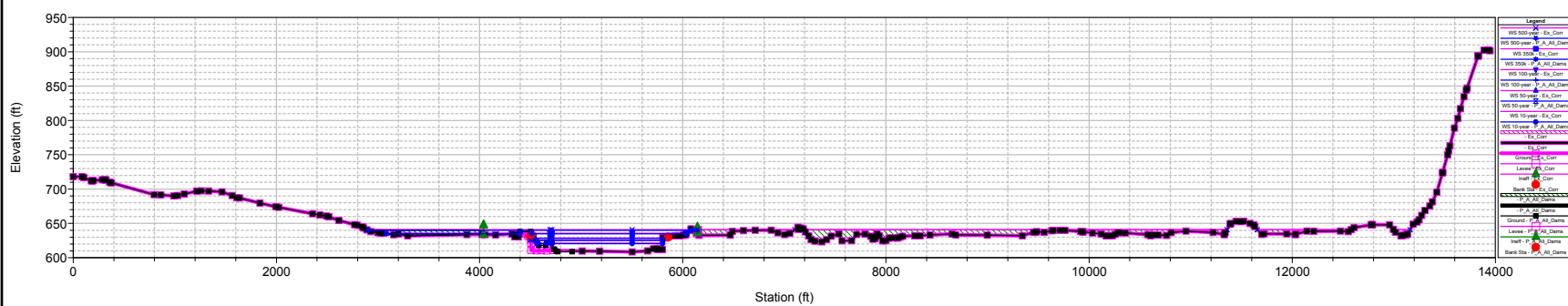
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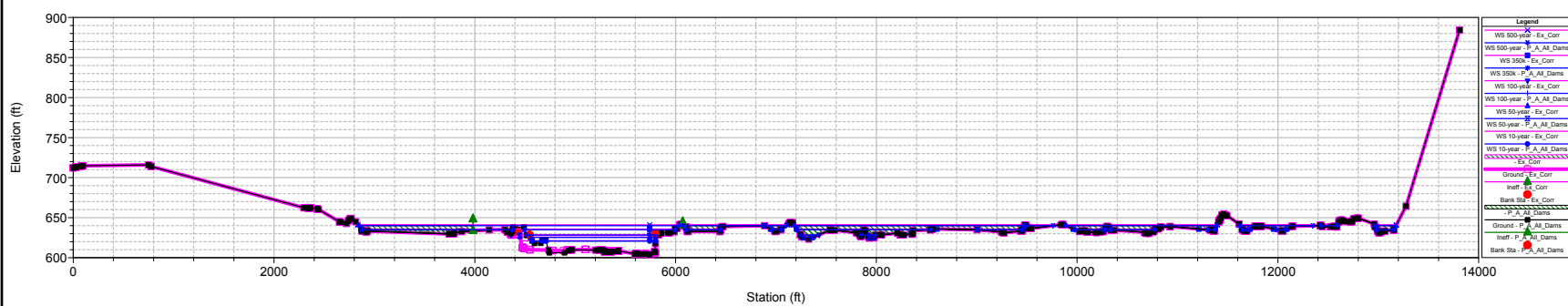
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 River = Arkansas River Reach = Tulsa County RS = 339443.4 John Zink Lake Low Water Dam Crest



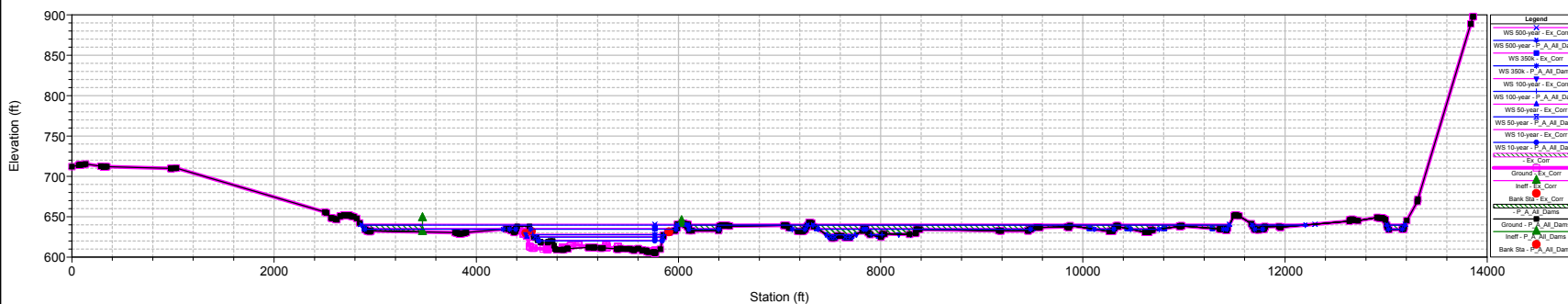
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 339414.4 Just below John Zink low water dam



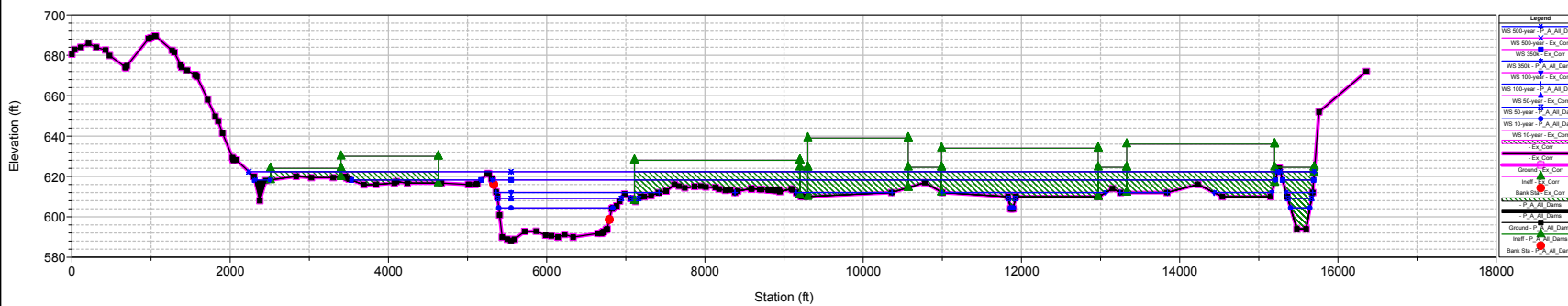
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 339376.6 recreational flume area



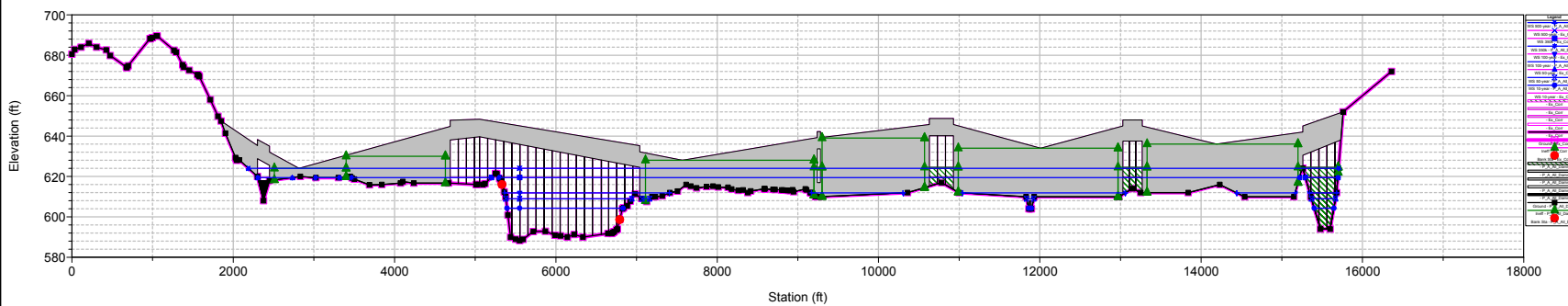
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 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 339284.2



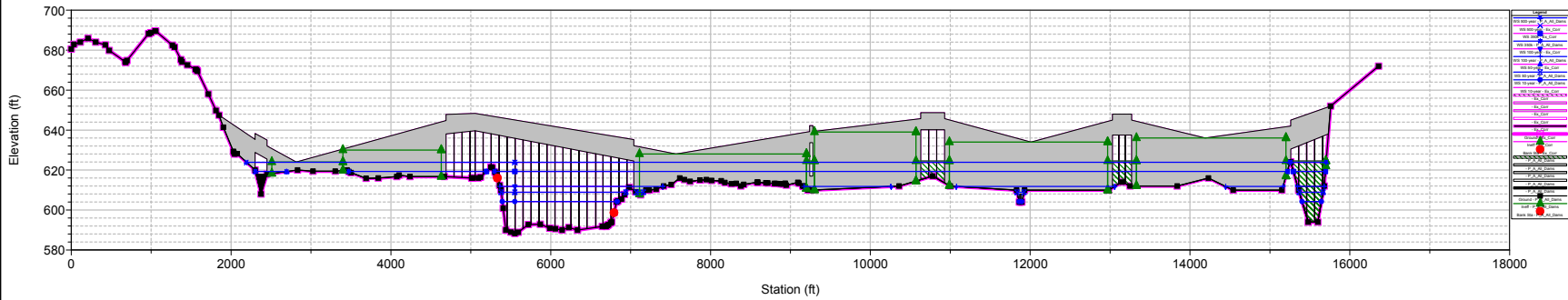
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 299383.8 BRIDGE DECK IS TAKEN FROM THE LOWEST LOW CHORD (WEST/NORTH) AND



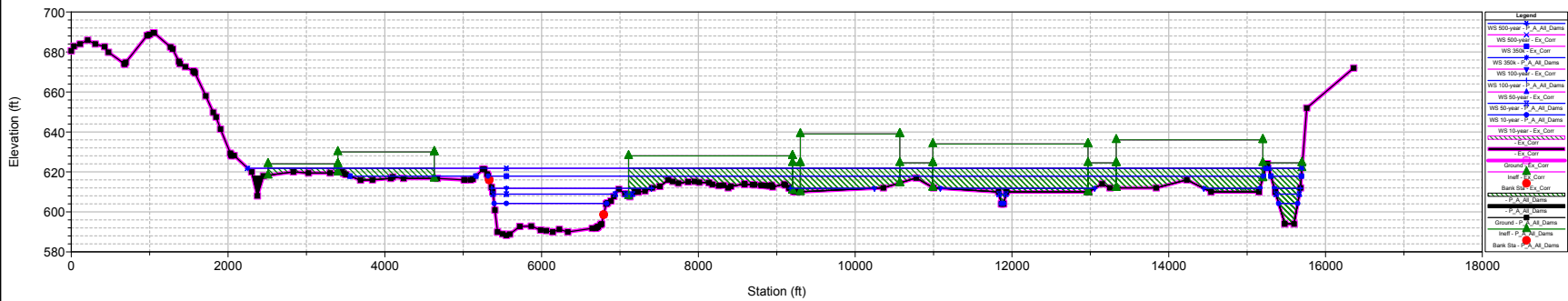
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 299203.8 MO Creek Tpk. Bridg CREEK TURNPIKE



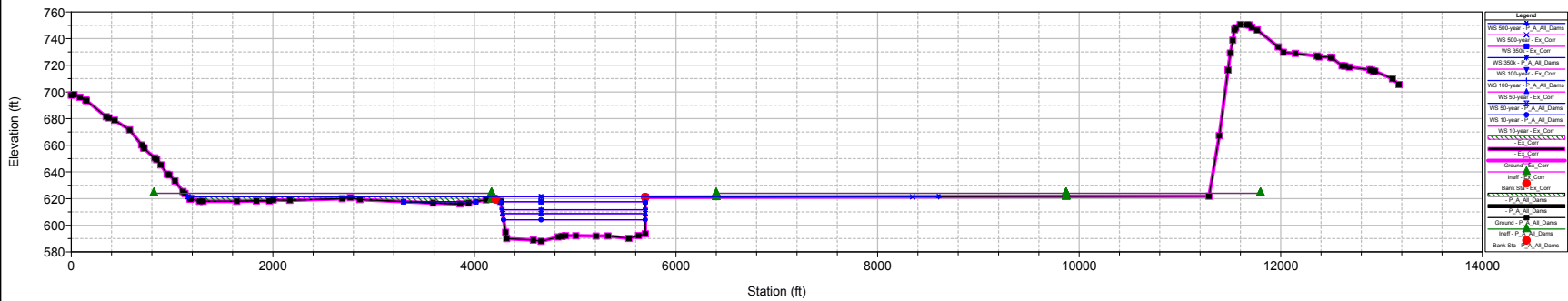
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 299203.8 MO Creek Tpk. Bridg CREEK TURNPIKE



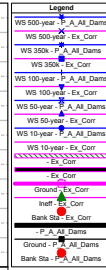
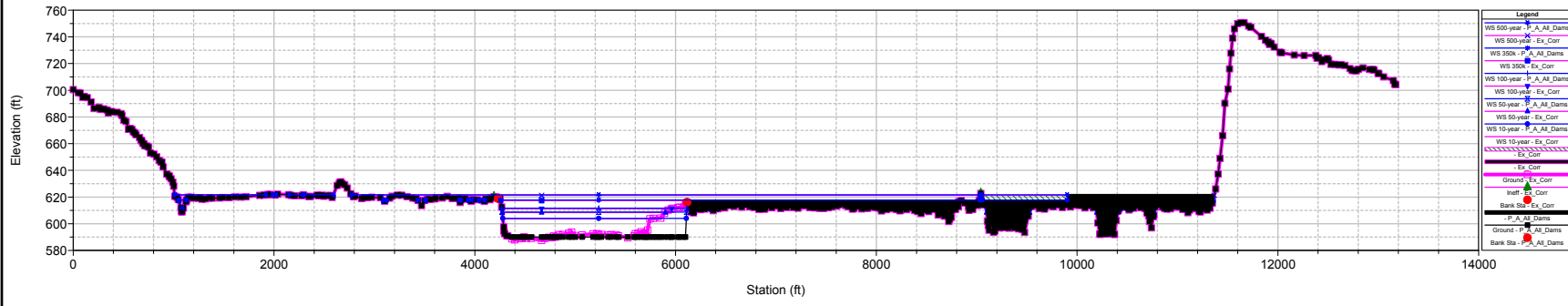
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 299023.8



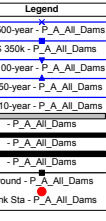
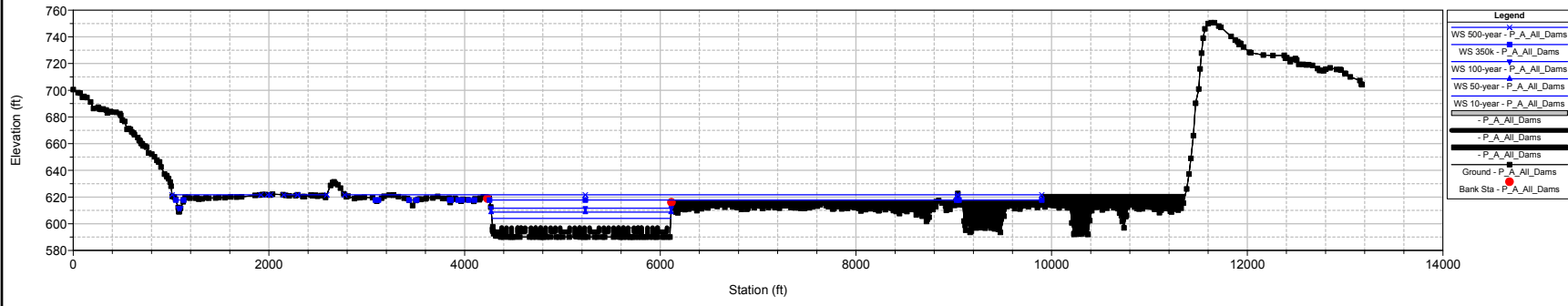
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 298676.5



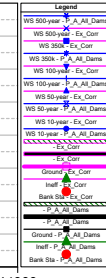
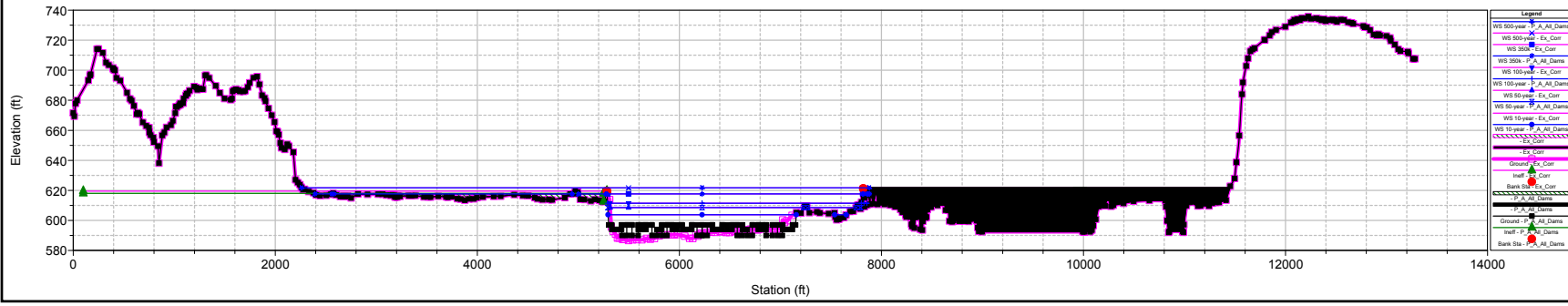
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 297137.5 Obstruction is proposed sea wall



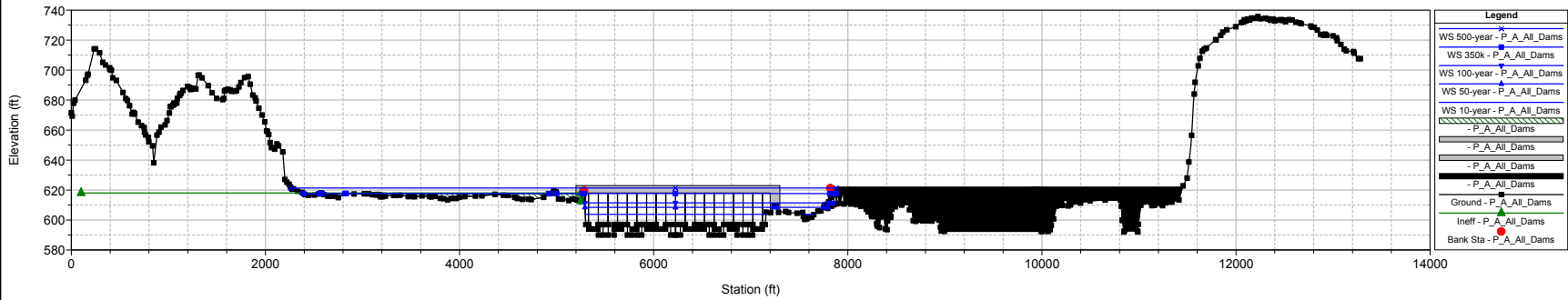
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 297136 IS JENKS PLAN Y1b



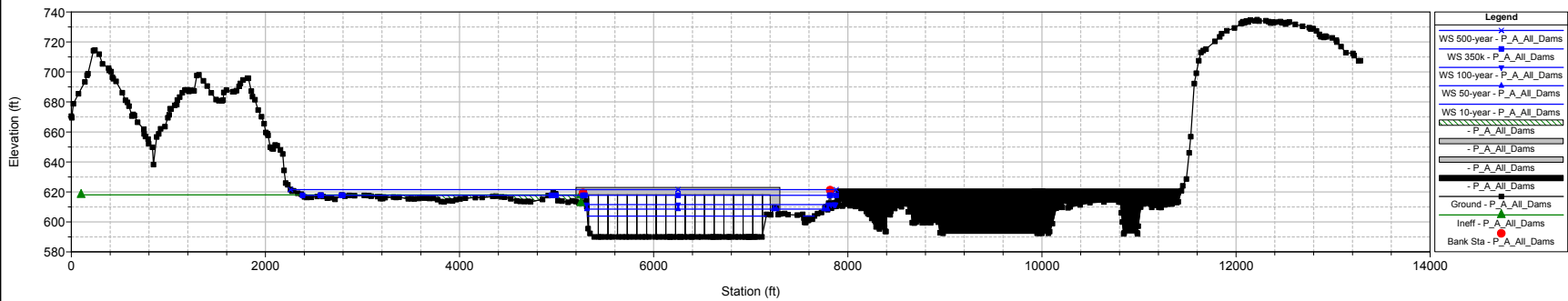
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 297127.5



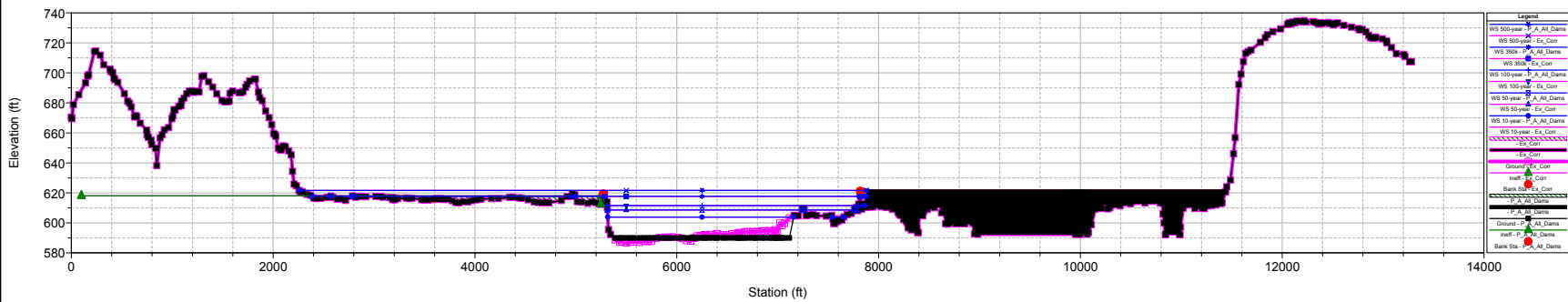
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 297120 BR Pedestrian Bridge at Jenks Dam



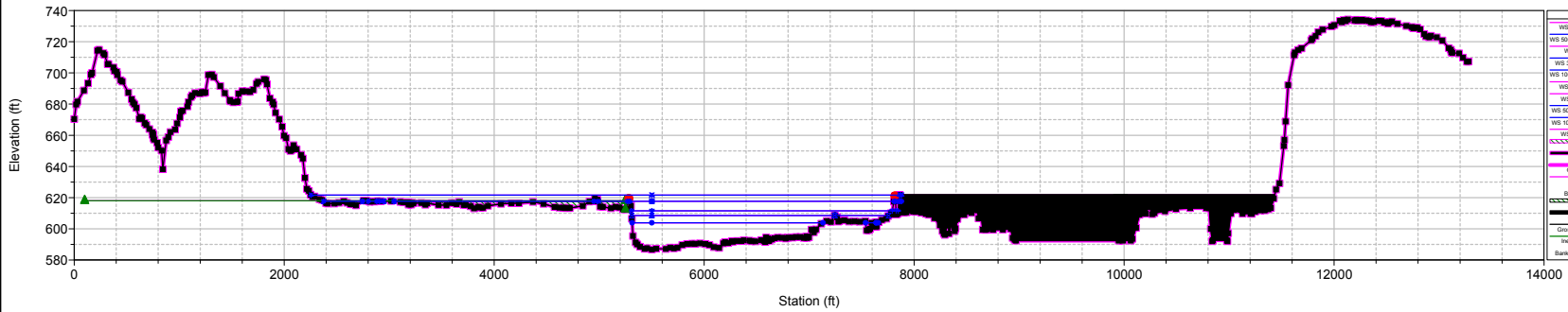
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 297120 BR Pedestrian Bridge at Jenks Dam



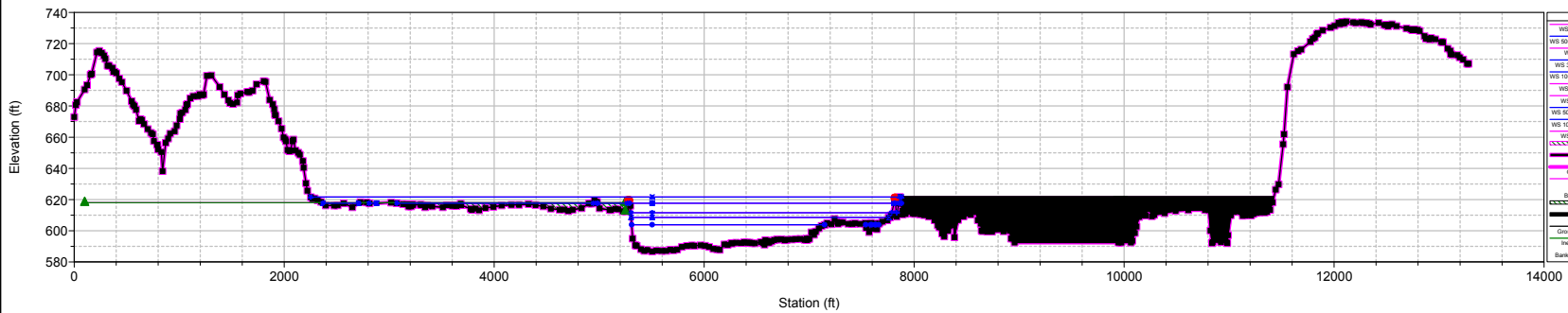
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 297117



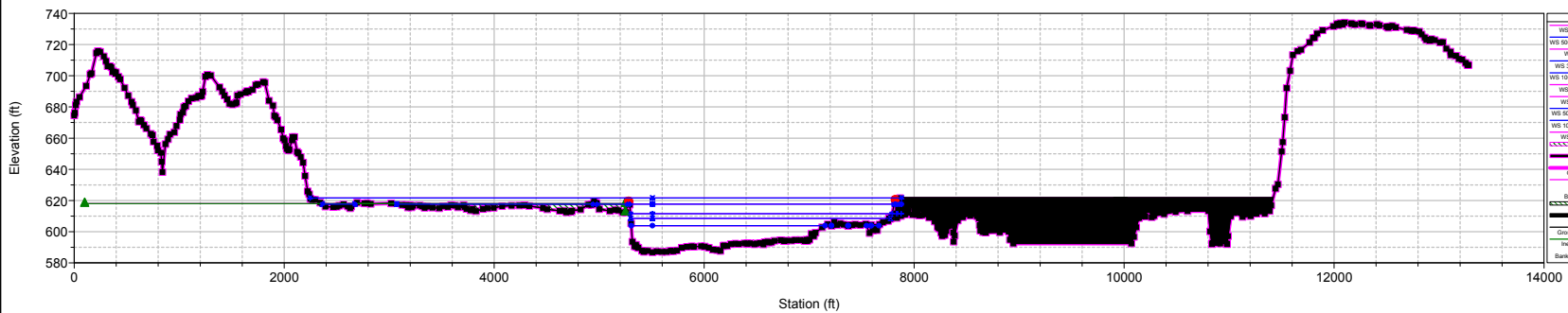
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
Geom: PLAN A Bixby Added
River = Arkansas River Reach = Tulsa County RS = 297107



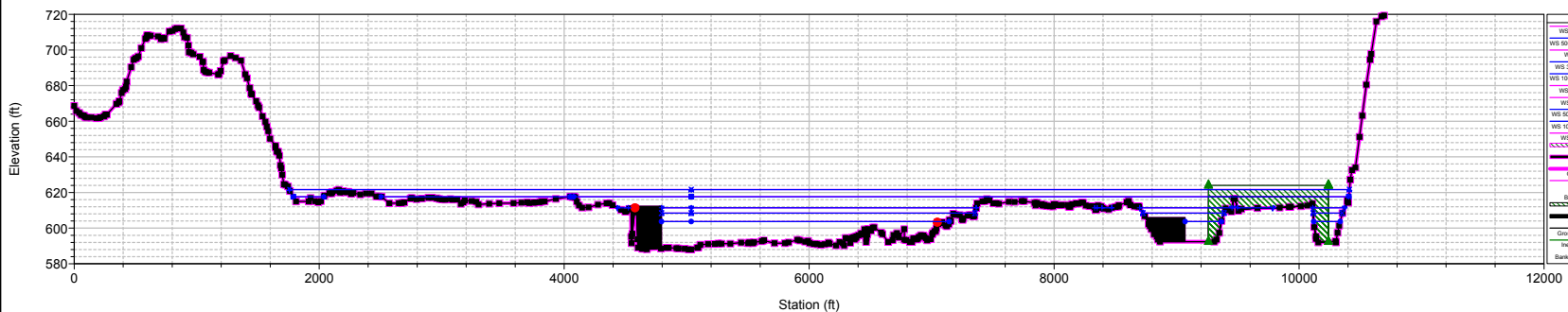
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
Geom: PLAN A Bixby Added
River = Arkansas River Reach = Tulsa County RS = 297097



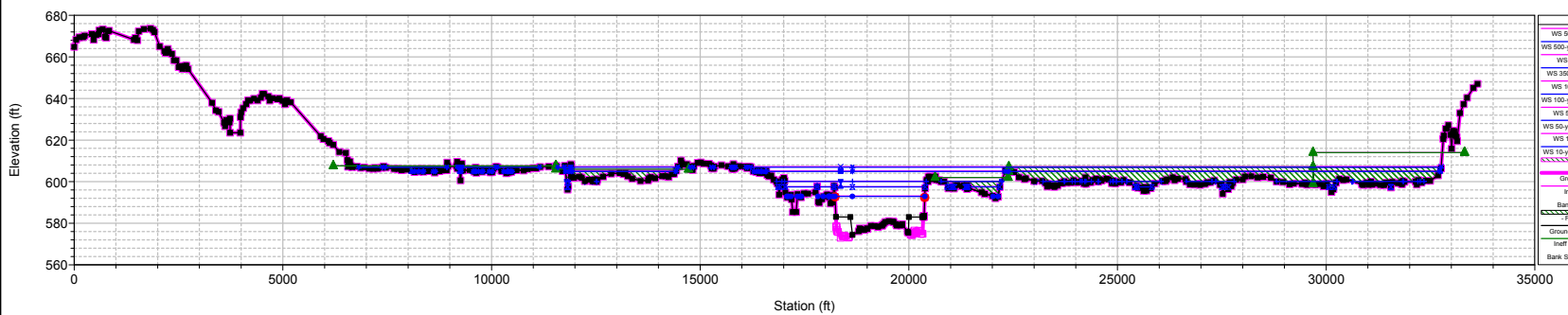
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
Geom: PLAN A Bixby Added
River = Arkansas River Reach = Tulsa County RS = 297087



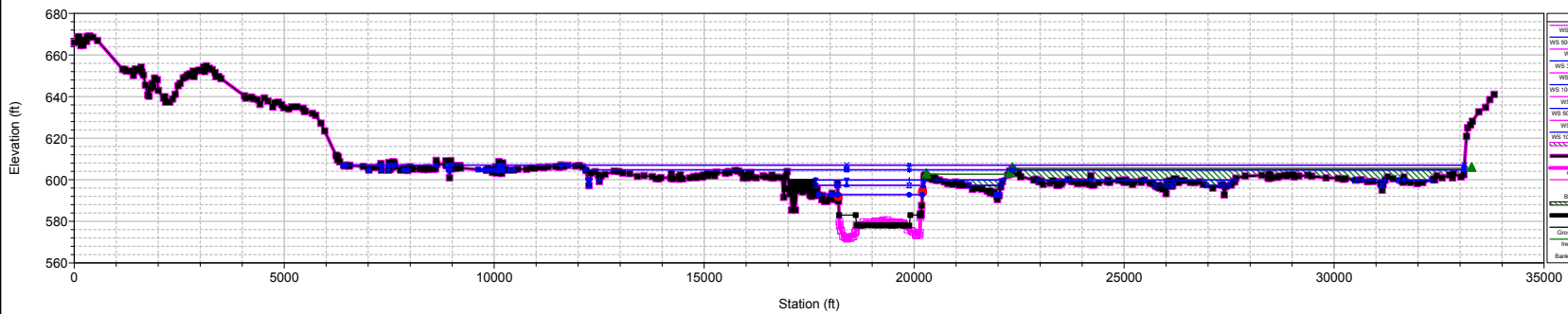
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 296133.8



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 264203 400 feet U/S of LW Dam



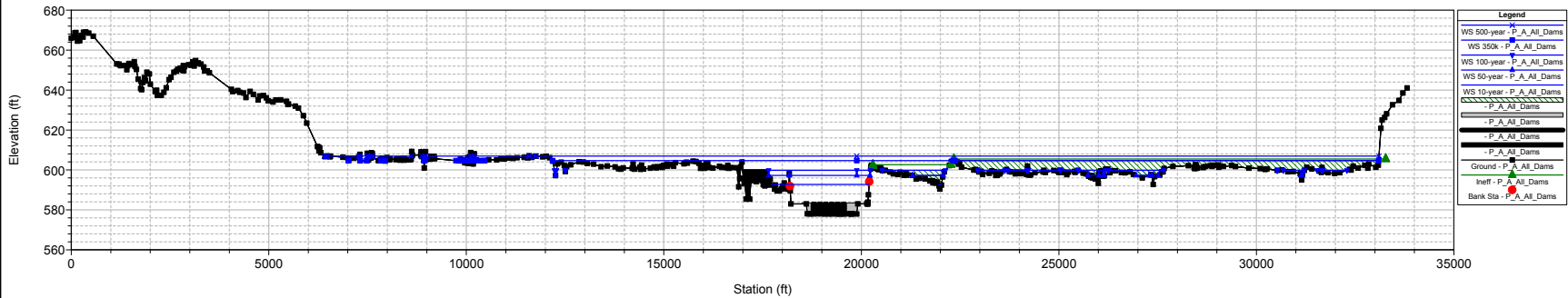
TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr
 Geom: PLAN A Bixby Added
 River = Arkansas River Reach = Tulsa County RS = 263812 Upstream side of Low Water Dam



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr

Geom: PLAN A Bixby Added

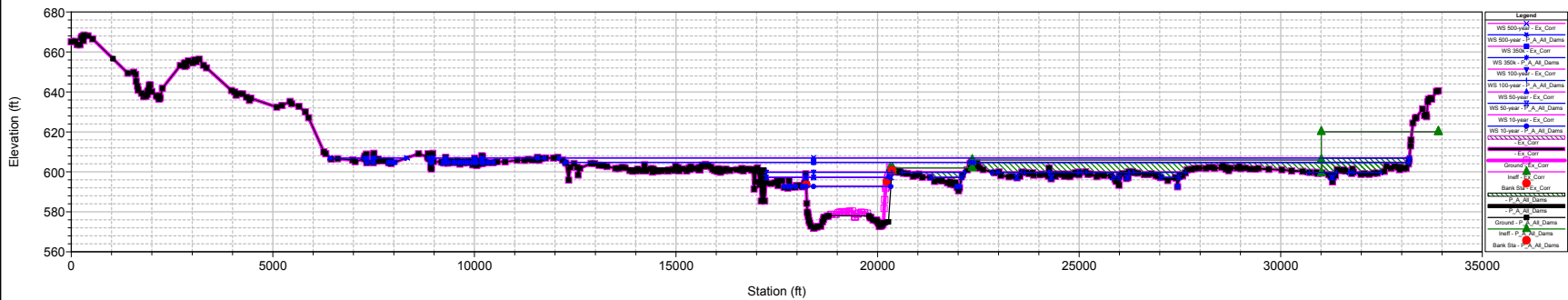
River = Arkansas River Reach = Tulsa County RS = 263777 IS Bixby Dam



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr

Geom: PLAN A Bixby Added

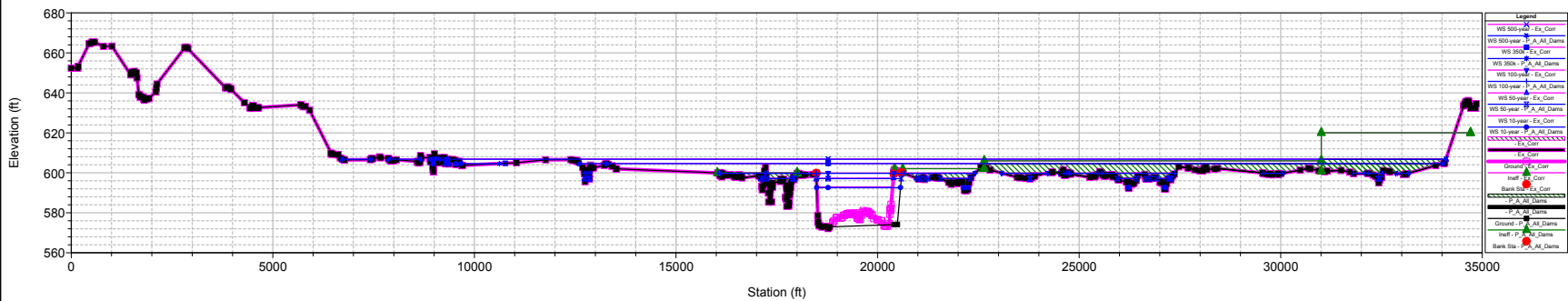
River = Arkansas River Reach = Tulsa County RS = 263742 Downstream Side of Low Water Dam



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr

Geom: PLAN A Bixby Added

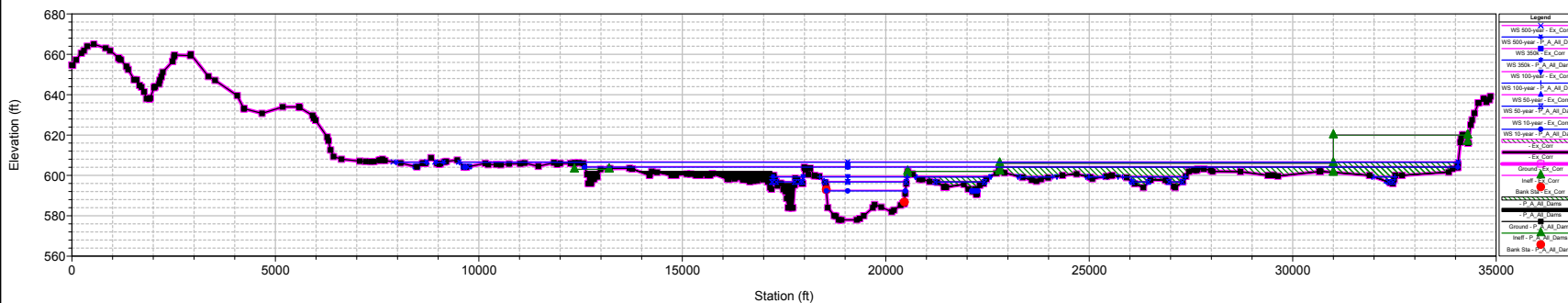
River = Arkansas River Reach = Tulsa County RS = 263458 New Section 370' D/S of proposed dam



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr

Geom: PLAN A Bixby Added

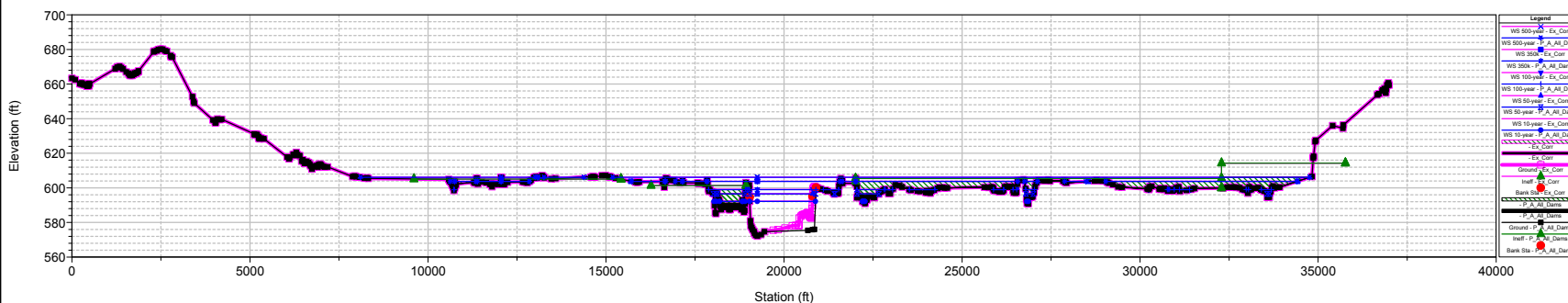
River = Arkansas River Reach = Tulsa County RS = 263220.6 602 ELEVATION DUE TO RIDGE ALONG RIGHT BANK OF ARK RIVER -



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr

Geom: PLAN A Bixby Added

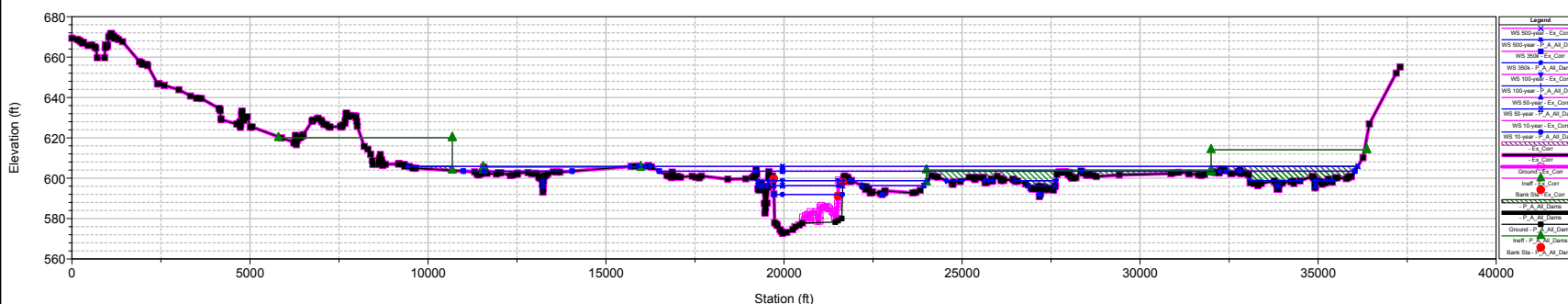
River = Arkansas River Reach = Tulsa County RS = 262133 New Section



TULSA CORRIDOR Study Plan: 1) P_A_All_Dams 2) Ex_Corr

Geom: PLAN A Bixby Added

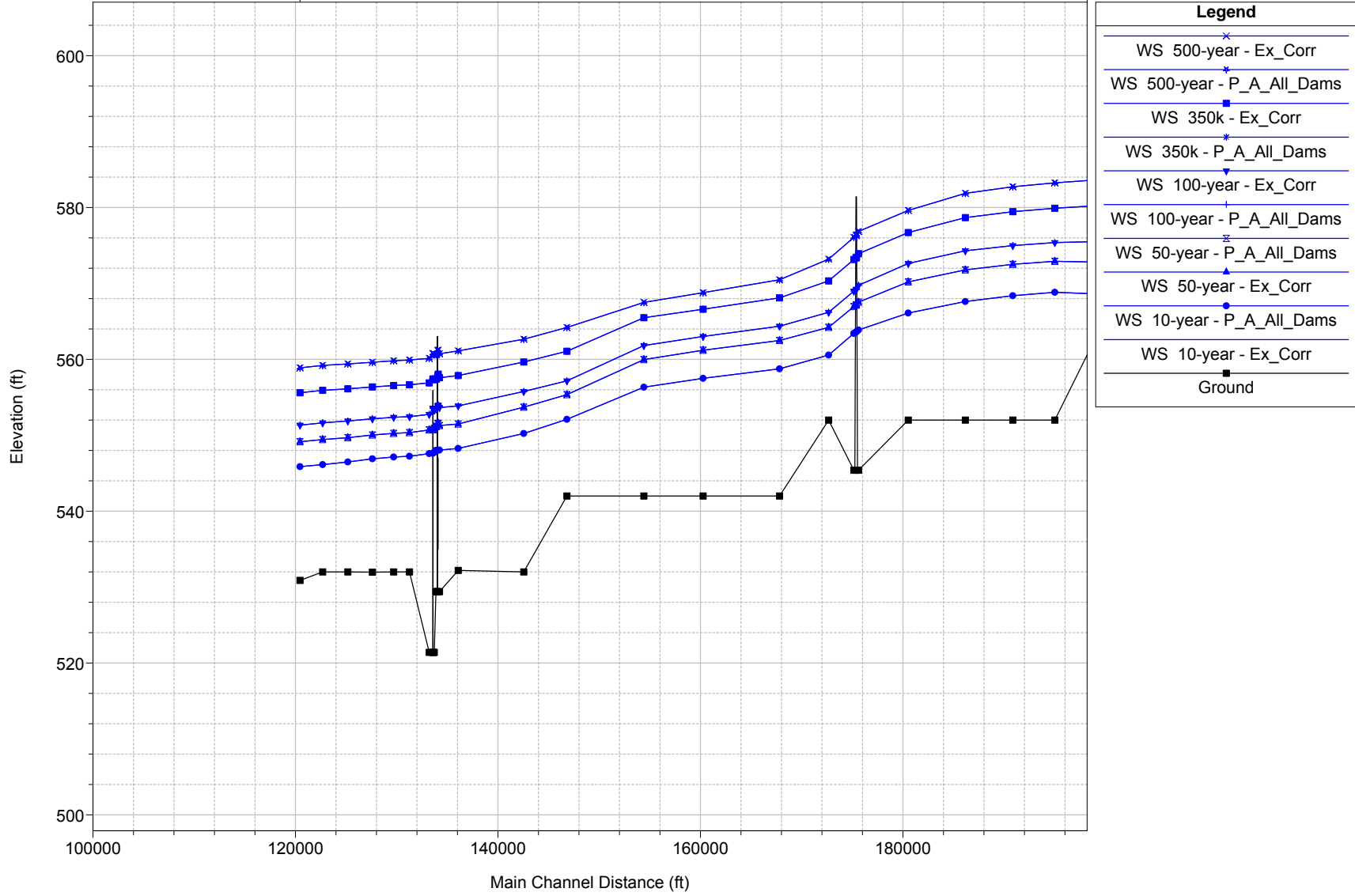
River = Arkansas River Reach = Tulsa County RS = 261285.1 Multiple restrictions due to high ground US and DS and roadway U



TULSA CORRIDOR Study Plan: 1) Ex_Corr 4/23/2015 2) P_A_All_Dams 4/23/2015

Geom: PLAN A Bixby Added

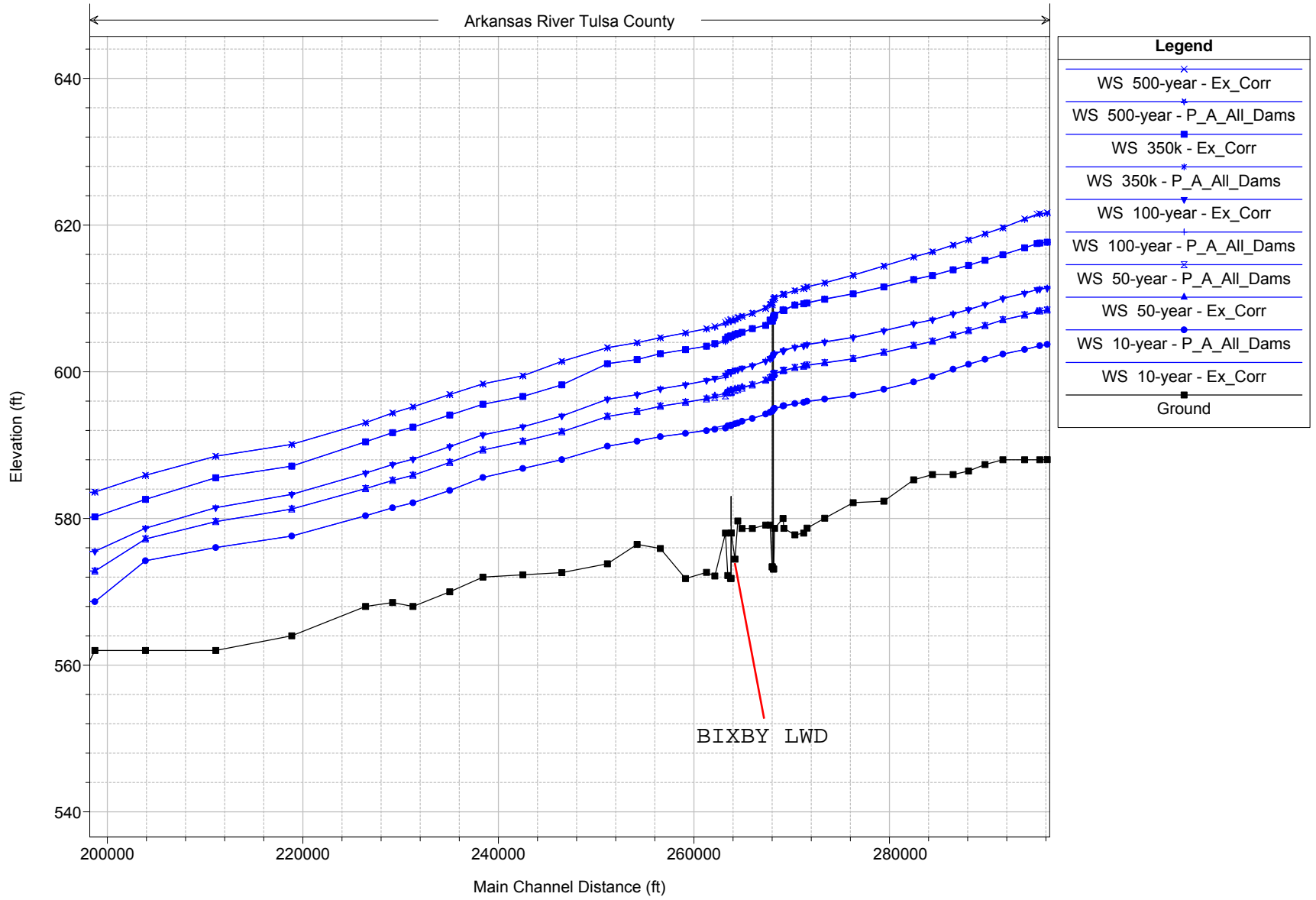
Arkansas River Tulsa County



1 in Horiz. = 15000 ft 1 in Vert. = 20 ft

TULSA CORRIDOR Study Plan: 1) Ex_Corr 4/23/2015 2) P_A_All_Dams 4/23/2015

Geom: PLAN A Bixby Added

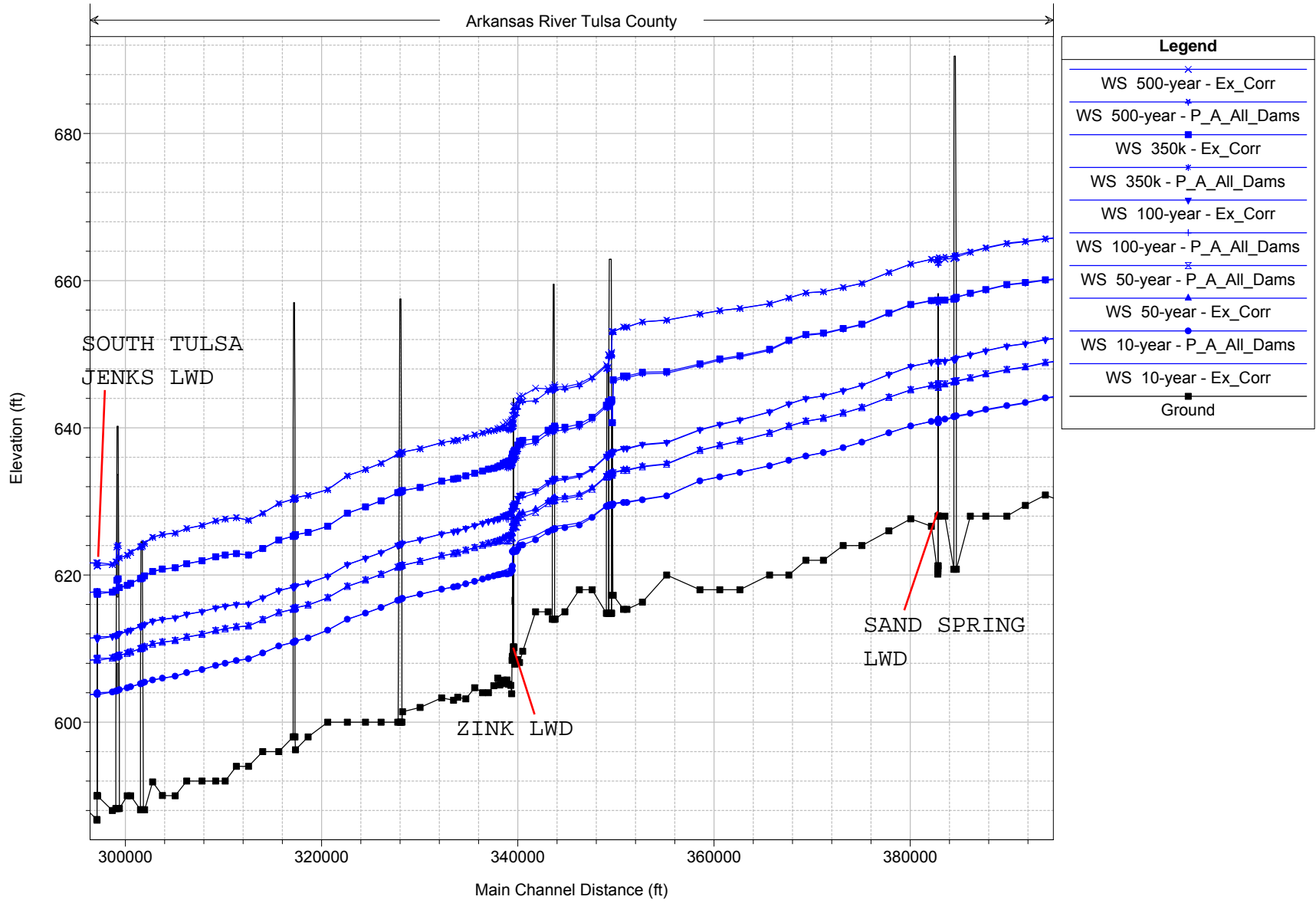


1 in Horiz. = 15000 ft 1 in Vert. = 20 ft

TULSA CORRIDOR Study Plan: 1) Ex_Corr 4/23/2015 2) P_A_All_Dams 4/23/2015

Geom: PLAN A Bixby Added

Arkansas River Tulsa County



1 in Horiz. = 15000 ft 1 in Vert. = 20 ft