Jordan Creek Feasibility Study Springfield, Missouri

Jordan Creek Feasibility Study H&H Report

Model Created By:

Errin Kemper

City of Springfield, MO.

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1. Introduction

Through a cooperative effort undertaken by the City of Springfield and US Army Corp of Engineers as part of the Jordan Creek Feasibility Study, a hydraulic and hydrologic study of Jordan Creek and a portion of Wilsons Creek, tributaries of the James River, located within the city limits of Springfield, Missouri was initiated in 2004. Historically, this basin has suffered numerous floods due to increased urbanization and insufficient drainage capacity. The purpose of this study is to determine the feasibility of flood damage reduction alternatives for the Jordan Creek watershed. This report presents a description of the analytical approach, analyses performed, and the results obtained for a detailed hydrologic and hydraulic study of the approximately 10.2 miles of Jordan Creek and Wilsons Creek that passes through the City. Results of this study include water surface profiles for the 100%, 50%, 20%, 10%, 4%, 2%, 1%, and 0.2% Annual Chance Exceedance (ACE) storm events for without-project (existing) conditions, without-project (future) conditions, and for several respective with-project alternatives.

2. General

2.1. Scope of Work

An analysis of the watershed and stream hydrology and hydraulics was performed using the US Army Corp of Engineers' HEC-1 flood hydrograph modeling package in conjunction with the HEC-RAS river analysis system. The results of this modeling effort were used to develop depth-duration-frequency rating curves for each portion of the study stream. The system was first analyzed under current and future development watershed conditions assuming no implementation of flood damage reduction alternatives. These scenarios were then modified to include a number of project alternatives aimed at reducing flood damages at different portions of the stream.

The downstream limit of federal interest is at the US Hwy 160 crossing of Wilsons Creek at RS 23800. The downstream modeling limit is at Scenic Drive near RS 31152 on Wilsons Creek. The effects of proposed project alternatives in the 1.4 mile reach between Scenic Drive and US Hwy 160 will be considered. Cumulative drainage area at the downstream model limit is about 19.3 sq-mi. The analyses extend upstream along Jordan Creek, North Branch of Jordan Creek, and South Branch of Jordan Creek. The upstream limit of federal interest on North Branch is at about RS 11300, where the drainage area is 1.85 sq-mi. Drainage area 300 feet upstream at RS 11600 is 1.35 sq-mi. The upstream limit of federal interest on South Branch is about 800 feet upstream of Chestnut Expressway at about RS 10950, where the drainage area is 1.58 sq-mi.

2.2. **Watershed Descriptions**

2.2.1. North Branch Jordan

The North Branch of Jordan Creek drains 3.59 sq-mi and is the smallest major sub-watershed in the study. North Branch has moderate stream slopes (although the highest in the study) and a high degree of urbanization. Most of the development in the watershed is evenly divided between industrial/commercial in the upper portions of the watershed and residential in the lower portions of the watershed. The stream travels in a pair of roadside ditches for the first 4000-ft and passes through a regional detention basin on its way through the watershed. Just before the joining the South Branch, the stream passes through a 1000-ft tunnel located under an industrial area. One unique characteristic of this watershed is the railroad line that crosses through the northeast portion. The culverts under this rail line are relatively small. The railroad embankment provides detention of runoff from the uppermost 0.5 sq-mi (14%) of the watershed, thereby reducing peak flow. The North Branch sub-watershed includes approximately 14 additional stormwater detention basins that were specifically constructed for that purpose.

2.2.2. South Branch Jordan

The South Branch of Jordan Creek is a moderately sloped reach. The watershed has a high degree of urbanization divided between industrial/commercial and residential development. South Branch is the largest major sub-watershed in the study, drainage 5.95 sq-mi. However, due to a number of sinkholes, much of the watershed contributes very little storm runoff. The South Branch sub-watershed includes 16 constructed stormwater detention basins.

2.2.3. Lower Branch Jordan

The North and South Branches converge to form the Lower Branch of Jordan Creek, which carries runoff form 4.21 sq-mi in addition to that contributed by the North and South Branch sub-watersheds. The stream has a moderate slope similar to the South Branch. The watershed is highly urbanized with a high number of industrial/commercial developments on the upstream side of the watershed and a large percentage of residential development on the downstream end. Just downstream of the confluence of the North and South branches, the stream enters a large tunnel which conveys stormwater nearly 3400-ft through the Springfield downtown area. Different portions of this tunnel, which measures approximately 30-ft wide and 10-ft tall, were constructed around the 1930s. The Lower Branch sub-watershed includes 3 constructed detention basins.

2.2.4. Wilsons Creek

Jordan Creek and Fassnight Creek converge to form Wilsons Creek approximately 2000-ft upstream of Scenic Avenue, with Fassnight Creek adding runoff from 5.52 sq-mi of drainage area. Due to limited floodplain development, only a short reach of Wilsons Creek has been included in the study. Wilsons Creek is a natural channel with a moderate slope.

2.3. **Available Historical Data**

Since 1999, the City of Springfield has maintained a number of rainfall gages throughout the Jordan Creek watershed. In the last several years, this number has increased significantly with the addition of a new gage network. Previous to 1999, the local airport was the best source for rainfall information. However, due to the spatial variability of intense storms in Springfield and the location of this gage, the local airport gage may inaccurately reflect the rainfall totals over the Jordan Creek watershed. For example: in June 2008, the airport reported a total precipitation depth of 3.88 inches while gages in the Jordan Creek watershed reported depths of 4.5 to 5.4 inches.

In recent years, including the July 2000 flood, Doppler radar images have provided a source of rainfall information. The results of published regional rainfall frequency analyses were used in lieu of analyses based on local data due to the short period of record for which local data is available. Reliable local precipitation data sufficient to accurately describe the spatial and temporal variation in significant observed rainfall events does not exist in conjunction with reliable observed peak stream flow data, and thus was not used for hydrologic model calibration.

The USGS has continually operated a flow gage at Scenic Avenue near the downstream limits of this study since 1931, but annual peak flow data is available only since 1999. During the flood of July 2000, this gage appeared to give inaccurate readings for the large flood flows. The rating curve for this gage has since been modified, but information on the July 2000 storm is still questionable. During the 2000 storm event, a local gage was in place on the North Branch of Jordan Creek and was destroyed by flood flows before any useful information was taken.

In addition to the USGS gage at Scenic Avenue, the pharmaceutical manufacturing plant just downstream of Bennett Street on Jordan Creek maintains a series of stream gages. Data for this gage was available during the flood of July 12, 2000.

Appendix HH-F summarizes the information available from the USGS gage at Scenic and the gage downstream of Bennett Street and compares this data to the hydrologic and hydraulic models created as part of this study. Appendix F also summarizes the estimated flood heights taken from high water marks found throughout the watershed.

2.4. **Previous Studies**

Hydrology and Hydraulics Report South Branch Jordan Creek – Box Culvert from National Avenue to Sherman Avenue; December 2004; Harrington and Cortelyou. Size an enclosed structure between National Avenue and Sherman Avenue.

Jordan Creek – South Branch Sinkhole Assessment Project; Spring 2005; SMSU. An evaluation of Sinkhole Flooding, Stability & Non-point Sources.

Jordan Creek – Story of an Urban Stream; Loring Bullard. An historic account of Jordan Creek.

Flood Insurance Study, City of Springfield, Missouri, 2002 – The City revised the Federal Emergency Management Agency (FEMA) preliminary flood insurance studies. The City developed more detailed hydrologic and hydraulic models and used recent aerial photos, two-foot contours, and GIS technology to produce improved mapping. The revised maps are currently issued by FEMA as "Preliminary". The potential effective date is unknown at this time.

Flood Insurance Study, City of Springfield, Missouri, FEMA, Preliminary by Michael Baker, Jr. Inc., June 2000 – This study revises and updates the previous Flood Insurance Study/Flood Insurance Rate Map for Springfield, Greene, and Christian counties, Missouri. The information will be used to update existing floodplain regulations and further promote sound land use and floodplain.

James River-Wilson Creek Study, Springfield, Missouri, U.S. Department of the Interior, June 1969. – The purpose of this study was to assess pollution problems associated with fish kills, storm runoff, and odorous and unsightly conditions in Wilson Creek. The project included measurements of physical and chemical parameters, biological studies, and a groundwater study.

Flood Plain Information – Wilson Creek and Tributaries; November 1968; U.S. Army Corps of Engineers, Little Rock District. Provides information and photographs regarding flooding.

Comprehensive Stormwater Report for Springfield Missouri; 1964; Crawford, Murphy, Tillie. Established peak flow rates and identified capital improvement needs.

Water Resources Data – Missouri; Annual Publication; USGS. Gage data at two to three locations below the Jordan Creek watershed.

Jordan Creek Baseline Water Quality Project – August 2004 to July 2005. Ozarks Environmental and Water Resources Institute and Missouri State University. This report describes the baseline water quality trends for the upper Wilson-Jordan Creek watershed.

Major Rainfall Events of 2000 – Springfield Missouri; 2000; Todd Wagner, PE., Engineering Division, Department of Public Works, City of Springfield, Missouri. Summarizes the rainfall events and flooding from the July 2000 rains.

Preliminary Report on Flood Damage Resulting From 7/12/2000 Rain Event; 2000; Todd Wagner, PE. Summary of the rainfall and flood damage that occurred during the July 12, 2000 rainfall event.

City of Springfield Inter-Office Memorandum: 634 E Phelps – Commercial Metal Property; 2008; Errin Kemper, PE. Department of Public Works, City of Springfield, Missouri., Memorandum on the reported flood depths at 634 E Phelps and 509 N Washington.

Lessons Learned – Flooding September 23-25, 1993 – November 1993. City of Springfield Missouri. Documents the lessons learned during the September 1993 floods.

2.5. **Historic Floods**

Records available to the City of Springfield indicate that the following flood events have occurred in the Jordan Creek watershed. Prior to the 1900's, major floods occurred in 1844, 1859, 1866, 1868, 1871, and 1876. The current large box culvert which carries the Jordan Creek through most of the downtown area was constructed in 1928, primarily as a response to the 1909 flood. Many of the other large box culverts and channels along Jordan Creek were constructed during the 1930s.

2.5.1. July 1909

The U.S. Weather Bureau recorded 6.55 inches of rainfall in 24 hours on July 7, 1909. The resulting flood was considered to be a landmark flood in later years. Newspaper articles stated that "the water was all over the Wilson and Jordan Creek bottoms" and that it was the "worst rain ever known in Springfield". Many people were rescued from the flood, but there were no human causalities. It was estimated that over 100 horses had drowned and damages to downtown businesses topped one-half million dollars.

2.5.2. June 1932

The precipitation on June 26-27 amounted to 6.8 inches in 24 hours with 3.4 inches occurring in a 2 hour period. Two persons drowned in streams in and near Springfield. The flood was the largest known flood up to that time on Jordan Creek. The peak discharge at the USGS gage on Wilson Creek was estimated to be about 3,600 cfs. It is assumed that the gage referenced in reports was located at Scenic Ave. The following are newspaper excerpts concerning the June 1932 flood at Springfield. *From the Springfield News Leader and Press – June 27, 1932*: "CITY SUFFERS HEAVILY IN FLOOD: CHIEF HAVOC ALONG THE JORDAN. Widespread damage from last night's sudden deluge and resulting floods were reported all day today. Chief damage was in the Jordan Valley, where everything was flooded, including homes and warehouses. Extensive, severe, and expensive damage to City streets was reported by the City Engineer…. In the offices of the Kelly Coal Company the water was 26 ½ inches above the floor, seven and a quarter inches higher than during the cloudburst of 1909."

2.5.3. July 1951

Total precipitation from this storm amounted to only 3.9 inches. However, 2.13 inches fell in one hour and 3.1 inches were recorded in a 3 hour period. The flood resulted in heavy damage along Jordan Creek. Water was over the platform of the Frisco freight station and was waist deep at the Hoffman-Taft plant on West Bennett Street. The following are newspaper excerpts concerning the July 1951 flood at Springfield. *From the Springfield News Leader and Press – July 4, 1951*: "HOLIDAY STORM BRINGS CITY FLASH FLOODS, HEAVY DAMAGE. Fickle weather last night and early today, sending rivers out of their banks; dashing Springfield with record rainfall and causing thousands of dollars of property damage….Jordan Creek ran out of its banks early in the night flooding numerous streets…leaving about a foot of water standing in the freight yards…Most extensive damage was caused at Hoffman-Taft, Inc., a pharmaceutical manufacturing plant…Hundreds of drums of valuable chemicals were carried away by the flash flood."

2.5.4. September 1993

Severe flooding occurred several times throughout September 1993, the most severe resulting from 8.3 inches of rainfall in 30 hours on September 24-25. With soil conditions already saturated from previous rains, the storms of September 24th and 25th produced massive flooding throughout the Jordan Creek watershed. The storm was categorized as a 100-yr flood and Greene County was declared a disaster area.

2.5.5. July 2000

On July 12, 2000, the Jordan Creek watershed received 6-8 inches of rain in approximately 6 hours (the majority of the rainfall occurring in a 2-hr timeframe), resulting in what appeared to be on the order of a 2% to 1% ACE event. The temporal distribution of this rainfall event appeared to match very closely to the Huff's 1st quartile distribution used for this hydrologic analysis. Floodwaters were 4 to 6 feet deep in some places and swept through at least 124 homes and displaced more than 100 people. The following day, city officials estimated at least $2 million in damages to public property including damages to roads and parks. Coal deliveries to the city's power plant were also delayed because of flood damages to railroad tracks (*Springfield News-Leader*, July 14, 2000). Immediately after the storm event, City crews collected photographs of a few of the high water marks left behind. These photos have allowed the City to compare flood heights from the 2000 storm with those produced by the hydraulic model. See Appendix HH-E and F for more information.

2.5.6. May 2002

On May 8, 2002 the Jordan Creek watershed received 3.47 inches of rain in approximately 6 hours (the total for the entire day was 4.72 inches). This storm was estimated at a 20% ACE event. The USGS gage estimated a peak flow of 4360 cfs while the HEC-1 model produced for this study indicates a 5-yr 6 hour peak flow of 4457 cfs.

2.5.7. September 2005

On September 15, 2005 the Jordan Creek watershed received 2.23 inches of rain in one hour. 3 hours later, the watershed received another 1.86 inches over a period of 1.5 hours. The USGS gage does not have a record of exactly when the river levels peaked compared to the rainfall event so it is difficult estimate the frequency of storm that caused the peak. However, given the response time of the watershed it is likely that the peak occurred during or after the second rainfall event. Since the HEC-1 model used for this study is a single-event simulation, it is difficult to make a reasonable flow comparison but it appears that the storm was on the order of a 50% to 20% ACE event with a short (1-2hr) duration.

2.5.8. June 2008

On June 13, 2008 the Jordan Creek watershed received 4.5 to 5.4 inches of rain over a period of about 8 hours. By 2008, the City of Springfield was operating a complex rain gage network across the city. The 4 gages located within the watershed indicated a storm with a 10% to 4% annual chance frequency. The USGS gage at Scenic Avenue along Wilsons Creek, at the downstream limits of the project, indicated a peak discharge of 5760 cfs. According to the hydrologic model produced as a part of this study, the corresponding peak flow rate should be between 5530 (10% ACE) and 6995 (4% ACE). In addition, field observations and flooding reports made during the June 13 have allowed the City to compare observed water surface elevations with those shown in the hydraulic study. See Appendix HH-F for more details.

3. **Without Project Hydrologic Modeling**

3.1. **Overview**

This report presents the results of a hydrologic modeling effort created by the City of Springfield in cooperation with the US Army Corp of Engineers. Each model was created using the Army Corp of Engineers HEC-1 flood hydrograph package and simulates the rainfall-runoff process for large storm events in the Jordan-Fassnight Creek watershed. Two separate models were created in order to simulate runoff for current land use conditions and expected ultimate development land use conditions. The *current* land use model reflects development in the watershed as of about 2003. This includes current impervious areas and all significant storm water improvements and detention basins. The *ultimate development* model is a variation of the current model with land uses projected to 2053 based on current zoning. More information on the development of these models is found below.

3.2. **Physical Watershed Parameters**

Each sub basin found in the HEC-1 model is defined as “an area contributing flow to the watershed”. Characteristics of each sub basin were input into the model in order to represent how the watershed responds to a rainfall event. In HEC-1, each watershed parameter is described on a “card” or line of code.

A GIS layer is available that shows the boundaries of each sub basin as well as information on the various characteristics of each. Each version of the model uses the same sub basin delineation. These sub basins are shown on Plate E.

3.2.1. Basin Statistics

The Table 1 includes the general statistics for each major watershed used in the model.

Table 1: Basin Statistics

	North Branch	South Branch	Lower Branch	Fassnight Creek
Number of Sub Basins	70	75	53	32
Total Area (acres)	2298	3239	2692	3531
Sub Basin Size Range (acres)	5.1 – 136.5	7.4 – 132.6	0.7 – 256.0	13.2 – 383.7
Sub Basin Mean Area (acres)	32.8	42.6	50.8	110.3

3.2.2. Area (BA Card)
The area for each individual sub basin in the model was calculated using ESRI's ArcMap software. Area for each basin is listed in both acres and square miles in the model input.

3.2.3. Overland Flow Elements (UK Card)
Most of the sub basins used in this model contain two overland flow elements. One element represents overland flow across the directly connected impervious areas found within each sub basin. The second element represents overland flow across the pervious surfaces within the sub basin. For each of these overland flow elements, an SCS Curve Number (CN) is defined in order to describe infiltration across the basin and to establish rainfall runoff volumes.

The length and slope of each overland flow element was estimated using the City's two-foot digital contours and digital aerial photos and represents an average value for each element in the sub basin.

A "Manning's roughness factor" for overland flow was used for each overland flow element. Typically, a roughness factor of 0.10 was used to describe the impervious flow element while a roughness factor of 0.20-0.25 was used to describe the pervious flow element.

3.2.4. SCS Curve Number and % Impervious (LS Card)

3.2.4.1 Current Development Model
For each type of overland flow element, an SCS Curve Number was defined in order to establish infiltration parameters. For the flow element representing impervious areas, a CN of 98 was chosen according to the SCS Curve Number guidelines. For the pervious overland flow element, a CN was used that best represented the pervious areas found in the watershed. CN values were determined using the City of Springfield's "Design Standards for Public Improvements" AMC II. This "pervious" CN was estimated through the use of an automated GIS procedure developed by the City of Springfield.

This procedure divides each watershed into a series of one-meter grid cells. Using infrared satellite imagery, the different color bands are manipulated so that each cell falls into one of three categories; tree cover (low reflectivity), w/o tree cover (med reflectivity), and impervious (high reflectivity). Each of these cells are then classified according to soil type, and land cover. A curve number is assigned to each grid cell according to this classification. Once a CN has been established for each cell, the average grid cell value is calculated over all of the pervious areas within a sub basin and a % impervious is calculated for all cells found to be impervious. The Table 2 shows the CN values used to calculate the composite CN for each basin. Appendix HH-A contains a table of all sub basins and their respective pervious Curve Numbers and % Imperviousness. The watershed is small urban and well defined which led the modeling to give a high degree of certainty (i.e. low uncertainty) with regards to the definition of the infiltration rates.

Table 2: Table of Curve Numbers

Grid Cell Classification	Curve Number
Impervious Areas	98
HSG B w/o Tree Cover	73
HSG B w Tree Cover	61
HSG C w/o Tree Cover	82
HSG C w Tree Cover	74
HSG D w/o Tree Cover	86
HSG D w Tree Cover	80
Compacted Fill w/o Tree Cover	86
Compacted Fill w Tree Cover	80

Future Conditions Model

For the future conditions model, GIS was used to find a percentage of imperviousness for each sub basin based on current zoning. A GIS layer was created that assigned a % impervious to each zoned area as well as each street and right-of-way. This layer was then used to assign a % impervious to each sub basin. Appendix HH-C contains values of % impervious used for each type of zoning. It should be noted that these values do not include streets and right-of-way. In other words: a zoning of R-SF (residential single family) may indicate an impervious value of 25% but with the streets included in the analysis, the overall impervious area for a totally R-SF sub basin will likely be around 40%.

In addition, for all pervious flow elements found in the model, the curve numbers used were 15% higher than those found in the current development model. This is an effort to simulate the effects of development (i.e. grading, compacting, sodding) on pervious areas. An industry standard when using the CN method is to increase infiltration one “letter grade” when the land is redeveloped. (B soils go to a C soil etc.) which equates to about 15 percent. It is a reasonable assumption to assume that there will be areas that redevelop more than other areas, but the soils in general will become more compacted during the period of evaluation.

3.2.5. Channel Flow Routing Elements

As part of the process of determining model parameters, the wave celerity output from HEC-1 was used as an estimate of runoff velocity in the modeled channels. Every channel section was checked during the modeling process to make sure the velocity estimate fell within a reasonable range (Usually 2-12 fps based on the slopes in this watershed). If a velocity was found to be too high or low either the channel’s geometry or roughness coefficient were modified accordingly. The modeler ensured that geometries and roughness coefficients fell within a range consistent from one sub basin to the next

Current Development Model

The channelized flow elements for each sub basin were determined by examining the information contained on the City’s GIS system. Aerial photographs and digital contours were used to estimate flow lengths, slopes, and geometry for each channel.

Manning’s roughness coefficients, as well as channel geometry, were established so that channel flow velocities would remain reasonable. While these parameters may not accurately reflect the physical geometry of the watershed, they force the kinematic wave and dynamic equations to more effectively model channelized flow during the overbank flooding condition.

Future Conditions Model

In an effort to simulate the effects of future stormwater conveyance on the watershed’s time of concentration, roughness factors for each of the channelized flow elements were reduced. The rational being that as a parcel of land develops, pipes and channels will be constructed that decrease the time it takes for water to move off-site.

A systematic procedure was used such that all channel roughness coefficients greater than 0.035 were reduced by 20%. In effect, this assumes that any “improved” channels will remain improved and any “rough channels” ($n > 0.035$) will be improved in the future.

3.2.6. Kinematic Wave Routing (RK Card)

For the overland flow elements and relatively short routing reaches in the headwaters, the Kinematic Wave equation was used to model channelized flow. While this method does not provide for attenuation of the flood wave, it is applicable in areas where flood storage is minor.

Overall, the use of Manning's roughness coefficients for channel flow was higher than those published for use with a "normal depth" type equation, simply because the kinematic wave equation produces higher velocities. However, the mannings n values were adjusted to produce a reasonable response time throughout each sub watershed.

3.2.7. Muskingum-Cunge Routing (RD Card)

For main channel routing in areas with a significant contributing watershed, the Muskingum-Cunge method is used with an 8-point cross section. In order to determine which reaches were to be modeled in this manner, the watershed was examined for areas with significant channel geometry as well as significant upstream drainage area. The Muskingum-Cunge procedure allows the use of multiple Manning's "n" values at different depths to better simulate peak attenuation during flood events. Each of these reaches were modeled using one of four representative 8-point cross sections; small, medium, large, and "downtown" (representing the large underground box culvert). Each channel was examined to determine which category it fit into and the corresponding 8-point cross section was used. The channel length and slope used was determined from the information available on the GIS. Cross sections of each of the three standard channel sections are included in Appendix HH-D.

3.2.8. Modified-Puls Routing (SV-SQ Cards)

For sub basins LJ34, LJ6, LJ2, LJ25, LJ8, LJ2, SJ27, SJ44A, SJ44B, SJ45, and NB58 the Modified-Puls method was used to better simulate peak attenuation due to large amounts of flood storage. These areas in the watershed were chosen because of the backwater effects caused by a nearby culvert or constriction. Using storage-flow values found in the HEC-RAS model, a relationship was built to route flow through each of these sub basins. Appendix HH-B contains a table of information used for each routing element. Some of these routing features provided very little attenuation of the flood hydrograph while others caused a significant decrease in peak flow.

3.2.9. Reservoir Routing Elements

Areas of detention within a watershed are one of the primary factors affecting the rainfall-runoff response. These detention areas include local detention basins, regional (in-line) detention basins, and areas of ponded water behind highway and railroad culverts.

The occurrence of debris in the waterway has very little impact on peak flows. The watershed is primarily urban with comparatively little woody vegetation adjacent to the waterway. Property owners are required to maintain detention basins and keep them functioning. Occasionally, clean out of debris from a culvert or pipe occurs, but the storage behind these structures is insignificant and does not impact overall peak flows (if the culvert backs up, the water just runs overland).

Elevation vs. Storage (SA and SE Cards)
The elevation-storage relationship for each reservoir routing element was determined from the City's digital two-foot contour maps. The area of each closed contour within a basin was calculated and entered into the HEC-1 model.

Elevation vs. Outflow (SQ and SE Cards)
The elevation-outflow relationship for each reservoir routing element was typically determined from field measurements of the controlling outlet structure. However, when as-built construction plans were available, they were used to develop the outflow-rating curve.

Future Conditions Model
The City of Springfield's Stormwater Detention Ordinance requires that all new development provide detention such that peak flows leaving the site do not increase. In an effort to simulate this in the *ultimate development* model, a number of "mock" detention basins were added at various locations. Each of these basins represent probable locations for on-site or regional detention as the watershed develops. A total of 38 "mock" detention basins were placed downstream of areas that showed significant amounts of potential development. Each of these basins were designed so that peak flows for the 1-, 10-, and 100-yr events matched the "current development" model at the same location. Many of these "fake basins" were placed downstream of small sub basins, but most were representative of regional detention and covered larger areas.

Nearly all potential development was accounted for using a "fake basin". However, in areas with small development potential or areas along the stream where the local ordinances would not require detention, basins were not included. As expected, the peak flows immediately downstream of each mock basin matched that produced in the current conditions model. However, the increase in runoff volume produced by additional impervious area (development) causes an increase in peak flows throughout each stream.

3.2.10. Sinkholes
Much of the South Branch of Jordan Creek contains sinkholes. Approximately 20% of this watershed contains sinkholes that do not overflow during a 1% ACE event and therefore do not contribute flow to the rest of the watershed. However, there are many sinks that do fill up during a rainfall event and eventually spill into a nearby sink or drainage way. These sinkholes were modeled in HEC-1 as a series of reservoirs. The depth-volume relationship was calculated using the City's 2' digital contour data and the depth-outflow characteristics were estimated using broad-crested weir equations to simulate sinkhole overtopping. The model contains all of the sinkholes that contribute flow to Jordan Creek as well as a few that do not overtop.

3.3. Rainfall Data
The HEC-1 models were set up using a single-event simulation of a synthetic rainfall event. The rainfall data used for each HEC-1 model is from the "Rainfall Frequency Atlas of the Midwest" by Floyd A. Huff

and James R. Angel. This report was prepared in conjunction with the Midwestern Climate Center and the Illinois State Water Survey. The City of Springfield feels that the information contained in this report provides an accurate representation of the types of storms seen in this area.

3.3.1. Depth

The depth of rainfall for each simulated storm was taken from Table 7 of the Rainfall Atlas of the Midwest - "Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years in Missouri." The entire table can be found in Appendix HH-H of this report. Tables 3-5 are a summary of this data.

Table 3: Duration vs. Depth of Rainfall

Storm Duration	1% ACE Rainfall Depth
24-hr	8.18
18-hr	7.69
12-hr	7.12
6-hr	6.14
3-hr	5.24
2-hr	4.74

For rainfall frequencies other than the 1% ACE, a fraction of the total 1% ACE rainfall depth was determined using Table 4.

Table 4: Frequency vs. % of Total 100-yr Depth

Frequency (yr)	% of Total 100-yr Depth
1	0.37
2	0.46
5	0.59
10	0.68
25	0.80
50	0.90
100	1

Table 5: Hypothetical Design Storm Precipitation

Hypothetical Design Storm Precipitation [in]								
Duration [hrs]	Recurrence Interval [yrs]							
	1	2	5	10	25	50	100	500
3	1.94	2.41	3.09	3.56	4.19	4.72	5.24	6.39
6	2.27	2.82	3.62	4.18	4.91	5.52	6.14	7.49
12	2.61	3.28	4.17	4.84	5.71	6.40	7.12	8.69

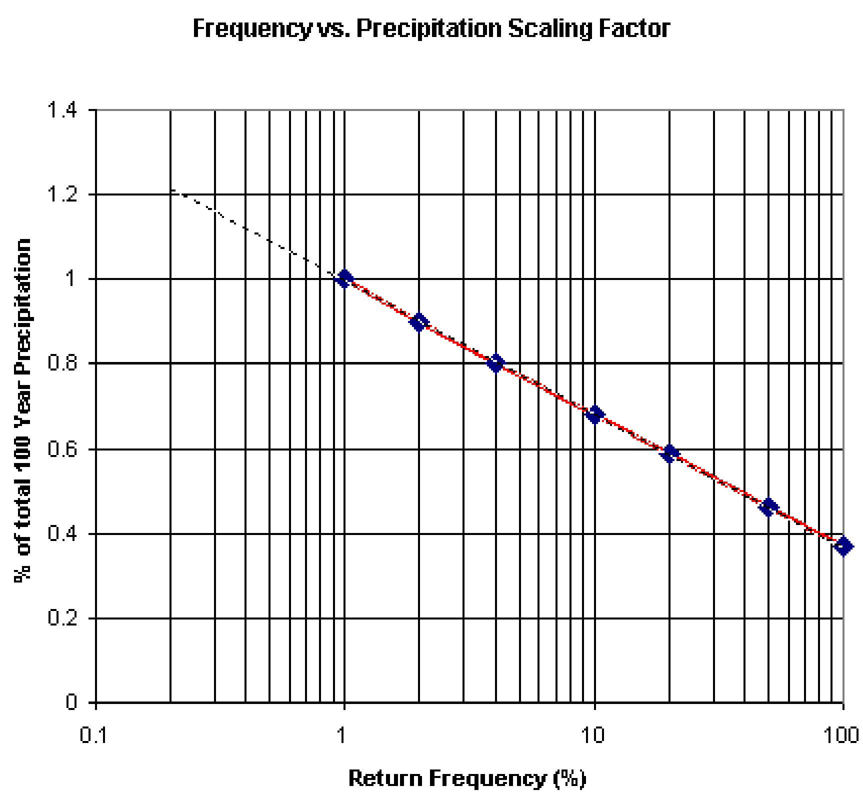
In addition, fractions of the 1% ACE rainfall depths found in table 4 were computed and used as the basis for extrapolating the 0.2% ACE rainfall depth which was found to be 122% of the 1% ACE event. Tables 6 displays this information.

Table 6: 500-yr Storm Extrapolation

The following information is from the "Rainfall Atlas of the Midwest" and was used to estimate the 0.2% ACE storm event

Recurrence interval	% Probability	% of 1% ACE event
1	100	0.3672
2	50	0.4609
5	20	0.5859
10	10	0.6797
25	4	0.8021
50	2	0.8984
100	1	1
500	0.2	

0.2% ACE event estimated at 122% of 100 year total rainfall



3.3.2. Duration

Simulations of the 2-hr, 3-hr, 6-hr, 12-hr, 18-hr, and 24-hr storms were performed using HEC-1. For each flow rate used in the HEC-RAS model, the largest peak flow rate simulated from each of these storms was used. However, due to the inability of a small duration storm to produce rainfall over a large area as it is simulated in the HEC-1, the 2-hour storm became inapplicable for a drainage area greater than 1.5 square miles. For the same reason, the 3-hour storm became inapplicable for a drainage area greater than 10 square miles.

3.3.3. Distribution

The distribution of each storm was taken from the "Rainfall Atlas of the Midwest - Table 10. *Median Time Distributions of Heavy Storm Rainfall at a Point."* Figure 1 is an illustration of these distributions. The City of Springfield recommends the use of these rainfall distributions in its design criteria manual. It has also been observed that many of the major rainfall events in this area tend to follow these distributions closely. The 1st Quartile distribution was used for all storms with duration of 1 to 6 hours. The 2nd Quartile distribution was used for all storms with a 12-hour duration and the 3rd Quartile distribution was used for all storms with 18 to 24 hour duration.

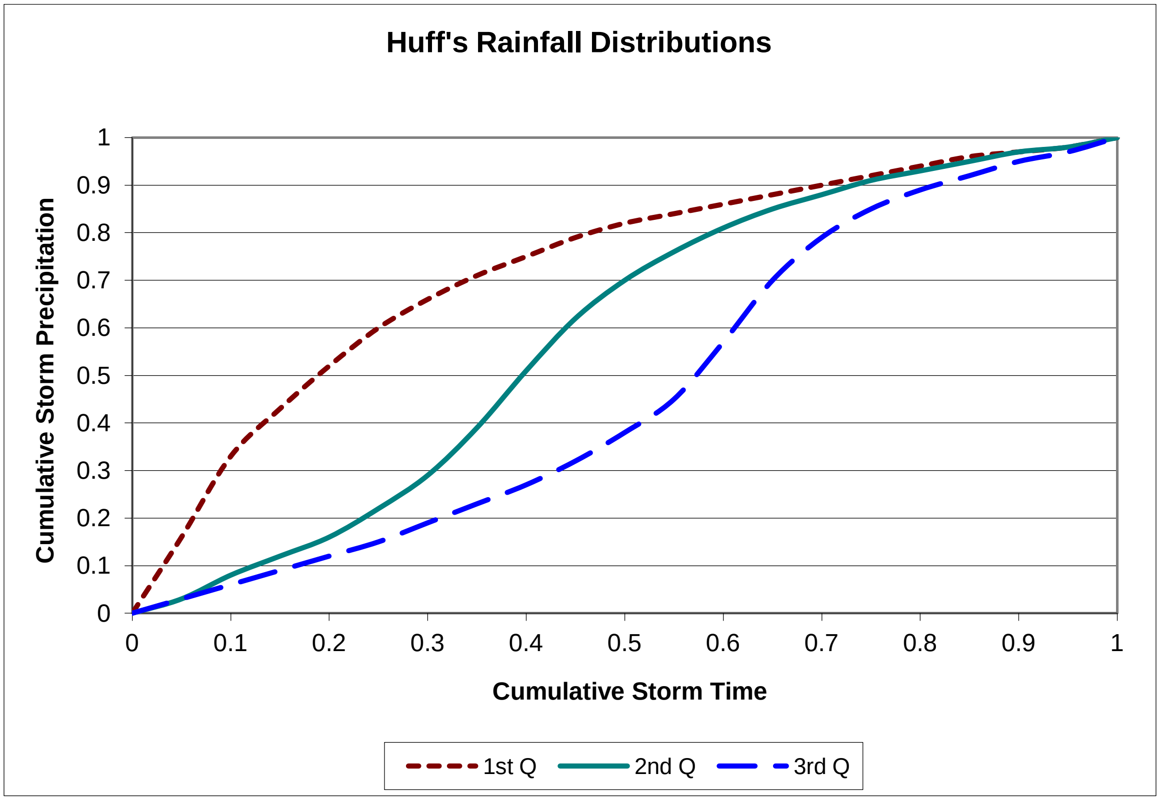


Figure 1: Huff's Rainfall Distributions

3.4. **Flow Analysis Results**

For each location in the watershed corresponding to a point in the hydraulic model, flows were determined for each frequency-duration combination. These results are summarized in Plate A. In addition, Appendix HH-F shows how flows from the HEC-1 model compare to the USGS Gage at Scenic Avenue located just downstream of the project area on Wilsons Creek.

4. **Without Project Hydraulic Modeling**

4.1. **Overview**

This HEC-RAS model was created as part of the USACE Jordan Creek Feasibility Study and includes all of Jordan Creek as well as portions of Fassnight Creek and Wilsons Creek. Included in Appendix HH-G of this report is photographic documentation of each reach as of October 2005.

4.1.1. Jordan Creek

Jordan Creek is a classic urban stream throughout most of its length. The upstream reaches consist of grass ditches with small culverts capable of carrying the 100% to 50% ACE events. The mid section of each reach includes concrete and natural channels, some regional detention, larger culverts capable of conveying the 20%-10% ACE event, and a number of very long tunnel reaches with varying capacity. The downstream portion of this stream is mostly natural channel with an assortment of conveyance improvements, bridge and culvert structures, and grade controls such as culverts and utility crossings.

4.1.2. Fassnight Creek

Fassnight Creek is primarily a natural urban stream with an assortment of culverts, utility crossings (i.e. grade controls), and channel improvements. Near the downstream end of the reach is a small lake that serves as an in-line regional detention basin. While Fassnight Creek is included in the hydraulic model, the reach is not a formal part of this study.

4.1.3. Wilsons Creek

The portion of Wilsons Creek included in this study is a natural urban stream with a gravel bed and very few man-made obstructions in the overbank areas. This reach includes two bridge structures and no channel conveyance improvements.

4.2. **Spatial Geometry**

The HEC-RAS model extends throughout the Jordan Creek and Fassnight Creek watersheds as well as a portion of the Wilsons Creek watershed. The extents of the detailed hydraulic modeling are included in Table 7 below.

Table 7: Stream Hydraulic Study Limits

Stream	Upstream Limit	Downstream Limit	Total Length
Jordan Creek – North Branch	40-ft downstream of Packer Rd.	Confluence with Jordan Creek – South Branch	18,653 ft (3.5 mi)
Jordan Creek – South Branch	200-ft upstream of Burton Ave.	Confluence with Jordan Creek – North Branch	14,475 ft (2.7 mi)
Jordan Creek – Lower Branch	Confluence with Jordan Creek North and South Branches	Confluence with Fassnight Creek	16,695 ft (3.2 mi)
Fassnight Creek	Fassnight Park 530-ft downstream of Campbell Ave.	Confluence with Lower Jordan	11,358 ft (2.2 mi)
Wilsons Creek	Confluence of Jordan Creek – Lower Branch and Fassnight Creek	1970-ft downstream of Scenic Ave.	3,963 ft (0.75 mi)

The HEC-RAS model is made up of a total of eleven different reaches representing the five streams and two major tunnels. There are a total of 553 cross sections, 63 bridges and culverts, and 2 lateral structures. Figure 2 shows the reach connectivity.

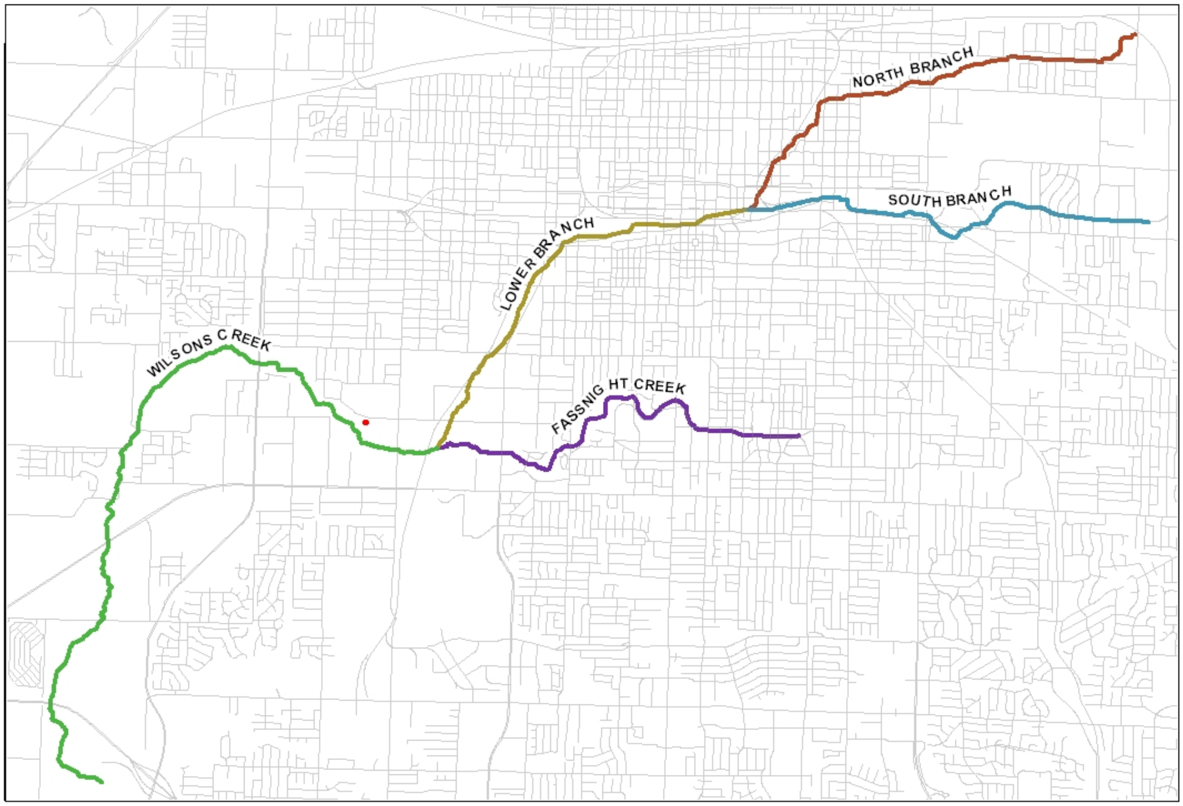


Figure 2: Reach Connectivity

4.3. **Hydraulic Model Parameters**

This model was created using HEC-RAS 3.1.3 as well as ESRI's ArcGIS. Many of the parameters used to build this model were processed in GIS before being imported into HEC-RAS through the use of HEC-GeoRAS.

4.3.1. Cross Section Geometry

The first step in building this model was to create a shapefile in GIS showing the proposed location of each cross section. This preliminary layout was sent to the USACE for review and discussion. Once the layout was finalized, the City of Springfield hired Landmark Surveying and Consulting, LLC to perform a very detailed survey of the study reaches. The City supplied Landmark Surveying with a map showing the location of all proposed cross sections (see Plate B). For each cross section, the surveyor was instructed to acquire elevation data at the top of bank, toe of bank, flow line, and any significant change in channel geometry. In addition, the survey was to include detailed drawing of all bridge and culvert structures. Once the survey was complete, Landmark Surveying provided the City with the following data: an electronic file containing the location of each survey point found within the stream channel; detailed drawings and measurements of all stream crossings, and a detailed drawing of the three major tunnel sections.

This digital data was imported directly into GIS as a series of points with elevation attributes. Since these points were surveyed at a specific location along the channel, they were placed in GIS at, or very near, the location of the cross section shapefile. Therefore, the next step was to slightly modify each cross-section so that it intersected each survey point at the proper location. This step was taken to ensure that once the elevation data was extrapolated from the TIN, the exact survey points would be used.

TIN Creation

In general, the detailed survey only included areas within the channel banks. GIS was used to create a 3D polyline shapefile (parallel to flow) that connected all points designated as a bank station. This resulted in a shapefile that encompassed all of the survey data. The next step was to create a TIN of the survey data using the imported points and the 3D boundary line as the source data. A TIN encompassing the entire cross section length was also created using the digital 2-foot elevation data available to the City based on a photogrammetric flight from 1999. The 3D polyline created from the survey was also included as data for this TIN. The 2-foot TIN was clipped by the 3D polyline and merged with the survey TIN. Since both TINs were created using the 3D polyline, there was a seamless transition between the two TINs when the data was merged. The result was a TIN file that included 2-foot contour data in the overbank areas and survey data in the channel.

Elevation data was extrapolated from the TIN at each cross section using HEC-GeoRAS. In addition, all downstream flow lengths were also calculated using GeoRAS.

Bank Elevations

When the station-elevation data was first extrapolated from HEC-GeoRAS, the bank stations were set according to the attributes assigned by the survey data. However, in order to create a more consistent channel section from one cross section to the next, many of these bank stations were adjusted in RAS.

4.3.2. Culvert Geometry

The stream survey included detailed elevations of the road deck at each stream crossing. A shapefile of bridge locations was created depicting each overflow cross section. Using this information, road deck elevations were extrapolated from a TIN in much the same way as the cross section data. Then, using the detailed drawings supplied by the surveyor, the bridge or culvert details were entered into HEC-RAS individually.

4.3.3. Tunnel Geometry

There are four major tunnels in the watershed: “Jordan Underground” on Lower Jordan, “Fremont to National” on South Branch, the “Tindle Mills tunnel” and a tunnel beneath the railroad tracks just downstream of Tindle Mills on North Branch. Each of these tunnels were surveyed in detail and included in the model as described below.

Tindle Mill Tunnel and Downstream Railroad Tunnel

The Tindle Mill tunnel is about 500 feet long; the railroad tunnel just downstream is about 300 feet long. Both were modeled as cross-sections with lids to better account for overland flow. The Tindle Mills tunnel is a 9'x9.3' culvert at the upstream end, opening to as large as 15'x14' as you move downstream, then contracting to 9'x9.7' at the downstream end. The tunnel opening portion of the lidded cross-sections was modeled at 9'x9.3' for its entire length under the assumption that this is likely the controlling section. The downstream tunnel under the railroad tracks consists of two 8.4'x8.4' barrels at the upstream end which transition to a single 10'x9.5 foot barrel about midway of the tunnel. The tunnel opening portion of the lidded cross-sections was modeled at 10'x9.5' assuming that this sections controls. The overtopping conditions were dictated by the overland portions of the cross sections and included significant blocked obstructions representing buildings in the flowpath.

Jordan Underground

The Jordan Underground tunnel starts at the confluence of the North and South Branches and travels through downtown 3354-ft to a point just upstream of Main Ave. The dimensions of this tunnel vary greatly throughout its length and as a consequence, the tunnel was modeled as a stream section with a lid. The lid was placed such that the water surface would not exceed the elevation of the lid; therefore the cross section area and wetted perimeter represent the actual geometry. While the flow through the tunnel was modeled in one reach called "Jordan Underground" the overland flow was modeled in another reach called "Lower Branch 2". This reach represents the flows as the box is overtopped.

Fremont to National Tunnel

This tunnel is located on South Branch of Jordan Creek and starts just downstream of Fremont Ave and extends 1643-ft downstream to National Ave. This box varies significantly throughout its length and contains a number of utility crossings that impede flow. As a result, the tunnel was modeled as a separate reach much like Jordan Underground. In this case, flow through the tunnel was modeled in a reach called "Fremont Box" and the overland flow was modeled in a separate reach called "South Branch 2".

4.3.4. Flow splits and junctions

This model includes six different flow splits and junctions occurring at each stream confluence and at each end of a tunnel reach. For a flow split, in order to properly quantify the flows through the structure, an initial estimate was made regarding the capacity of the tunnel at various flood frequencies. Then, the "optimize flows" option was checked in the model. Flow optimizations at junctions are performed by computing the water surface profiles for all of the reaches, then comparing the computed energy grade lines for the cross sections just downstream of the junction. If the energy in all the reaches below a junction is not within a specified tolerance (0.1 feet), then the flow going to each reach is redistributed and the profiles are recalculated. This methodology continues until a balance is reached. For each stream junction, the backwater analysis for each upstream cross section begins from the downstream section in the junction. Due to the connectivity of the study stream, the only downstream boundary condition needed for this model was for the Wilsons Creek reach. Flow optimization, as described above, was performed for the Current Conditions without Project HEC-RAS model. From this analysis, a rating curve of box capacity through the Jordan Creek Underground section and the Fremont Box was established and used to set peak flows for all subsequent models. The resulting rating curves can be found in Appendix HH-M.

4.3.5. Roughness coefficients

Roughness coefficients for each cross section were determined from aerial photos and digital field photos. Initially, all roughness coefficients were extracted from GIS using GeoRAS. This resulted in a number of horizontally varying coefficients across each section. Per advice from the USACE, the number of coefficients used for each section was greatly reduced. For most cross sections, three roughness coefficients were found to represent the channel and each overbank for the reach downstream of the cross section. In some areas where the overbank roughness varied significantly with water surface elevation or the channel was not clearly defined, multiple roughness coefficients were input that vary horizontally.

4.3.6. Ineffective Flow Areas

There were three instances where IFAs were used in this model: areas downstream of buildings (shadows), areas within a channel or overbank where it was determined to not actively convey flow, and areas around bridges and culverts that did not actively convey flow.

Building Shadows

Using GIS, a shapefile was created representing the ineffective flow area behind each building. This generally resulted in a triangular shaped polygon. The location of these IFAs was extrapolated out of GIS using HEC-GeoRAS.

Channel and Overbank IFAs

IFAs were entered at various locations throughout the model where it was determined that a section of the channel or overbank did not actively convey flow. This was usually due to a geometric constraint either upstream or downstream of the cross section. An example of this can be seen on North Branch at RS 4286 where an IFA was used so that a tributary channel was not used to convey flow. IFAs were also used in some circumstances where a utility crossing was not addressed with an in-line structure.

Bridge and Culvert IFAs

When applicable, IFAs were used around bridge and culvert structures to indicate portions of the cross section that did not actively convey flow. It was generally assumed that flow contracted at a 1:1 ratio upstream of a structure and expanded at a 4:1 ratio downstream of a structure.

4.3.7. Blocked Obstructions

When the finished floor elevations along the stream were surveyed, a shapefile was created depicting the boundary of each structure. This shapefile was used by Geo-RAS to mark the location of each blocked obstruction. This generally included buildings only, whereas any obstruction caused by fences, trees, cars, etc was accounted for with roughness coefficients.

4.3.8. Interpolated cross sections

Interpolated cross sections were created at various locations in the model. Generally, this was done to better represent a transition between two cross sections. Specific examples of interpolated cross sections are described under "Special Conditions".

4.3.9. Calculation Tolerances

The default calculation tolerances in HEC-RAS were modified for the "Current" and "Ultimate Development" plans. The following changes were made: 1) the maximum number of iterations was increased from 20 to 30, 2) the maximum number of iterations used for split flow was decreased from 60 to 20, 3) the maximum difference in junction split flow was increased from 0.02' to 0.05'.

4.3.10. Special Conditions

In order to model the flow conditions effectively, a number of unique methods were used. These are independently described below.

Confluence at North and South Branch

A "natural ground" lateral weir was used just upstream of the confluence of North and South Branches to model high flow interchange of flow between the branches near the confluence.

Upstream Section of North Branch

The detention basin upstream of RS 16820 was included in the RAS model. An inline structure was used to model the uncontrolled outflow and the profile elevations through the pond verified against the HEC-1 routing results.

Jordan Creek Improvements Phase 1&2

In 2006-2007, a large section of North Branch between National Avenue and Fremont Avenue (immediately downstream of RS 6990) was modified to reduce flooding and improve the neighborhood. The old concrete box culvert has been removed and an open channel was constructed. Once the project was complete, an as-built survey was used to update the HEC-RAS model in this area to reflect the new improvements.

Lower Jordan at Kansas Exp

Each cross section of Lower Jordan Creek between RS 5689 and RS 3859 includes the main channel and floodplain to the west of Kansas Expressway and the ditch to the east of Kansas Expressway. A left levee was used to accurately reflect flow conditions in this reach since Kansas Expressway in this reach does not overtop.

Lower Jordan South of Bennett

An industrial facility is located in the right overbank of this area and is protected by a concrete floodwall. This wall is included in the surveyed cross sections. Ineffective flow designations and increased n-values were used to simulate the flow restriction due to congestion in the industrial facility behind the flood wall. A lateral weir was used in the right overbank to model movement of high flows across the railroad track embankment and Bennett Street west of the railroad embankment. Flow leaving across the lateral weir re-entered Wilsons Creek just downstream of the railroad embankment.

Changes in Water Surface Elevation

In some locations throughout the model, certain profiles would default to critical depth when an elevation could not be found within the specified tolerance. At these locations, the water surface elevation was manually set to a reasonable elevation, often defined by the bounding profiles. This approach allowed the model to produce a set of smooth and reasonable profiles. When comparing two sets of profiles for FDA (for example Current vs. Future Flow conditions) each cross section was checked to make sure that a lower peak flow did not result in a higher water surface elevation. When these instances occurred, the profile with the lower peak flow was manually adjusted to produce a lower water surface. These instances were very few and minor in nature, usually on the order of a 0.01', and did not significantly affect the results.

4.3.11. Water Surface Profiles

Water surface profiles for each simulation are included in Plates C & D.

4.4. Steady Flow Data

The HEC-1 and HEC-RAS models were examined in order to determine the best places to perform a flow change in the RAS model. These points are shown in a shapefile called "HEC-1 Points of Interest" and each flow rate is listed in an Excel spreadsheet table included in Plate Series A – Flow Data Tables. The Ultimate Conditions Model and the Current Conditions Model share the same stream geometry and differ only in the flows simulated.

4.4.1. Current Flow Conditions

This represents flows from the HEC-1 model titled "JRDFSNT.HC1". These flowrates represent the watershed under 2003 (approximately) development conditions.

4.4.2. Future Flow Conditions

This represents flows from the HEC-1 model titled "JRDFSNTU.HC1". These flowrates represent the watershed under estimated ultimate development (2053) conditions.

4.5. Risk and Uncertainty Analysis

EM 1110-2-1619, *Risk Based Analysis for Flood Damage Reduction Studies*, August 1, 1996 requires that an uncertainty analysis be performed for Flood Damage Reduction Studies. For this study, the current conditions model was modified by raising the roughness coefficients by a set percentage. All channel roughness was increased by 40% (i.e. a coefficient of 0.05 was increased to 0.07), all overbank coefficients were increased by 33% (i.e. a coefficient of 0.12 was increased to 0.16) and all tunnel sections were increased by 10%. These increases were based on a reasonable range of "n" factors for each section type and appear to give reasonable results. After looking at the options, the City settled on this approach because they didn't want the results to be influenced by judgment at a particular portion of the stream. The resulting water surface profiles are smooth and appear to be reasonable.

The current conditions model was also modified by reducing all roughness coefficients by 40%. Based on earlier comments by the Corps, the City did not expect a set of reasonable profiles. However, in most places, they were better than expected. There were still quite a few crossing profiles and errors. As a result, all positive changes in WSE (where lower n factors provided a higher WSE) were excluded from the sample.

Appendix HH-J indicates the "SD of Error" for each stream reach. At every cross section at each reach, the WSE from the current model was compared to the WSE for the two modifications mentioned above. The standard deviation of "error" was found for 1) each profile in each reach, 2) all profiles in each reach. The SD was calculated using the following formula:

$$\sqrt{\frac{\sum (x-\bar{x})^2}{n}}$$

It was assumed that the data studied made up the entire sample.

Also included in this analysis is the "Stage where error becomes constant" for each reach. Appendix HH-J contains graphs showing how the standard deviation of error for each reach corresponds to each profile. Based on this analysis and discussions between the City and USACE, it was determined that the 10% ACE (10-yr) profile is the stage where error becomes constant.

4.6. Summary of Conclusions

The results of this hydraulic analysis were compared against historic stream gage data in an effort to check for reasonableness. Results of this comparison are found in Appendix HH-F. Overall, the water surface profiles calculated by HEC-RAS compare reasonably well with historic flood levels.

The HEC-1 created as a part of this study included simulations of both the Current and Future development conditions. As expected, anticipated development produces an increase in peak flow throughout the watershed. This increase ranged from 3.0% to 32.7% in the North and South Branches of Jordan Creek. Overall, the greatest potential impact of development occurs on South Branch. Downstream of the North and South Branch confluence, peak flow increases are on the order of 10%. See Plate A for a comparison of peak flows throughout the modeled area.

The HEC-RAS model was used to simulate the change in water surface elevations as a result of anticipated development. Table 8 summarizes the change in the 1% ACE water surface due to potential development in the watershed. See Plates C & D for the hydraulic profiles.

Table 8: Change is Water Surface Elevation (WSE) due to Developement

Average Change in WSE	0.25
Median Change in WSE	0.21
Standard Deviation in WSE	0.21
Max Change in WSE	1.26

Since settlement first occurred along the Jordan Valley, this stream has been the source of severe flood losses. This analysis clearly shows that the flooding along Jordan Creek will continue to become worse if left unchecked. In addition, with the flood hazards reduced and the aesthetic attributes improved, this stream has the potential to become a great asset to the community.

5. With Project Hydrologic Modeling

5.1. Regional Detention Analysis

In order to determine the effectiveness of regional detention basins throughout the watershed, the HEC-1 model was modified to include a number of proposed detention basins.

5.1.1. Preliminary Analysis

Initially, 24 different sites were selected throughout the watershed as possible locations for regional detention. Figure 3 shows the location of these sites.

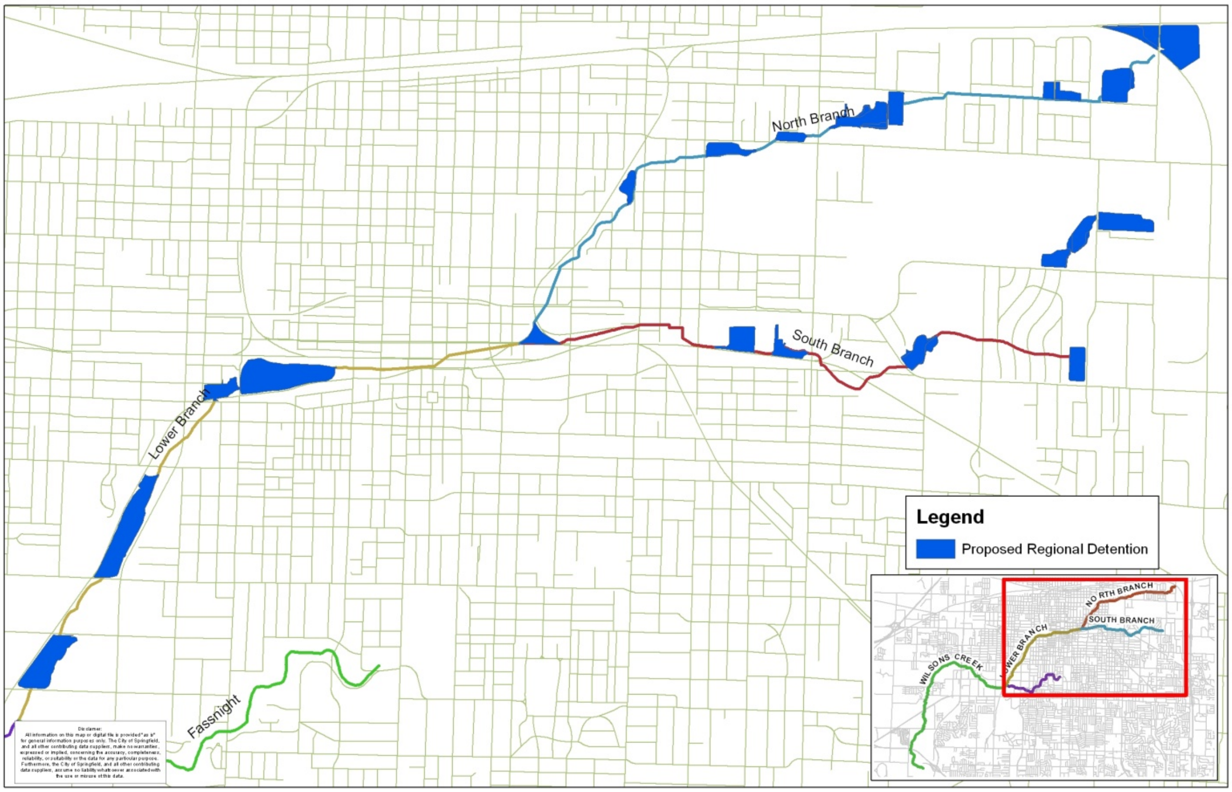


Figure 3: Preliminary Regional Detention Basins

The Current Conditions HEC-1 model was modified appropriately and each detention basin was designed to maximize effectiveness while remaining within reasonable vertical and horizontal limitations. Once this initial analysis was complete, each basin was examined to determine the potential flow reduction. Basins were analyzed both individually and in series with other basins. Appendix HH-K gives a summary of each preliminary basin and outlines the peak flow reduction immediately downstream as well as the specific design constraints. Many of these basins could not be made large enough to have a significant impact on peak flows. This was especially true as the contributing watershed increased. From this analysis, it was determined that nine basins had the potential to significantly reduce peak flows under both current and ultimate development conditions.

5.1.2. Refined Analysis

Based on the preliminary analysis, it was determined that nine regional detention basins have the potential to significantly reduce flows along Jordan Creek. Figure 4 shows the location of each of these basins. In addition, some of these basins (B11 & B11A) were modified to preserve riparian vegetation and in one case (B6B) a similar basin was analyzed in a new location.

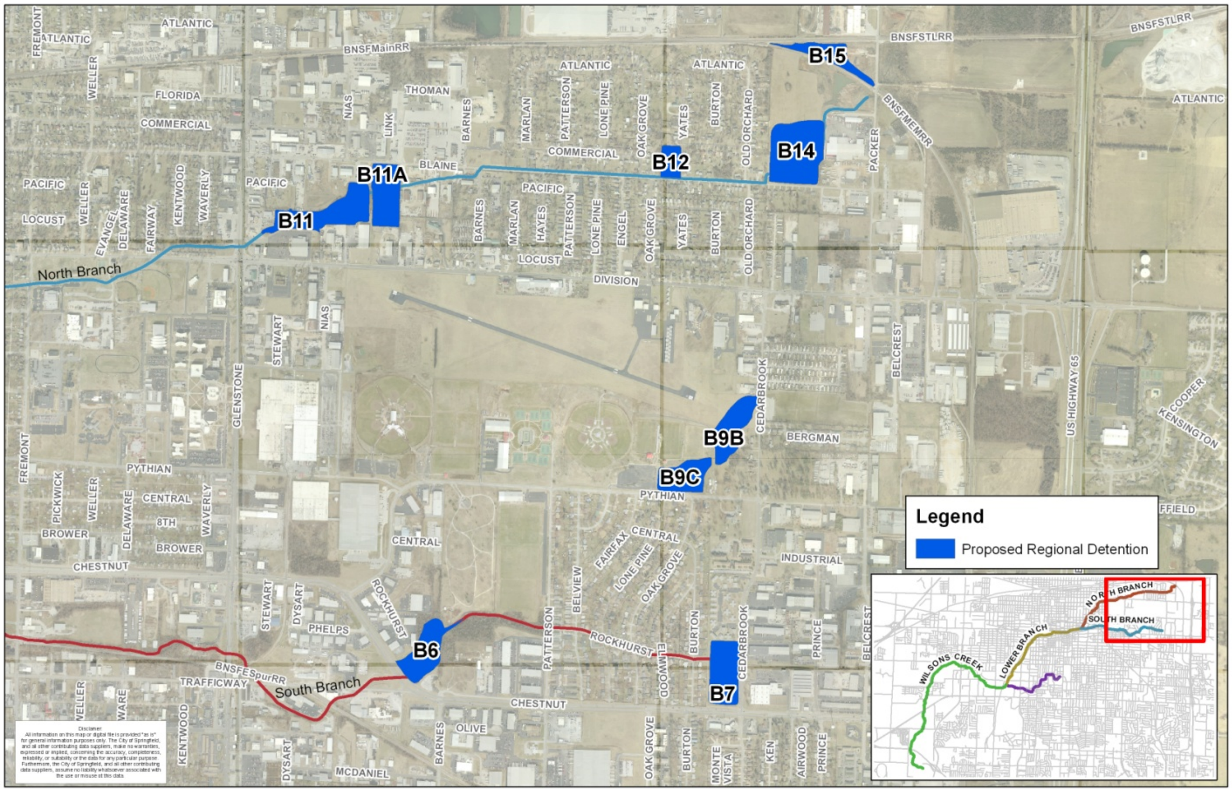


Figure 4: Regional Detention Basins (Refined Analysis)

5.1.3. Current Conditions

For the Current Conditions with Regional Detention Analysis, peak flows from the HEC-1 model JRDFSNTX.HC1 were entered into the HEC-RAS model. The geometry remained unchanged from the existing conditions geometry.

Special Conditions

South Branch – Glenwood Basin to Patterson Ave.

The proposed regional detention basin B7 includes two 42" RCPs that extend from the basin outlet, along Rockhurst Street, to Patterson Ave. According to the detention basin rating curve found in the HEC-1 model, these pipes carry 130-161cfs during a storm event. Since these flows will be contained in a pipe, the corresponding flows were subtracted from the peak flows found in the HEC-RAS model which only simulates the remaining channel. To facilitate this removal, a flow change location was added at RS 12079 (proposed pipe discharge location) and estimated pipe flows were removed from the modeled flows at RS 14475 & 12585. This change will adequately simulate the overflows from the proposed detention basin.

North Branch – Blaine Street

The proposed detention basins B14 and B12 would likely require construction of a 42-48" RCP along Blaine Street to carry discharge from the basins. These pipes would have a larger capacity than the existing channel. The HEC-RAS model assumes that the existing channel will be carrying the resulting flows from these basins and the water surface elevations reflect this. In reality, if pipes were constructed, the 1% ACE flow could be contained in the pipe and damages along Blaine Street (Damage Reach N11 and N12) would be greatly reduced. These damage reaches are outside of the federal limits pertaining to this study.

Jordan Underground

In order to properly simulate the existing capacity of the large system, the HEC-RAS model was ran using the flow optimization on the upstream junction of "Jordan Underground". The calculated capacity of the box for each storm event was then entered as the peak flows to "Jordan Underground". These peak flows were subtracted from the flows found for Lower Branch 2 and the result was an estimate of overland flows through this reach.

In-line Structures

In some locations there are in-line structures included in the HEC-RAS geometry to simulate flow over an existing detention basin control structure. If regional detention is constructed in these locations (i.e. the existing basin is expanded) the resulting in-line structure will likely be somewhat different. However, comparing the WSE at these locations with the WSE in the proposed regional detention model shows the two to be comparable. Therefore, the in-line structures were not modified and the "current conditions" geometry remains unchanged from that used in the current conditions model.

5.1.4. Future (Ultimate Development) Conditions

For the Future Conditions with Regional Detention Analysis, peak flows from the HEC-1 model JRDFSNTZ.HC1 were entered into the HEC-RAS model. The geometry remained unchanged from the existing conditions geometry.

Special Conditions

South Branch – Glenwood Basin to Patterson Avenue

In the Current Conditions model, peak flows were decreased in this area to simulate the two pipes needed for basin B7. The Future Conditions did not account for the potential underground piping system. It is anticipated that this will cause an increase in damages through this area, above what would be expected. However, this damage reach (S10) is outside of the federal limits pertaining to this study.

North Branch – Blaine Street

The proposed detention basins B14 and B12 would likely require construction of a 42-48" RCP along Blaine Street to carry discharge from the basins. These pipes would have a larger capacity than the existing channel. The HEC-RAS model assumes that the existing channel will be carrying the resulting flows from these basins and the water surface elevations reflect this. In reality, if pipes were constructed, the 1% ACE flow could be contained in the pipe and damages along Blaine Street (Damage Reach N11 and N12) would be greatly reduced. These damage reaches are outside of the federal limits pertaining to this study.

Jordan Underground

In order to properly simulate the existing capacity of the large system, the HEC-RAS model was ran using the flow optimization on the upstream junction of “Jordan Underground”. The calculated capacity of the box for each storm event was then entered as the peak flows to “Jordan Underground”. These peak flows were subtracted from the flows found for Lower Branch 2 and the result was an estimate of overland flows through this reach.

In-line Structures

In some locations there are in-line structures included in the HEC-RAS geometry to simulate flow over an existing detention basin control structure. If regional detention is constructed in these locations (i.e. the existing basin is expanded) the resulting in-line structure will likely be somewhat different. However, comparing the WSE at these locations with the WSE in the proposed regional detention model shows the two to be comparable. Therefore, the in-line structures were not modified and the “current conditions” geometry remains unchanged from that used in the current conditions model.

A simplified analysis of each basin was performed to determine each basin’s impact on peak flows throughout the watershed. This analysis included an examination of the 2 hr 1% ACE peak flow immediately downstream of each basin (at the next downstream hydrograph combination) as well as an assessment of the impact throughout the project reach. Flow points were assessed at Glenstone Ave and Central Street on the North Branch, Chestnut Expressway and Fremont Ave on the South Branch, the confluence of North Branch and South Branch (upstream end of the downtown reach), and Catalpa Street on the Lower Branch. Results of this study are found in Appendix HH-L and summarized in the “Conclusions” of this section. Plate F shows each proposed regional basin in detail.

Basin B15

This regional detention basin is located along North Branch of Jordan Creek just north of the RR tracks near Packer Road. This area currently ponds water during a storm event and discharges through a 30-inch pipe. The proposed basin would require the excavation of additional material and a new 12-inch RCP outflow pipe. Design assumptions include:

- Current 1% ACE water surface elevation will not increase such that it does not encroach additionally on RR right-of-way.
- The remaining adjacent lot will be developable.
- The storage area currently fills to Elev 1380+ and spills over to the west.
- In order to add a 12” RCP at a lower elevation, a new pipe would likely need to be bored under the RR Tracks.

Basin B14

There is an existing regional detention basin located on this parcel of City-owned property. The flow line of the basin would be lowered to a point that matches the existing downstream channel. The discharge will be a 42" RCP at this elevation. In addition, this basin will be expanded to the north. This basin lowers peak flows to a point that the 1% ACE flow can be contained in a pipe or series of pipes along Blaine Street. The City anticipates that, with the development of this basin, pipes would be installed along Blaine Street to Barnes Avenue. This system would carry flows from the basin as well as additional flows from this area. Blaine street would eventually be widened to a curb and gutter street. Design assumptions include:

- Additional land acquisitions would be necessary since proposed basin encroaches on adjacent property.
- All slopes are a maintainable 4:1 or greater.
- Stormwater flows from the Packer Road-Blaine Street intersection will be diverted into this basin. These flows are currently carried in a ditch along the south side of Blaine Street.

Basin B12

There is an existing wet pond located in the North West corner of Blaine Street and Yates Avenue. The proposed basin would require additional excavation of this area to a depth of approximately 5 feet. This basin would act as an in-line storage area for the system along Blaine Street. Stormwater would be diverted into the basin from either the existing channel or the anticipated pipe system. The control structure for this system would consist of the downstream piping or channel system. The neighborhood to the north of this area has some serious flooding issues. By building basin B12, the City would have the vertical depth required to construct a stormwater improvement into this neighborhood. Design assumptions include:

- 1% ACE water surface elevation will remain below the top of the street.
- The system along Blaine Street would surcharge into this basin and be metered out based on the capacity of the downstream system.
- This area could be further excavated to provide a permanent pool water feature for the neighborhood.

Basin B11A

This proposed basin is located south of Blaine Street at Link Avenue and is currently a vacant wooded area. This area would be excavated and a control structure added. Design assumptions include:

- Side slope of basin would be 15:1. This would accommodate the planting of new trees to replace some of those removed during construction.
- The precise dimensions of an outlet structure were not determined but rather the basin was designed around a rating curve that optimized storage. It appears that this rating curve could be reasonably achieved through the use of a pipe and weir system.

- Basin B11A is located just upstream of Basin B11 but is elevated enough that tail water conditions created by B11 do not submerge the control structure.

Basin B11C

A modification of B11A, this basin attempts to minimize the impact to vegetation by only including excavation on the south side of the stream. This area would be excavated to the depth of the existing channel and a control structure would be added downstream. This would leave the north portion of the lot available for development and should make land acquisition more palatable to the owner. Design assumptions include:

- Side slope of basin would be 6:1. Area could be planted with wetland vegetation to provide additional water quality benefits.
- The outlet structure was assumed to be an 18-ft sharp crested weir at elevation 1333.
- Basin B11C is elevated high enough that the backwater from B11 does not submerge the control structure.

Basin B11

An existing regional detention basin is currently located upstream of Glenstone Avenue. The proposed basin would expand the existing basin to the east. Additional land acquisition and/or stormwater easements wound need to be pursued from adjacent property owners. The outlet for this basin would likely consist of a 15-foot weir located near the current control structure. Design assumptions include:

- Peak flows would not exceed the capacity of the box under Glenstone Avenue.
- Since the initial sizing of this basin, many of the surrounding businesses have added fill and expanded into the proposed basin area. This has somewhat reduced the available area, and effectiveness, of basin B11. However, final design may include expansion into these areas. For example: the new detention basin to the north could be removed and graded as part of the regional facility. This business could then discharge runoff directly into the regional basin. By using this area, the basin will likely not impact any of the space currently used by surrounding businesses.

Basin B11B

Since basin B11 includes extensive removal of riparian vegetation, B11B attempts to minimize this impact by leaving the stream area intact. Excavation will take place in adjacent detention basins, lowering their flow line to match the stream channel. Design assumptions include:

- The outlet structure would be very similar to what was designed for B11.
- Each adjacent detention basin was excavated to the channel flow line with 4:1 side slopes.

Basin B9B

This proposed basin is located north of Pythian Street and just west of Cedarbrook Avenue and is part of two proposed basins. The existing valley would be excavated to a depth of 8-feet and a berm constructed on the downstream end. The control structure would consist of two 36-inch RCPs and an overflow weir that would discharge into basin B9C. This basin encroaches on parts of 4 different privately owned properties and land acquisitions or stormwater easements would be necessary. Design assumptions include:

- The calculations for the outlet structure do not include tail water conditions from basin B9C. However, this basin is elevated enough that the effect should be minimal.
- If we are able to increase flows from Basin B9C with an additional pipe, the size of this basin could be reduced.

Basin B9C

Located just downstream of Basin B9B, this basin includes expansion of the existing regional detention facility at Cooper Park. The outflow for this basin would consist of the existing 4-inch CMP that runs down Pythian Street and Patterson Avenue. The neighborhood to the south of this basin experiences significant flooding and the basin has overtopped a number of times in recent years. Design assumptions include:

- The existing 48-inch CMP system along Pythian Street has been damaged in several locations. These areas would need to be repaired to accommodate the design flows.
- The design includes blocking the existing weir and box structure that discharges at Lone Pine Avenue. If needed, this system could be used to carry some flow during a large storm event. However, these ditches are often the source of flooding in the neighborhood and existing capacity should not be exceeded.

Basin B7

Located in Glenwood Park, this existing regional basin would be expanded to control peak flows and reduce flooding along Rockhurst Street. The existing basin would be excavated an additional 5-feet and the park area would be excavated an additional 2-feet. The lower portion of the basin would overtop into the park area at about the 5 to 10-yr event. The outlet structure would consist of two 42-inch RCPs that would travel along Rockhurst Street and discharge downstream of Patterson Avenue. The structure would also include a 5-foot high flow weir that would discharge into the existing ditch system along Rockhurst. Design assumptions include:

- The estimated capacity of the existing system along Rockhurst is 250 cfs. The basin was designed so that the 1% ACE overflow would not exceed this capacity.
- There is a sanitary sewer line along Rockhurst that may cause a conflict. It was assumed that this could be worked around during final design.

Basin B6

This proposed basin is located just upstream of Chestnut Expressway along the South Branch of Jordan Creek. The stream valley would be excavated to a depth of approximately 9 feet and expanded to the northeast. There are at least three property owners who would be impacted by this project and the City would need to acquire the land or obtain an easement from each. In conjunction with other basins in this watershed, this basin will reduce peak flows and keep the 1% ACE water surface elevation from overtopping Chestnut Expressway. Design assumptions include:

- A detailed outlet structure was not designed for this basin. Instead, the rating curve was adjusted to optimize the storage capacity. An outlet that produces this assumed rating curve would likely consist of a weir-pipe configuration just upstream of the existing box culvert.

Basin B6B
This basin is located in the soccer field just downstream of Patterson Avenue on South Branch and was designed as an alternative to B6. This basin could potentially include a dam across the stream and excavation of the area north of the channel with minimal impact to vegetation on the south side of the channel. Design assumptions include:

- 10:1 side slopes.
- The outlet structure was assumed to be a 15-ft sharp crested weir at elevation 1318. This produced a 1% ACE water surface elevation lower than the edge of Patterson Ave.
- It was assumed that the backwater from this basin would not affect the culvert under Patterson Ave. This would need further analysis and is dependent on construction of basins B9 and B7.

Alternative Locations
B9A – Proposed Basin B9A, located in the soccer fields east of Cedarbrook Avenue and north of Bergman Street, could be a reasonable alternative to Basin B9C. Although not included in the analysis, this basin would include excavating the soccer fields to a depth of 5-feet and allowing them to flood during heavy rain. The proposed grading would require that the new fields be orientated east-west and would probably result in the loss of at least one field. However, the new grading would result in an elevated viewing area along each side of the field which could be viewed as an amenity.

B12A – Proposed basin B12A includes excavation of the residential lots north of Blaine Street, just upstream of basin B12. Initial analysis indicates that this would produce results very similar to basin B12.

5.1.5. Conclusions
Based on the simplified analysis of each basin individually and in series, the following conclusions were made:

North Branch
Basin B15 does an excellent job of reducing peak flows immediately downstream. However, the total 1% ACE flow reduction is on the order of 50 cfs which has little to no impact once you move downstream any distance. In addition, this basin would require significant excavation and land acquisition from the railroad. **Basin B15 is not considered a viable alternative for regional detention.**

Basins B14 and B12 reduce peak flows immediately downstream, greatly reducing flooding along Blain Street. However, these reductions are very small within the limits of federal interest (2.6% reduction downstream of Glenstone). **These basins are a very attractive alternative for the City to reduce local flooding, but do not appear to provide a significant benefit for this project.**

Basins B11, B11A, B11B, and B11C are all variations of a regional detention facility located just upstream of Glenstone Ave on North Branch. Of these, Basins B11 and B11C appear to be the most attractive alternatives. B11 includes enlarging the existing basin to the east and B11C will require excavation along the south side of the stream. Together these basins reduce flows along North Branch by 13 to 30% and reduce flows through the downtown area by almost 6%. It should be noted that **these two basins are responsible for nearly all of the peak flow reduction downstream of the North/South Branch confluence.**

South Branch

Basins B9B and B9C, located upstream of Pythian Street, reduce peak flows to the capacity of the existing local system. Of these two basins, B9B is responsible for nearly all of the peak flow reduction. **By constructing basin B9B, we can reduce flows throughout South Branch by 2 to 9%.** This basin contributes very little to flow reduction downstream of the confluence.

Basin B7 involves expanding the existing Glenwood Park regional basin. By itself, **this basin reduces peak flows along South Branch by 4 to 24%,** but contributes very little to flow reduction downstream of the confluence.

Basins B6 and B6B are somewhat similar regional basins located upstream of Chestnut Expressway. Both basins reduce peak flows when used in series with B6B and B7, but have very little flow reduction when used independently. B6B would require a dam structure across the stream and excavation of the soccer fields on the north side of the stream. This will likely result in tail water effects along the Rockhurst Street stormwater system. Basin B6 would require less excavation since Chestnut Expressway would be used as the downstream control structure and would **result in peak flow reductions of 6 to 12% along South Branch**. This basin contributes very little to flow reduction downstream of the confluence.

Recommendation

Based on this analysis, the City of Springfield recommends further study of the following basins:

- B11 – Expansion of the existing basin upstream of Glenstone Ave. The west end of the existing basin would remain undisturbed and the basin would be expanded to the east.
- B11C – Construction of a new basin south of Blaine at Link. A control structure would be built across the channel and excavation would take place south of the stream channel. The vegetation north of the channel would remain undisturbed and the area would be available for future development.
- B9B – New basin in Cooper Park. A control structure would be built and the new basin would discharge directly into the existing regional basin along Pythian Street.
- B7 – Expansion of the existing basin at Glenwood Park. A new system would be constructed along Rockhurst Street allowing the flow line of the basin to be lowered.
- B6 – Expansion of the existing storage area behind Chestnut Expressway.

It appears that these basins represent the greatest potential reduction in peak flow within the limits of federal interest. Each group of basins, North Branch & South Branch, is responsible for reducing flows in different areas. The City proposes that the entire group of basins be analyzed to determine their cost effectiveness. Based on this analysis, it should be apparent whether or not each group is independently viable.

5.1.6. Final Basin Analysis

Since proposed regional detention basins within a specific (North or South) reach perform in series with other basins in the same reach, the recommended basins were modeled as either North Branch basins only, South Branch basins only, or All basins. The results are described below.

North Branch Basins

The North Branch series of basins included **B11 and B11C**. The resulting model, titled "JRDFSB111.HC1", was simulated for all frequency/duration combinations under Current Conditions watershed development. Each basin was sized according to reasonable geometric restraints and the outlet structure was optimized to reduce flows during flood conditions and maintain approximately 1-ft of freeboard during the 1% ACE event.

South Branch Basins

The South Branch series of basins included **B9B, B6 and B7**. The resulting model, titled "JRDFSSOUTH.HC1", was simulated for all frequency/duration combinations under Current Conditions watershed development. Each basin was sized according to reasonable geometric restraints and the outlet structure was optimized to reduce flows during flood conditions and maintain approximately 1-ft of freeboard during the 1% ACE event.

All Recommended Basins

The All Basins analysis included **B11 and B11C as well as B9B, B6 and B7**. The resulting model, titled "JRDFSALL.HC1", was simulated for all frequency/duration combinations under Current Conditions watershed development. Each basin was sized according to reasonable geometric restraints and the outlet structure was optimized to reduce flows during flood conditions and maintain approximately 1-ft of freeboard during the 1% ACE event.

Results

From the FDA analysis, it was determined that the "All Recommended Basins" scenario provided the greatest benefits in damage reduction. Based on this analysis, the resulting flow rates were used for design in each of the hydraulic alternatives.

6. **With Project Hydraulic Modeling**

6.1. **Detention Analysis**

For each of the detention scenarios modeled (See With Project Hydrologic Modeling) the HEC-RAS model was modified with the revised flows from the HEC-1 analysis. At both the confluence of the North and South Branches and at Fremont Avenue, the flow splits into two separate reaches, one representing the large underground box and another representing overland flow. All model geometry remained the same for these reaches but the rating curve indicating the capacity of each culvert section had to be modified since the incoming flows had changed. Appendix HH-M contains the rating curve used for each structure. These curves were originally derived through an iterative process using the Without Project HEC-RAS model.

6.2. **Channel Improvements**

For the With-Project HEC-RAS models, multiple scenarios were modeled covering different frequency events at different locations. Several design assumptions were held consistent throughout each scenario:

- Proposed improvements were sized using flows from the Ultimate Development w/ All Recommended Basins HEC-1 model. Once the structure geometry was determined, the Current Conditions w/ All Recommended Basins model flows were added so that the HEC-RAS model reflects both Current and Ultimate Conditions Water Surface Elevations.
- Assumed very little residual buyouts or floodproofing. (i.e. Protect all structures within reason, unless they must be removed to construct the improvement).
- Construct linear trail system along channel
- Address in-stream habitat quality and quantity (channel modifications to include mild, natural side slopes, w/ natural bottoms and specific low-flow channels where appropriate)
- At the confluence of the North and South Branches, it is anticipated that a new structure would need to be built that would direct a portion of the flow into the proposed channel improvements and a portion of the flow into the existing box culvert. Because the existing model simulated the downtown area as two separate reaches, including the existing box culvert, it was necessary to insert a new rating curve at this location to model flows into the new structure. This rating curve can be found in Appendix HH-N.

6.2.1. Plan A – 1% ACE

Plan A includes channel and bridge modifications throughout the study area at all locations where significant economic damages were found. In areas where no significant damages were present, improvements were not considered. Details regarding plan A can be found in Appendix HH-O.

Design Methodology:

Modify the Current Conditions Geometry with channel and bridge modifications such that the 1% ACE profile is lower than each of the adjacent finished floor elevations. While this does not eliminate all damages to streets and parking lots, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 1% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface.

Special Conditions:

Pharmaceutical Plant Downstream of Bennett:

The pharmaceutical plant downstream of Bennett Street is protected by a flood wall with an approximate height of 1222.5. Based on a field inspection of this flood wall, it was determined that the wall would stay in place. The proposed improvements for Plan A were designed to keep the 1% ACE profile below the top of this wall. During scoping for this plan, the team considered the option of constructing a taller flood wall around the plant and installing a flood gate at the entrance. Initial cost estimates for this proposal indicated that it was not economically feasible. In addition, the team examined the possibility of constructing a box culvert upstream of Bennett Street and diverting flows to the west side of the plant. Several factors (including cost, environmental concerns, and topography) led to the determination that this option was not economically feasible.

Confluence of North and South Branch:

The confluence of the North and South Branches of Jordan Creek is located in the downtown area near Washington Street. The Without Project HEC-RAS model separates this portion of the stream into two different reaches (see W/O Project Hydraulic Model) where one reach represents the large box culvert that runs underground, while the other reach represents the overland flow through downtown. For the With Project scenario, the overland reach was modified with all channel improvements and the underground reach remained to carry the box culvert flows. It is anticipated that the upstream section of the existing box culvert would need to be reconstructed to gather flows from the confluence and divert the resulting flows into the existing box and the new channel improvements. Modeling of this was accomplished with a rating curve derived from HY-8 (see Appendix HH-N).

South Branch at Fremont

There is an existing box culvert that extends from Fremont Avenue to National Avenue along the South Branch of Jordan. All channel improvement scenarios assume that this box will be removed where reasonable and abandoned in place in a few locations. As a result, the box culvert portion of the model received 1cfs of flow for all scenarios. All other flows were assumed to be carried by the new improvements.

Results

The Plan A alternative includes improvements that greatly reduce damages up to the 1% ACE for every section of the study area. A spreadsheet outlining these improvements can be found in Appendix HH-O and Plate(s) G show the general limits of these improvements.

6.2.2. Plan B – 1% ACE (Cost Effective Plan)

Plan B is a copy of Plan A with the several areas removed because it was determined through a preliminary analysis that these areas were not economically justified. Details regarding plan B can be found in Appendix HH-P.

Design Methodology

Once Plan A was complete, the economic benefits were established for each reach. These benefits were compared to a preliminary cost estimate and those reaches that were obviously not feasible were not included in Plan B.

Grand Street Improvements

The FDA analyses from Plan A indicated that damage reduction due to the proposed Grand Street Improvements were approximately $4500 annually. An initial estimate done by the local sponsor showed construction costs for replacing the Grand Street bridge and the corresponding channel improvements to be around $1.4 million resulting in an annual cost of approximately $32,000. Even if initial estimates are grossly inaccurate, it was apparent that this portion of the project was not economically feasible simply because there are very few structures in this area.

Smith Park Improvements

The FDA analysis from Plan A indicated annual damages of approximately $1800 to several small structures in Smith Park. The preliminary cost estimate to replace two pedestrian bridges and widen the channel was approximately $400,000 with an annual cost of $8500. Considering that these structures were not generally inhabited and were only used for park functions, it was apparent that improvements to Smith Park were not feasible.

Rail Road Crossing at Chestnut Street

The FDA analysis indicated that annual damages were very low at an estimated $2000. The preliminary cost estimated for this improvement was $2.5 million. Under Without Project Conditions, these railroad crossings cause backwater, resulting in significant flooding. However, they are located high in the reach and the proposed detention basins reduce peak flows to the point where additional improvements are not feasible.

Phelps Street (Washington to Jefferson)

Based on the preliminary cost estimate for this segment of improvements, it was determined that there were significant cost savings by constructing an open channel rather than a box culvert from Washington Avenue to Jefferson Avenue just downstream of the confluence. This change was implemented in Plan B.

Results

By using preliminary cost estimates to remove areas that were clearly not feasible, Plan B significantly reduces damages at the 1% ACE in all areas where a proposed project is reasonable. A spreadsheet summary of these improvements can be found in Appendix HH-P and Plate(s) H show the general limits of these improvements.

6.2.3. Plan C – 2% ACE (50 year)

Plan C represents the channel improvements necessary to provide a 2% ACE level of protection throughout the project area. Details regarding plan C can be found in Appendix HH-Q.

Design Methodology

Plan C began as a copy of Plan B, with the same geographic extents. However, the channel modifications from Plan B were further modified until the 2% ACE water surface profile is lower than each of the adjacent finished floor elevations. While this does not eliminate all damages to streets and parking lots in the 2% ACE event, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 2% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface.

Results

The 2% ACE plan does not quite provide the same level of protection as the 1% ACE and the bridge and channel structures are generally smaller. To decrease the capacity of the channel, in many cases we were able to shorten or remove retaining walls needed in the 1% ACE plan.

6.2.4. Plan D – 0.2% ACE (500 year)

Plan D represents the channel improvements necessary to provide a 0.2% ACE level of protection throughout the project area. Details regarding plan D can be found in Appendix HH-R.

Design Methodology

Plan D also began as a copy of Plan B, with the same geographic extents. The channel modifications from Plan B were further modified to meet the following guidance: 1)The 0.2% ACE water surface profile is lower than each of the adjacent finished floor elevations. 2) The proposed channel must contain the 1% ACE profile, and 3) Consistent with the City's design standards, each bridge and culvert must convey the 1% ACE profile. While this does not eliminate all damages to streets and parking lots in the 0.2% ACE event, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 0.2% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface. However, this plan should nearly eliminate overland and parking lot flooding during the 1% ACE event.

Results

In general, the 0.2% ACE resulted in channel and structure sizes that were larger than the 1% ACE. This plan reduces damages above the 1% ACE plan and has the added benefit of generally containing the 1% ACE profile and should keep any future FEMA SFHA within the channel boundary.

6.2.5. Plan E – 4% ACE (25 year)

Plan E represents the channel improvements necessary to provide at 4% ACE level of protection throughout the project area. Details regarding plan E can be found in Appendix HH-S.

Design Methodology

Plan E began as a copy of Plan B, with nearly the same geographic extents (see the exception below). However, the channel modifications from Plan B were further modified until the 4% ACE water surface profile is lower than each of the adjacent finished floor elevations. While this does not eliminate all damages to streets and parking lots in the 4% ACE event, it should eliminate nearly all structure and content damage for each building. The proposed improvements may or may not contain the 4% ACE and some overland flooding will result in areas where the finished floor elevations are elevated above the ground surface.

Fremont Avenue (South Branch)

In each of the previous plans, the Fremont Avenue bridge on South Branch was replaced. In this plan, the existing structure is left in place and the downstream channel improvements provide the necessary level of protection.

6.2.6. Plan F – 1% ACE Reach 3 & 6 with 0.2% ACE Reach 1

Plan F includes a 1% ACE channel through reaches 3 & 6 with a 0.2% ACE channel through reach 1. Includes sections of projects from the previously developed models.

Design Methodology

After examining the economic results from plans A through E, sections of these plans were selected based on their benefit-cost ratio, net benefits, and other factors considered important by the Team but not necessarily reflected in the economic results. Plan F began as a copy of Plan B and sections of the geometry were imported from other HEC-RAS files as outlined below.

Reach E1 – Downstream of Bennett Street

Since the economic results indicate that a 0.2% ACE level of protection will provide the greatest net benefits in this area, the geometry from Plan D was selected. This reach is hydraulically independent of the other project areas, so the selection of a level of protection throughout this reach did not impact the water surface profiles for any other reach.

Reach E2 – Mt Vernon Street to Fort Avenue

The economic results from the previous plans indicate that channel and bridge improvements in this reach are not economically feasible. As a result, all improvements were removed from the model (the Without Project Geometry was imported into this reach). This reach is hydraulically independent and modifying these improvements have no impact on other study areas.

Reach E3 & E6 – Downtown to Fremont Avenue
The economic results indicated that the 4% ACE level of protection plan resulted in the greatest net benefits. However, due to other considerations (outlined elsewhere in this report) this plan reflects the 1% ACE level of protection found in Plan B for these two reaches. These reaches are NOT hydraulically independent and improvements in reaches E3 & E6 have an impact on the water surface profiles for reach E4.

Reach E4 – Confluence to Central Street
The economic results indicate that channel and bridge improvements in this reach are not economically feasible. However, by making improvements in reaches E3 & E6, the reduced backwater effects result in lower water surface profiles through reach E4. No improvements were assumed through this reach.

6.2.7. Plan G – 4% ACE Reach 3 & 6 with 0.2% ACE Reach 1
Plan G includes a 4% ACE channel through reaches 3 & 6 with a 0.2% ACE channel through reach 1. Includes sections of projects from the previously developed models.

Design Methodology
After examining the economic results from plans A through E, sections of these plans were selected based exclusively on the total net benefits. Plan F began as a copy of Plan E and sections of the geometry were imported from other HEC-RAS files as outlined below.

Reach E1 – Downstream of Bennett Street
Since the economic results indicate that a 0.2% ACE level of protection will provide the greatest net benefits in this area, the geometry from Plan D was selected. This reach is hydraulically independent of the other project areas, so the selection of a level of protection throughout this reach did not impact the water surface profiles for any other reach.

Reach E2 – Mt Vernon Street to Fort Avenue
The economic results from the previous plans indicate that channel and bridge improvements in this reach are not economically feasible. As a result, all improvements were removed from the model (the Without Project Geometry was imported into this reach). This reach is hydraulically independent and modifying these improvements have no impact on other study areas.

Reach E3 & E6 – Downtown to Fremont Avenue
The economic results indicated that the 4% ACE level of protection plan resulted in the greatest net benefits through these two reaches. As a result, the geometry represents what is found in Plan E. These reaches are NOT hydraulically independent and improvements in reaches E3 & E6 have an impact on the water surface profiles for reach E4.

Reach E4 – Confluence to Central Street
The economic results indicate that channel and bridge improvements in this reach are not economically feasible. However, by making improvements in reaches E3 & E6, the reduced backwater effects result in lower water surface profiles through reach E4. No improvements were assumed through this reach.

6.2.8. Plan H – 4% ACE (Select Locations)
Plan H includes the 4% ACE channel found in previous plans, but reduced to select locations where the apparent benefits could be maximized.

Design Methodology
After examining the economic results from plan G, this plan attempts to remove some of the more costly portions of the project in an effort to optimize the net benefits. Plan H began as a copy of Plan G and sections of the geometry were imported from other HEC-RAS files as outlined below.

Reach E1 – Downstream of Bennett Street
Since the economic results indicate that a 0.2% ACE level of protection will provide the greatest net benefits in this area, the geometry from Plan D was selected. This reach is hydraulically independent of the other project areas, so the selection of a level of protection throughout this reach did not impact the water surface profiles for any other reach.

Reach E2 – Mt Vernon Street to Fort Avenue
The economic results from the previous plans indicate that channel and bridge improvements in this reach are not economically feasible. As a result, all improvements were removed from the model (the Without Project Geometry was imported into this reach). This reach is hydraulically independent and modifying these improvements have no impact on other study areas.

Reach E3 & E6 – Downtown to Fremont Avenue
This plan includes channel improvements from Main Avenue to Boonville Avenue and from just downstream of National Avenue to Fremont Avenue. This removes a large portion of improvements in between Boonville and National. These reaches are NOT hydraulically independent and improvements in reaches E3 & E6 have an impact on the water surface profiles for reach E4, although not as significant as in earlier plans.

Reach E4 – Confluence to Central Street
The economic results indicate that channel and bridge improvements in this reach are not economically feasible. However, by making improvements in reaches E3 & E6, the reduced backwater effects result in lower water surface profiles through reach E4. No improvements were assumed through this reach.

6.2.9. Plan I – Plan G w/o Detention
Plan I is a copy of plan G, but the flows were modified such that the detention basins were not included.

Design Methodology
Plan I began as a copy of Plan G and the flow inputs were copied from the Without Project model(s).

6.2.10. Plan J – Regional Detention & Reach E1

Plan J includes the five regional detention basins with the 0.2% ACE improvements in reach E1.

Design Methodology

Plan J is a copy of the Without Project plan with the geometry from Plan D (0.2% ACE).

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Plate A: Flow data tables

Point of Interest		Current Development 100 Yr Peak Flow	Critical 100yr Duration (hr) 1	2	3	6	12	18	24	Future Development 100 Yr Peak Flow	Critical 100yr Duration (hr) 1	2	3	6	12	18	24	% Increase
North Branch	X-SEC																	
HCNB9	18653	166	----	----	----	----	X	----	----	175	----	----	----	----	X	----	----	5.4%
RRNB31	16668	193	----	----	----	----	X	X	----	204	----	----	----	----	X	----	----	5.7%
NB17	15747	213	----	----	----	----	----	X	----	225	----	----	----	----	----	X	----	5.6%
HCNB12	14505	626	----	X	----	----	----	----	----	676	----	X	----	----	----	----	----	8.0%
HCNB13	13249	745	----	X	----	----	----	----	----	819	----	X	----	----	----	----	----	9.9%
NB12	11949	756	----	----	X	----	----	----	----	844	----	----	X	----	----	----	----	11.6%
HCNB17	11140	1055	----	----	X	----	----	----	----	1169	----	----	X	----	----	----	----	10.8%
HCNB19	10225	1179	----	----	X	----	----	----	----	1285	----	----	X	----	----	----	----	9.0%
RNB39B	10068	1175	----	----	X	----	----	----	----	1280	----	----	X	----	----	----	----	8.9%
HCNB21	9515	1511	----	----	X	----	----	----	----	1564	----	----	X	----	----	----	----	3.5%
NB42	8776	1575	----	----	X	----	----	----	----	1623	----	----	X	----	----	----	----	3.0%
HCNB25	8293	1625	----	----	X	----	----	----	----	1681	----	----	X	----	----	----	----	3.4%
NB44	7084	1714	----	----	X	----	----	----	----	1767	----	----	X	----	----	----	----	3.1%
NB54	5346	2216	----	----	X	----	----	----	----	2318	----	----	X	----	----	----	----	4.6%
HCNB29	5026	2280	----	----	X	----	----	----	----	2377	----	----	X	----	----	----	----	4.3%
HCNB30	3659	2429	----	----	X	----	----	----	----	2516	----	----	X	----	----	----	----	3.6%
HCNB31	1837	2627	----	----	X	----	----	----	----	2746	----	----	X	----	----	----	----	4.5%
HCNB32	610	2734	----	----	X	----	----	----	----	2848	----	----	X	----	----	----	----	4.2%
South Branch																		
RRSJ6	14475	773	----	X	----	----	----	----	----	835	----	X	----	----	----	----	----	8.0%
HCSJ6	12585	1378	----	X	----	----	----	----	----	1676	----	X	----	----	----	----	----	21.6%
HCSJ7	10710	1585	----	X	----	----	----	----	----	1955	----	X	----	----	----	----	----	23.3%
HCSJ8	8856	1917	----	----	X	----	----	----	----	2523	----	----	X	----	----	----	----	31.6%
SJ34	7825	1927	----	----	X	----	----	----	----	2478	----	----	X	----	----	----	----	28.6%
HCSJ11	7131	2069	----	----	X	----	----	----	----	2673	----	----	X	----	----	----	----	29.2%
HCSJ12	6309	2160	----	----	X	----	----	----	----	2683	----	----	X	----	----	----	----	24.2%
SJ37	5006	2247	----	----	X	----	----	----	----	2749	----	----	X	----	----	----	----	22.3%
Est Box Capacity	1643	725	----	----	X	----	----	----	----	728	----	----	X	----	----	----	----	0.4%
SJ37 - Box Capacity	4432	1523	----	----	X	----	----	----	----	2021	----	----	X	----	----	----	----	32.7%
SJ44A	2584	2674	----	----	X	----	----	----	----	3064	----	----	X	----	----	----	----	14.6%
SJ44B	1390	2868	----	----	X	----	----	----	----	3202	----	----	X	----	----	----	----	11.6%
SJ45	761	2897	----	----	X	----	----	----	----	3218	----	----	X	----	----	----	----	11.1%
Lower Branch																		
HC75	16700	5608	----	----	X	----	----	----	----	6022	----	----	X	----	----	----	----	7.4%
Est Box Capacity	3354	2346	----	----	X	----	----	----	----	2374	----	----	X	----	----	----	----	1.2%
HC75 – Box Capacity	16690	3262	----	----	X	----	----	----	----	3648	----	----	X	----	----	----	----	11.8%
HC75	13427	5608	----	----	X	----	----	----	----	6022	----	----	X	----	----	----	----	7.4%
HCLJ7	13132	5683	----	----	X	----	----	----	----	6163	----	----	X	----	----	----	----	8.4%
HCLJ15	9733	6060	----	----	----	X	----	----	----	6650	----	----	----	X	----	----	----	9.7%
HCLJ16	8274	6157	----	----	----	X	----	----	----	6771	----	----	----	X	----	----	----	10.0%
HCL25X	5689	6341	----	----	----	X	----	----	----	6969	----	----	----	X	----	----	----	9.9%
HCLJ19	3859	6737	----	----	----	X	----	----	----	7411	----	----	----	X	----	----	----	10.0%
HCLJ20	2266	6806	----	----	----	X	----	----	----	7491	----	----	----	X	----	----	----	10.1%
HCL34X	621	6777	----	----	----	X	----	----	----	7482	----	----	----	X	----	----	----	10.4%
Fassnight Creek																		
F11B	11358	3270	----	----	X	----	----	----	----	3963	----	----	X	----	----	----	----	21.2%
COMB14	9487	3988	----	----	X	----	----	----	----	4854	----	----	X	----	----	----	----	21.7%
F14	7121	3988	----	----	X	----	----	----	----	4854	----	----	X	----	----	----	----	21.7%
COMB9	6405	4650	----	----	X	----	----	----	----	5641	----	----	X	----	----	----	----	21.3%
COMB10	4641	4726	----	----	X	----	----	----	----	5739	----	----	X	----	----	----	----	21.4%
COMB11	3883	4726	----	----	X	----	----	----	----	5739	----	----	X	----	----	----	----	21.4%
COMB12	2816	4354	----	----	X	----	----	----	----	5753	----	----	X	----	----	----	----	32.1%
COMB13	2020	4456	----	----	X	----	----	----	----	5692	----	----	X	----	----	----	----	27.7%
Wilsons Creek																		
COMBJF	33108	9859	----	----	----	X	----	----	----	11009	----	----	----	X	----	----	----	11.7%

Point of Interest	Current Development Maximum 100 yr Flowrate (cfs)	Critical 100 yr Duration (hr) Hr	1	2	3	6	12	18	24		Point
North Branch											North Branch
HCNB9	166	12	----	----	----	----	X	----	----	5	HCNB9
RRNB31	193	12	----	----	----	----	X	X	----	5	RRNB31
NB17	213	18	----	----	----	----	----	X	----	6	NB17
HCNB12	626	2	----	X	----	----	----	----	----	2	HCNB12
HCNB13	745	2	----	X	----	----	----	----	----	2	HCNB13
NB12	756	3	----	----	X	----	----	----	----	3	NB12
HCNB17	1055	3	----	----	X	----	----	----	----	3	HCNB17
HCNB19	1179	3	----	----	X	----	----	----	----	3	HCNB19
RNB39B	1175	3	----	----	X	----	----	----	----	3	RNB39B
HCNB21	1511	3	----	----	X	----	----	----	----	3	HCNB21
NB42	1575	3	----	----	X	----	----	----	----	3	NB42
HCNB25	1625	3	----	----	X	----	----	----	----	3	HCNB25
NB44	1714	3	----	----	X	----	----	----	----	3	NB44
NB54	2216	3	----	----	X	----	----	----	----	3	NB54
HCNB29	2280	3	----	----	X	----	----	----	----	3	HCNB29
HCNB30	2429	3	----	----	X	----	----	----	----	3	HCNB30
HCNB31	2627	3	----	----	X	----	----	----	----	3	HCNB31
HCNB32	2734	3	----	----	X	----	----	----	----	3	HCNB32
South Branch											South Branch
RRSJ6	773	2	----	X	----	----	----	----	----	2	RRSJ6
HCSJ6	1378	2	----	X	----	----	----	----	----	2	HCSJ6
HCSJ7	1585	2	----	X	----	----	----	----	----	2	HCSJ7
HCSJ8	1917	3	----	----	X	----	----	----	----	3	HCSJ8
SJ34	1927	3	----	----	X	----	----	----	----	3	SJ34
HCSJ11	2069	3	----	----	X	----	----	----	----	3	HCSJ11
HCSJ12	2160	3	----	----	X	----	----	----	----	3	HCSJ12
SJ37	2247	3	----	----	X	----	----	----	----	3	SJ37
Est Box Capacity	725	3	----	----	X	----	----	----	----	3	Est Box Capacity
SJ37 - Box Capacity	1523	3	----	----	X	----	----	----	----	3	SJ37 - Box Capacity
SJ44A	2674	3	----	----	X	----	----	----	----	3	SJ44A
SJ44B	2868	3	----	----	X	----	----	----	----	3	SJ44B
SJ45	2897	3	----	----	X	----	----	----	----	3	SJ45
Lower Branch											Lower Branch
HC75	5608	3	----	----	X	----	----	----	----	3	HC75
Est Box Capacity	2346	3	----	----	X	----	----	----	----	3	Est Box Capacity
HC75 - Box Capacity	3262	3	----	----	X	----	----	----	----	3	HC75 - Box Capacity
HC75	5608	3	----	----	X	----	----	----	----	3	HC75
HCLJ7	5683	3	----	----	X	----	----	----	----	3	HCLJ7
HCLJ15	6060	6	----	----	----	X	----	----	----	4	HCLJ15
HCLJ16	6157	6	----	----	----	X	----	----	----	4	HCLJ16
HCL25X	6341	6	----	----	----	X	----	----	----	4	HCL25X
HCLJ19	6737	6	----	----	----	X	----	----	----	4	HCLJ19
HCLJ20	6806	6	----	----	----	X	----	----	----	4	HCLJ20
HCL34X	6777	6	----	----	----	X	----	----	----	4	HCL34X
Fassnight Creek											
F11B	3270	3	----	----	X	----	----	----	----	3	F11B
F14	3988	3	----	----	X	----	----	----	----	3	F14
F14	3988	3	----	----	X	----	----	----	----	3	F14
COMB10	4650	3	----	----	X	----	----	----	----	3	COMB10
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB12	4354	3	----	----	X	----	----	----	----	3	COMB12
COMB13	4456	3	----	----	X	----	----	----	----	3	COMB13
Wilsons Creek											
COMBJF	9859	6	----	----	----	X	----	----	----	4	COMBJF

Point	1 Hour Peak Flows								2 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9									56	71	92	107	123	133	154	173
RRNB31									51	63	81	106	140	156	172	215
NB17									56	69	89	113	153	172	192	241
HCNB12									113	173	261	335	443	530	626	844
HCNB13									136	208	306	392	525	630	745	1009
South Branch																
RRSJ6									176	250	363	451	570	667	773	1038
HCSJ6									226	337	518	678	890	1074	1378	1981
HCSJ7									279	434	671	861	1114	1322	1585	2279

Point	3 Hour Peak Flows								6 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	54	73	101	118	137	156	165	177	47	66	98	116	142	157	165	178
RRNB31	52	73	109	131	152	173	188	214	51	69	108	129	155	173	189	218
NB17	57	78	115	140	162	185	203	246	55	74	114	138	163	182	205	245
HCNB12	113	166	243	309	400	478	560	744	106	147	204	250	312	363	427	571
HCNB13	135	201	294	372	484	581	682	915	125	178	247	305	388	457	529	702
NB12	157	234	337	425	547	647	756	1009	143	205	287	356	454	534	620	815
HCNB17	225	341	496	617	777	908	1055	1391	197	290	417	516	657	771	886	1148
HCNB19	263	389	564	699	872	1014	1179	1552	224	329	476	589	747	873	1002	1301
RNB39B	257	383	556	693	868	1010	1175	1544	223	325	471	583	742	867	994	1295
HCNB21	343	490	714	889	1120	1301	1511	1970	287	415	603	745	943	1094	1253	1632
NB42	358	508	742	925	1165	1355	1575	2058	299	431	627	776	981	1138	1303	1698
HCNB25	369	522	763	951	1200	1397	1625	2124	308	443	645	798	1009	1170	1339	1748
NB44	387	547	802	999	1263	1473	1714	2248	324	465	678	840	1064	1233	1412	1845
NB54	507	723	1054	1310	1653	1923	2216	2916	420	603	882	1097	1389	1609	1837	2364
HCNB29	521	743	1082	1345	1699	1978	2280	2998	432	619	905	1128	1428	1657	1892	2433
HCNB30	551	790	1148	1429	1808	2107	2429	3185	457	657	961	1199	1519	1764	2017	2591
HCNB31	593	854	1237	1542	1952	2279	2627	3425	493	709	1036	1295	1643	1911	2190	2813
HCNB32	625	895	1294	1612	2034	2373	2734	3558	519	746	1084	1355	1716	1995	2287	2939
South Branch																
RRSJ6	163	231	332	411	516	602	693	914	126	179	257	315	393	456	524	680
HCSJ6	216	320	497	638	829	1048	1325	1856	184	276	421	528	692	872	1077	1475
HCSJ7	273	417	643	820	1056	1253	1551	2178	236	352	541	681	871	1053	1289	1784
HCSJ8	348	540	819	1060	1390	1616	1917	3182	305	461	702	906	1242	1503	1758	2648
SJ34	351	544	824	1063	1396	1626	1927	3118	309	467	709	914	1253	1515	1772	2628
HCSJ11	415	641	952	1213	1523	1781	2069	3379	368	555	822	1053	1396	1671	1952	2881
HCSJ12	453	687	1015	1285	1585	1871	2160	3379	400	600	883	1125	1473	1757	2053	2951
SJ37	480	719	1060	1337	1636	1940	2247	3456	424	634	931	1182	1533	1829	2137	3047
Est Box Capacity	479	718	751	744	733	729	725	717								
SJ37 - Box Capacity	1	1	309	593	903	1212	1523	2739								
SJ44A	557	821	1204	1536	1940	2273	2674	3813	507	740	1086	1368	1795	2133	2501	3446
SJ44B	595	868	1269	1616	2096	2444	2868	3953	550	793	1160	1457	1935	2266	2660	3613
SJ45	601	876	1279	1628	2119	2477	2897	3974	556	802	1172	1471	1957	2287	2685	3639
Lower Branch																
HC75	1202	1700	2477	3093	4145	4842	5608	7440	1069	1513	2199	2733	3656	4260	4881	6409
Est Box Capacity	1201	1699	2039	2120	2249	2307	2346	2436								
HC75 - Box Capacity	1	1	438	973	1896	2535	3262	5004								
HC75	1202	1700	2477	3093	4145	4842	5608	7440	1069	1513	2199	2733	3656	4260	4881	6409
HCLJ7	1401	1955	2813	3438	4370	4998	5683	7279	1252	1747	2522	3120	3995	4591	5213	6665
HCLJ15									1505	2076	2955	3652	4629	5361	6060	7657
HCLJ16									1530	2112	3003	3710	4692	5438	6157	7772
HCL25X									1573	2169	3079	3806	4801	5595	6341	7994
HCLJ19									1665	2289	3243	4010	5057	5933	6737	8466
HCLJ20									1681	2309	3268	4042	5094	5979	6806	8548
HCL34X									1688	2314	3273	4046	5092	5941	6777	8561
F11B	783	1024	1392	1722	2267	2740	3270	4467	634	810	1080	1351	1787	2143	2533	3430
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
COMB10	1091	1459	2017	2530	3296	3934	4650	6291	897	1177	1609	1989	2621	3155	3734	5053
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB12	1097	1484	2043	2538	3160	3742	4354	6260	922	1206	1657	2048	2665	3139	3686	5119
COMB13	1111	1511	2099	2616	3247	3831	4456	6392	933	1236	1712	2130	2768	3256	3819	5213
COMBJF									2293	3158	4457	5530	6995	8355	9859	12777

Point	12 Hour Peak Flows								18 Hour Peak Flows								24 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																								
HCNB9	47	66	98	117	143	157	166	182	49	67	98	117	142	154	163	181	45	62	89	107	133	148	157	175
RRNB31	52	72	112	132	161	179	193	225	54	74	112	132	160	177	193	224	51	69	101	124	152	169	183	211
NB17	57	77	120	142	171	192	211	256	58	79	120	143	171	193	213	256	55	74	109	134	163	183	200	238
HCNB12	107	145	199	246	318	374	428	542	109	147	199	253	320	364	415	522	100	133	180	231	287	326	372	459
HCNB13	125	174	237	288	371	436	505	645	128	173	232	289	368	423	480	608	117	156	210	261	329	374	425	533
NB12	143	200	272	330	414	489	568	730	145	197	263	321	408	474	537	678	132	176	237	287	367	418	473	593
HCNB17	196	277	381	462	573	666	777	995	196	269	362	438	554	645	731	917	175	237	321	385	491	560	640	801
HCNB19	224	314	431	521	646	745	865	1111	222	302	407	489	614	715	811	1015	197	264	357	428	542	619	704	882
RNB39B	221	309	428	517	641	742	861	1107	219	298	403	485	609	711	807	1011	194	262	354	425	538	616	702	879
HCNB21	281	390	538	648	801	923	1061	1363	274	370	500	599	743	867	984	1230	240	322	433	519	650	744	845	1059
NB42	292	405	559	673	831	958	1100	1413	284	384	518	621	769	897	1018	1273	248	333	447	536	671	769	873	1094
HCNB25	300	416	574	691	853	984	1128	1451	291	393	531	637	787	919	1044	1305	254	341	458	550	686	788	894	1124
NB44	314	436	603	726	897	1038	1186	1527	304	411	557	668	824	962	1097	1373	266	356	480	577	717	828	940	1183
NB54	401	557	779	946	1167	1349	1536	1954	386	524	715	858	1055	1224	1400	1749	335	454	614	738	907	1051	1192	1498
HCNB29	412	571	802	974	1202	1389	1582	2010	395	538	735	882	1086	1258	1440	1799	343	466	631	758	931	1080	1225	1539
HCNB30	435	605	852	1036	1280	1479	1684	2138	417	570	780	938	1154	1335	1529	1912	362	494	669	805	987	1145	1299	1633
HCNB31	467	652	920	1122	1387	1603	1826	2313	447	613	841	1013	1247	1440	1650	2066	389	532	722	869	1064	1234	1402	1762
HCNB32	489	684	962	1173	1448	1672	1902	2407	468	641	878	1057	1298	1497	1715	2144	407	556	753	905	1107	1283	1458	1831
South Branch																								
RRSJ6	111	159	222	266	326	374	424	522	107	147	201	237	288	328	371	456	90	123	167	200	240	273	309	384
HCSJ6	184	271	391	486	637	778	917	1159	182	261	368	452	581	673	795	993	160	226	315	385	491	567	645	825
HCSJ7	235	344	498	613	792	948	1126	1440	232	330	465	566	723	835	977	1227	203	285	397	484	611	704	799	1020
HCSJ8	307	446	665	908	1217	1410	1645	2273	306	436	707	902	1161	1356	1595	2061	268	379	622	778	993	1186	1429	1784
SJ34	311	452	672	915	1228	1421	1658	2286	310	441	713	909	1171	1366	1608	2075	271	383	627	785	1000	1194	1438	1795
HCSJ11	369	527	776	1034	1374	1580	1840	2494	368	511	802	1021	1309	1534	1759	2309	321	446	705	884	1121	1312	1592	1991
HCSJ12	398	568	830	1094	1450	1678	1936	2595	398	549	848	1080	1384	1621	1841	2421	347	479	749	938	1186	1380	1671	2092
SJ37	420	601	875	1142	1513	1759	2018	2682	420	578	886	1128	1444	1690	1912	2517	366	505	782	981	1238	1441	1735	2176
Est Box Capacity																								
SJ37 - Box Capacity																								
SJ44A	499	708	1018	1302	1768	2090	2390	3076	494	678	1019	1308	1705	1995	2262	2938	430	591	904	1143	1439	1702	2013	2543
SJ44B	540	761	1090	1377	1882	2232	2560	3293	533	728	1079	1388	1816	2125	2419	3118	464	634	959	1209	1519	1815	2130	2703
SJ45	546	770	1101	1389	1900	2254	2586	3325	539	737	1089	1400	1833	2144	2441	3145	469	641	968	1220	1532	1832	2147	2726
Lower Branch																								
HC75	1035	1441	2027	2485	3304	3916	4479	5727	1006	1360	1904	2392	3128	3640	4150	5278	874	1189	1680	2094	2613	3114	3600	4552
Est Box Capacity																								
HC75 - Box Capacity																								
HC75	1035	1441	2027	2485	3304	3916	4479	5727	1006	1360	1904	2392	3128	3640	4150	5278	874	1189	1680	2094	2613	3114	3600	4552
HCLJ7	1207	1666	2338	2854	3663	4271	4851	6119	1167	1568	2171	2706	3438	3974	4498	5633	1012	1380	1902	2366	2939	3457	3952	4948
HCLJ15	1441	1965	2748	3350	4230	4950	5619	7048	1390	1856	2531	3114	3963	4604	5200	6447	1213	1661	2223	2755	3426	4009	4577	5735
HCLJ16	1465	1999	2792	3407	4289	5025	5711	7162	1416	1891	2579	3163	4025	4680	5288	6559	1234	1691	2262	2800	3480	4067	4646	5820
HCL25X	1506	2053	2867	3500	4393	5170	5883	7374	1459	1946	2650	3242	4119	4803	5459	6761	1257	1746	2332	2884	3584	4183	4781	5996
HCLJ19	1596	2170	3028	3701	4625	5484	6259	7848	1553	2065	2806	3420	4331	5082	5821	7208	1333	1861	2480	3062	3805	4434	5074	6370
HCLJ20	1612	2191	3055	3733	4663	5512	6315	7932	1570	2086	2832	3450	4366	5123	5871	7285	1344	1883	2505	3091	3841	4474	5124	6432
HCL34X	1621	2202	3067	3748	4683	5488	6321	7950	1573	2096	2844	3467	4381	5126	5853	7289	1337	1897	2516	3102	3855	4485	5141	6457
F11B	427	643	966	1212	1536	1793	2069	2665	438	629	897	1102	1374	1590	1818	2313	380	537	751	921	1143	1319	1507	1909
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920	472	670	943	1160	1444	1668	1907	2420
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920	472	670	943	1160	1444	1668	1907	2420
COMB10	628	937	1421	1796	2292	2683	3102	4014	637	925	1329	1645	2057	2389	2737	3491	556	794	1124	1384	1726	1995	2283	2901
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568	566	810	1147	1414	1764	2039	2335	2968
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568	566	810	1147	1414	1764	2039	2335	2968
COMB12	650	970	1472	1852	2363	2720	3112	4017	659	959	1378	1701	2126	2460	2781	3519	576	825	1167	1439	1789	2068	2369	2968
COMB13	670	1003	1530	1930	2467	2839	3248	4194	682	998	1437	1777	2224	2575	2908	3683	596	860	1219	1505	1874	2169	2486	3112
COMBJF	2232	3069	4238	5202	6538	7693	9042	11725	2205	3021	3983	4823	6036	7080	8206	10616	1854	2727	3540	4289	5343	6188	7135	9277

Point of Interest	Ultimate Development Maximum 100 yr Flowrate (cfs)	Hr	1	2	3	6	12	18	24		Point
North Branch											North Branch
HCNB9	175	12	----	----	----	----	X	----	----	5	HCNB9
RRNB31	204	12	----	----	----	----	X	----	----	5	RRNB31
NB17	225	18	----	----	----	----	----	X	----	6	NB17
HCNB12	676	2	----	X	----	----	----	----	----	2	HCNB12
HCNB13	819	2	----	X	----	----	----	----	----	2	HCNB13
NB12	844	3	----	----	X	----	----	----	----	3	NB12
HCNB17	1169	3	----	----	X	----	----	----	----	3	HCNB17
HCNB19	1285	3	----	----	X	----	----	----	----	3	HCNB19
RNB39B	1280	3	----	----	X	----	----	----	----	3	RNB39B
HCNB21	1564	3	----	----	X	----	----	----	----	3	HCNB21
NB42	1623	3	----	----	X	----	----	----	----	3	NB42
HCNB25	1681	3	----	----	X	----	----	----	----	3	HCNB25
NB44	1767	3	----	----	X	----	----	----	----	3	NB44
NB54	2318	3	----	----	X	----	----	----	----	3	NB54
HCNB29	2377	3	----	----	X	----	----	----	----	3	HCNB29
HCNB30	2516	3	----	----	X	----	----	----	----	3	HCNB30
HCNB31	2746	3	----	----	X	----	----	----	----	3	HCNB31
HCNB32	2848	3	----	----	X	----	----	----	----	3	HCNB32
South Branch											South Branch
RRSJ6	835	2	----	X	----	----	----	----	----	2	RRSJ6
HCSJ6	1676	2	----	X	----	----	----	----	----	2	HCSJ6
HCSJ7	1955	2	----	X	----	----	----	----	----	2	HCSJ7
HCSJ8	2523	3	----	----	X	----	----	----	----	3	HCSJ8
SJ34	2478	3	----	----	X	----	----	----	----	3	SJ34
HCSJ11	2673	3	----	----	X	----	----	----	----	3	HCSJ11
HCSJ12	2683	3	----	----	X	----	----	----	----	3	HCSJ12
SJ37	2749	3	----	----	X	----	----	----	----	3	SJ37
Est Box Capacity	728	3	----	----	X	----	----	----	----	3	Est Box Capacity
SJ37 - Box Capacity	2021	3	----	----	X	----	----	----	----	3	SJ37 - Box Capacity
SJ44A	3064	3	----	----	X	----	----	----	----	3	SJ44A
SJ44B	3202	3	----	----	X	----	----	----	----	3	SJ44B
SJ45	3218	3	----	----	X	----	----	----	----	3	SJ45
Lower Branch											Lower Branch
HC75	6022	3	----	----	X	----	----	----	----	3	HC75
Est Box Capacity	2374	3	----	----	X	----	----	----	----	3	Est Box Capacity
HC75 - Box Capacity	3648	3	----	----	X	----	----	----	----	3	HC75 - Box Capacity
HC75	6022	3	----	----	X	----	----	----	----	3	HC75
HCLJ7	6163	3	----	----	X	----	----	----	----	3	HCLJ7
HCLJ15	6650	6	----	----	----	X	----	----	----	4	HCLJ15
HCLJ16	6771	6	----	----	----	X	----	----	----	4	HCLJ16
HCL25X	6969	6	----	----	----	X	----	----	----	4	HCL25X
HCLJ19	7411	6	----	----	----	X	----	----	----	4	HCLJ19
HCLJ20	7491	6	----	----	----	X	----	----	----	4	HCLJ20
HCL34X	7482	6	----	----	----	X	----	----	----	4	HCL34X
Fassnight Creek											
F11B	3963	3	----	----	X	----	----	----	----	3	F11B
F14	4854	3	----	----	X	----	----	----	----	3	F14
F14	4854	3	----	----	X	----	----	----	----	3	F14
COMB10	5641	3	----	----	X	----	----	----	----	3	COMB10
COMB11	5739	3	----	----	X	----	----	----	----	3	COMB11
COMB11	5739	3	----	----	X	----	----	----	----	3	COMB11
COMB12	5753	3	----	----	X	----	----	----	----	3	COMB12
COMB13	5692	3	----	----	X	----	----	----	----	3	COMB13
Wilsons Creek											
COMBJF	11009	6	----	----	----	X	----	----	----	4	COMBJF

Point	1 Hour Peak Flows								2 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
HCNB9									68	84	104	119	130	137	160	177
RRNB31									64	77	110	133	152	163	178	223
NB17									68	84	118	144	167	184	216	283
HCNB12									158	220	311	383	488	574	676	933
HCNB13									189	261	375	468	600	704	819	1106
RRSJ6									222	301	417	505	622	714	835	1095
HCSJ6									323	444	619	753	1114	1402	1676	2291
HCSJ7									363	503	721	936	1325	1630	1955	2666

Point	3 Hour Peak Flows								6 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	68	92	117	133	157	167	172	184	63	89	117	140	160	167	173	185
RRNB31	70	90	129	145	170	184	197	219	67	93	127	152	175	185	198	223
NB17	74	95	137	154	179	196	216	275	72	98	134	159	183	197	215	251
HCNB12	160	216	298	363	455	533	627	846	146	190	256	307	379	446	515	686
HCNB13	190	259	364	448	566	660	769	1014	173	227	312	377	465	541	629	816
NB12	210	284	402	495	620	725	844	1111	192	255	350	425	526	609	702	918
HCNB17	291	391	585	712	875	1015	1169	1490	261	346	500	615	758	870	993	1278
HCNB19	323	435	645	781	960	1117	1285	1644	292	389	557	688	845	969	1106	1425
RNB39B	315	431	637	776	954	1111	1280	1639	287	386	551	682	839	961	1101	1419
HCNB21	387	537	771	942	1157	1351	1564	2057	353	480	677	842	1034	1184	1361	1749
NB42	397	556	795	978	1203	1402	1623	2141	365	497	701	872	1072	1228	1412	1814
HCNB25	412	578	823	1014	1249	1450	1681	2218	378	515	723	901	1108	1268	1457	1871
NB44	433	605	860	1065	1316	1523	1767	2335	394	539	757	943	1161	1330	1529	1965
NB54	588	822	1157	1420	1752	2014	2318	3095	518	711	997	1235	1520	1733	1973	2543
HCNB29	604	842	1185	1455	1797	2068	2377	3173	530	728	1021	1264	1558	1778	2021	2609
HCNB30	639	888	1252	1536	1903	2195	2516	3346	558	767	1078	1332	1650	1889	2141	2763
HCNB31	698	968	1365	1672	2079	2403	2746	3621	603	829	1170	1442	1795	2061	2337	2997
HCNB32	728	1007	1417	1734	2153	2491	2848	3743	629	862	1219	1499	1864	2142	2431	3110
South Branch																
RRSJ6	210	280	381	458	559	640	727	950	177	228	298	353	432	496	565	717
HCSJ6	311	420	579	721	1070	1324	1570	2104	274	362	481	623	882	1062	1246	1631
HCSJ7	358	497	696	921	1283	1560	1858	2496	324	439	613	795	1078	1296	1513	2001
HCSJ8	433	640	934	1190	1596	1930	2523	3713	397	573	820	1074	1445	1744	2054	3050
SJ34	438	644	938	1197	1604	1937	2478	3642	403	580	828	1083	1453	1755	2066	3034
HCSJ11	532	750	1088	1338	1729	2082	2673	3980	484	675	963	1210	1593	1914	2248	3338
HCSJ12	576	798	1153	1420	1787	2143	2683	3941	526	722	1028	1272	1660	1990	2333	3398
SJ37	610	835	1201	1484	1841	2204	2749	4024	562	760	1083	1331	1717	2056	2413	3512
Est Box Capacity	609	747	746	736	731	733	728	711								
SJ37 - Box Capacity	1	88	455	748	1110	1471	2021	3313								
SJ44A	719	982	1398	1800	2174	2462	3064	4480	666	896	1274	1619	2027	2347	2747	4002
SJ44B	787	1060	1488	1947	2397	2753	3202	4710	730	972	1366	1747	2211	2515	2893	4237
SJ45	793	1068	1498	1961	2421	2786	3218	4730	736	980	1378	1762	2233	2543	2913	4263
Lower Branch																
HC75	1497	2035	2843	3674	4567	5270	6022	7923	1358	1823	2543	3219	4095	4672	5273	7109
Est Box Capacity	1496	1928	2090	2199	2285	2341	2374	2456								
HC75 - Box Capacity	1	107	753	1475	2282	2929	3648	5467								
HC75	1497	2035	2843	3674	4567	5270	6022	7923	1358	1823	2543	3219	4095	4672	5273	7109
HCLJ7	1766	2380	3283	4008	4867	5501	6163	8048	1595	2126	2931	3596	4476	5041	5661	7392
HCLJ15									1924	2557	3514	4205	5249	5945	6650	8338
HCLJ16									1960	2606	3582	4282	5338	6050	6771	8465
HCL25X									2009	2672	3671	4395	5492	6227	6969	8665
HCLJ19									2125	2827	3879	4649	5834	6624	7411	9176
HCLJ20									2143	2850	3910	4688	5878	6683	7491	9265
HCL34X									2148	2852	3911	4693	5828	6658	7482	9261
F11B	1045	1373	1853	2256	2869	3390	3963	5271	831	1087	1446	1738	2183	2582	3013	3995
F14	1341	1780	2394	2882	3581	4185	4854	6384	1078	1424	1905	2286	2826	3300	3828	5028
F14	1341	1780	2394	2882	3581	4185	4854	6384	1078	1424	1905	2286	2826	3300	3828	5028
COMB10	1572	2079	2794	3371	4182	4873	5641	7400	1284	1688	2255	2707	3357	3913	4533	5946
COMB11	1601	2116	2844	3433	4258	4960	5739	7525	1314	1727	2306	2771	3436	4001	4631	6073
COMB11	1601	2116	2844	3433	4258	4960	5739	7525	1314	1727	2306	2771	3436	4001	4631	6073
COMB12	1614	2098	2734	3219	3979	4587	5753	6340	1331	1736	2308	2713	3308	3861	4423	6165
COMB13	1646	2148	2801	3291	4054	4662	5692	6493	1367	1790	2382	2803	3412	3973	4542	6232
COMBJF									2919	3840	5256	6420	8075	9547	11009	13579

Point	12 Hour Peak Flows								18 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
HCNB9	58	83	114	137	157	166	175	188	58	80	110	133	152	161	170	187
RRNB31	66	90	129	153	177	191	204	232	65	88	125	148	172	188	201	230
NB17	71	96	137	162	188	206	223	265	70	93	135	157	186	205	225	265
HCNB12	140	180	243	297	365	418	470	588	133	172	236	287	345	391	444	543
HCNB13	165	213	281	347	433	497	560	695	156	202	270	332	404	459	520	638
NB12	184	238	314	384	480	551	623	774	173	223	297	365	446	505	571	704
HCNB17	245	318	432	526	656	756	855	1059	229	296	396	489	606	688	772	987
HCNB19	274	356	483	587	725	836	947	1178	256	329	439	535	668	758	850	1078
RNB39B	271	353	480	583	722	832	942	1175	254	327	436	532	665	755	846	1076
HCNB21	335	438	593	718	883	1015	1150	1441	312	402	535	642	805	916	1026	1295
NB42	347	454	616	745	915	1051	1191	1492	323	416	554	664	832	946	1061	1337
HCNB25	358	469	635	768	942	1082	1226	1538	332	428	570	683	855	973	1091	1373
NB44	375	492	666	805	988	1134	1285	1620	347	448	596	714	893	1018	1144	1434
NB54	480	633	859	1038	1276	1456	1647	2068	440	571	757	909	1130	1294	1457	1805
HCNB29	491	649	880	1065	1311	1496	1693	2127	450	584	774	931	1157	1329	1497	1853
HCNB30	517	684	930	1130	1392	1590	1798	2259	473	617	817	987	1225	1409	1589	1965
HCNB31	557	742	1009	1228	1511	1727	1952	2451	510	669	887	1071	1327	1526	1721	2128
HCNB32	580	774	1051	1277	1571	1796	2026	2542	531	696	922	1113	1376	1583	1785	2204
RRSJ6	144	184	237	274	324	365	419	534	125	159	204	237	279	312	347	442
HCSJ6	244	318	430	546	715	841	956	1210	220	285	376	468	593	698	800	998
HCSJ7	291	389	545	687	892	1048	1196	1511	263	339	471	589	738	871	998	1245
HCSJ8	361	518	772	1006	1309	1572	1809	2437	328	482	749	935	1192	1446	1689	2104
SJ34	366	524	779	1014	1319	1582	1822	2451	333	486	757	945	1203	1456	1702	2119
HCSJ11	434	608	871	1134	1452	1748	1995	2683	395	550	851	1053	1336	1599	1864	2362
HCSJ12	473	651	918	1195	1518	1826	2090	2793	433	584	899	1110	1403	1672	1948	2478
SJ37	506	685	963	1245	1575	1893	2170	2888	463	614	943	1160	1464	1736	2024	2578
SJ44A	601	803	1156	1460	1864	2203	2538	3323	546	742	1104	1354	1716	2023	2325	3037
SJ44B	659	869	1242	1552	1998	2340	2701	3520	596	800	1176	1443	1833	2166	2471	3243
SJ45	666	877	1252	1564	2016	2357	2723	3546	602	807	1185	1455	1849	2184	2492	3269
HC75	1245	1633	2262	2769	3568	4105	4699	6066	1133	1480	2064	2527	3223	3763	4266	5466
HC75	1245	1633	2262	2769	3568	4105	4699	6066	1133	1480	2064	2527	3223	3763	4266	5466
HCLJ7	1460	1908	2602	3163	3972	4532	5138	6497	1327	1709	2356	2877	3578	4133	4657	5840
HCLJ15	1753	2292	3096	3748	4652	5309	5963	7485	1592	2040	2773	3374	4191	4790	5394	6706
HCLJ16	1786	2336	3152	3814	4736	5411	6076	7605	1625	2082	2822	3435	4265	4880	5494	6827
HCL25X	1841	2400	3236	3914	4857	5571	6254	7816	1681	2136	2892	3516	4361	4997	5668	7013
HCLJ19	1963	2546	3428	4140	5141	5933	6665	8282	1801	2267	3057	3711	4593	5289	6056	7475
HCLJ20	1984	2571	3461	4178	5185	5990	6739	8364	1822	2290	3084	3743	4631	5332	6106	7552
HCL34X	1998	2582	3475	4194	5196	5985	6747	8391	1835	2302	3097	3756	4646	5340	6097	7550
F11B	572	804	1144	1398	1729	1990	2265	2864	542	738	1014	1222	1497	1713	1941	2432
F14	742	1030	1464	1789	2212	2544	2896	3656	691	941	1294	1559	1909	2183	2473	3096
F14	742	1030	1464	1789	2212	2544	2896	3656	691	941	1294	1559	1909	2183	2473	3096
COMB10	881	1218	1742	2130	2637	3036	3459	4372	818	1120	1543	1861	2282	2612	2958	3710
COMB11	902	1244	1782	2178	2698	3105	3539	4473	836	1145	1579	1903	2334	2671	3026	3796
COMB11	902	1244	1782	2178	2698	3105	3539	4473	836	1145	1579	1903	2334	2671	3026	3796
COMB12	923	1269	1803	2204	2685	3066	3476	4387	854	1166	1607	1930	2365	2669	3009	3757
COMB13	962	1323	1874	2288	2789	3183	3604	4545	889	1213	1670	2007	2459	2777	3129	3905
COMBJF	2847	3568	4769	5789	7178	8442	9804	12377	2646	3307	4259	5136	6378	7410	8611	10912

Point	24 Hour Peak Flows							
	1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
HCNB9	53	72	98	121	143	154	162	180
RRNB31	60	80	114	136	163	178	190	216
NB17	65	86	124	146	176	193	211	245
HCNB12	120	155	210	257	307	348	393	475
HCNB13	140	181	239	296	354	403	456	554
NB12	155	200	261	324	390	442	501	612
HCNB17	204	264	348	429	524	594	689	865
HCNB19	227	293	384	469	577	653	751	945
RNB39B	225	290	382	467	574	651	748	941
HCNB21	273	353	463	560	689	782	890	1120
NB42	282	365	478	578	711	807	917	1155
HCNB25	290	375	492	593	731	829	941	1185
NB44	303	392	514	619	764	869	982	1240
NB54	382	496	649	777	966	1101	1241	1560
HCNB29	391	509	667	798	991	1131	1275	1601
HCNB30	412	538	706	845	1049	1198	1351	1695
HCNB31	445	582	765	915	1134	1295	1460	1830
HCNB32	463	606	796	950	1176	1343	1515	1895
RRSJ6	106	136	174	203	238	266	296	366
HCSJ6	192	249	327	392	502	574	650	823
HCSJ7	232	298	403	493	624	714	816	1027
HCSJ8	291	432	648	801	1017	1253	1457	1814
SJ34	296	438	654	808	1025	1262	1467	1826
HCSJ11	351	494	735	899	1131	1386	1618	2027
HCSJ12	382	525	778	951	1186	1448	1697	2128
SJ37	407	551	815	997	1235	1503	1762	2214
SJ44A	482	655	964	1176	1455	1753	2065	2596
SJ44B	524	697	1031	1257	1547	1868	2200	2767
SJ45	529	703	1039	1267	1560	1883	2217	2789
HC75	992	1284	1808	2191	2701	3218	3728	4677
HC75	992	1284	1808	2191	2701	3218	3728	4677
HCLJ7	1155	1485	2058	2491	3060	3571	4099	5095
HCLJ15	1376	1776	2428	2927	3588	4170	4737	5877
HCLJ16	1403	1811	2474	2981	3651	4239	4819	5977
HCL25X	1453	1875	2543	3071	3761	4362	4965	6163
HCLJ19	1556	2008	2705	3269	4001	4629	5279	6560
HCLJ20	1576	2031	2730	3300	4038	4669	5324	6627
HCL34X	1589	2043	2741	3311	4049	4679	5328	6646
F11B	458	621	840	1012	1235	1411	1596	1997
F14	585	794	1074	1294	1579	1804	2040	2550
F14	585	794	1074	1294	1579	1804	2040	2550
COMB10	696	947	1285	1549	1891	2162	2448	3062
COMB11	712	969	1315	1586	1936	2213	2506	3136
COMB11	712	969	1315	1586	1936	2213	2506	3136
COMB12	729	990	1340	1617	1967	2248	2536	3130
COMB13	759	1030	1396	1684	2049	2343	2642	3263
COMBJF	2285	2970	3795	4561	5592	6413	7369	9530

Point of Interest		Current Development Peak Flow 100yr	Critical 100yr Duration (hr) 1	2	3	6	12	18	24	Current w/ Regional Detention Peak Flow 100yr	Critical 100yr Duration (hr) 1	2	3	6	12	18	24	% Increase
North Branch	X-SEC																	
HCNB9	18653	166	----	----	----	----	X	----	----	122	----	----	----	----	X	X	----	-26.5%
RRNB31	16668	193	----	----	----	----	X	X	----	141	----	----	----	----	----	X	----	-26.9%
NB17	15747	213	----	----	----	----	----	X	----	147	----	----	----	----	----	X	----	-31.0%
HCNB12	14505	626	----	X	----	----	----	----	----	299	----	X	----	----	----	----	----	-52.2%
HCNB13	13249	745	----	X	----	----	----	----	----	434	----	X	----	----	----	----	----	-41.7%
NB12	11949	756	----	----	X	----	----	----	----	530	----	----	X	----	----	----	----	-29.9%
HCNB17	11140	1055	----	----	X	----	----	----	----	802	----	----	X	----	----	----	----	-24.0%
HCNB19	10225	1179	----	----	X	----	----	----	----	962	----	----	X	----	----	----	----	-18.4%
RNB39B	10068	1175	----	----	X	----	----	----	----	793	----	----	X	----	----	----	----	-32.5%
HCNB21	9515	1511	----	----	X	----	----	----	----	1022	----	----	X	----	----	----	----	-32.4%
NB42	8776	1575	----	----	X	----	----	----	----	1074	----	----	X	----	----	----	----	-31.8%
HCNB25	8293	1625	----	----	X	----	----	----	----	1113	----	----	X	----	----	----	----	-31.5%
NB44	7084	1714	----	----	X	----	----	----	----	1194	----	----	X	----	----	----	----	-30.3%
NB54	5346	2216	----	----	X	----	----	----	----	1715	----	----	X	----	----	----	----	-22.6%
HCNB29	5026	2280	----	----	X	----	----	----	----	1800	----	----	X	----	----	----	----	-21.1%
HCNB30	3659	2429	----	----	X	----	----	----	----	1993	----	----	X	----	----	----	----	-17.9%
HCNB31	1837	2627	----	----	X	----	----	----	----	2243	----	----	X	----	----	----	----	-14.6%
HCNB32	610	2734	----	----	X	----	----	----	----	2359	----	----	X	----	----	----	----	-13.7%
South Branch																		
RRSJ6	14475	773	----	X	----	----	----	----	----	373	----	X	X	----	----	----	----	-51.7%
HCSJ6	12585	1378	----	X	----	----	----	----	----	679	----	X	----	----	----	----	----	-50.7%
HCSJ7	10710	1585	----	X	----	----	----	----	----	992	----	X	----	----	----	----	----	-37.4%
HCSJ8	8856	1917	----	----	X	----	----	----	----	1471	----	----	X	----	----	----	----	-23.3%
SJ34	7825	1927	----	----	X	----	----	----	----	1486	----	----	X	----	----	----	----	-22.9%
HCSJ11	7131	2069	----	----	X	----	----	----	----	1753	----	----	X	----	----	----	----	-15.3%
HCSJ12	6309	2160	----	----	X	----	----	----	----	1889	----	----	X	----	----	----	----	-12.5%
SJ37	5006	2247	----	----	X	----	----	----	----	1999	----	----	X	----	----	----	----	-11.0%
Est Box Capacity	1643	725	----	----	X	----	----	----	----	725	----	----	X	----	----	----	----	0.0%
SJ37 - Box Capacity	4432	1523	----	----	X	----	----	----	----	1274	----	----	X	----	----	----	----	-16.3%
SJ44A	2584	2674	----	----	X	----	----	----	----	2505	----	----	X	----	----	----	----	-6.3%
SJ44B	1390	2868	----	----	X	----	----	----	----	2791	----	----	X	----	----	----	----	-2.7%
SJ45	761	2897	----	----	X	----	----	----	----	2833	----	----	X	----	----	----	----	-2.2%
Lower Branch																		
HC75	16700	5608	----	----	X	----	----	----	----	5150	----	----	X	----	----	----	----	-8.2%
Est Box Capacity	3354	2346	----	----	X	----	----	----	----	2332	----	----	X	----	----	----	----	-0.6%
HC75 - Box Capacity	16690	3262	----	----	X	----	----	----	----	2818	----	----	X	----	----	----	----	-13.6%
HC75	13427	5608	----	----	X	----	----	----	----	5150	----	----	X	----	----	----	----	-8.2%
HCLJ7	13132	5683	----	----	X	----	----	----	----	5332	----	----	X	----	----	----	----	-6.2%
HCLJ15	9733	6060	----	----	----	X	----	----	----	5724	----	----	----	X	----	----	----	-5.5%
HCLJ16	8274	6157	----	----	----	X	----	----	----	5821	----	----	----	X	----	----	----	-5.5%
HCL25X	5689	6341	----	----	----	X	----	----	----	6016	----	----	----	X	----	----	----	-5.1%
HCLJ19	3859	6737	----	----	----	X	----	----	----	6438	----	----	----	X	----	----	----	-4.4%
HCLJ20	2266	6806	----	----	----	X	----	----	----	6491	----	----	----	X	----	----	----	-4.6%
HCL34X	621	6777	----	----	----	X	----	----	----	6457	----	----	----	X	----	----	----	-4.7%
Fassnight Creek																		
F11B	11358	3270	----	----	X	----	----	----	----	3270	----	----	X	----	----	----	----	0.0%
COMB14	9487	3988	----	----	X	----	----	----	----	3988	----	----	X	----	----	----	----	0.0%
F14	7121	3988	----	----	X	----	----	----	----	3988	----	----	X	----	----	----	----	0.0%
COMB9	6405	4650	----	----	X	----	----	----	----	4650	----	----	X	----	----	----	----	0.0%
COMB10	4641	4726	----	----	X	----	----	----	----	4726	----	----	X	----	----	----	----	0.0%
COMB11	3883	4726	----	----	X	----	----	----	----	4726	----	----	X	----	----	----	----	0.0%
COMB12	2816	4354	----	----	X	----	----	----	----	4354	----	----	X	----	----	----	----	0.0%
COMB13	2020	4456	----	----	X	----	----	----	----	4456	----	----	X	----	----	----	----	0.0%
Wilsons Creek																		
COMBJF	33108	9859	----	----	----	X	----	----	----	9627	----	----	----	X	----	----	----	-2.4%

Point of Interest	Current Flows w/ Regional Detention Maximum 100 yr Flowrate (cfs)	Hr	Critical 100 yr Duration (hr) 1	2	3	6	12	18	24		Point
North Branch											North Branch
HCNB9	122	12	----	----	----	----	X	X	----	5	HCNB9
RRNB31	141	18	----	----	----	----	----	X	----	6	RRNB31
NB17	147	18	----	----	----	----	----	X	----	6	NB17
HCNB12	299	2	----	X	----	----	----	----	----	2	HCNB12
HCNB13	434	2	----	X	----	----	----	----	----	2	HCNB13
NB12	530	3	----	----	X	----	----	----	----	3	NB12
HCNB17	802	3	----	----	X	----	----	----	----	3	HCNB17
HCNB19	962	3	----	----	X	----	----	----	----	3	HCNB19
RNB39B	793	3	----	----	X	----	----	----	----	3	RNB39B
HCNB21	1022	3	----	----	X	----	----	----	----	3	HCNB21
NB42	1074	3	----	----	X	----	----	----	----	3	NB42
HCNB25	1113	3	----	----	X	----	----	----	----	3	HCNB25
NB44	1194	3	----	----	X	----	----	----	----	3	NB44
NB54	1715	3	----	----	X	----	----	----	----	3	NB54
HCNB29	1800	3	----	----	X	----	----	----	----	3	HCNB29
HCNB30	1993	3	----	----	X	----	----	----	----	3	HCNB30
HCNB31	2243	3	----	----	X	----	----	----	----	3	HCNB31
HCNB32	2359	3	----	----	X	----	----	----	----	3	HCNB32
South Branch											South Branch
RRSJ6	373	2	----	X	X	----	----	----	----	2	RRSJ6
HCSJ6	679	2	----	X	----	----	----	----	----	2	HCSJ6
HCSJ7	992	2	----	X	----	----	----	----	----	2	HCSJ7
HCSJ8	1471	3	----	----	X	----	----	----	----	3	HCSJ8
SJ34	1486	3	----	----	X	----	----	----	----	3	SJ34
HCSJ11	1753	3	----	----	X	----	----	----	----	3	HCSJ11
HCSJ12	1889	3	----	----	X	----	----	----	----	3	HCSJ12
SJ37	1999	3	----	----	X	----	----	----	----	3	SJ37
Est Box Capacity	725	3	----	----	X	----	----	----	----	3	Est Box Capacity
SJ37 - Box Capacity	1274	3	----	----	X	----	----	----	----	3	SJ37 - Box Capacity
SJ44A	2505	3	----	----	X	----	----	----	----	3	SJ44A
SJ44B	2791	3	----	----	X	----	----	----	----	3	SJ44B
SJ45	2833	3	----	----	X	----	----	----	----	3	SJ45
Lower Branch											Lower Branch
HC75	5150	3	----	----	X	----	----	----	----	3	HC75
Est Box Capacity	2332	3	----	----	X	----	----	----	----	3	Est Box Capacity
HC75 - Box Capacity	2818	3	----	----	X	----	----	----	----	3	HC75 - Box Capacity
HC75	5150	3	----	----	X	----	----	----	----	3	HC75
HCLJ7	5332	3	----	----	X	----	----	----	----	3	HCLJ7
HCLJ15	5724	6	----	----	----	X	----	----	----	4	HCLJ15
HCLJ16	5821	6	----	----	----	X	----	----	----	4	HCLJ16
HCL25X	6016	6	----	----	----	X	----	----	----	4	HCL25X
HCLJ19	6438	6	----	----	----	X	----	----	----	4	HCLJ19
HCLJ20	6491	6	----	----	----	X	----	----	----	4	HCLJ20
HCL34X	6457	6	----	----	----	X	----	----	----	4	HCL34X
Fassnight Creek											
F11B	3270	3	----	----	X	----	----	----	----	3	F11B
F14	3988	3	----	----	X	----	----	----	----	3	F14
F14	3988	3	----	----	X	----	----	----	----	3	F14
COMB10	4650	3	----	----	X	----	----	----	----	3	COMB10
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB11	4726	3	----	----	X	----	----	----	----	3	COMB11
COMB12	4354	3	----	----	X	----	----	----	----	3	COMB12
COMB13	4456	3	----	----	X	----	----	----	----	3	COMB13
Wilsons Creek											
COMBJF	9627	6	----	----	----	X	----	----	----	4	COMBJF

Point	1 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	2 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
HCNB9									27	35	49	61	73	82	103	122
RRNB31									34	45	61	67	77	83	91	103
NB17									39	52	71	80	99	113	129	166
HCNB12									66	101	140	175	223	256	299	393
HCNB13									89	142	212	260	320	374	434	562
RRSJ6									109	131	176	222	278	323	373	477
HCSJ6									166	227	317	392	497	586	679	887
HCSJ7									217	304	448	565	722	853	992	1325

Point	3 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	6 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																
HCNB9	31	45	64	75	89	105	115	128	37	51	70	86	102	113	119	133
RRNB31	39	52	65	73	83	92	99	110	45	61	75	85	97	104	110	157
NB17	42	57	73	83	97	109	122	152	47	64	78	90	103	110	118	166
HCNB12	68	99	137	171	215	251	289	373	64	90	125	155	194	222	253	323
HCNB13	93	136	200	247	300	351	406	522	83	121	169	206	258	302	345	447
NB12	115	172	258	322	399	462	530	680	103	151	217	263	324	378	435	556
HCNB17	179	274	418	522	624	709	802	1004	156	234	342	422	523	594	673	845
HCNB19	224	323	488	613	742	848	962	1214	184	274	401	497	622	701	792	994
RNB39B	201	291	415	511	617	702	793	992	177	257	362	445	550	631	712	894
HCNB21	277	385	541	662	799	906	1022	1275	237	341	474	582	722	820	924	1156
NB42	292	402	564	691	838	952	1074	1341	248	356	496	608	757	860	970	1214
HCNB25	302	416	582	713	868	986	1113	1390	257	368	512	629	783	890	1004	1257
NB44	321	442	616	755	926	1054	1194	1504	272	389	543	667	833	948	1071	1343
NB54	440	624	871	1058	1305	1502	1715	2199	368	527	743	914	1144	1316	1488	1859
HCNB29	455	646	907	1105	1367	1576	1800	2306	379	544	767	944	1182	1363	1543	1929
HCNB30	485	695	986	1209	1505	1741	1993	2557	405	583	824	1016	1272	1469	1668	2089
HCNB31	529	761	1090	1345	1684	1955	2243	2879	441	636	903	1113	1395	1615	1840	2315
HCNB32	562	804	1149	1418	1777	2054	2359	3030	469	674	956	1175	1470	1701	1937	2443
South Branch																
RRSJ6	109	130	175	220	277	321	373	481	99	126	167	207	262	305	350	455
HCSJ6	167	225	320	396	504	585	674	875	162	224	306	376	470	544	623	799
HCSJ7	216	303	455	565	712	833	961	1268	207	292	411	505	640	742	850	1096
HCSJ8	272	405	597	744	1034	1241	1471	2004	265	382	558	729	972	1150	1354	1810
SJ34	276	410	602	750	1038	1253	1486	2032	269	388	565	737	983	1160	1369	1830
HCSJ11	332	509	742	919	1197	1479	1753	2411	320	470	674	839	1124	1355	1586	2136
HCSJ12	360	557	818	1019	1296	1586	1889	2591	346	513	737	912	1199	1451	1704	2291
SJ37	379	591	877	1097	1401	1669	1999	2750	366	545	789	979	1258	1531	1801	2423
Est Box Capacity	479	718	751	744	733	729	725	717								
SJ37 - Box Capacity	1	1	126	353	668	940	1274	2033								
SJ44A	468	711	1066	1341	1792	2139	2505	3413	437	651	951	1184	1487	1840	2195	2979
SJ44B	520	764	1147	1447	1976	2375	2791	3739	475	703	1029	1283	1619	1979	2368	3223
SJ45	528	772	1159	1462	2002	2409	2833	3794	481	712	1041	1298	1639	2008	2395	3260
Lower Branch																
HC75	1089	1547	2225	2766	3722	4427	5150	6815	937	1341	1951	2425	3064	3706	4270	5664
Est Box Capacity	1089	1547	1988	2079	2202	2274	2332	2409								
HC75 - Box Capacity	1	1	237	687	1520	2153	2818	4406								
HC75	1089	1547	2225	2766	3722	4427	5150	6815	937	1341	1951	2425	3064	3706	4270	5664
HCLJ7	1313	1841	2624	3223	4073	4724	5332	6756	1130	1614	2291	2843	3543	4173	4736	6053
HCLJ15									1412	1991	2779	3432	4278	4992	5724	7187
HCLJ16									1440	2028	2829	3493	4355	5075	5821	7327
HCL25X									1483	2083	2910	3592	4480	5239	6016	7575
HCLJ19									1577	2209	3085	3808	4755	5595	6438	8119
HCLJ20									1591	2229	3111	3841	4796	5617	6491	8211
HCL34X									1573	2233	3115	3844	4800	5565	6457	8197
Fassnight Creek																
F11B	783	1024	1392	1722	2267	2740	3270	4467	634	810	1080	1351	1787	2143	2533	3430
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
F14	914	1230	1716	2154	2813	3366	3988	5411	743	980	1352	1674	2221	2669	3158	4273
COMB10	1091	1459	2017	2530	3296	3934	4650	6291	897	1177	1609	1989	2621	3155	3734	5053
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB11	1107	1480	2049	2573	3352	3999	4726	6393	913	1198	1639	2029	2672	3216	3807	5152
COMB12	1097	1484	2043	2538	3160	3742	4354	6260	922	1206	1657	2048	2665	3139	3686	5119
COMB13	1111	1511	2099	2616	3247	3831	4456	6392	933	1236	1712	2130	2768	3256	3819	5213
Wilsons Creek																
COMBJF									2174	3113	4364	5424	6869	8149	9627	12610

Point	12 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	18 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr	24 Hour Peak Flows 1yr	2yr	5yr	10yr	25yr	50yr	100yr	500yr
North Branch																								
HCNB9	40	55	75	90	108	115	122	136	41	56	76	92	108	115	122	136	40	54	73	88	104	114	120	134
RRNB31	49	64	81	94	105	112	134	174	50	65	83	96	107	114	141	178	49	64	81	94	106	115	137	177
NB17	51	67	84	98	109	117	139	182	52	68	86	100	111	120	147	188	51	67	84	98	110	119	143	188
HCNB12	70	95	132	158	191	214	241	301	76	102	137	161	191	213	239	296	72	97	128	149	177	197	221	271
HCNB13	87	122	167	205	251	286	322	404	93	127	173	206	246	276	310	386	87	118	160	188	222	250	280	346
NB12	106	150	206	250	306	352	395	495	112	153	207	249	296	334	374	465	103	140	188	223	264	298	333	411
HCNB17	158	224	311	378	464	523	591	734	161	223	303	366	442	494	551	681	145	198	270	323	387	437	490	606
HCNB19	186	260	361	436	535	605	684	848	186	255	346	418	504	565	631	779	166	226	305	366	438	495	555	687
RNB39B	176	248	337	408	502	567	639	793	177	244	326	391	474	533	593	730	160	219	293	350	421	476	533	658
HCNB21	232	323	436	525	644	731	821	1018	229	313	414	495	600	678	755	926	204	278	367	439	528	598	669	824
NB42	243	338	456	550	674	765	860	1066	239	326	431	516	625	708	788	967	212	288	382	456	550	623	697	858
HCNB25	251	349	470	567	695	789	888	1101	246	335	444	531	643	729	812	997	218	296	392	469	566	641	719	886
NB44	265	369	499	601	737	839	945	1177	259	353	468	560	680	773	866	1065	229	312	414	495	601	681	766	945
NB54	350	488	669	811	998	1148	1295	1609	338	465	625	749	914	1042	1172	1443	298	408	548	655	796	905	1019	1260
HCNB29	360	503	692	838	1032	1188	1341	1667	348	479	645	773	944	1077	1212	1493	307	420	565	676	821	934	1052	1301
HCNB30	383	538	742	900	1109	1277	1444	1798	370	511	691	828	1013	1156	1302	1607	326	448	603	722	878	999	1127	1394
HCNB31	415	585	811	985	1215	1400	1586	1978	401	555	753	904	1106	1264	1426	1763	353	485	656	785	957	1090	1230	1523
HCNB32	437	618	854	1036	1276	1469	1666	2074	423	583	790	947	1158	1323	1493	1844	371	509	687	822	1001	1139	1286	1592
South Branch																								
RRSJ6	95	125	159	193	244	283	325	416	92	123	149	176	222	256	292	369	81	109	129	156	190	222	253	322
HCSJ6	166	230	306	369	463	531	605	763	168	231	297	350	431	493	558	703	150	206	264	315	379	437	498	626
HCSJ7	210	301	401	485	608	704	803	1019	211	297	383	464	566	653	743	933	189	262	346	412	500	574	653	817
HCSJ8	272	396	587	758	991	1168	1343	1797	275	396	621	776	976	1134	1338	1773	245	370	570	702	862	1024	1239	1548
SJ34	276	401	593	765	1001	1181	1359	1811	279	402	629	784	986	1144	1350	1787	248	374	575	709	870	1033	1248	1561
HCSJ11	331	475	674	879	1145	1356	1574	2031	331	470	720	902	1136	1315	1511	2029	297	424	659	809	995	1148	1401	1763
HCSJ12	359	514	729	938	1221	1448	1688	2172	360	510	768	966	1215	1406	1600	2150	323	454	704	864	1062	1218	1481	1870
SJ37	379	545	776	985	1285	1524	1779	2294	382	540	807	1016	1277	1479	1682	2251	341	480	739	908	1116	1280	1545	1960
Est Box Capacity																								
SJ37 - Box Capacity																								
SJ44A	452	653	928	1151	1542	1851	2169	2817	456	639	942	1200	1532	1792	2045	2692	405	564	860	1074	1324	1542	1822	2336
SJ44B	489	705	1005	1233	1647	1992	2337	3045	494	690	1006	1280	1627	1927	2202	2879	438	607	914	1141	1406	1644	1940	2499
SJ45	495	713	1017	1248	1663	2014	2362	3078	501	698	1016	1293	1643	1947	2225	2906	443	614	923	1152	1419	1660	1957	2523
Lower Branch																								
HC75	930	1313	1845	2250	2862	3475	4013	5143	920	1262	1757	2192	2763	3269	3716	4739	812	1118	1572	1952	2403	2784	3238	4111
Est Box Capacity																								
HC75 - Box Capacity																								
HC75	930	1313	1845	2250	2862	3475	4013	5143	920	1262	1757	2192	2763	3269	3716	4739	812	1118	1572	1952	2403	2784	3238	4111
HCLJ7	1102	1540	2162	2635	3259	3889	4448	5606	1081	1471	2026	2510	3142	3652	4133	5153	949	1306	1798	2227	2745	3149	3622	4559
HCLJ15	1339	1852	2578	3147	3885	4586	5260	6611	1307	1772	2408	2936	3665	4304	4877	6037	1148	1587	2128	2624	3251	3713	4269	5359
HCLJ16	1364	1888	2625	3206	3961	4662	5355	6739	1333	1808	2456	2992	3736	4377	4963	6145	1169	1616	2166	2669	3305	3774	4337	5445
HCL25X	1405	1945	2701	3301	4081	4791	5534	6966	1377	1873	2531	3078	3845	4501	5135	6365	1160	1670	2236	2754	3407	3893	4471	5623
HCLJ19	1495	2068	2867	3507	4341	5082	5919	7461	1468	2011	2692	3270	4082	4773	5498	6823	1229	1787	2386	2933	3629	4148	4758	6000
HCLJ20	1512	2090	2894	3540	4383	5128	5972	7548	1482	2034	2719	3301	4120	4815	5516	6904	1237	1809	2411	2962	3667	4192	4808	6062
HCL34X	1514	2103	2907	3555	4402	5145	5959	7556	1478	2045	2730	3316	4136	4826	5494	6911	1228	1823	2423	2973	3682	4211	4827	6091
Fassnight Creek																								
F11B	427	643	966	1212	1536	1793	2069	2665	438	629	897	1102	1374	1590	1818	2313	380	537	751	921	1143	1319	1507	1909
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920	472	670	943	1160	1444	1668	1907	2420
F14	533	797	1203	1515	1929	2257	2606	3365	542	783	1121	1382	1727	2003	2293	2920	472	670	943	1160	1444	1668	1907	2420
COMB10	628	937	1421	1796	2292	2683	3102	4014	637	925	1329	1645	2057	2389	2737	3491	556	794	1124	1384	1726	1995	2283	2901
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568	566	810	1147	1414	1764	2039	2335	2968
COMB11	640	954	1449	1832	2339	2739	3167	4100	648	943	1356	1679	2101	2441	2796	3568	566	810	1147	1414	1764	2039	2335	2968
COMB12	650	970	1472	1852	2363	2720	3112	4017	659	959	1378	1701	2126	2460	2781	3519	576	825	1167	1439	1789	2068	2369	2968
COMB13	670	1003	1530	1930	2467	2839	3248	4194	682	998	1437	1777	2224	2575	2908	3683	596	860	1219	1505	1874	2169	2486	3112
Wilsons Creek																								
COMBJF	2118	3039	4118	5057	6356	7463	8671	11400	2095	2975	3898	4713	5885	6828	7924	10280	1714	2650	3459	4180	5214	6026	6857	8922

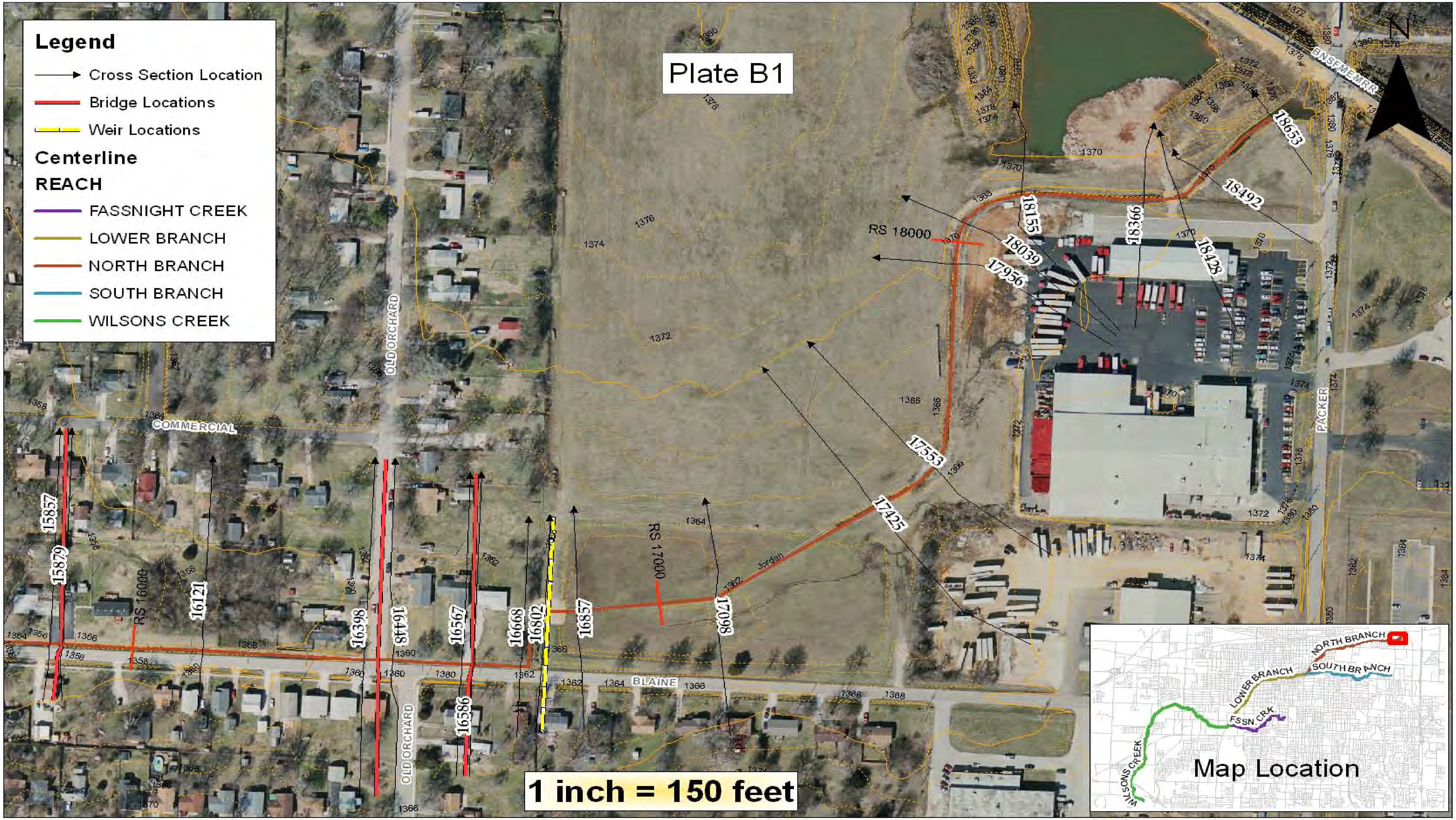


Plate B1
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
COMMERCIAL
BLAINE
OLD ORCHARD
PACKER
RS 18000
RS 17000
RS 16000
15857
15879
16121
16398
16418
16567
16586
16668
16802
16857
17098
17425
17553
17956
18039
18155
18366
18428
18492
18653


Plate B2
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
N
COMMERCIAL
BLAINE
PACIFIC
PATTERSON
LONE PINE
OAK GROVE
YATES
ENGEL
HAYES
MARLAN
13546
13626
13677
13739
13910
13949
14018
RS 14000
14035
14071
14295
14373
14392
14505
14970
RS 15000
15078
15128
15215
15476
15611
15636
15747
15857
15879
Map Location
1 inch = 150 feet

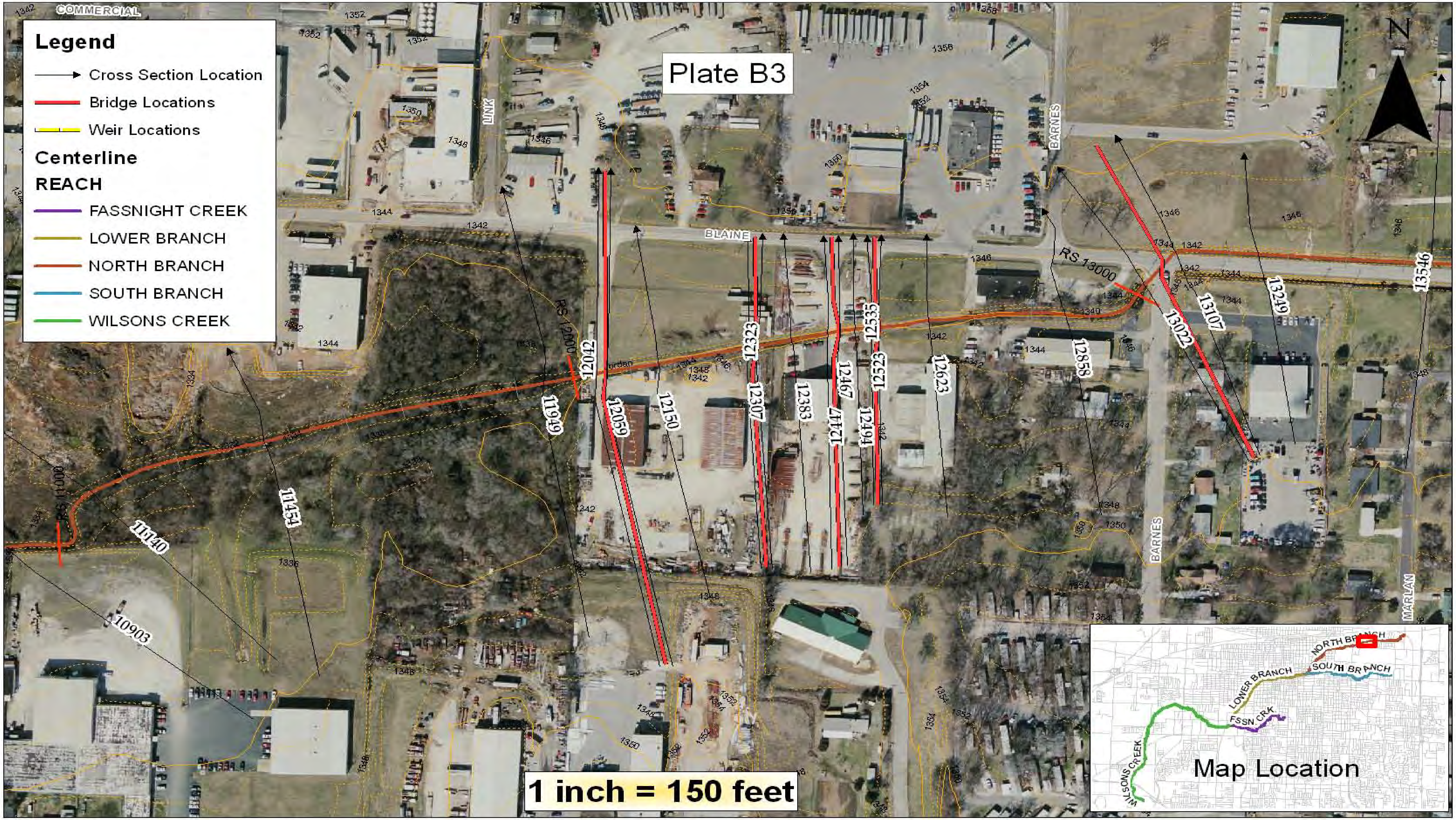
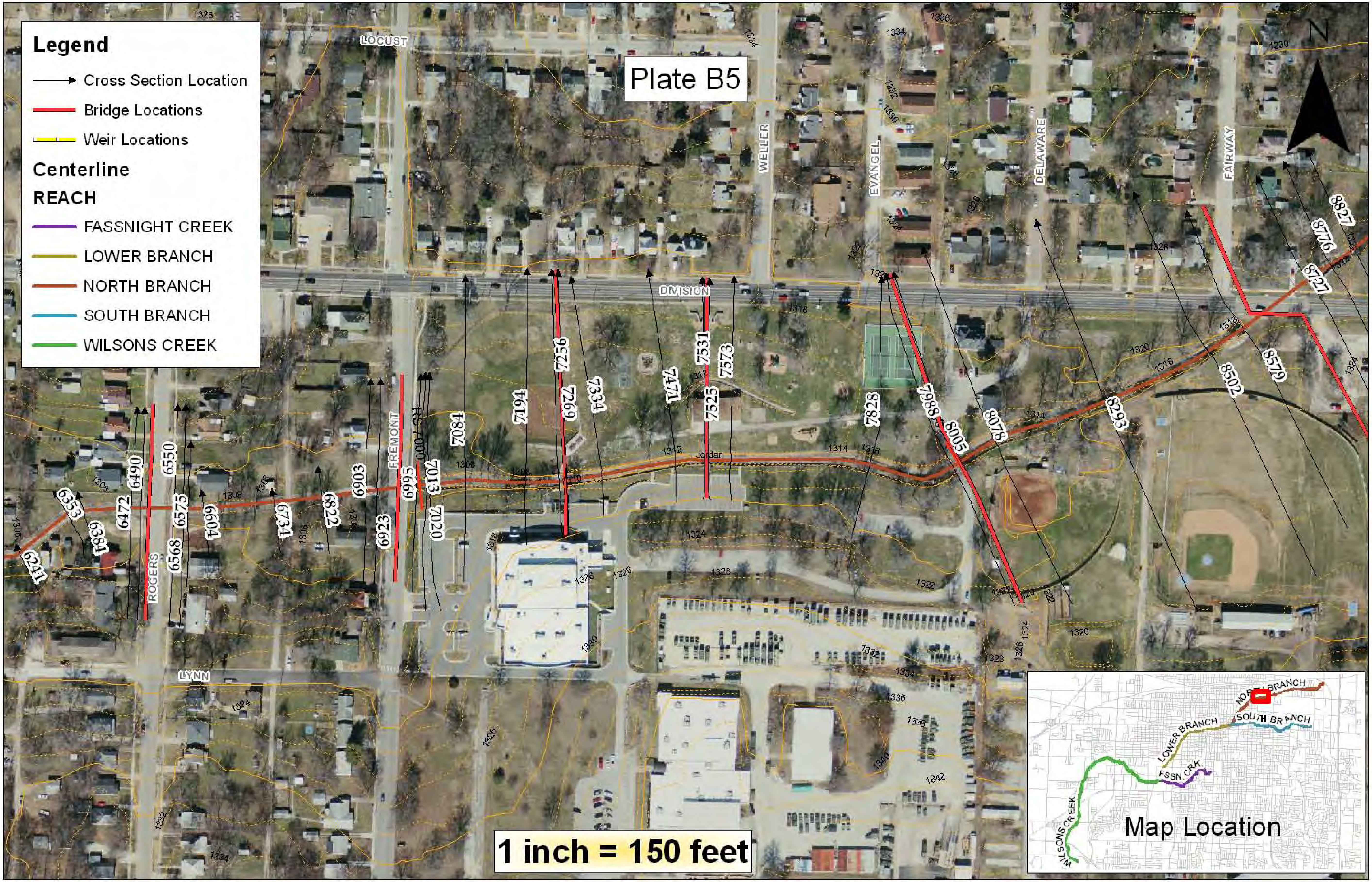


Plate B3
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
COMMERCIAL
LINK
BLAINE
BARNES
MARLAN
RS 11000
RS 12000
RS 13000
10903
11140
11454
11949
12042
12059
12150
12307
12323
12383
12417
12467
12494
12523
12535
12623
12858
13022
13107
13249
13546
N
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Plate B4
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
PACIFIC
WAVERLY
FAIRWAY
LOCUST
GLENSTONE
DIVISION
Jordan
RS 9000
RS 10000
RS 11000
8502
8579
8727
8776
8827
9250
9515
9726
10068
10225
10651
10903
11140
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK



Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B5
1 inch = 150 feet
Map Location
LOCUST
DIVISION
WELLER
EVANGEL
DELAWARE
FAIRWAY
ROGERS
FREMONT
LYNN
N


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B6
1 inch = 150 feet
Map Location
FRISCO
HAMPTON
NATIONAL
PROSPECT
ROGERS
LYNN
CALHOUN
WEBSTER
TEXAS
FLORENCE
BNSF-Loop RR
RS 5000
RS 6000
5026
4823
4517
4400
4293
4286
4130
3932
3825
3659
5459
5346
5544
5576
5607
5694
5799
5882
5953
5981
6043
6061
6094
6157
6241
6353
6384
6472
6490
6550
6568
6604

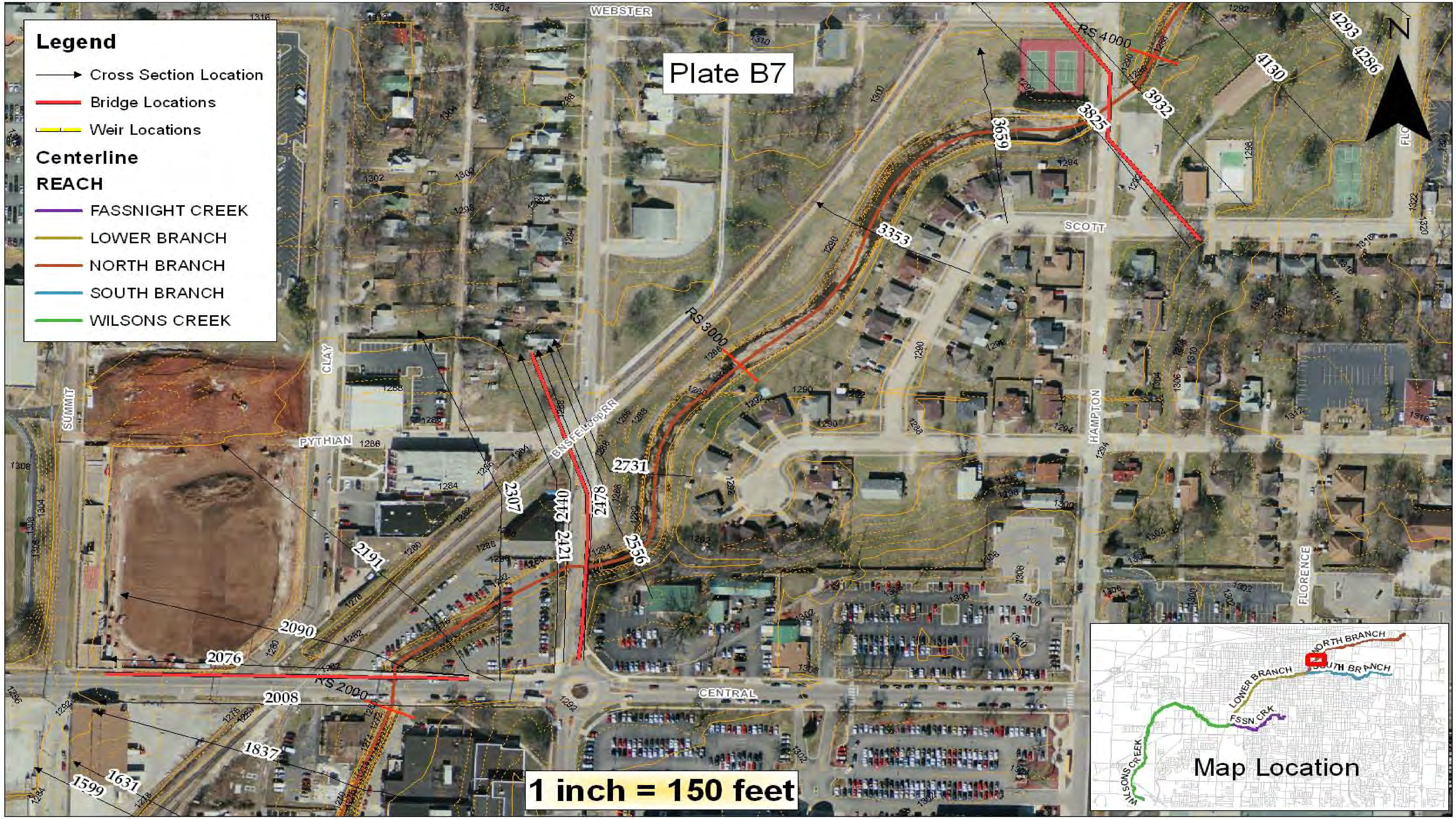
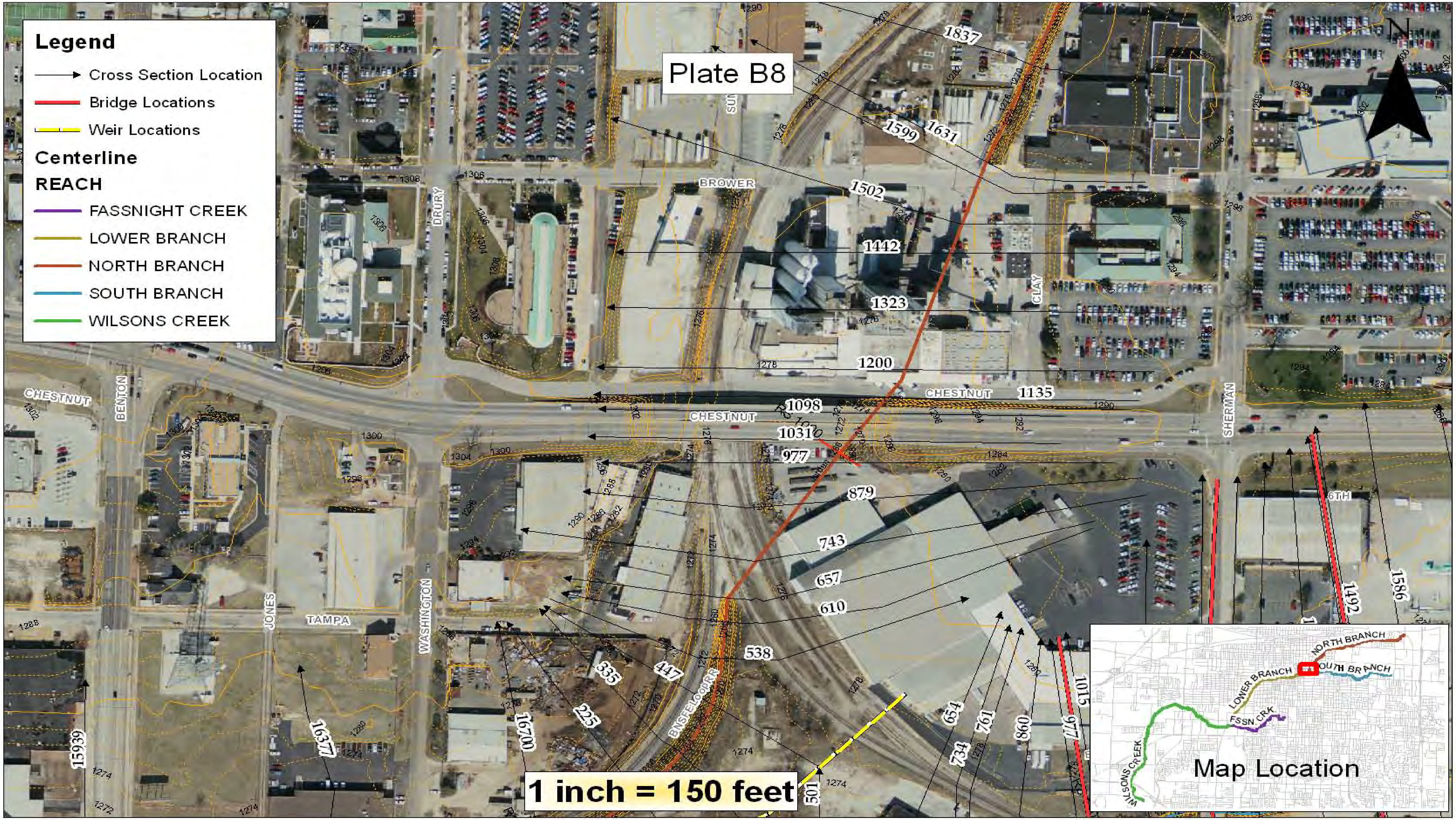


Plate B7
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
WEBSTER
SCOTT
CLAY
PYTHIAN
SUMMIT
HAMPTON
FLORENCE
CENTRAL
BNSF-Loop RR
RS 4000
RS 3000
RS 2000
4293
4286
4130
3932
3825
3659
3353
2731
2556
2478
2421
2440
2307
2191
2090
2076
2008
1837
1631
1599
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B8
1 inch = 150 feet
Map Location
CHESTNUT
BROWER
DRURY
BENTON
JONES
TAMPA
WASHINGTON
CLAY
SHERMAN
6TH
BNSF LOOP RR
1837
1631
1599
1502
1442
1323
1200
1135
1098
1031
977
879
743
657
610
538
447
335
225
16700
16377
15939
501
654
734
761
860
977
1015
1492
1586


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B9
1 inch = 150 feet
Map Location
ROCKHURST
ELMWOOD
CEDARBROOK
CHESTNUT
13038
13205
13320
13344
13400
13458
13545
13648
13738
13838
13905
RS 14000
14073
14231
14287
14475
RS 15000

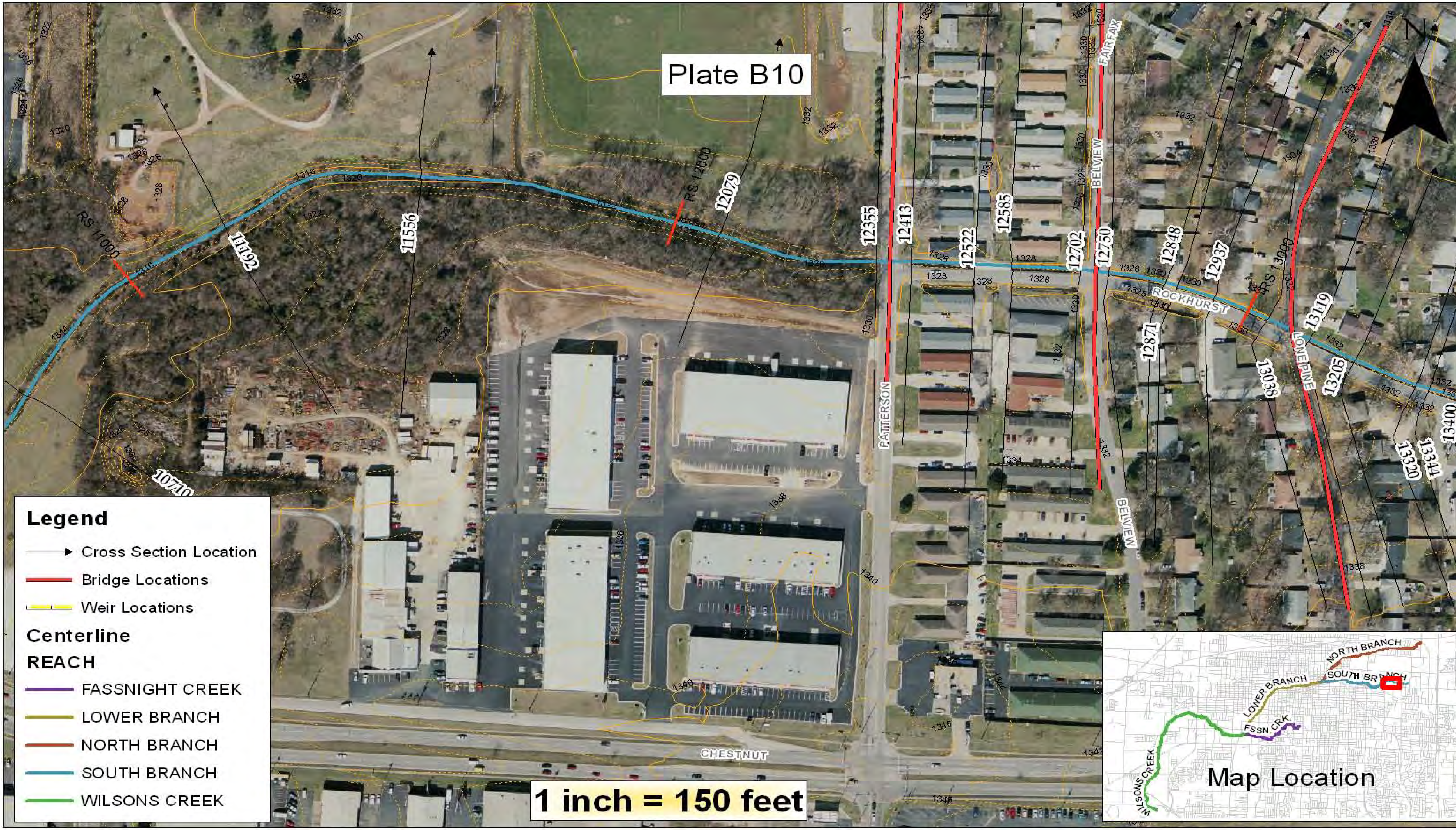
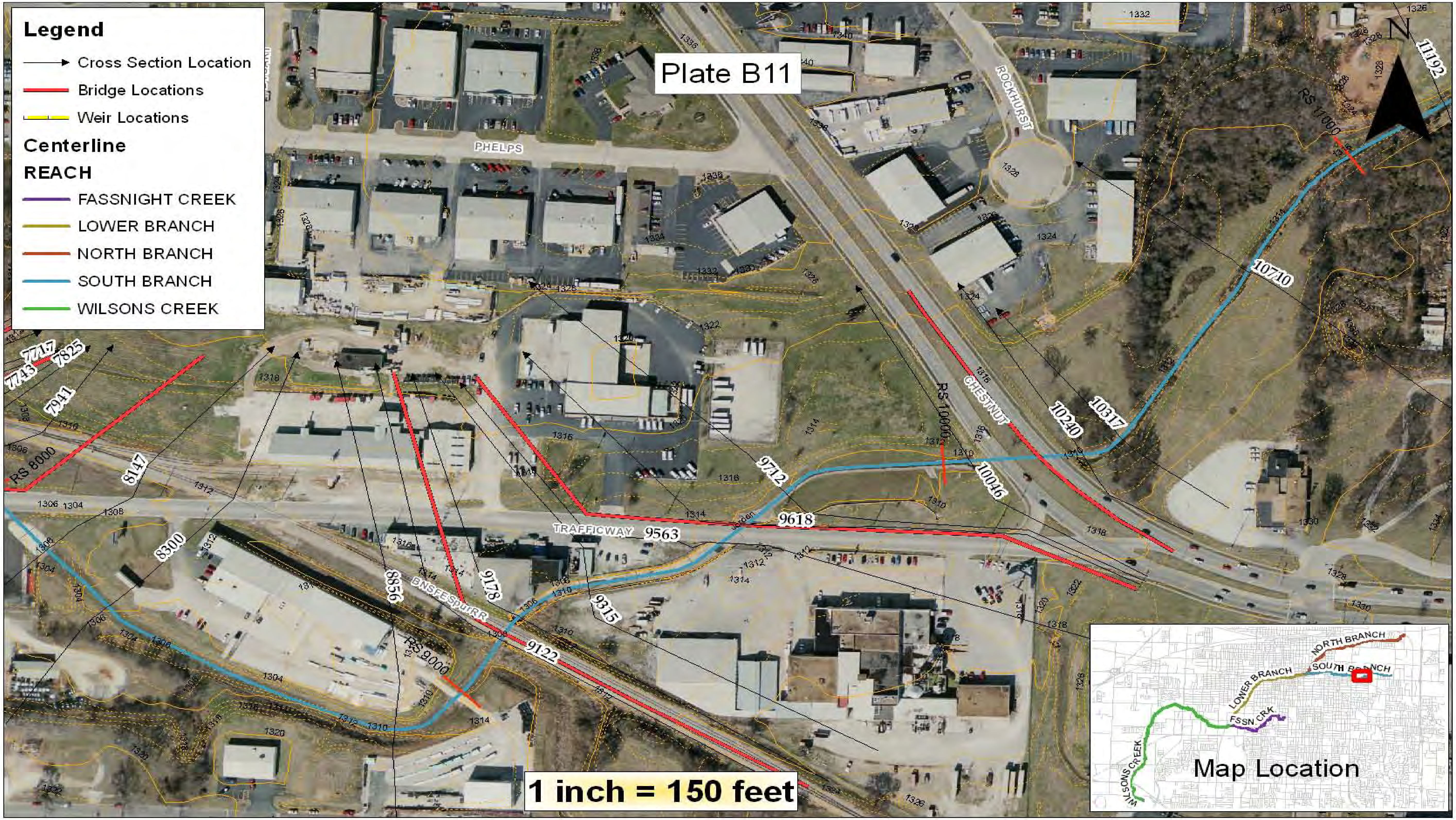


Plate B10
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
RS 11000
RS 12000
RS 13000
10710
11162
11556
12079
12355
12413
12522
12585
12702
12750
12848
12871
12937
13036
13119
13205
13320
13344
13400
PATTERSON
BELVIEW
FAIRFAX
ROCKHURST
LONE PINE
CHESTNUT
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK



Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B11
PHELPS
ROCKHURST
CHESTNUT
TRAFFICWAY
BNSF Spur RR
RS 8000
RS 9000
RS 10000
RS 11000
7717
7743
7825
7941
8147
8300
8856
9122
9178
9315
9563
9618
9712
10046
10240
10317
10710
11192
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK
N

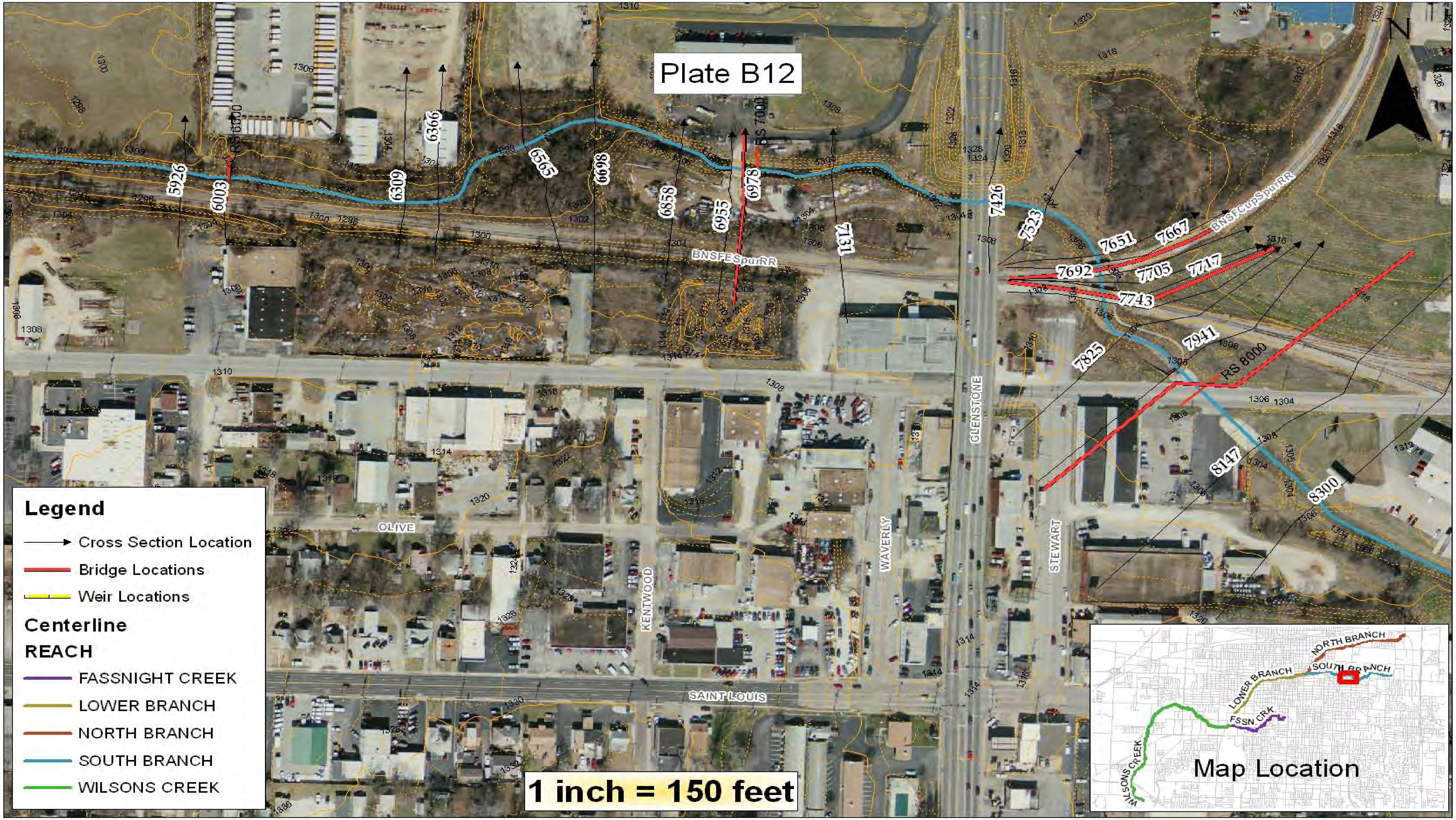
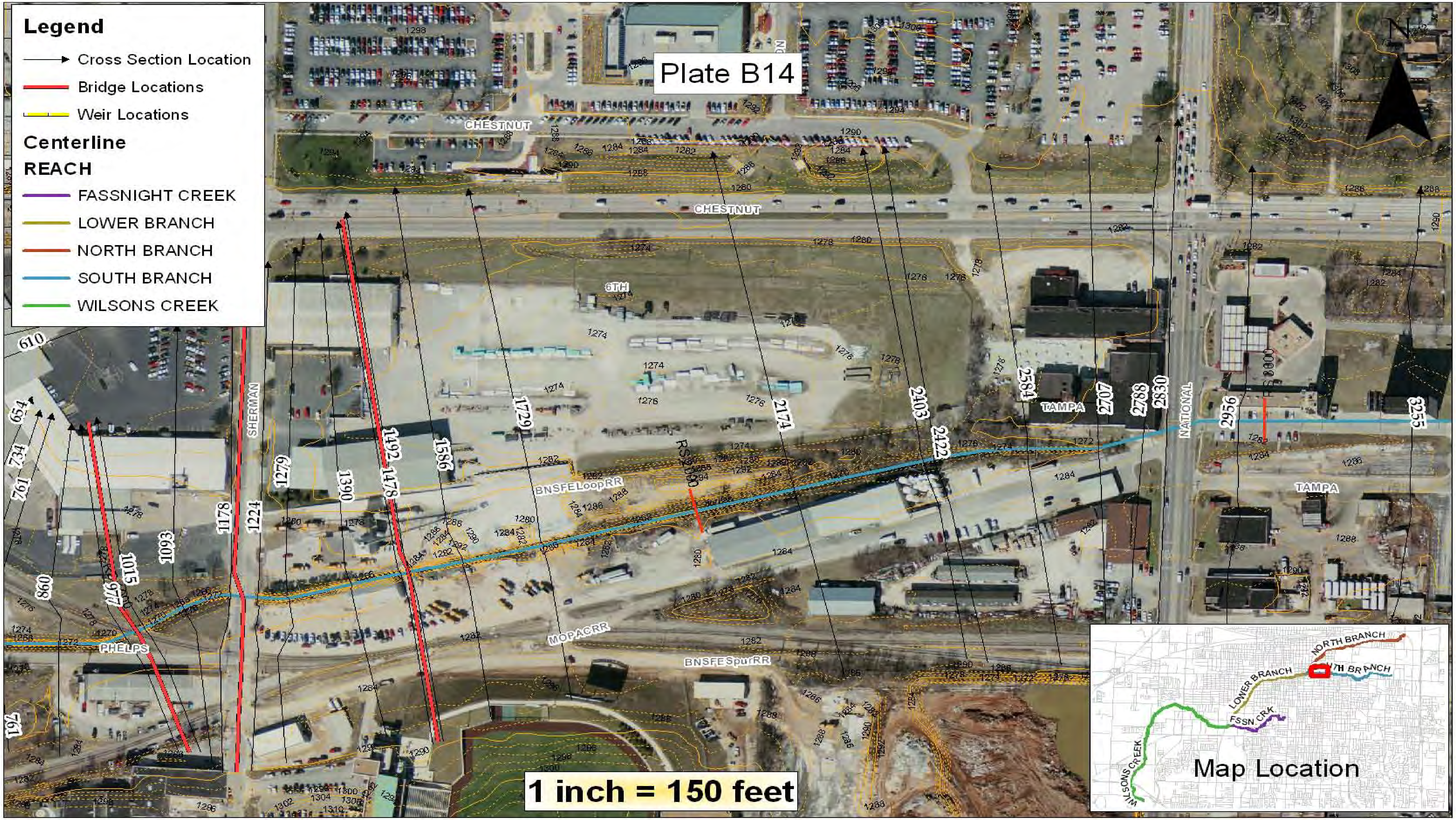
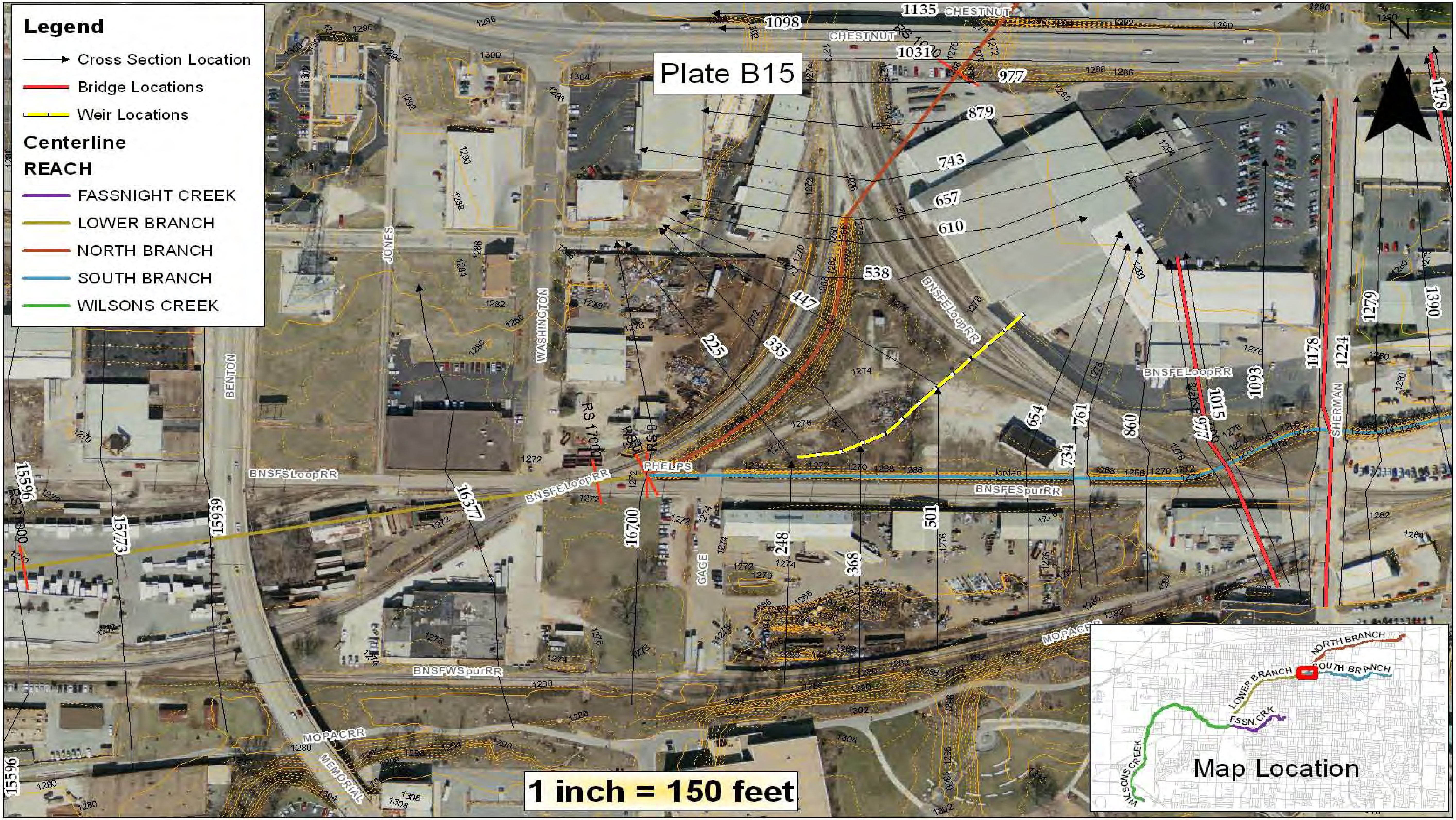
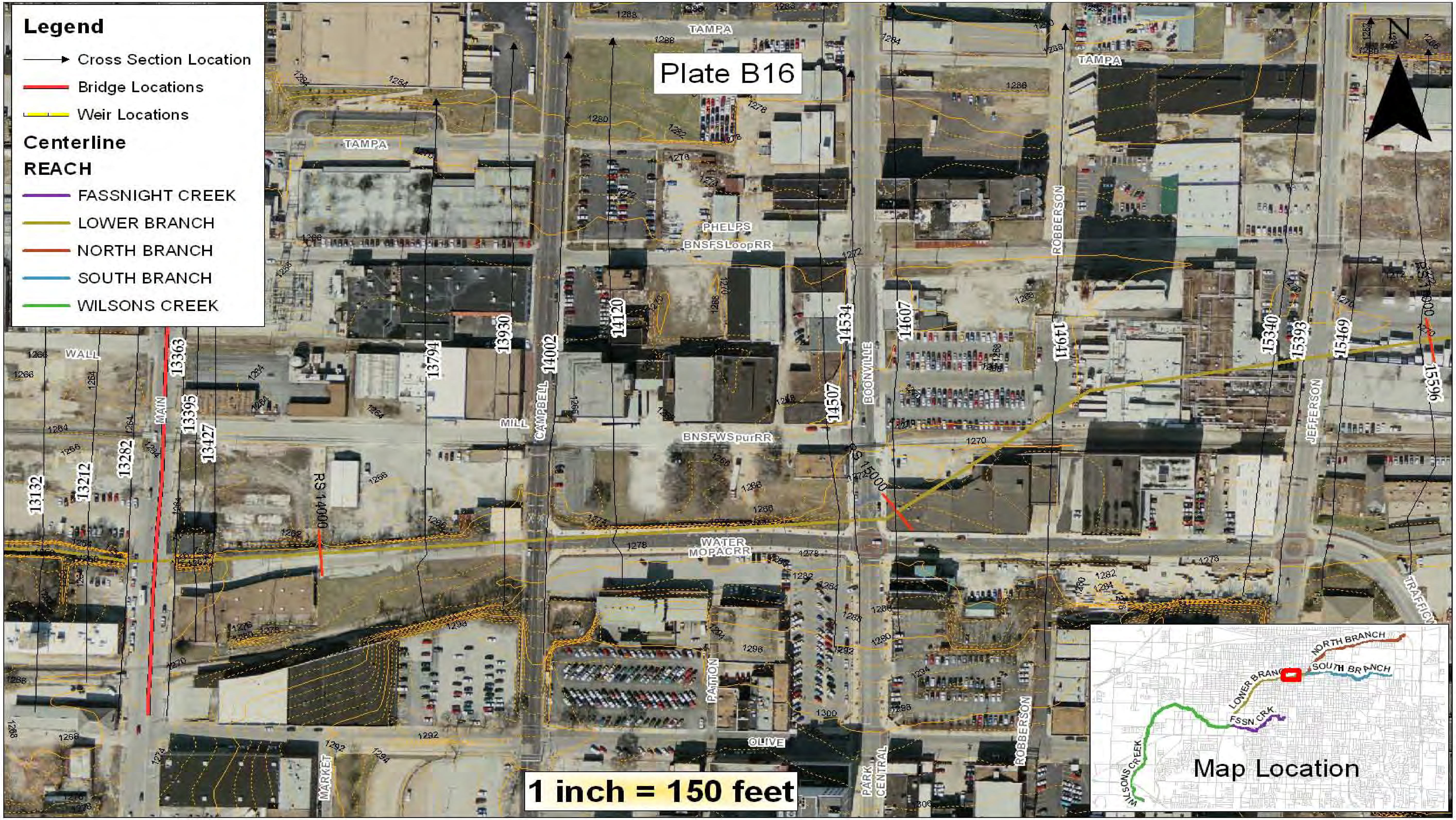


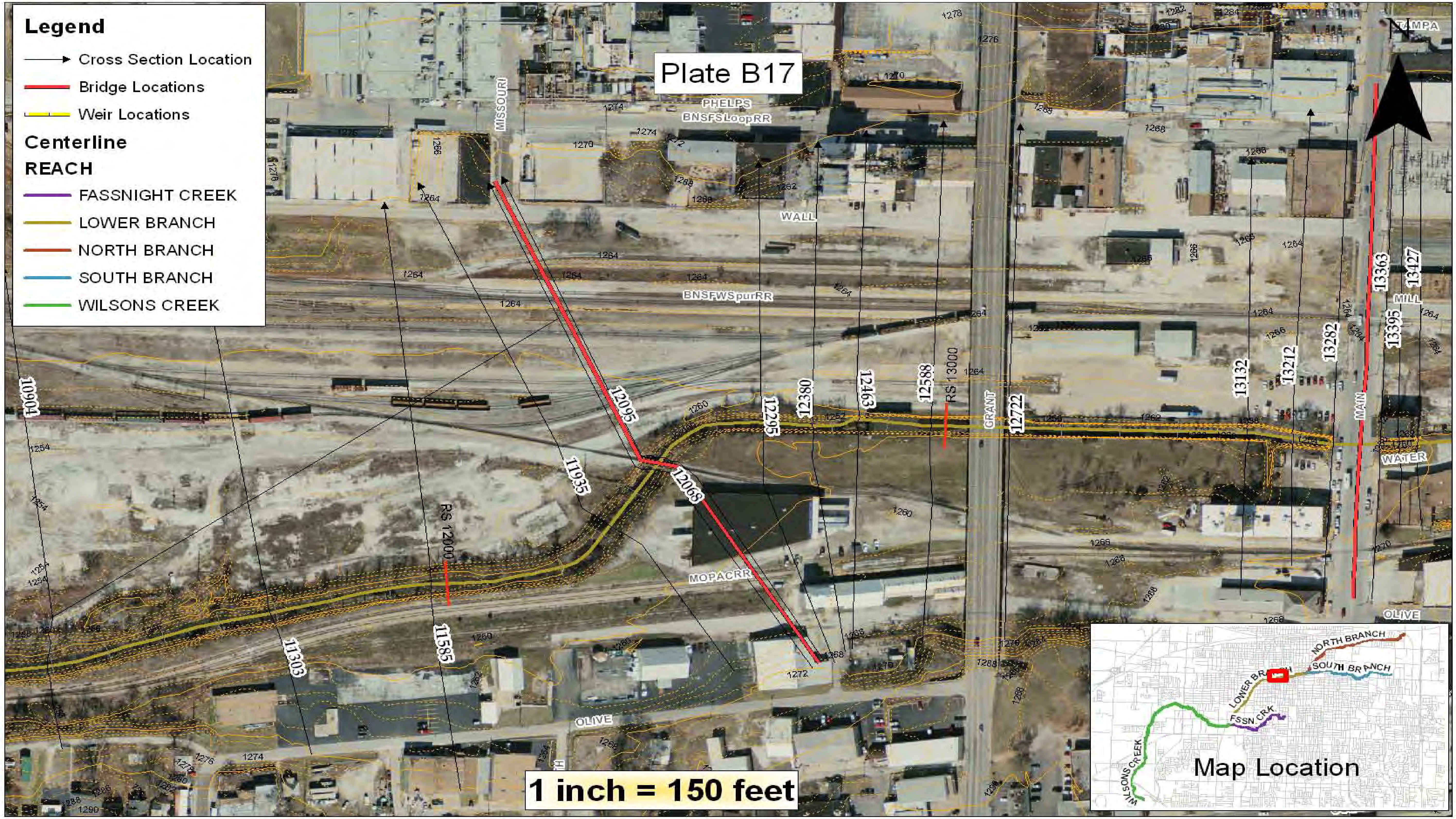
Plate B12
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
N
5926
6003
RS 6000
6309
6366
6565
6698
6858
6955
6978
RS 7000
7131
7426
7523
7651
7667
7692
7705
7717
7743
7825
7941
RS 8000
8147
8300
BNSFESpurRR
BNSFCupSpurRR
GLENSTONE
STEWART
WAVERLY
KENTWOOD
OLIVE
SAINT LOUIS


Plate B13
3255
3380
3977
RS 4000
4432
4510
4576
4647
RS 5000
5006
5499
5926
PROSPECT
TAMPA
FREMONT
BNSFE Spur RR
TRAFFICWAY
OLIVE
Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
1 inch = 150 feet
Map Location
NORTH BRANCH
LOWER BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK
N

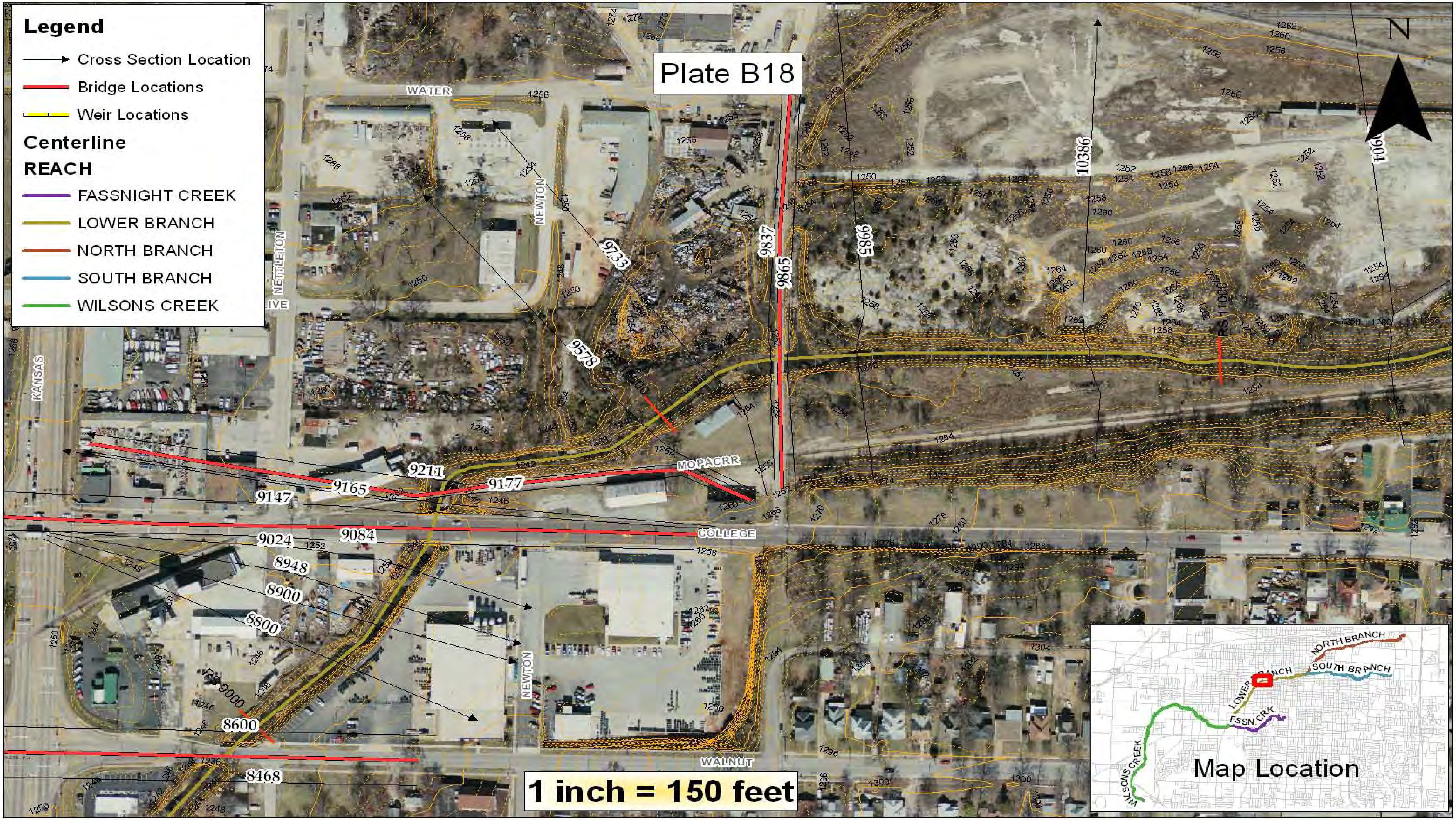

Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B14
CHESTNUT
6TH
SHERMAN
NATIONAL
TAMPA
PHELPS
BNSFE Loop RR
MOPAC RR
BNSFE Spur RR
1 inch = 150 feet
Map Location
NORTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B15
1 inch = 150 feet
Map Location
N
CHESTNUT
PHELPS
BENTON
JONES
WASHINGTON
SHERMAN
GAGE
MEMORIAL
BNSFELoopRR
BNSFESpurRR
BNSFWSpurRR
MOPACRR
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B16
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK
TAMPA
PHELPS
BNSFSLoopRR
BNSFWSpurRR
WATER
MOPACRR
WALL
MAIN
MILL
CAMPBELL
BOONVILLE
ROBBERSON
JEFFERSON
PATTON
OLIVE
MARKET
PARK CENTRAL
TRAFFIC
13132
13212
13282
13363
13395
13427
RS 14000
13794
13930
14002
14120
14507
14534
RS 15000
14607
14911
15340
15393
15469
RS 15500
15596



Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B17
N
PHELPS
BNSFSLoopRR
WALL
BNSFWSpurRR
MOPACRR
OLIVE
WATER
MILL
TAMPA
MISSOURI
GRANT
MAIN
10904
11303
11585
RS 12000
11935
12095
12068
12295
12380
12463
12588
RS 13000
12722
13132
13212
13282
13363
13395
13427
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK

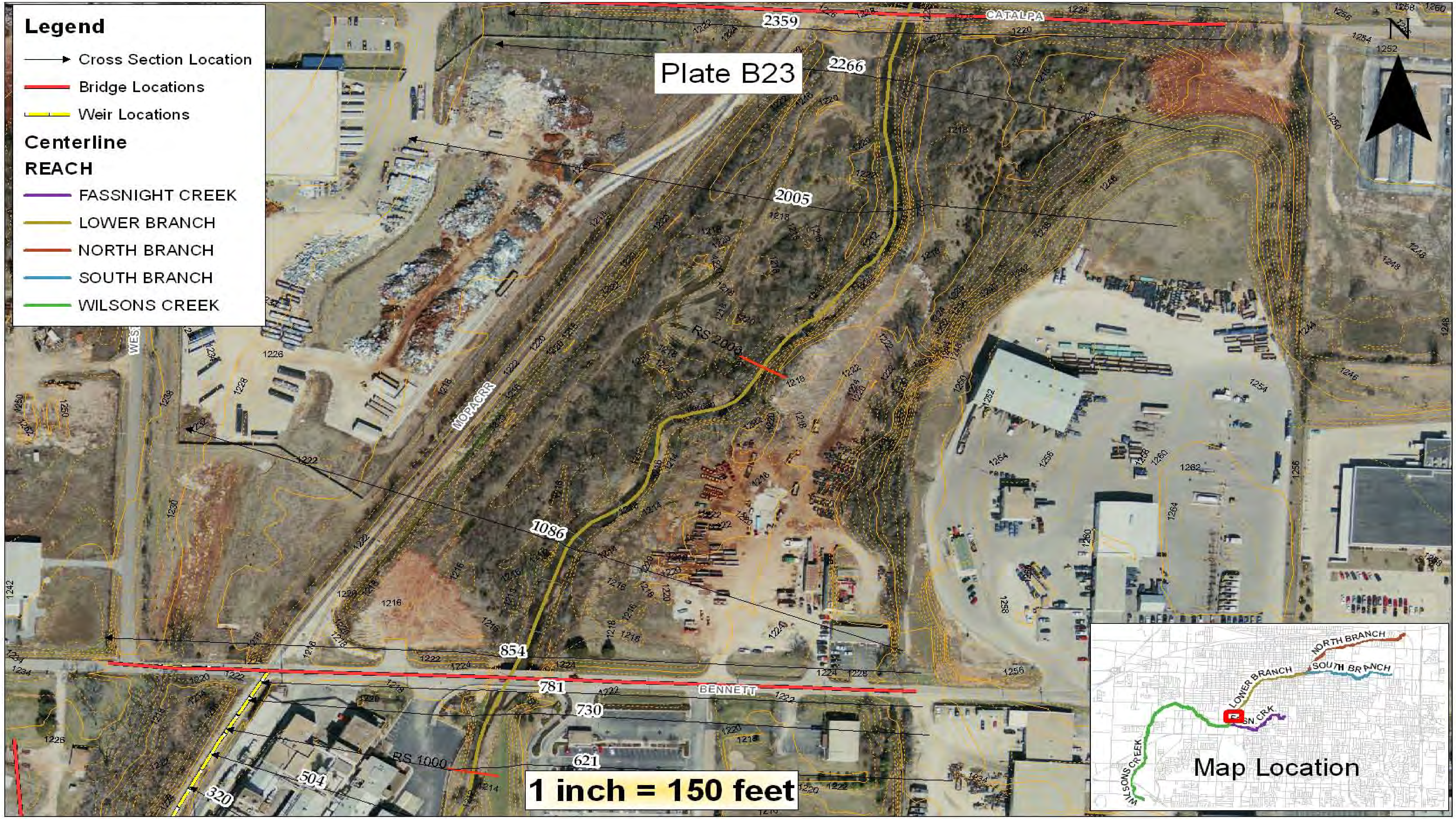

Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B18
N
WATER
NEWTON
NETTLETON
KANSAS
MOPACRR
COLLEGE
WALNUT
9837
9865
9965
10386
10904
9733
9578
9211
9165
9177
9147
9024
9084
8948
8900
8800
8600
8468
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER
FSSN CRK
WILSONS CREEK

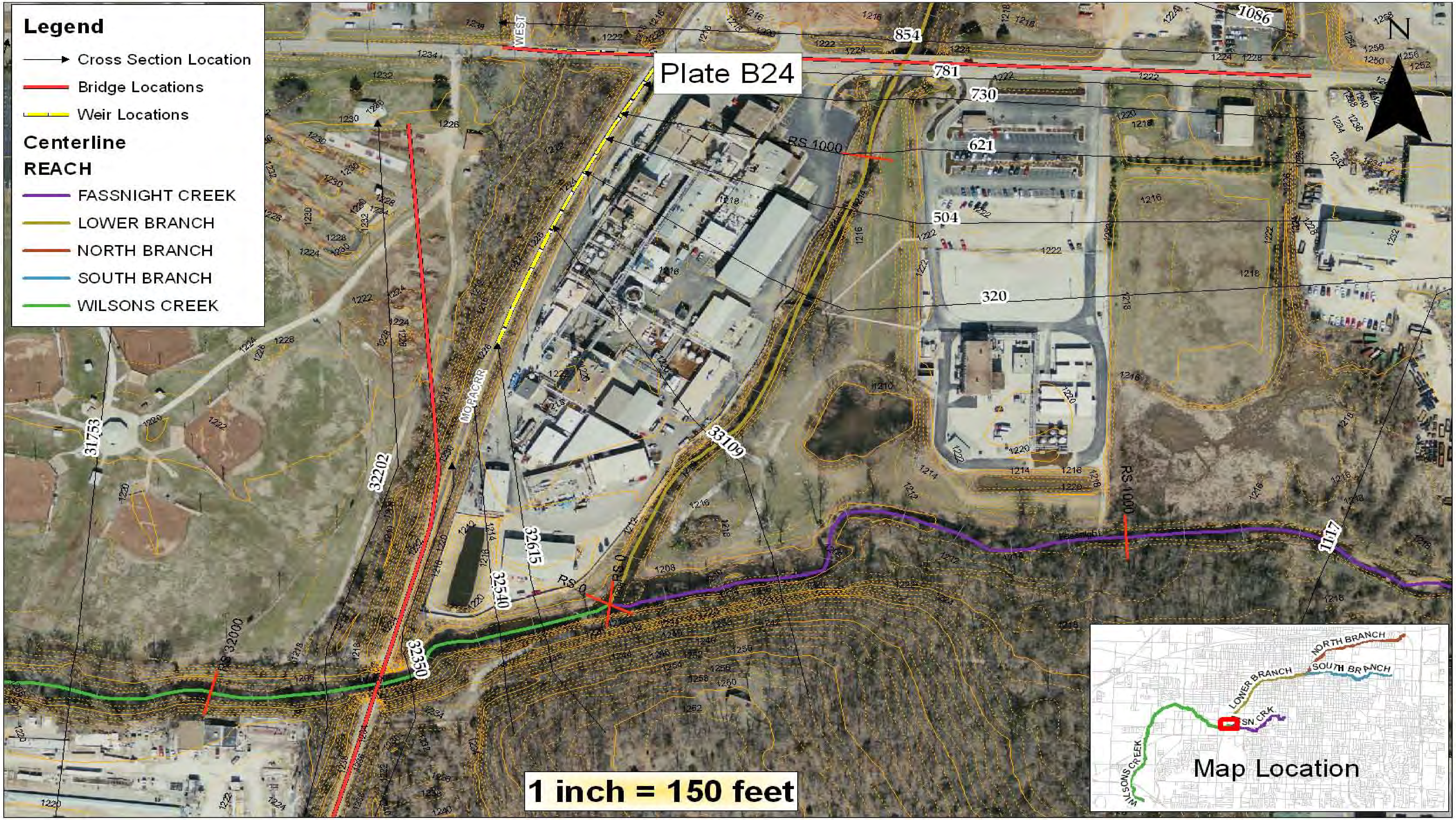

Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B19
N
8600
8468
8277
8128
7984
7848
7671
RS 8000
7314
7152
7073
6929
6594
RS 7000
WALNUT
KANSAS
NETTLETON
NEWTON
LEXINGTON
CLOUD
MOPAC RR
LINCOLN
MOUNT VERNON
WABASH
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOW BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B20
6929
6594
5689
5003
RS 6000
HARRISON
LA FONTAINE
WABASH
MOPAC RR
KANSAS
STATE
N
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B21
N
RS 6000
5689
5003
4790
4638
4419
4137
4052
3859
KANSAS
LOMBARD
BELMONT
GRAND
MOPACRR
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B22
GRAND
4137
4052
3859
RS 4000
3300
MOPACRR
KANSAS
2722
2677
RS 3000
2515
2432
CATALPA
2359
2266
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B23
CATALPA
BENNETT
MOPAC RR
2359
2266
2005
RS 2000
1086
854
781
730
621
RS 1000
504
320
N
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B24
N
1 inch = 150 feet
Map Location
854
781
730
621
504
320
1086
RS 1000
33109
31753
32202
32615
32540
32350
RS 32000
RS 0
1117


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B25
N
30367
30828
31064
SCENIC
31152
31328
31753
RS 30000
RS 31000
Wilsons
1 inch = 150 feet
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN CRK
WILSONS CREEK


Legend
Cross Section Location
Bridge Locations
Weir Locations
Centerline
REACH
FASSNIGHT CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH
WILSONS CREEK
Plate B26
BENNETT
29145
29796
30367
30828
RS 29000
RS 30000
1 inch = 150 feet
Map Location
NORTH BRANCH
LOWER BRANCH
SOUTH BRANCH
FSSN CRK
WILSONS CREEK

Plate Series C – Without Project Hydraulic Profiles

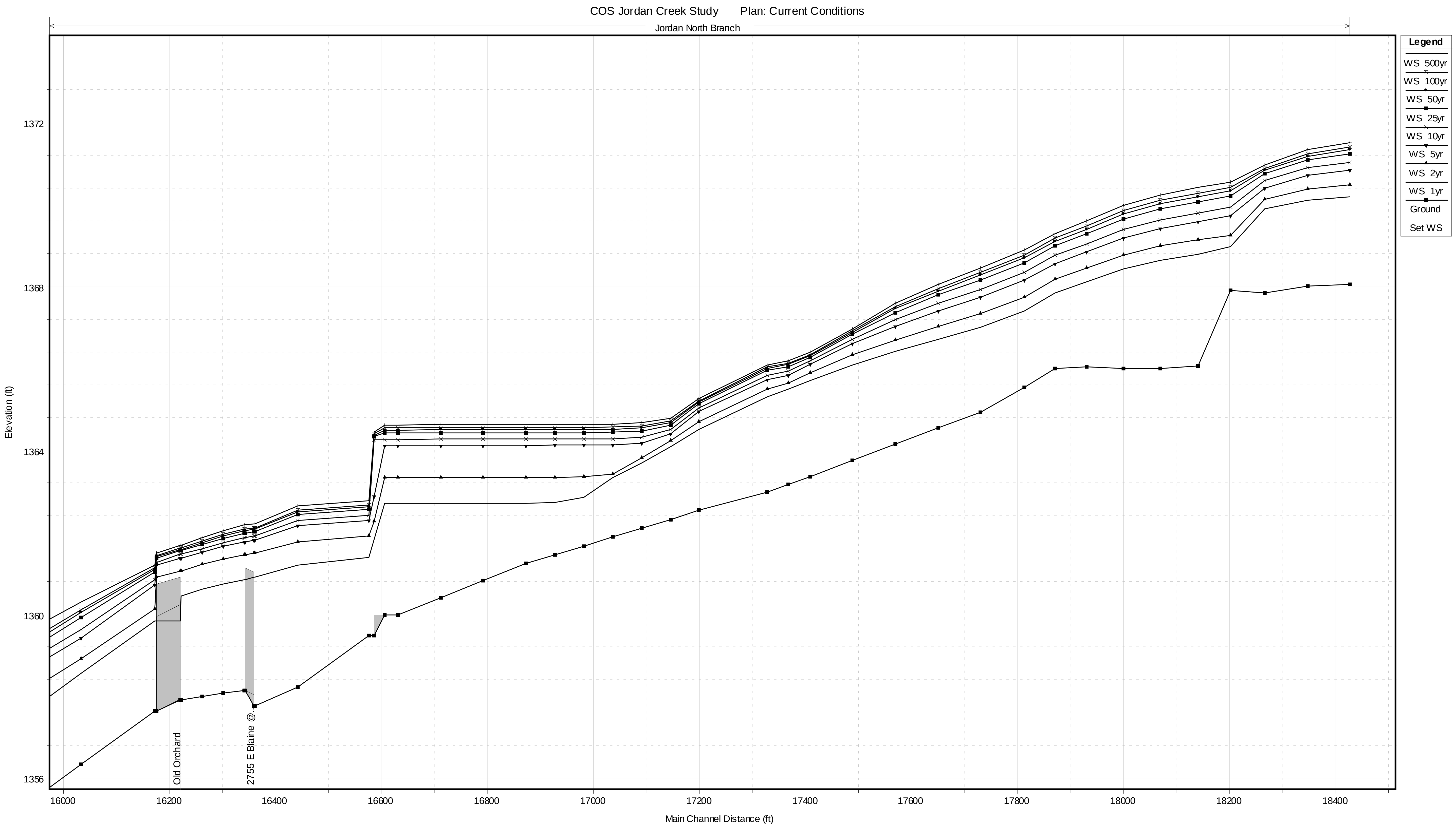
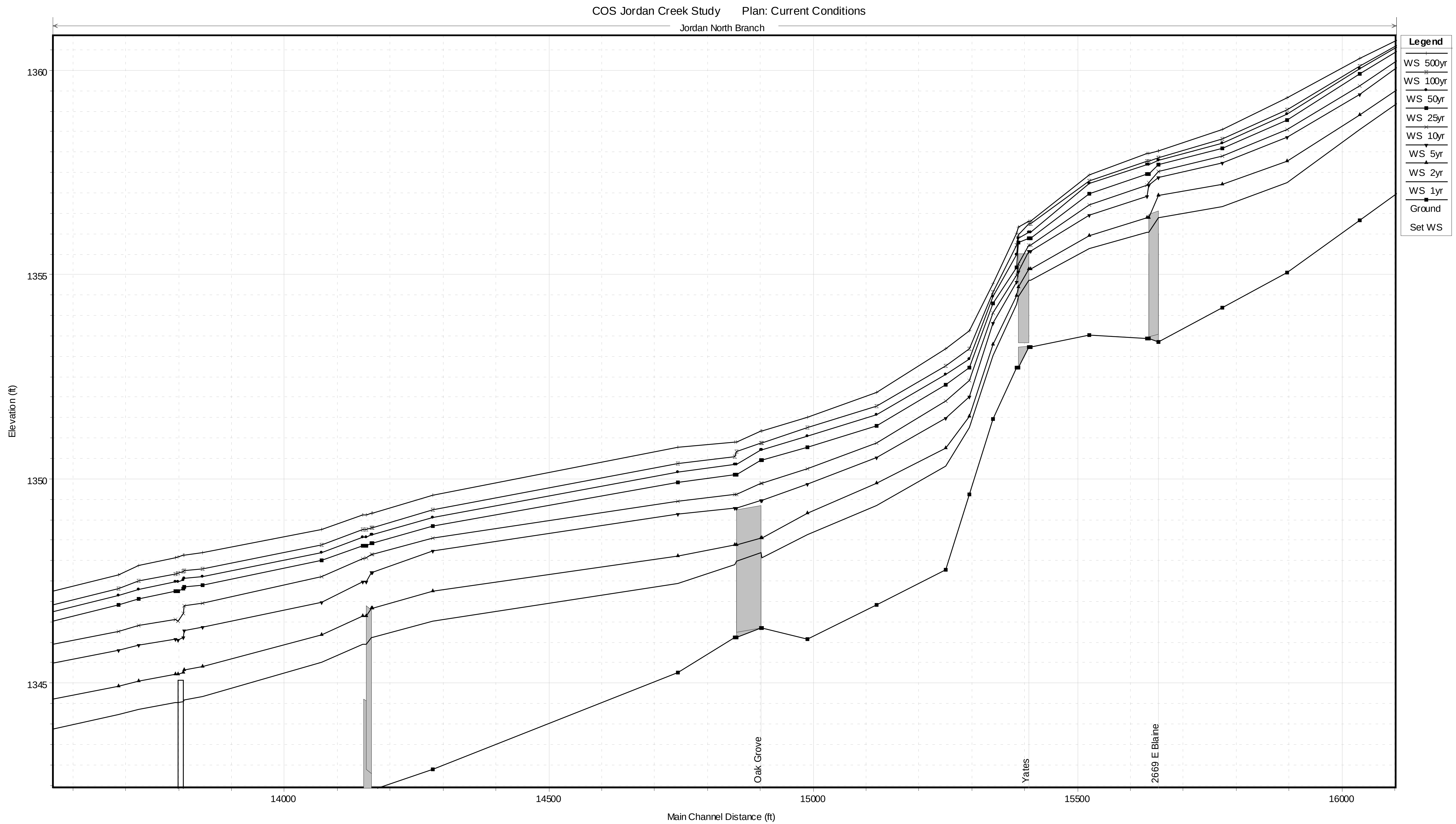
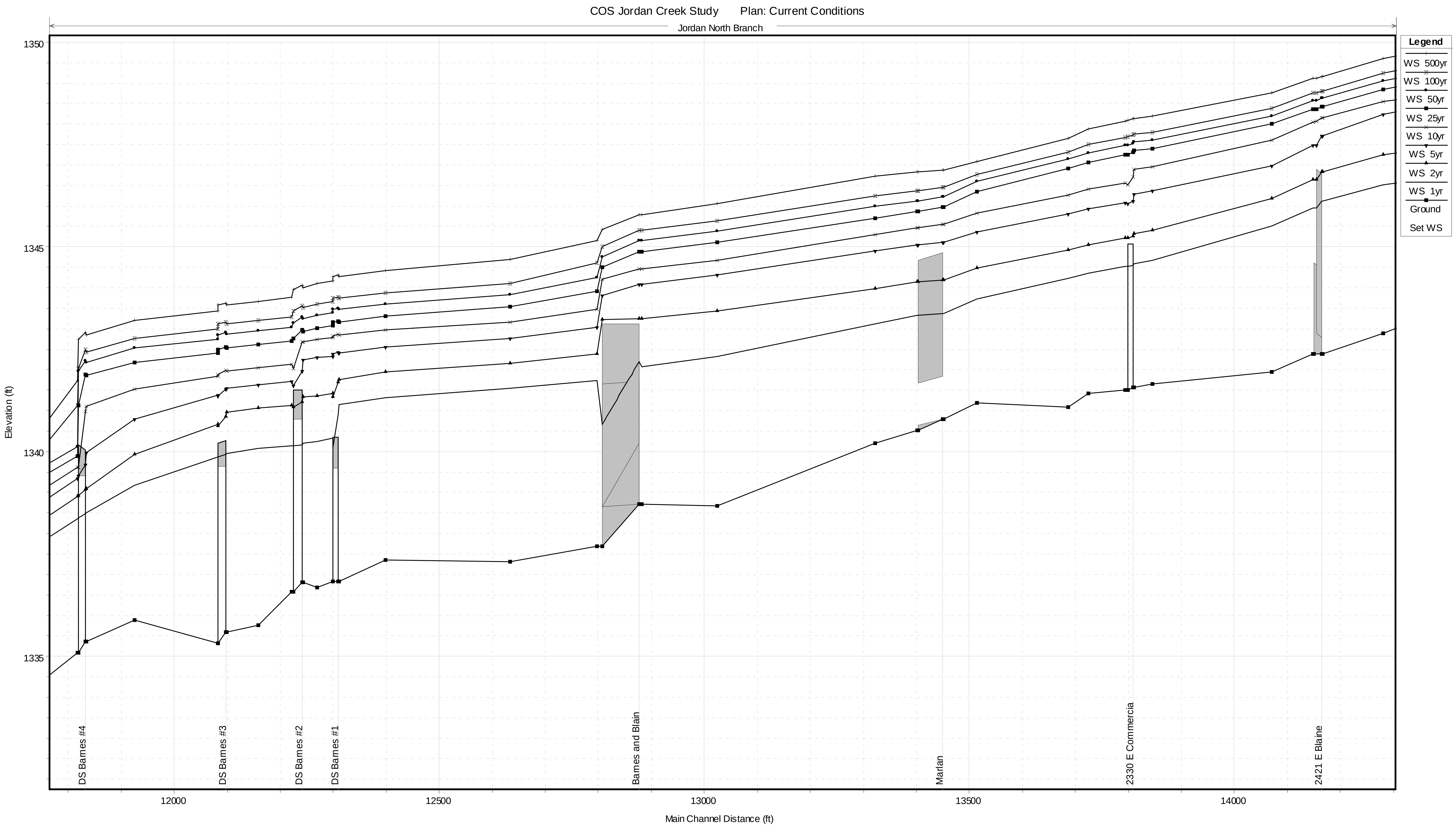
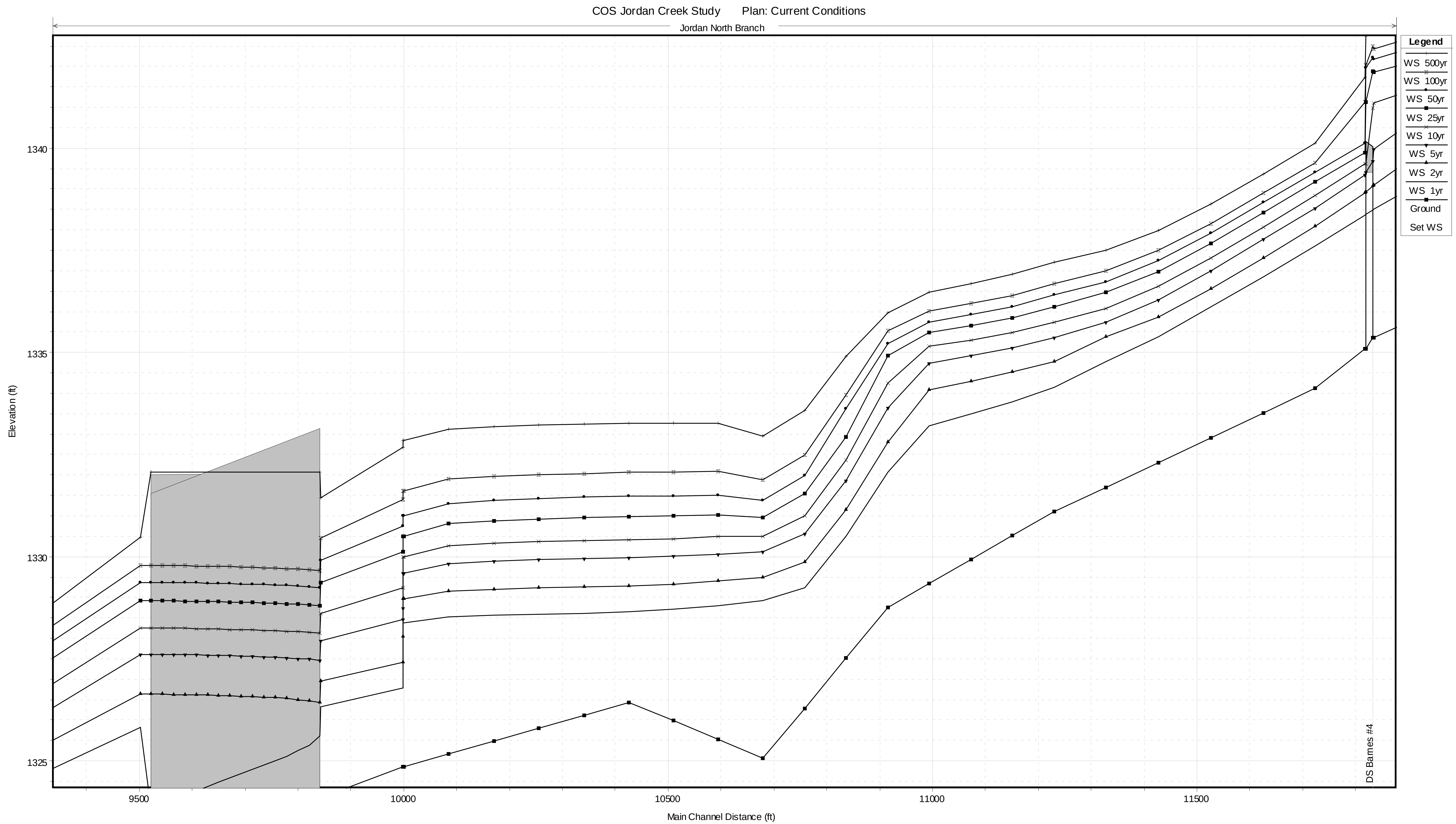


Plate Series C – Without Project Hydraulic Profiles

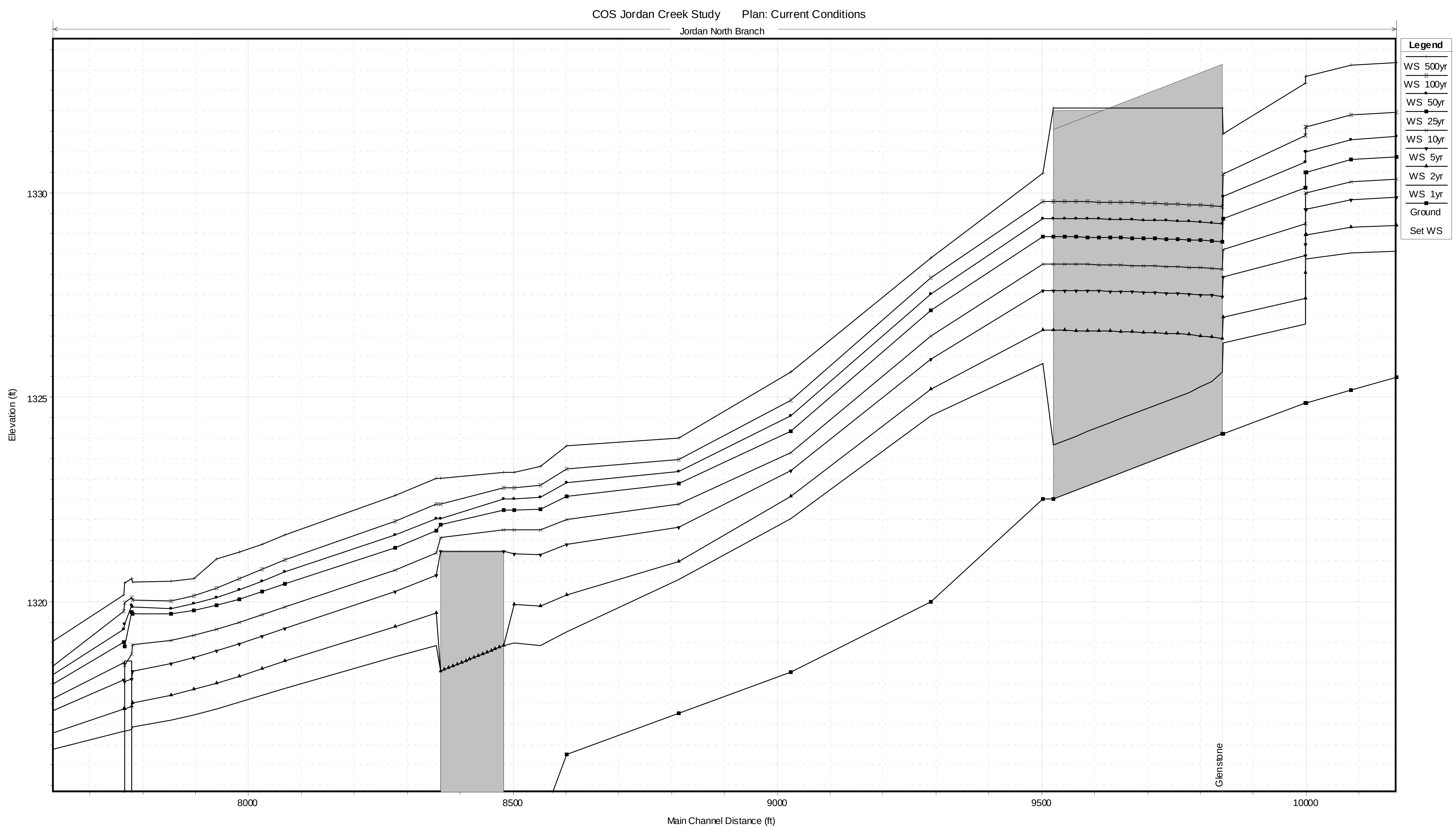


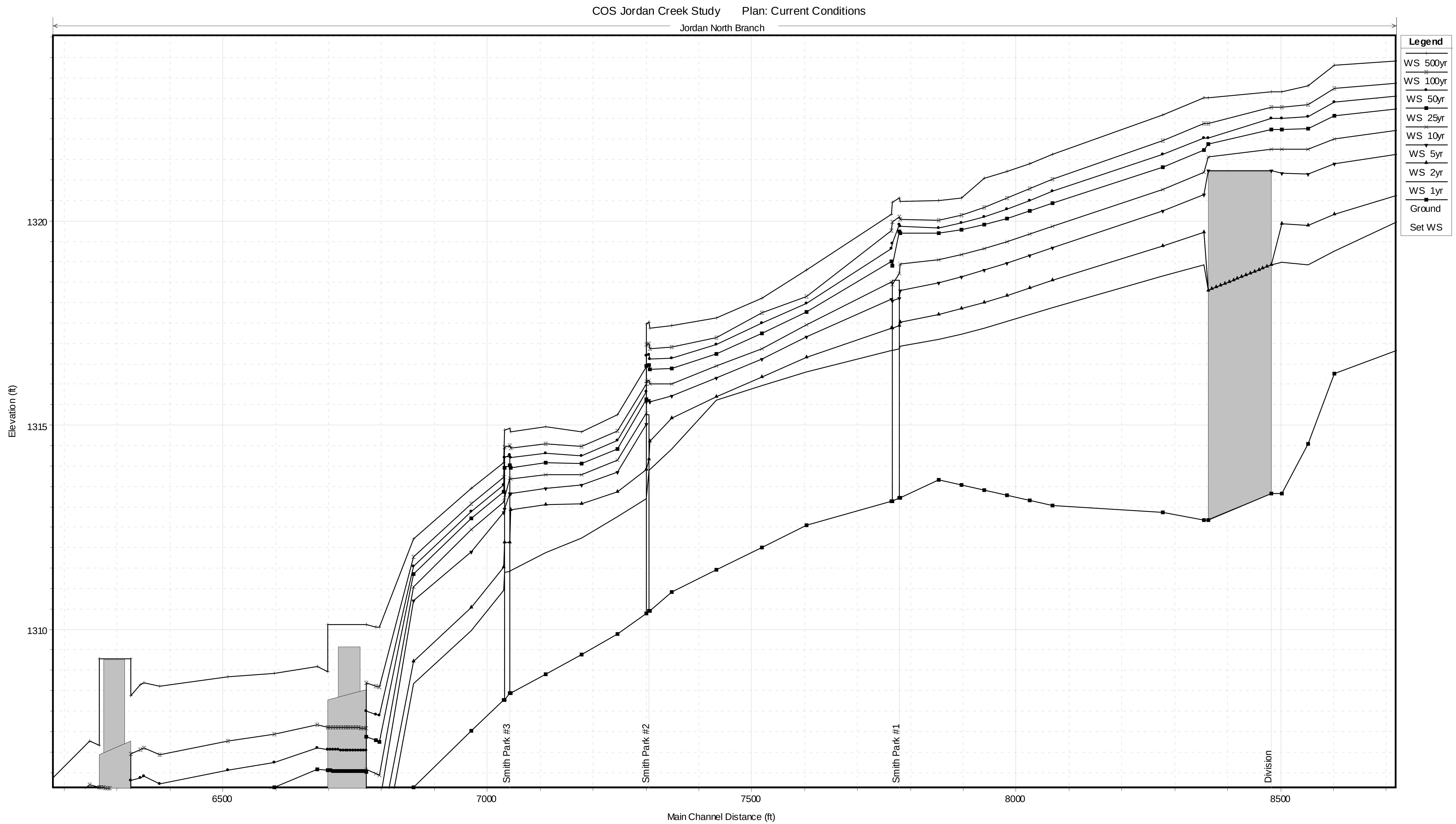

COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1350
1345
1340
1335
DS Barnes #4
DS Barnes #3
DS Barnes #2
DS Barnes #1
Barnes and Blain
Marlan
2330 E Commercia
2421 E Blaine
12000
12500
13000
13500
14000
Main Channel Distance (ft)



COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1325
1330
1335
1340
9500
10000
10500
11000
11500
Main Channel Distance (ft)
DS Barnes #4

Plate Series C – Without Project Hydraulic Profiles




COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1320
1315
1310
6500
7000
7500
8000
8500
Main Channel Distance (ft)
Smith Park #3
Smith Park #2
Smith Park #1
Division

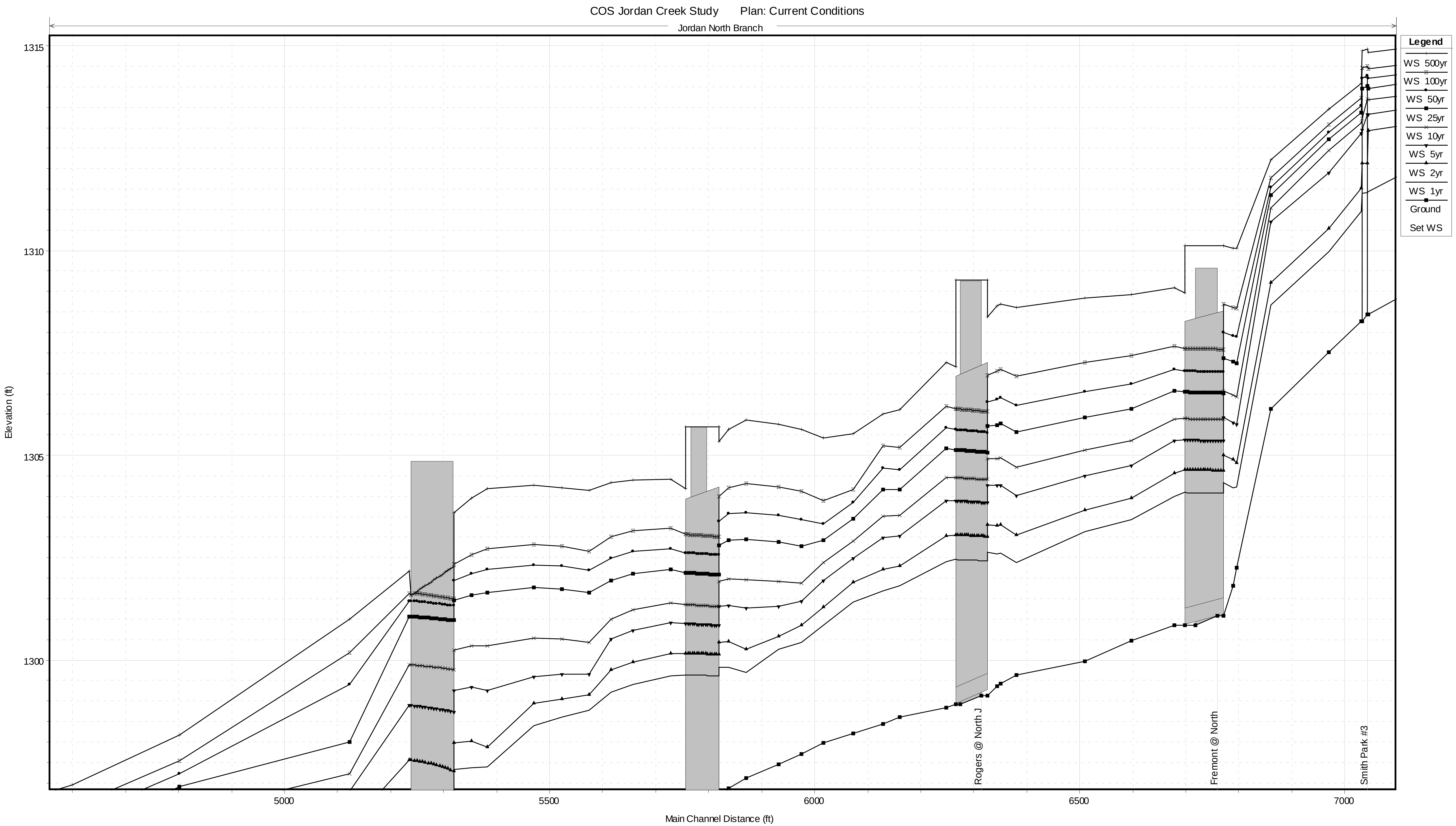
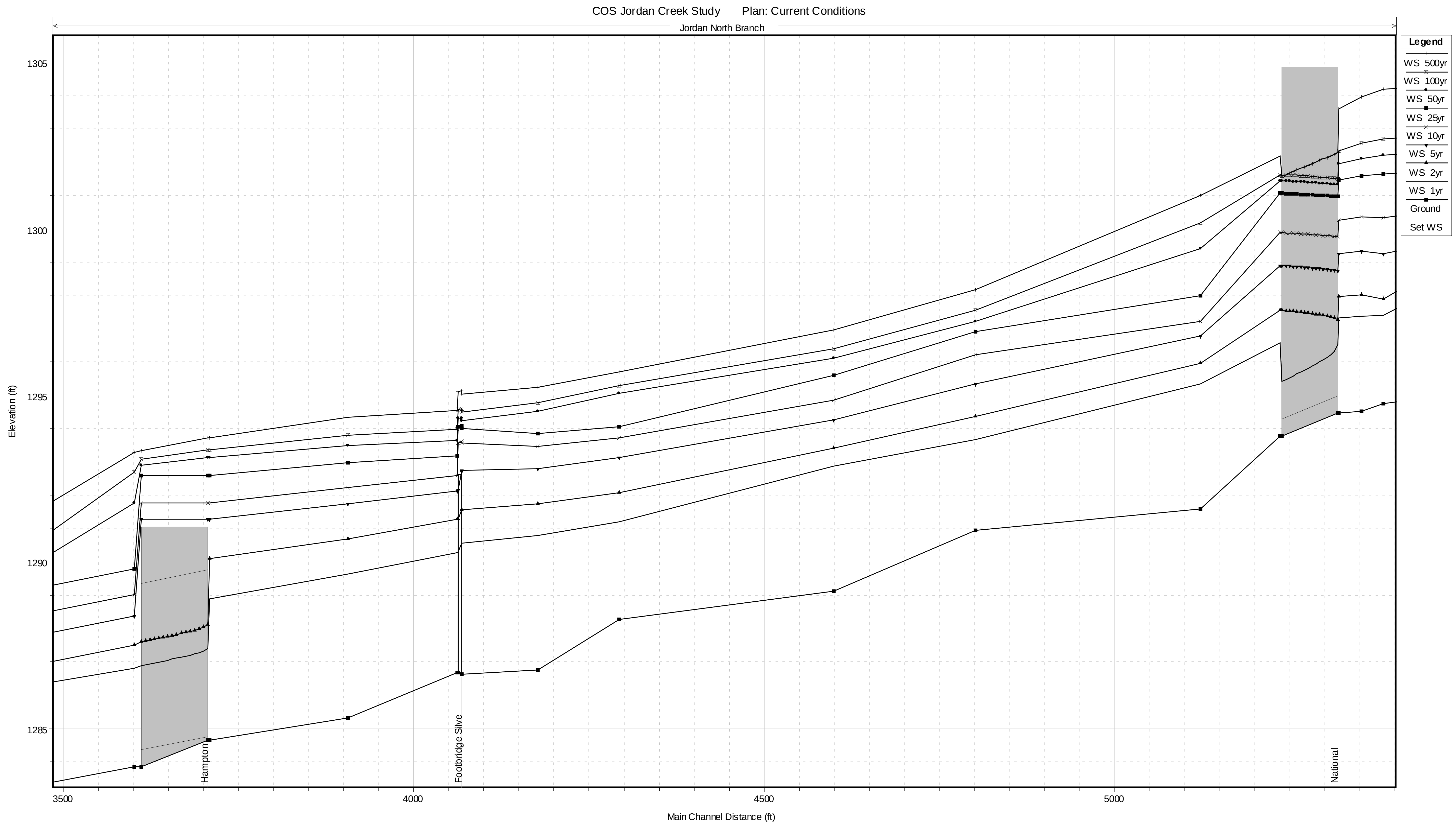

COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
1315
1310
1305
1300
Elevation (ft)
Rogers @ North J
Fremont @ North
Smith Park #3
5000
5500
6000
6500
7000
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



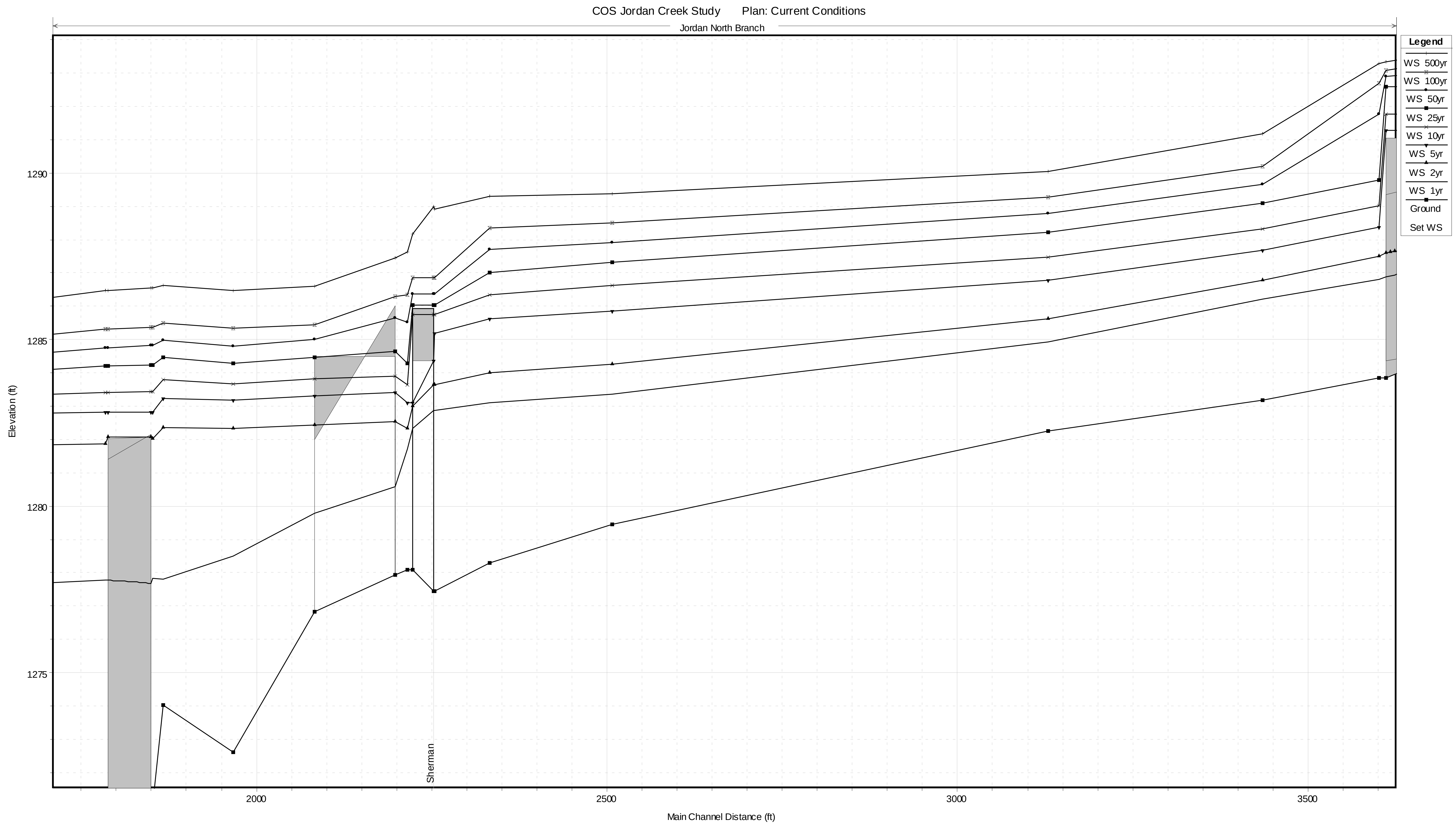
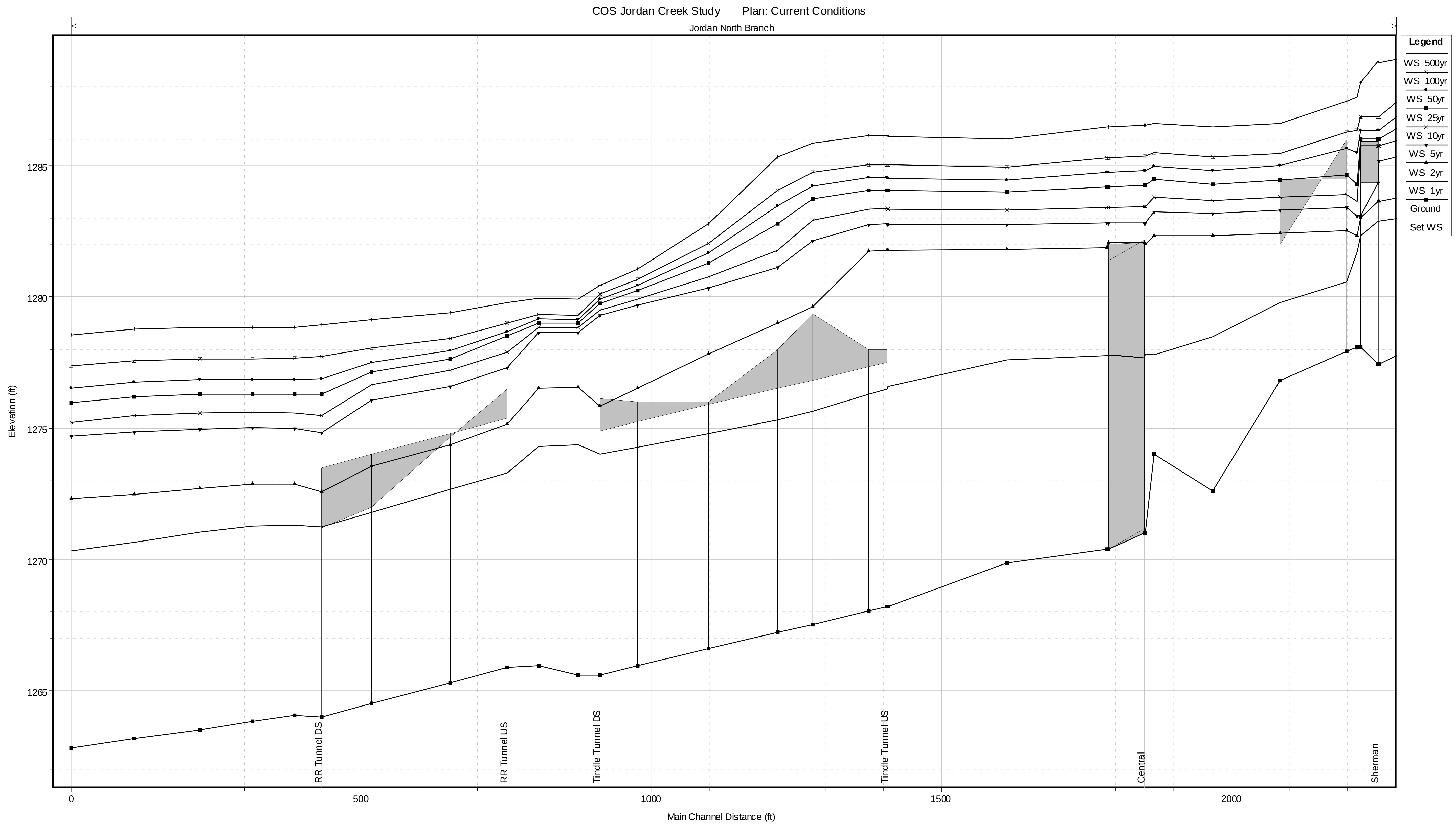

COS Jordan Creek Study Plan: Current Conditions
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1290
1285
1280
1275
Sherman
2000
2500
3000
3500
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



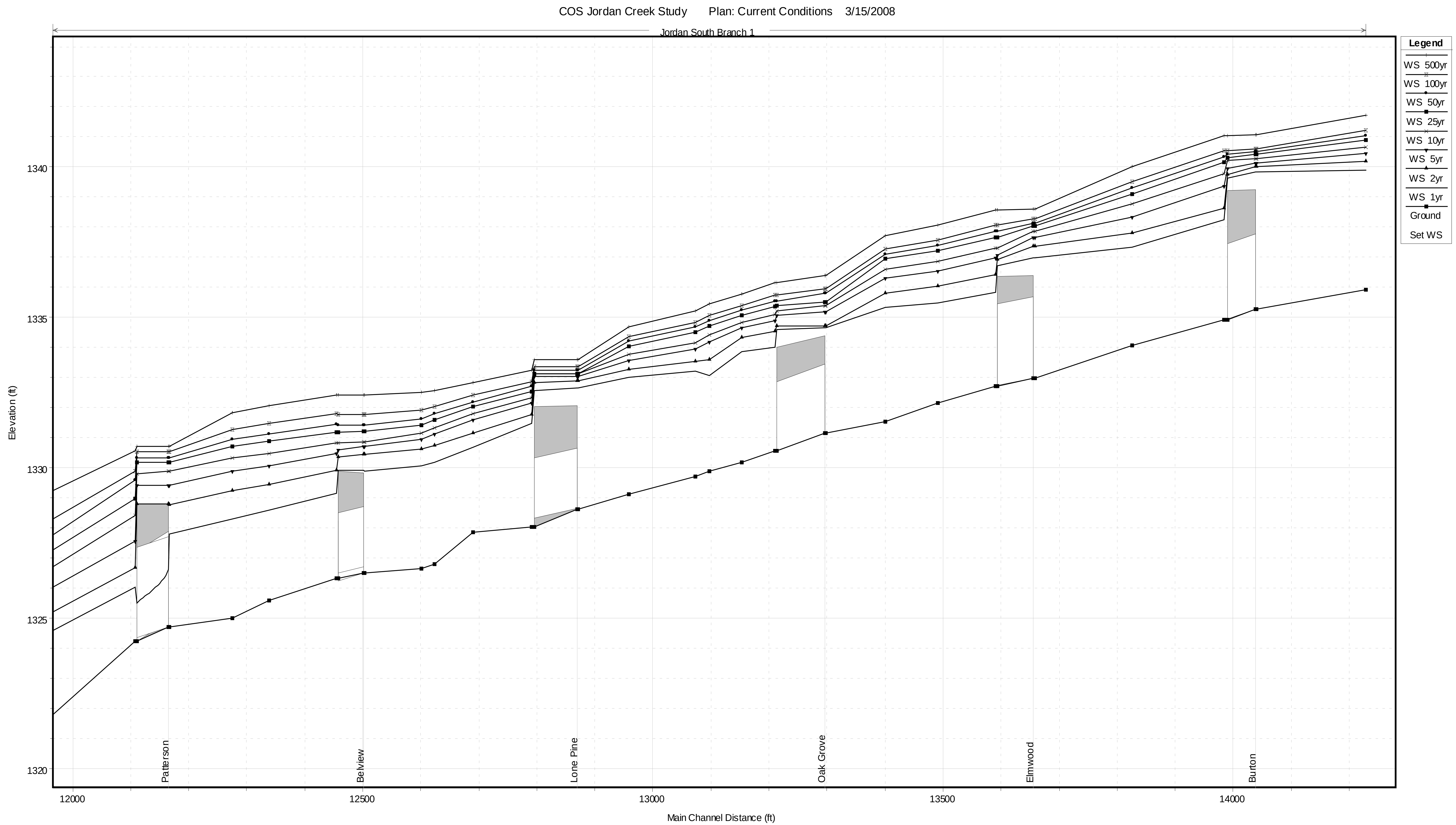
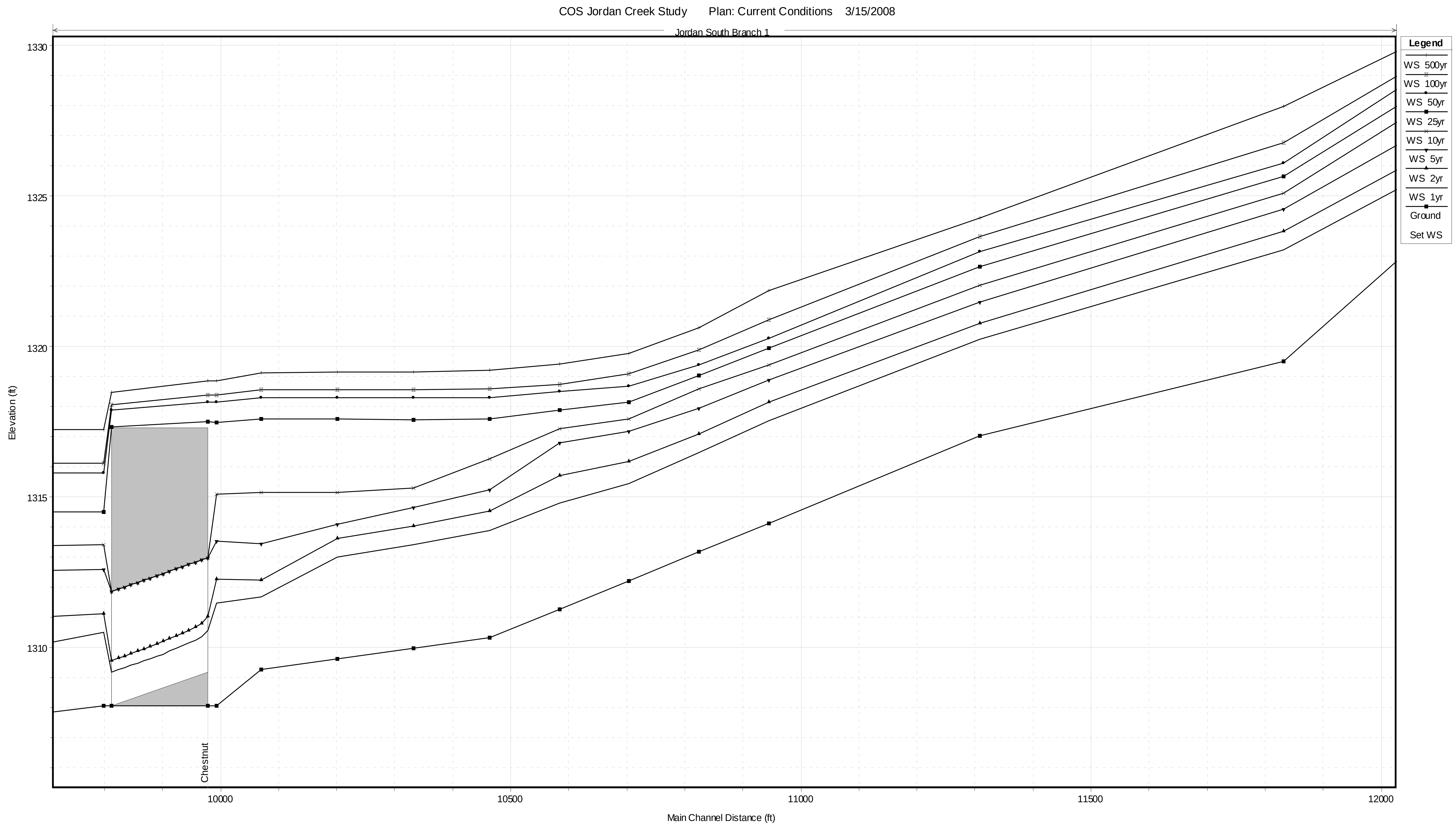

COS Jordan Creek Study Plan: Current Conditions 3/15/2008
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1340
1335
1330
1325
1320
Patterson
Belview
Lone Pine
Oak Grove
Elmwood
Burton
12000
12500
13000
13500
14000
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



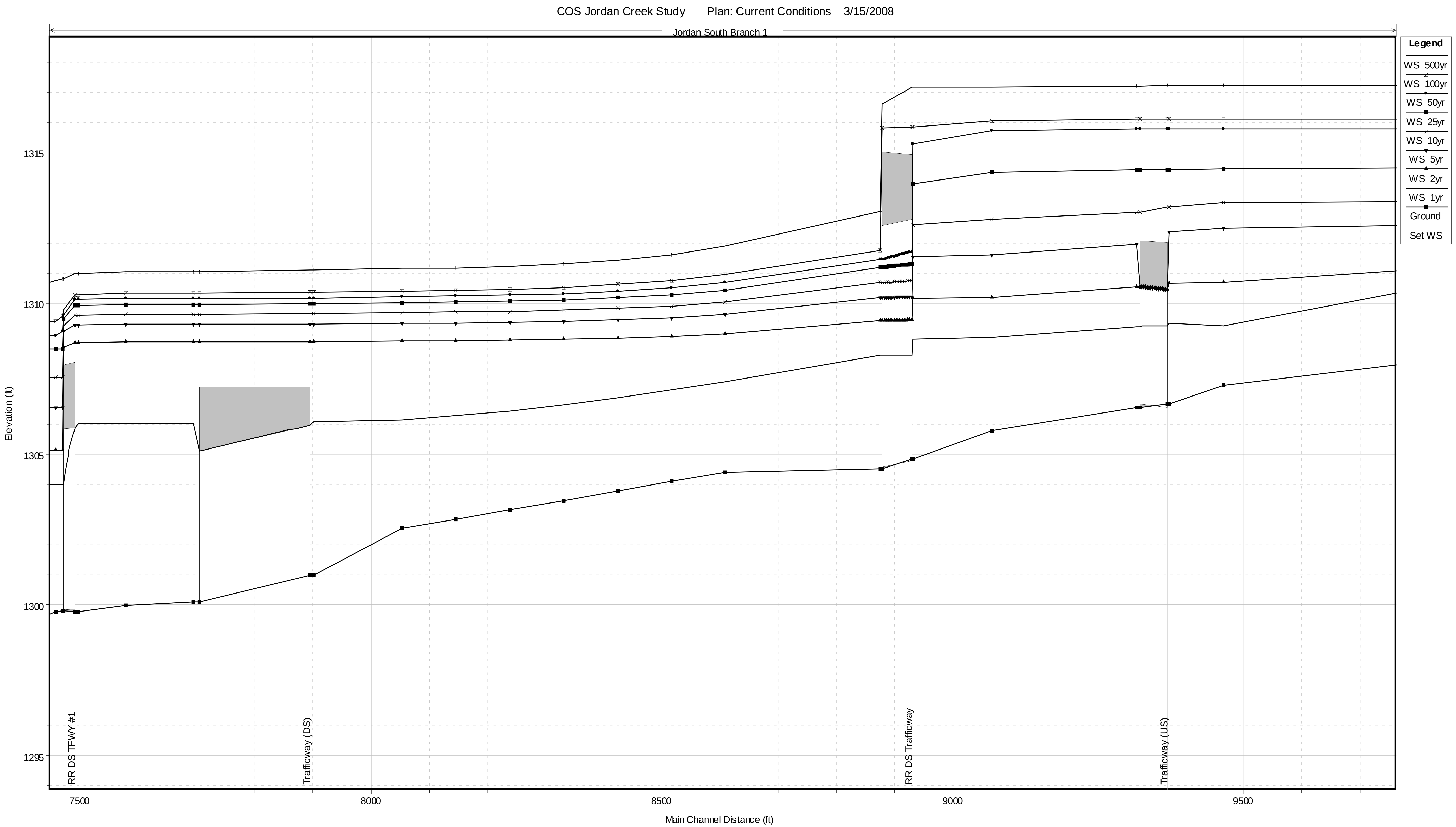

COS Jordan Creek Study Plan: Current Conditions 3/15/2008
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1315
1310
1305
1300
1295
RR DS TFWY #1
Trafficway (DS)
RR DS Trafficway
Trafficway (US)
7500
8000
8500
9000
9500
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles

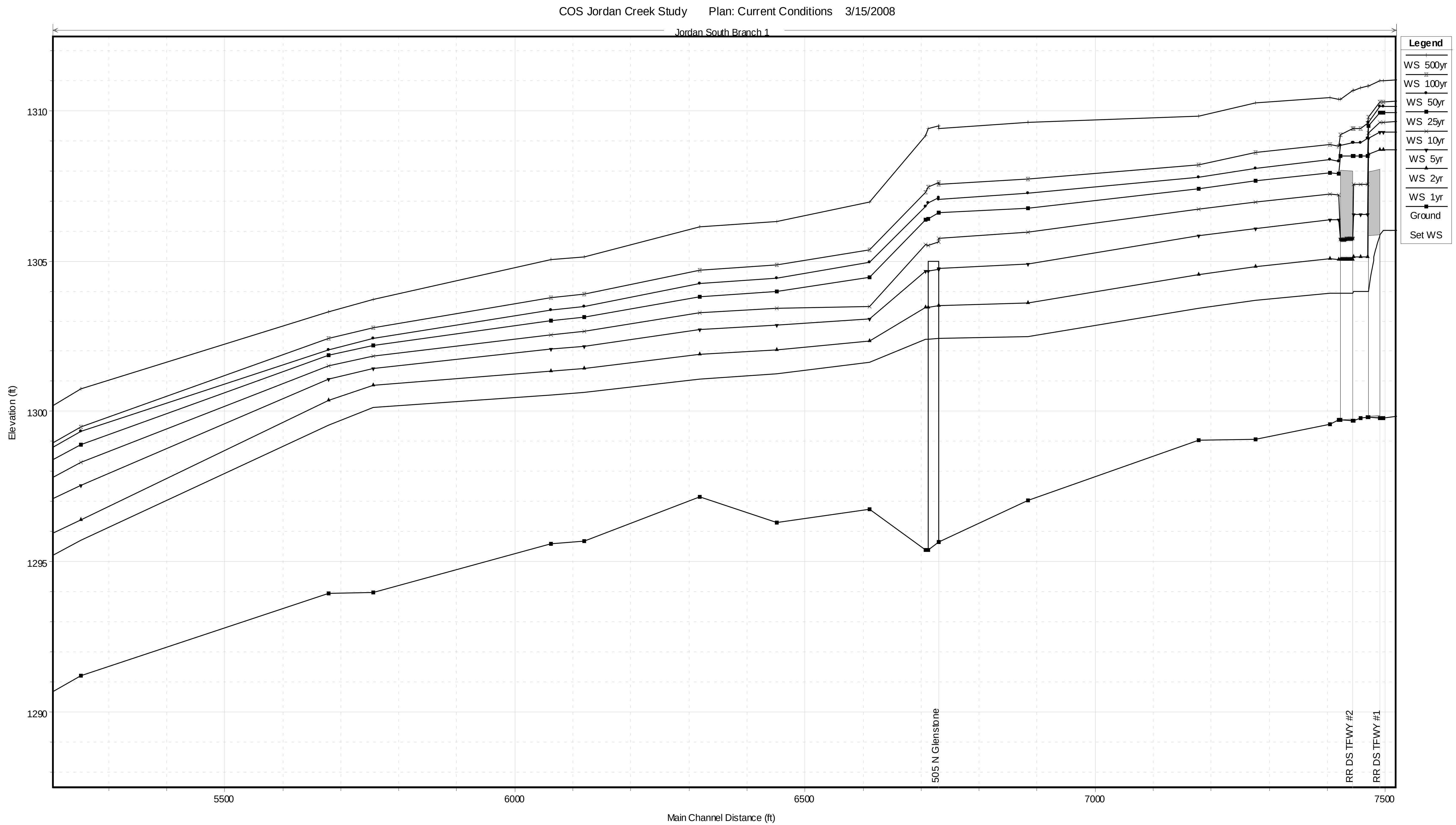


Plate Series C – Without Project Hydraulic Profiles

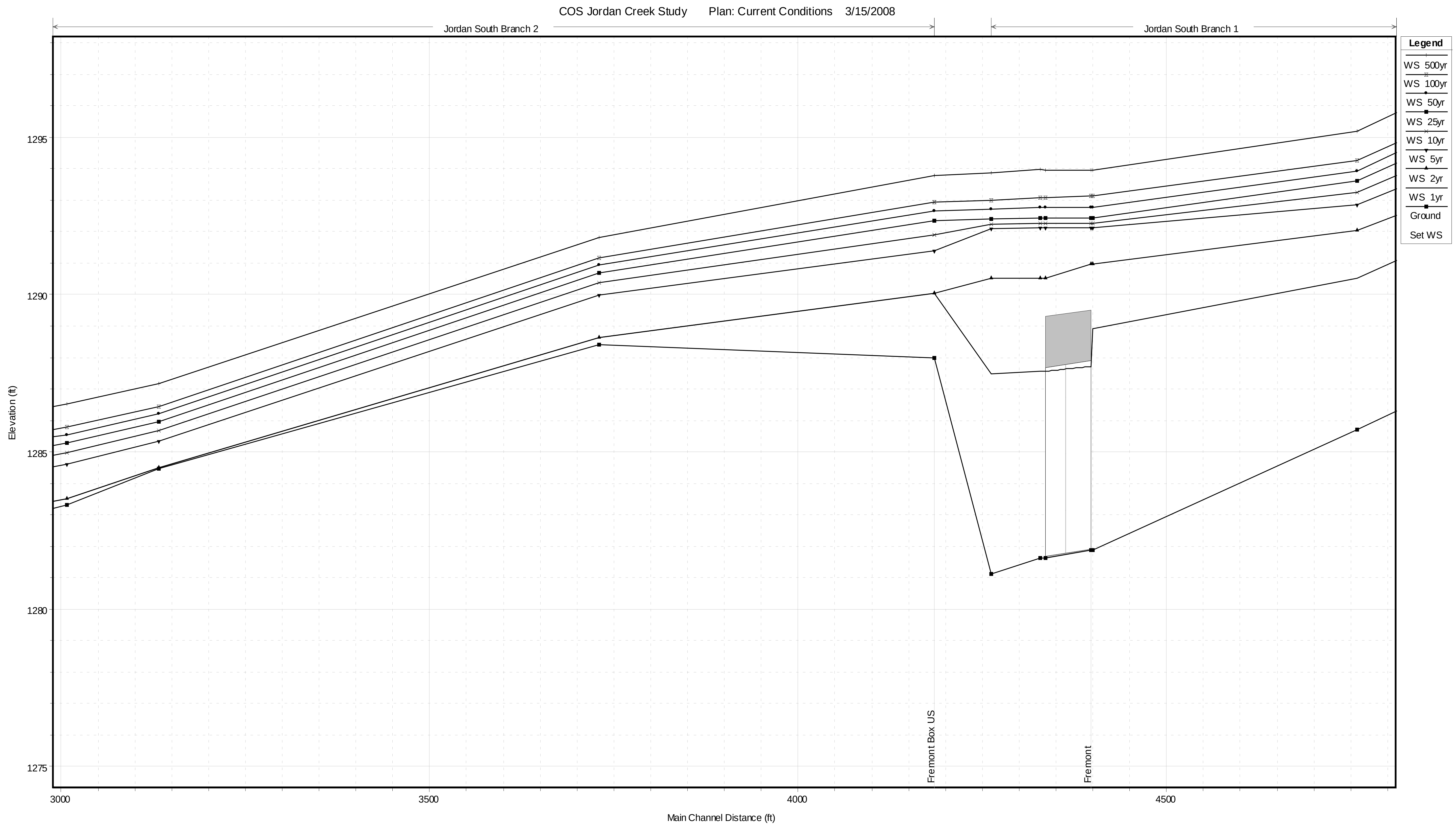
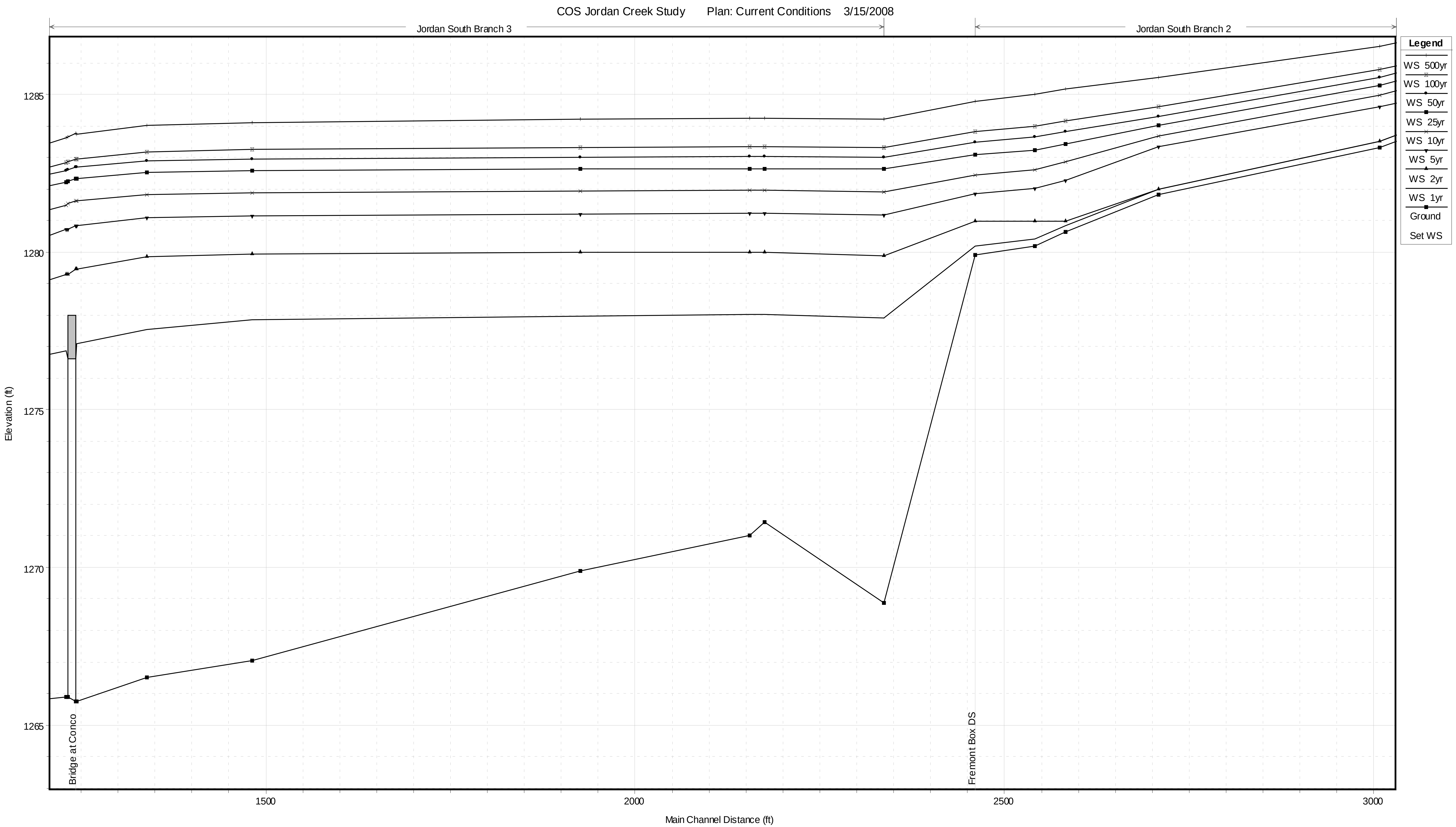
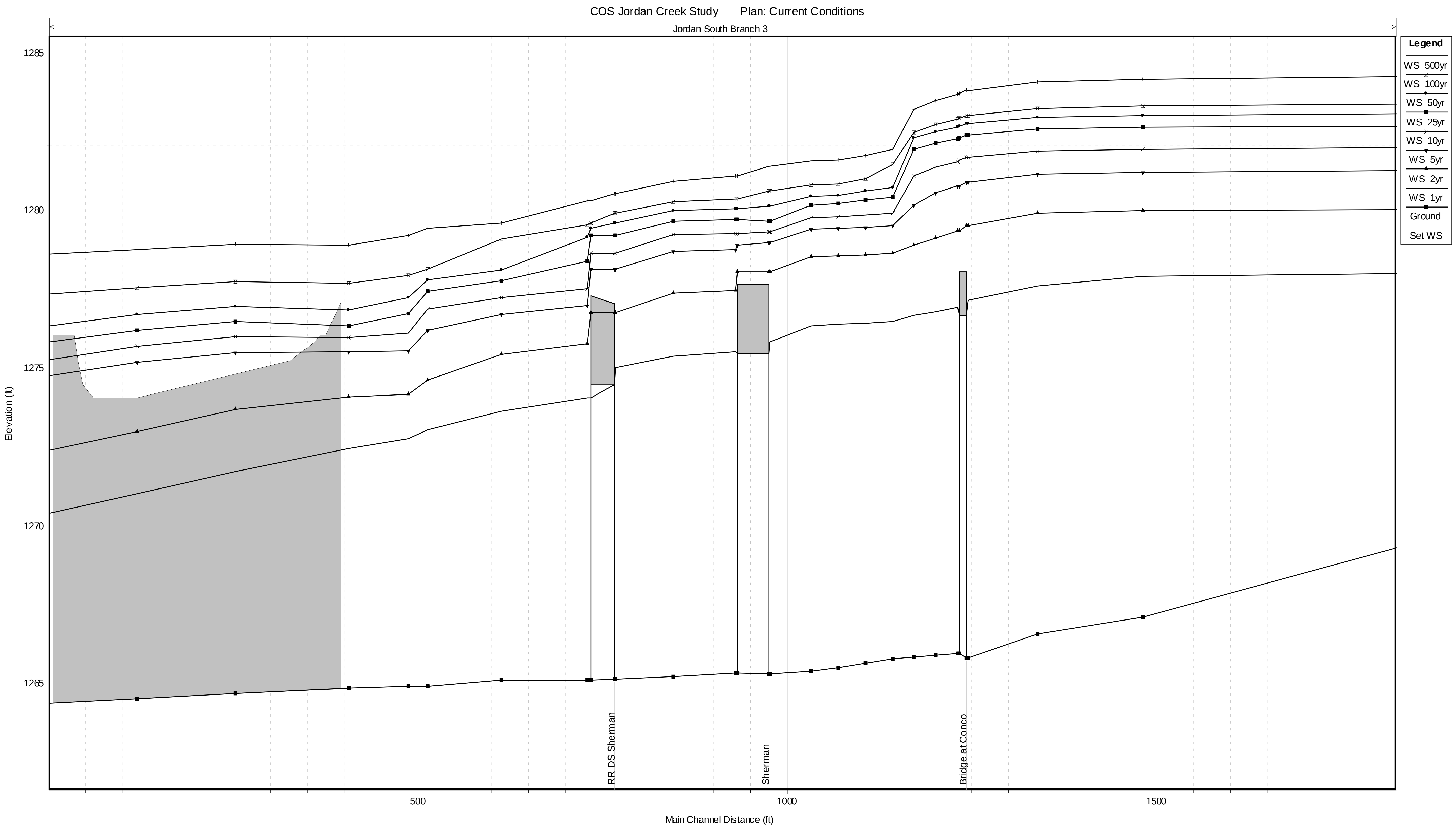


Plate Series C – Without Project Hydraulic Profiles




COS Jordan Creek Study Plan: Current Conditions
Jordan South Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1285
1280
1275
1270
1265
RR DS Sherman
Sherman
Bridge at Conco
500
1000
1500
Main Channel Distance (ft)

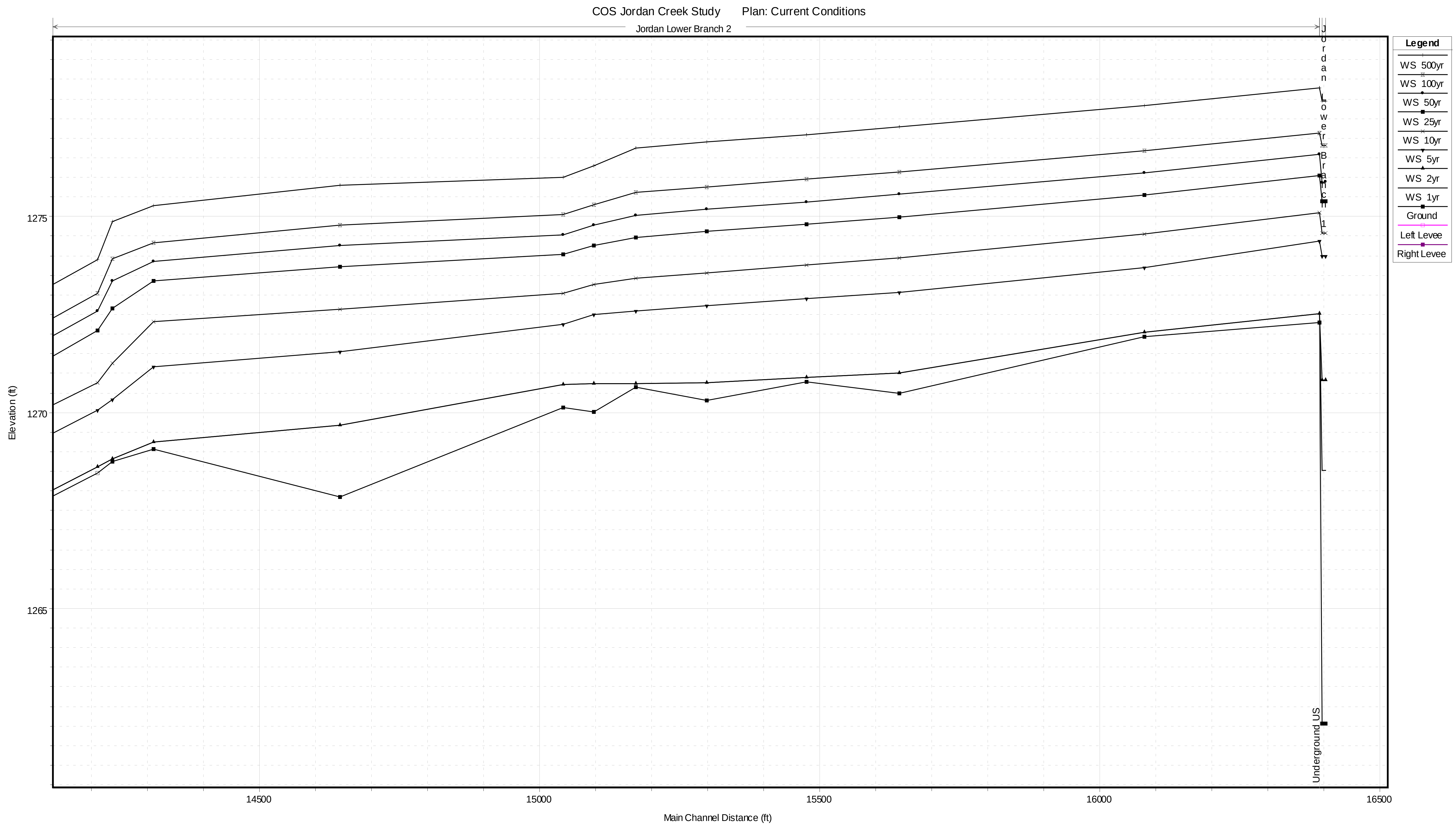
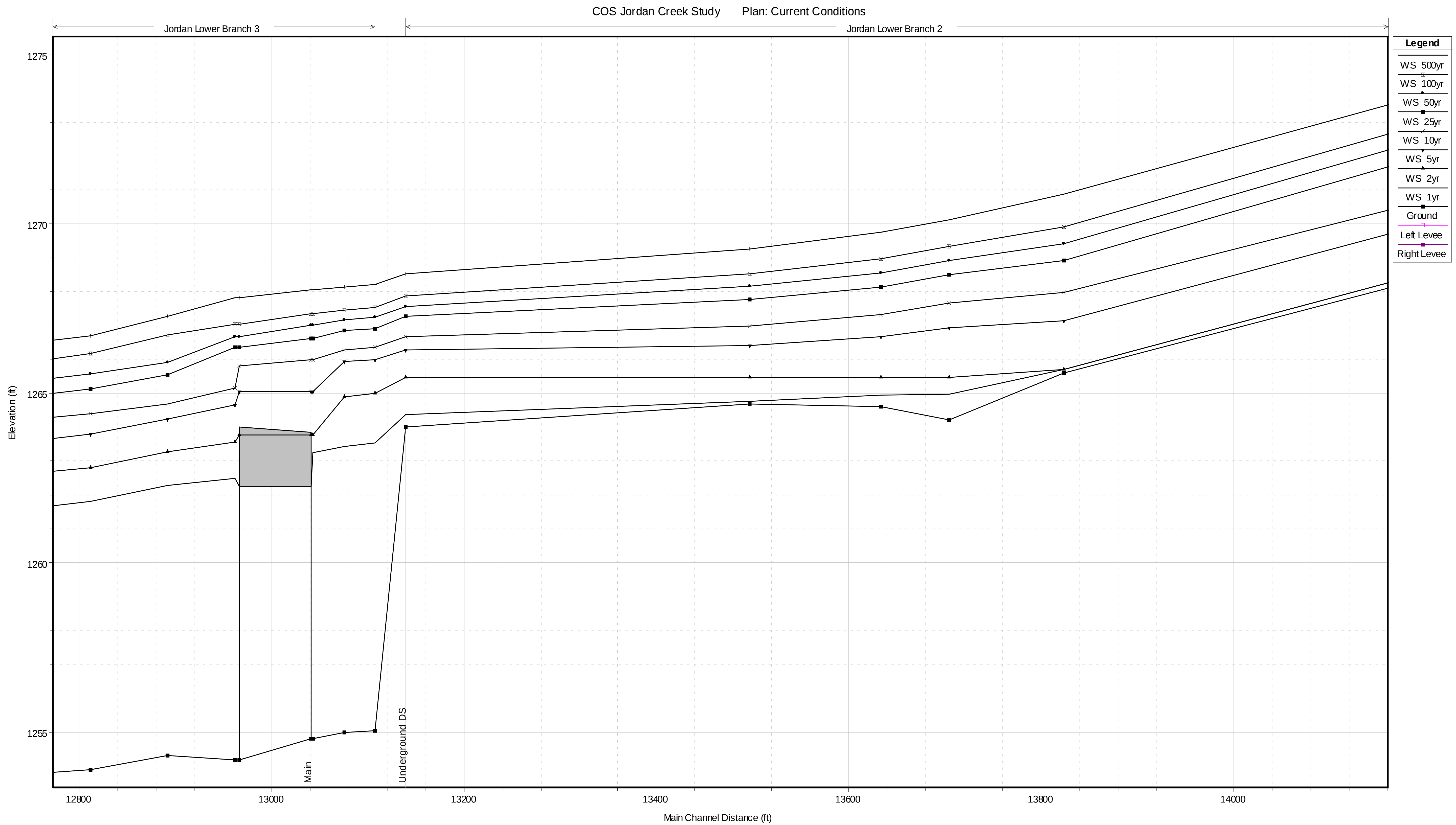
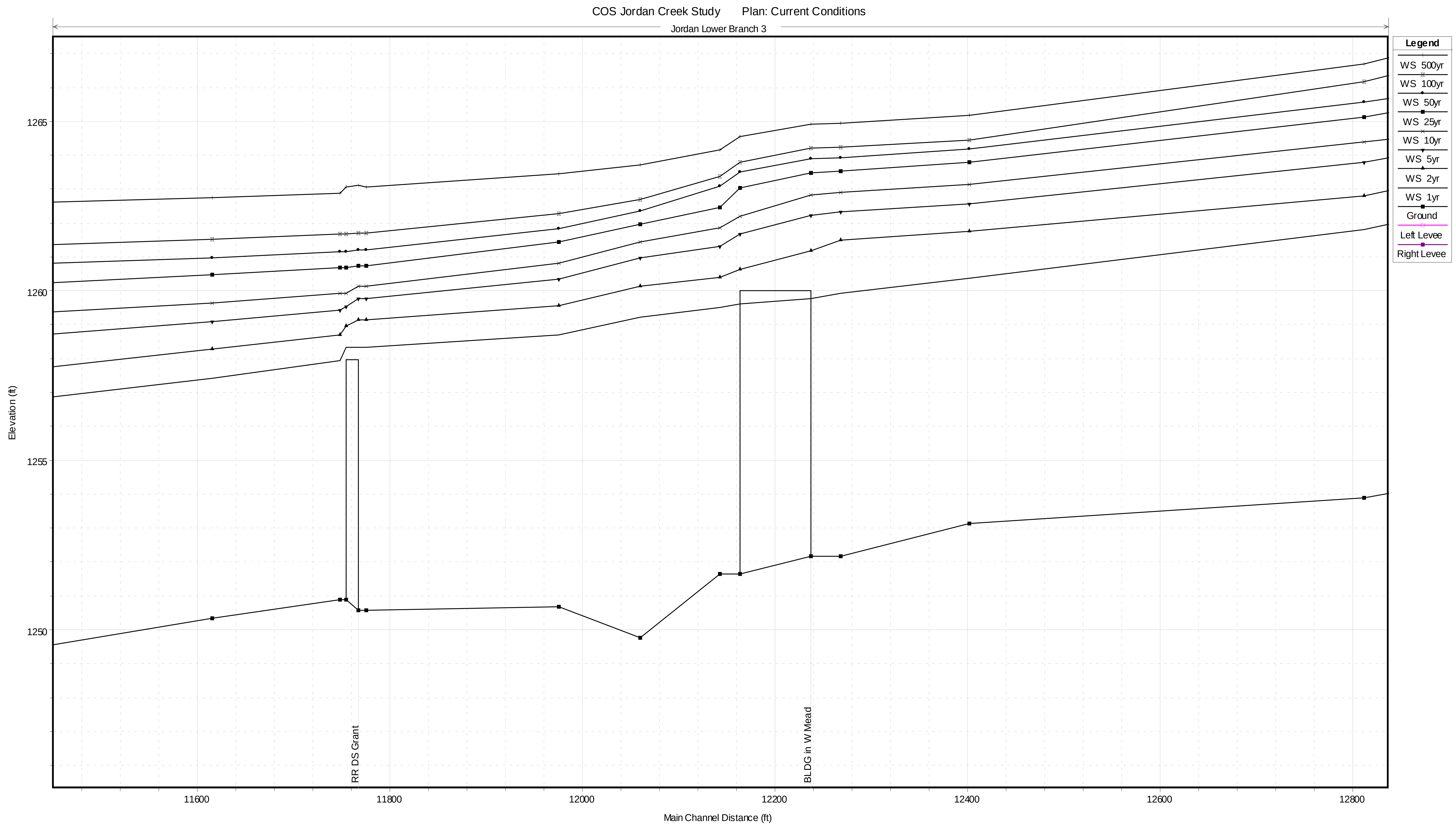

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 2
Jordan Lower Branch 1
Underground US
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1275
1270
1265
14500
15000
15500
16000
16500
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles





COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
1265
1260
1255
1250
Elevation (ft)
RR DS Grant
BLDG in W Mead
11600
11800
12000
12200
12400
12600
12800
Main Channel Distance (ft)

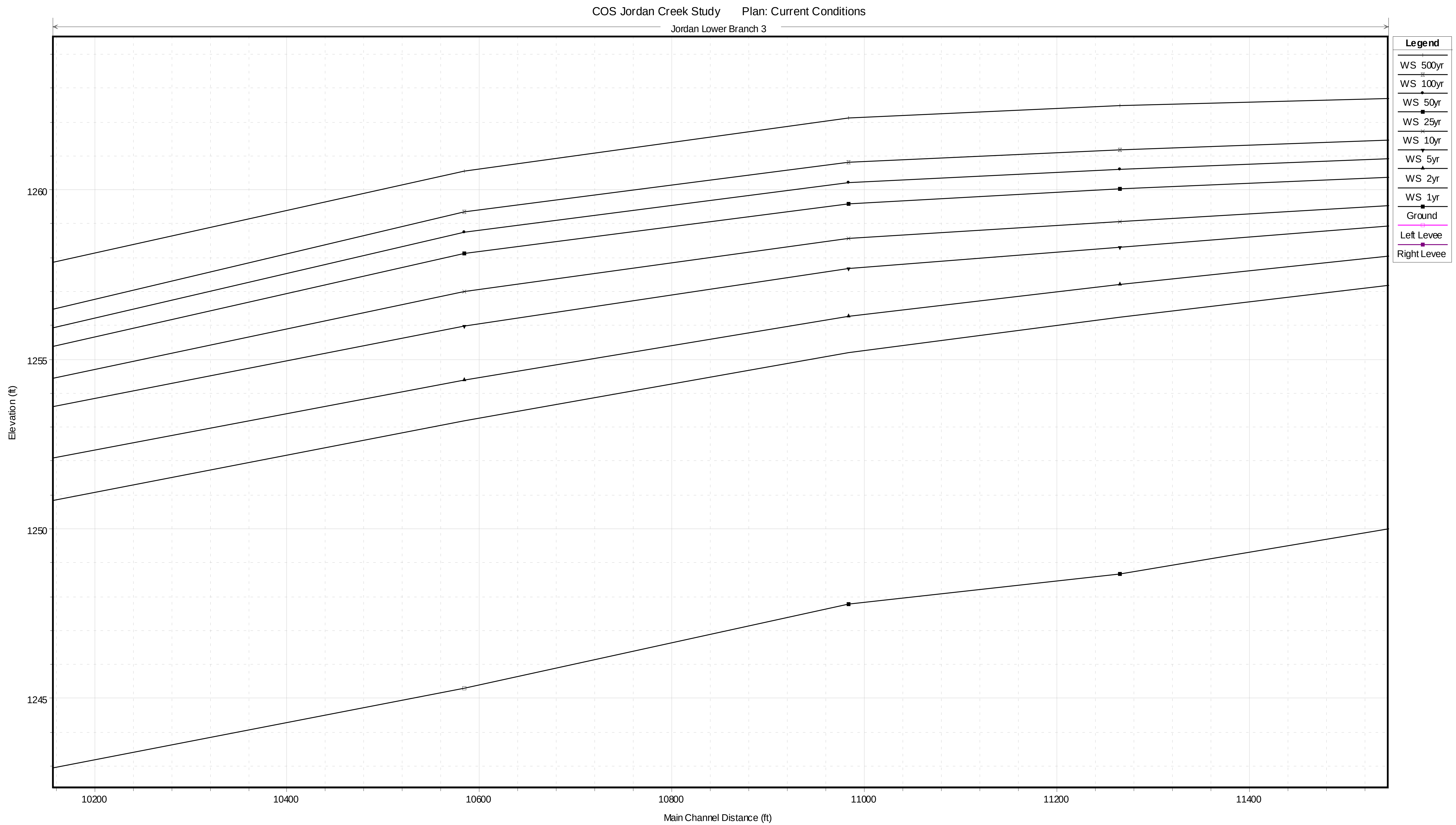
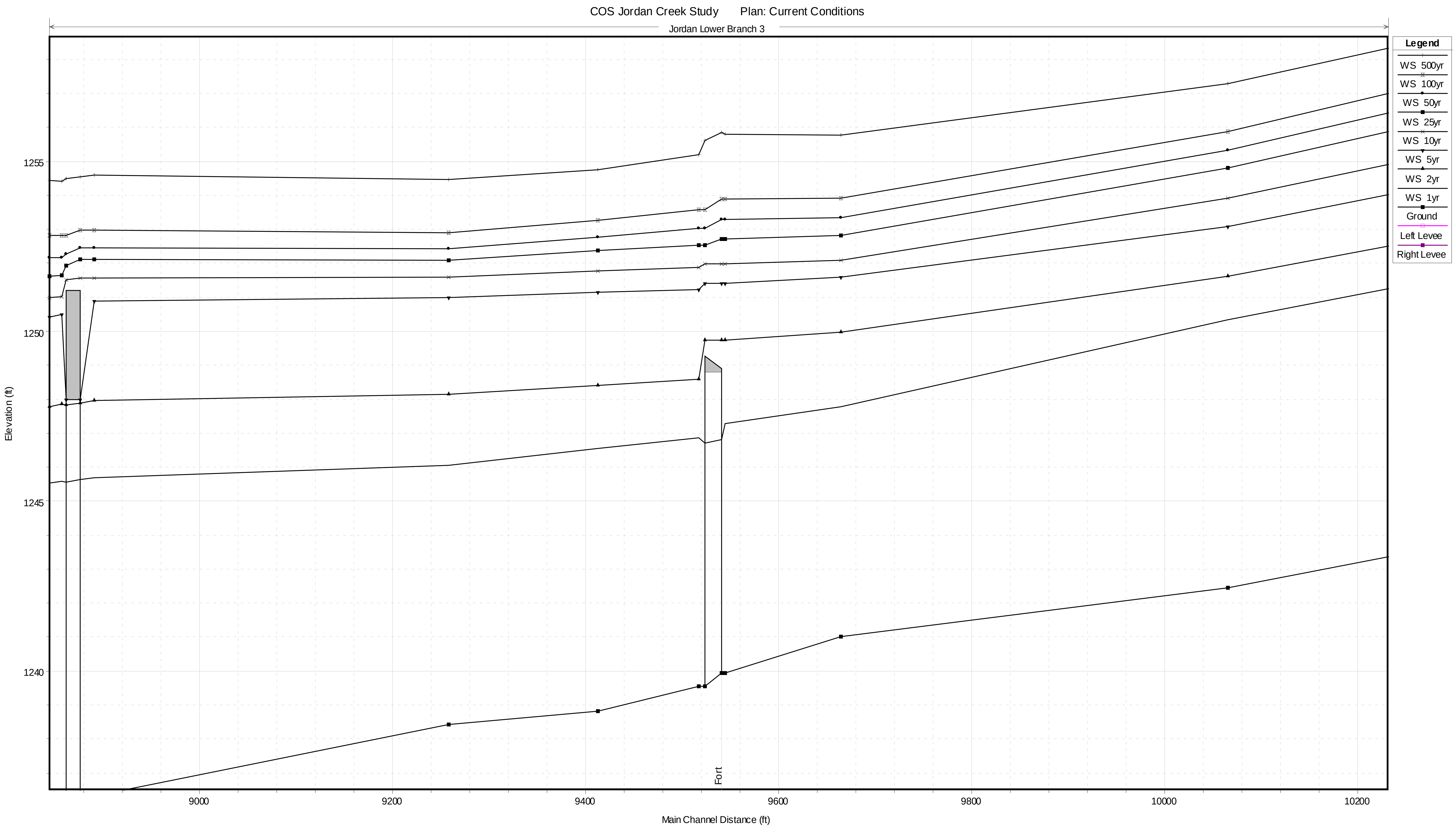

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1260
1255
1250
1245
10200
10400
10600
10800
11000
11200
11400
Main Channel Distance (ft)

Plate Series C – Without Project Hydraulic Profiles



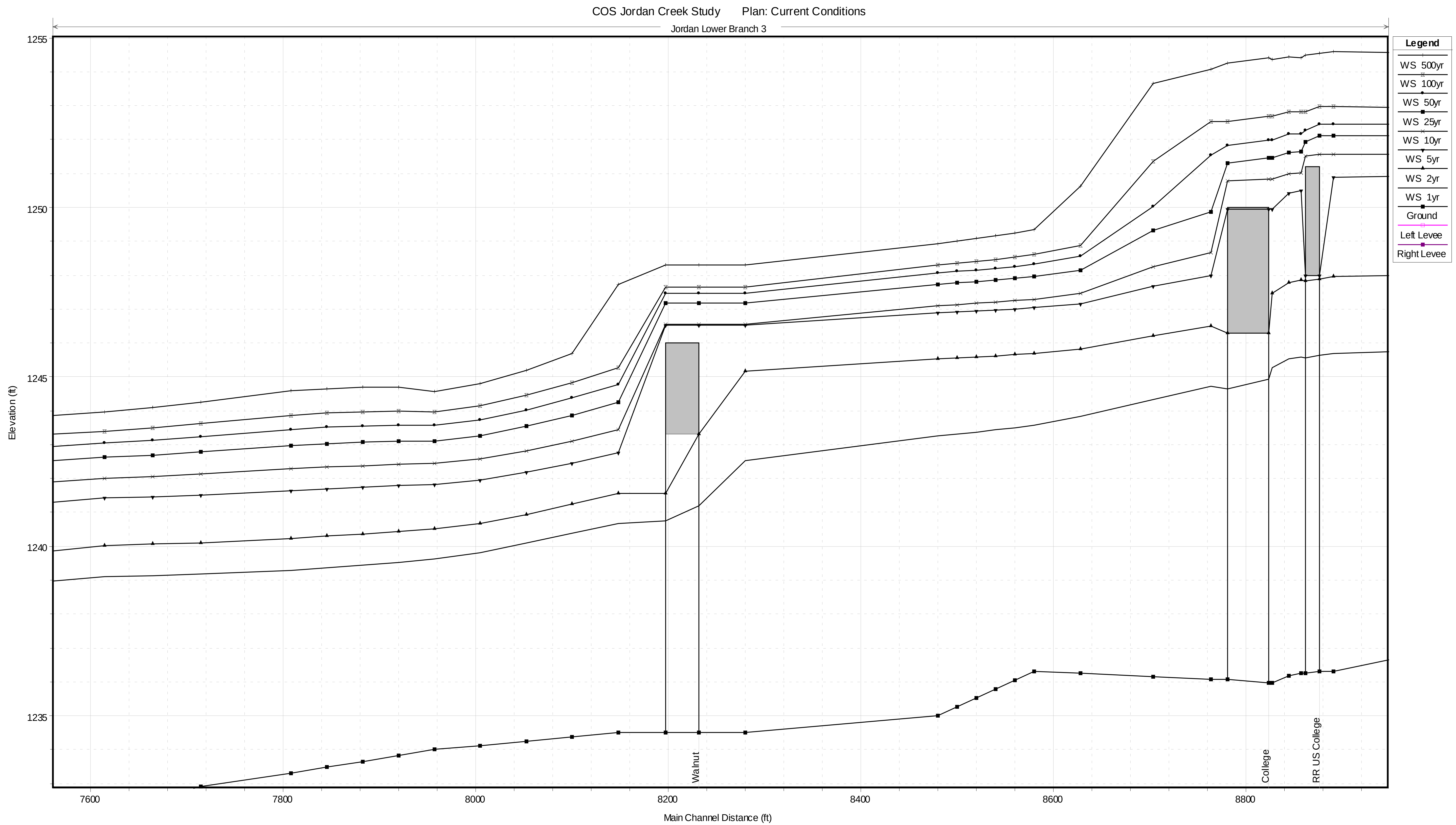

COS Jordan Creek Study Plan: Current Conditions
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Elevation (ft)
1255
1250
1245
1240
1235
Main Channel Distance (ft)
7600
7800
8000
8200
8400
8600
8800
Walnut
College
RR US College

Plate Series C – Without Project Hydraulic Profiles

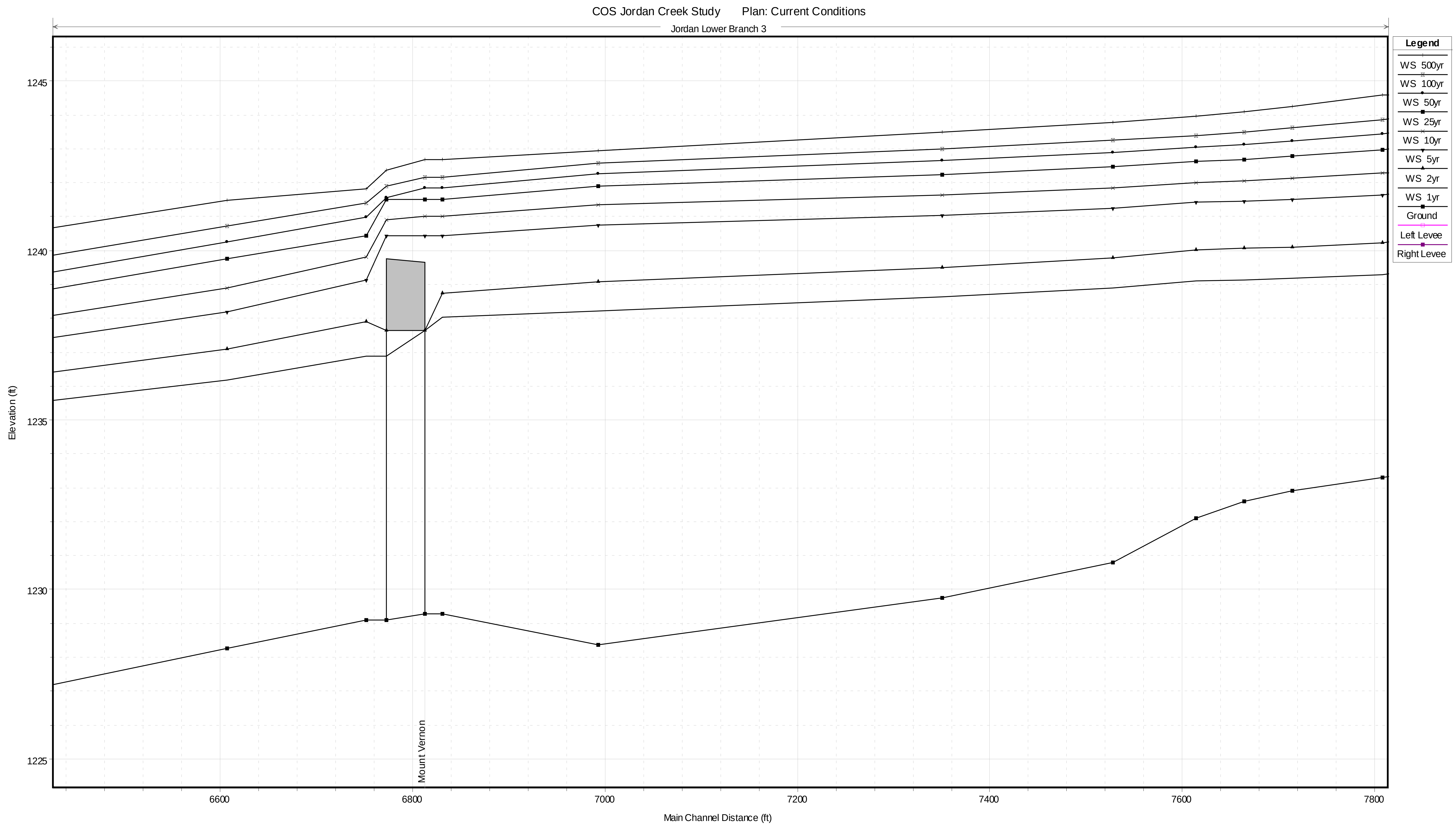


Plate Series C – Without Project Hydraulic Profiles

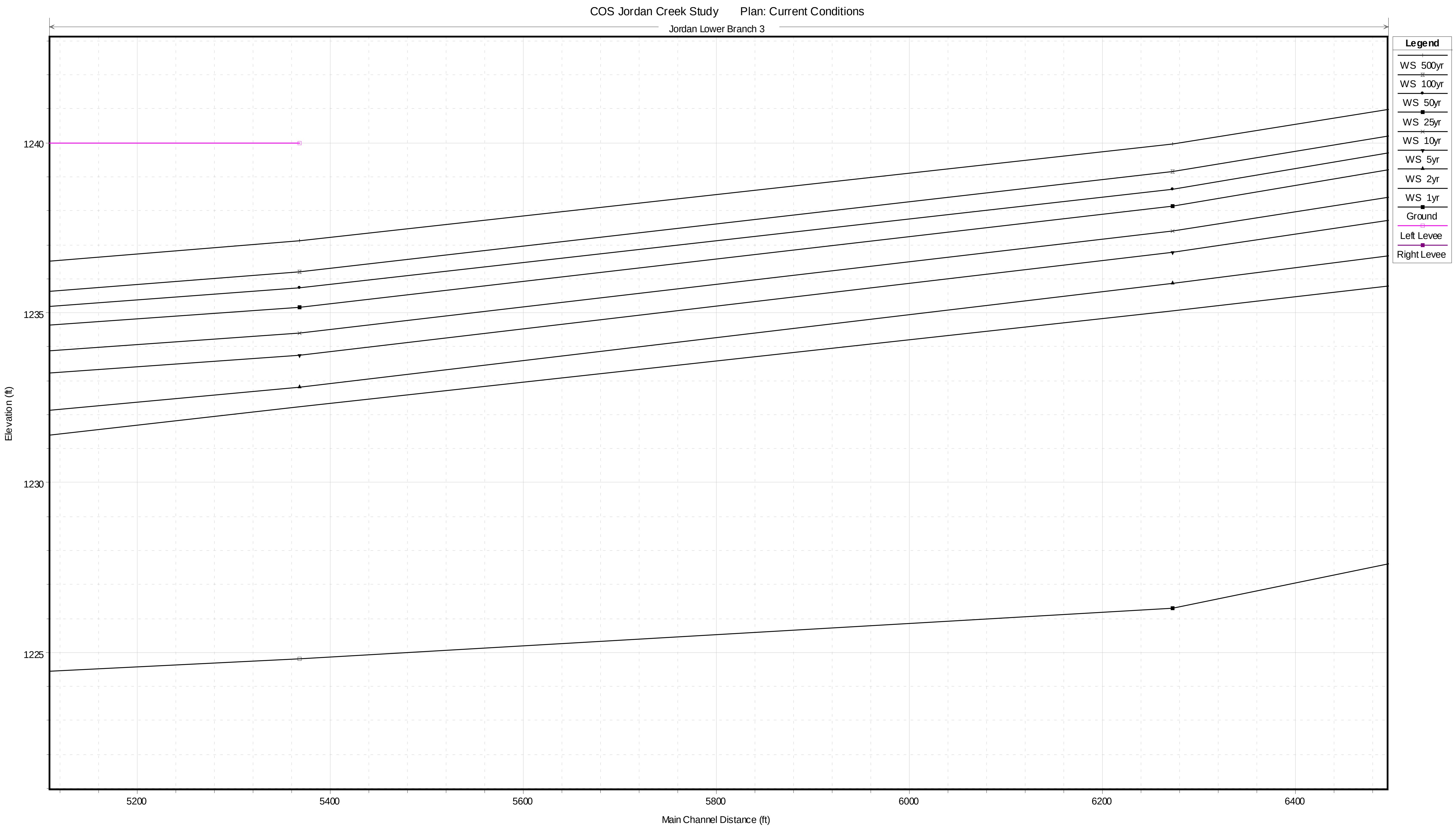


Plate Series C – Without Project Hydraulic Profiles

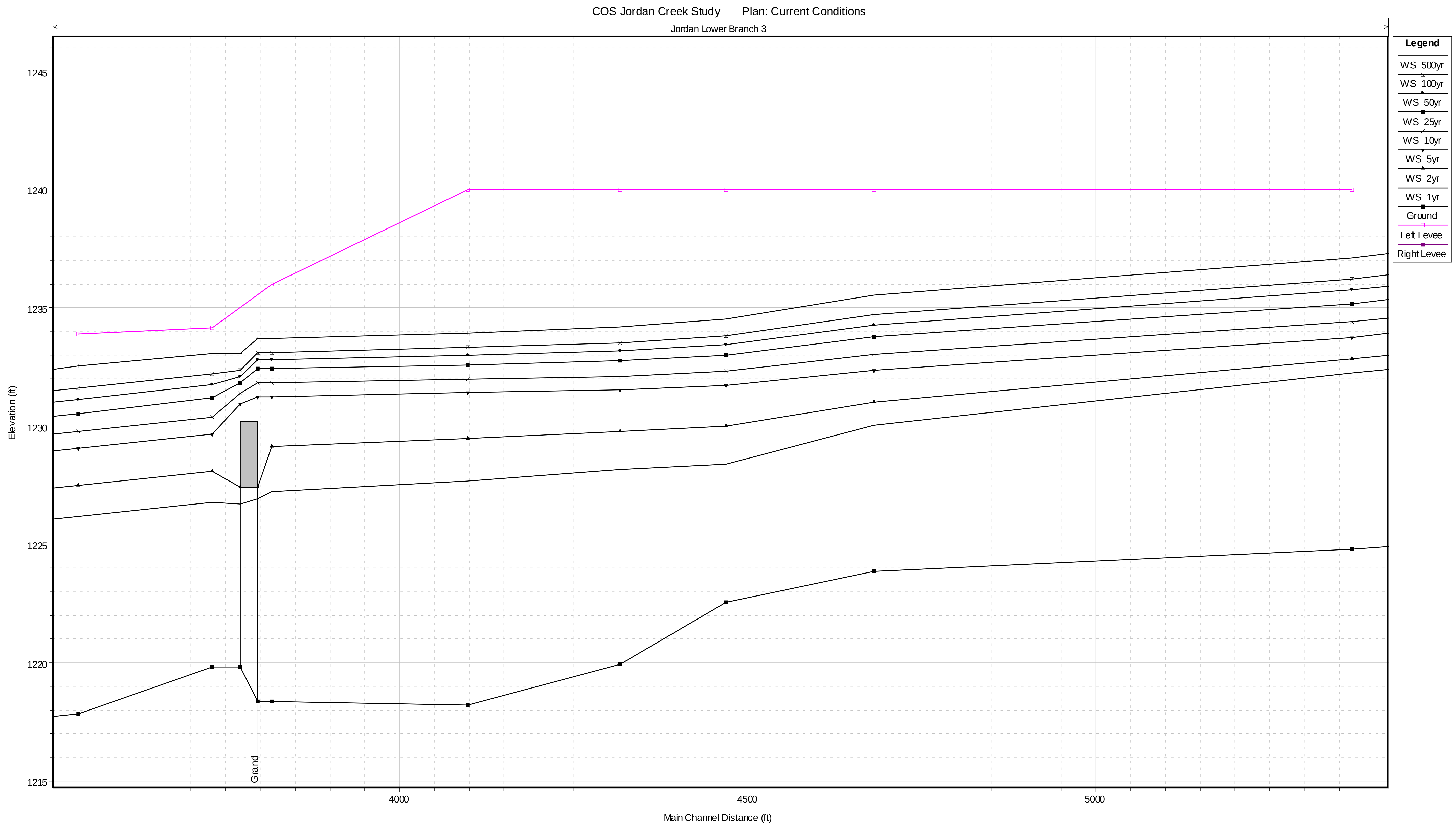


Plate Series C – Without Project Hydraulic Profiles

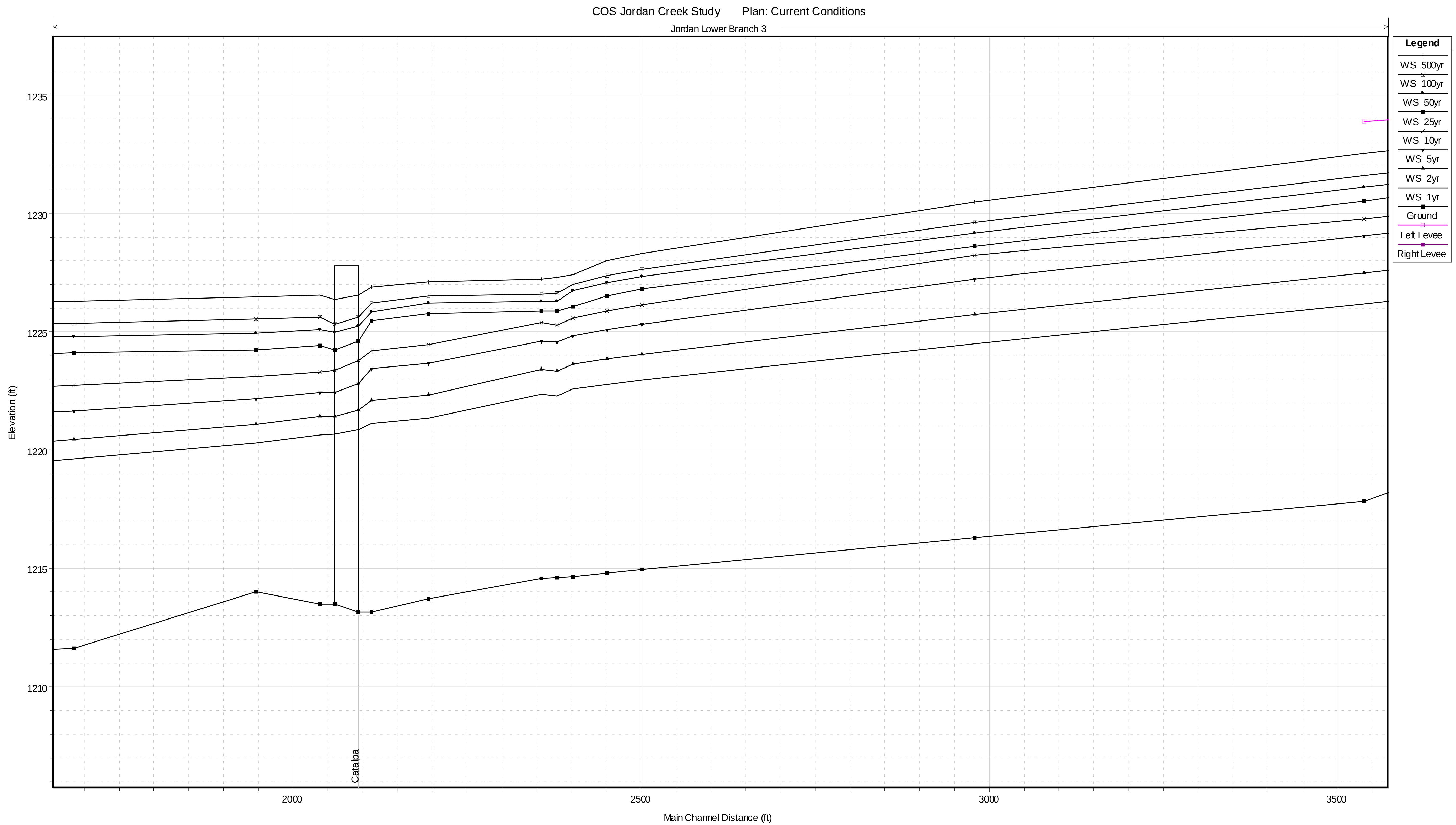


Plate Series C – Without Project Hydraulic Profiles

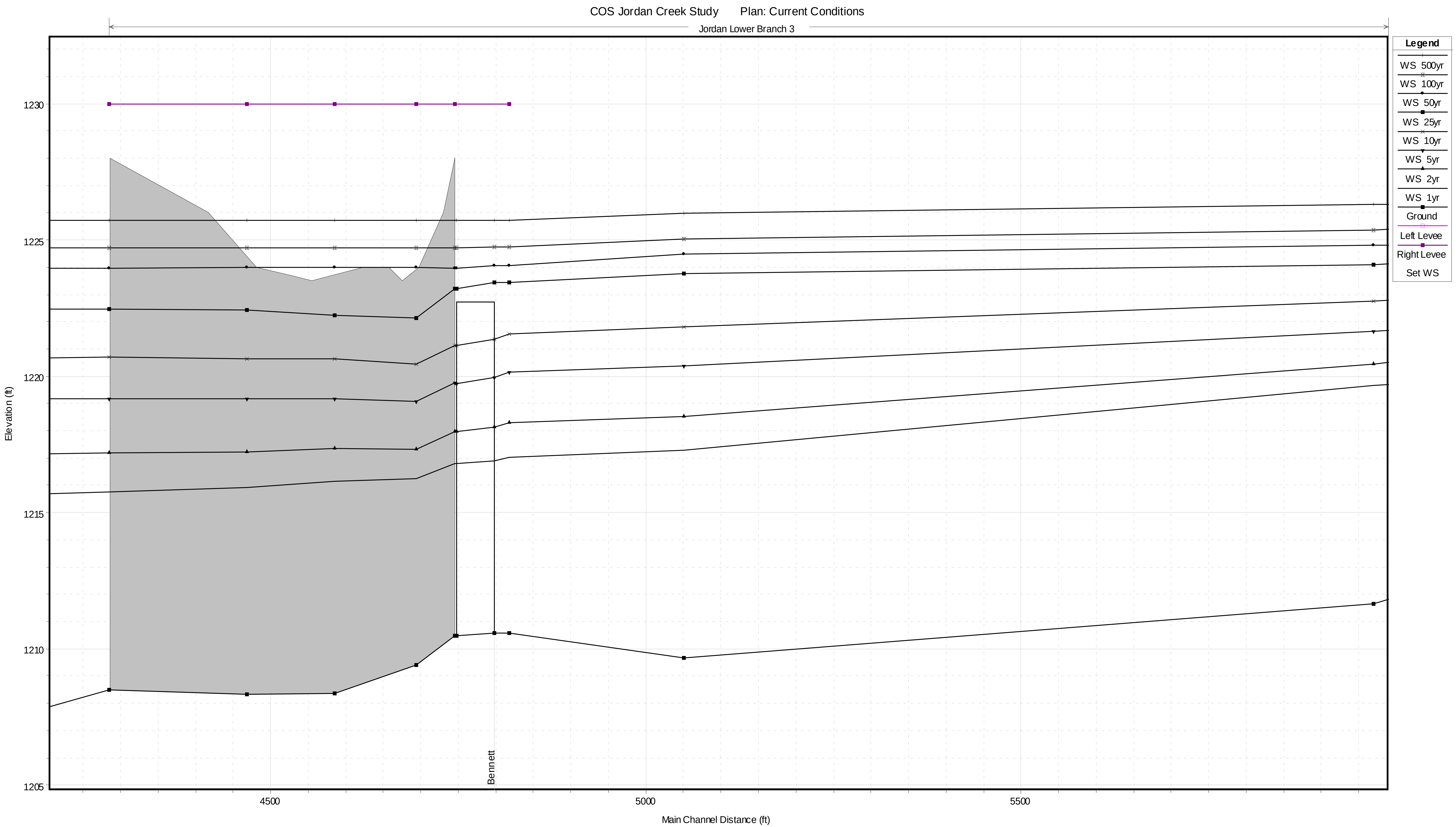
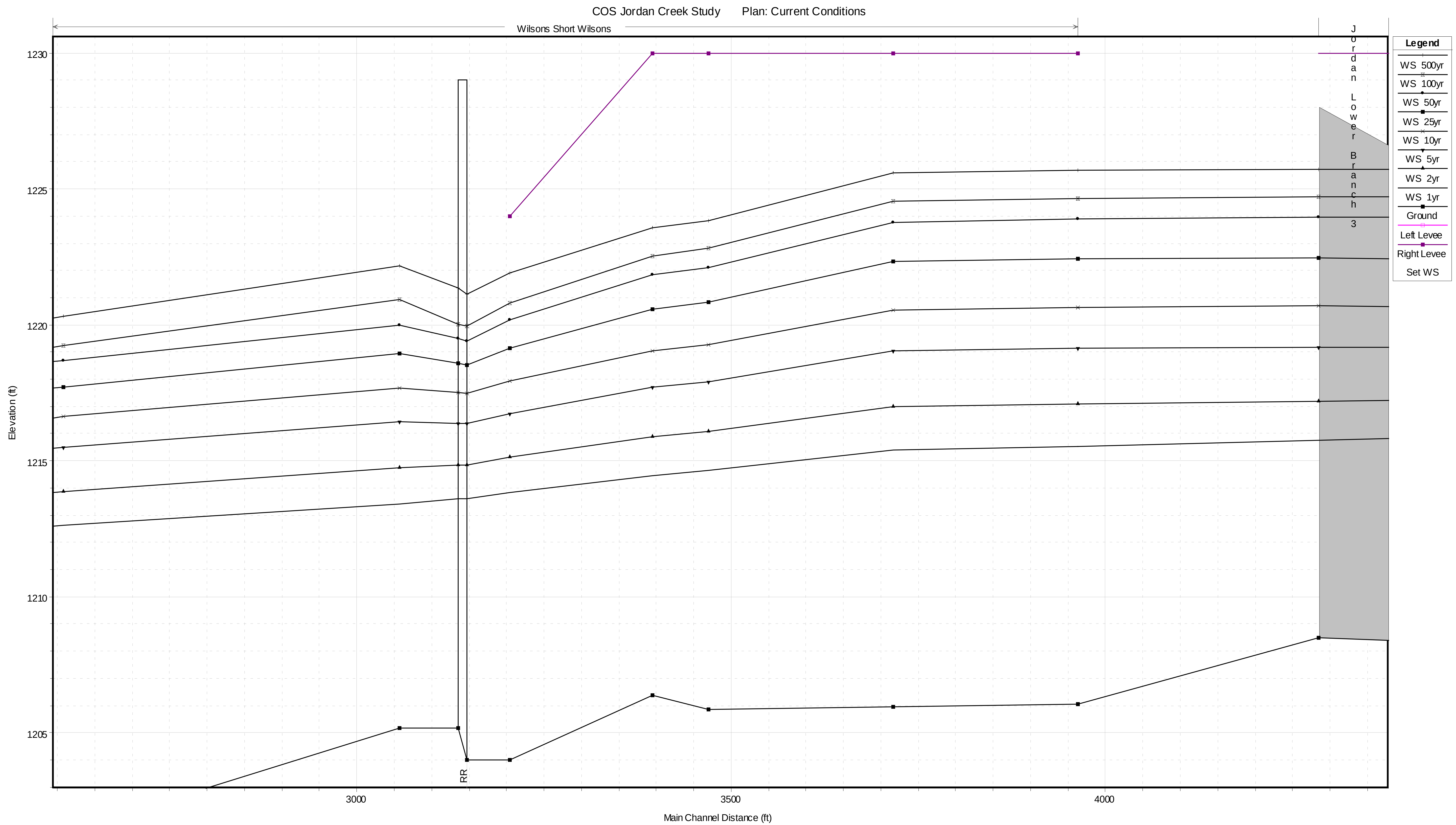
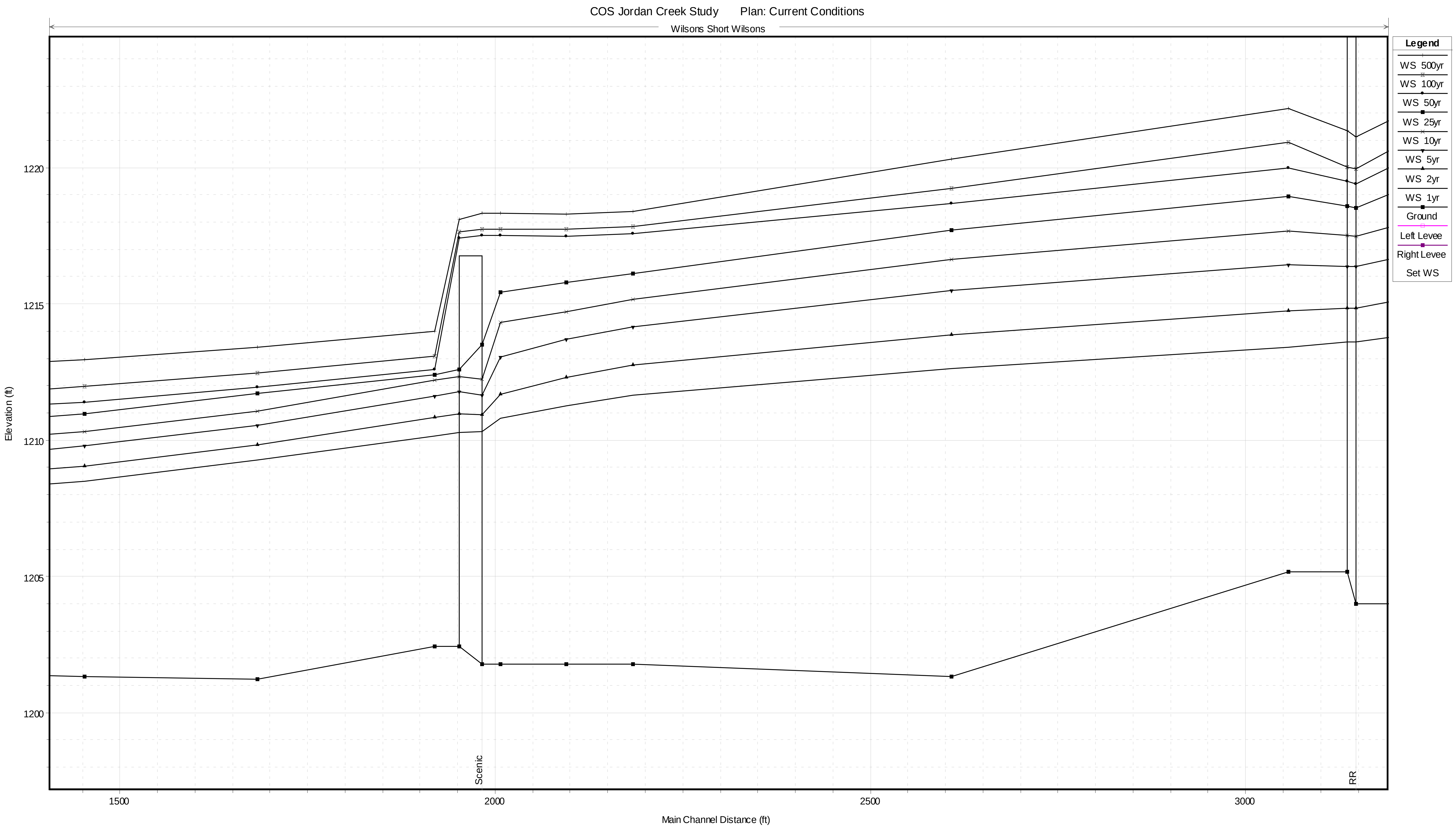


Plate Series C – Without Project Hydraulic Profiles




COS Jordan Creek Study Plan: Current Conditions
Wilsons Short Wilsons
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
1220
1215
1210
1205
1200
Elevation (ft)
Scenic
RR
1500
2000
2500
3000
Main Channel Distance (ft)

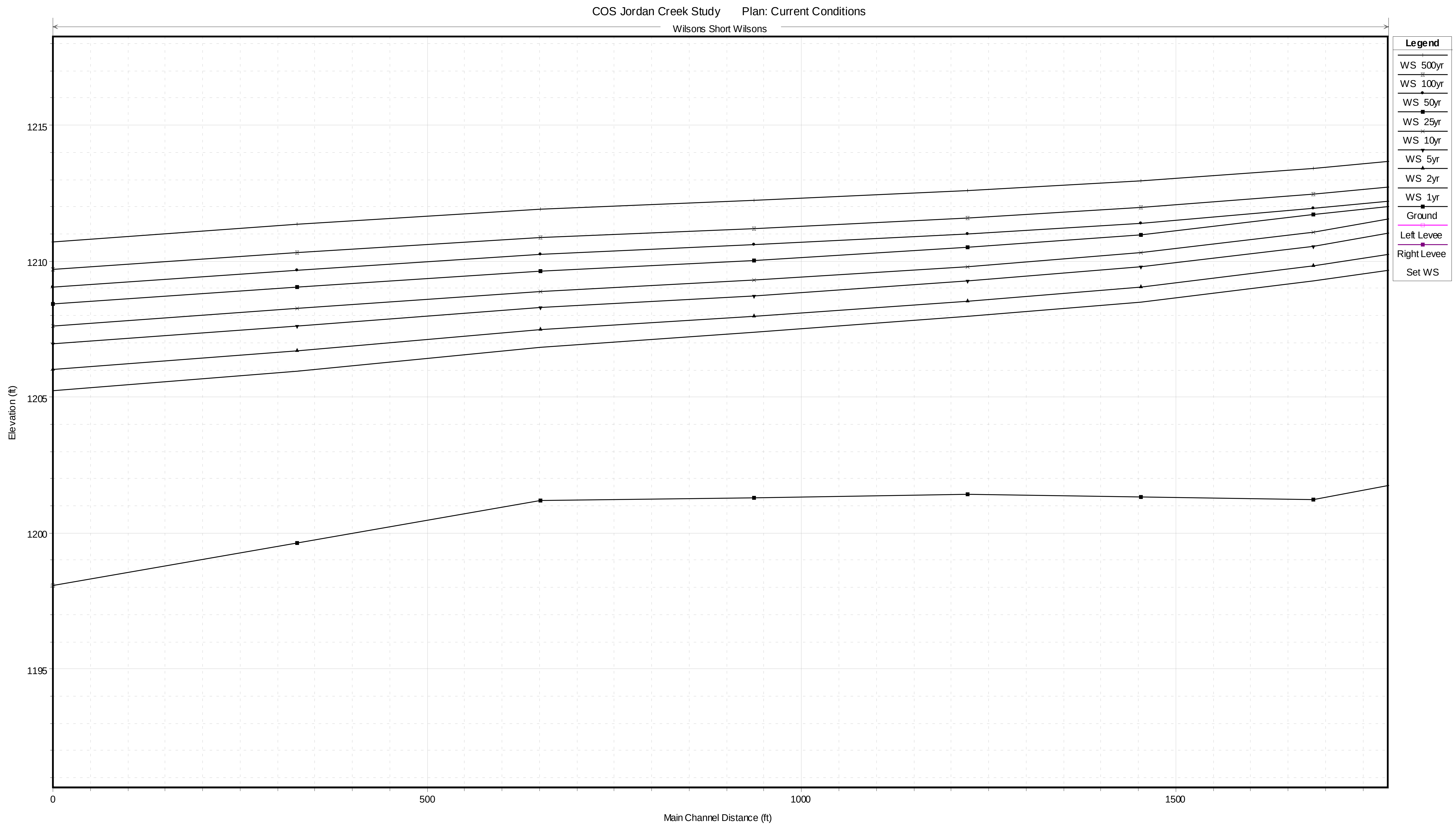

COS Jordan Creek Study Plan: Current Conditions
Wilsons Short Wilsons
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
1215
1210
1205
1200
1195
Elevation (ft)
0
500
1000
1500
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

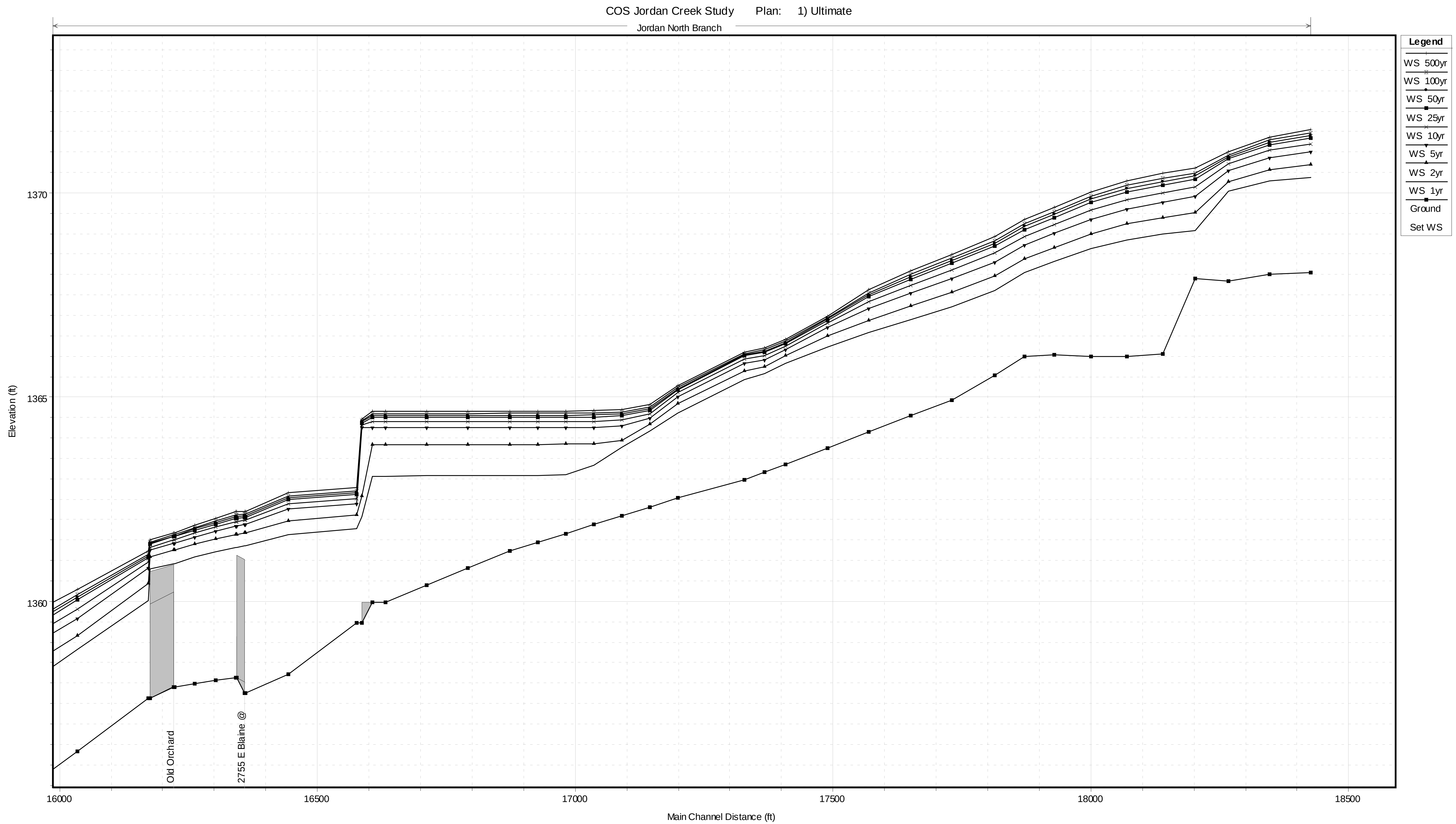


Plate Series D – Future Conditions Without Project Hydraulic Profiles

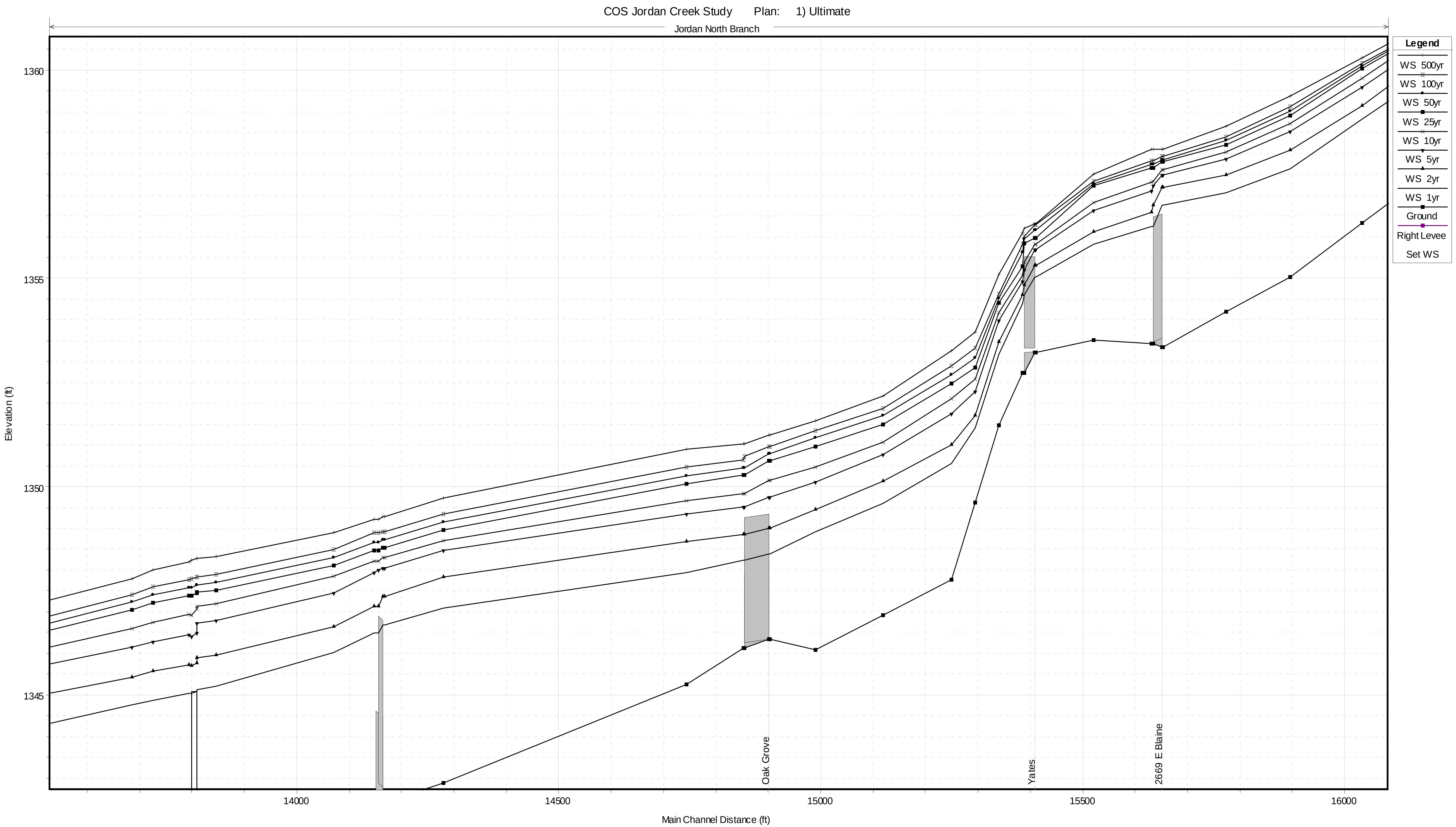
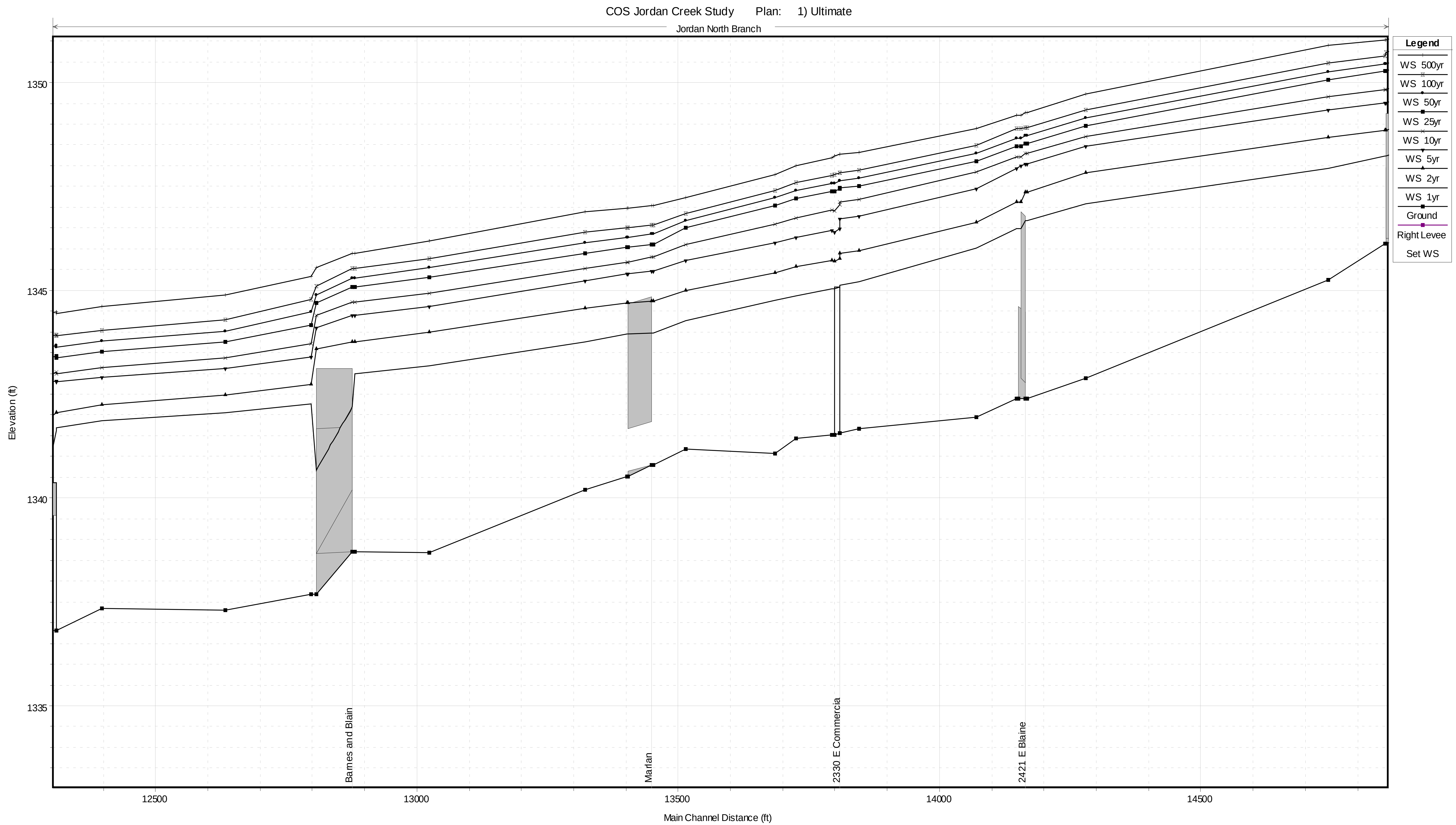


Plate Series D – Future Conditions Without Project Hydraulic Profiles



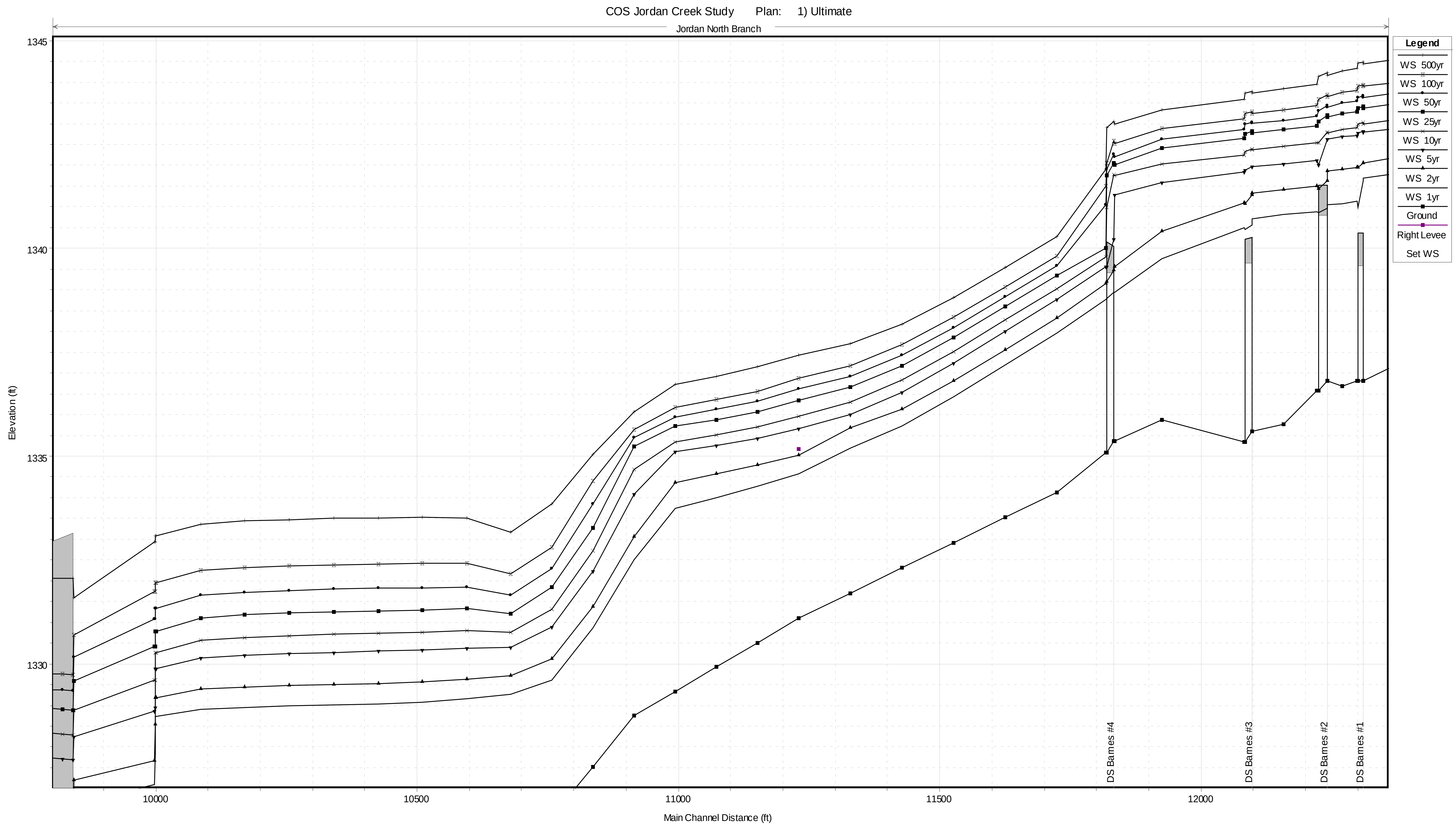

COS Jordan Creek Study Plan: 1) Ultimate
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
1345
1340
1335
1330
Elevation (ft)
10000
10500
11000
11500
12000
Main Channel Distance (ft)
DS Barnes #4
DS Barnes #3
DS Barnes #2
DS Barnes #1

Plate Series D – Future Conditions Without Project Hydraulic Profiles

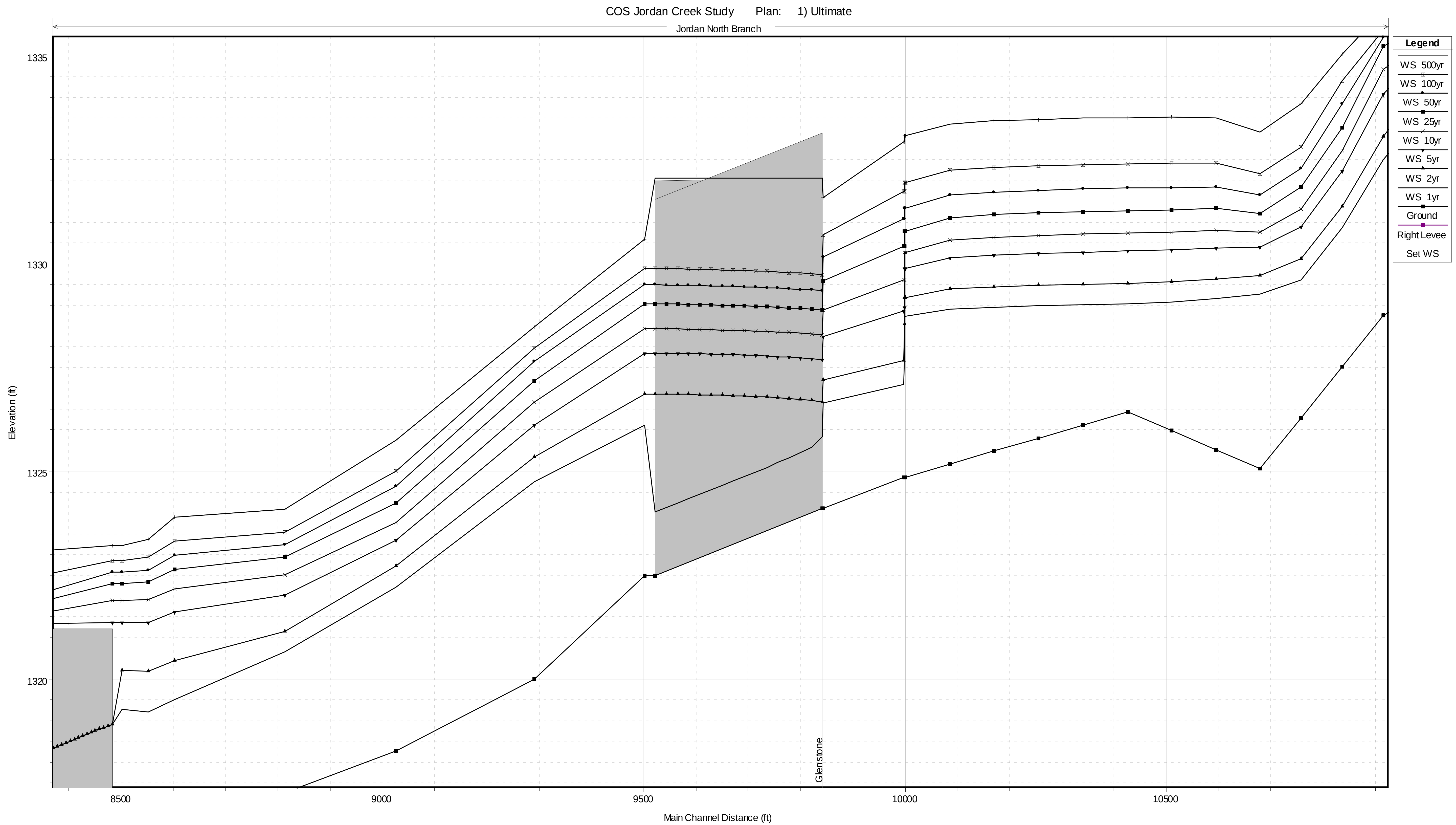


Plate Series D – Future Conditions Without Project Hydraulic Profiles

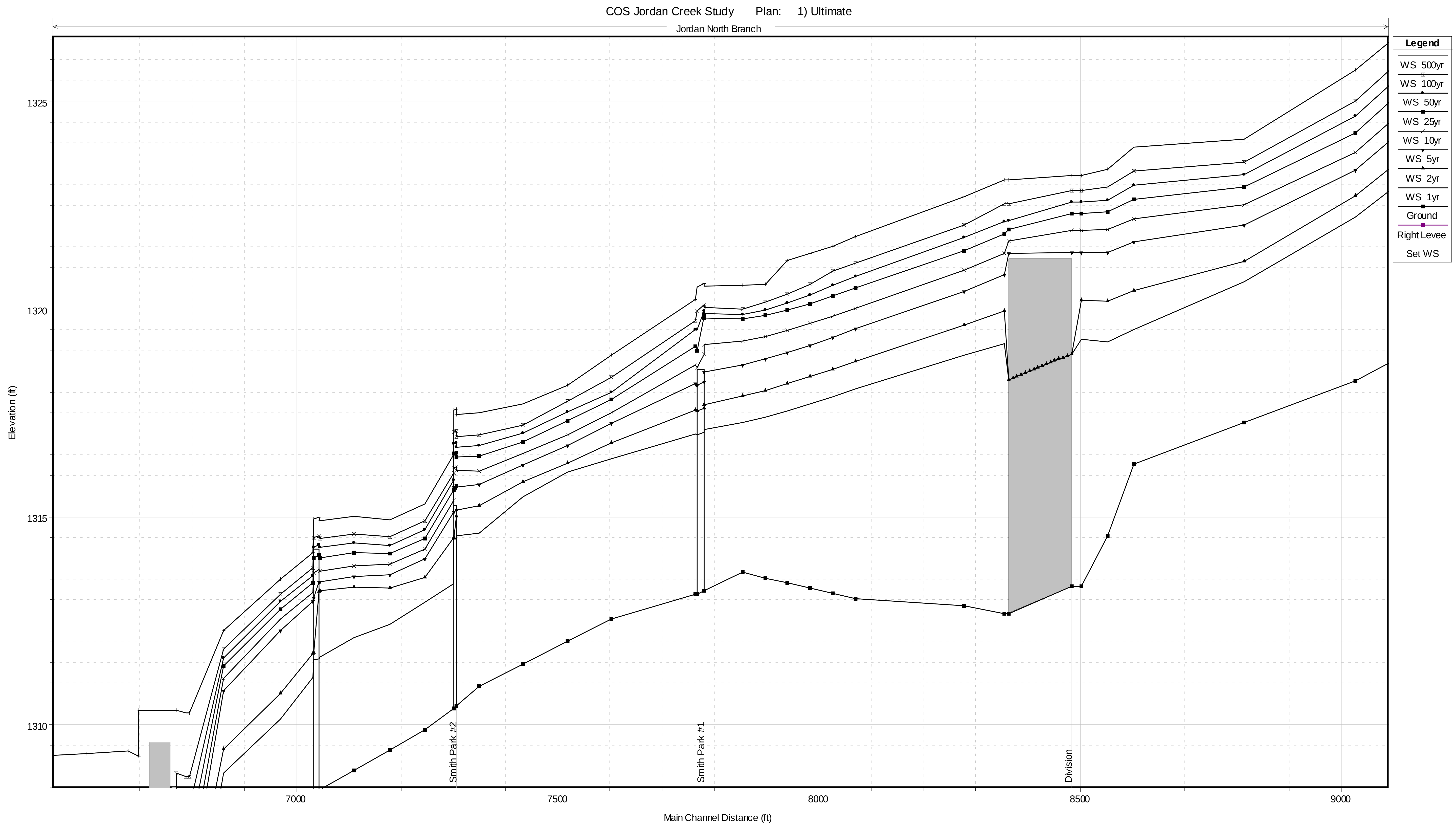
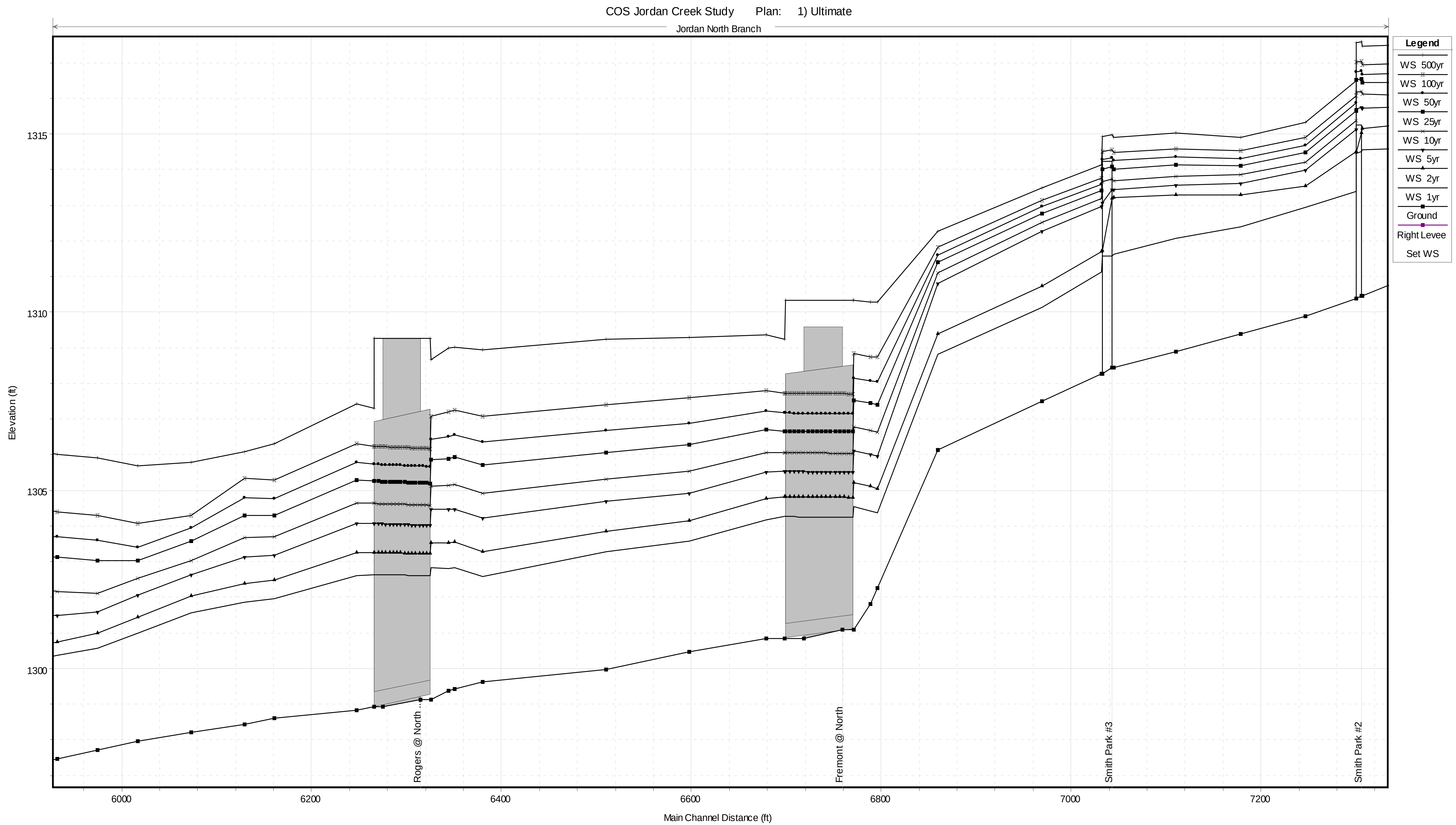


Plate Series D – Future Conditions Without Project Hydraulic Profiles



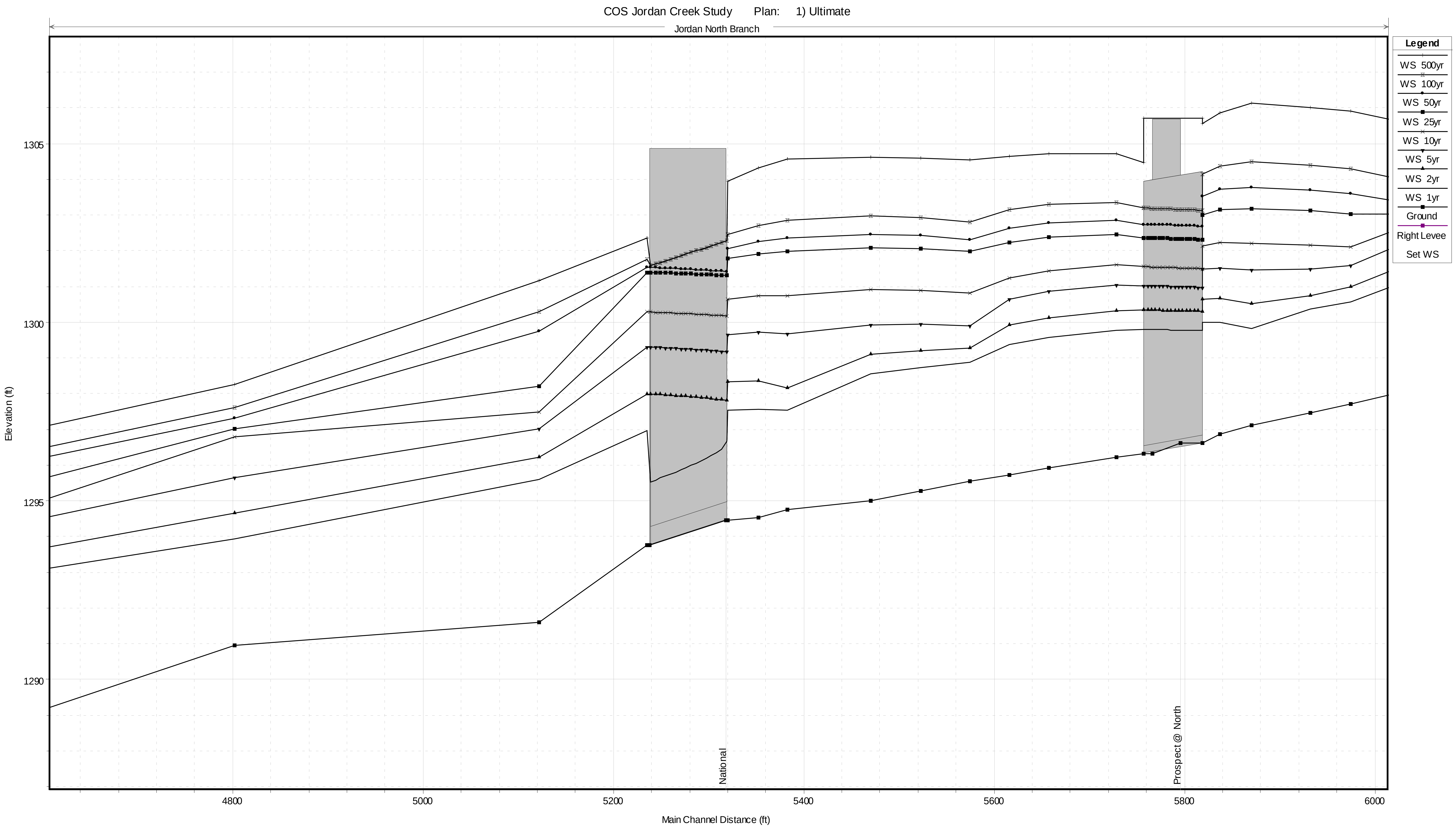
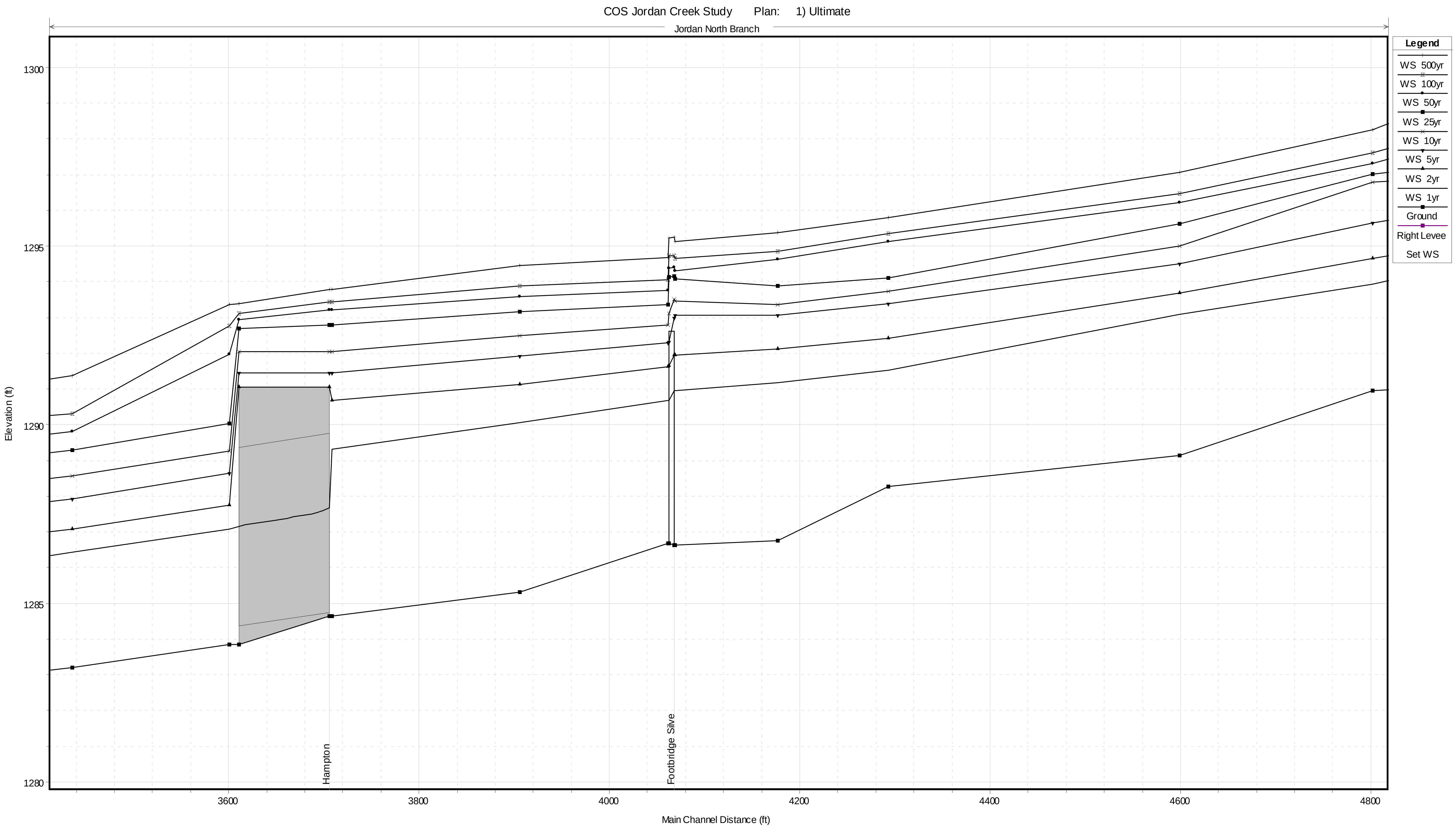

COS Jordan Creek Study Plan: 1) Ultimate
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
Elevation (ft)
1305
1300
1295
1290
National
Prospect @ North
4800
5000
5200
5400
5600
5800
6000
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles



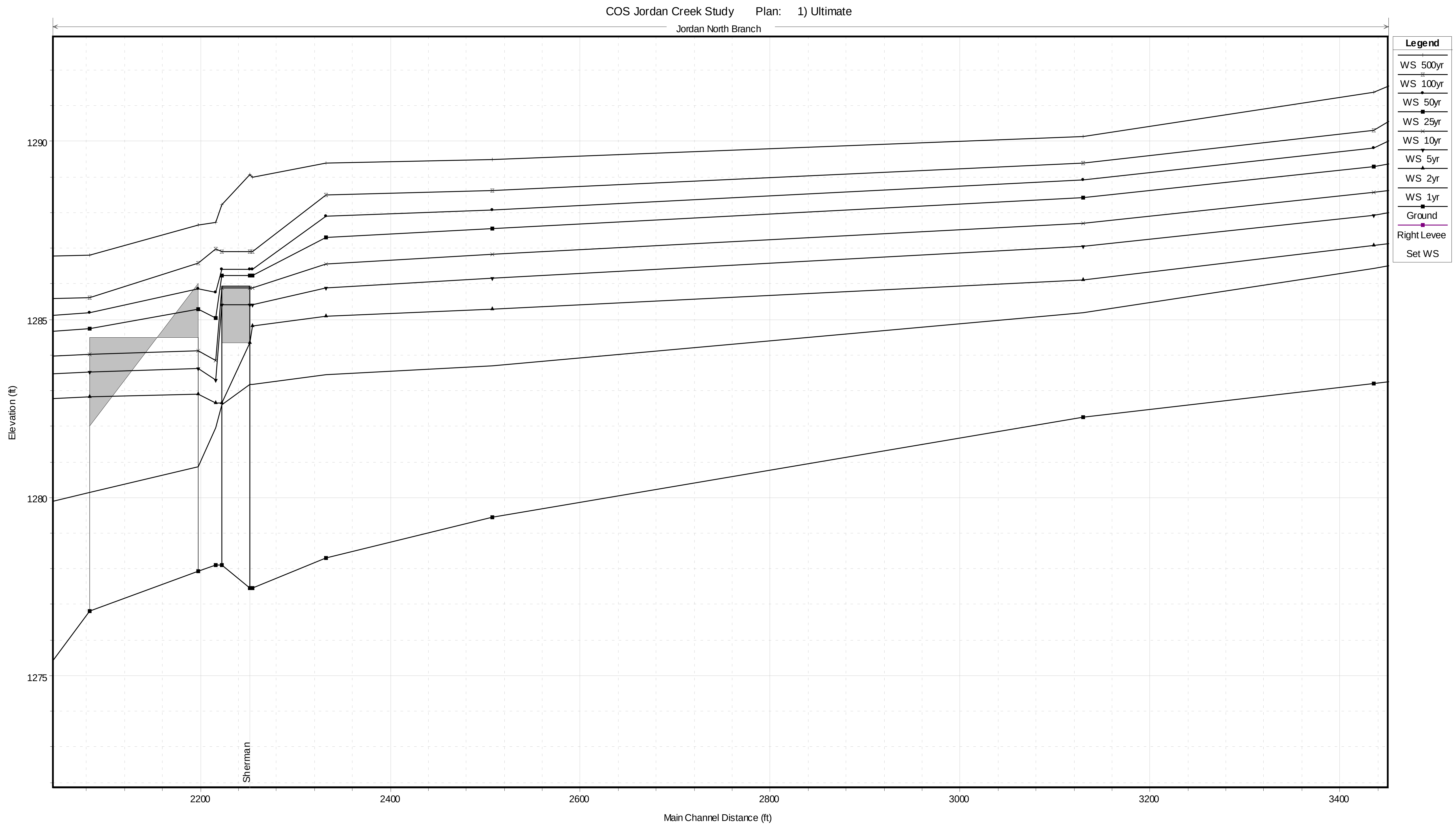

COS Jordan Creek Study Plan: 1) Ultimate
Jordan North Branch
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
1290
1285
1280
1275
Elevation (ft)
Sherman
2200
2400
2600
2800
3000
3200
3400
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

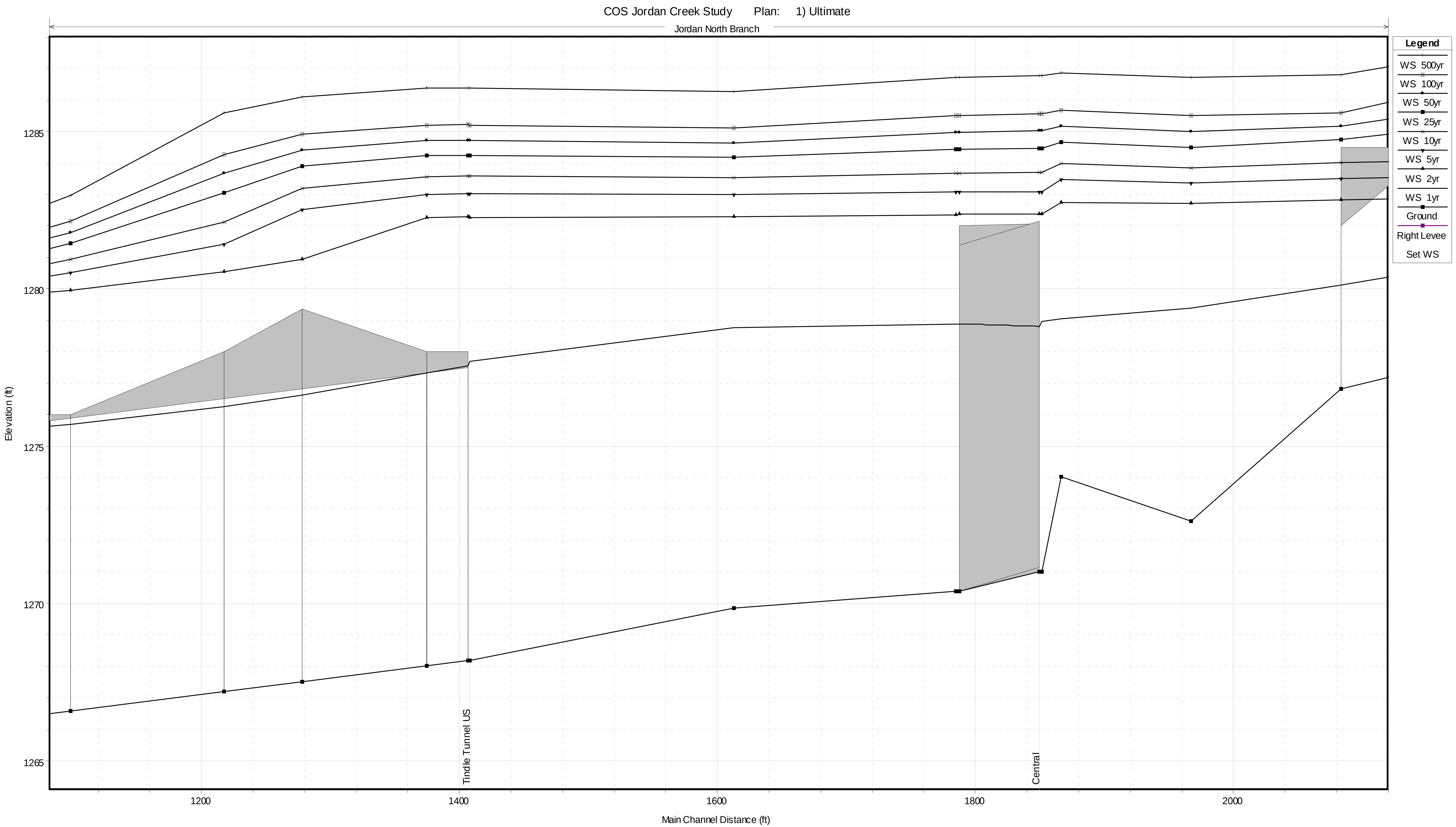
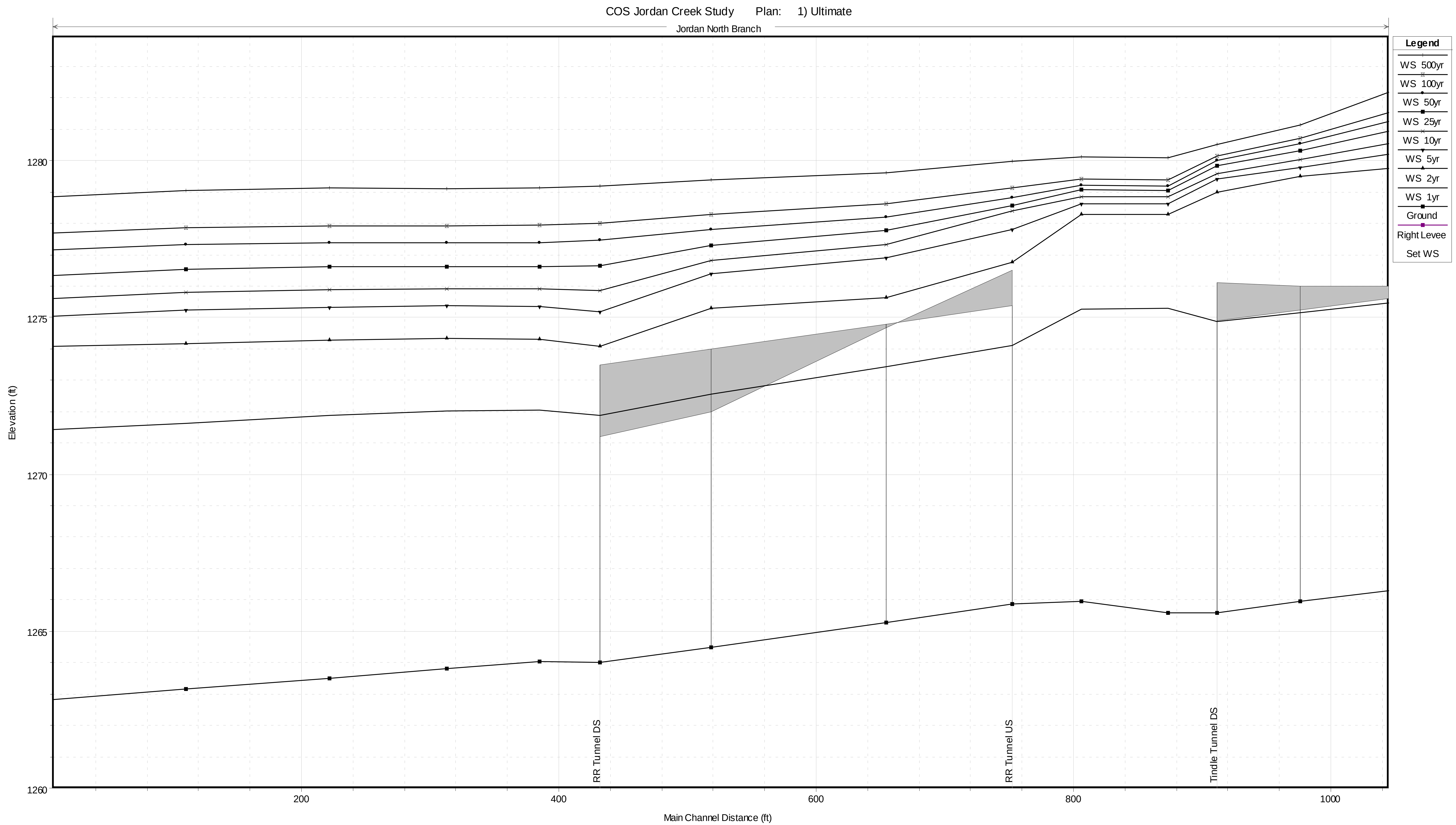
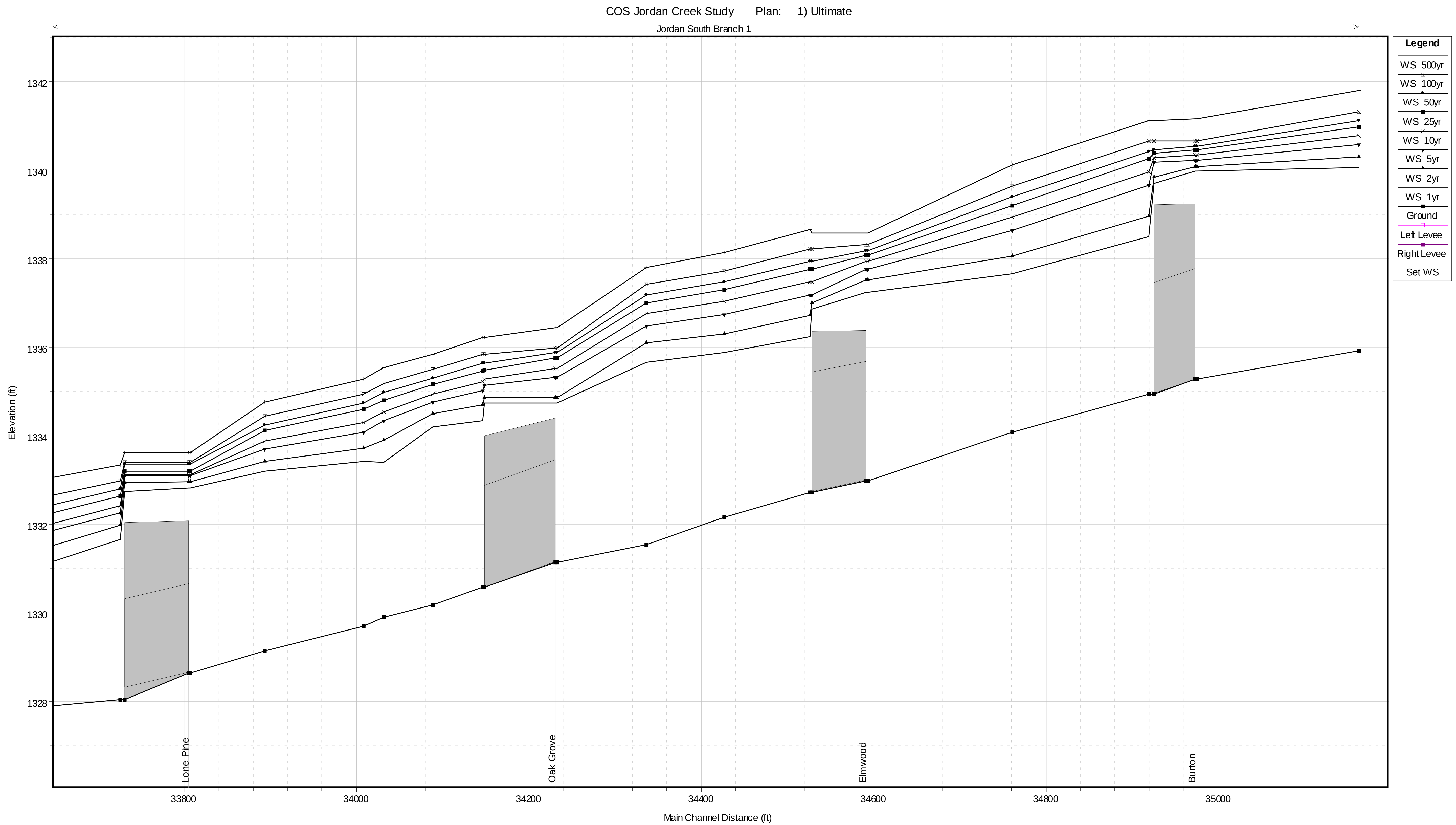
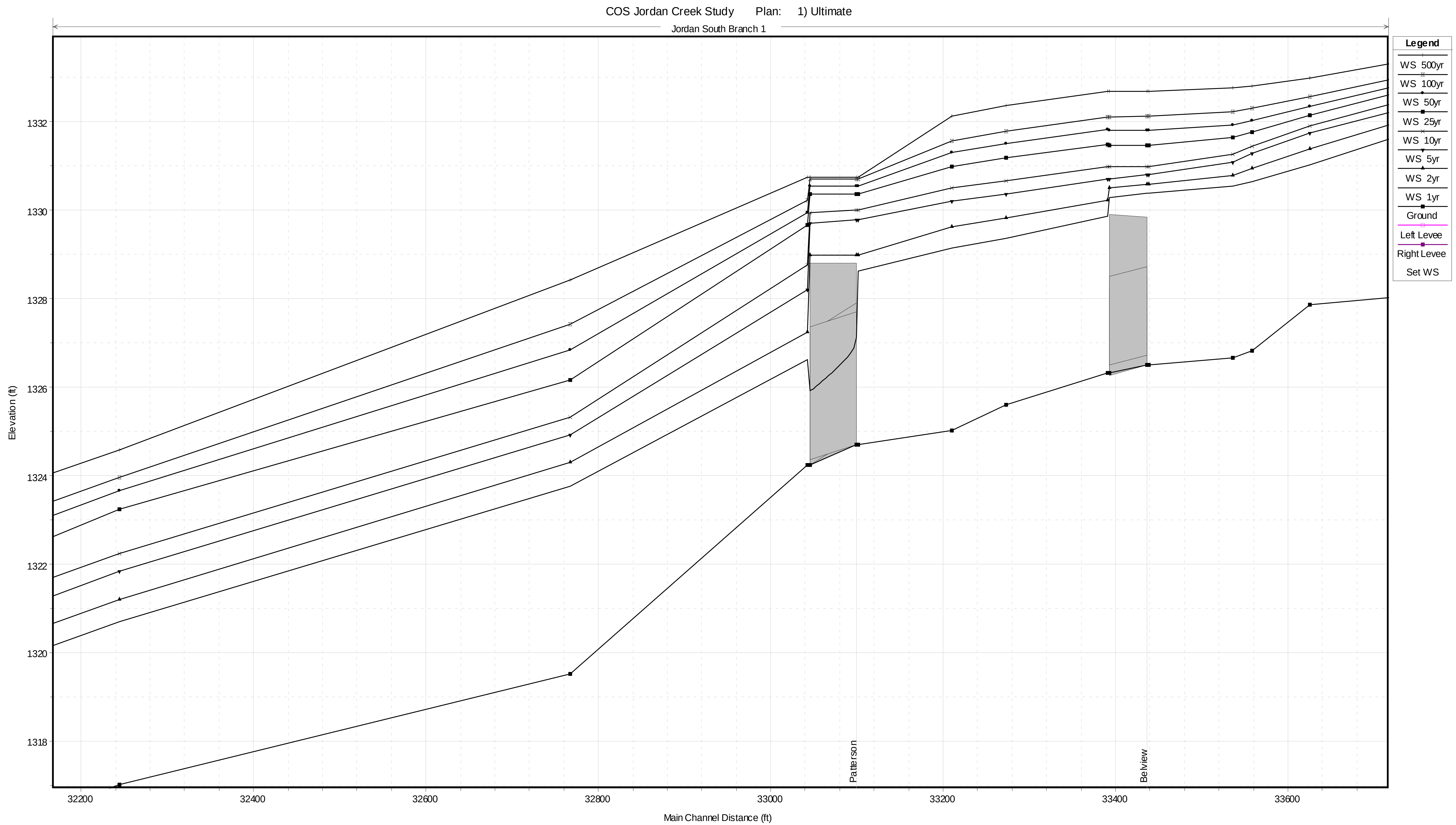


Plate Series D – Future Conditions Without Project Hydraulic Profiles




COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
Elevation (ft)
1342
1340
1338
1336
1334
1332
1330
1328
Lone Pine
Oak Grove
Elmwood
Burton
33800
34000
34200
34400
34600
34800
35000
Main Channel Distance (ft)



COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
Elevation (ft)
1332
1330
1328
1326
1324
1322
1320
1318
Patterson
Belview
32200
32400
32600
32800
33000
33200
33400
33600
Main Channel Distance (ft)

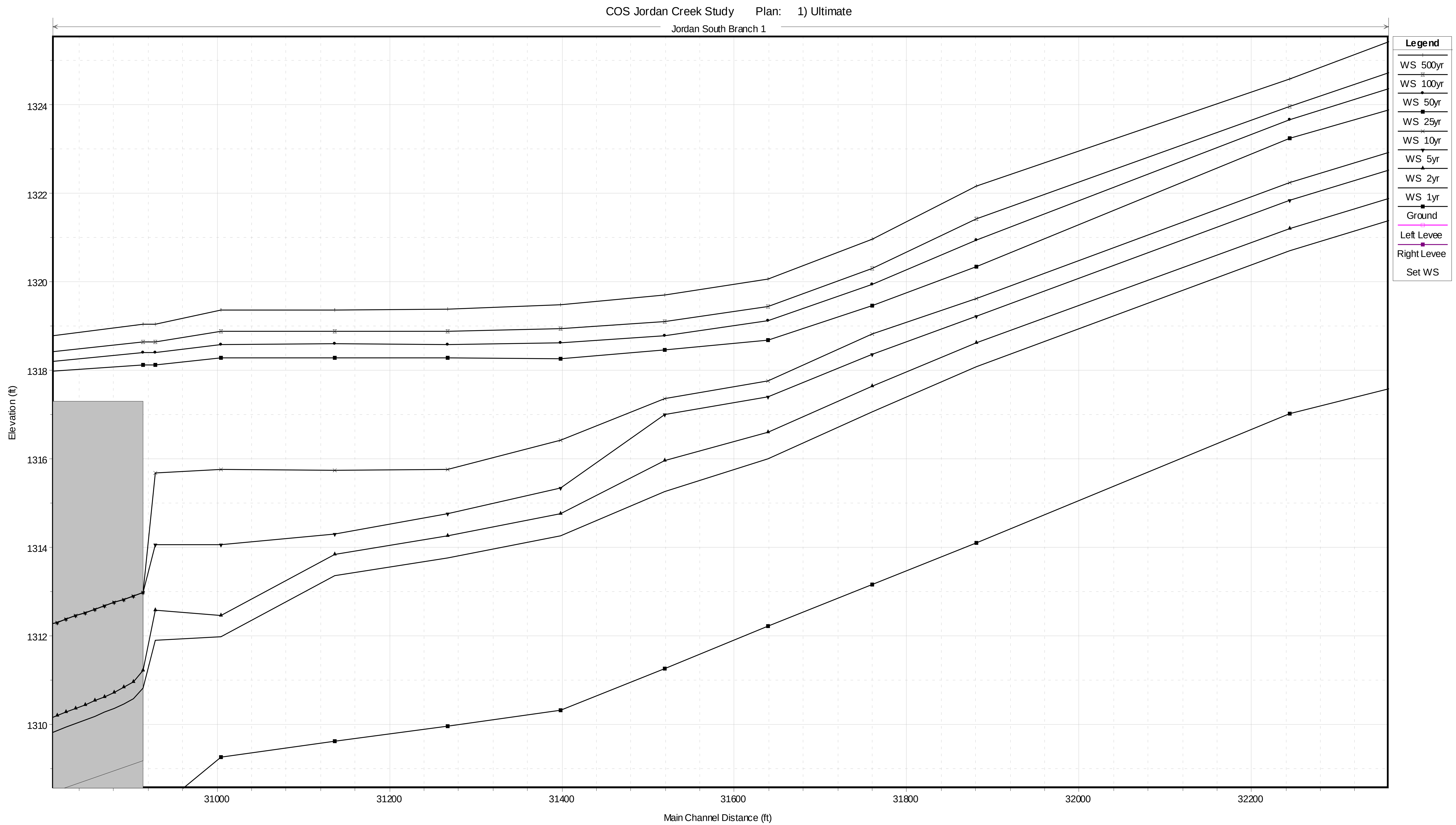
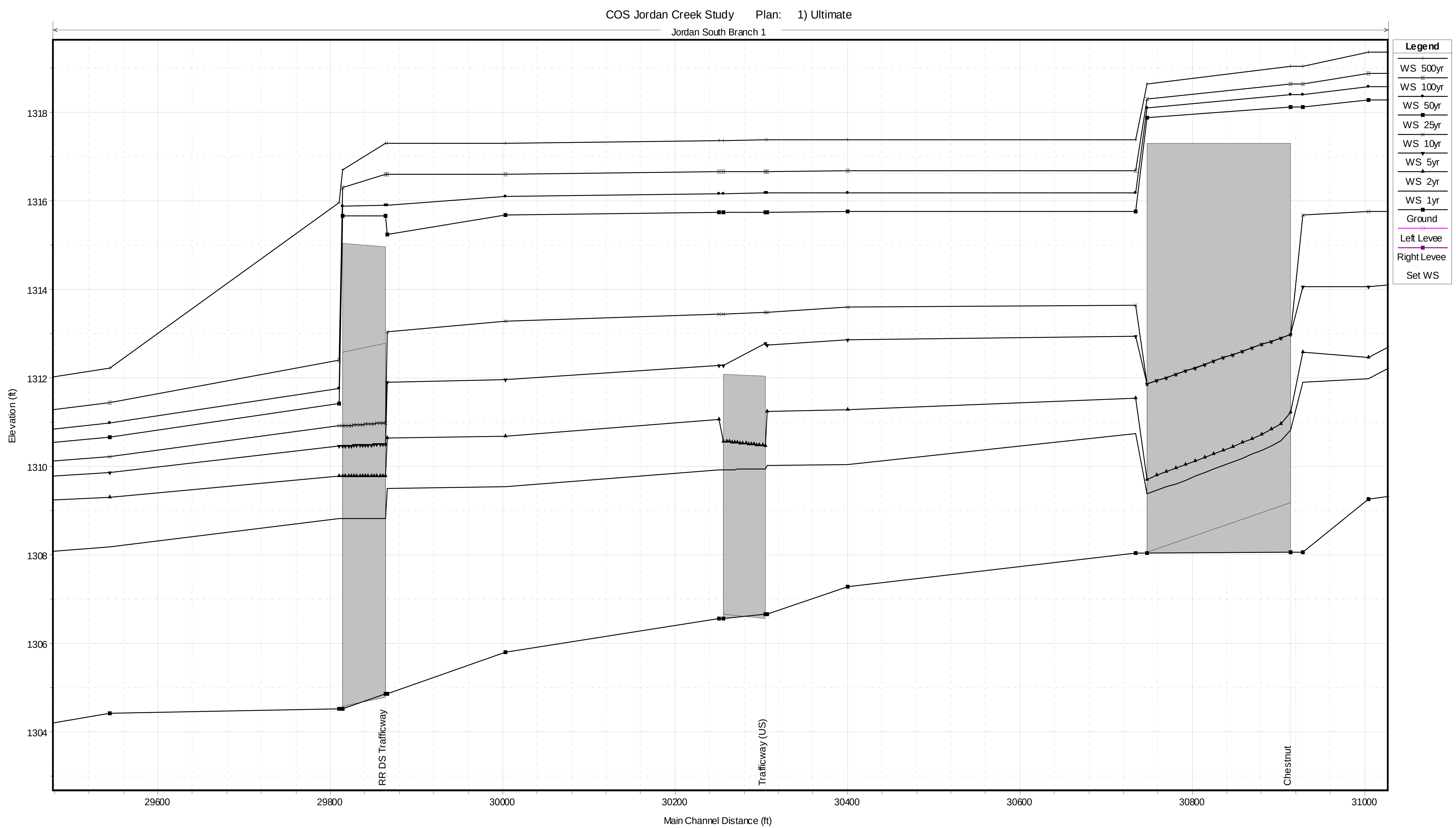

COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
Elevation (ft)
1310
1312
1314
1316
1318
1320
1322
1324
31000
31200
31400
31600
31800
32000
32200
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles



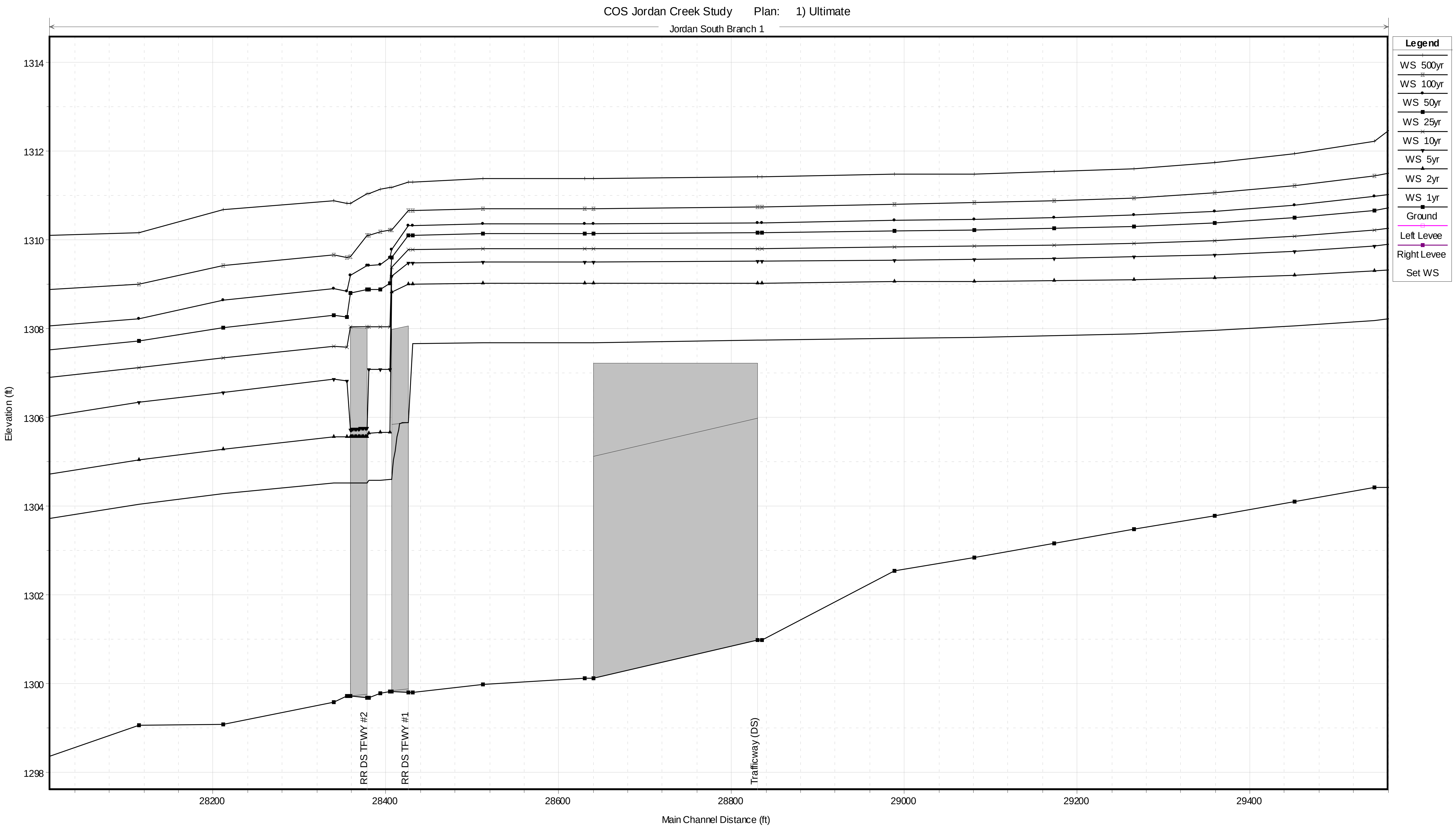
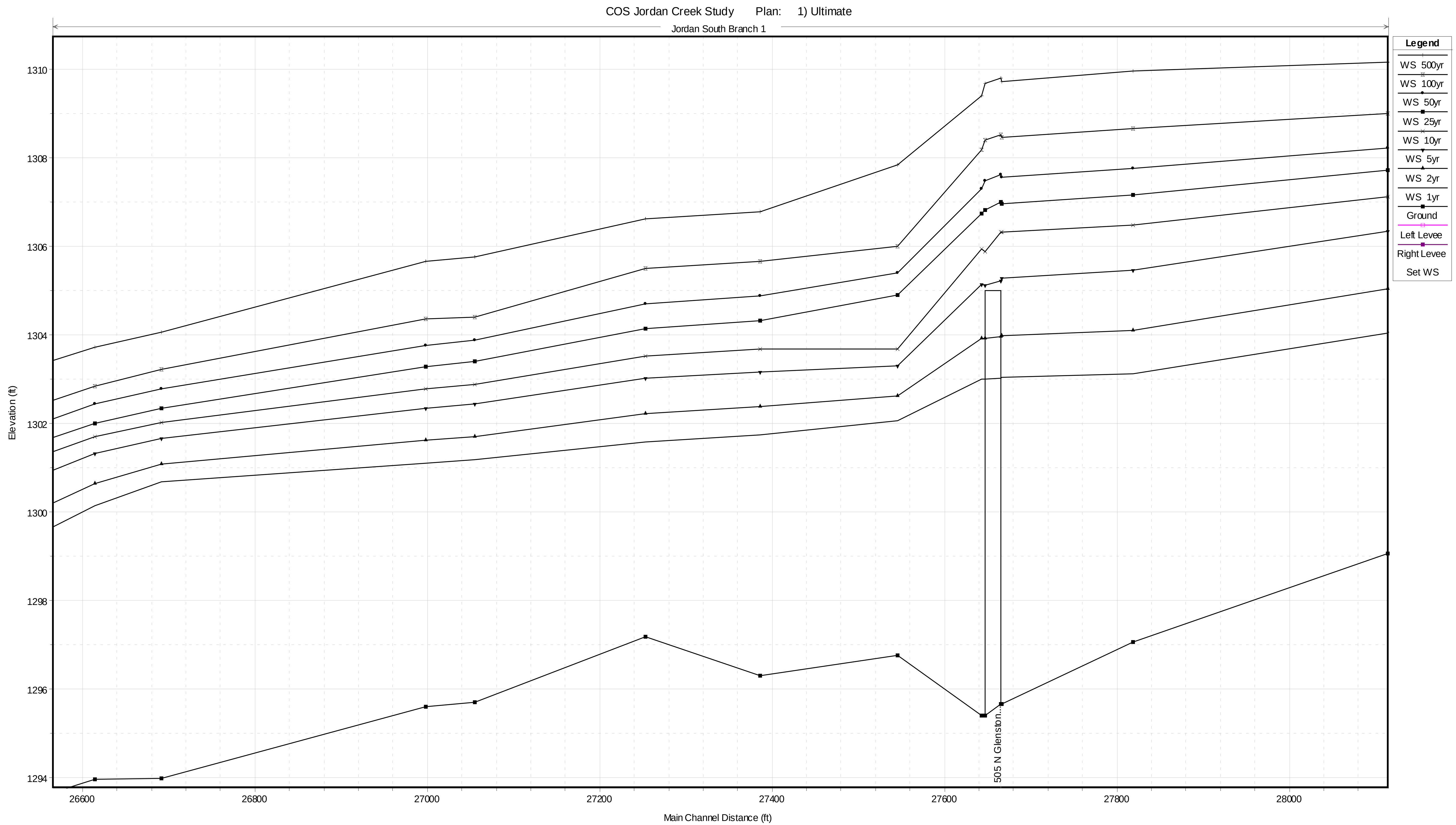

COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Left Levee
Right Levee
Set WS
Elevation (ft)
1314
1312
1310
1308
1306
1304
1302
1300
1298
RR DS TFWY #2
RR DS TFWY #1
Trafficway (DS)
28200
28400
28600
28800
29000
29200
29400
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles



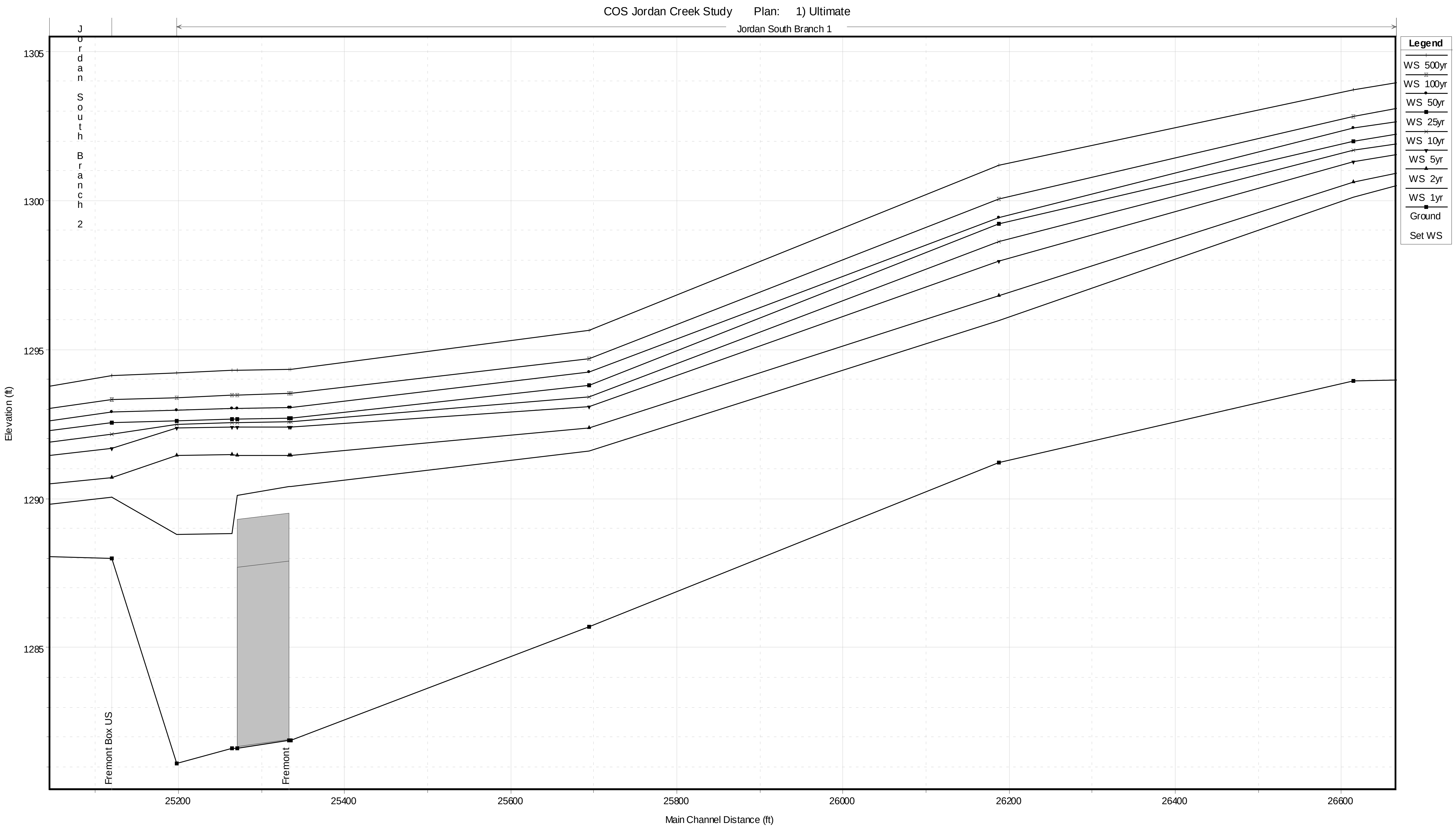

COS Jordan Creek Study Plan: 1) Ultimate
Jordan South Branch 1
Jordan South Branch 2
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1305
1300
1295
1290
1285
Fremont Box US
Fremont
25200
25400
25600
25800
26000
26200
26400
26600
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

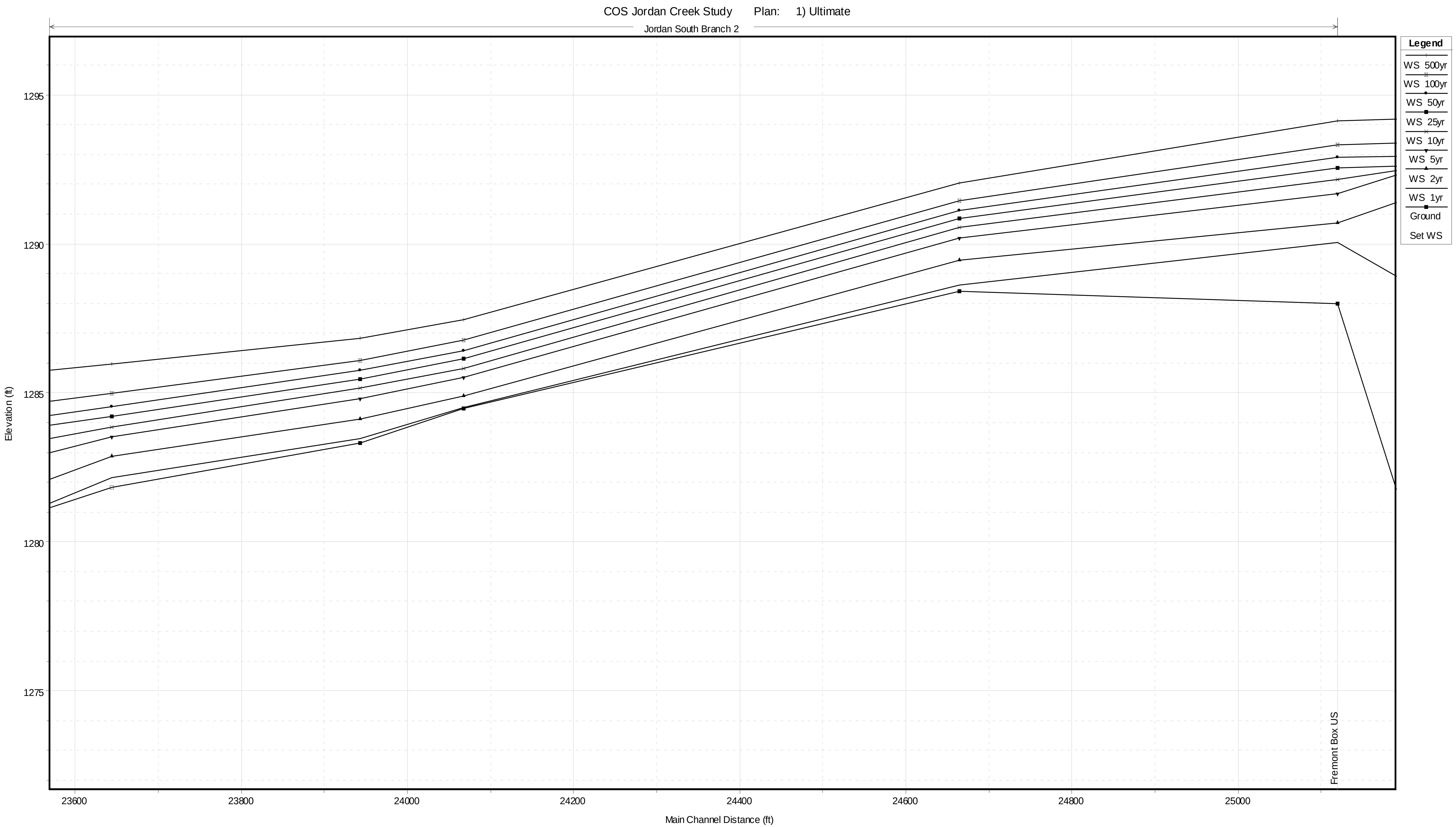


Plate Series D – Future Conditions Without Project Hydraulic Profiles

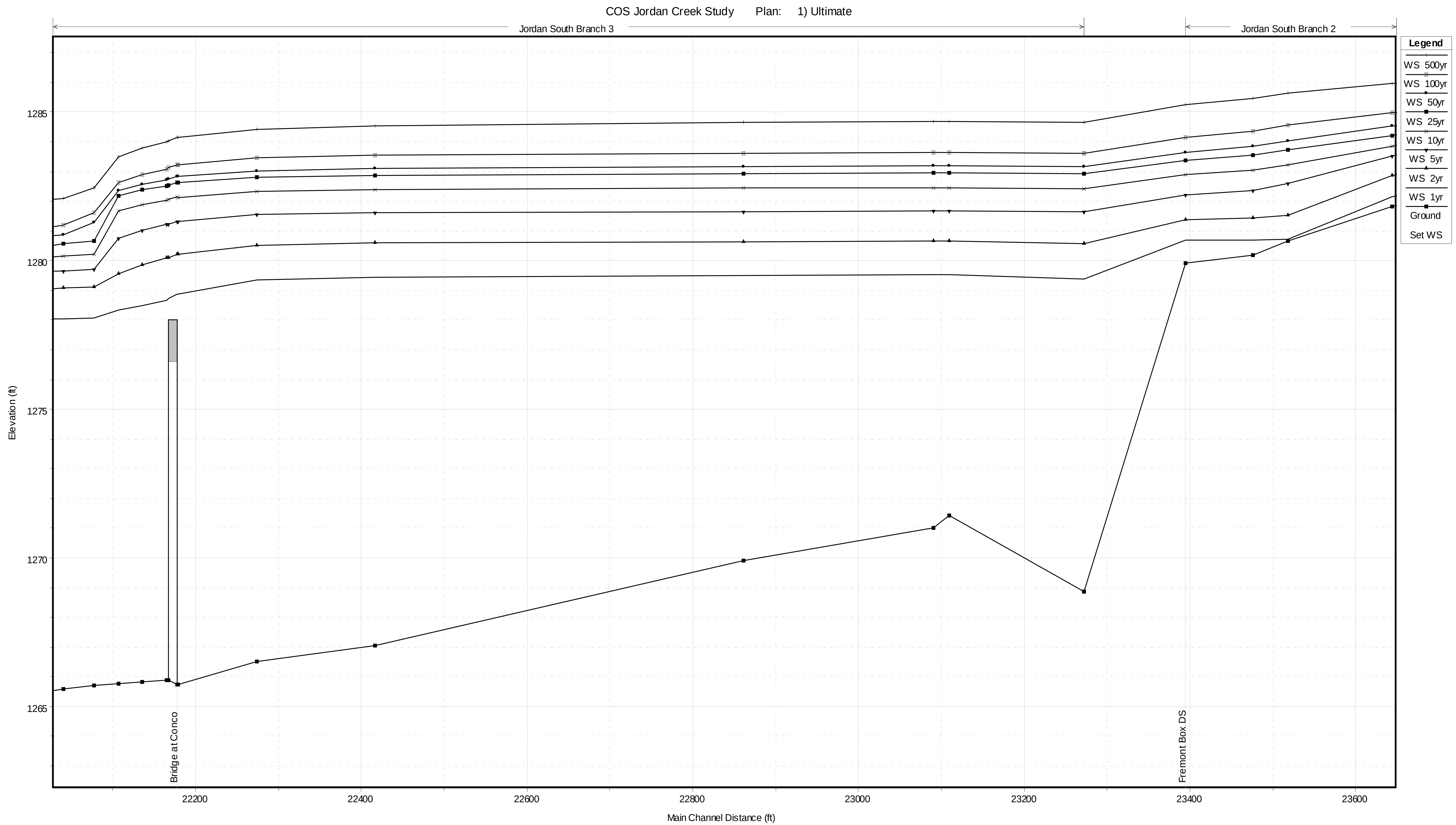


Plate Series D – Future Conditions Without Project Hydraulic Profiles

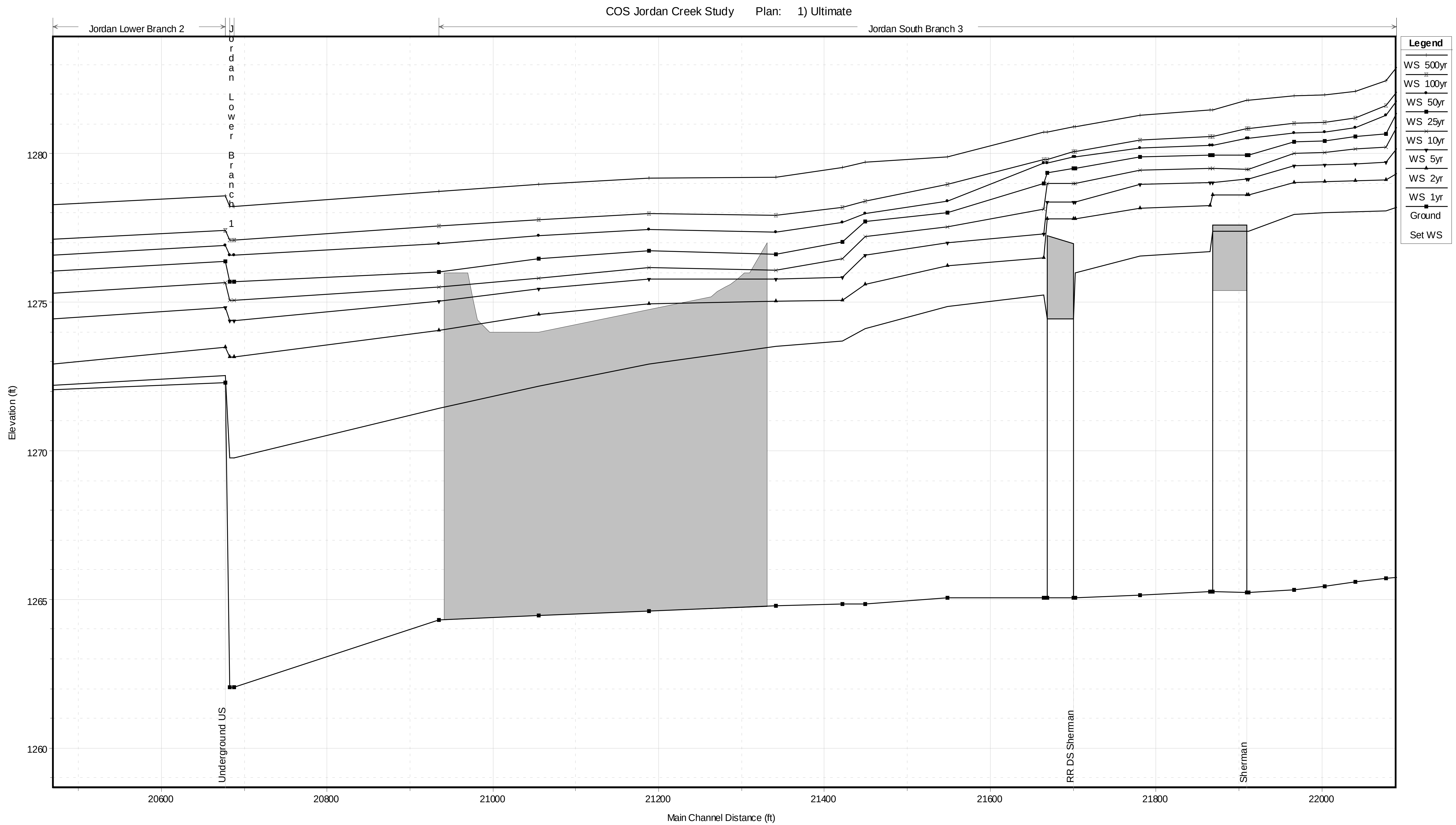


Plate Series D – Future Conditions Without Project Hydraulic Profiles

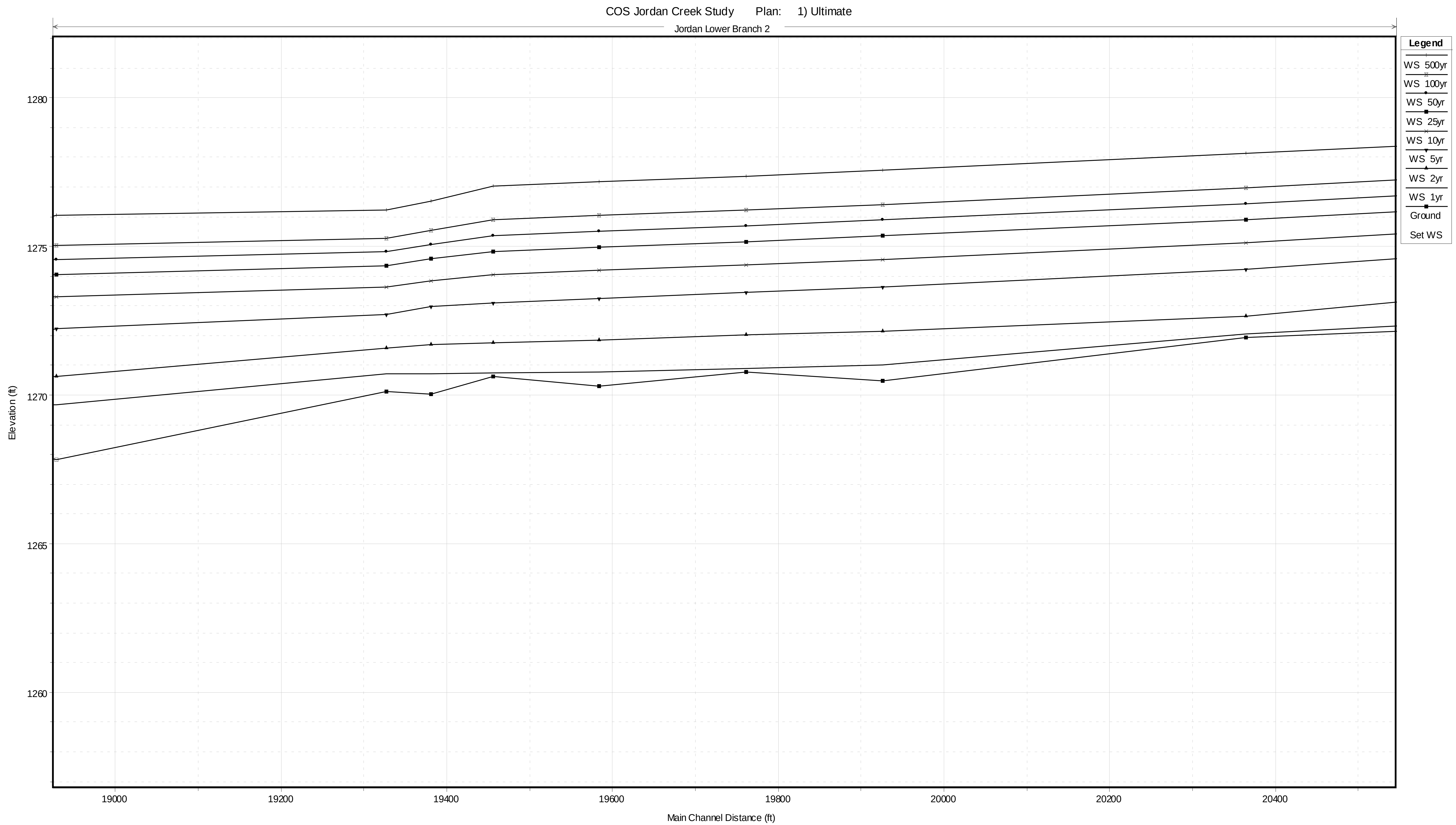
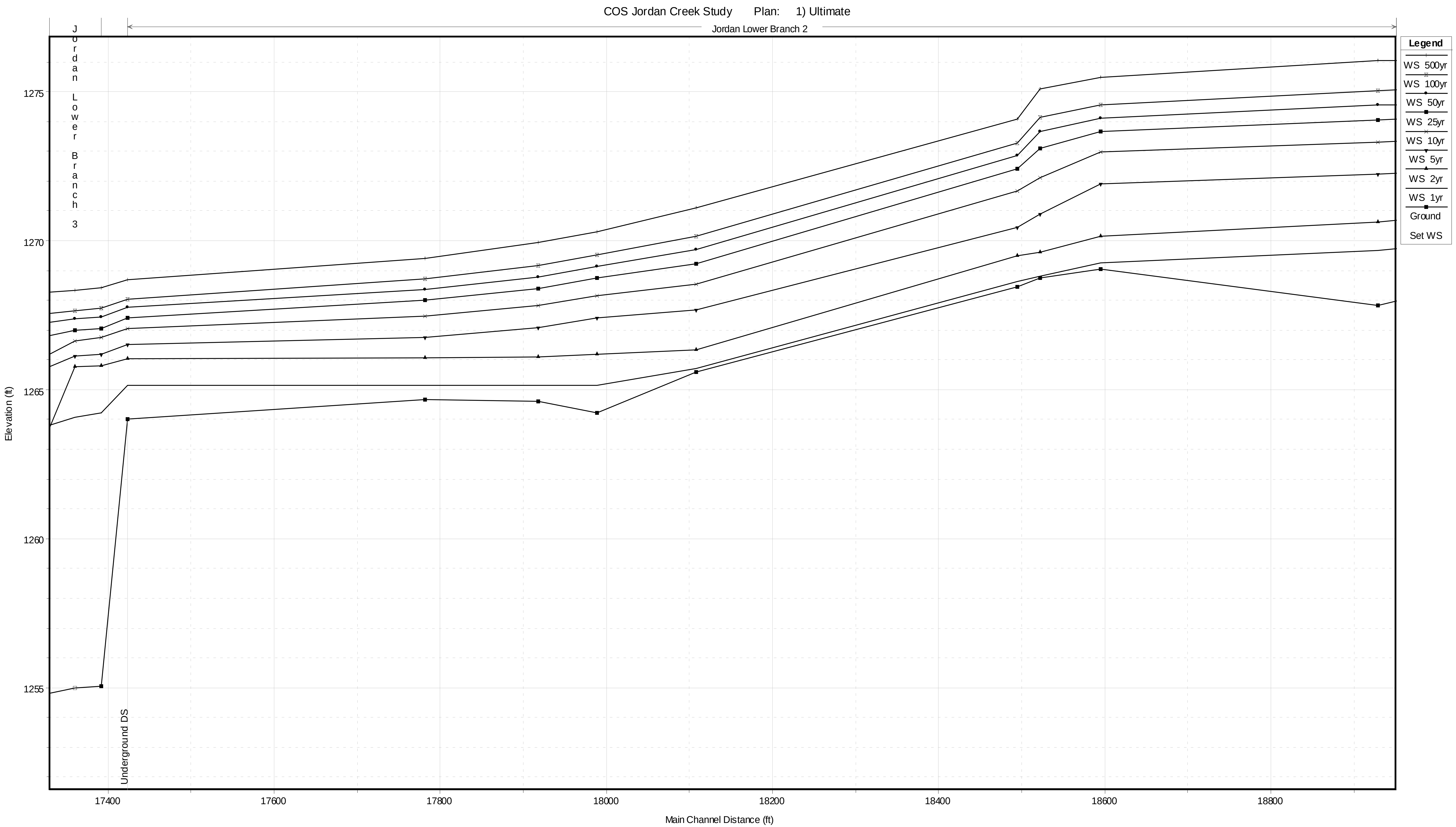
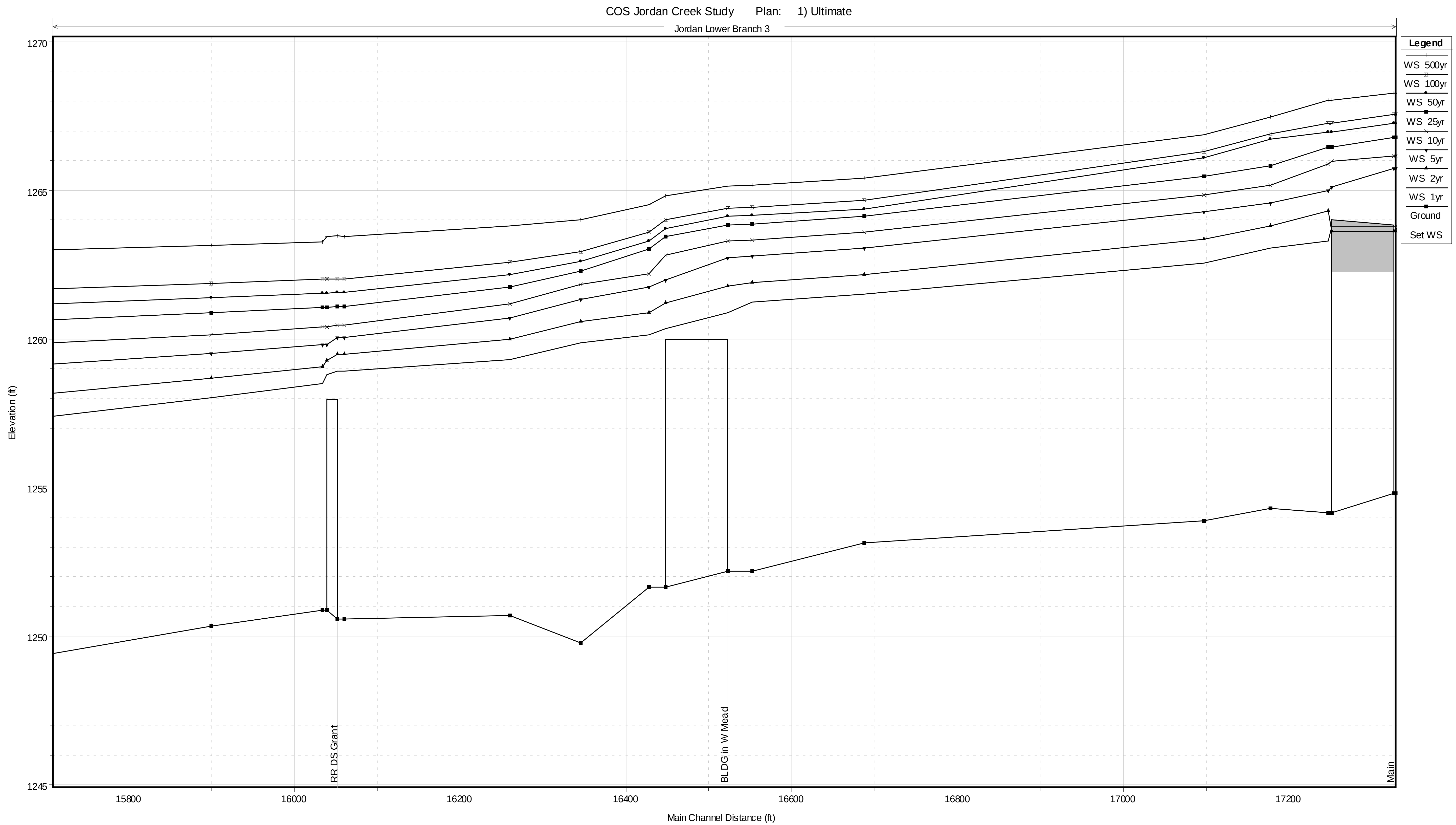


Plate Series D – Future Conditions Without Project Hydraulic Profiles





COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
1270
1265
1260
1255
1250
1245
Elevation (ft)
RR DS Grant
BLDG in W Mead
Main
15800
16000
16200
16400
16600
16800
17000
17200
Main Channel Distance (ft)

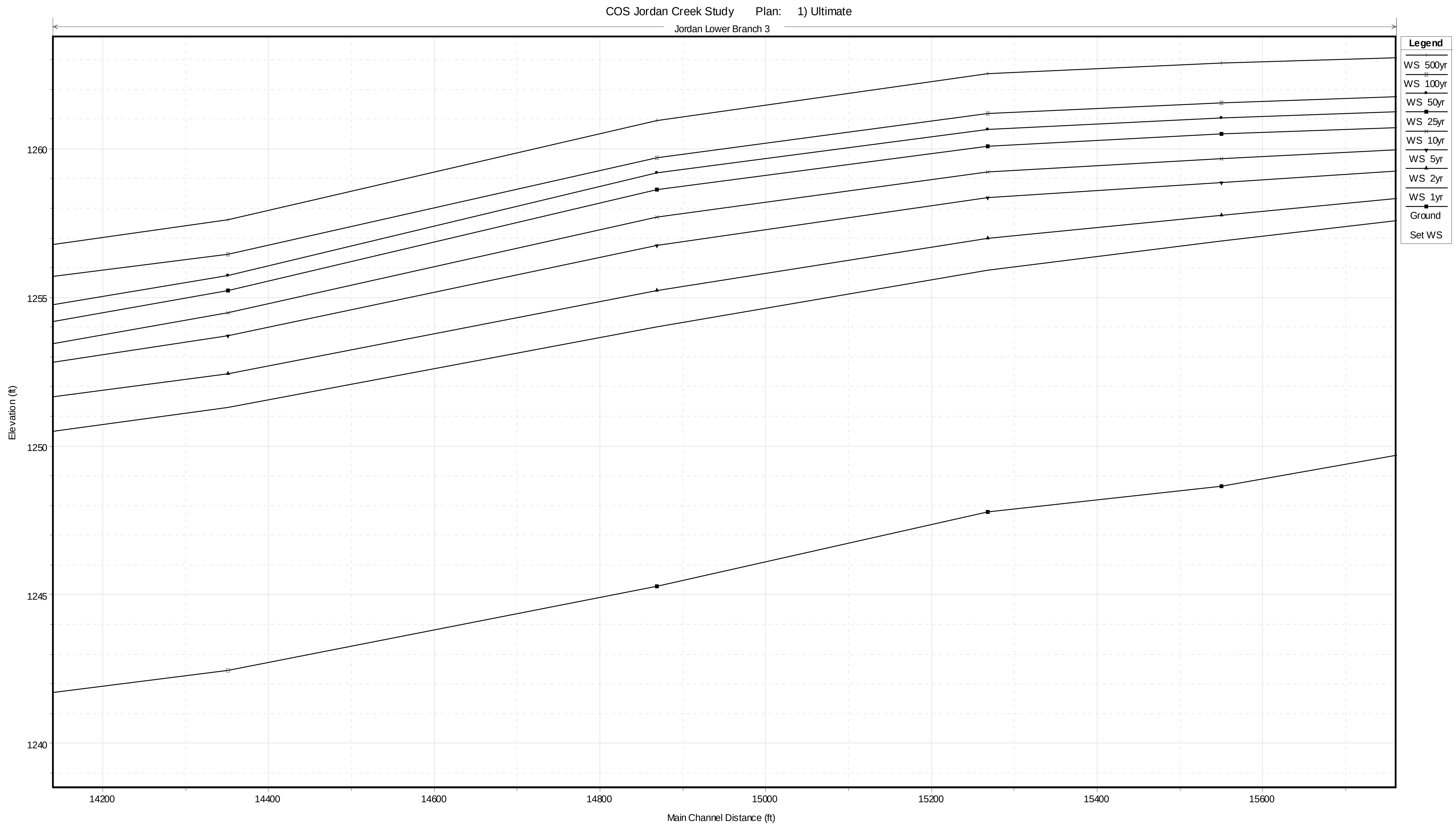

COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1260
1255
1250
1245
1240
14200
14400
14600
14800
15000
15200
15400
15600
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

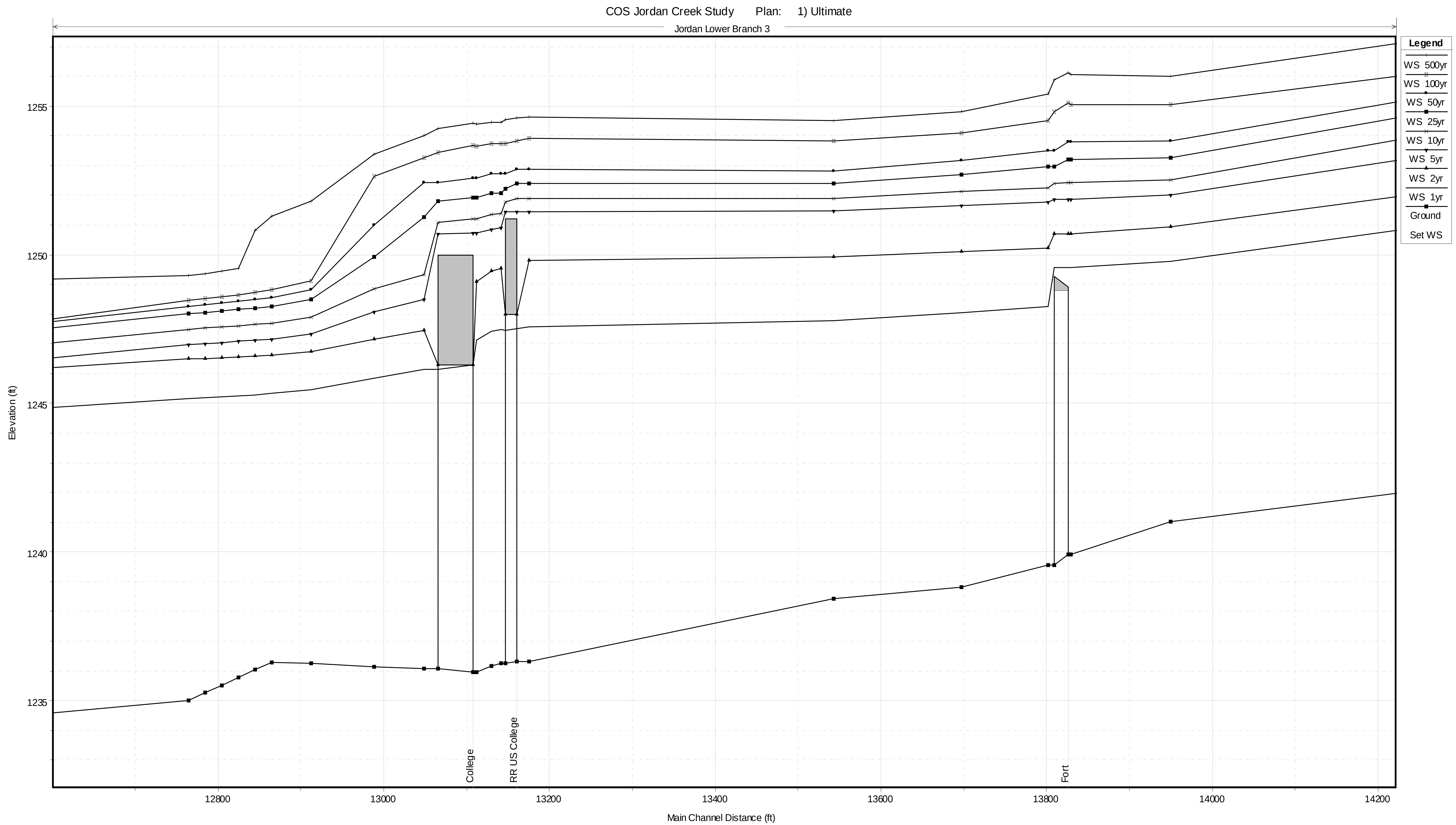
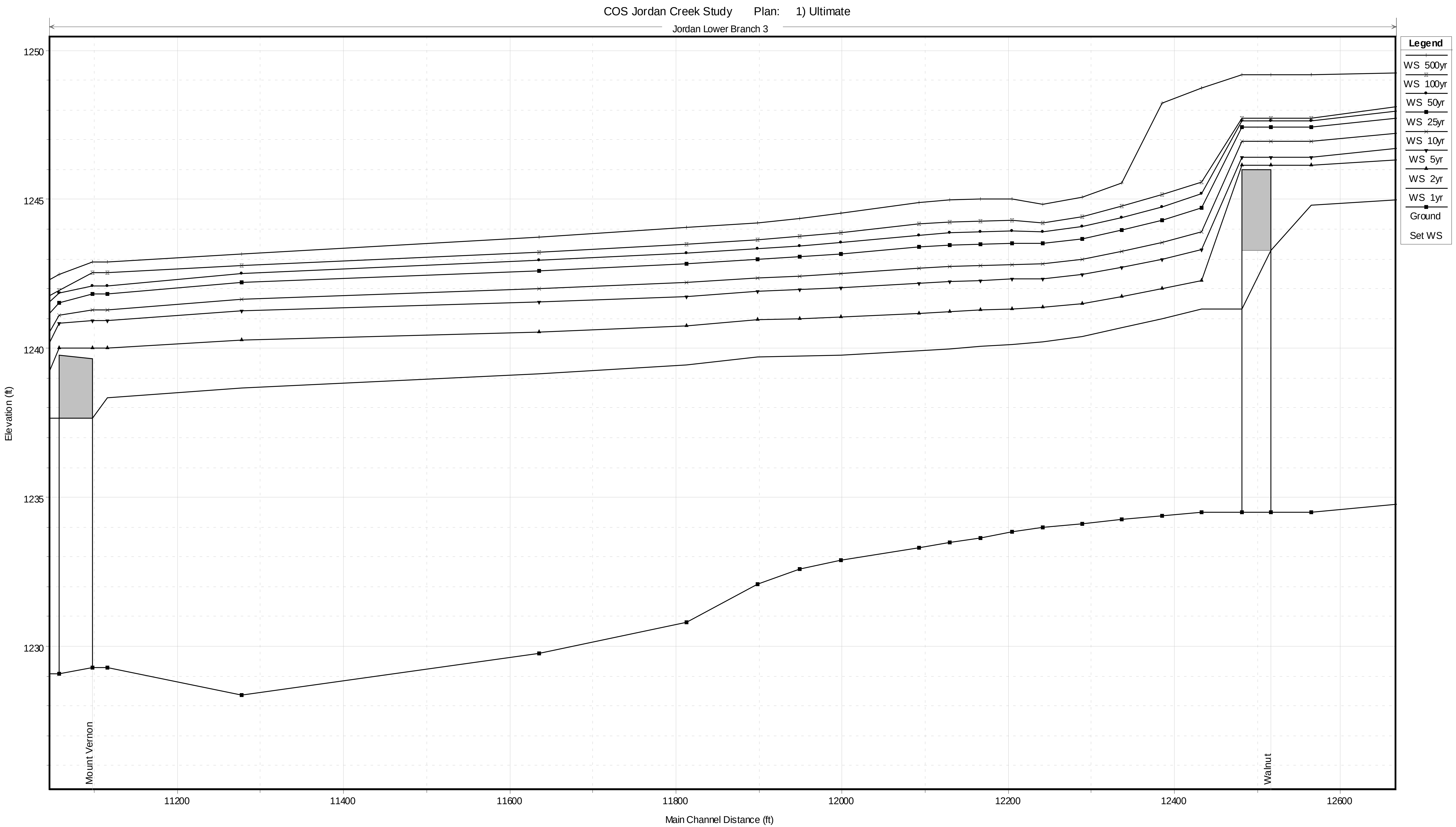
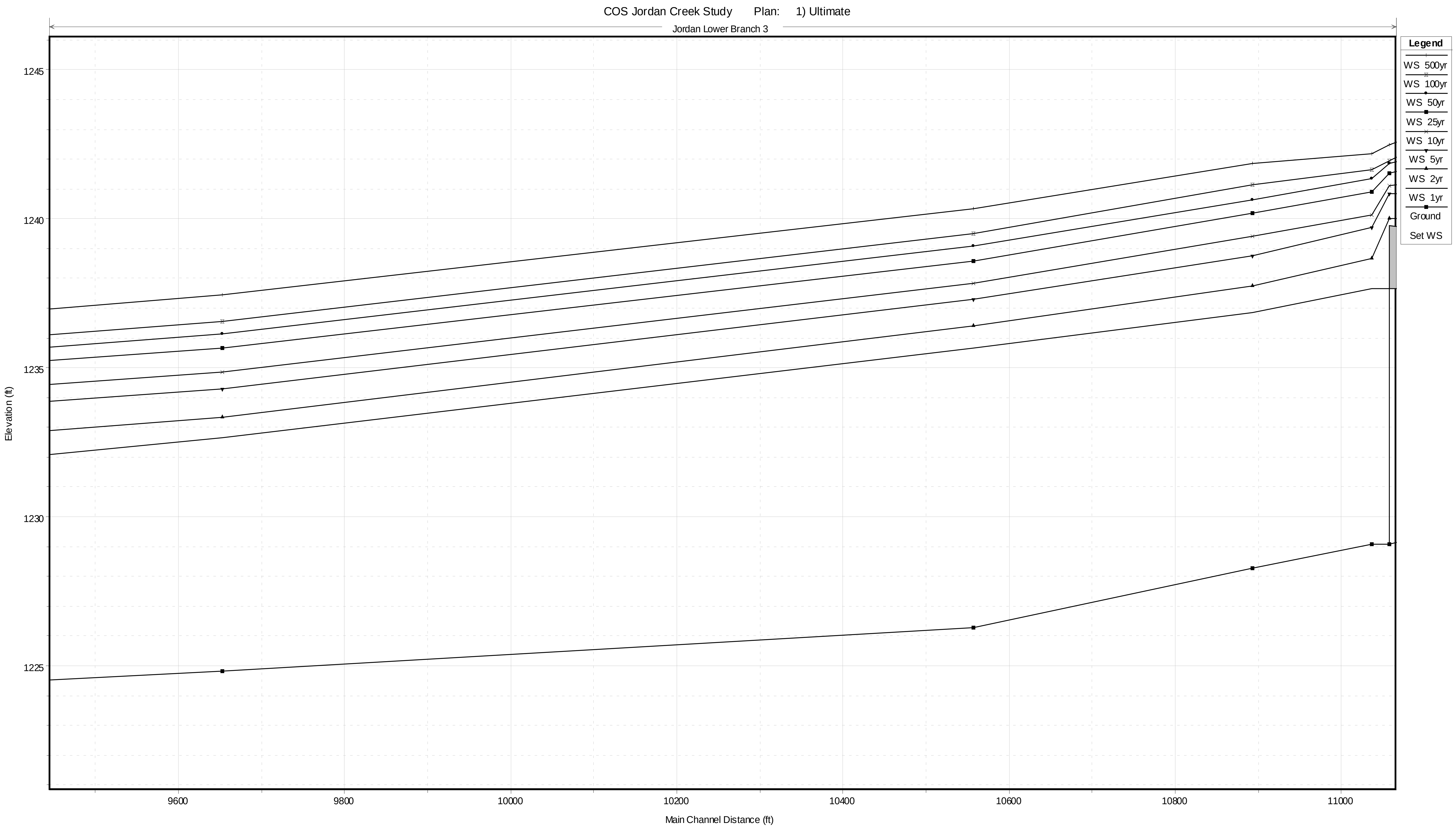


Plate Series D – Future Conditions Without Project Hydraulic Profiles





COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
1245
1240
1235
1230
1225
Elevation (ft)
9600
9800
10000
10200
10400
10600
10800
11000
Main Channel Distance (ft)

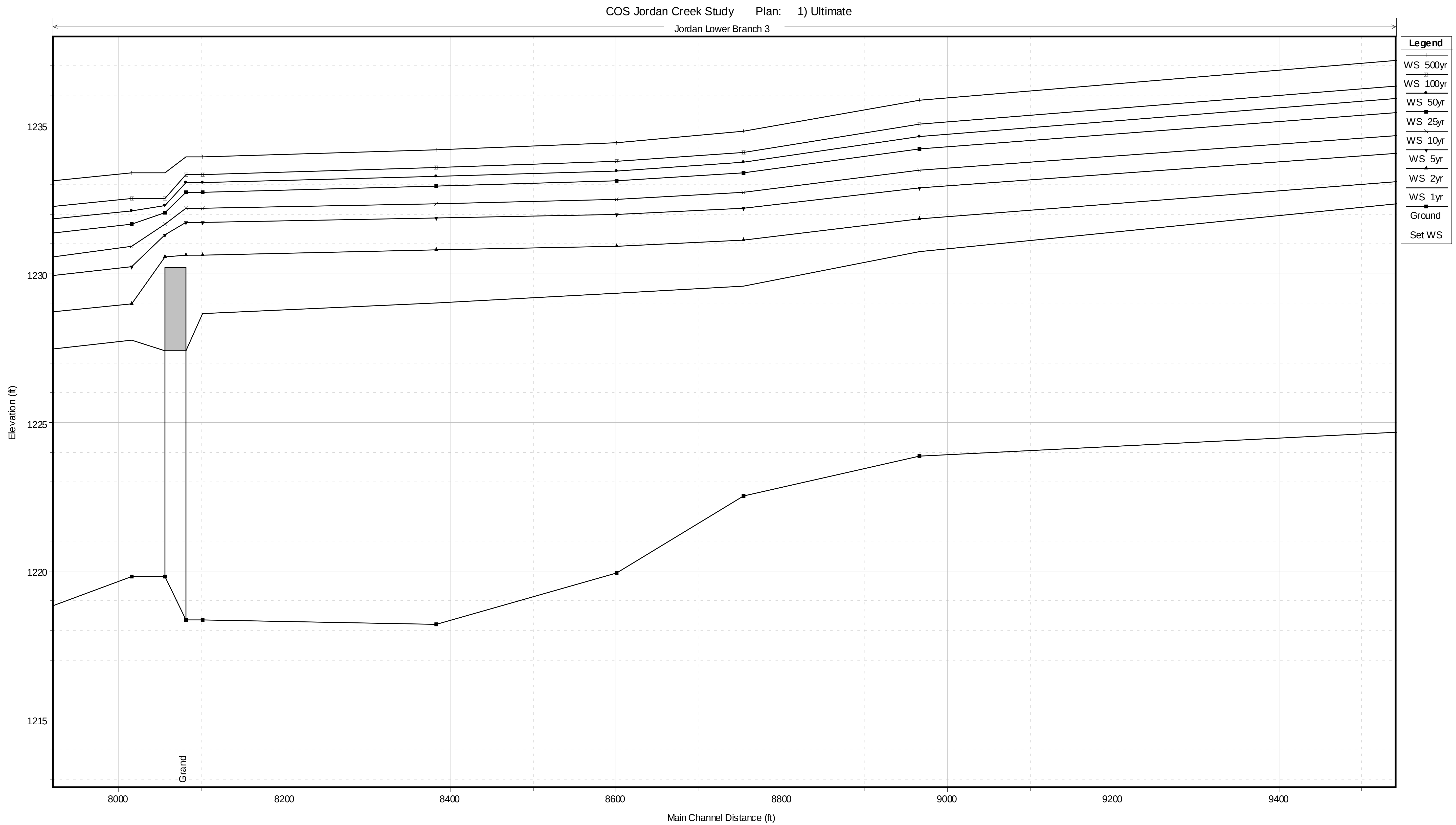

COS Jordan Creek Study Plan: 1) Ultimate
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Set WS
Elevation (ft)
1235
1230
1225
1220
1215
Grand
8000
8200
8400
8600
8800
9000
9200
9400
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

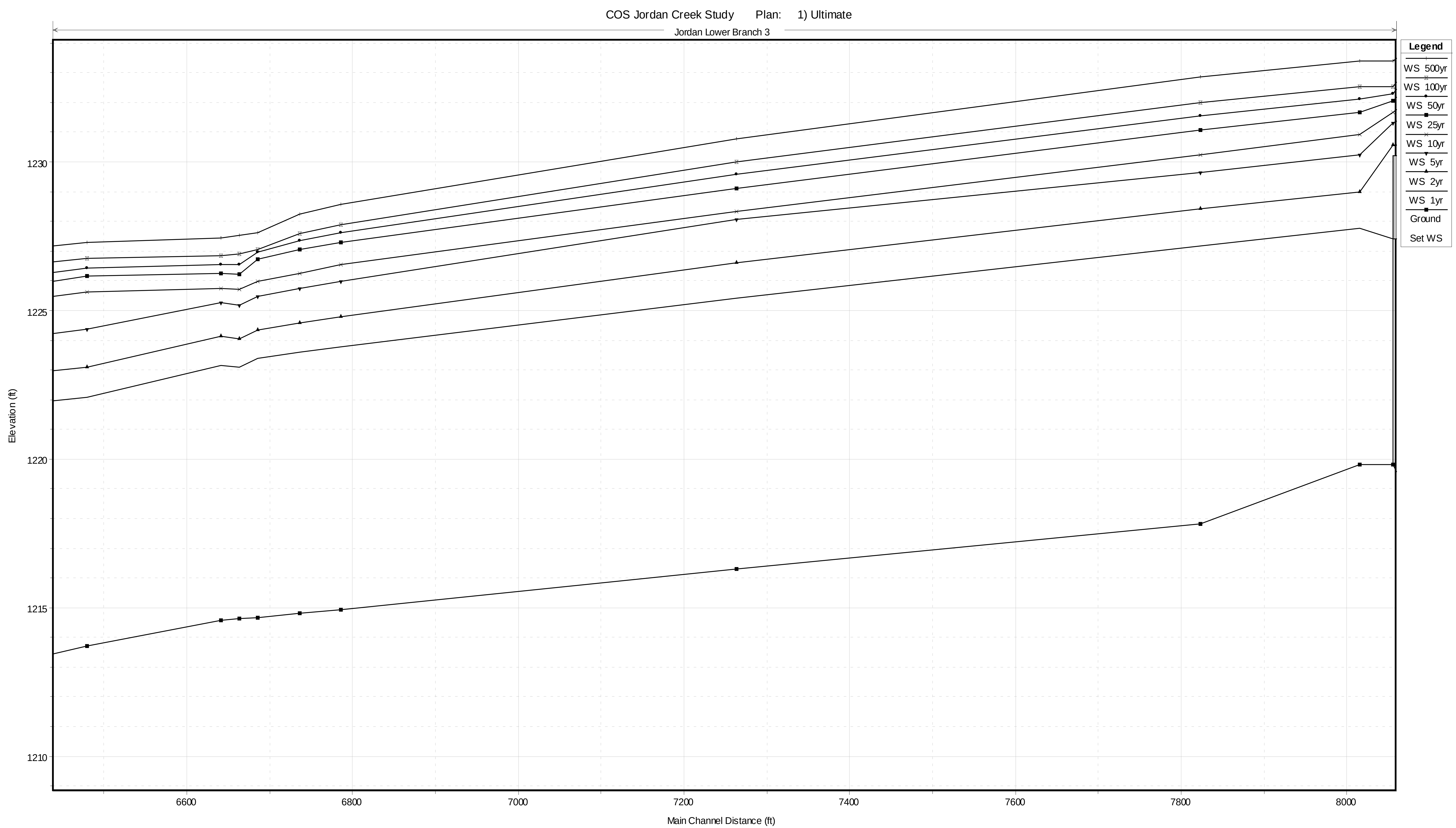
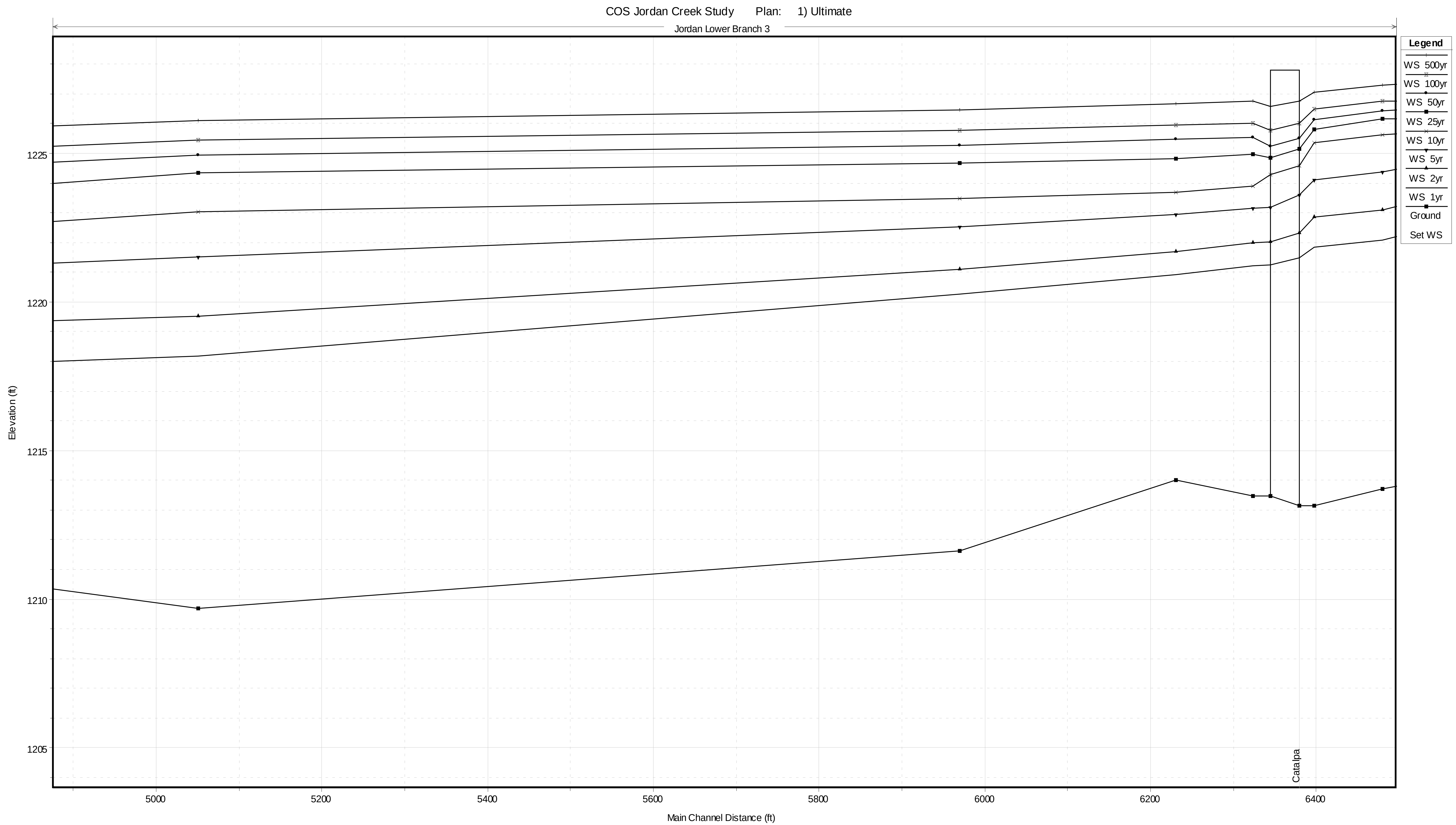


Plate Series D – Future Conditions Without Project Hydraulic Profiles



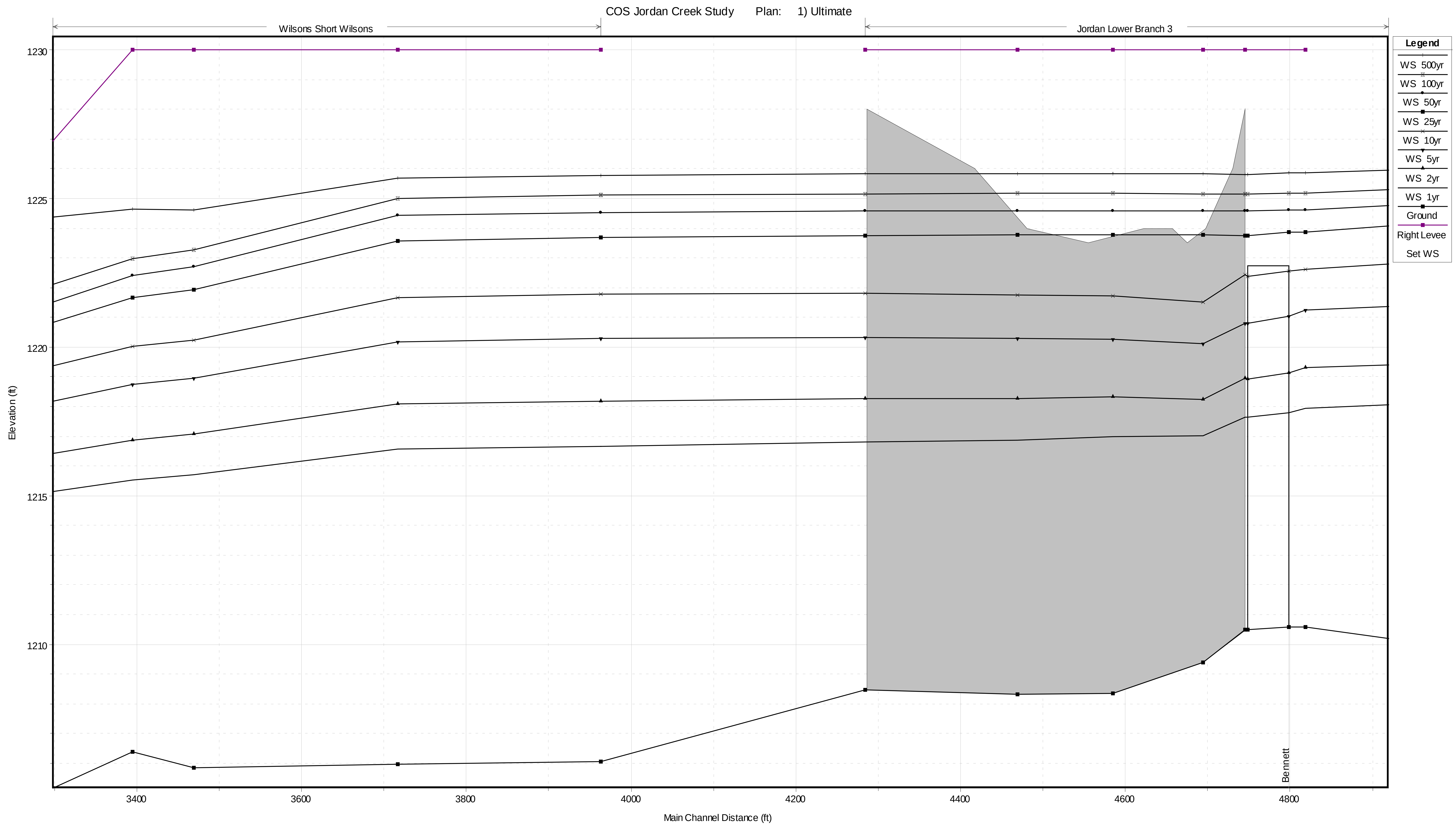

COS Jordan Creek Study Plan: 1) Ultimate
Wilsons Short Wilsons
Jordan Lower Branch 3
Legend
WS 500yr
WS 100yr
WS 50yr
WS 25yr
WS 10yr
WS 5yr
WS 2yr
WS 1yr
Ground
Right Levee
Set WS
Elevation (ft)
1230
1225
1220
1215
1210
Bennett
3400
3600
3800
4000
4200
4400
4600
4800
Main Channel Distance (ft)

Plate Series D – Future Conditions Without Project Hydraulic Profiles

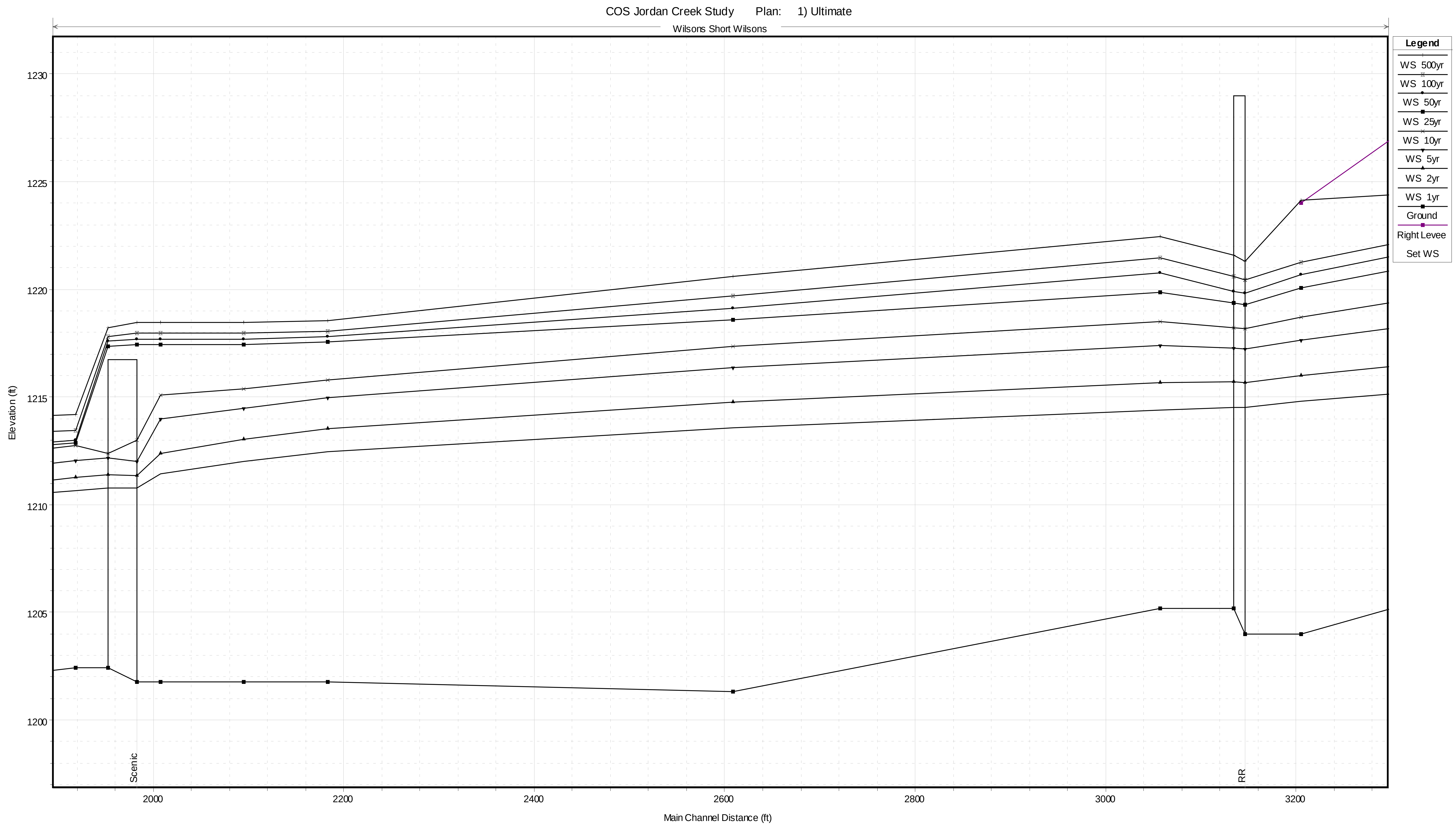


Plate Series D – Future Conditions Without Project Hydraulic Profiles

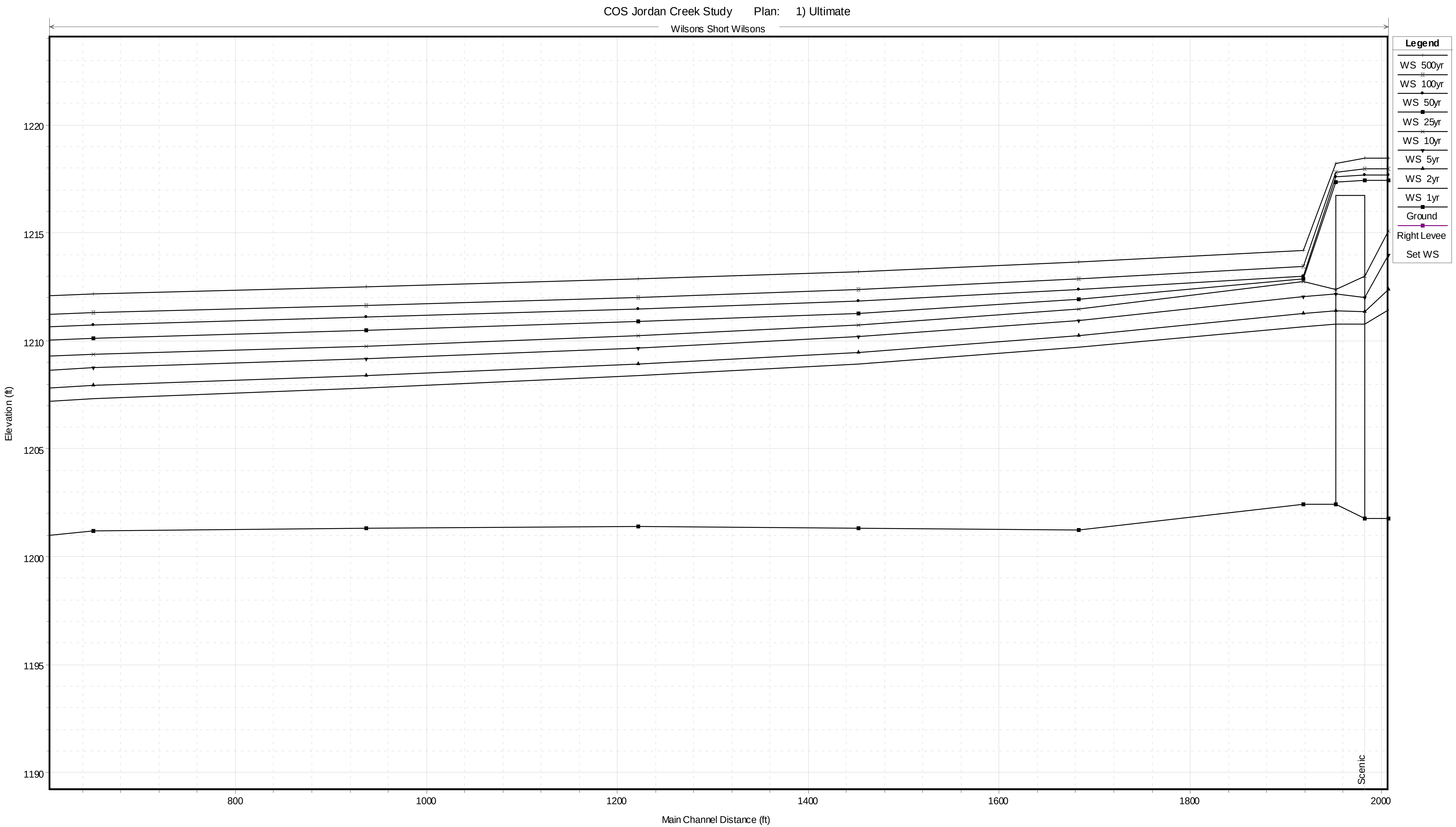
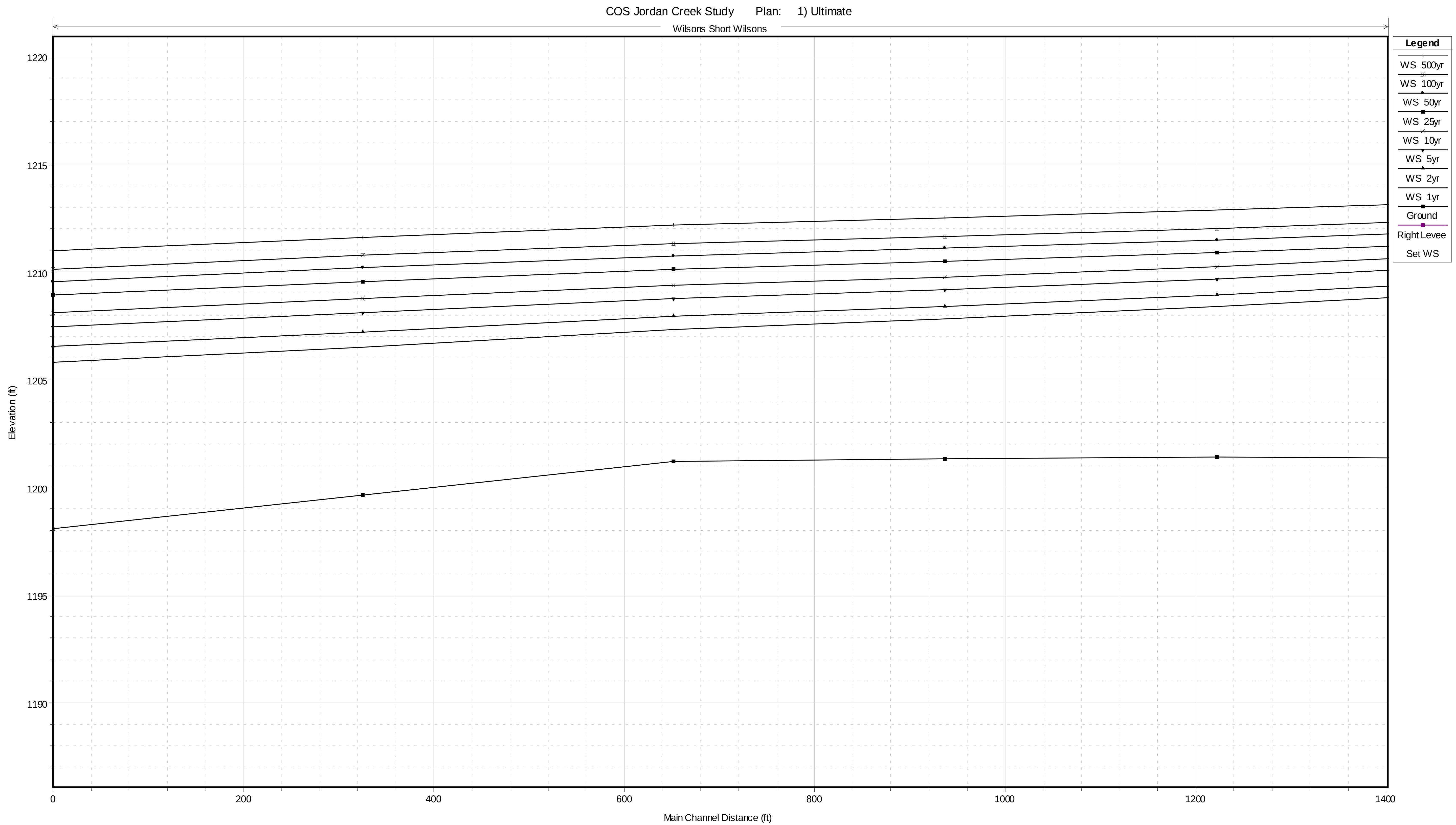
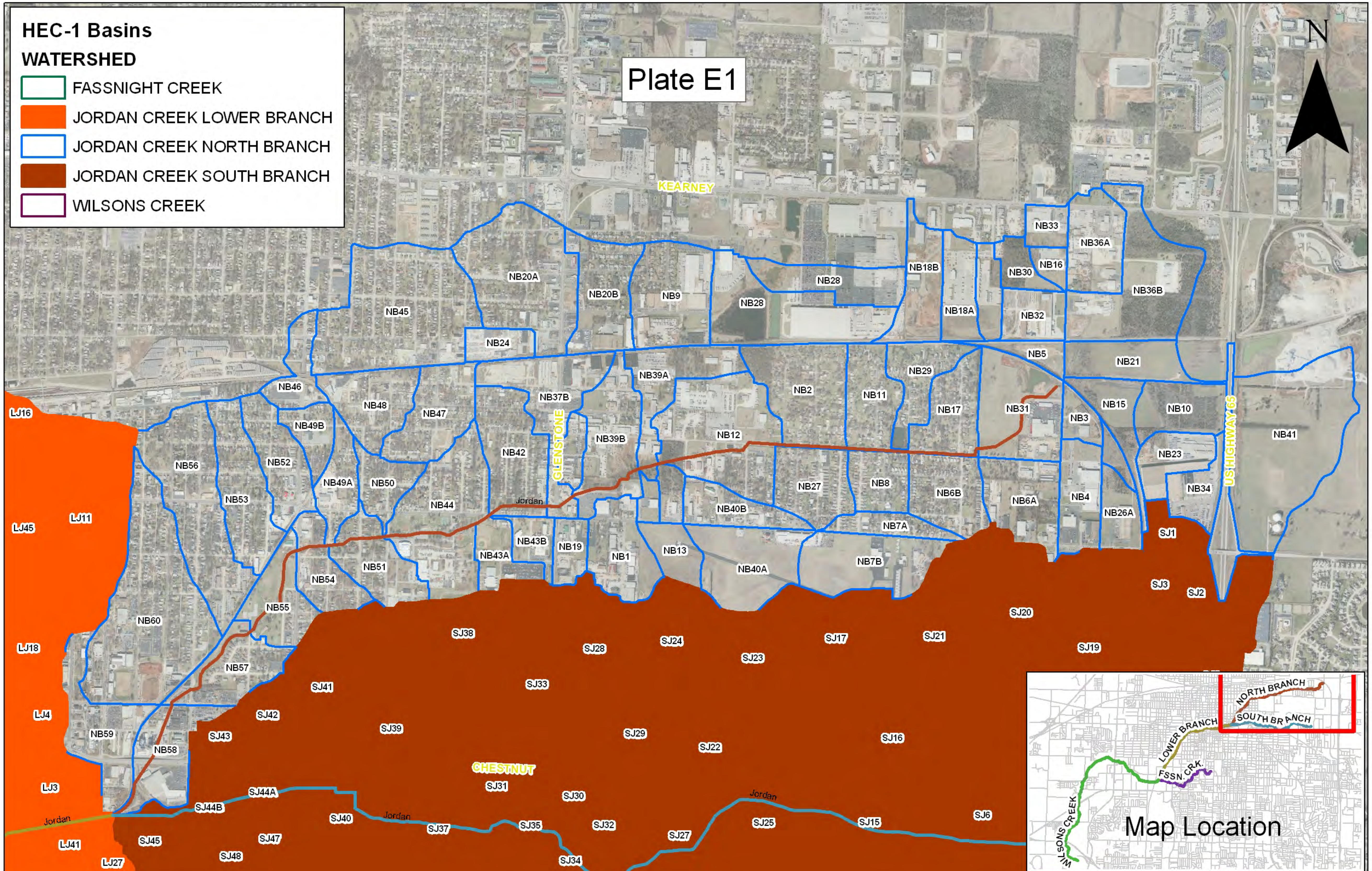


Plate Series D – Future Conditions Without Project Hydraulic Profiles





HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E1
N
KEARNEY
GLENSTONE
US HIGHWAY 65
CHESTNUT
Jordan
NB33
NB36A
NB16
NB30
NB18B
NB28
NB20A
NB20B
NB9
NB36B
NB18A
NB32
NB45
NB24
NB5
NB21
NB46
NB39A
NB29
NB48
NB37B
NB2
NB11
NB17
NB31
NB15
NB10
NB47
NB3
NB49B
NB39B
NB12
NB41
NB42
NB23
NB56
NB52
NB49A
NB50
NB27
NB8
NB6B
NB34
NB53
NB44
NB40B
NB6A
NB4
NB26A
NB7A
NB43B
NB19
NB43A
NB1
NB13
NB7B
NB51
NB40A
NB54
NB55
NB60
NB57
NB59
NB58
LJ16
LJ11
LJ45
LJ18
LJ4
LJ3
LJ41
LJ27
SJ1
SJ3
SJ2
SJ20
SJ38
SJ28
SJ24
SJ17
SJ21
SJ19
SJ23
SJ41
SJ33
SJ42
SJ39
SJ43
SJ29
SJ22
SJ16
SJ31
SJ30
SJ44A
SJ44B
SJ40
SJ37
SJ35
SJ32
SJ27
SJ25
SJ15
SJ6
SJ45
SJ47
SJ48
SJ34
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN. CRK.
WILSONS CREEK
Map Location

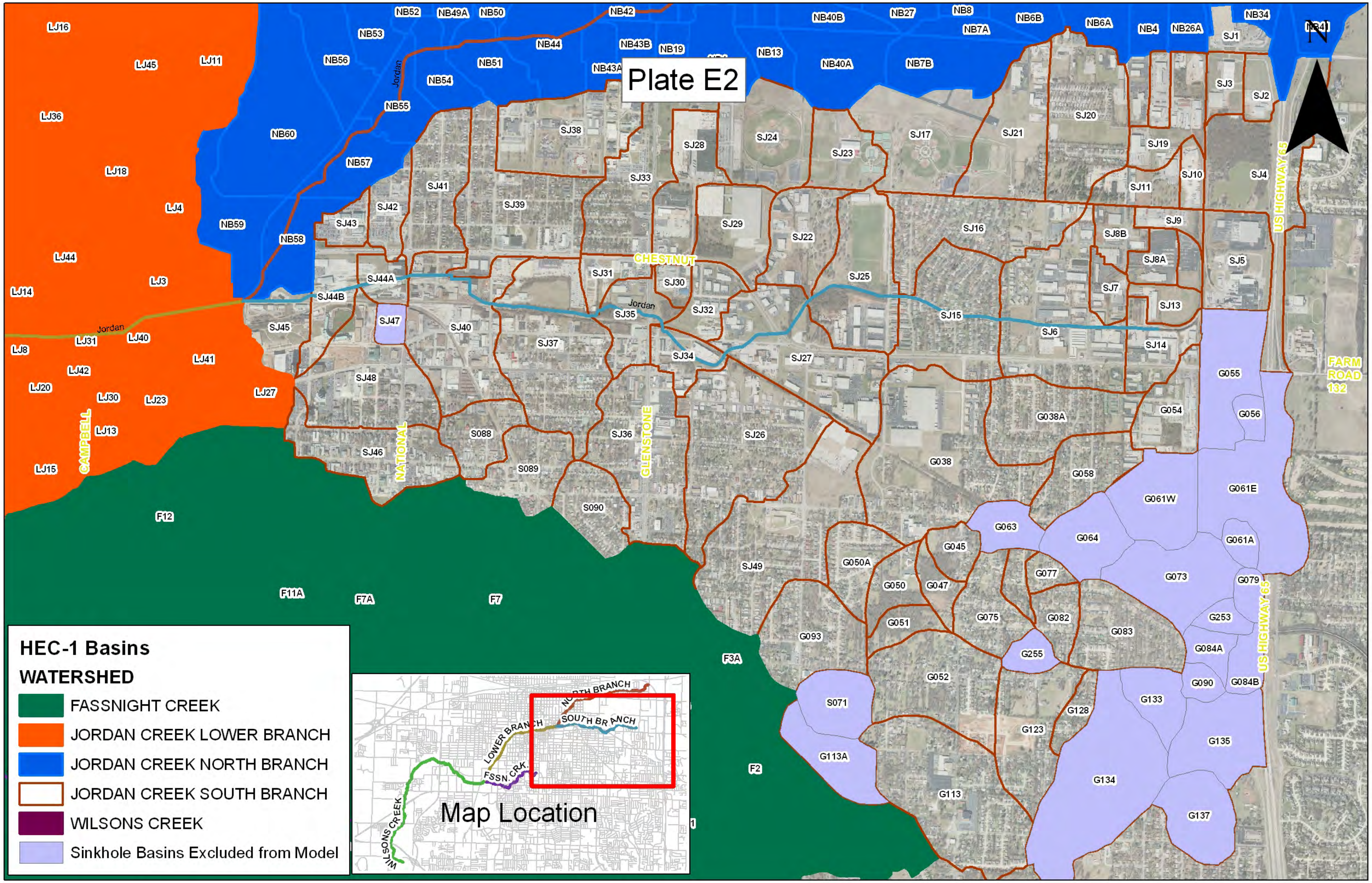
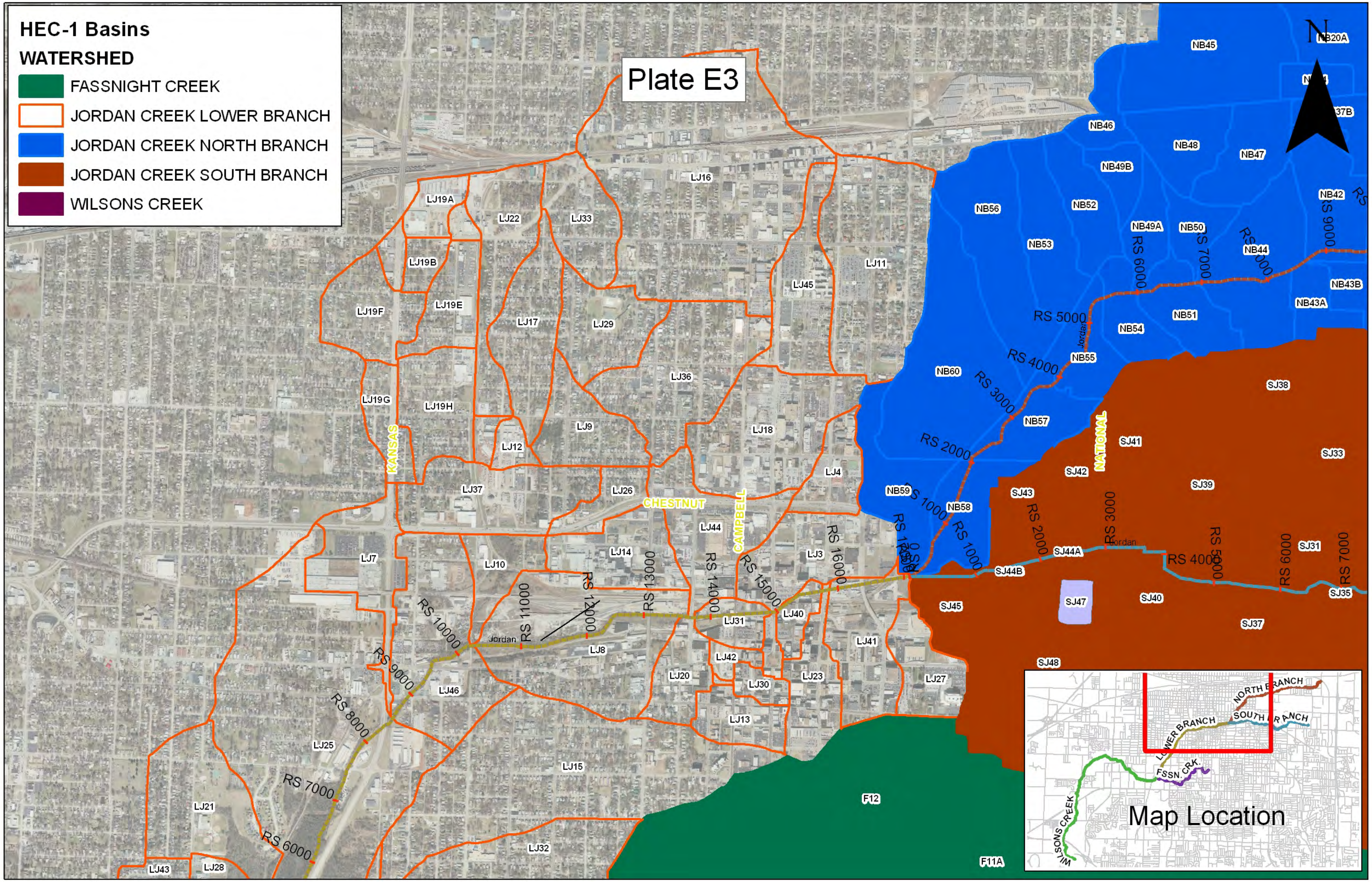
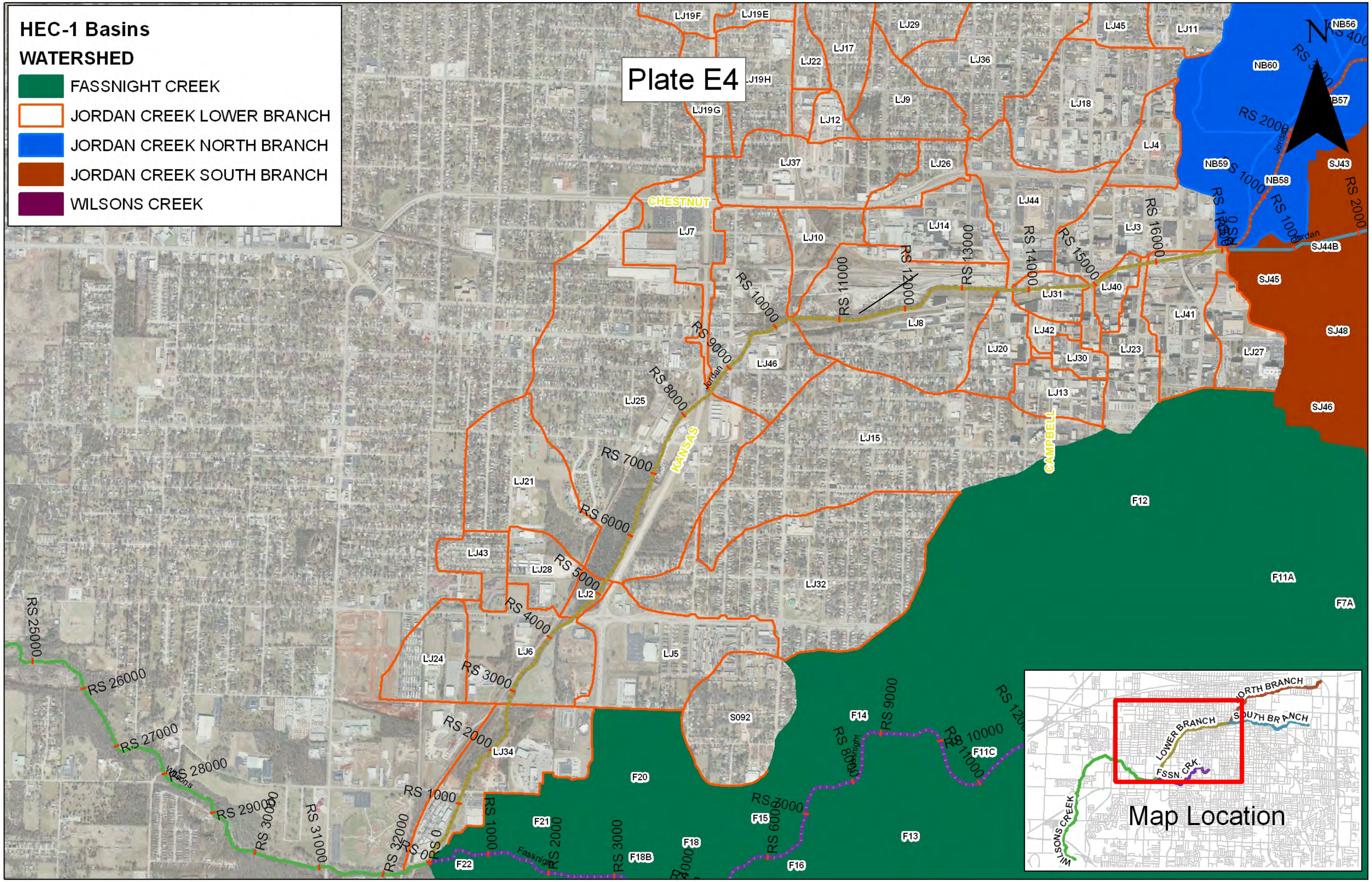
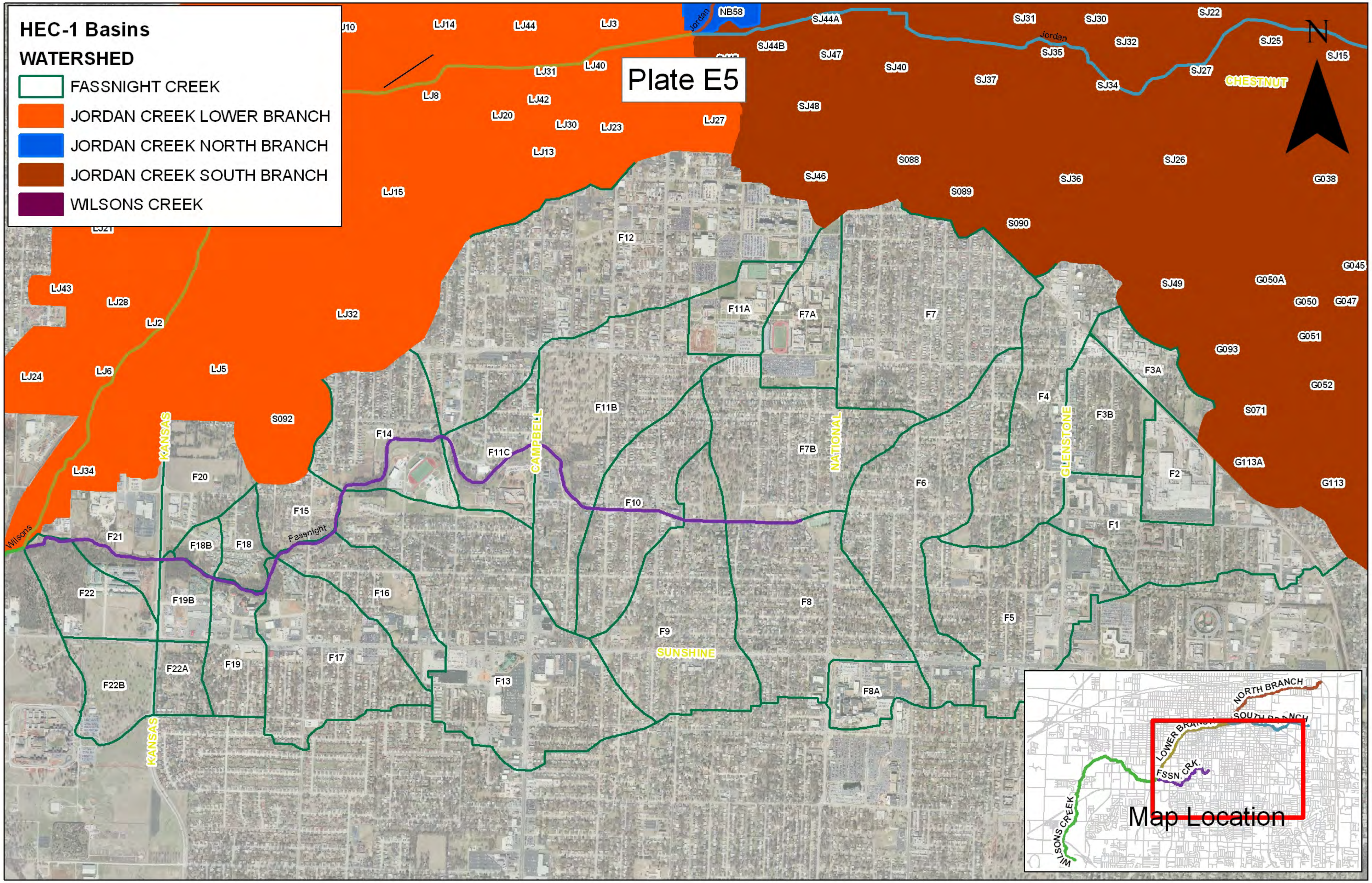
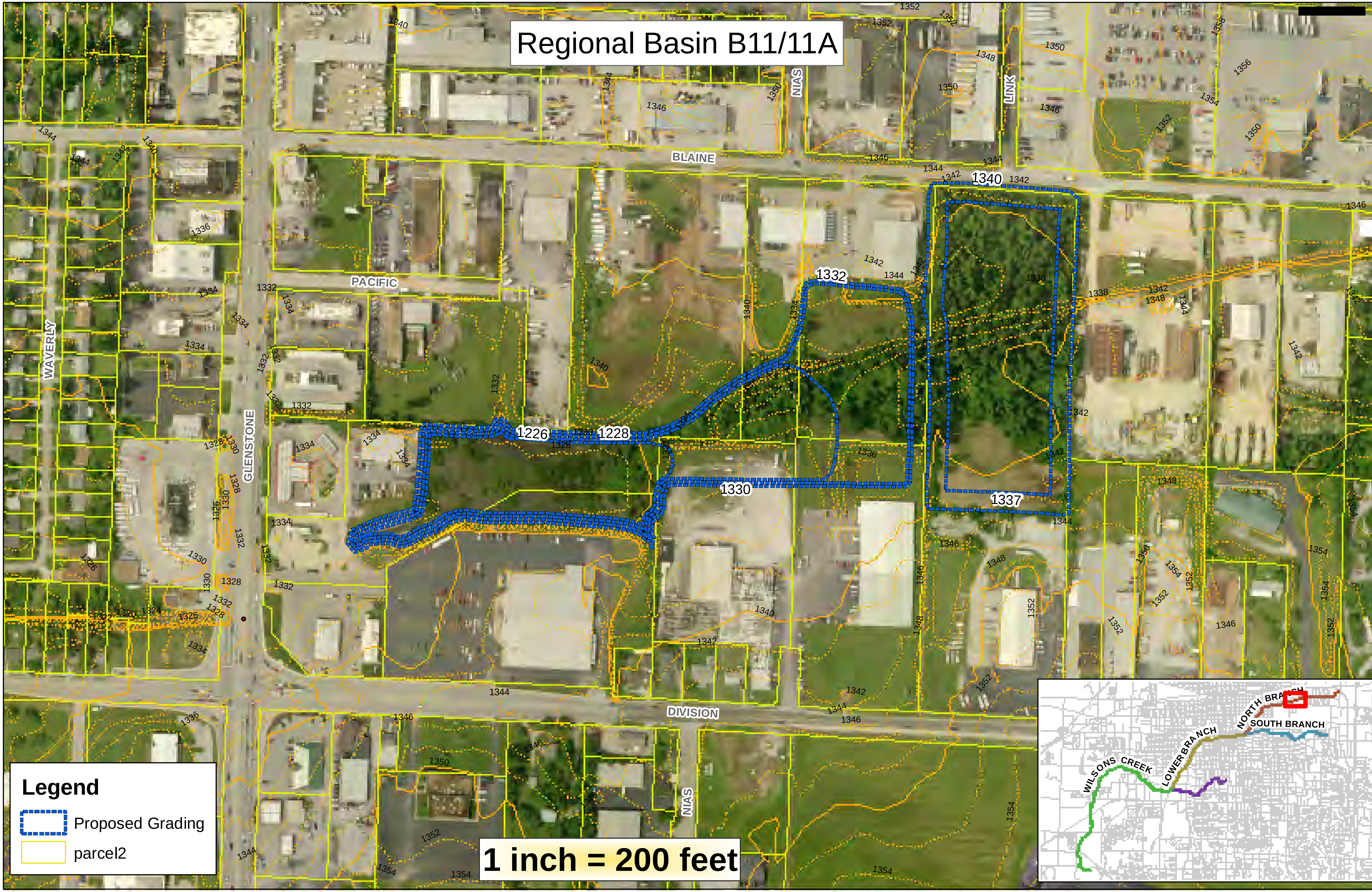


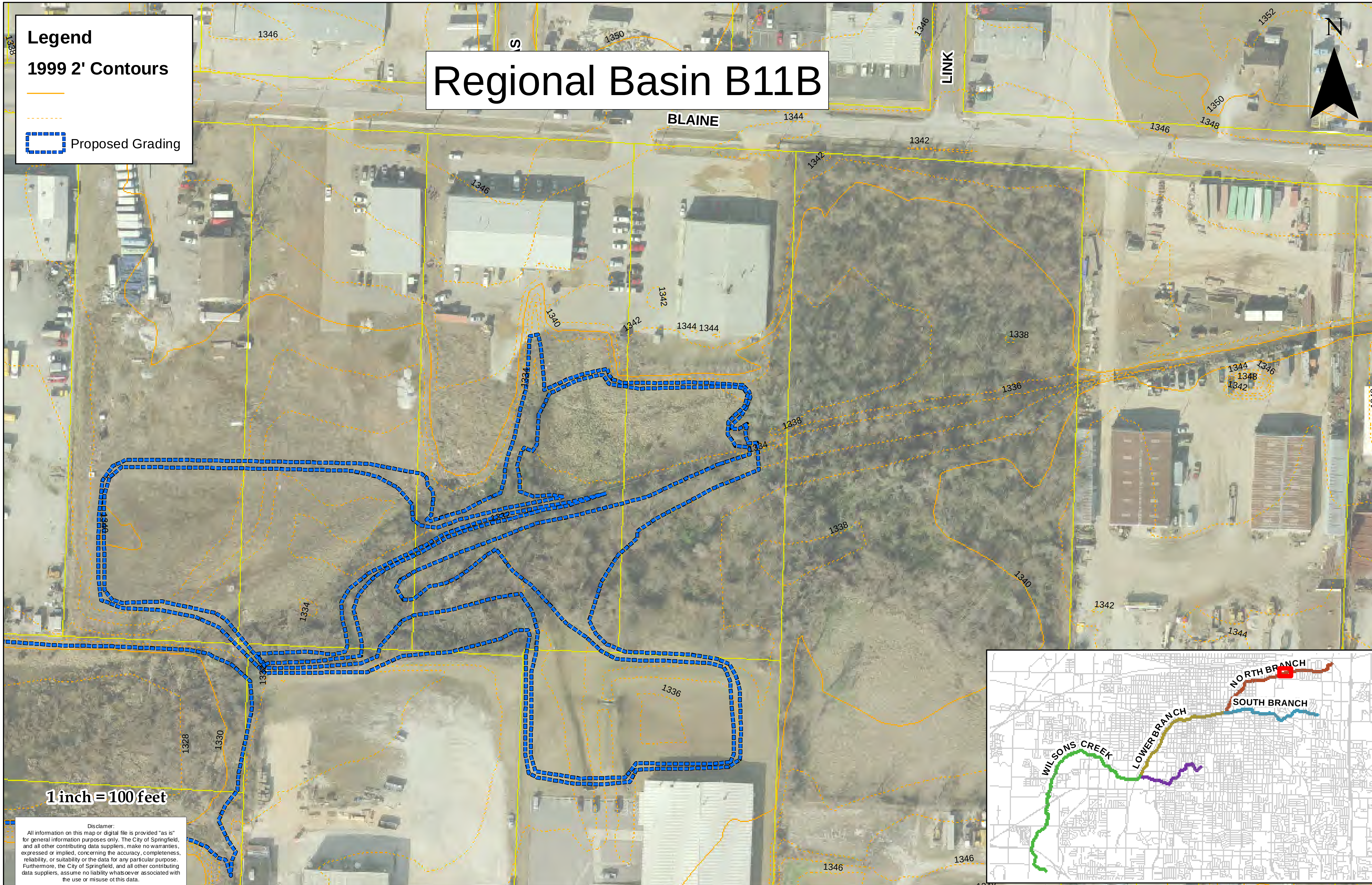
Plate E2
N
CHESTNUT
CAMPBELL
NATIONAL
GLENSTONE
US HIGHWAY 65
FARM ROAD 132
Jordan
HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Sinkhole Basins Excluded from Model
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN. CRK.
WILSONS CREEK


HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E3
N
KANSAS
CHESTNUT
CAMPBELL
NATIONAL
Map Location
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FSSN. CRK.
WILSONS CREEK


HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E4
CHESTNUT
KANSAS
CAMPBELL
Map Location
N


HEC-1 Basins
WATERSHED
FASSNIGHT CREEK
JORDAN CREEK LOWER BRANCH
JORDAN CREEK NORTH BRANCH
JORDAN CREEK SOUTH BRANCH
WILSONS CREEK
Plate E5
N
KANSAS
CAMPBELL
NATIONAL
GLENSTONE
SUNSHINE
CHESTNUT
Map Location
NORTH BRANCH
LOWER BRANCH
WILSONS CREEK


Regional Basin B11/11A
BLAINE
PACIFIC
DIVISION
GLENSTONE
WAVERLY
NIAS
LINK
1340
1332
1226
1228
1330
1337
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK
Legend
Proposed Grading
parcel2
1 inch = 200 feet



Regional Basin B11B
Legend
1999 2' Contours
Proposed Grading
N
BLAINE
LINK
1 inch = 100 feet
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK
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Regional Basin B11C
Legend
1999 2' Contours
Proposed Grading
BLAINE
N
1 inch = 100 feet
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK
1350
1348
1346
1344
1342
1340
1338
1336
1334
1332
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Regional Basin B12
1349
1353
Proposed Pipes
Legend
Proposed Grading
parcel2
1 inch = 100 feet
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK

Regional Basin B14

Regional Basin B15
1380
1373
Use Existing Pipe
Legend
Proposed Grading
parcel2
1 inch = 100 feet
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK

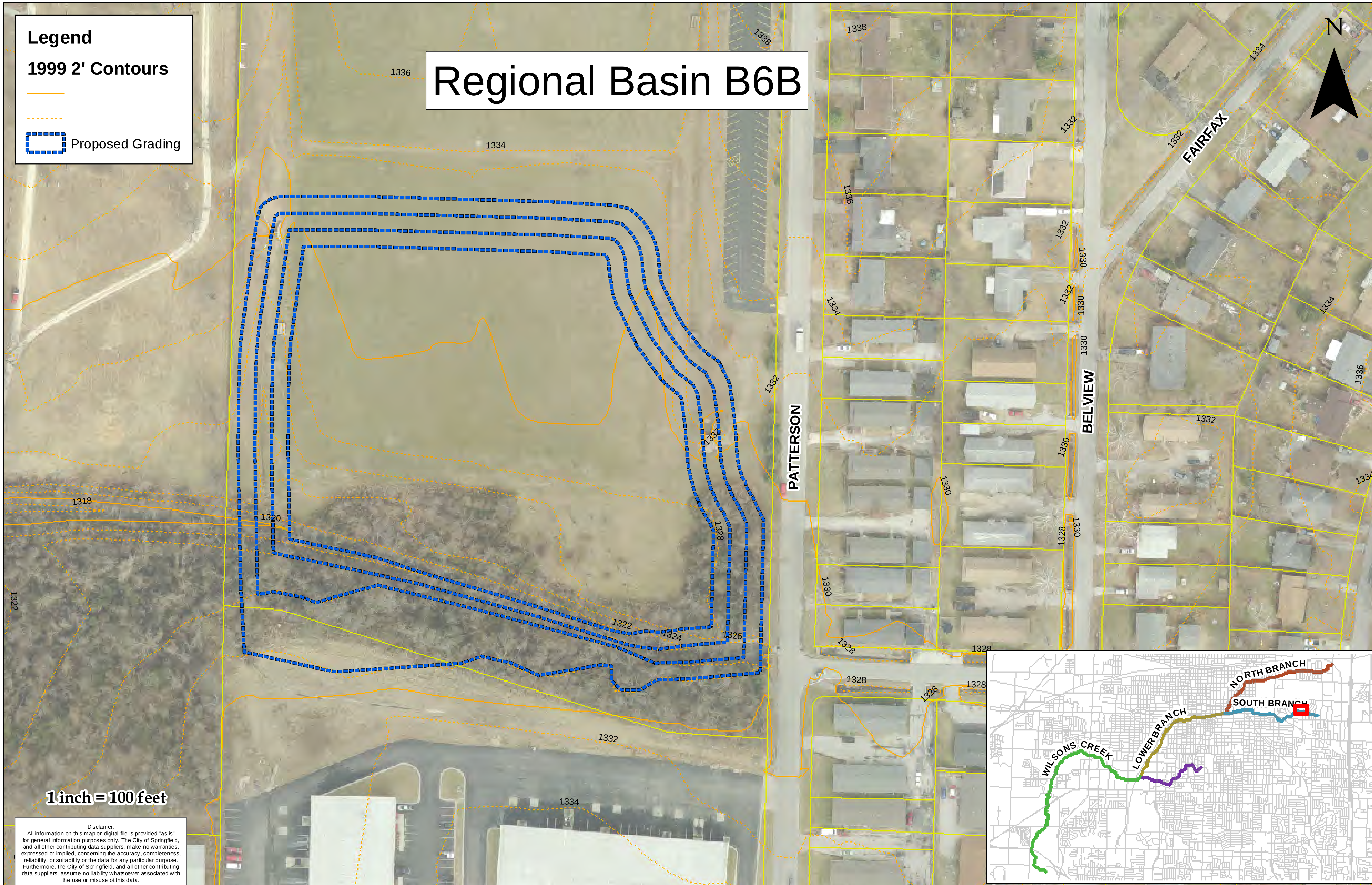
Regional Basin B6

Legend

Proposed Grading

parcel2

1 inch = 100 feet



Regional Basin B6B
Legend
1999 2' Contours
Proposed Grading
N
PATTERSON
BELVIEW
FAIRFAX
1336
1334
1338
1332
1330
1328
1326
1324
1322
1320
1318
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
WILSONS CREEK
1 inch = 100 feet
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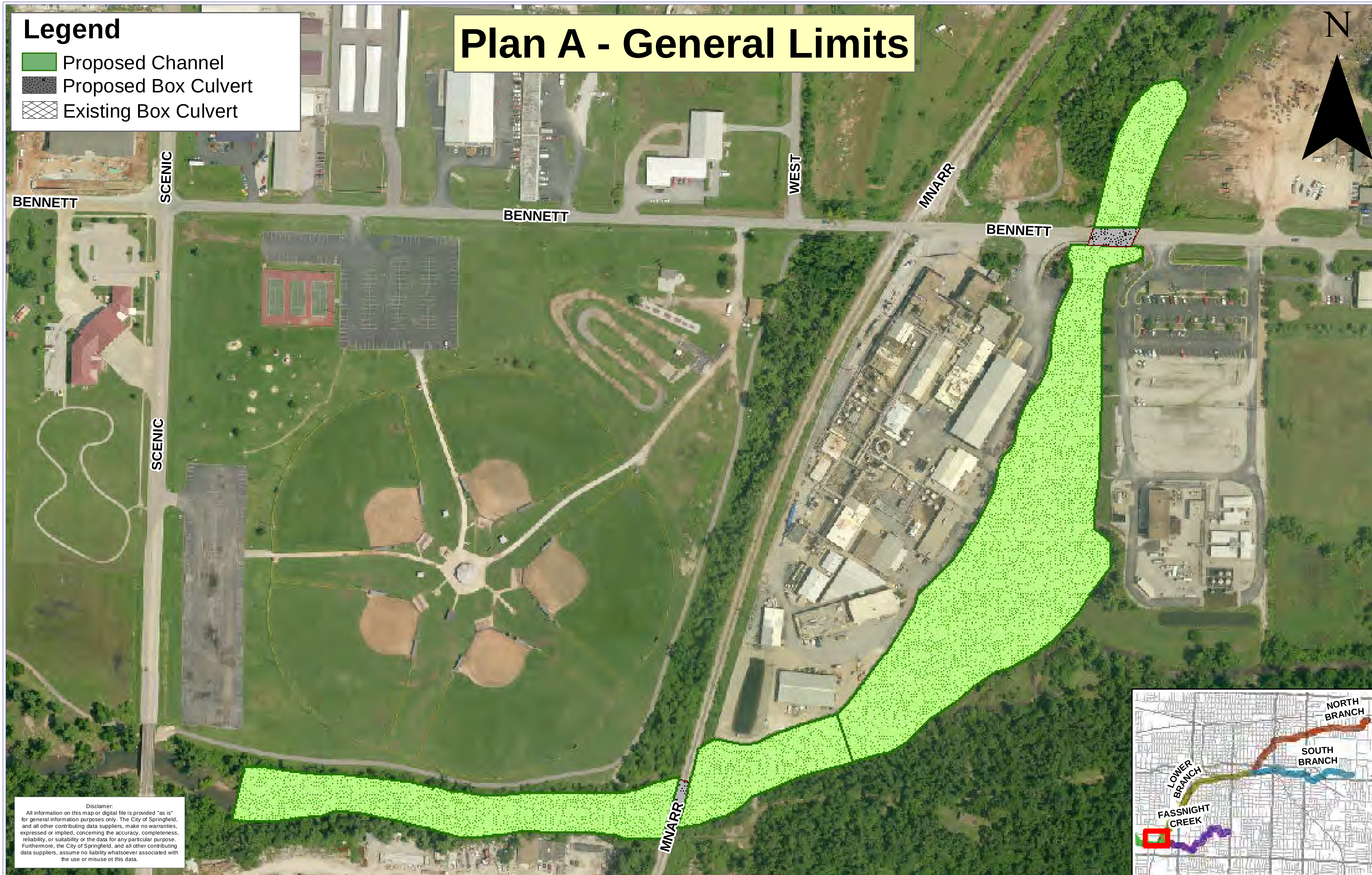
Regional Basin B7
Pipe System
1 inch = 100 feet
Legend
Proposed Grading
parcel2
ELMWOOD
ROCKHURST
BURTON
CEDARBROOK
CHESTNUT
1342
1336
1332
1334
1338
1340
WILSONS CREEK
LOWER BRANCH
NORTH BRANCH
SOUTH BRANCH

Regional Basin B9B/B9C


Plan A - General Limits
Legend
Proposed Channel
Proposed Box Culvert
Existing Box Culvert
N
BENNETT
SCENIC
BENNETT
WEST
MNARR
BENNETT
SCENIC
MNARR
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FASSNIGHT CREEK
Disclamer:
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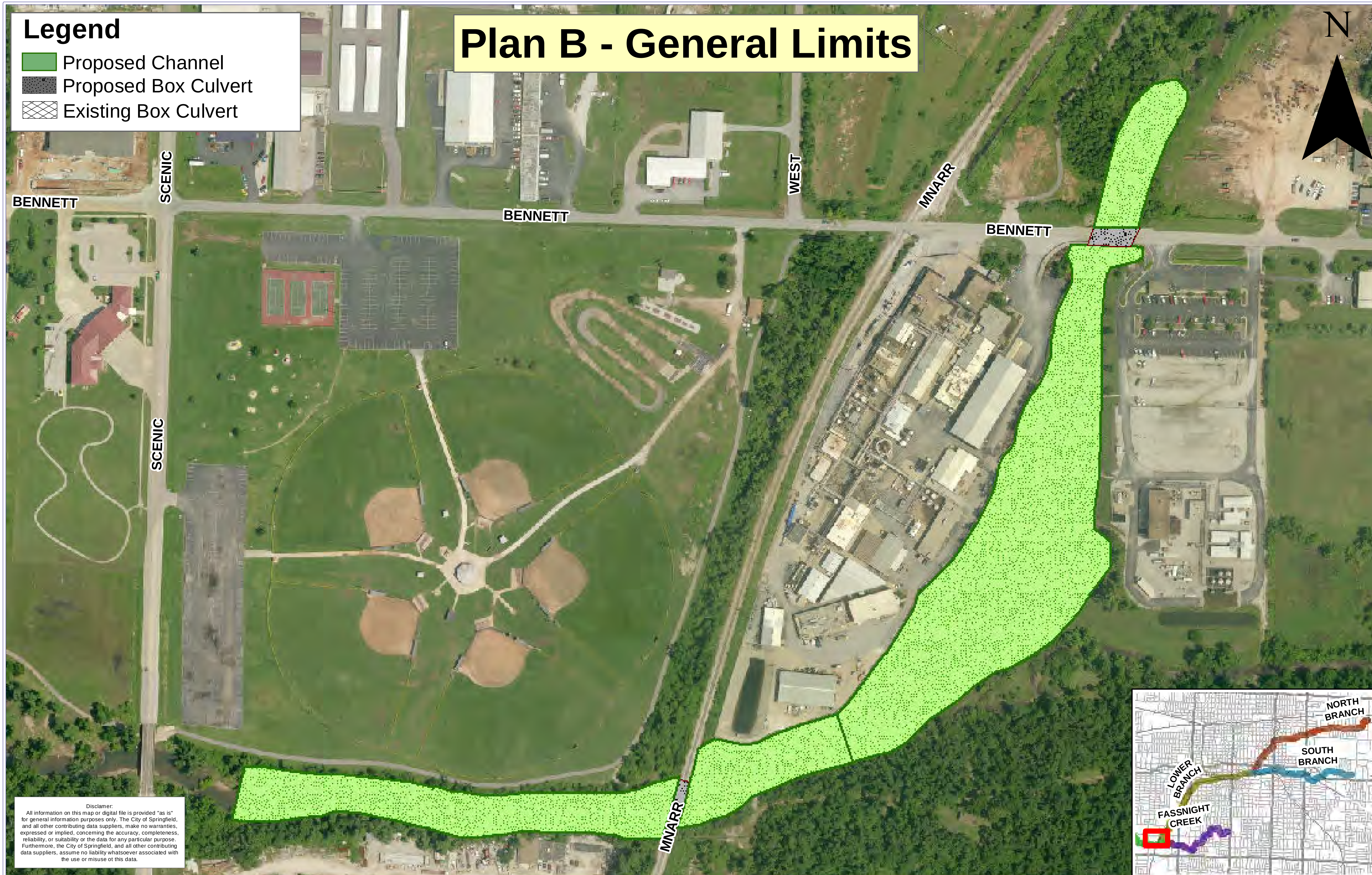

Plan B - General Limits
Legend
Proposed Channel
Proposed Box Culvert
Existing Box Culvert
N
BENNETT
SCENIC
BENNETT
WEST
MNARR
BENNETT
SCENIC
MNARR
NORTH BRANCH
SOUTH BRANCH
LOWER BRANCH
FASSNIGHT CREEK
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Appendix HH-A – Sub Basin Information

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
F7B	0.2528	161.8	67.0	30.0	40.0	FASSNIGHT CREEK
F15	0.0580	37.1	65.0	15.0	42.0	FASSNIGHT CREEK
F18	0.0423	27.1	65.0	15.0	64.0	FASSNIGHT CREEK
F6	0.2961	189.5	73.0	40.0	45.0	FASSNIGHT CREEK
F11A	0.0772	49.4	74.0	70.0	80.0	FASSNIGHT CREEK
F20	0.0983	62.9	65.0	20.0	58.0	FASSNIGHT CREEK
F9	0.2741	175.4	63.0	35.0	40.0	FASSNIGHT CREEK
F4	0.2283	146.1	76.0	45.0	50.0	FASSNIGHT CREEK
F10	0.1800	115.2	66.0	35.0	40.0	FASSNIGHT CREEK
F21	0.1087	69.6	76.0	8.0	76.0	FASSNIGHT CREEK
F18B	0.0206	13.2	72.0	8.0	79.0	FASSNIGHT CREEK
F12	0.5995	383.7	68.0	38.0	66.0	FASSNIGHT CREEK
F16	0.1072	68.6	62.0	35.0	53.0	FASSNIGHT CREEK
F14	0.1739	111.3	75.0	30.0	40.0	FASSNIGHT CREEK
F11B	0.3152	201.7	64.5	30.0	35.0	FASSNIGHT CREEK
F13	0.4619	295.6	67.0	43.0	56.0	FASSNIGHT CREEK
F22B	0.0834	53.4	60.0	10.0	80.0	FASSNIGHT CREEK
F7A	0.1091	69.8	74.0	40.0	45.0	FASSNIGHT CREEK
F19B	0.0470	30.1	62.0	40.0	82.0	FASSNIGHT CREEK
F7	0.3708	237.3	75.0	35.0	40.0	FASSNIGHT CREEK
F1	0.2336	149.5	74.0	40.0	45.0	FASSNIGHT CREEK
F3B	0.1072	68.6	77.0	25.0	35.0	FASSNIGHT CREEK

F17	0.2188	140.0	62.0	42.0	57.0	FASSNIGHT CREEK
F19	0.0834	53.4	61.0	43.0	61.0	FASSNIGHT CREEK
F22A	0.0430	27.5	64.0	38.0	48.0	FASSNIGHT CREEK
F5	0.2625	168.0	72.0	45.0	50.0	FASSNIGHT CREEK
F22	0.0942	60.3	61.0	5.0	76.0	FASSNIGHT CREEK
F11C	0.1064	68.1	68.0	30.0	43.0	FASSNIGHT CREEK
F2	0.0788	50.4	79.0	80.0	85.0	FASSNIGHT CREEK
F3A	0.0630	40.3	74.0	35.0	45.0	FASSNIGHT CREEK
F8	0.2581	165.2	64.0	40.0	45.0	FASSNIGHT CREEK
F8A	0.0634	40.6	64.0	85.0	85.0	FASSNIGHT CREEK
LJ33	0.0592	37.9	81.9	18.5	66.5	JORDAN CREEK LOWER BRANCH
LJ38	0.0087	5.6	73.0	35.8	82.8	JORDAN CREEK LOWER BRANCH
LJ3	0.0855	54.7	76.4	65.3	81.4	JORDAN CREEK LOWER BRANCH
LJ19F	0.0613	39.2	83.0	25.0	45.0	JORDAN CREEK LOWER BRANCH

Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
LJ15	0.2859	183.0	77.1	16.9	47.4	JORDAN CREEK LOWER BRANCH
LJ42	0.0102	6.5	78.6	76.9	80.7	JORDAN CREEK LOWER BRANCH
LJ26	0.0287	18.4	82.0	26.7	70.9	JORDAN CREEK LOWER BRANCH
LJ43	0.0295	18.9	78.3	16.5	40.8	JORDAN CREEK LOWER BRANCH
S092	**0.0928**	**59.4**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK LOWER BRANCH**
LJ18	0.1258	80.5	82.0	58.4	75.1	JORDAN CREEK LOWER BRANCH
LJ9	0.0586	37.5	79.5	9.8	47.3	JORDAN CREEK LOWER BRANCH
LJ19A	0.0233	14.9	87.0	95.0	95.0	JORDAN CREEK LOWER BRANCH
LJ29	0.0650	41.6	78.2	13.1	38.1	JORDAN CREEK LOWER BRANCH
LJ39	0.0011	0.7	82.0	96.7	96.7	JORDAN CREEK LOWER BRANCH
LJ44	0.0875	56.0	81.1	63.9	81.2	JORDAN CREEK LOWER BRANCH
LJ8	0.1734	111.0	79.6	38.5	65.0	JORDAN CREEK LOWER BRANCH
LJ12	0.0133	8.5	73.9	54.6	81.0	JORDAN CREEK LOWER BRANCH
LJ24	0.0525	33.6	78.0	13.4	55.6	JORDAN CREEK LOWER BRANCH
LJ34	0.1097	70.2	79.1	23.6	80.8	JORDAN CREEK LOWER BRANCH

LJ40	0.0169	10.8	74.8	85.7	85.7	JORDAN CREEK LOWER BRANCH
LJ23	0.0509	32.6	78.3	81.0	81.0	JORDAN CREEK LOWER BRANCH
LJ16	0.3600	230.4	81.9	38.0	62.6	JORDAN CREEK LOWER BRANCH
LJ13	0.0361	23.1	82.0	83.1	83.1	JORDAN CREEK LOWER BRANCH
LJ5	0.1164	74.5	78.0	22.7	64.5	JORDAN CREEK LOWER BRANCH
LJ19D	0.0069	4.4	87.0	98.0	98.0	JORDAN CREEK LOWER BRANCH
LJ7	0.0727	46.5	84.3	46.4	84.3	JORDAN CREEK LOWER BRANCH
LJ19C	0.0111	7.1	85.0	60.0	75.0	JORDAN CREEK LOWER BRANCH
LJ36	0.1261	80.7	81.9	24.0	48.4	JORDAN CREEK LOWER BRANCH
LJ25	0.4000	256.0	76.2	16.7	61.2	JORDAN CREEK LOWER BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
LJ31	0.0239	15.3	78.2	64.7	80.6	JORDAN CREEK LOWER BRANCH
LJ27	0.0470	30.1	81.1	63.6	76.8	JORDAN CREEK LOWER BRANCH
LJ22	0.0822	52.6	80.3	18.0	66.6	JORDAN CREEK LOWER BRANCH
LJ30	0.0136	8.7	82.0	96.9	96.9	JORDAN CREEK LOWER BRANCH
LJ2	0.0100	6.4	85.6	7.5	85.6	JORDAN CREEK LOWER BRANCH
LJ6	0.0980	62.7	77.2	9.4	69.5	JORDAN CREEK

						LOWER BRANCH
LJ19H	0.0655	41.9	82.0	30.0	65.0	JORDAN CREEK LOWER BRANCH
LJ45	0.0767	49.1	82.0	53.0	72.1	JORDAN CREEK LOWER BRANCH
LJ21	0.1061	67.9	74.8	15.4	40.0	JORDAN CREEK LOWER BRANCH
LJ46	0.1361	87.1	74.3	25.3	74.3	JORDAN CREEK LOWER BRANCH
LJ17	0.0772	49.4	80.9	15.0	45.4	JORDAN CREEK LOWER BRANCH
LJ41	0.0755	48.3	79.6	70.1	78.4	JORDAN CREEK LOWER BRANCH
LJ4	0.0375	24.0	80.4	54.4	80.9	JORDAN CREEK LOWER BRANCH
LJ11	0.1664	106.5	82.0	27.6	58.8	JORDAN CREEK LOWER BRANCH
LJ35	0.0080	5.1	81.6	79.9	80.0	JORDAN CREEK LOWER BRANCH
LJ19G	0.0331	21.2	87.0	44.0	50.0	JORDAN CREEK LOWER BRANCH
LJ20	0.0394	25.2	80.5	62.9	76.0	JORDAN CREEK LOWER BRANCH
LJ28	0.0353	22.6	72.4	21.2	76.6	JORDAN CREEK LOWER BRANCH
LJ19E	0.0450	28.8	87.0	57.0	65.0	JORDAN CREEK LOWER BRANCH
LJ37	0.0997	63.8	76.5	30.1	68.6	JORDAN CREEK LOWER BRANCH
LJ10	0.0380	24.3	75.4	14.9	83.2	JORDAN CREEK LOWER BRANCH
LJ14	0.0648	41.5	81.0	76.7	81.7	JORDAN CREEK

						LOWER BRANCH
LJ32	0.2433	155.7	76.1	13.1	41.4	JORDAN CREEK LOWER BRANCH
NB8	0.0317	20.3	78.9	30.3	34.4	JORDAN CREEK NORTH BRANCH
NB13	0.0239	15.3	81.1	6.1	80.4	JORDAN CREEK NORTH BRANCH
NB15	0.0322	20.6	81.5	30.2	65.0	JORDAN CREEK NORTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
NB7B	0.0681	43.6	79.1	16.3	80.5	JORDAN CREEK NORTH BRANCH
NB42	0.0673	43.1	78.8	36.9	53.1	JORDAN CREEK NORTH BRANCH
NB56	0.1078	69.0	77.7	40.2	49.6	JORDAN CREEK NORTH BRANCH
NB31	0.0738	47.2	80.9	23.8	77.5	JORDAN CREEK NORTH BRANCH
NB44	0.0995	63.7	76.2	35.0	45.0	JORDAN CREEK NORTH BRANCH
NB23	0.0317	20.3	81.5	82.1	93.0	JORDAN CREEK NORTH BRANCH
NB38	0.0200	12.8	81.3	53.6	80.4	JORDAN CREEK NORTH BRANCH
NB52	0.0477	30.5	78.9	42.6	59.5	JORDAN CREEK NORTH BRANCH
NB6B	0.0489	31.3	79.0	31.2	35.1	JORDAN CREEK NORTH BRANCH
NB37A	0.0148	9.5	77.8	78.1	79.2	JORDAN CREEK NORTH BRANCH
NB34	0.0264	16.9	79.1	86.0	86.0	JORDAN CREEK NORTH BRANCH

NB47	0.0552	35.3	78.8	41.4	62.9	JORDAN CREEK NORTH BRANCH
NB11	0.0458	29.3	83.1	28.4	36.4	JORDAN CREEK NORTH BRANCH
NB55	0.0447	28.6	72.6	37.3	46.2	JORDAN CREEK NORTH BRANCH
NB43B	0.0191	12.2	78.7	51.2	80.7	JORDAN CREEK NORTH BRANCH
NB4	0.0408	26.1	80.6	53.9	81.2	JORDAN CREEK NORTH BRANCH
NB9	0.0716	45.8	77.4	50.9	69.0	JORDAN CREEK NORTH BRANCH
NB7A	0.0214	13.7	78.8	33.6	43.8	JORDAN CREEK NORTH BRANCH
NB12	0.1072	68.6	78.4	48.3	77.9	JORDAN CREEK NORTH BRANCH
NB36B	0.1002	64.1	80.6	27.0	78.6	JORDAN CREEK NORTH BRANCH
NB49A	0.0306	19.6	78.1	51.6	78.2	JORDAN CREEK NORTH BRANCH
NB19	0.0192	12.3	79.1	78.1	79.4	JORDAN CREEK NORTH BRANCH
NB3	0.0155	9.9	81.2	45.8	84.5	JORDAN CREEK NORTH BRANCH
NB32	0.0291	18.6	79.8	80.0	80.5	JORDAN CREEK NORTH BRANCH
NB37B	0.0684	43.8	78.9	77.3	78.8	JORDAN CREEK NORTH BRANCH

NB40A	0.0680	43.5	79.0	7.9	80.4	JORDAN CREEK NORTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
NB17	0.0452	28.9	79.9	24.4	33.7	JORDAN CREEK NORTH BRANCH
NB59	0.0650	41.6	75.7	78.8	84.7	JORDAN CREEK NORTH BRANCH
NB20B	0.0592	37.9	79.1	49.6	58.4	JORDAN CREEK NORTH BRANCH
NB2	0.0758	48.5	80.2	26.2	41.3	JORDAN CREEK NORTH BRANCH
NB18B	0.0445	28.5	81.0	22.4	82.1	JORDAN CREEK NORTH BRANCH
NB39A	0.0525	33.6	74.4	59.0	81.5	JORDAN CREEK NORTH BRANCH
NB49B	0.0231	14.8	78.8	39.2	69.4	JORDAN CREEK NORTH BRANCH
NB6A	0.0550	35.2	80.1	37.4	71.5	JORDAN CREEK NORTH BRANCH
NB45	0.1483	94.9	79.0	43.7	64.7	JORDAN CREEK NORTH BRANCH
NB20A	0.1147	73.4	79.0	49.7	62.6	JORDAN CREEK NORTH BRANCH
NB26A	0.0258	16.5	80.1	36.6	83.9	JORDAN CREEK NORTH BRANCH
NB54	0.0378	24.2	74.5	50.7	66.7	JORDAN CREEK NORTH BRANCH
NB26B	0.0083	5.3	80.4	8.7	60.0	JORDAN CREEK NORTH BRANCH
NB29	0.0394	25.2	82.2	28.0	36.3	JORDAN CREEK NORTH BRANCH

NB36A	0.0481	30.8	79.3	80.9	80.9	JORDAN CREEK NORTH BRANCH
NB48	0.0494	31.6	79.1	40.6	77.7	JORDAN CREEK NORTH BRANCH
NB51	0.0475	30.4	76.5	33.2	63.1	JORDAN CREEK NORTH BRANCH
NB43A	0.0270	17.3	78.2	39.6	79.9	JORDAN CREEK NORTH BRANCH
NB16	0.0106	6.8	78.7	46.8	79.7	JORDAN CREEK NORTH BRANCH
NB5	0.0150	9.6	81.3	28.4	60.0	JORDAN CREEK NORTH BRANCH
NB21	0.0412	26.4	82.3	10.0	65.0	JORDAN CREEK NORTH BRANCH
NB27	0.0480	30.7	79.0	32.4	46.6	JORDAN CREEK NORTH BRANCH
NB33	0.0158	10.1	79.1	58.0	81.0	JORDAN CREEK NORTH BRANCH
NB60	0.1608	102.9	78.1	40.3	59.5	JORDAN CREEK NORTH BRANCH
NB58	0.0536	34.3	70.3	84.8	84.8	JORDAN CREEK NORTH BRANCH
NB41	0.1564	100.1	77.7	9.5	85.4	JORDAN CREEK NORTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
NB57	0.0497	31.8	70.6	40.3	54.5	JORDAN CREEK NORTH BRANCH
NB50	0.0278	17.8	77.4	36.5	56.5	JORDAN CREEK NORTH BRANCH
NB35	0.0080	5.1	79.4	30.6	81.4	JORDAN CREEK NORTH BRANCH
NB1	0.0502	32.1	79.0	61.8	80.6	JORDAN CREEK

						NORTH BRANCH
NB25	0.0278	17.8	79.5	89.9	89.9	JORDAN CREEK NORTH BRANCH
NB24	0.0195	12.5	78.8	85.4	85.4	JORDAN CREEK NORTH BRANCH
NB40B	0.0339	21.7	79.0	48.0	75.6	JORDAN CREEK NORTH BRANCH
NB39B	0.0659	42.2	76.2	58.2	79.7	JORDAN CREEK NORTH BRANCH
NB53	0.0641	41.0	77.6	38.1	48.2	JORDAN CREEK NORTH BRANCH
NB10	0.0409	26.2	82.3	8.1	80.7	JORDAN CREEK NORTH BRANCH
NB18A	0.0328	21.0	80.2	51.5	80.1	JORDAN CREEK NORTH BRANCH
NB46	0.0281	18.0	79.1	42.8	65.0	JORDAN CREEK NORTH BRANCH
NB14	0.0125	8.0	79.4	32.5	80.7	JORDAN CREEK NORTH BRANCH
NB30	0.0177	11.3	79.0	8.4	80.0	JORDAN CREEK NORTH BRANCH
NB28	0.0437	28.0	77.5	76.1	76.1	JORDAN CREEK NORTH BRANCH
NB28	0.0916	58.6	77.5	76.1	76.1	JORDAN CREEK NORTH BRANCH
SJ1	0.0216	13.8	82.0	85.5	85.5	JORDAN CREEK SOUTH BRANCH
G054	0.0517	33.1	87.0	50.0	81.6	JORDAN CREEK SOUTH BRANCH
G064	**0.0497**	**31.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ8B	0.0266	17.0	78.9	50.0	81.4	JORDAN CREEK

						SOUTH BRANCH
S090	0.0512	32.8	77.7	12.7	39.8	JORDAN CREEK SOUTH BRANCH
SJ17	0.1091	69.8	81.9	5.9	70.0	JORDAN CREEK SOUTH BRANCH
G133	**0.0344**	**22.0**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ35	0.0486	31.1	74.3	37.4	81.4	JORDAN CREEK SOUTH BRANCH
SJ2	0.0209	13.4	82.0	25.1	81.1	JORDAN CREEK SOUTH BRANCH
SJ8A	0.0234	15.0	78.9	90.0	90.0	JORDAN CREEK SOUTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
SJ18	0.0155	9.9	81.7	64.9	80.6	JORDAN CREEK SOUTH BRANCH
G075	0.0516	33.0	71.0	15.0	34.3	JORDAN CREEK SOUTH BRANCH
G082	0.0278	17.8	70.0	10.0	32.8	JORDAN CREEK SOUTH BRANCH
G255	**0.0166**	**10.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ39	0.1319	84.4	79.3	24.7	45.0	JORDAN CREEK SOUTH BRANCH
SJ10	0.0164	10.5	80.3	64.2	80.3	JORDAN CREEK SOUTH BRANCH
G123	0.0856	54.8	76.2	5.0	31.7	JORDAN CREEK SOUTH BRANCH
G137	**0.0559**	**35.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ42	0.0314	20.1	74.1	50.7	63.0	JORDAN CREEK SOUTH BRANCH

SJ40	0.1322	84.6	77.6	60.2	70.0	JORDAN CREEK SOUTH BRANCH
S089	0.0570	36.5	78.3	14.2	51.7	JORDAN CREEK SOUTH BRANCH
SJ33	0.1056	67.6	80.2	52.6	69.3	JORDAN CREEK SOUTH BRANCH
G135	**0.0697**	**44.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G038A	0.0958	61.3	76.8	30.0	40.5	JORDAN CREEK SOUTH BRANCH
SJ48	0.1167	74.7	77.9	48.4	70.8	JORDAN CREEK SOUTH BRANCH
SJ4	0.1484	95.0	76.9	15.2	84.8	JORDAN CREEK SOUTH BRANCH
SJ24	0.0894	57.2	82.0	22.1	70.0	JORDAN CREEK SOUTH BRANCH
G045	0.0234	15.0	62.9	5.0	27.5	JORDAN CREEK SOUTH BRANCH
G056	**0.0120**	**7.7**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G063	**0.0286**	**18.3**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G058	0.0589	37.7	82.4	10.0	33.0	JORDAN CREEK SOUTH BRANCH
G061W	**0.0692**	**44.3**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ44A	0.0225	14.4	74.1	49.1	82.9	JORDAN CREEK SOUTH BRANCH
G084A	**0.0186**	**11.9**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G076	0.0155	9.9	70.9	5.0	31.4	JORDAN CREEK SOUTH BRANCH

SJ27	0.1405	89.9	78.3	48.0	82.5	JORDAN CREEK SOUTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
SJ19A	0.0159	10.2	82.0	85.7	85.7	JORDAN CREEK SOUTH BRANCH
SJ44B	0.0483	30.9	74.6	61.5	80.9	JORDAN CREEK SOUTH BRANCH
SJ36	0.1336	85.5	79.2	39.3	61.6	JORDAN CREEK SOUTH BRANCH
SJ13	0.0222	14.2	79.0	19.5	80.4	JORDAN CREEK SOUTH BRANCH
SJ23	0.0498	31.9	81.4	7.1	70.0	JORDAN CREEK SOUTH BRANCH
SJ7	0.0222	14.2	72.6	63.8	81.0	JORDAN CREEK SOUTH BRANCH
SJ49	0.1819	116.4	77.1	17.5	50.0	JORDAN CREEK SOUTH BRANCH
G128	0.0189	12.1	77.3	29.3	29.3	JORDAN CREEK SOUTH BRANCH
SJ45	0.0434	27.8	78.6	47.6	60.0	JORDAN CREEK SOUTH BRANCH
SJ5	0.0677	43.3	77.6	54.9	72.0	JORDAN CREEK SOUTH BRANCH
SJ3	0.0241	15.4	81.2	39.2	82.4	JORDAN CREEK SOUTH BRANCH
SJ11	0.0338	21.6	78.4	37.8	80.1	JORDAN CREEK SOUTH BRANCH
G052	0.1106	70.8	69.9	15.0	30.0	JORDAN CREEK SOUTH BRANCH
SJ15	0.1200	76.8	79.4	10.3	44.1	JORDAN CREEK SOUTH BRANCH
SJ29	0.0642	41.1	80.6	44.8	80.8	JORDAN CREEK

						SOUTH BRANCH
G084B	**0.0209**	**13.4**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G038	0.2072	132.6	64.0	50.0	56.2	JORDAN CREEK SOUTH BRANCH
SJ26	0.1703	109.0	76.6	18.9	59.6	JORDAN CREEK SOUTH BRANCH
G083	0.0781	50.0	76.8	15.0	34.8	JORDAN CREEK SOUTH BRANCH
SJ22	0.0658	42.1	80.2	27.3	80.9	JORDAN CREEK SOUTH BRANCH
S071	**0.0434**	**27.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ41	0.0775	49.6	77.9	16.4	50.0	JORDAN CREEK SOUTH BRANCH
G061A	**0.0139**	**8.9**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G073	**0.0806**	**51.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G058	0.0003	0.2	82.4	10.0	33.0	JORDAN CREEK SOUTH BRANCH
SJ38	0.1095	70.1	81.8	32.7	80.4	JORDAN CREEK SOUTH BRANCH
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
G047	0.0203	13.0	64.8	2.0	24.3	JORDAN CREEK SOUTH BRANCH
G134	**0.1614**	**103.3**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ14	0.0455	29.1	78.8	64.0	82.8	JORDAN CREEK SOUTH BRANCH
G061E	**0.1195**	**76.5**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**

G090	**0.0133**	**8.5**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G079	**0.0144**	**9.2**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ34	0.0313	20.0	75.7	44.2	81.7	JORDAN CREEK SOUTH BRANCH
S088	0.0448	28.7	78.5	14.5	50.3	JORDAN CREEK SOUTH BRANCH
SJ37	0.1600	102.4	76.4	34.0	72.0	JORDAN CREEK SOUTH BRANCH
SJ19	0.0516	33.0	81.4	46.5	79.2	JORDAN CREEK SOUTH BRANCH
G253	**0.0138**	**8.8**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
SJ25	0.1091	69.8	78.8	19.7	78.1	JORDAN CREEK SOUTH BRANCH
G050A	0.0442	28.3	80.0	20.0	34.7	JORDAN CREEK SOUTH BRANCH
SJ21	0.0978	62.6	81.9	5.9	70.0	JORDAN CREEK SOUTH BRANCH
SJ6	0.1542	98.7	79.7	47.9	67.0	JORDAN CREEK SOUTH BRANCH
G050	0.0308	19.7	72.4	6.0	26.0	JORDAN CREEK SOUTH BRANCH
G055	**0.0744**	**47.6**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
G093	0.0866	55.4	77.0	10.0	34.4	JORDAN CREEK SOUTH BRANCH
SJ20	0.1191	76.2	80.4	19.2	54.5	JORDAN CREEK SOUTH BRANCH
SJ31	0.0245	15.7	76.2	61.5	81.1	JORDAN CREEK SOUTH BRANCH

SJ12	0.0127	8.1	79.5	58.1	80.7	JORDAN CREEK SOUTH BRANCH
SJ30	0.0138	8.8	81.8	48.5	71.5	JORDAN CREEK SOUTH BRANCH
G077	0.0139	8.9	72.9	8.0	30.7	JORDAN CREEK SOUTH BRANCH
SJ28	0.0697	44.6	81.5	74.0	77.1	JORDAN CREEK SOUTH BRANCH
SJ16	0.1086	69.5	79.7	14.4	46.7	JORDAN CREEK SOUTH BRANCH
SJ47	**0.0116**	**7.4**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**
Sub Basin	*Square Miles*	*Acres*	*Pervious CN*	*Current % Imp*	*Ultimate % Imp*	*Watershed*
G051	0.0217	13.9	66.7	23.0	23.0	JORDAN CREEK SOUTH BRANCH
SJ9	0.0167	10.7	79.8	54.1	80.9	JORDAN CREEK SOUTH BRANCH
SJ43	0.0200	12.8	73.0	63.7	79.2	JORDAN CREEK SOUTH BRANCH
SJ32	0.0356	22.8	80.9	48.2	84.7	JORDAN CREEK SOUTH BRANCH
G113	0.1683	107.7	77.5	12.0	34.1	JORDAN CREEK SOUTH BRANCH
SJ46	0.0900	57.6	76.5	40.7	67.8	JORDAN CREEK SOUTH BRANCH
G113A	**0.0483**	**30.9**	**0.0**	**0.0**	**0.0**	**JORDAN CREEK SOUTH BRANCH**

**Highlighted Basins have been excluded from the model because they do not contribute flow due to the presence of a sinkhole or quarry.

Appendix HH-B – Modified-Puls Routing Elements

South Branch

From STA		1729		**To STA**		2584				**MP44**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr		2.68		**3**		3.98		**4**	**262**	**1**	Length	855
1yr	0	4.26	0.45	**5**	0	6.89	5.8	**13**	**524**	**8**	Velocity	2.6
10yr	3.89	7.77	13.6	**25**	4.39	12.91	52.12	**69**	**1480**	**44**	**NSTPS**	**5**
25yr	6.25	8.27	18.38	**33**	7.01	13.7	61.63	**82**	**1941**	**49**		
100yr	10.98	9.02	27.3	**47**	12.35	14.84	77.09	**104**	**2715**	**57**		
500yr	16.06	9.68	36.09	**62**	18.53	15.9	92.62	**127**	**3651**	**65**		
150% 500yr	26.35	10.76	51.49	**89**	31.74	17.6	118.9	**168**	**5476.5**	**80**		

South Branch

From STA		1224		**To STA**		1729				**MP44B**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr		1.82		**2**		2.68		**3**	**308**	**1**	Length	505
1yr	0	2.89	0.03	**3**	0	4.26	0.45	**5**	**616**	**2**	Velocity	1.9
10yr	3.19	5.52	6.03	**15**	3.89	7.77	13.6	**25**	**1716**	**11**	**NSTPS**	**4**
25yr	5.09	5.92	8.8	**20**	6.25	8.27	18.38	**33**	**2256**	**13**		
100yr	8.97	6.55	14.93	**30**	10.98	9.02	27.3	**47**	**3159**	**17**		
500yr	12.93	7.08	20.7	**41**	16.06	9.68	36.09	**62**	**4178**	**21**		
150% 500yr	21.16	7.95	31.01	**60**	26.35	10.76	51.49	**89**	**6267**	**28**		

South Branch

From STA		297		**To STA**		1178				**MP45**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr		0.51		**1**		1.74		**2**	**312**	**1**	Length	881
1yr		0.83	0.03	**1**	0	2.77	0.03	**3**	**624**	**2**	Velocity	3.23
10yr	0.93	1.76	1.08	**4**	3.13	5.36	5.82	**14**	**1751**	**11**	**NSTPS**	**5**
25yr	2.16	1.93	2.28	**6**	4.98	5.75	8.42	**19**	**2297**	**13**		

100yr	3.37	2.08	3.39	**9**	8.77	6.36	14.24	**29**	**3204**	**21**
500yr	4.66	2.23	4.45	**11**	12.63	6.88	19.74	**39**	**4231**	**28**
150% 500yr	7.68	2.51	6.6	**17**	20.62	7.74	29.51	**58**	**6346.5**	**41**

South Branch

	From STA	9178			**To STA**	11192				**MP27**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	0.88	7.97	1.02	**10**	0.89	9.72	1.05	**12**	**124**	**2**	Length	2014
1yr	1.27	11.89	2.29	**15**	1.37	14.78	2.43	**19**	**248**	**3**	Velocity	5.14
10yr	9.54	23.57	12.57	**46**	12.8	32.28	15.01	**60**	**809**	**14**	**NSTPS**	**7**
25yr	13.78	25.68	16.23	**56**	21.91	36.66	23.57	**82**	**1043**	**26**		
100yr	21.09	28.51	24.74	**74**	41.55	43.8	45.08	**130**	**1487**	**56**		
500yr	33.19	32.78	41.32	**107**	58.56	49.37	66.6	**175**	**2024**	**67**		
150% 500yr	48.45	37.75	66.77	**153**	80.53	55.87	98.32	**235**	**3036**	**82**		

Lower Branch

	From STA	9865			**To STA**	12068				**MP8**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	1.65	46.58	7.22	**55**	1.65	53.49	7.28	**62**	**708**	**7**	Length	2203
1yr	8.92	75.84	29.77	**115**	8.92	87.36	30.46	**127**	**1415**	**12**	Velocity	2.25
10yr	102.4	147.1	230	**479**	110.6	168.8	271.6	**551**	**3949**	**71**	**NSTPS**	**16**
25yr	148	160.6	321.3	**630**	161.6	184.3	379.2	**725**	**4858**	**95**		
100yr	227.9	180.4	456.5	**865**	250.4	206.9	540	**997**	**6340**	**132**		
500yr	331.5	201.1	607.2	**1140**	363.7	230.3	718.4	**1312**	**8048**	**172**		
150% 500yr	681.3	254	1053	**1988**	733.5	288.1	1225	**2246**	**12072**	**258**		

Lower Branch

	From STA	320		**To STA**		2359				**MP34**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	0.2	2.22		**2**	1.58	11.28	3.19	**16**	**960**	**14**	Length	2039
1yr	1.33	4.9	0	**6**	8.28	17.9	13.38	**40**	**1920**	**33**	Velocity	1.3
10yr	8.18	13.06	0.13	**21**	60	36.35	68.76	**165**	**5181**	**144**	**NSTPS**	**26**
25yr	13.3	15.62	7.04	**36**	88.68	41.83	117.3	**248**	**6617**	**212**		
100yr	21.9	19.59	27.53	**69**	145.2	50.79	194	**390**	**8869**	**321**		
500yr	32.09	23.88	39.97	**96**	216.6	61.42	283.8	**562**	**11242**	**466**		
150% 500yr	61.57	34.03	78.28	**174**	412.8	87.89	543.8	**1044**	**16863**	**871**		

Lower Branch

	From STA	2432		**To STA**		4081				**MP6**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	1.58	11.63	3.2	**16**	1.65	20.43	3.2	**25**	**960**	**9**	Length	1649
1yr	8.3	18.36	13.45	**40**	8.84	31.74	14.01	**55**	**1920**	**14**	Velocity	4.3
10yr	60.44	37.07	69.46	**167**	73.32	58.75	91.85	**224**	**5181**	**57**	**NSTPS**	**6**
25yr	89.67	42.67	119	**251**	111.5	66.84	156.3	**335**	**6617**	**83**		
100yr	146.7	51.73	196.6	**395**	177.3	77.58	241.9	**497**	**8869**	**102**		
500yr	219.1	62.44	288.1	**570**	259.5	90.27	344.9	**695**	**11242**	**125**		
150% 500yr	420.3	89.32	555.9	**1065**	558.5	128.2	699.8	**1386**	**16863**	**321**		

Lower Branch

	From STA	4137		**To STA**		4419				**MP2**		
		Volume				Volume			**Flow**	**Volume**		
50% 1yr	1.65	20.71	3.2	**26**	1.65	22.23	3.21	**27**	**912**	**2**	Length	282
1yr	8.84	32.17	14.02	**55**	8.86	34.72	14.66	**58**	**1824**	**3**	Velocity	2.2
10yr	73.51	59.33	92.24	**225**	78.8	64.66	105.1	**249**	**4926**	**24**	**NSTPS**	**2**
25yr	112	67.49	157.6	**337**	117.7	72.98	171.3	**362**	**6240**	**25**		
100yr	178.2	78.33	243.8	**500**	185.5	84.23	259.9	**530**	**8305**	**29**		
500yr	262.6	91.11	347.3	**701**	275.6	97.46	366.3	**739**	**10459**	**38**		

150% 500yr	563	129.1	702.9	**1395**	579.2	135.9	724.4	**1440**	**15689**	**44**

Lower Branch

<u>From STA</u>		4419		**<u>To STA</u>**		7848				**MP25**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr	1.65	22.23	3.21	**27**	1.65	36.77	7.22	**46**	**912**	**19**	Length	3429
1yr	8.86	34.72	14.66	**58**	8.91	58.39	29.74	**97**	**1824**	**39**	Velocity	2.2
10yr	78.8	64.66	105.1	**249**	94.78	110.8	205.6	**411**	**4926**	**163**	**NSTPS**	**26**
25yr	117.7	72.98	171.3	**362**	137.2	122.4	289.5	**549**	**6240**	**187**		
100yr	185.5	84.23	259.9	**530**	211.9	139	411.7	**763**	**8305**	**233**		
500yr	275.6	97.46	366.3	**739**	310.4	157.3	551	**1019**	**10459**	**279**		
150% 500yr	579.2	135.9	724.4	**1440**	647.5	204.6	968.6	**1821**	**15688.5**	**381**		

North Branch

<u>From STA</u>		335		**<u>To STA</u>**		2800				**MP58**		
		Volume				Volume			**<u>Flow</u>**	**<u>Volume</u>**		
50% 1yr		0.58		**1**		2.99		**3**	**329**	**2**	Length	2465
1yr		1.02	0.03	**1**		5.3	0.04	**5**	**657**	**4**	Velocity	2
10yr	1.1	2.69	2.35	**6**	1.48	9.98	11.8	**23**	**1789**	**17**	**NSTPS**	**21**
25yr	1.85	2.93	3.61	**8**	3.98	11.4	17.24	**33**	**2261**	**24**		
100yr	2.77	3.21	5.15	**11**	6.61	13.23	26.15	**46**	**3030**	**35**		
500yr	3.82	3.47	6.73	**14**	9.71	14.37	34.86	**59**	**3909**	**45**		
150% 500yr	6.51	3.95	10.27	**21**	16.76	16.23	50.08	**83**	**5863.5**	**62**		

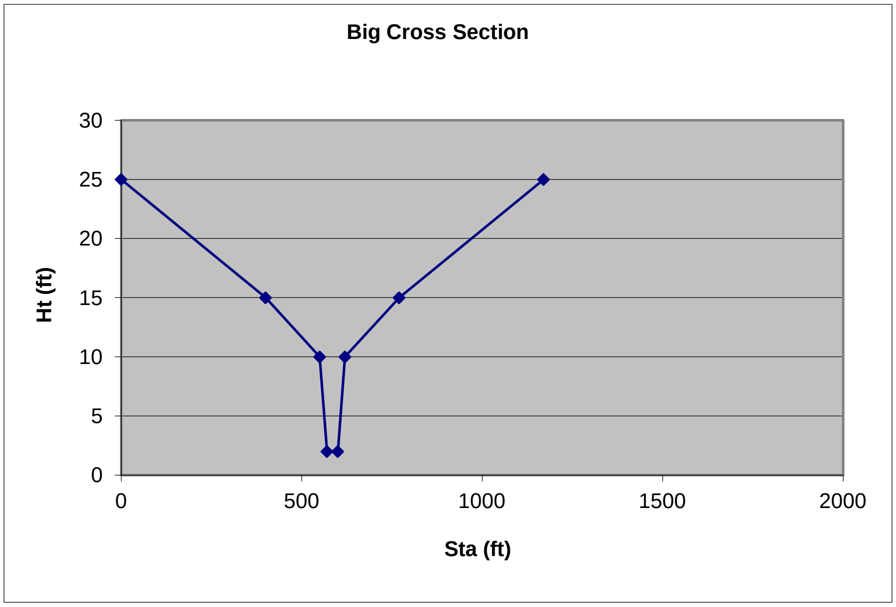
Velocity is avg of 100yr US and DS.

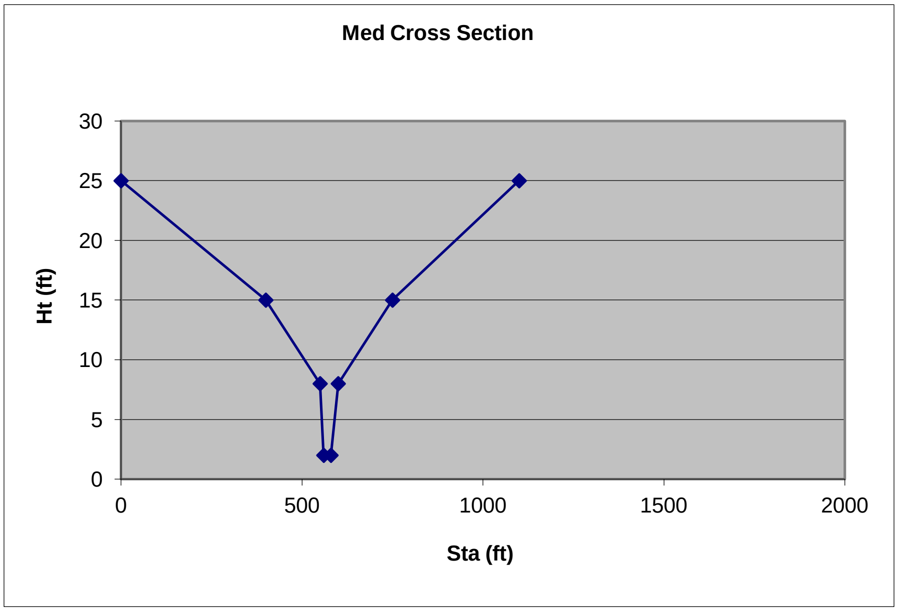
Appendix HH-C – Ultimate Impervious Values Based on Zoning

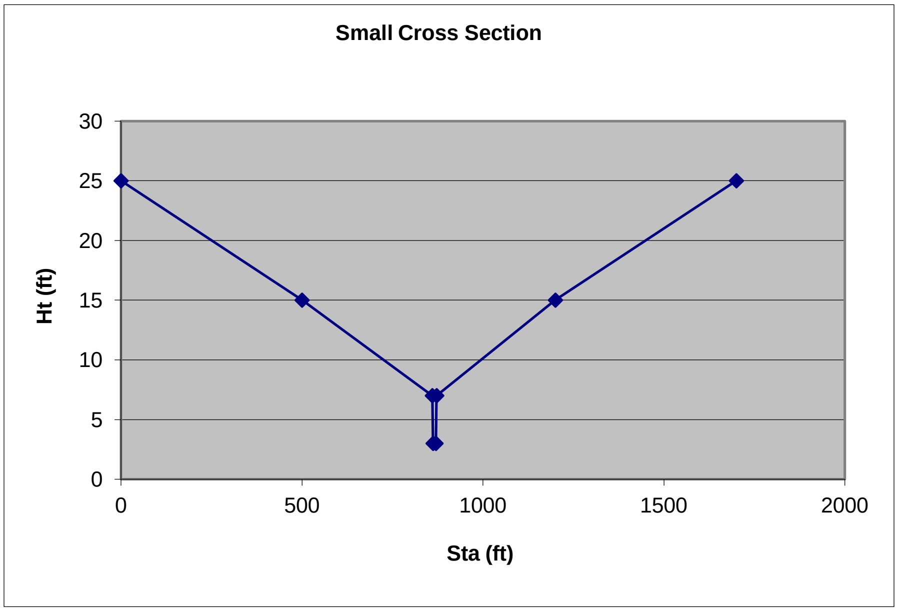
These impervious percentages have been estimated by the City of Springfield's Storm Water Services Division for the purpose of estimating runoff for the USACE Jordan Creek Study.

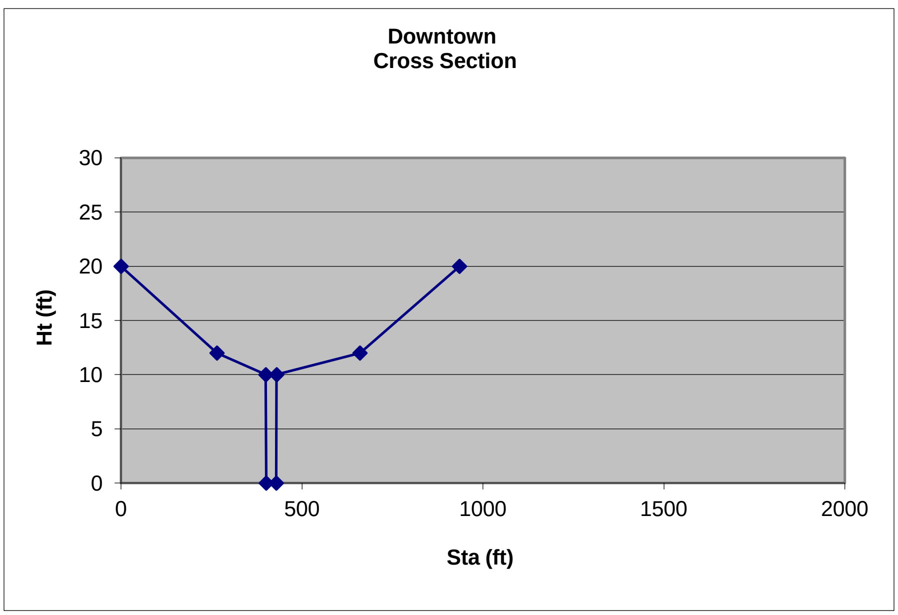
Zoning District	Description	% Impervious
R-SF	Single Family Residential	25
R-TH	Townhouse Residential	40
R-LD	Low-Density Multi-Family Residential	45
PD	Planned Development	85
AO	Airport Overlay	75
LB	Limited Business	60
GR	General Retail	75
HC	Highway Commercial	85
CS	Commercial Service	72
CC	Center City	72
RI	Restricted Industrial	72
LI	Light Industrial	70
R-MD	Medium-Density Multi-Family Residential	55
R-HD	High-Density Multi-Family Residential	60
R-MHC	Manufactured Homes	20
O-1	Office	70
O-1	Office	70
GI	Governmental and Institutional	80
UN	University	40
UC	Urban Conservation	10
L	Landmarks	45
GM	General Manufacturing	80
HM	Heavy Manufacturing	80
IC	Industrial Commercial	85

Appendix HH-D – Dynamic Routing Cross Sections






Small Cross Section
30
25
20
15
10
5
0
Ht (ft)
0
500
1000
1500
2000
Sta (ft)


Downtown
Cross Section
30
25
20
15
10
5
0
Ht (ft)
0
500
1000
1500
2000
Sta (ft)

Appendix HH-E – Historic Flood Photos

South Branch of Jordan Creek at Fremont Avenue (looking South along Fremont Ave) July 12, 2000 South Branch RS 4647

South Branch of Jordan Creek at National Avenue and Chestnut Expressway (looking South along National Ave) July 12, 2000. Note that the depth of water at this time is approximately 2-feet over National. This photo was taken after the peak of the storm has occurred.

South Branch RS 2830.

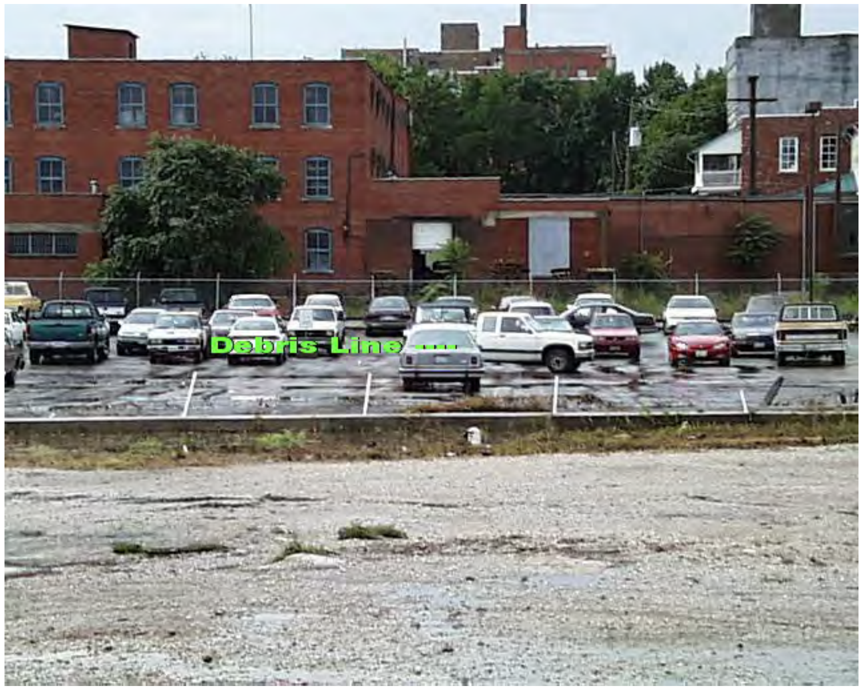
South Branch of Jordan Creek (looking south at Pharmaceutical Manufacturing Plant South of Bennett Street) July 12, 2000. This photo was taken at approximately 6:30 AM, after the peak flow had occurred. Many structures in this facility were flooded during this event.

(Lower Branch RS 621)

South Branch of Jordan Creek (looking south across Chestnut Expressway and the river valley, just downstream of National Avenue (Lower Branch RS 2174). July 12, 2000.

Lower Branch of Jordan Creek. 210 N Nettleton Avenue (Lower Branch RS 9211). The debris line on the garage door measures 34-inches from the floor. The FFE of the building is 1248.14, giving a WSE of 1250.97. This photo was taken after flood waters receded on July 12, 2000. See Appendix F for WSE comparison.

North Branch of Jordan Creek, on N Hampton Avenue crossing. (North Branch RS 3825). The debris line on the ground is estimated at elevation 1292+. This photo was taken after flood waters receded on July 12, 2000. See Appendix F for WSE comparison.



Lower Branch of Jordan Creek, at 410 N Boonville Avenue (between Lower Branch RS 14607 & 14941). The ground elevation is estimated at 1269.5 with an estimated distance of 3.5-ft to the top of the trunk. This photo was taken after flood waters receded on July 12, 2000. See Appendix F for WSE comparison.

Appendix HH-F – Model Comparisons with Observed High Water Marks and Stream Gage Data

The following appendix shows a comparison of the Without Project Current Conditions hydraulic and hydrologic models with stream gage data and observed high water marks from various recorded storm events. These comparisons do not attempt to comment on the accuracy of the models nor do they constitute a model calibration. The accuracy of many of these observations is subject to the time the observation was made, the accuracy with which the high water mark was estimated, the accuracy of available rainfall data, and the precision of the gage data.

Storm Event	Location of Observation	Notes	Estimated Flood Height	Corresponding WSE from "Jordan Creek Feasibility Study"	Difference
12-Jul-00	410 N Boonville Ave between RS 14607 and 14941 on Lower Branch	Flood height estimated from photo of a car in parking lot showing a debris line on trunk. Used limited survey data to establish ground elevation.	1273	1274.5	-1.5
12-Jul-00	634 E Phelps, 120-ft downstream of RS 248 on South Branch	Flood height reported by Commercial Metals	1275	1277	-2
12-Jul-00	509 N Washington Ave. at RS 16377 on Lower Branch	Flood height reported by property owner	1275.9	1276.68	-0.78
12-Jul-00	N Hampton Ave. upstream of RS 3825 on North Branch	Flood height estimated from photo of debris line and limited survey data.	1292	1292.68	-0.68

12-Jul-00	210 N Nettleton Ave. at RS 9211	Flood height estimated from photo of debris line and FFE survey of building.	1250.97	1252.97	-2
12-Jul-00	Pharmaceutical Manufacturing Plant - Downstream of Bennett Street on Lower Branch	WSE reported from stream gage.	1219.8	1219.95	-0.15
13-Jun-08	634 E Phelps, 120-ft downstream of RS 248 on South Branch	Flood height reported by Commercial Metals	1273.5	*1275.2 (10-yr) 1275.78 (25-yr)	**-1.99
13-Jun-08	509 N Washington Ave. at RS 16377 on Lower Branch	Flood height reported by property owner	1273.5	*1274.54 (10-yr) 1275.55 (25-yr)	**-1.55
13-Jun-08	600 N Prospect Ave. at RS 3977	Measured debris line from floor of building. FFE is known.	1290.9	*1290.37 (10-yr) 1290.69 (25-yr)	**.37

*Estimated frequency of storm is 10 to 25-yr.

**Average of 10-yr and 25-yr WSE was used for comparison.

Storm Event	USGS Gage at Scenic Ave. (Gage #07052000)	Estimated Frequency of Storm from City's Rain Gage Network	Peak Flow from "Jordan Creek Feasibility Study"
12-Jul-00	*6750	50-100yr	8355-9859 cfs
8-May-02	4360 cfs	5yr	4457 cfs
15-Sep-05	2890 cfs	2-5 yr	**3303-3914 cfs
13-Jun-08	5760 cfs	10-25yr (2 gages reporting 10-yr, 1 gage reporting 25-yr)	5530-6995 cfs

*Gage data was shown to be incorrect. USGS revised the reading, but there still may be issues with its accuracy.

**Peak flows are a result of simulating the 1 and 2hr storm events.

Appendix HH-G – October 2004 Stream Photos

The following appendix includes photos and documentation from the site visit taken by Travis Stanford, CEWL-EC-HH on October 25-29, 2004:

DATE: 5-Nov-04
REF: Springfield, MO - Section 905b Study
SUBJ: Notes from Site Visit of 25-29 October 2004
BY: Travis Stanford, CESWL-EC-HH

<u>The site visit included field inspection of the following stream reaches:</u>

North Branch Jordan Creek:	Packer Road crossing D/S to confluence with South Branch Jordan Creek
South Branch Jordan Creek:	Cedarbrook Avenue crossing D/S to confluence with North Branch Jordan Creek
Jordan Creek:	Head of Jordan Creek at confluence of North and South Branches D/S to head of Wilson Creek at confluence of Jordan Creek with Fassnight Creek
Wilson Creek:	Head of Wilson Creek at confluence of Jordan Creek with Fassnight Creek D/S to U.S. Hwy 160 (West Bypass) crossing

<u>The site visit included field inspection of the following tunnels:</u>

Jordan Underground Tunnel
North Branch Fremont to National Tunnel
South Branch Fremont to National Tunnel
Tindle Mills Tunnel
Cooper Supply and RR Tunnel

Insp. Date: **26-Oct-04**

North Branch Jordan Creek

Walked D/S from Packer Road crossing to confluence of North Branch with South Branch just east of Washington St. at U/S end of Jordan Underground.

RR embankments in vicinity of Packer Road crossing form three significant detention areas U/S of Packer Road and one lesser detention area D/S of Packer Road, all of which feed North Branch Jordan Creek.

Photo Sequence #	Filename	Description / Notes
14	DCP_3683	D/S from Packer Road crossing.
		Riprap channel bed lining extends D/S about 700 FT then intermittent stretches of riprap and natural cobble to U/S end of detention pond. Grasslined side slopes typical this reach. Packer Road to detention pond reach reconstructed about 10 years ago as per Errin Kemper.
15	DCP_3684	D/S from about 700 FT below Packer Road. Directly behind first business on left bank downstream of and fronting on Packer Road.
16	DCP_3685	D/S from U/S end of detention pond constructed by the city. Blaine St. runs along south side of basin (to left of photo). Pond outlet is just U/S of intersection of Blaine St. with Old Orchard St.
17	DCP_3686	D/S from right bank levee at detention pond outlet.
18	DCP_3687	D/S at Blaine St. north side ditch at confluence with detention pond outlet.
		+/- 1.5 hours after brief morning storm observed leading edge of runoff migrating down Blaine St. south side ditch at this location.
19	DCP_3688	D/S from intersection of Blaine and Yates.
20	DCP_3689	U/S at ditch on west side of Yates from intersection of Blaine and Yates.
		Eastmost route for Industrial Park runoff into North Branch Jordan Creek. Observed leading edge of runoff migrating down this ditch at about 0930 hours.
21	DCP_3690	D/S at +/- 2.5 FT tall low flow diversion structure. Intersection of Blaine and Hayes is to left of photo.
		Structure diverts flow from the north side to the south side of Blaine through a culvert which connects to the culvert at the Hayes St. crossing of the ditch on the south side of Blaine. Flow overtopping the diversion structure continues D/S in the north side ditch to the intersection of Blaine and Barnes where high flows overtop Blaine and flow across the Blaine/Barnes intersection into the channel D/S of Barnes.
22	DCP_3691	D/S at Hayes St. crossing of the ditch along the south side of Blaine St.
23	DCP_3692	D/S from intersection of Barnes and Blaine.
		Channel migrates southward from Blaine St. Channel changes abruptly from clean grasslined above Barnes St. to thick brushy banks below Barnes St.
24	DCP_3693	D/S at channel from D/S face of Barnes St.
25	DCP_3694	Location is D/S of Barnes St. where business drive to Springfield Bumper and Body Parts crosses channel. Looking U/S at channel.
26	DCP_3695	Location is D/S of Barnes St. where business drive to Springfield Bumper and Body Parts crosses channel. Looking D/S at channel. Crossing seen just D/S is business drive to Design Fabrication.
27	DCP_3696	Location is detention pond behind Cabinet Mart, Inc. on south side of Blaine between Barnes and Glenstone. Looking D/S at detention pond wall along right bank of channel.
28	DCP_3697	Location is detention pond behind Cabinet Mart, Inc. on south side of Blaine between Barnes and Glenstone. Looking D/S at channel from D/S (SW) corner of detention pond where detention pond low flow outlet is located.
29	DCP_3698	Location is detention pond behind Cabinet Mart, Inc. on south side of Blaine

		between Barnes and Glenstone. Looking U/S from left bank just below detention pond outlet located at SW corner of pond. Low flow outlet active but not visible. Clogged but flowing this day.
		Incised channel with wooded and thicketed overbanks typical from Cabinet Mart detention pond outlet D/S to +/- 600 FT U/S of Glenstone, then transitions to broad broad wetland type area (thick grass/weeds and scattered willows) that continues D/S to parking lots U/S of Glenstone crossing.
30	DCP_3699	D/S from left bank at culverts under parking lot and Glenstone.
31	DCP_3700	U/S from U/S end of culverts under parking lot and Glenstone.
32	DCP_3701	D/S from D/S end of culverts under parking lot and Glenstone.
33	DCP_3702	D/S from right bank at D/S end of culverts under parking lot and Glenstone.
		Box culvert storm drain contributes flow from right bank (bottom right of photo); Pipe contributes left bank. Culvert crosses under Glenstone just north of the intersection of Glenstone and Division.
34	DCP_3703	U/S from U/S end of entrance channel to double box under Division St.
		Steep treelined banks typical Glenstone to head of this entrance channel. Note significant drop in channel bed.
35	DCP_3704	D/S from U/S end of entrance channel to double box under Division St.
		Culverts cross Division St. just east of intersection of Division and Fairway St.
36	DCP_3705	D/S from D/S end of Division St. crossing.
37	DCP_3706	U/S at Division St. crossing from left bank just below.
		Note pooled water.
38	DCP_3707	D/S at the most U/S Smith Park footbridge.
		Natural rock channel bed from Glenstone to this first footbridge below Division Street, then masonry stone bed and banks through Smith Park to Fremont St.
39	DCP_3708	D/S from right bank in Smith Park at typical channel section between most U/S footbridge and Fremont St.
		Several drops in channel bed along this reach.
40	DCP_3709	D/S at Fremont to National double box tunnel entrance.
41	DCP_3710	U/S from entrance to right barrel of Fremont to National double box tunnel.
		Channel drops +/- 3 FT over about 275 feet distance from most D/S footbridge in Smith Park to U/S end of tunnel at Fremont.
		As per Errin Kemper City has developed a three phase plan for converting the North Branch Jordan Creek Fremont to National tunnel to open channel. Phase 1 is currently out for bids.

42	DCP_3711	U/S from just D/S of Rogers St. crossing of Fremont to National double box culvert.
43	DCP_3712	D/S from just D/S of Rogers St. crossing of Fremont to National double box culvert.
		Top of tunnel on grade for entire reach.
44	DCP_3713	U/S at Fremont to National tunnel exit from right bank in Silver Springs Park.
		Note vertical drop from tunnel floor to channel bed.
45	DCP_3714	D/S in Silver Springs Park from right bank just D/S of D/S end of Fremont to National tunnel. Cars traveling National St. to left of photo.
46	DCP_3715	D/S from right bank about 50 FT U/S of footbridge in Silver Springs Park. U/S end of Hampton St. double box crossing in distance.
47	DCP_3716	D/S from D/S end of Hampton St. double box crossing.
48	DCP_3717	D/S from right bank +/- 150 FT D/S of Hampton St. crossing where channel bends sharply to the left.
		Willows across channel not as thick as appears in this photo.
49	DCP_3718	U/S at typical channel with gabion side walls between Hampton and Sherman.
50	DCP_3719	D/S from right bank just above Sherman St. double box crossing.
51	DCP_3720	D/S at entrance to double box under parking lot immediately D/S of Sherman St.
		About 15 FT distance between D/S face of Sherman St. crossing and U/S face of this double box under the parking lot.
66	DCP_3734	U/S at exit of double box beneath parking lot located immediately D/S of Sherman St.
65	DCP_3733	D/S at entrance of Central St. single barrel box from right edge of channel +/- 100 FT U/S.
		Channel bends sharp left and drops +/- 2 FT over about 10 feet distance into mouth of culvert.
64	DCP_3732	D/S at entrance to Central St. single barrel box from right bank just U/S.
53	DCP_3721	D/S from D/S face of Central St. crossing. Entrance to tunnel under Brower St. and Tindle Mills in distance.
54	DCP_3722	U/S from Brower St. D/S end of Central St. crossing in distance.
55	DCP_3723	D/S from U/S face of Chestnut Expressway overpass immediately south of Tindle Mills. Outlet of tunnel under Brower St. and Tindle Mills is in foreground of photo just beyond guardrail. Entrance to tunnel under Cooper Supply Co. lot and RR tracks in distance.
56	DCP_3724	U/S at outlet of tunnel under Brower St. and Tindle Mills from U/S end of tunnel under Cooper Supply Co. lot and RR tracks.
		Open channel beneath Chestnut Expressway between the two tunnels.
57	DCP_3725	U/S into tunnel under Tindle Mills looking through eastmost opening connecting tunnel to loading dock parking lot on south side of Tindle Mills. See photo DCP_3726.
58	DCP_3726	U/S at rectangular openings connecting tunnel under Tindle Mills to loading dock parking lot on south side of Tindle Mills. Photo DCP_3725 taken through rectangular opening to right of this photo. Photo DCP_3727 taken through rectangular opening to left of this photo.
		CMP arch to right of photo not connected to tunnel - carries flow under Tindle Mills from north side of building to south side.

59	DCP_3727	U/S through westmost rectangular opening connecting tunnel under Tindle Mills to loading dock parking lot on south side of Tindle Mills. **Tunnel under Tindle Mills is actually part tunnel and part restricted open channel. Top of wall along right of channel under building is seen to right of photo. Rectangular openings connecting the north side parking lot to the channel beneath the building can be seen (daylight) in distance. +/- 1 FT space between ground and bottom of building support beams.**
60	DCP_3728	D/S from exit of tunnel under Cooper Supply Co. lot and RR tracks.
61	DCP_3729	U/S at exit of tunnel under Cooper Supply Co. lot and RR tracks from 100 FT D/S.
62	DCP_3730	U/S at Chestnut Expressway overpass (and Tindle Mills beyond) from right bank +/- 100 FT below D/S end of tunnel under Cooper Supply Co. lot and RR tracks. Cooper Supply Co. building to right of photo.
63	DCP_3731	D/S at entrance to Jordan Underground from left bank of South Branch Jordan Creek at confluence with North Branch Jordan Creek.

Insp. Date: **27-Oct-04**

South Branch Jordan Creek

Walked D/S from Cedarbrook Avenue crossing to confluence of South Branch with North Branch just east of Washington St. at U/S end of Jordan Underground.

RR embankments in vicinity of Packer Road crossing form three significant detention areas U/S of Packer Road and one lesser detention area D/S of Packer Road, all of which feed North Branch Jordan Creek.

Photo Sequence #	Filename	Description / Notes
P29	DCP_3763	U/S from U/S end of Cedarwood Avenue double box crossing. U/S face vertical; no wingwalls.
P30	DCP_3764	D/S from D/S end of Cedarwood Avenue double box crossing. Tapered wingwalls parallel to channel this end of culvert. Looking west across Glenwood Park detention basin at outlet in distance.
P31	DCP_3765	U/S (east) from Glenwood Park detention basin outlet. Cedarwood Avenue double box crossing in distance.
P32	DCP_3766	D/S (west) from Glenwood Park detention basin outlet. Burton St. single barrel culvert crossing in distance.
P33	DCP_3767	D/S from Burton St. crossing at typical concrete lined channel extending from Burton to Belview St. along north side of Rockhurst St. Channel crossed by numerous private drives and a few streets.
P34	DCP_3768	U/S from Belview St. crossing.
P35	DCP_3769	U/S from intersection of Belview and Rockhurst at typical ditch along south side of Rockhurst between Burton and Patterson St.
P36	DCP_3770	D/S from Belview St. crossing.
P37	DCP_3771	D/S from Patterson St. crossing. Concrete apron extends 50 FT D/S of Patterson then transitions to natural channel. Medium to large chunks of rock and concrete in channel bed for +/- 100 FT beyond end of concrete apron, then cobbles anf gravel. Thicket cover medium to dense both banks.
P38	DCP_3772	U/S at Patterson crossing from 50 FT D/S. Main channel double box to left of photo. Single box to right of photo carries flow from the ditch along the south side of Rockhurst.
P39	DCP_3773	D/S from +/- 500 FT below Patterson. Soccer fields in ROB.
P40	DCP_3774	Looking north from top RB at detention pond outlet along west side of soccer fields in ROB between Patterson Avenue and Lincoln Cemetary.
P41	DCP_3775	D/S from a point opposite Lincoln Cemetary on ROB.
P42	DCP_3776	U/S at low weir (+/- 2.5 FT above channel bed) located about 200 FT D/S of SW corner of Lincoln Cemetary.
P43	DCP_3777	D/S from just below low weir shown in photo DCP_3776.
P44	DCP_3778	D/S at Chestnut Expressway triple box crossing.
P45	DCP_3779	U/S from +/- 100 FT U/S of U/S end of Chestnut Expressway crossing.
P46	DCP_3780	D/S from Chestnut Expressway triple box crossing. Trafficway St. upstream crossing in distance to left of photo.
P47	DCP_3781	U/S at exit of Chestnut Expressway crossing.

P48	DCP_3782	D/S at upstream Trafficway St. triple box crossing.
P49	DCP_3783	D/S at RR crossing below upstream Trafficway St. crossing from +/- 100 FT U/S.
P50	DCP_3784	U/S from +/- 100 FT above RR crossing just below upstream Trafficway St. crossing.
P51	DCP_3785	D/S from atop RR crossing just below upstream Trafficway St. crossing. Tributary enters on LB immediately below RR crossing.
P52	DCP_3786	U/S at RR crossing below upstream Trafficway St. crossing from LB in center of channel bend to right +/- 300 FT below RR crossing.
P53	DCP_3787	D/S from from LB in center of channel bend to right +/- 300 FT below RR crossing below upstream Trafficway St. crossing.
P54	DCP_3788	D/S at downstream Trafficway St. crossing from RB +/- 150 FT U/S of crossing. Culverts appeat to have recently been extended U/S to facilitate left bank parking lot expansion. Current total length +/- 200 FT.
P55	DCP_3789	D/S from LB in center of sharp right bend +/- 150 FT below downstream Trafficway St. crossing. Looking at the upstream of two closely spaced RR crossings where RR splits just U/S of Glenstone St. overpass.
P56	DCP_3790	U/S at downstream Trafficway St. crossing from LB +/-150 FT D/S.
P57	DCP_3791	U/S at the downstream of two closely spaced RR crossings where RR splits just U/S of Glenstone St. overpass.
P58	DCP_3792	D/S at Glenstone St. bridge. D/S of Glenstone the uniform trapezoidal channel transitions to incised channel with thick brush on steep banks. NOTE: Bridge shown in aerial photos +/- 100 FT D/S of Glenstone no longer exists. Apparently moved to location +/- 350 FT D/S of Glenstone (see photo DCP_3794)
P59	DCP_3793	D/S from +/- 150 FT D/S of Glenstone.
P60	DCP_3794	U/S at double box crossing behind Pinnacle Sign Co. +/- 350 FT D/S of Glenstone.
P61	DCP_3795	D/S from double box crossing behind Pinnacle Sign Co. +/- 350 FT D/S of Glenstone.
		+/- 200 FT D/S of Pinnacle Sign Co. crossing the stream braids through a mini-bottomland area with significant log/debris jams. A significant tributary enters on the RB about 500 FT below this double box crossing.
P62	DCP_3796	U/S at main channel from confluence with right bank tributary.
P63	DCP_3797	U/S at right bank tributary from confluence with main channel.
P64	DCP_3798	D/S from confluence.
P65	DCP_3799	D/S from +/- 150 FT below confluence of right bank tributary. From this point the stream parallels the RR tracks on the north side of the tracks down to Fremont St.
P66	DCP_3800	D/S from about half-way between confluence of right bank tributary and Fremont St. Log/debris jam functioning as +/- 3 FT tall weir.
P67	DCP_3801	U/S from about half-way between confluence of right bank tributary and Fremont St. Log/debris jam functioning as +/- 3 FT tall weir.
P17	DCP_3751	D/S at Fremont St. double barrel crossing from LB +/- 100 FT U/S.
P16	DCP_3750	U/S from Fremont St. crossing.
P15	DCP_3749	D/S from Fremont St. crossing. Entrance to Fremont to National tunnel is +/-180 FT D/S of Fremont St.

P14	DCP_3748	U/S at Fremont St. crossing from LB +/- 100 FT D/S
P68	DCP_3802	D/S from D/S end of Fremont to National tunnel located +/- 150 FT D/S of National St.
P69	DCP_3803	U/S from end of concrete channel +/- 300 FT below D/S end of Fremont to National tunnel. 30-inch diameter storm drain enters from right bank this location.
P70	DCP_3804	D/S from end of concrete channel +/- 300 FT below D/S end of Fremont to National tunnel. Rock riffle at this location backs water an estimated 700 FT.
P71	DCP_3805	U/S from willow tree debris jam functioning as +/- 3 FT weir. Location is +/- 130 FT D/S of west end of DOC warehouse building sitting on left bank. Willow growing horizontally across channel from right bank. Vertical limestone left bank; steep vegetated right bank.
P72	DCP_3806	D/S from willow tree debris jam functioning as +/- 3 FT weir. Vertical limestone LB; steep vegetated RB. Debris on right side of channel D/S is dilapidated masonry retaining wall.
P73	DCP_3807	Looking down from LB on willow tree debris jam functioning as +/- 3 FT weir.
P74	DCP_3808	U/S from driveway bridge across channel at Concrete Co. of Springfield.
P75	DCP_3809	D/S from driveway bridge across channel at Concrete Co. of Springfield.
P76	DCP_3810	U/S at driveway bridge across channel at Concrete Co. of Springfield from +/- 50 FT D/S.
P77	DCP_3811	D/S at Sherman St. crossing.
P78	DCP_3812	D/S from atop Sherman St. crossing.
P79	DCP_3813	U/S at RR crossing just below Sherman St.
P80	DCP_3814	D/S from RR crossing just below Sherman St. Channel parallels Phelps St. on north side of Phelps down to confluence of South Branch with North Branch at U/S end of Jordan Underground. Two driveways cross the channel between this RR crossing and the confluence.

At 1500 hours flow in channel is +/- 4 inches deep in channel thalweg formed by channel bottom that drops about 6 inches from sidewalls to center.

Heavy rain begins about 1508 hours. Heavy rainfall transitions to light rain in about 1 minute at about 1530 hours.

Watched water rise about 1.5 FT from 1524 to 1544 hours.

At 1550 hours estimated 15 fps velocity in South Branch channel just U/S of confluence with North Branch. Velocity high but noticeably slower in North Branch.

Insp. Date: **28-Oct-04**

Jordan Creek

Walked D/S from Main St. crossing to confluence of Jordan and Fassnight Creeks at head of Wilson Creek.

Photo Sequence #	Filename	Description / Notes
P10	DCP_3679	D/S at channel and Main St. crossing from D/S end of Jordan Underground left barrel.
P11	DCP_3680	D/S from D/S face of Main St. bridge.
P12	DCP_3681	D/S from location of confluence of left bank tributary +/- 100 FT below Main St. bridge.
P13	DCP_3682	U/S at left bank tributary from confluence with Jordan Creek +/- 100 FT below Main St. bridge.
		P10 thru P13 shot on 25 Oct 04.
P1	2004_10280003	D/S at ROB from U/S side of Main St. Trees and low concrete wall to left are on RB of Jordan Creek.
		Appears a significant amount of ROB overland flow crossing Main St. probably does not enter the Jordan Creek channel immediately D/S fo the Jordan Underground exit due to high ground and low concrete wall along the RB of Jordan Creek that extends D/S from the Main St. bridge and ends +/- 50 FT U/S of the U/S face of the Grant St. overpass. Appears ROB overland flow would enter the Jordan Creek channel significantly at and below the Grant St. overpass.
		D/S of the Grant St. overpass the ROB is old gravel paved area between Jordan Creek and the RR tracks in the ROB.
P2	2004_10280004	D/S at building over creek +/- 100 FT D/S of D/S face of Grant St. overpass.
P3	2004_10280005	U/S at Grant St. overpass from U/S face of building over creek +/- 100 FT D/S of D/S face of overpass.
		Unable to estimate what appeared to be a significant grade change at rock riffle beneath the Grant St. overpass.
P4	2004_10280006	D/S from D/S face of building over creek +/- 100 FT D/S of D/S face of Grant St. overpass.
		Standing atop what appears to be a pair of 5 FT outside diameter storm sewer risers that stick up +/- 6 FT above the channel bed. Risers are in line with flow, thus block a 5 FT width of the right side of the channel. RB tributary enters through double box +/- 20 FT D/S of D/S face of building over creek.
P5	2004_10280007	U/S from +/- 100 FT U/S of RR crossing. Building over creek and Grant St. overpass in background.
P6	2004_10280008	D/S from +/- 100 FT U/S of RR crossing.
P7	2004_10280009	D/S from D/S face of RR bridge.
P8	2004_10280010	D/S from +/- 600 FT below RR bridge.
		Noted a number of rock riffle channel bed elevation changes from RR bridge down to this point.
P9	2004_10280011	D/S from +/-750 FT U/S of Fort St. crossing at point opposite small mountain of concrete waste on ROB near creek.
		Note concrete washed into channel from upslope.
		Observed what appeared to be a transient encampment on the RB +/- 500 FT below the small mountain of concrete waste.
P10	2004_10280012	D/S from left edge of channel at D/S face of Fort St. bridge. Note significant ponding U/S of this rock/debris riffle.
		Note ponding U/S of this rock/debris riffle.
P11	2004_10280013	U/S at Fort St. bridge from channel +/- 60 FT D/S. Left and right overbanks at this crossing noticeably higher elevation than top of roadway.
		Left and right overbanks at this crossing noticeably higher elevation than top of roadway.
P12	2004_10280014	D/S at remnants of old crossing structure +/-350 FT below Fort St. crossing.
P13	2004_10280015	D/S from remnants of old crossing structure +/-350 Ft below Fort St. crossing.
P14	2004_10280016	U/S at remnants of old crossing structure +/-350 Ft below Fort St. crossing from +/- 60 FT D/S.

		+/- 250 FT D/S of this old structure the creek bends sharply left and passes under a RR and College St.
P15	2004_10280017	D/S at College St. crossing from atop RR crossing just U/S of College St.
P16	2004_10280018	U/S at RR crossing from U/S face right end of College St. crossing.
P17	2004_10280019	D/S from D/S face left end of College St. crossing.
		Vertical wall left side of channel for +/- 250 FT D/S of College St. Note what appears to be rock riffle / channel restriction in vicinity of end of wall.
P18	2004_10280020	**Rock/debris forms low water dam at D/S end of left barrel at College st. crossing.**
P19	2004_10280021	D/S at Walnut St. bridge from +/- 100 FT U/S.
		Bridge deck is skewed but barrels are aligned +/- parallel to flow.
P20	2004_10280022	U/S from atop U/S face of Walnut St. bridge.
		Rock riffle in distance appears significant but cannot estimate elevation drop.
P21	2004_10280023	D/S from atop D/S face of Walnut St. bridge.
P22	2004_10280024	Looking west from center of Walnut St. crossing at intersection of Walnut St. with Kansas Expressway.
		Observation of intersection topography - low point in Kansas Expwy is just south of where RR crosses Kansas Expwy on grde between College and Walnut Streets. High flow in ROB will first overtop Kansas Expwy at this point, cross Walnut St. just west of Kansas Expwy, and flow into the ROB D/S of Walnut and west of Kansas Expwy.
P23	2004_10280025	D/S from +/-150 FT U/S of Kansas Expwy.
		Significant rock deposit island around willows on left side of channel. Noted 4 FT diameter storm drain enters from RB just U/S of Kansas Expwy.
P24	2004_10280026	Creek under Kansas Expwy from RB at U/S end of right abutment.
P25	2004_10280027	D/S from right edge of channel beneath center of northbound (U/S) lanes.
		Large rock/debris island in center of channel at D/S face of bridge. Requires flow depth to +/- 10 FT below bridge low chord to submerge solid part of island (excluding vegetation growing from island). Flow passes to right and left of island.
P26	2004_10280028	U/S from left edge of channel at D/S face of Kansas Expwy bridge.
		Note island at U/S face of bridge on left side of channel (right side of this photo) and gravel bar extending U/S in center of channel under bridge.
P27	2004_10280029	D/S from atop D/S face of Kansas Expwy. Standing +/- 40 FT riverward of U/S end of right abutment.
P28	2004_10280030	U/S at Mt Vernon triple box bridge from +/- 100 FT D/S.
P29	2004_10280031	D/S from +/- 100 FT D/S of Mt. Vernon St. crossing.
		Channel contraction in photo is +/- 200 FT D/S of Mt. Vernon St. crossing.
P30	2004_10280032	U/S from atop U/S face of Mt. Vernon St. crossing.
		D/S of Kansas Expwy began to note more significant pooling of water U/S of riffles as evidenced by lower velocity in pools and began to see gravel and coarse sand deposits.
P31	2004_10280033	D/S at ROB +/- 800 FT below Mt. Vernon St. crossing.
		Typical bottomland environment. Medium density undergrowth with light amount of deadfalls; not as dense as appears in photo. Discovered maintained walking path on right bank alongside creek. Did not see upstream terninus on way down RR tracks from Mt. Vernon St.
		Where's Waldo? Near the center of this photo is a nice sized whitetail deer staring at the camera.
P32	2004_10280034	U/S from left edge of channel +/- 900 FT below Mt. Vernon St. crossing.
P33	2004_10280035	D/S from left edge of channel +/- 900 FT below Mt. Vernon St. crossing.
		Note exposed rock slabs on left edge of channel and gravel bed just U/S of them.
P34	2004_10280036	**Typical wooded overbank between Mt. Vernon and Grand Street crossings. Generally thin to medium density undergrowth between well spaced trees with**

		occassional deadfalls. Ground carpeted with vinelike vegetation.
P35	2004_10280037	See description of photo 2004_10280036.
P36	2004_10280038	U/S from minor rock riffle +/- 250 FT above Grand St. crossing.
		Looking at D/S end of major rock riffle that appears to drop several feet over a relatively short distance.
		Located major rock riffle next morning. Left bank tributary passes under Kansas Expwy +/- 570 FT north of the intersection of Kansas Expwy and Grand St. and enters enters Jordan Creek 100 FT D/S at about midway of the riffle. Riffle easily accessed from tributary crossing of Kansas Expwy. Estimate +/- 6 FT drop in elevation of channel bed over about 250 feet distance along the creek.
P37	2004_10280039	D/S at Grand St. crossing from right edge of channel at minor rock riffle +/- 250 FT U/S.
		Tributary enters on right bank +/- 200 FT U/S of Grand St. crossing. Do not know if it carries runoff from the west side of the RR tracks.
P38	2004_10280040	D/S from D/S face of Grant St. bridge at left abutment.
		Note rough finished concrete weir +/- 40 FT D/S of bridge.
P39	2004_10280041	D/S from right edge of channel +/- 500 FT below Grand St. crossing.
		Rock riffle +/- 50 FT D/S.
P40	2004_10280042	U/S from at concrete encased pipe that forms weir +/- 300 FT U/S of Catalpa St. crossing.
		Photo taken from atop concrete foundation/encasement around base of power pole on right edge of channel about 50 FT below weir.
P41	2004_10280043	U/S from atop U/S face of Catalpa St. crossing.
P42	2004_10280044	D/S from atop D/S face of Catalpa St. crossing at right end of bridge.
		Catalpa street bridge noticeably perched. Flood flows will overtop roadway left of bridge first.
P43	2004_10280045	U/S from right edge of channel +/- 250 Ft below Catalpa St. crossing.
P44	2004_10280046	D/S from +/- 500 FT below Catalpa St.
		Creek begins to assume a more winding pattern below Catalpa Street.
P45	2004_10280047	D/S from right edge of channel between Catalpa and Bennett St
		Gravel point bar in bend.
P46	2004_10280048	D/S from right edge of channel +/- 350 FT U/S of Bennett St. crossing.
P47	2004_10280049	Standing at intersection of Bennett St. and RR mainline just west of Bennett St. crossing of Jordan Creek. Looking +/- NE at rock dike.
		Crown of rock dike +/- 4 FT higher than RR tracks but dike will first overtop where right end of dike ties into RR embankment. Overflow of any significant duration may be expected to erode the RR embankment and/or the rock dike.
P48	2004_10280050	Looking west along Bennett St. from U/S side of Bennett St. bridge at right abutment.
		Left end of rock dike shown in photo 2004_10280049 can be seen here ending on the west side of the paved entrance to a substantial area of ROB fill. Ditch to right of photo connected directly to Jordan Creek immediately U/S of Bennett St. bridge on RB.
		Expected to find a significant culvert under Bennett St. immediately west of the RR tracks but could not locate. If one exists at this location it is small and/or clogged and overgrown.
		D/S of Mt. Vernon St. the RR on the right bank transitions from constructed on grade to embankment above grade which continues down to the Wilson Creek crossing just below the head of Wilson Creek at the confluence of Jordan and Fassnight Creeks. Appears from some point just below Mt. Vernon St. runoff from west of the RR tracks passes down the west side of the RR embankment to Wilson Creek, but may have missed connections which allow runoff from west of the tracks to flow into Jordan Creek.
		Post-field trip inspection of contours and aerial photography indicates there may be an opening through the RR embankment about 1600 FT south of Mt. Vernon St as measured along the RR tracks. This correlates with the tributary observed entering the right bank of Jordan Creek +/- 200 FT U/S of the Grand St. crossing.
P49	2004_10280051	D/S from atop Bennett St. crossing.
		1415 hours - received permission from Clariant security (bob McCoy) to walk along creek through Clariant property.

P50	2004_10280052	U/S from +/- 150 FT below Bennett St. bridge. **Note Clariant LOB parking lot fill posing flow restriction as flow exits bridge opening. Bridge opening otherwise quite hydraulically efficient - abutment slopes concrete paved and radiused U/S and D/S of both abutments. Bridge significantly perched with 30-inch curb walls U/S and D/S. Roadway will overtop bridge to left and right before bridge overtops.**
P51	2004_10280053	D/S from +/- 150 FT below Bennett St. bridge.
P52	2004_10280054	U/S from LOB at first footbridge D/S of Bennett St.
P53	2004_10280055	U/S from LOB at second footbridge D/S of Bennett St.
P54	2004_10280056	D/S at Wilson Creek from head at confluence of Jordan and Fassnight Creeks.
P55	2004_10280057	U/S at Jordan Creek from head of Wilson Creek at confluence of Jordan and Fassnight Creeks.
P56	2004_10280058	U/S at Fassnight Creek from head of Wilson Creek at confluence of Jordan (at left of photo) and Fassnight Creeks. **Clariant RB floodwall extends from Bennett St. bridge down past confluence of Jordan and Fassnight Creeks, along RB of Wilson Creek, and ties in to the RR embankment.**

Insp. Date: **28-Oct-04**

Wilson Creek

Walked D/S from head of Wilson Creek at confluence of Jordan and Fassnight Creeks to U.S. Hwy 160 (West Bypass) crossing.

Photo Sequence #	Filename	Description / Notes
P54	2004_10280056	D/S at Wilson Creek from head at confluence of Jordan and Fassnight Creeks.
P57	2004_10280059	D/S at RR crossing located +/- 450 FT below head of Wilson Creek.
		Departed Clariant property via RR embankment at 1445 hours.
P58	2004_10280060	U/S at RR bridge from +/- 60 FT D/S of right abutment. Looking +/- SE across creek at left abutment.
		Ditch along west side of RR tracks enters Wilson Creek immediately D/S of RR crossing.
P59	2004_10280061	D/S from 20 FT below RR crossing.
P60	2004_10280062	U/S from +/- 120 FT below RR crossing.
P61	2004_10280063	D/S from +/- 150 FT U/S of Scenic Drive crossing.
		USGS gage at Scenic Drive crossing.
P62	2004_10280064	U/S from +/- 200 FT below Scenic Drive crossing.
P63	2004_10280065	D/S from +/- 200 FT below Scenic Drive crossing.
		Note raft of logs and debris right side of channel.
P64	2004_10280066	U/S from +/- 1300 FT below Scenic Drive.
		Log jam has formed debris/sediment bar.
P65	2004_10280067	D/S from +/- 1300 FT below Scenic Drive.
		Channel splits around two islands in succession. U/S island +/- 200 FT long and maximum of about 4 FT tall above channel bed. D/S island starts about 30 FT D/S of U/S island. D/S island +/- 100 FT long and maximum of about 5 FT tall above channel bed. D/S island can be seen to left of photo 2004_10280068.
P66	2004_10280068	D/S from +/- 1500 FT below Scenic Drive.
		ROB undergrowth thin to medium density between Scenic Drive and old Golden St. crossing.
P67	2004_10280069	D/S from +/- 2000 FT below Scenic Drive.
		Channel restriction where +/- 10-inch pipe crosses.
P68	2004_10280070	U/S from +/- 2250 FT below Scenic Drive.
P69	2004_10280071	D/S from +/- 2250 FT below Scenic Drive.
		Channel bends sharply left at this location. Right bank actively eroding in bend.
P70	2004_10280072	D/S at old Golden St. crossing from RB +/- 60 FT U/S.
		Exit geometry typical of entrance geometry.
P71	2004_10280073	D/S from old Golden St. crossing.
		Roadway embankments still in place to left and right of crossing.
P72	2004_10280074	D/S from +/- 600 FT below old Golden St. crossing.
		Tributary enters from right bank at this location. Can be seen to

		right of photo.
P73	2004_10280075	D/S from +/- 1400 FT below old Golden St. crossing.
		Pasture with horses on ROB this location. Medium to dense undergrowth in ROB from pastures to ROB ball fields +/- 1000 FT farther D/S.
P74	2004_10280076	D/S from +/- 1300 FT above U.S. Hwy 160 crossing.
		Tributary enters from RB +/- 800 U/S of U.S. Hwy 160 crossing.
P75	2004_10280077	D/S from +/- 500 FT above U.S. Hwy 160 crossing.
		Medium to heavy density brush/thicket cover in LOB for +/- 700 FT U/S of U.S. Hwy 160.
P76	2004_10280078	D/S at U.S. Hwy 160 crossing. Standing on LB +/- 150 FT U/S of left abutment.
		Three pier bents between abutments all parallel with flow.
P77	2004_10280079	D/S from rock riffle beneath D/S face of U.S. Hwy 160 bridge.
P78	2004_10280080	U/S from rock riffle beneath D/S face of U.S. Hwy 160 bridge.

Insp. Date: **25-Oct-04**

Jordan Creek Underground

Three sections of double box culvert connected by bridge openings, one large single barrel box culvert, and a large opening beneath a building structure.

Walked left barrel from D/S end at Main St. to U/S end at confluence of North and South Branches of Jordan Creek just east of Washington St. Returned D/S through right barrel.

Typical characteristics of the double box culvert sections of the tunnel:

a) Floor of each barrel of the double box culvert slopes from base of walls to center forming triangular low flow section. Center is +/- 1.5 FT lower elevation than wall at base.
b) Exposed aggregate typical for about the middle third of floor.
c) Occasional limited deposits of gravel and rock. May be expected to deposit during flow recession and wash out at high flows.
d) Typically uniform geometry but some changes in cross-sectional area due to differing culvert roof height, occasional roof beams that probably support some overhead structure, and overhead pipes across box culvert barrels.

Photo Sequence #	Filename	Description / Notes
1	DCP_3670	D/S from U/S face of old stonework single arch bridge at Campbell St. crossing.
		Double box culvert transitions to bridge opening at U/S and D/S faces of bridge. Note misalignment on left reduces effective flow area at transition from bridge opening to culvert.
2	DCP_3671	D/S from left barrel just above Campbell Street crossing.
		Note misalignment on left reduces effective flow area where left barrel transitions to bridge opening.
		+/- 1 FT diameter hole in left barrel roof between Campbell and Booneville Streets connects to storm drain catch basin above. Located at about STA 1100 as previously designated by City paint marks on tunnel wall.
3	DCP_3672	U/S from middle of single concrete arch bridge at Booneville St. crossing.
		D/S face of single arch bridge transitions to double box culvert. U/S face of bridge opening transitions to larger single opening underneath building structure supported by concrete columns and steel beams (unseen beyond concrete columns). U/S side of opening under building transitions to large single barrel culvert with some steel beams overhead and floor sloping downward from base of walls to center forming triangular low flow section. Observed small amount of debris and gravel through opening under building and a few large rocks.
4	DCP_3673	D/S from single large culvert at transition from single barrel culvert to opening under building structure located immediately U/S of Booneville St. crossing.
		Overhead steel beams limit effective depth to +/- 8 FT for significant distance under building. Overhead concrete arch also limits effective flow area. Single large culvert extends U/S some distance and transitions to double box culvert which continues to upstream end of tunnel at confluence of North and South Branches of Jordan Creek.
5	DCP_3674	**Typical arch doorway opening observed at random locations provides flow interchange between barrels of double box culvert.**
6	DCP_3675	U/S from U/S end of left barrel at confluence of North Branch Jordan Creek (to left of photo) and South Branch of Jordan Creek (to right of photo).
7	DCP_3676	U/S at gravel bar in right barrel of double box between U/S end (at confluence of North and South branches) and Booneville St.
		In this reach of double box culvert noted more gravel bars in right barrel than left barrel. Most significant deposit observed near D/S end of this reach.
8	DCP_3677	D/S at some larger rocks on floor and overhead steel beams in single barrel upstream of Boonville St.
9	DCP_3678	D/S at opening under building just U/S of Booneville St.
10	DCP_3679	D/S at Main St. bridge from left barrel at D/S end of Jordan Underground

Insp. Date: **27-Oct-04**

North Branch Fremont to National Double Box Tunnel

Walked right barrel from U/S end at Fremont St. to D/S end at National St. Returned U/S through left barrel. Tunnel passes under Fremont, Rogers, Prospect, and National Streets.

General Observations

Controlling flow section appears to be Fremont St. crossing at U/S end of tunnel. However, additional flow enters the tunnel via two lateral storm drains and via street gutters at road crossings.

Variable flow depth and velocity throughout tunnel indicates variations in slope but did not observe any abrupt changes in slope of tunnel floor. Possibly one in vicinity of Rogers St. crossing in left barrel but floor covered with rock deposits.

Fine aggregate typically exposed across width of tunnel floor. Noticeably more in right barrel than left barrel. Flow volume and duration probably greater in right barrel due to connecting lateral storm drains.

Photo Sequence #	Filename	Description / Notes
		Tunnel height increases about 8-inches immediately D/S fo Fremont St. crossing. +/- 6 FT wide X 4 FT high storm drain enters right side of right barrel immediately D/S of Fremont St. Invert of storm drain outlet +/- 1 FT higher than tunnel invert.
P1	DCP_3735	D/S in right barrel.
		Presence of a few large rocks indicative of quite high velocity flow.
P2	DCP_3736	D/S in right barrel.
		Large rocks deposited to left of right barrel just U/S of 30-degree right bend.
		+/- 3 FT wide X 5 FT high storm drain enters right side of right barrel immediately U/S of Prospect St. Invert of storm drain outlet +/- 1 FT higher than tunnel invert.
		Observed +/- 1FT high X 2 FT wide port at base of divider wall between Fremont and Rogers Streets; and a second just D/S of Prospect St.
P3	DCP_3737	U/S in left barrel.
		Large rocks deposited to left of left barrel just U/S of 30-degree right bend.
P4	DCP_3738	U/S in left barrel from just below Rogers St. crossing.
		Rock deposits may be due to widening of left barrel at Rogers St. but notes incomplete. Left barrel widens from +/- 12 FT wide U/S of Rogers St. to +/- 18 FT wide through the Rogers Street crossing, then back down to +/- 12 FT wide D/S of Rogers St. Uncertain if right barrel did the same at the Rogers St. crossing.

Insp. Date: **27-Oct-04**

South Branch Fremont to National Double Box Tunnel

Walked tunnel from U/S end +/- 175 FT below Fremont St. down to within +/- 300 FT of outlet. Could see daylight from outlet but water knee deep at this point. Later this day found cause of backwater - rock riffle +/- 275 FT D/S of tunnel outlet.

General Observations

Tunnel dimensions +/- 8 FT X 8 FT.

Tunnel constructed for hydraulic efficiency. Tunnel bends are smooth large radius curves. Floor of tunnel slopes from sidewalls to center thalweg. +/- 4-inch drop from sidewall to center of tunnel floor.

Photo Sequence #	Filename	Description / Notes
P5	DCP_3739	D/S at U/S end of tunnel.
		Note 1955 stamp on tunnel entrance.
P6	DCP_3740	U/S from just inside U/S end of tunnel.
P7	DCP_3741	D/S at +/- 10-inch pipe crossing tunnel.
P8	DCP_3742	U/S from just D/S of significant grade change.
		Tunnel floor and roof drop +/- 2 FT over about 10 feet distance.
P9	DCP_3743	U/S at +/- 12-inch pipe crossing tunnel.
		Pipe located +/- 30 FT D/S of grade change.
P10	DCP_3744	U/S at lateral tunnel entering from right.
		Lateral tunnel +/- 6 FT X 6FT and 60 FT long. Enters main tunnel about 75 FT D/S of grade change. Lateral tunnel invert +/- 2 FT higher than main tunnel invert. Post-trip inspcetion of topo and aerial photography indicates this lateral tunnel enters the main tunnel about 850 FT U/S of the main tunnel outlet.
P11	DCP_3745	U/S at lateral tunnel inlet.
		Tributary makes sharp left and drops +/- 5 FT into lateral tunnel entrance.
P12	DCP_3746	U/S from U/S end of lateral tunnel.
		Thick rock/gravel deposit across entire floor of main tunnel begins just D/S of lateral tunnel connection, extends D/S +/- 200 FT then transitions back to concrete floor.
P13	DCP_3747	D/S at +/- 12-inch pipe crossing tunnel somewhere D/S of lateral tunnel connection. Barely visible in photo but it is there.

Insp. Date: **27-Oct-04**

Tindle Mills Tunnel

Walked tunnel from D/S end at U/S face of Chestnut Expwy overpass just south of Tindle mills to within +/- FT of U/S end at north side of Brower St. Knee deep water at this point.

General Observations

Tunnel under Tindle Mills is actually part tunnel and part restricted open channel. Top of wall along right of channel under building is below bottom of building support beams. Rectangular openings connect both the north side and south side parking lots to the channel beneath the building. +/- 1 FT space between ground and bottom of building support beams to right of right side retaining wall under building. Uncertain if flow can enter or leave the channel beneath the building at other than the rectangular ports on the U/S and D/S faces of the building and one port observed in left channel wall.

Gravel with medium to large rocks typical in bed of larger section of the tunnel throughout. Smaller dimension sections at the U/S and D/S ends have relatively clean bed with exposed aggregate but also contain gravel deposits along the inside of bends.

Photo Sequence #	Filename	Description / Notes
P56	DCP_3724	U/S at D/S end of tunnel. D/S end of tunnel located approximately coincident with the U/S face of Chestnut Expwy overpass.
		Tunnel +/- 10 FT X 10 FT from D/S end U/S to south (D/S) face of Tindle Mills building.
P18	DCP_3752	D/S from D/S face of loading dock on south side of Tindle Mills building.
P19	DCP_3753	U/S from D/S face of loading dock on south side of Tindle Mills building.
		+/- 10 FT wide tunnel D/S of Tindle Mills building widens to about 18 FT just U/S of the D/S (south) face of the building. Note ledges on right side of channel, overhead beams and rough cut port at top of wall on left side of channel.
P20	DCP_3754	U/S from about midway of Tindle Mills building.
		Note significant rock deposit on floor.
P21	DCP_3755	D/S from about midway of Tindle Mills building.
		Channel under building reduces to '+/- 10 FT X 10 FT tunnel at D/S face of building (to right of photo).
P22	DCP_3756	D/S from U/S face of Tindle Mills building.
P23	DCP_3757	U/S from U/S face of Tindle Mills building.
		Note concrete ledge on left side of channel (right side of photo) beyond protruding wingwall. Ledge is +/- 4 FT wide and 2.5 FT tall above tunnel floor.
P24	DCP_3758	D/S from about center of bend near U/S end of tunnel.
P25	DCP_3759	U/S from about center of bend near U/S end of tunnel.
		Tunnel width reduces from +/- 15 FT wide to +/- 10 FT X 10 FT. Tunnel height increases about 1.5 FT at this point. Section +/- 10 FT X 10 FT from U/S end to about 100 FT below U/S entrance.

Insp. Date: **27-Oct-04**

Cooper Supply and RR Tunnel

Walked tunnel from U/S end at D/S face of Chestnut Expwy overpass to D/S end.

General Observations

From U/S end tunnel is double box for about half its length then each barrel contracts and the tunnel transitions to a single barrel.

Medium to large rock and gravel typical across bed of both barrels in double barrel section.

Floor of single barrel section clean with exposed aggregate throughout.

Photo Sequence #	Filename	Description / Notes
55	DCP_3723	D/S from U/S face of Chestnut Expressway overpass immediately south of Tindle Mills. Entrance to tunnel under Cooper Supply Co. lot and RR tracks in distance.
P26	DCP_3760	D/S from just inside U/S end of right barrel.
P27	DCP_3761	D/S at +/- 24-inch pipe crossing tunnel just U/S of transition from double to single barrel.
		Pipe hard to see but there. Passes through double barrel divider wall and crosses left barrel of tunnel.
P28	DCP_3762	D/S in right barrel from pipe crossing.
		About 20 FT D/S of the pipe crossing both barrels contract to about 5 FT width at transition to +/- 12 FT wide single barrel.
61	DCP_3729	U/S at exit of tunnel under Cooper Supply Co. lot and RR tracks from 100 FT D/S.

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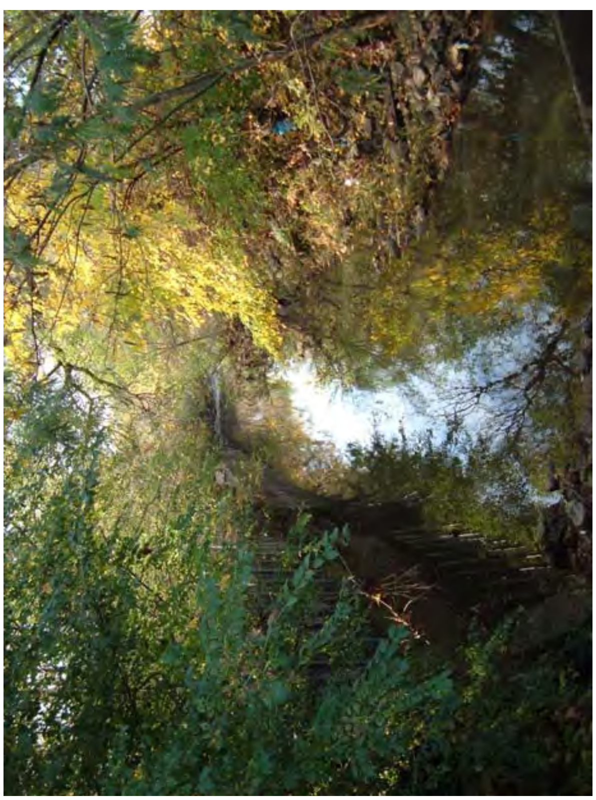

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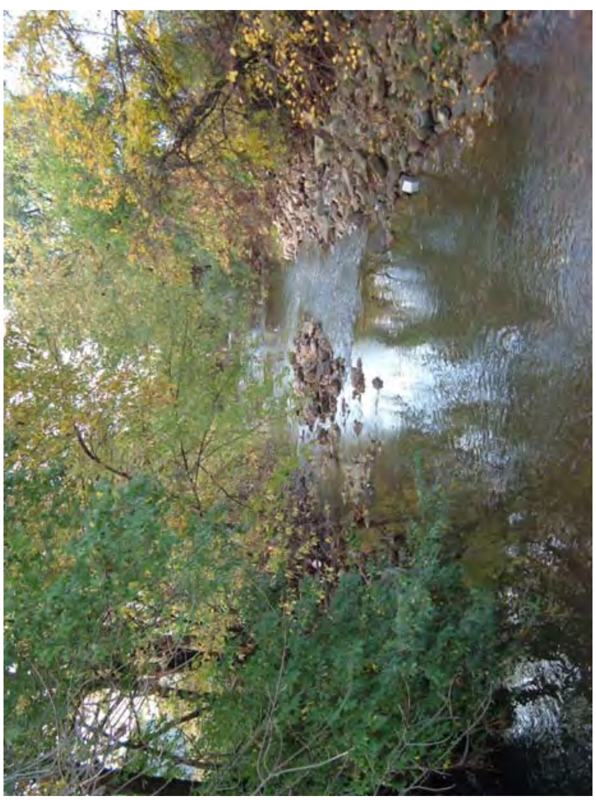
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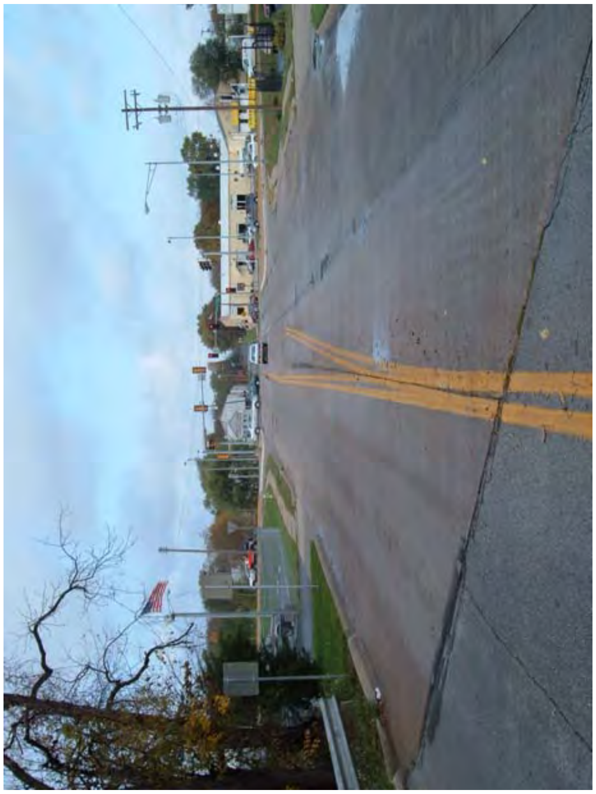
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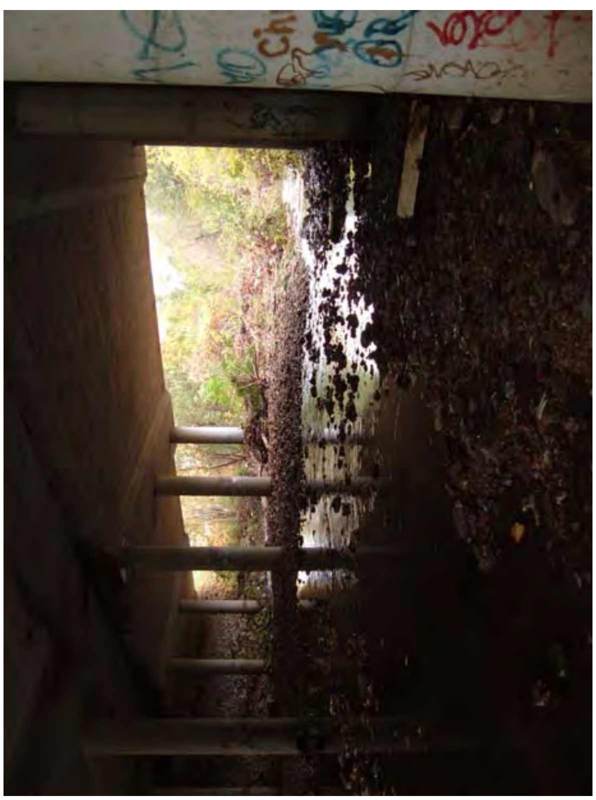

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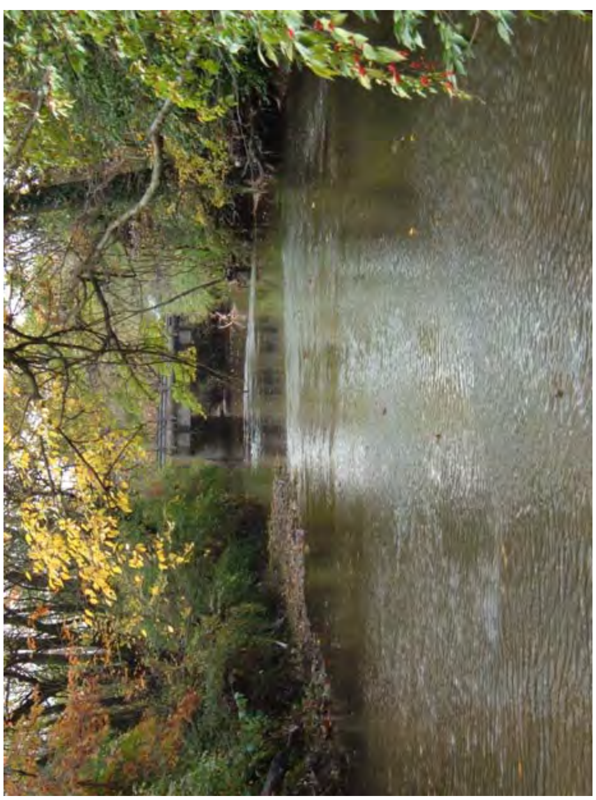
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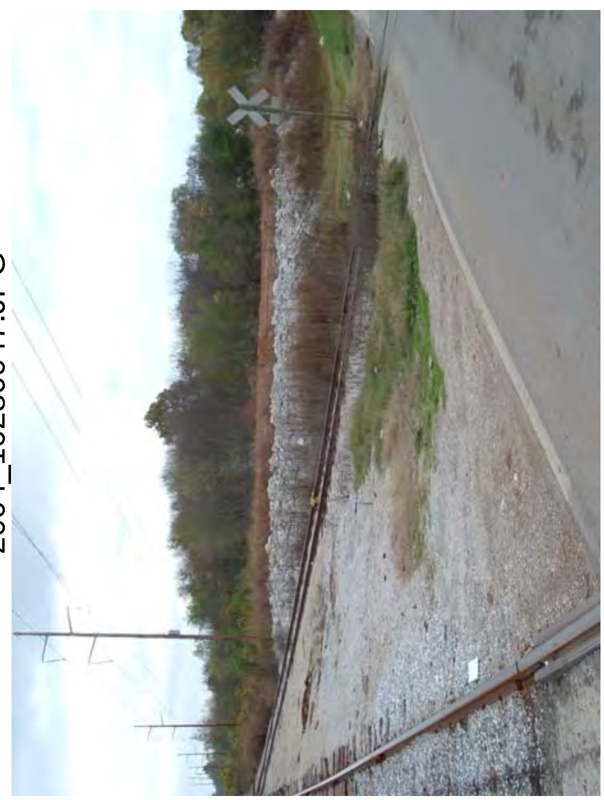
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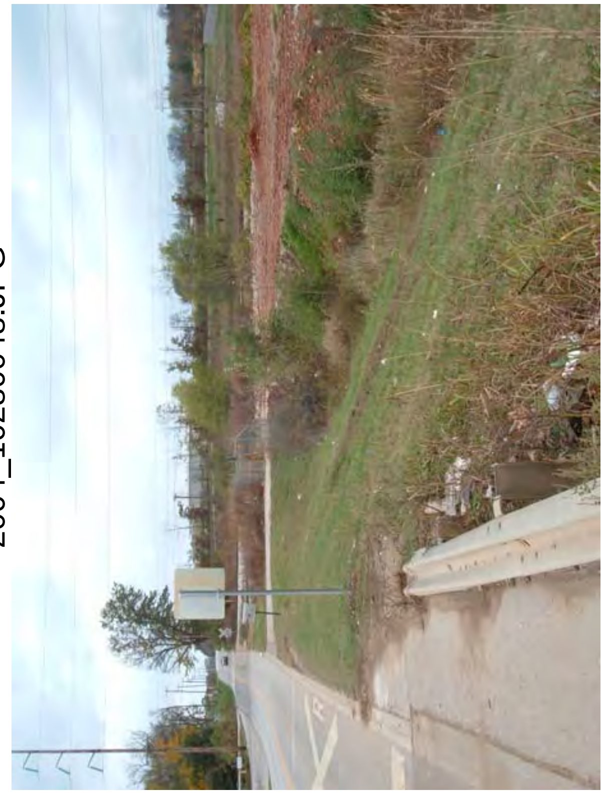
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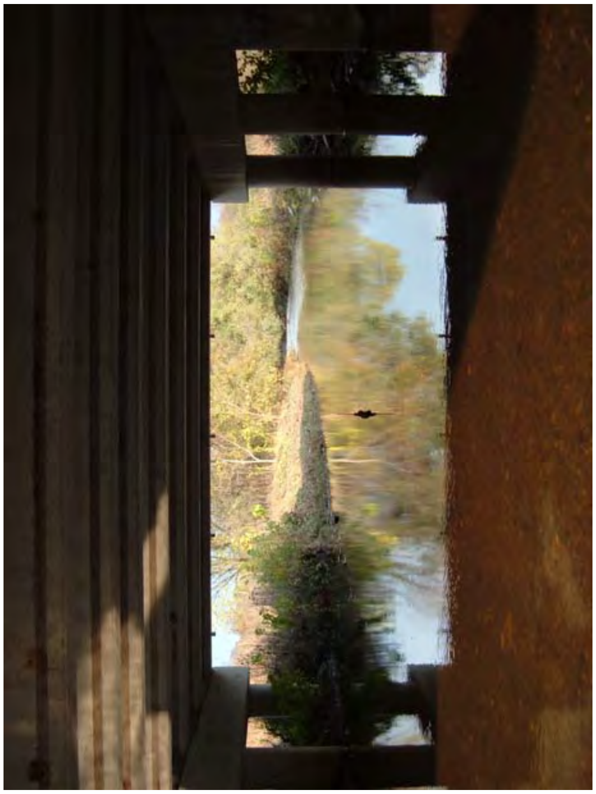

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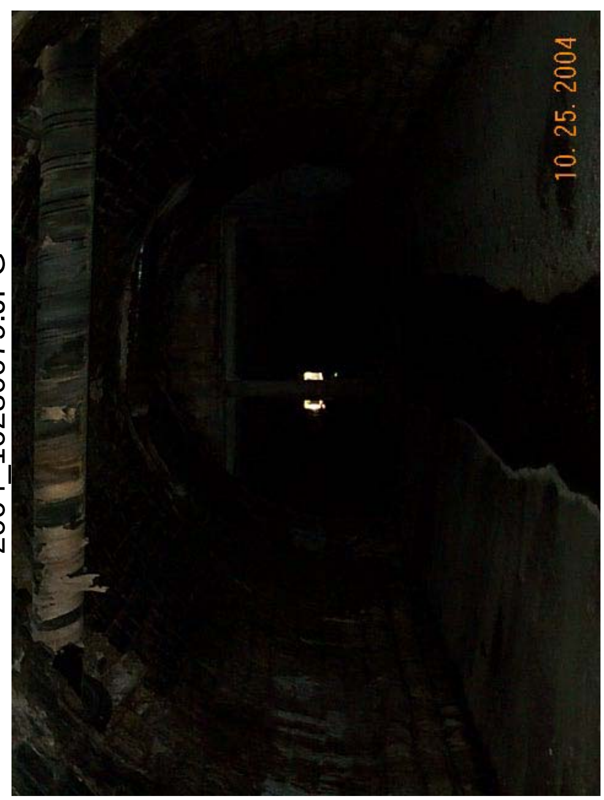

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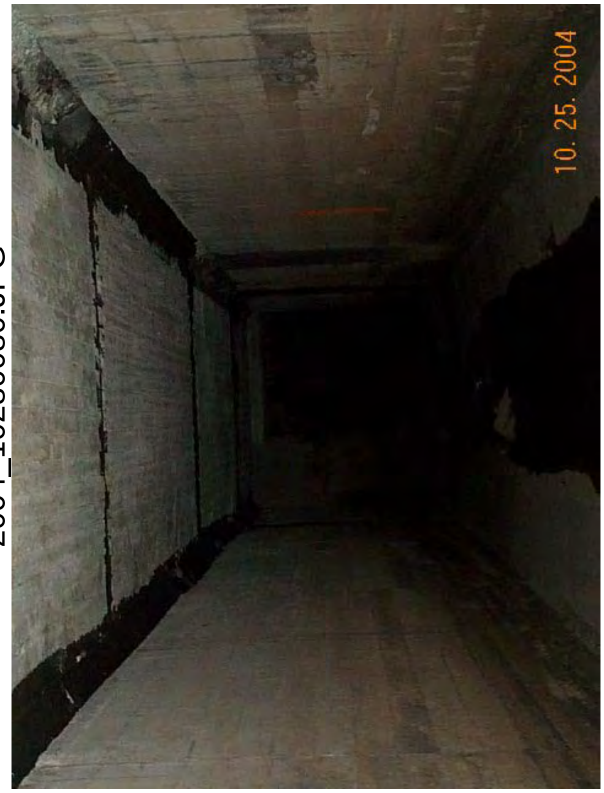

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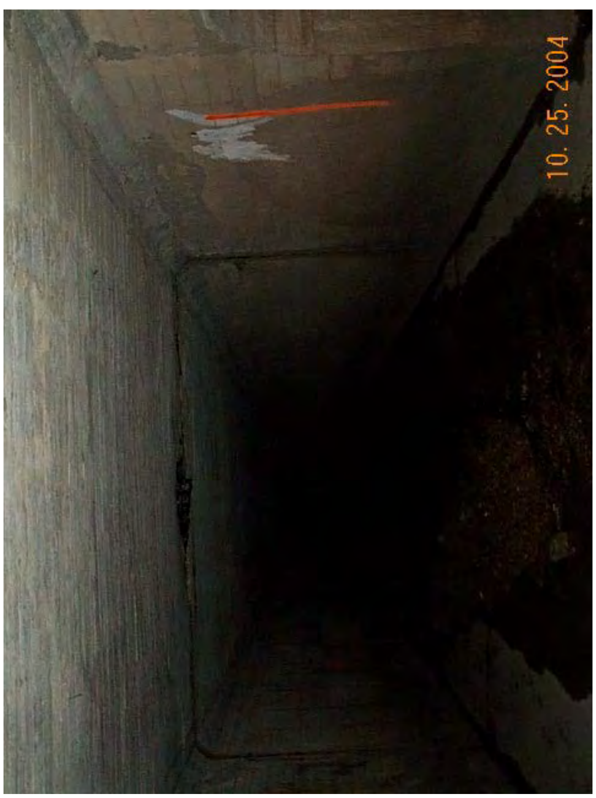

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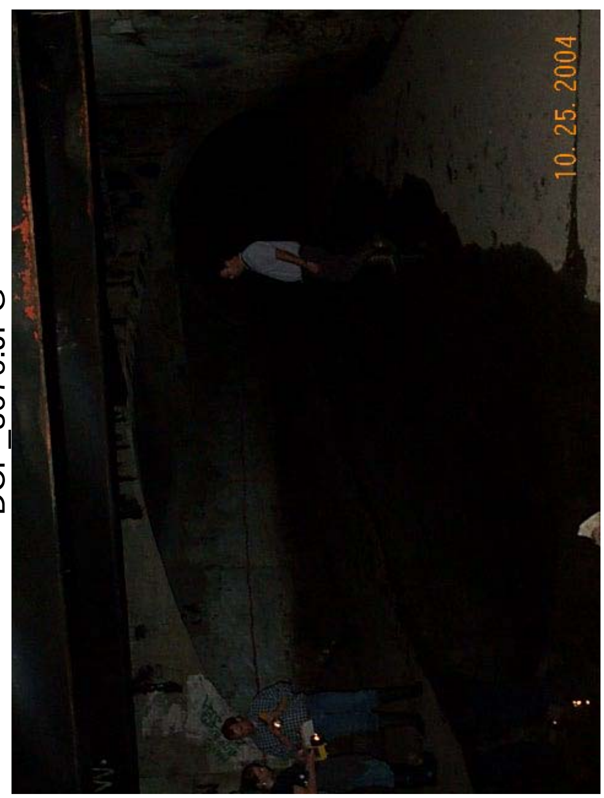

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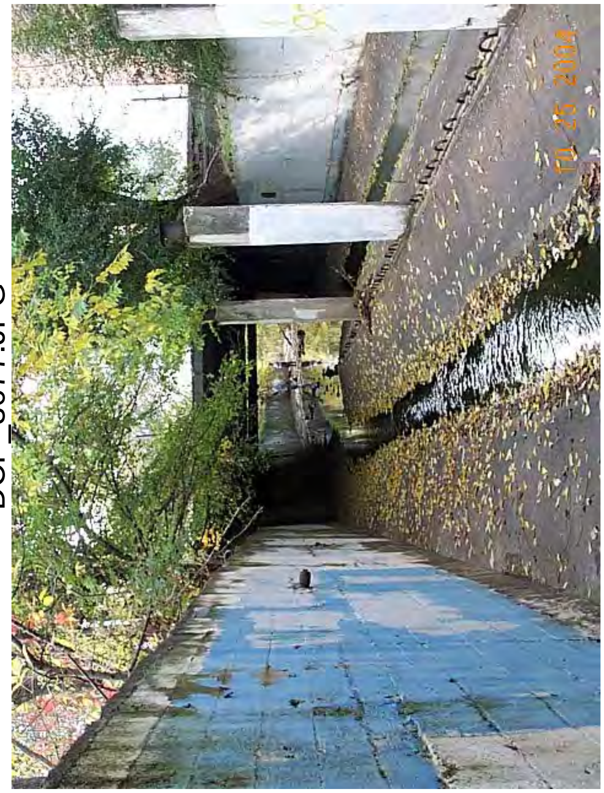

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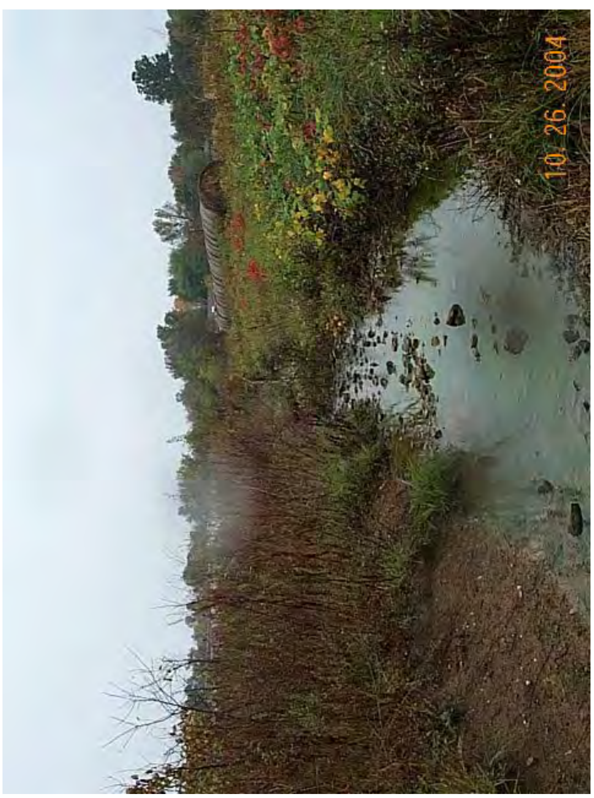

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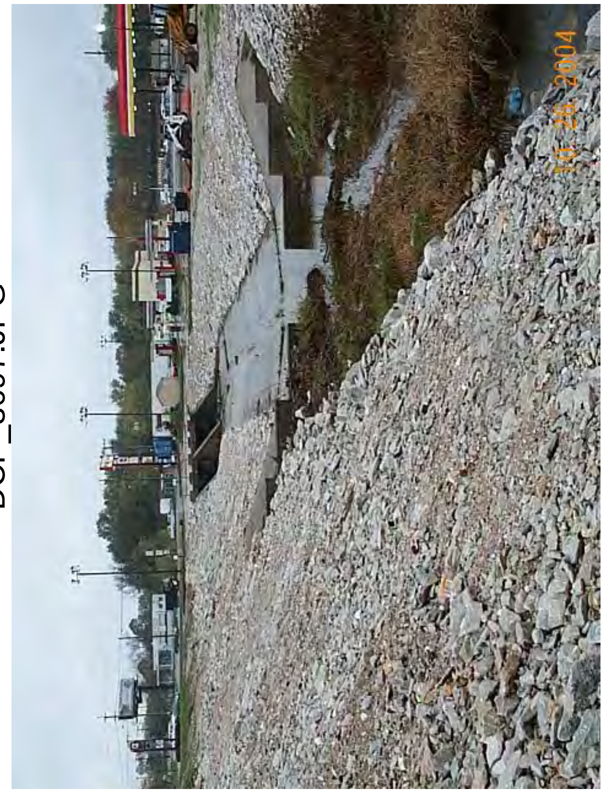

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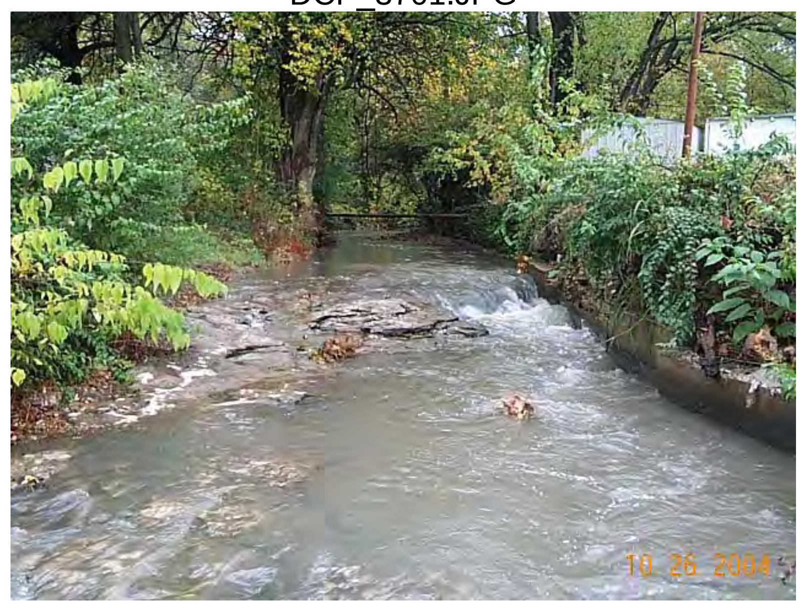

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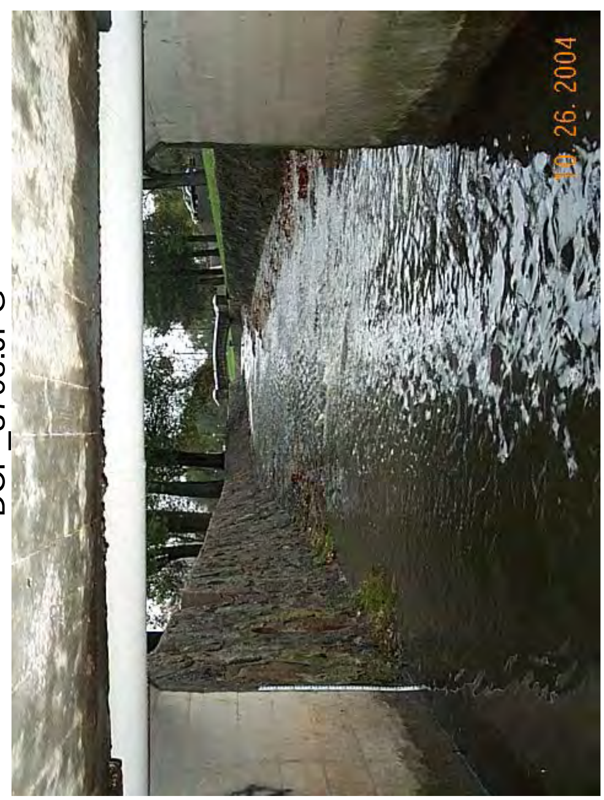

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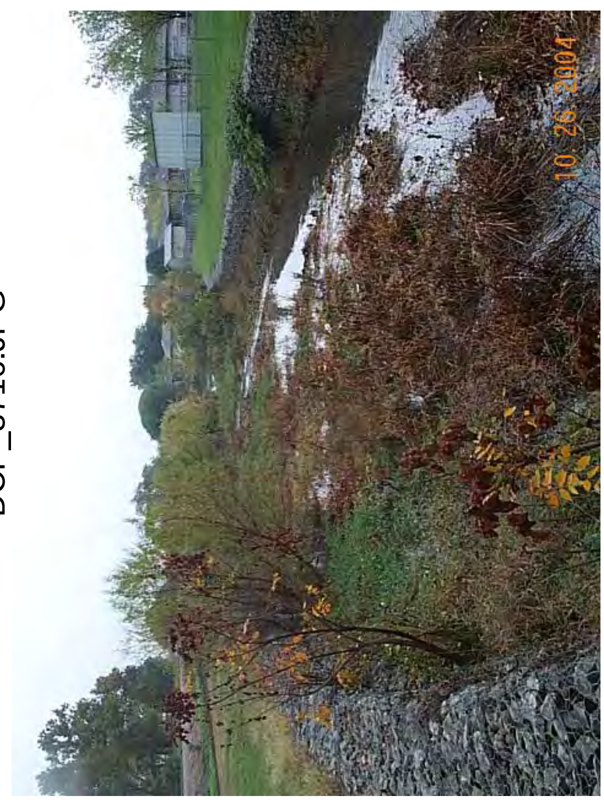

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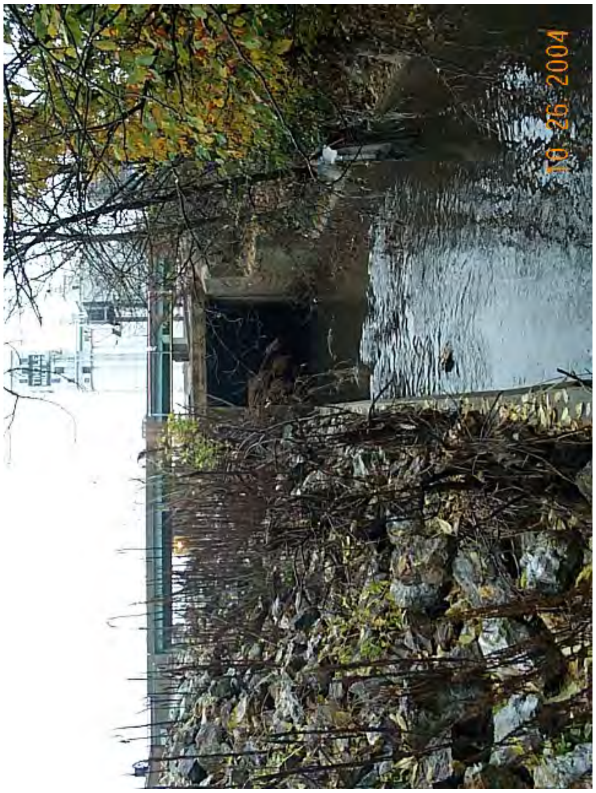

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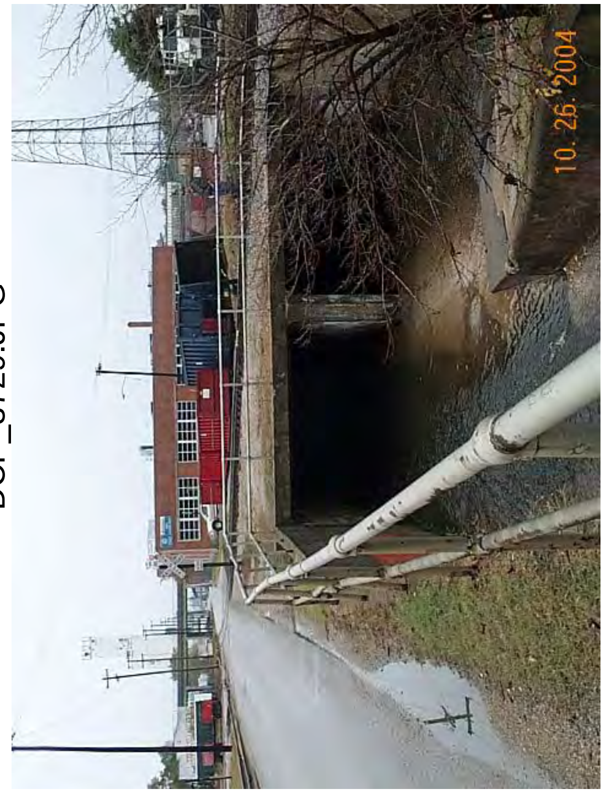

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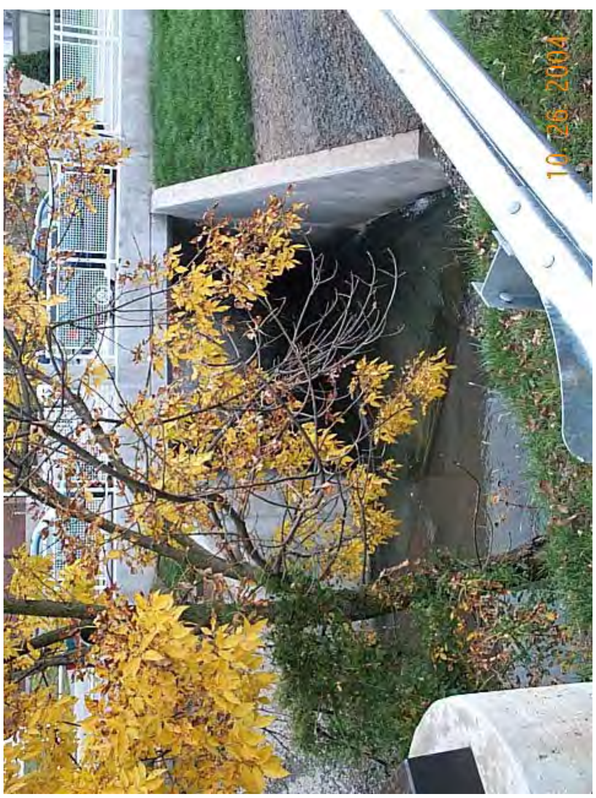

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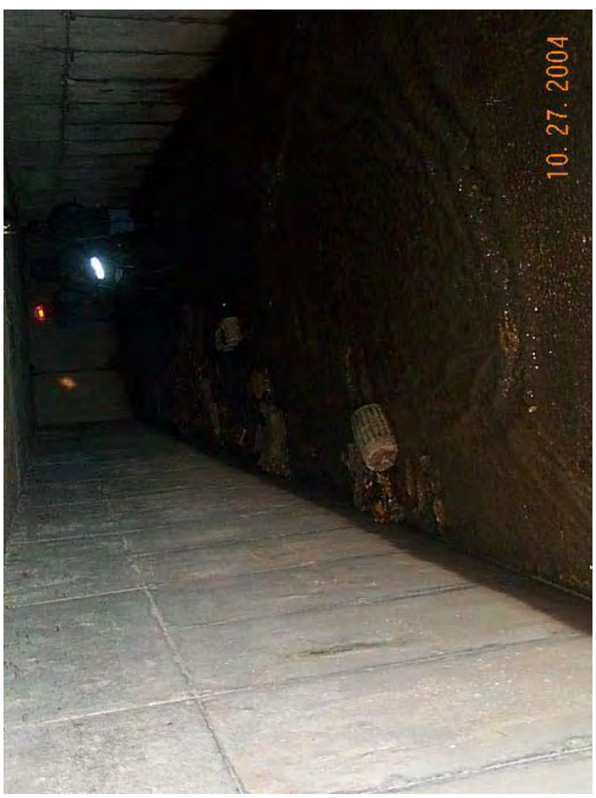

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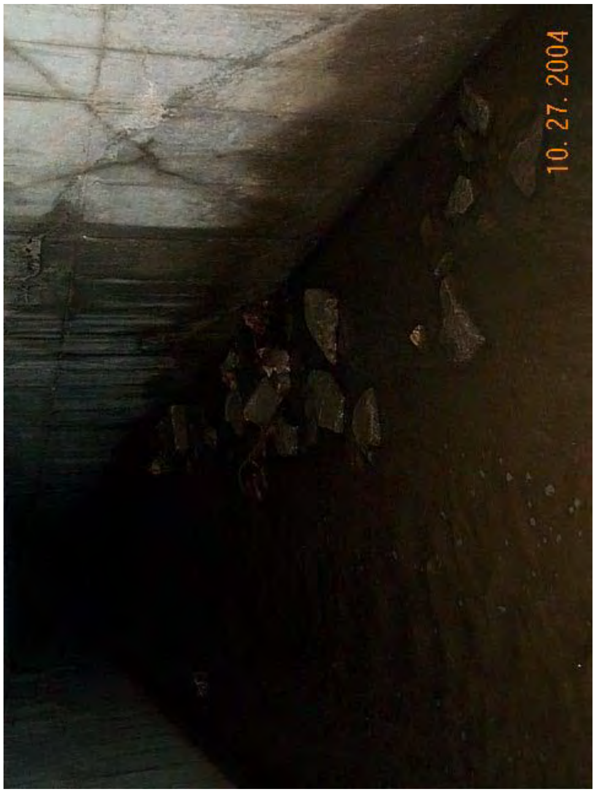

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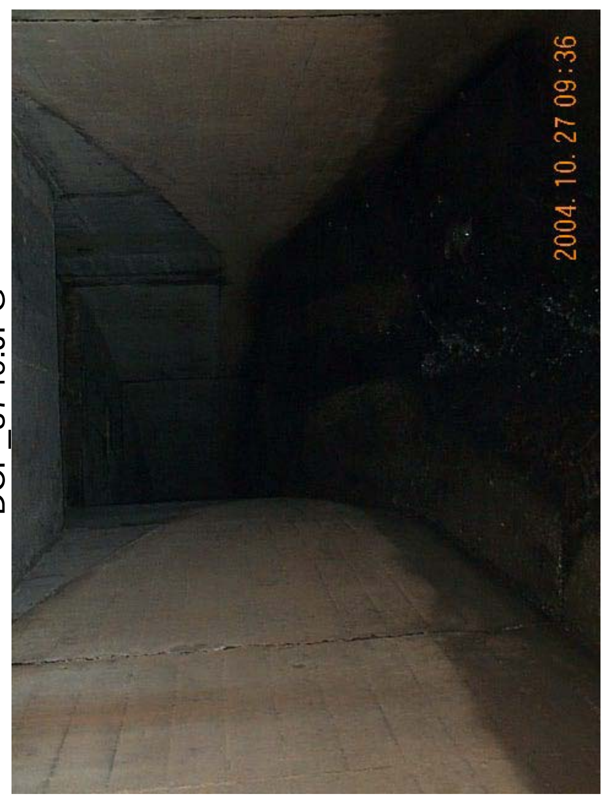

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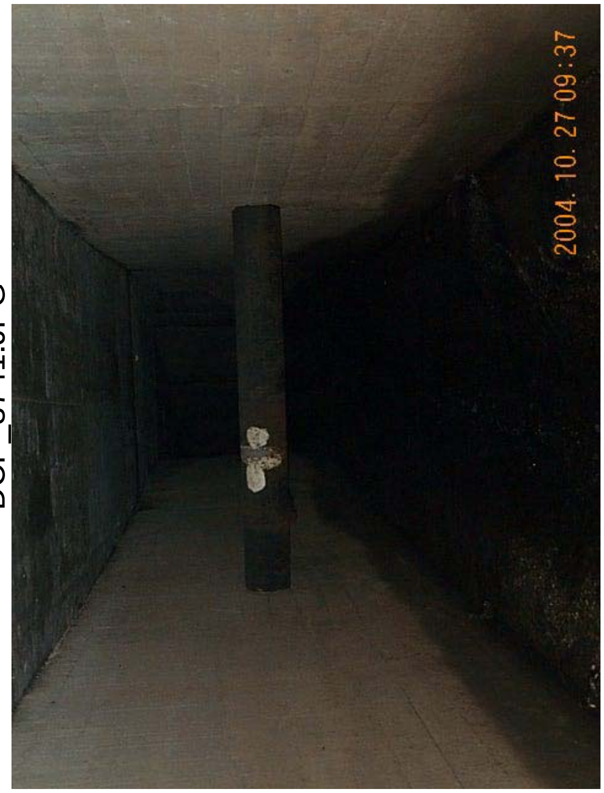

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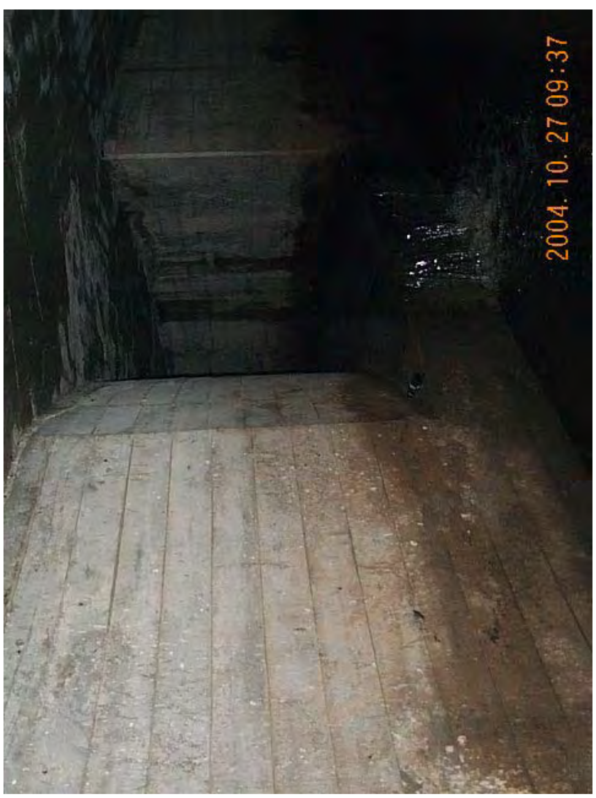

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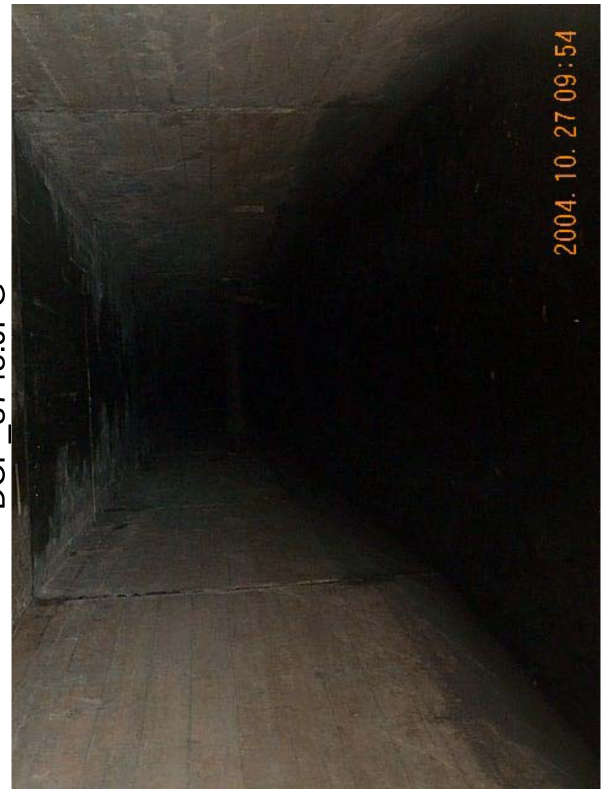

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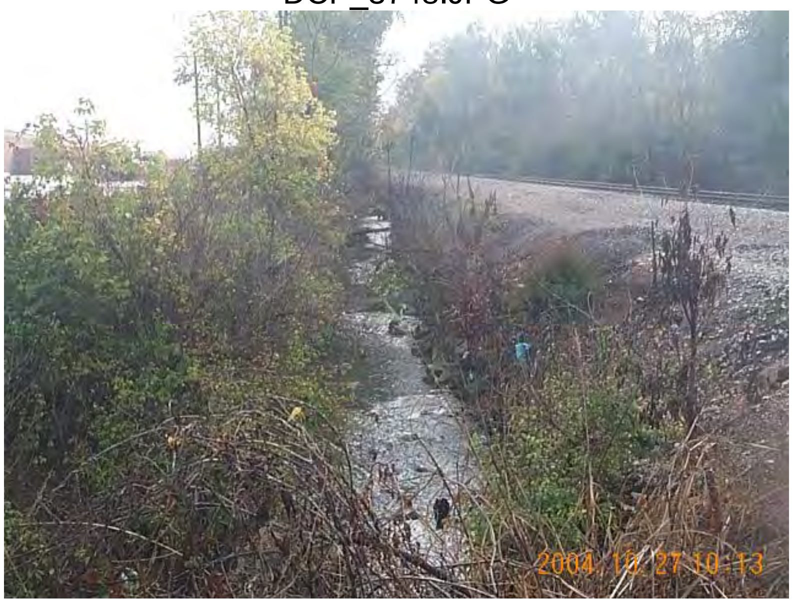

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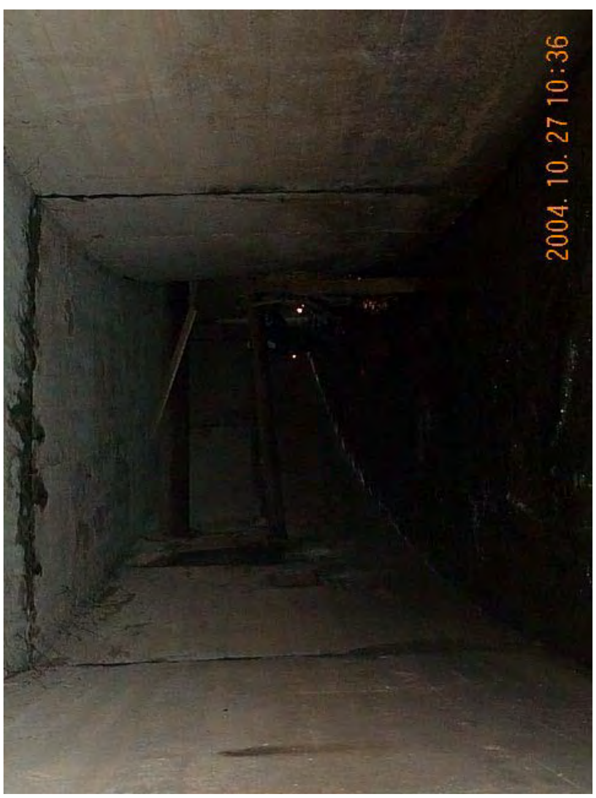

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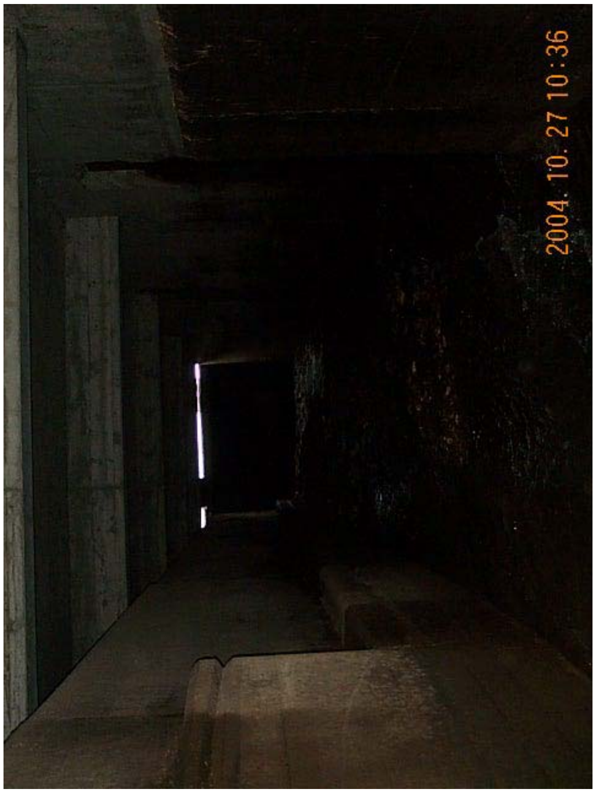

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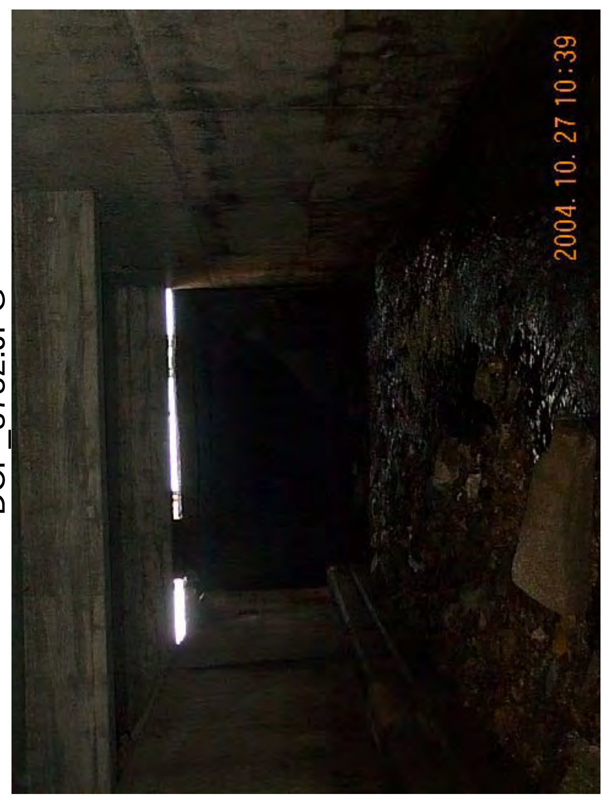

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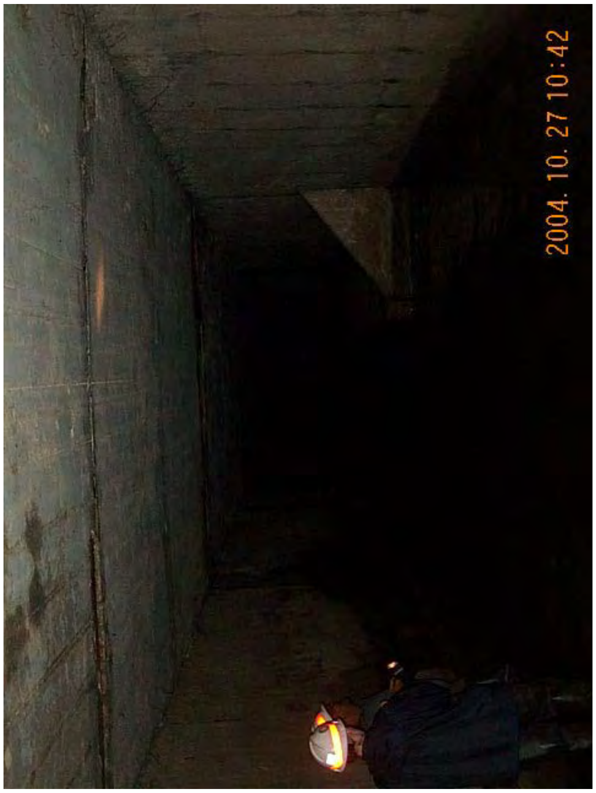

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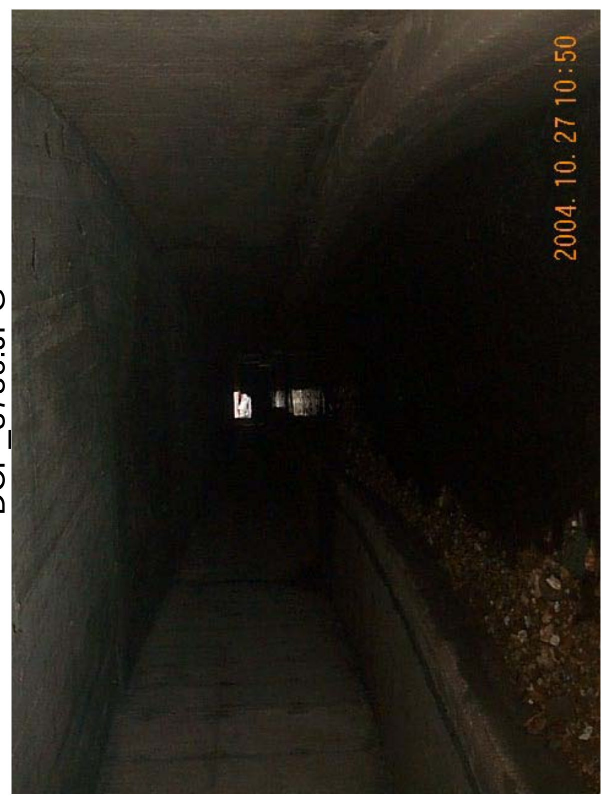

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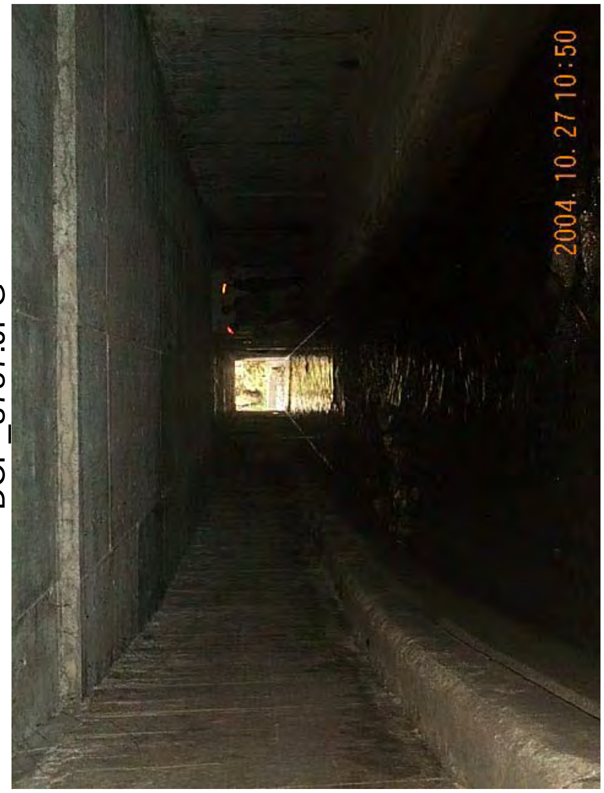

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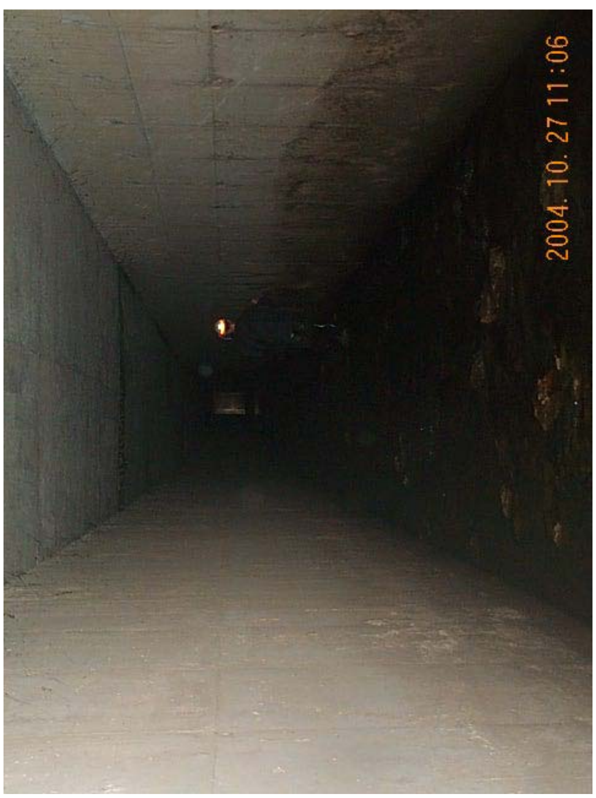

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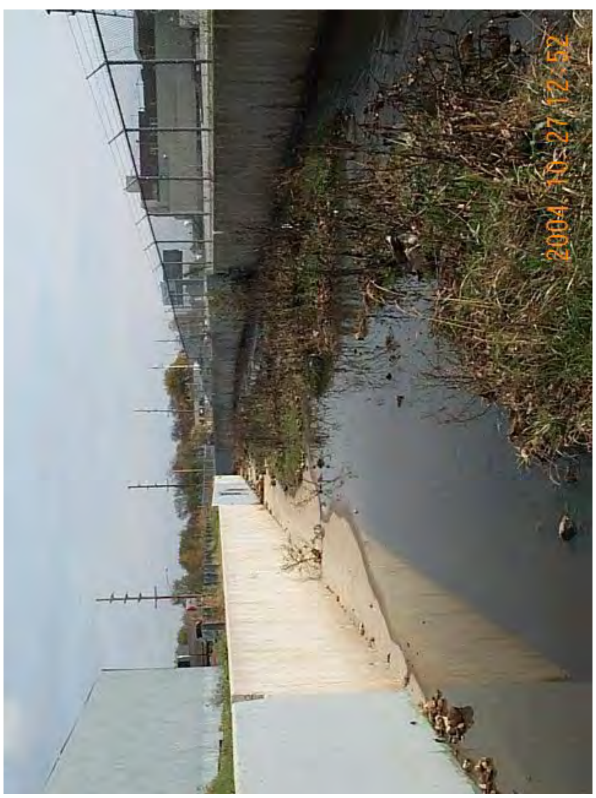

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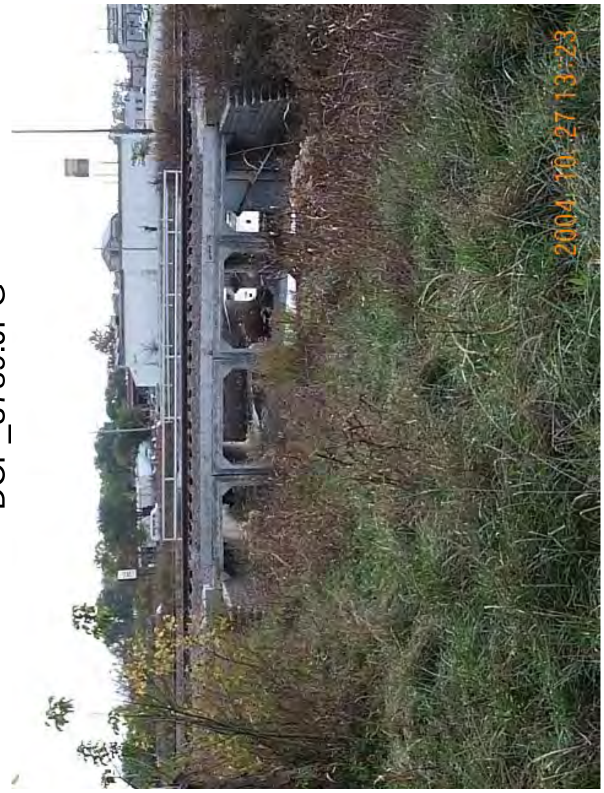

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Appendix HH-H – Rainfall Table from the Rainfall Atlas of the Midwest

The following appendix includes Sectional Mean Frequency Distributions from the "Rainfall Frequency Atlas of the Midwest" by Floyd A. Huff and James R. Angel. Midwestern Climate Center – National Weather Service, Bulletin 71 (MCC Research Report 92-03). 1992.

Table 7. Sectional Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years in Missouri

Sectional code (see figure 1 on page 4)

01 - Northwest Prairie *04 - West Ozarks*
02 - Northeast Prairie *05 - East Ozarks*
03 - West Central Plains *06 - Bootheel*

Rainfall (inches) for given recurrence interval

Section	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
01	10-day	2.18	2.62	3.02	3.55	4.08	4.44	5.60	7.01	8.01	9.27	10.20	11.25
01	5-day	1.82	2.17	2.46	2.85	3.28	3.56	4.50	5.69	6.60	7.78	8.71	9.71
01	72-hr	1.62	1.90	2.15	2.50	2.87	3.12	3.99	5.11	5.98	7.07	7.92	8.82
01	48-hr	1.48	1.73	1.93	2.23	2.57	2.79	3.59	4.63	5.43	6.43	7.17	7.99
01	24-hr	1.39	1.62	1.77	2.05	2.33	2.53	3.27	4.25	4.98	5.89	6.58	7.30
01	18-hr	1.31	1.52	1.67	1.93	2.19	2.38	3.07	3.99	4.68	5.54	6.19	6.86
01	12-hr	1.21	1.41	1.54	1.78	2.02	2.20	2.84	3.70	4.33	5.12	5.72	6.35
01	6-hr	1.04	1.22	1.33	1.54	1.75	1.90	2.45	3.19	3.74	4.42	4.93	5.48
01	3-hr	0.89	1.04	1.13	1.31	1.49	1.62	2.09	2.72	3.19	3.77	4.21	4.67
01	2-hr	0.81	0.94	1.03	1.19	1.35	1.47	1.90	2.46	2.89	3.42	3.82	4.23
01	1-hr	0.65	0.76	0.83	0.96	1.09	1.19	1.54	2.00	2.34	2.77	3.09	3.43
01	30-min	0.52	0.60	0.66	0.76	0.86	0.94	1.21	1.57	1.84	2.18	2.43	2.70
01	15-min	0.37	0.44	0.48	0.55	0.63	0.68	0.88	1.15	1.34	1.59	1.78	1.97
01	10-min	0.29	0.34	0.37	0.43	0.49	0.53	0.69	0.89	1.05	1.24	1.38	1.53
01	5-min	0.17	0.19	0.21	0.24	0.28	0.30	0.39	0.51	0.60	0.71	0.79	0.88
02	10-day	2.21	2.66	3.07	3.61	4.15	4.51	5.41	6.64	7.62	8.90	9.92	11.02
02	5-day	1.79	2.14	2.42	2.81	3.23	3.51	4.27	5.37	6.27	7.53	8.51	9.57
02	72-hr	1.63	1.91	2.16	2.50	2.88	3.13	3.82	4.81	5.66	6.81	7.74	8.76
02	48-hr	1.48	1.74	1.93	2.24	2.58	2.80	3.44	4.33	5.09	6.14	6.99	7.91
02	24-hr	1.38	1.60	1.75	2.03	2.30	2.50	3.10	3.94	4.64	5.60	6.38	7.21
02	18-hr	1.29	1.50	1.64	1.90	2.16	2.35	2.91	3.70	4.36	5.26	6.00	6.78
02	12-hr	1.19	1.39	1.52	1.76	2.00	2.17	2.70	3.43	4.04	4.87	5.55	6.27
02	6-hr	1.03	1.20	1.32	1.52	1.73	1.88	2.32	2.95	3.48	4.20	4.78	5.41
02	3-hr	0.88	1.02	1.12	1.30	1.47	1.60	1.98	2.52	2.97	3.58	4.08	4.61
02	2-hr	0.80	0.93	1.01	1.17	1.33	1.45	1.80	2.29	2.69	3.25	3.70	4.18
02	1-hr	0.64	0.75	0.82	0.95	1.08	1.17	1.46	1.85	2.18	2.63	3.00	3.39
02	30-min	0.51	0.60	0.65	0.75	0.86	0.93	1.15	1.46	1.72	2.07	2.36	2.67
02	15-min	0.37	0.44	0.48	0.55	0.63	0.68	0.84	1.06	1.25	1.51	1.72	1.95
02	10-min	0.29	0.33	0.36	0.42	0.48	0.52	0.65	0.83	0.97	1.18	1.34	1.51
02	5-min	0.17	0.19	0.21	0.24	0.28	0.30	0.37	0.47	0.56	0.67	0.77	0.87
03	10-day	2.38	2.87	3.30	3.89	4.47	4.86	6.10	7.59	8.62	9.88	10.87	11.72
03	5-day	2.04	2.44	2.76	3.20	3.68	4.00	4.92	6.12	7.06	8.33	9.31	10.36
03	72-hr	1.79	2.10	2.38	2.76	3.17	3.45	4.25	5.33	6.20	7.39	8.32	9.30
03	48-hr	1.66	1.94	2.16	2.50	2.88	3.13	3.90	4.92	5.71	6.78	7.66	8.57
03	24-hr	1.55	1.80	1.97	2.28	2.59	2.81	3.50	4.41	5.16	6.16	6.93	7.74
03	18-hr	1.45	1.69	1.85	2.14	2.43	2.64	3.29	4.15	4.85	5.79	6.51	7.28
03	12-hr	1.34	1.56	1.71	1.98	2.24	2.44	3.05	3.84	4.49	5.36	6.03	6.73
03	6-hr	1.16	1.35	1.48	1.71	1.94	2.11	2.62	3.31	3.87	4.62	5.20	5.80
03	3-hr	0.99	1.15	1.26	1.46	1.66	1.80	2.24	2.82	3.30	3.94	4.44	4.95
03	2-hr	0.90	1.04	1.14	1.32	1.50	1.63	2.03	2.56	2.99	3.57	4.02	4.49
03	1-hr	0.73	0.84	0.92	1.07	1.21	1.32	1.64	2.07	2.43	2.90	3.26	3.64
03	30-min	0.57	0.67	0.73	0.84	0.96	1.04	1.30	1.63	1.91	2.28	2.56	2.86
03	15-min	0.42	0.49	0.53	0.62	0.70	0.76	0.95	1.19	1.39	1.66	1.87	2.09
03	10-min	0.32	0.38	0.41	0.48	0.54	0.59	0.73	0.93	1.08	1.29	1.46	1.63
03	5-min	0.19	0.22	0.24	0.28	0.31	0.34	0.42	0.53	0.62	0.74	0.83	0.93

Table 7. Concluded

Rainfall (inches) for given recurrence interval

Section	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
04	10-day	2.63	3.17	3.65	4.30	4.94	5.37	6.59	8.05	9.13	10.49	11.52	12.61
04	5-day	2.12	2.54	2.87	3.33	3.83	4.16	5.21	6.50	7.45	8.70	9.68	10.77
04	72-hr	1.91	2.24	2.54	2.94	3.39	3.68	4.62	5.81	6.69	7.90	8.85	9.85
04	48-hr	1.75	2.05	2.28	2.64	3.04	3.30	4.14	5.25	6.07	7.17	8.05	8.97
04	24-hr	1.65	1.92	2.10	2.43	2.76	3.00	3.77	4.79	5.55	6.56	7.34	8.18
04	18-hr	1.55	1.80	1.97	2.28	2.59	2.82	3.54	4.50	5.22	6.17	6.90	7.69
04	12-hr	1.44	1.67	1.83	2.11	2.40	2.61	3.28	4.17	4.83	5.71	6.39	7.12
04	6-hr	1.24	1.44	1.57	1.82	2.07	2.25	2.83	3.59	4.16	4.92	5.51	6.14
04	3-hr	1.06	1.23	1.34	1.56	1.77	1.92	2.41	3.07	3.55	4.20	4.70	5.24
04	2-hr	0.96	1.11	1.22	1.41	1.60	1.74	2.19	2.78	3.22	3.80	4.26	4.74
04	1-hr	0.78	0.90	0.99	1.14	1.30	1.41	1.77	2.25	2.61	3.08	3.45	3.84
04	30-min	0.61	0.71	0.78	0.90	1.02	1.11	1.39	1.77	2.05	2.43	2.72	3.03
04	15-min	0.45	0.52	0.57	0.66	0.75	0.81	1.02	1.29	1.50	1.77	1.98	2.21
04	10-min	0.35	0.40	0.44	0.51	0.58	0.63	0.79	1.01	1.17	1.38	1.54	1.72
04	5-min	0.20	0.23	0.25	0.29	0.33	0.36	0.45	0.57	0.67	0.79	0.88	0.98
05	10-day	2.30	2.77	3.20	3.76	4.32	4.70	5.96	7.36	8.29	9.48	10.34	11.31
05	5-day	1.92	2.30	2.60	3.02	3.47	3.77	4.78	5.99	6.86	8.02	8.97	9.93
05	72-hr	1.75	2.05	2.32	2.69	3.09	3.36	4.24	5.31	6.10	7.15	7.99	8.90
05	48-hr	1.61	1.88	2.09	2.42	2.79	3.03	3.82	4.78	5.50	6.47	7.24	8.06
05	24-hr	1.53	1.79	1.95	2.26	2.57	2.79	3.51	4.39	5.03	5.94	6.64	7.42
05	18-hr	1.44	1.68	1.83	2.12	2.41	2.62	3.30	4.13	4.73	5.58	6.24	6.97
05	12-hr	1.34	1.56	1.70	1.97	2.24	2.43	3.05	3.82	4.38	5.17	5.78	6.46
05	6-hr	1.15	1.34	1.46	1.69	1.92	2.09	2.63	3.29	3.77	4.45	4.98	5.57
05	3-hr	0.98	1.15	1.25	1.45	1.65	1.79	2.25	2.81	3.22	3.80	4.25	4.75
05	2-hr	0.89	1.04	1.13	1.31	1.49	1.62	2.04	2.55	2.92	3.45	3.85	4.30
05	1-hr	0.72	0.84	0.92	1.06	1.21	1.31	1.65	2.06	2.36	2.79	3.12	3.49
05	30-min	0.57	0.66	0.72	0.83	0.95	1.03	1.30	1.62	1.86	2.20	2.46	2.75
05	15-min	0.41	0.48	0.52	0.61	0.69	0.75	0.95	1.19	1.36	1.60	1.79	2.00
05	10-min	0.32	0.38	0.41	0.48	0.54	0.59	0.74	0.92	1.06	1.25	1.39	1.56
05	5-min	0.18	0.21	0.23	0.27	0.30	0.33	0.42	0.53	0.60	0.71	0.80	0.89
06	10-day	2.45	2.94	3.39	3.99	4.59	4.99	6.43	7.99	9.01	10.25	11.15	12.07
06	5-day	2.09	2.50	2.83	3.28	3.77	4.10	5.19	6.46	7.31	8.39	9.20	10.04
06	72-hr	1.91	2.24	2.53	2.94	3.38	3.67	4.67	5.81	6.60	7.58	8.35	9.12
06	48-hr	1.74	2.03	2.26	2.62	3.02	3.28	4.14	5.13	5.84	6.75	7.47	8.21
06	24-hr	1.64	1.91	2.09	2.42	2.75	2.99	3.74	4.65	5.29	6.16	6.83	7.51
06	18-hr	1.55	1.80	1.97	2.28	2.59	2.81	3.52	4.37	4.97	5.79	6.42	7.06
06	12-hr	1.43	1.66	1.82	2.11	2.39	2.60	3.25	4.05	4.60	5.36	5.94	6.53
06	6-hr	1.23	1.43	1.57	1.81	2.06	2.24	2.81	3.49	3.97	4.62	5.12	5.63
06	3-hr	1.05	1.22	1.34	1.55	1.76	1.91	2.39	2.98	3.39	3.94	4.37	4.81
06	2-hr	0.95	1.11	1.21	1.40	1.59	1.73	2.17	2.70	3.07	3.57	3.96	4.36
06	1-hr	0.78	0.90	0.99	1.14	1.30	1.41	1.76	2.19	2.49	2.90	3.21	3.53
06	30-min	0.61	0.71	0.78	0.90	1.02	1.11	1.38	1.72	1.96	2.28	2.53	2.78
06	15-min	0.45	0.52	0.57	0.66	0.75	0.81	1.01	1.26	1.43	1.66	1.84	2.03
06	10-min	0.35	0.40	0.44	0.51	0.58	0.63	0.79	0.98	1.11	1.29	1.43	1.58
06	5-min	0.20	0.23	0.25	0.29	0.33	0.36	0.45	0.56	0.63	0.74	0.82	0.90

Appendix HH-I – Summary Table of Regional Detention Basins

Proposed Regional Detention Basins

Basin Name	Reach Name	Location Description	Station	Top of Berm Elevation	Depth (ft)	Surface Area (acres)	Volume (ac-ft)	Est. Excavation Volume (cubic yd)	Outlet Description	Weir Length (ft)	Weir Elevation	Pipe Size (in)	Pipe Elevation	Notes
B15	North Branch	West side of Packer Rd, N of RR	18653	1380	11	3.99	30.1	38,900	12" RCP	N/A	N/A	12	1369	Keep WSE at existing and do not encroach on RR ROW. Currently overtopps. Lower existing pipe
B14	North Branch	North of Blaine, W of Packer	16668	1366	7.8	11.39	53.9	67,500	42" RCP	N/A	N/A	42	1358.2	As drawn, low flow does not have enough slope. May need to move basin north to avoid recent building dev.
B12	North Branch	Corner of Blaine and Yates	15476	1353	5.2	2.29	9.4	15,000	No Outlet	N/A	N/A	N/A	1347.8	In-line basin that catches flow from the north. Proposed system along Blaine would surcharge into basin and be released based on system capacity.
B11A	North Branch	South of Blaine at Link	11949	1340	7	6.24	19.2	19,000	12' Sharp Crest Weir	12	1333	N/A	N/A	15:1 SS. Basin not affected by TW from B11. Would have to remove & replant a number of trees.
B11	North Branch	South of Blaine US Glenstone	10225	1332	7.7	8.68	36.4	24,800	15' Weir into Box	15	1325	N/A	N/A	Keeps peak flows low enough to eliminate flooding along Glenstone Ave.
B9B	South Branch	NW Corner of Pythian & Cedarbrook	N/A	1352	8	5.68	27.7	34,700	2-36" RCP and Weir	20	1351	36	1344	Construct berm on DS end. Does not account for TW from B9C.
B9C	South Branch	NW Corner of Pythian & Cedarbrook	N/A	1344	8	5.02	30.5	29,800	48" RCP	N/A	N/A	48	1338	Discharge into existing system. Basin will keep flows in system. Current basin overtopps.
B6	South Branch	Upstream of Chestnut Exp.	10240	1317	8.7	5.99	35.6	51,300	Weir into Box	Unknown	Unknown	N/A	N/A	Physical outlet not designed. Design based on reasonable rating curve. Outlet probably consists of something like a 10' weir at ele 1309
B7	South Branch	East end of Rockhurst Street	14475	1342	12	6.73	46.2	58,000	2-42" RCP & 5' Weir	5	1336	42	1331	Lower FL of basin. Discharge through two 42" pipes that run along Rockhurst St to Patterson. Any flows reaching the weir can be conveyed using existing drainage along Rockhurst.

Appendix HH-J – Standard Deviation of Error for Without Project – Current Conditions Model

Reach	Profile	Standard Deviation of Error for all x-sec in reach based on a HIGHER "n" factor (40% in channel, 33% in overbank)	Standard Deviation of Error for all x-sec in reach based on a LOWER "n" factor (40% overall reduction)	Standard Deviation of Error for all x-sec in reach based on both "n" value assumptions	Stage where Error Becomes Constant
South	1yr	0.33	0.82	0.64	
	2yr	0.27	0.42	0.36	
	5yr	0.23	0.43	0.35	
	10yr	0.22	0.39	0.32	
	25yr	0.29	0.60	0.46	
	50yr	0.27	0.35	0.31	
	100yr	0.23	0.29	0.27	
	500yr	0.26	0.35	0.31	
	ALL	**0.27**	**0.50**	**0.40**	
Use	**0.3**	0.25	0.40	0.34	**10 year**
North	1yr	0.97	0.60	0.82	
	2yr	0.53	1.30	1.00	
	5yr	0.22	0.57	0.42	
	10yr	0.28	0.52	0.41	
	25yr	0.37	0.39	0.38	
	50yr	0.29	0.30	0.30	
	100yr	0.27	0.33	0.31	
	500yr	0.25	0.25	0.25	
	ALL	**0.47**	**0.66**	**0.57**	
Use	**0.3**	0.28	0.39	0.34	**10 year**
Lower	1yr	0.43	0.52	0.49	
	2yr	0.40	0.53	0.47	
	5yr	0.40	0.58	0.51	
	10yr	0.39	0.64	0.53	
	25yr	0.39	0.67	0.55	
	50yr	0.35	0.65	0.53	
	100yr	0.37	0.68	0.54	
	500yr	0.50	0.52	0.51	
	ALL	**0.41**	**0.61**	**0.52**	
Use	**0.45**				**10 year**
Wilsons	1yr	0.29	0.36	0.34	
	2yr	0.30	0.38	0.36	
	5yr	0.35	0.38	0.38	
	10yr	0.42	0.37	0.46	
	25yr	0.37	0.30	0.42	
	50yr	0.29	0.49	0.44	
	100yr	0.37	0.54	0.49	
	500yr	0.58	0.63	0.61	
	ALL	**0.39**	**0.47**	**0.46**	
Use	**0.4**				**10 year**

Notes by Travis Stanford:

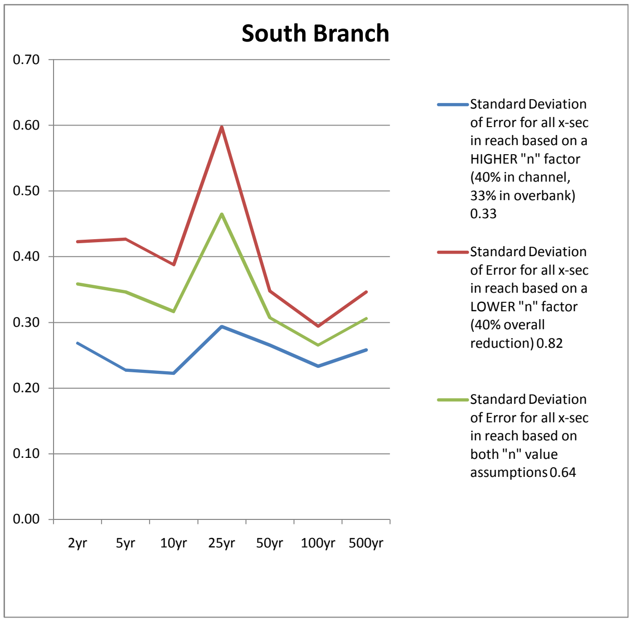
SOUTH: 1-yr error for lower n-values looked like an outlier. Averaged the other values, then estimated use 0.30 to give more weight to error based on higher n-values.

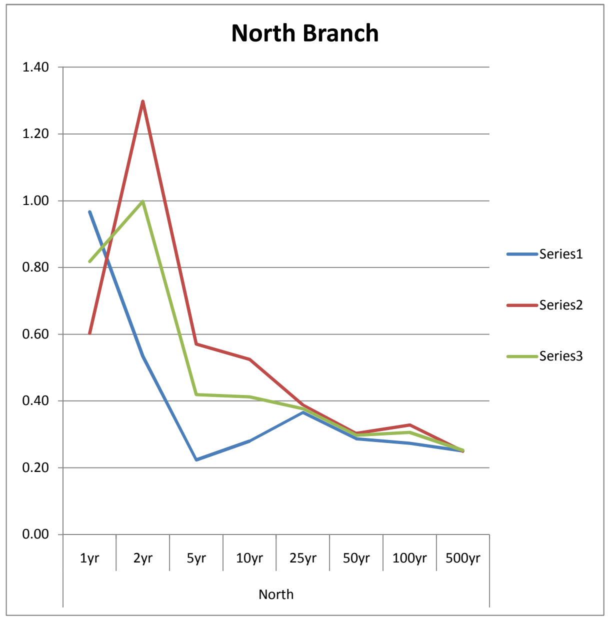
NORTH: 1-yr error for higher n-values and 2-yr error for lower n-values looked like outliers. Averaged the other values, then estimated use 0.30 to give more weight to error based on higher n-values.

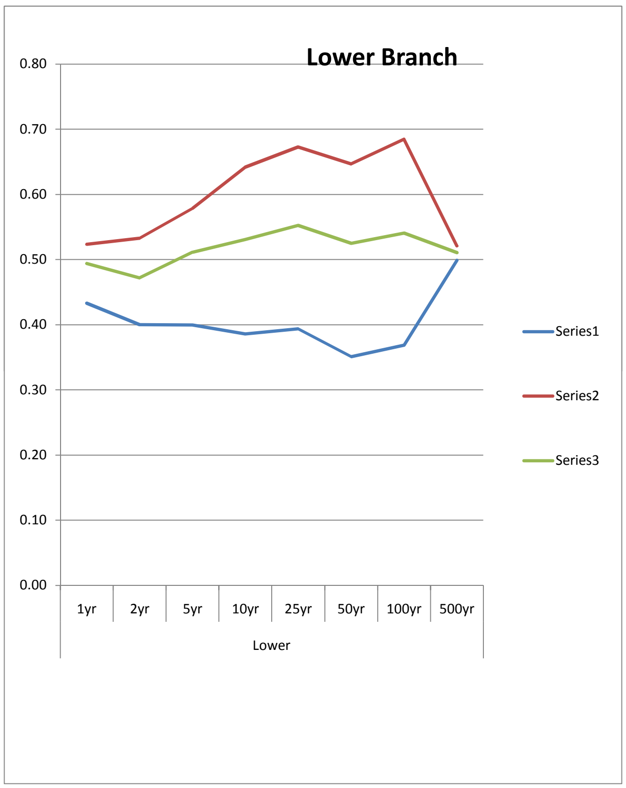
LOWER: No apparent outliers. Estimated use 0.45 to give more weight to error based on higher n-values.

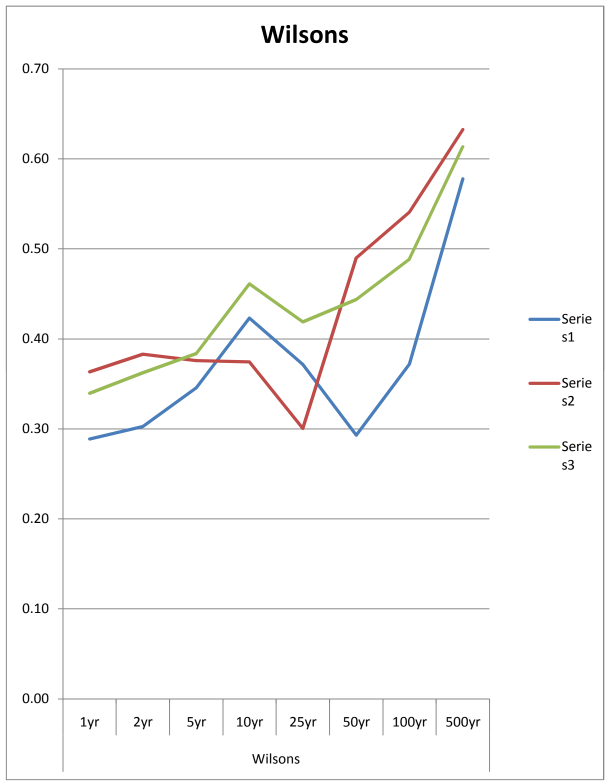
WILSONS: No apparent outliers. Estimated use 0.4 to give more weight to error based on higher n-values.

Estimated 10-year for stage where error becomes constant from visual inspection of 10-yr stage at cross-sections in each reach. 10-year was out of channel at most locations in all the reaches. Selecting the 10-yr stage will result in zero error at the thalweg, with the error increasing linearly to the maximum at the 10-yr stage, then constant maximum erro for all higher stages.


South Branch
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2yr
5yr
10yr
25yr
50yr
100yr
500yr
Standard Deviation of Error for all x-sec in reach based on a HIGHER "n" factor (40% in channel, 33% in overbank) 0.33
Standard Deviation of Error for all x-sec in reach based on a LOWER "n" factor (40% overall reduction) 0.82
Standard Deviation of Error for all x-sec in reach based on both "n" value assumptions 0.64


North Branch
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1yr
2yr
5yr
10yr
25yr
50yr
100yr
500yr
North
Series1
Series2
Series3


Lower Branch
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1yr
2yr
5yr
10yr
25yr
50yr
100yr
500yr
Lower
Series1
Series2
Series3


Wilsons
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
1yr
2yr
5yr
10yr
25yr
50yr
100yr
500yr
Wilsons
Series1
Series2
Series3

Appendix HH-K – Proposed Regional Detention – Preliminary Basin Summary

Proposed Regional Detention Basins - Preliminary Analysis

Basin Name	Reach Name	Location Description	Approx Surface Area (acres)	Approx Storage Volume (ac-ft)	Approx Peak Flow Reduction at discharge (initial estimate - based on 100yr event)	Notes
B1	Lower Branch	Upstream of Bennett Street	18	170	<1% for 100yr Event	Preliminary analysis showed that there was not enough storage volume available to cause a significant reduction in peak flow.
B2	Lower Branch	Upstream of Grand Street	25	300	< 1%	Preliminary analysis showed that there was not enough storage volume available to cause a significant reduction in peak flow.
B3	Lower Branch	West Meadows Area (upstream of Fort)	29	140	5%	The West Meadows is a Brownfield site and the cost of excavation would be very high. Even in series with other basins, this facility did not cause a significant reduction in peak flow.
B3A	Lower Branch	Between Fort Ave and College Street	6	75	1%	Construction of this basin would involve relocation of the railroad or the construction of a large railroad bridge spanning the basin. The reduction in peak flow was not significant.
B4	Confluence	East "Wye" - Confluence of North and South Branch	4	35	<1%	Not enough available storage volume to cause a significant decrease in the peak.
B5	South Branch	1000-ft upstream of Fremont Avenue	9	96	6%	While basin resulted in a 6% reduction in peak flow, it will require acquisition of private property, significant excavation, modification to the downstream channel, and loss of riparian corridor. Also, the control structure required to regulate the basin might cause the 500yr WSE to surcharge in an extremely large event.
B5A	South Branch	2000-ft upstream of Fremont Avenue	5	37	6%	While basin resulted in a 6% reduction in peak flow, it will require acquisition of private property, significant excavation, and loss of riparian corridor.

B6	South Branch	Upstream of Chestnut Exp.	5.99	35.6	24%	Basin provides good reduction in peak. While it includes significant excavation and land acquisition, it was further analyzed as a viable alternate.
B7	South Branch	East end of Rockhurst Street	6.73	46.2	70%	Basin could potentially reduce peak flows to the capacity of the existing system. Basin was included as a viable alternate.
B9A	South Branch	East side of Cedarbrook Avenue, Norh of Pythian Street	11	157	97%	Construction of this basin would involve excavating the existing soccer fields. Of the three basins (9A, B, & C) only two of three are needed. It was determined that this was the least likely due to it's impact on the soccer fields.
B9B	South Branch	NW Corner of Pythian & Cedarbrook	5.68	27.7	97%	The upper stage of a two-stage basin with B9C. Together they reduce flows to the capacity of the existing system.
B9C	South Branch	NW Corner of Pythian & Cedarbrook	5.02	30.5	97%	Discharge into existing system. Basin will keep flows in system. Current basin overtops.
B10	North Branch	Downstream of National Ave. (Silver Springs Park)	4	25	1-8%	8% reduction only occurs when in series with B14, B12, B11, B10B. It was determined that this basin gave marginal results.
B10A	North Branch	Downstream of Division Street. (Smith Park)	6	40	<10%	Limited flow reduction and located in a Historic Park. Construction would result in destruction of historic structures.
B10B	North Branch	Downstream of Glenstone Ave.	3	26	7-30%	30% reduction only occurs when in series with B14, B12, and B11. Requires acquisition of 11 homes and damage to riparian corridor.

B11	North Branch	South of Blaine US Glenstone	8.68	36.4	80%	Basin construction would involve acquisition from 8 property owners, significant excavation, and damage to the riparian corridor. However, the peak flow reductions were significant, so this basin was included as a viable alternative.
B11A	North Branch	South of Blaine at Link	6.24	19.2	50%	Basin construction would involve removal of several trees. The peak flow reduction was significant, so it was included as a viable alternate.
B12	North Branch	NW Corner of Blaine and Yates	2.29	9.4	25%	In-line basin that catches flow from the north. Proposed system along Blaine would surcharge into basin and be released based on system capacity. Was considered as a viable alternative.
B12A	North Branch	NE Corner of Blaine and Yates	3	6	2%	Gave marginal results when depth was limited to existing sytem. Would likely be comparable to B12 with similar volume. Requires acquisition of 4 homes.
B14	North Branch	North of Blaine, W of Packer	11.39	53.9	95%	Requires expansion of City owned basin. Considered a viable alternative.
B15	North Branch	West side of Packer Rd, N of RR	3.99	30.1	98%	Would likely require permission from Railroad and land acquisition. Were unable to determine if upstream water actually reached the basin or was diverted.
B16-17-18	North Branch	East of Packer Rd, N of RR	18	400	45-70%	Three separate basins were analyzed in this area, divided by the two RR tracks and the access road. The storage area was also designed as one large basin (with each area joined by a large pipe). Regardless of how the basin was analyzed, it did not provide a substantial decrease in peak flows when compared to the existing constriction under the railroad tracks.

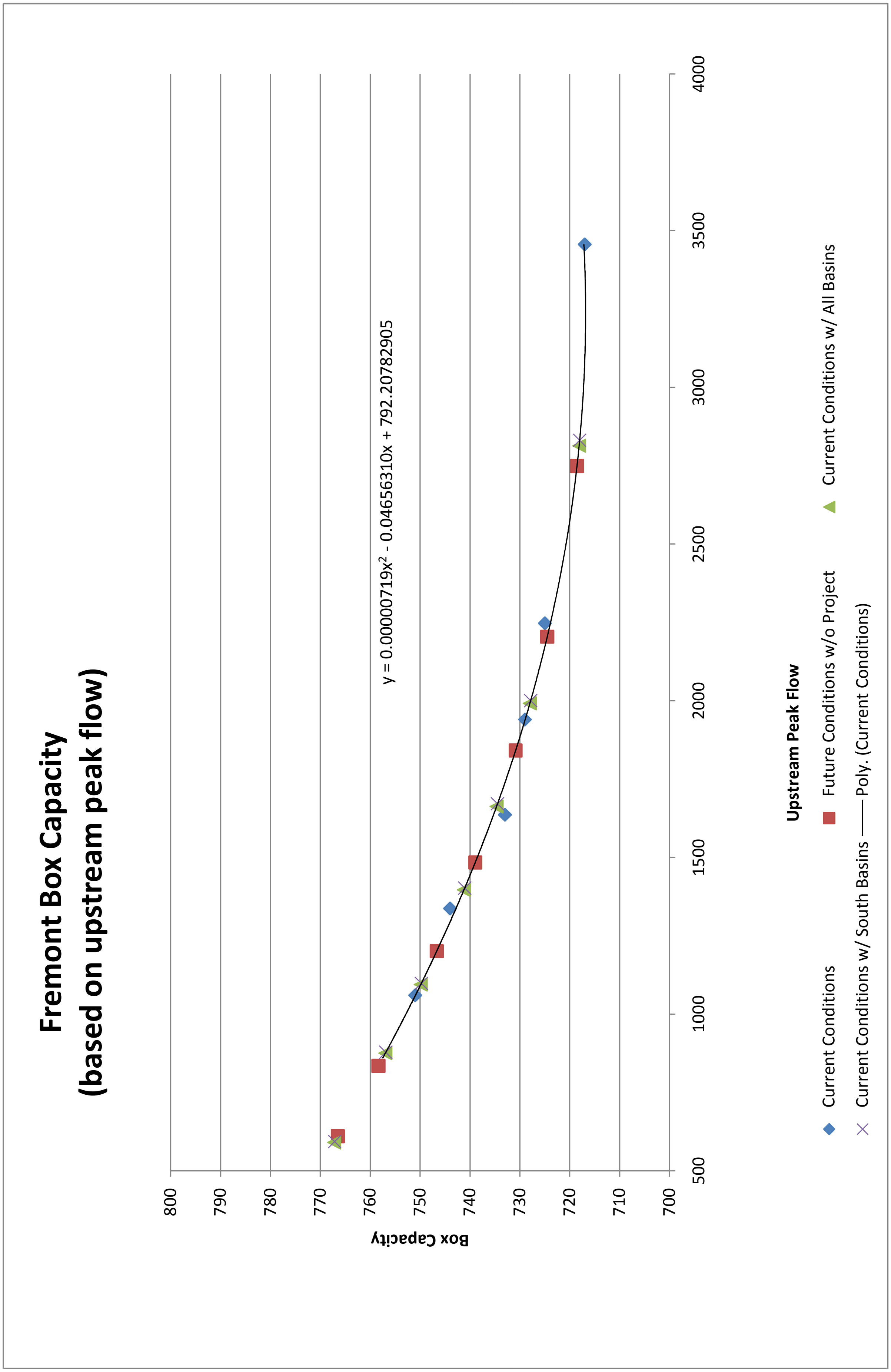
Appendix HH-L – Summary Table of Regional Detention Analysis

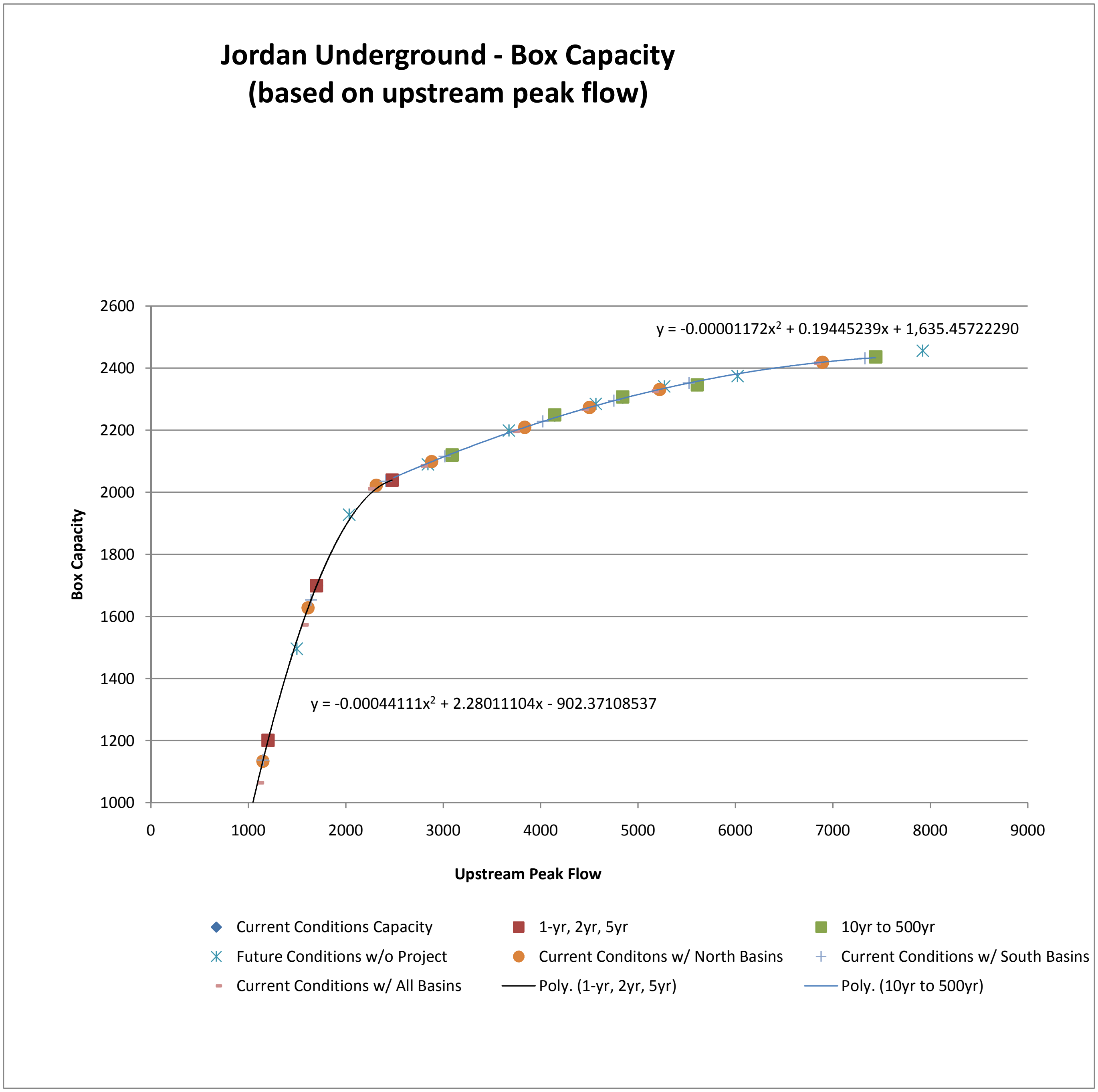
Proposed Regional Detention Basins - Analysis of Impact on Peak Flows

Basin Configuration	Reach Name	Location Description	Approx Surface Area of Basin (acres)	Approx Storage Volume (ac-ft)	Analysis Point DS	Reduction In 100yr Peak Immediately Downstream of Basin (located at next hydrograph combination)	With Basin Peak Flow DS	W/O Bains Peak Flow DS	Confluence of NB & SB: Reduction in 100yr Peak Flow @ Confluence (HC75)	Confluence of NB & SB: With Basin Peak Flow @ HC75	Confluence of NB & SB: W/O Basin Peak Flow @ HC75	Catalpa Street on LB: Reduction in 100yr Peak Flow @ Catalpa St (HCLJ20)	Catalpa Street on LB: With Basin Peak Flow @ HCLJ202	Catalpa Street on LB: W/O Basins Peak Flow @ HCLJ20	NB DS of Glenstone: Reduction in 100yr Peak Flow @ HCNB21	NB DS of Glenstone: With Basin Peak Flow @ HCNB21	NB DS of Glenstone: W/O Basin Peak Flow @ HCNB21	NB at Central Street: Reduction in 100yr Peak Flow @ HCNB31	NB at Central Street: With Basin Peak Flow @ HCNB31	NB at Central Street: W/O Basin Peak Flow @ HCNB31	SB at RR DS of Trafficway: Reduction in 100yr Peak Flow @ Confluence HCSJX	SB at RR DS of Trafficway: With Basin Peak Flow @ HCSJX	SB at RR DS of Trafficway: W/O Basin Peak Flow @ HCSJX	SB at Fremont: Reduction in 100yr Peak Flow @ SJ37	SB at Fremont: With Basin Peak Flow @ SJ37	SB at Fremont: W/O Basin Peak Flow @ SJ37	Notes
B6	South Branch	Upstream of Chestnut Exp.	5.99	35.6	HCSJX	0.0%	1522.0	1522.0	0.0%	5876.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	This basin only functions when in series with B7 & B9(B&C). When the flows are reduced by these upstream basins, a control structure can be placed upstream of Chestnut. Otherwise, the storage behind the culvert is already accounted for with Modified Puls Routing element MP27.
B6B	South Branch	West side of Patterson	7.5	39.8	SJ25	14.6%	1207	1414	0.0%	5874	5874	0.0%	7103	7103	0.0%	1627	1627	0.0%	2781	2781	6.0%	1431	1522	0.0%	2260	2260	This basin includes excavation of the stream valley and soccer field just downstream of Patterson Ave on South Branch. It appears to function very similar to Basin B6 with less reduction and more excavation.
B6 (IN SERIES WITH B9B & C AND B7)	South Branch					N/A		N/A	N/A			N/A		N/A	0.0%	1627	1627.0	0.0%	2781	2781.0	11.8%	*	1522.0	5.7%	*	2260.0	This line shows the effects of B6 without any other basins. The fields were calculated by finding the difference between the following scenarios (All Basins - Basins B9B&C and B7)
B6B (IN SERIES WITH B9B & C AND B7)	South Branch					N/A		N/A	N/A		N/A	N/A		N/A	0.0%	1627	1627	0.0%	2781	2781	2.7%	*	1522	2.7%	*	2260	This line shows the effect of B6B without any other basins. The field was calculated by finding the difference between the following scenarios (B6B IN SERIES WITH B9B & C, B7 AND B9B & C, B7)
B7	South Branch	East end of Rockhurst Street	6.73	46.2	SJ15	51.7%	431.0	892.0	0.4%	5848.0	5874.0	0.1%	7099.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	24.4%	1150.0	1522.0	3.8%	2173.0	2260.0	Glenwood Park Basin. Basin could potentially reduce peak flows to the capacity of the existing system and solve a number of local flooding problems along Rockhurst Street.
B9B	South Branch	NW Corner of Pythian & Cedarbrook	5.68	27.7	RRSJ21	75.8%	104.0	429.0	0.1%	5868.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	8.7%	1390.0	1522.0	2.3%	2207.0	2260.0	The upper stage of a two-stage basin with B9C. Together they reduce flows to the capacity of the existing system. Notice that you get nearly the same results without construction basin B9C and leaving the existing basin in place.
B9C	South Branch	NW Corner of Pythian & Cedarbrook	5.02	30.5	RRSJ21	53.6%	199.0	429.0	0.1%	5868.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	6.2%	1428.0	1522.0	2.2%	2211.0	2260.0	Plan calls for regrading existing regional basin. Discharge into existing system. Basin will keep flows in system. Current basin overtops.
B9B & C	South Branch	NW Corner of Pythian & Cedarbrook	14.92	58.2	RRSJ21	80.7%	83	429	0.1%	5868.0	5874.0	0.0%	7103.0	7103.0	0.0%	1627.0	1627.0	0.0%	2781.0	2781.0	8.9%	1387.0	1522.0	2.3%	2207.0	2260.0	Two basins work in series with each other. The reductions shown here are not much greater than those shown with B9B.
B11	North Branch	South of Blaine US Glenstone	8.68	36.4	HCNB21	19.2%	1315.0	1627.0	3.7%	5656.0	5874.0	0.7%	7056.0	7103.0	19.2%	1315.0	1627.0	9.3%	2521.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Basin construction would involve acquisition from 8 property owners, significant excavation, and damage to the riparian corridor. The existing regional basin would remain but the area east would require extensive regrading.
B11A	North Branch	South of Blaine at Link	6.24	19.2	HCNB17	15.5%	935.0	1106.0	2.7%	5718.0	5874.0	0.5%	7067.0	7103.0	12.8%	1418.0	1627.0	6.4%	2603.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Basin construction would involve removal of several trees and property acquisition.
B11B	North Branch	Upstream of Glenstone	N/A		HCNB19	4.6%	1170	1227	2.5%	5730	5874	0.4%	7072	7103	10.6%	1455	1627	6.2%	2608	2781	0.0%	1522	1522	0.0%	2260	2260	Since Basins B11 and B11A require extensive grading and damage to vegetation, Basin B11B includes minimal grading within riparian corridor. Basins adjacent to stream are excavated and connected to the main channel. A small dam and weir is located on DS end. Peak flow reduction immediatly downstream from basin is small, but the change

B11C	North Branch	South of Blaine at Link			HCNB17	13.8%	953	1106	3.4%	5673	5874	0.7%	7055	7103	14.0%	1400	1627	8.5%	2546	2781	0.0%	1522	1522	0.0%	2260	2260	This is a modification of B11A. This basin preserves the trees north of the stream. The area south of the stream will be excavated to the flowline of the stream with 6:1 side slopes. An 18-ft weir and dam will be placed dowstream of the basin area.
B11 & B11C						N/A		N/A	5.6%	5546	5874	1.1%	7022	7103	30.8%	1126	1627	13.1%	2418	2781	0.0%	1522	1522	0.0%	2260	2260	Represents the combination of B11 with B11B. While this will significantly impact the riparian vegitation, the impacts to peak flows are significant. The basin will have a minimal slope, allowing aquatic vegitation and potential wetlands.
B11 & B11A						N/A		N/A	5.9%	5525	5874	1.2%	7015	7103	33.6%	1080	1627	13.7%	2399	2781	0.0%	1522	1522	0.0%	2260	2260	Two regional basins which appear to give the greatest benefit throughout Lower Branch.
B12	North Branch	NW Corner of Blaine and Yates	2.29	9.4	HCNB12	22.5%	485.0	626.0	0.2%	5864.0	5874.0	0.0%	7102.0	7103.0	2.4%	1588.0	1627.0	0.4%	2769.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	In-line basin that catches flow from the north. Proposed system along Blaine would surcharge into basin and be released based on system capacity. Is considered as a viable alternative for reducting local peaks when used in series with B14. This basin would also provide a lower flowline for a future system to the north.
B14	North Branch	North of Blaine, W of Packer	11.39	53.9	HCNB11	49.3%	273.0	538.0	0.1%	5869.0	5874.0	0.0%	7103.0	7103.0	0.7%	1615.0	1627.0	0.1%	2778.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Requires expansion of City owned basin. Basin B14 does an excelent job of reducing peak flows to the capacity of a new pipe under Blaine street, but does not provide much downstream reduction. Even though the reduction is outside of the project area, this basin could significantly reduce flooding for many homes along Blaine.
B14 & B12 (IN SERIES)						N/A		N/A	0.1%	5866	5874.0	0.0%	7102	7103.0	2.6%	1584	1627.0	0.5%	2767	2781.0	0.0%	1522	1522.0	0.0%	2260	2260.0	Basin B14 in series with B12. The addition of B12 provides slightly more peak flow reduction. This reduction is more significant along Blaine Street.
B15	North Branch	West side of Packer Rd, N of RR	3.99	30.1	HCNB9	33.1%	103	154	0.1%	5869	5874.0	0.0%	7103	7103.0	0.4%	1620.0	1627.0	0.1%	2778.0	2781.0	0.0%	1522.0	1522.0	0.0%	2260.0	2260.0	Would likely require permission from Railroad and land acquisition. Were unable to determine if upstream water actually reached the basin or was diverted. This basin is not a likely alternative.
All 9 Regional Basins in Series (B15, B14, B12, B11, B11A, B9B, B9C, B7, B6)	Norh/South Branch	All Basins Combined In Series	65	387		N/A		N/A	6.4%	5498	5874	1.3%	7008	7103	36.1%	1039	1627	13.7%	2399	2781	43.9%	854	1522	9.6%	2042	2260	The "Basic 9" proposed regional detention basins in series together.
Basins B14, B9B & C, B7 (CITY OWNED BASINS)						N/A		N/A	0.5%	5847	5874.0	0.1%	7099	7103.0	1.4%	1605.0	1627.0	0.3%	2773.0	2781.0	32.1%	1034.0	1522.0	3.9%	2172.0	2260.0	All Detention Basins on City Owned Property . These Basins Give the greatest reduction immediately downstream.
City's Preferred Option						N/A		N/A	6.1%	5518	5874.0	1.2%	7016	7103.0	30.8%	1126.0	1627.0	13.1%	2418.0	2781.0	43.8%	855.0	1522.0	9.6%	2042.0	2260.0	Based on this analysis. Basins B11, B11C, B9B, B7, & B6 appear to be the optimal combination of regional detention to reduce flows within the Federal Study Limits.

Appendix HH-M – Overland Rating Curves for Determining HEC-RAS Flows


Fremont Box Capacity
(based on upstream peak flow)
y = 0.00000719x² - 0.04656310x + 792.20782905
Box Capacity
800
790
780
770
760
750
740
730
720
710
700
500
1000
1500
2000
2500
3000
3500
4000
Upstream Peak Flow
Current Conditions
Future Conditions w/o Project
Current Conditions w/ All Basins
Current Conditions w/ South Basins
Poly. (Current Conditions)



Jordan Underground - Box Capacity
(based on upstream peak flow)
y = -0.00001172x² + 0.19445239x + 1,635.45722290
y = -0.00044111x² + 2.28011104x - 902.37108537
2600
2400
2200
2000
1800
1600
1400
1200
1000
Box Capacity
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Upstream Peak Flow
Current Conditions Capacity
1-yr, 2yr, 5yr
10yr to 500yr
Future Conditions w/o Project
Current Condititons w/ North Basins
Current Conditions w/ South Basins
Current Conditions w/ All Basins
Poly. (1-yr, 2yr, 5yr)
Poly. (10yr to 500yr)

Appendix HH-N – HY-8 Rating Curves for Determining Flow Split at Confluence during With Project Conditions

Existing Box Culvert 2 @ 15' W x 8' H

Conventional Headwall		Existing Box Culvert w/ improved 1.5:1 (90°) beveled headwall		Existing Box Culvert w/ 4:1 Side Tapered Inlet (35' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.12	0	1262.12	0	1262.12	0
1264.35	250	1264.23	250	1264.22	250
1265.81	500	1265.66	500	1265.66	500
1267.25	750	1267.09	750	1267.09	750
1268.39	1000	1268.22	1000	1268.21	1000
1269.50	1250	1269.30	1250	1269.30	1250
1270.72	1500	1270.51	1500	1270.51	1500
1272.56	1750	1272.31	1750	1272.30	1750
1274.50	2000	1274.18	2000	1274.17	2000
1274.99	2050	1276.63	2250	1276.61	2250
1275.48	2100				
1275.97	2150				
1276.46	2200				
1277.04	2250				
1279.46	2500				

New Box Culvert 1 @ 30' W x 10' H

Conventional Headwall		New Box Culvert w/ improved 1.5:1 (90°) beveled headwall		New Box Culvert w/ 4:1 Side Tapered Inlet (38' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.14	0	1262.14	0	1262.14	0
1266.14	600	1265.83	600	1265.83	600
1268.51	1200	1268.00	1200	1268.00	1200
1270.49	1800	1269.82	1800	1269.82	1800
1272.26	2400	1271.45	2400	1271.45	2400
1273.87	3000	1272.94	3000	1273.32	3000
1275.36	3500	1274.33	3600	1274.32	3500
1277.82	4200	1275.65	4200	1275.99	4200
		1277.11	4800		
		1278.91	5400		

New Box Culvert 1 @ 32' W x 10' H

Conventional Headwall		New Box Culvert w/ improved 1.5:1 (90°) beveled headwall		New Box Culvert w/ 4:1 Side Tapered Inlet (38' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.14	0	1262.14	0	1262.14	0
1265.06	400	1264.85	400	1264.84	400
1266.80	800	1266.43	800	1266.43	800
1268.25	1200	1267.76	1200	1267.76	1200
1269.55	1600	1268.95	1600	1268.95	1600
1270.74	2000	1270.04	2000	1270.04	2000
1271.85	2400	1271.06	2400	1271.06	2400
1272.89	2800	1272.02	2800	1272.02	2800
1273.89	3200	1272.94	3200	1273.13	3200
1274.96	3600	1273.88	3600	1273.82	3600
1276.20	4000	1274.94	4000	1274.67	4000

New Box Culvert 2 @ 20' W x 10' H

Conventional Headwall		New Box Culvert w/ improved 1.5:1 (90°) beveled headwall		New Box Culvert w/ 4:1 Side Tapered Inlet (38' Face Width) Square Edge top (90°) wingwall	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1262.14	0	1262.14	0	1262.14	0
1264.66	400	1264.47	400	1264.55	400
1266.13	800	1265.83	800	1265.83	800
1267.37	1200	1266.98	1200	1266.98	1200
1268.47	1600	1268.00	1600	1268.00	1600
1269.48	2000	1268.94	2000	1268.94	2000
1270.43	2400	1269.83	2400	1269.83	2400
1271.32	2800	1270.66	2800	1270.66	2800
1272.17	3200	1271.46	3200	1271.46	3200
1272.99	3600	1272.22	3600	1272.22	3600
1273.79	4000	1272.96	4000	1272.96	4000

New Box Culvert at Sta. 977 @ 38' W x 9.5' H

Conventional Headwall		New Box Culvert w/ improved		New Box Culvert w/ 4:1 Side	
HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)	HW (Elev.)	Q (cfs)
1265.87	0	1265.87	0		
1268.11	320	1267.86	320		
1269.40	640	1269.02	640		
1270.50	960	1270.00	960		
1271.44	1280	1270.88	1280		
1272.52	1600	1272.18	1600		
1274.06	1920	1273.81	1920		
1275.78	2240	1275.60	2240		
1276.96	2560	1276.78	2560		
1278.04	2880	1277.81	2880		
1279.16	3200	1278.82	3200		