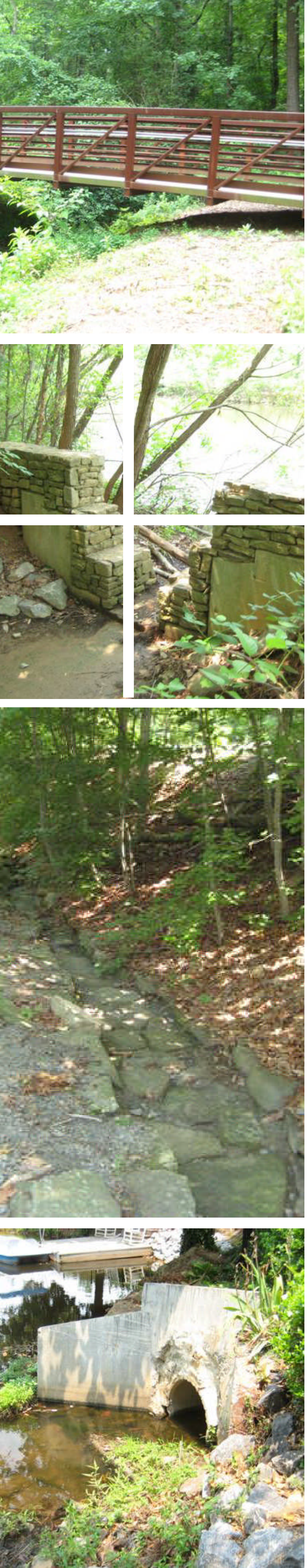

Webb Bridge Park Drainage Study

Alpharetta
GEORGIA • USA

City of Alpharetta, Georgia

June 8, 2012

Prepared by:

Manhard
CONSULTING

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I. EXECUTIVE SUMMARY

OVERVIEW

Webb Bridge Park is a 95-acre property located along the eastern perimeter of the City of Alpharetta. Refer to Figure 1: "Location Map". The park is accessed from Webb Bridge Road and is encircled by a paved roadway system, which provides entry to the majority of the park amenities. The park is popular with local residents, who enjoy year-round use of the extensive gravel trail system, athletic fields, and the large playground area.

Since the site's original construction in 1997, residents on adjacent properties have brought concerns to the City regarding stream/slope erosion, potential water quality issues, and downstream sediment accumulation in Lake Windward. The City has been able to address many of the issues as they arise with treatments to stabilize eroded channel banks and educating the neighboring subdivisions on proper use of fertilizers and debris disposal. However, problems associated with stream and property erosion remain both on and downstream of the park property. Additionally, park staff is tasked monthly with debris and sediment removal from roadside ditches that become obstructed following rain events.

A brief orientation of surrounding landmarks which will be mentioned throughout this report: The park is bordered by the Nottingham Gate and Parkside Manor subdivisions on the west, the Thornbury Parc subdivision to the northeast and the Benton House to the southeast. Kimball Bridge Road is located to the south and Lake Windward lies to the north. Refer to Figure 2: "Site Map".

The park has two primary contributory drainage areas – 105 acres that collect stormwater runoff from the western portion of the park, which is conveyed through a perennial stream, and 73 acres that convey runoff from the eastern portion of the park. Figure 3, "Park Map", provides reference of the park layout and key stormwater drainage features. Runoff from the western side of the park is conveyed by a combination of short pipe segments and overland flow, routed down steep earthen slopes to a perennial stream that flows in a northerly direction from the park property, onto private property, and back onto park property. The stream ultimately discharges into a slough on the south side of Lake Windward. The Windward Association has requested the City evaluate the park's potential role in contributing to sediment accumulation in the lake.

Runoff from the eastern portion of the park is captured by a wet pond, which discharges to a stream which flows offsite and into a pond in Thornbury Parc. The Thornbury pond receives runoff from both the park and the residential lots in the neighborhood. The subdivision's pond discharges into a stream segment that runs in a westerly direction to a confluence with the park's western perennial stream, mentioned in the previous paragraph. The park staff has recently had to dredge the onsite pond and they believe the solids runoff from the upstream parking lots and children's playground area are primary contributing factors to the sedimentation.

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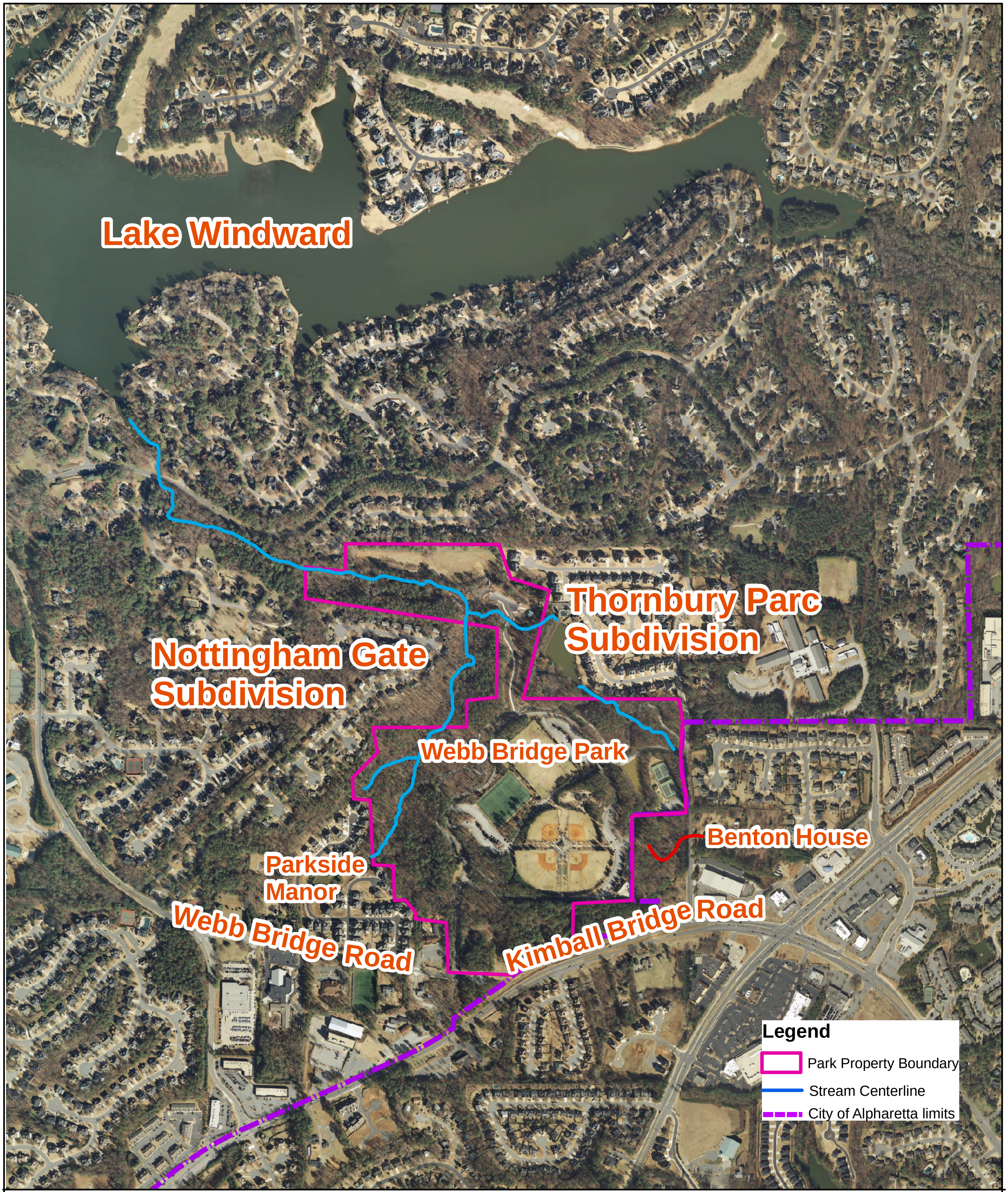
Webb Bridge Park Drainage Study
Figure 1: Location Map



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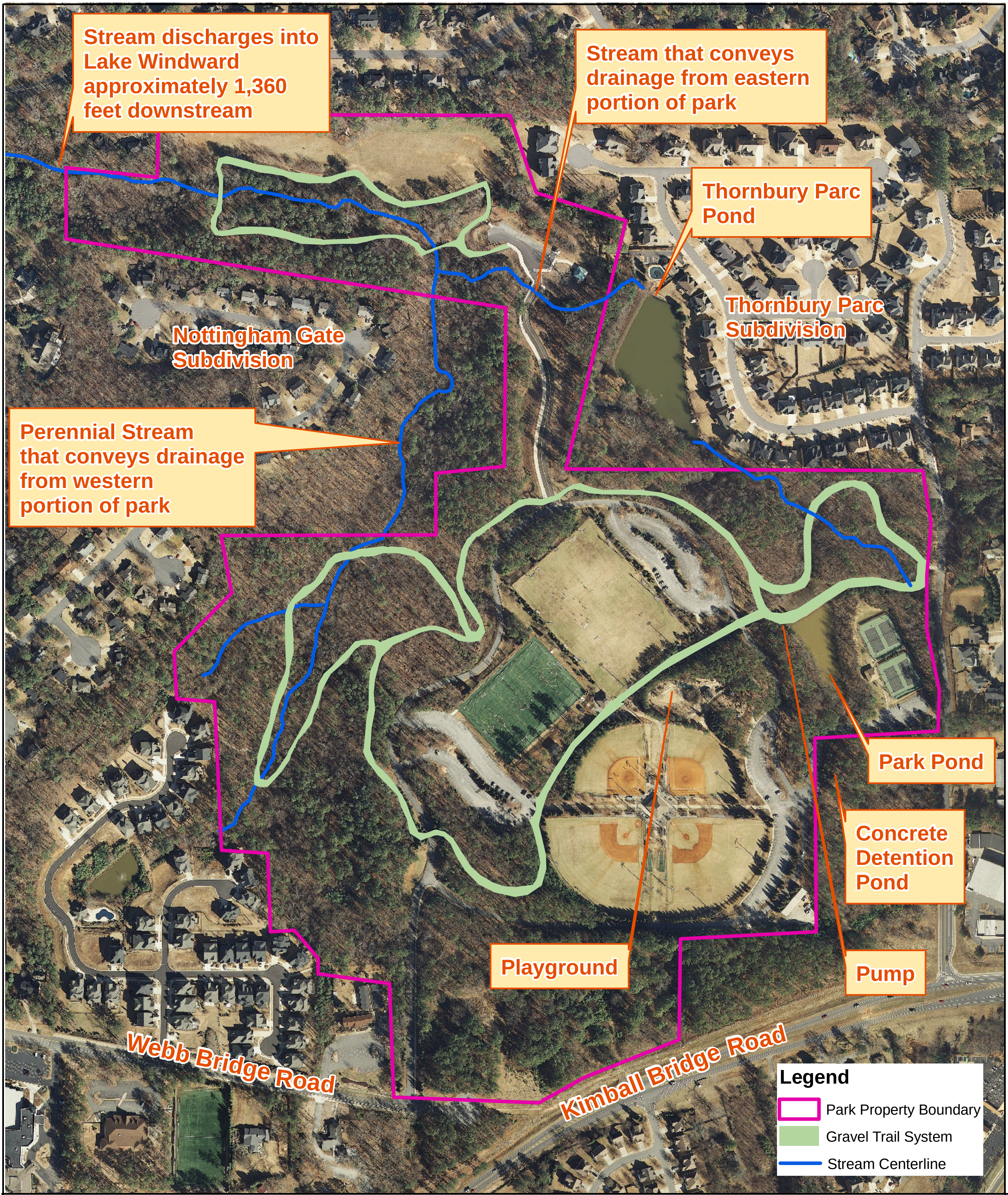
Webb Bridge Park Drainage Study
Figure 2: Site Map

N W E S

-No Scale-



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Webb Bridge Park Drainage Study
Figure 3: Park Map

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The purpose of this drainage study is to develop:

(1) An overall plan to reduce stream erosion and the resultant sedimentation both on and downstream of the park;

(2) A plan to improve water quality conditions and reduce sedimentation in the park pond; and

(3) A determination of whether or not runoff from the park contributes to storage volume reduction in Lake Windward.

INTRODUCTION

To thoroughly evaluate both the causes of and solutions to stormwater-related issues both on the park and downstream, the drainage study consisted of two primary elements: a methodical field, water quality, and habitat assessment (as detailed in the Approach section) and an in-office modeling analysis to evaluate the park's "response" following a given storm event. The modeling exercise evaluated the runoff response from various rain events (small, frequent events to larger storms), to determine how the park's streams and ponds convey the runoff. The field evaluations provided valuable data on actual conditions (areas of erosion and visible impairments) and determined locations of possible nutrient loadings to the water bodies and streams, to support the implementation of future BMPs, restoration activities, and retrofits. Additionally, the habitat assessment offers insight on the overall health of the contributory watershed and stream, based on species present in the water.

The following paragraphs introduce some key physical features of the park that were evaluated during this study. More inclusive information and detail is provided within the report sections.

The park's ball fields include four baseball fields, two soccer fields (one with artificial turf and one with natural grass cover), and four tennis courts. The playground area is located just north of the baseball fields. Three parking lots are located within the park. While these lots were originally constructed with the intent of incorporating pervious pavement, the pavement has not infiltrated runoff as designed and essentially performs as traditional impervious pavement. Additionally, the gravel on the top layers has become loose, contributing to the solids loading in the park's streams and pond. A fourth parking lot paved with traditional asphalt pavement is located to the south of the tennis courts.

During the months of May through September, a well pump (which is located adjacent to the walking trail and creek) is run daily and pumps water up to a small rock channel in the playground area. This channel discharges the water into a pipe system, then a short ditched system, and ultimately routes the water back to the pond. The playground includes a large sandbox area that the City replenishes every spring with approximately 18 tons of sand. Given the proximity of the sandbox to the rock channel, children routinely place sand in the channel.

When the pump is running or a rain event occurs, this sand is conveyed into the downstream drainage system. The City has dredged the park pond, which was built during original park construction, once in the past fourteen years in spring 2011. In addition to the full dredging that was done in 2011, the City has completed multiple small dredging efforts around the vicinity of an irrigation pump located at the northwest corner of the pond.

Another existing stormwater feature that is hydraulically connected to the park pond is a concrete detention pond located just south of the park pond. This concrete detention pond is located in the Benton House development of Johns Creek, off of Fox Road, and was constructed in 2011. The relationship between the playground and these two ponds, with respect to water quality, will be elaborated in the Approach section.

An extensive gravel trail system winds through the park property. The 2.2-mile trail system covers 4.7 acres of land. Approximately 54 tons of gravel is required annually to replenish areas that have become bare due to washoff.

As the reader will see in the following sections, this drainage study fulfills the three-part purpose highlighted above. Furthermore, in the development of project recommendations for Webb Bridge Park, we were cognizant of both the overall goals and costs. A prioritized list of projects to correct deficiencies and improve water quality is set forth in the recommendations. Aesthetics, permitting requirements, design regulations, and existing physical constraints were all considered during this process.

II. PROJECT APPROACH AND EXECUTION

FIELD EVALUATIONS AND SITE ASSESSMENT

Field reconnaissance took place throughout the duration of the drainage study, which was conducted over the months of August to December 2011. A preliminary site visit took place on June 28th, prior to the official project commencement, to assist in the scope development. Site visits were conducted to obtain different specific data, both visual and measured.

It is important to note that certain stormwater-related issues tend to be more indicative of seasonal occurrences (temperatures, application of fertilizers) while other problems have been established over time as a result of increased runoff due to upstream development. The solution to one problem may include the modification of activities or processes, while another problem may be better mitigated with more structural, physical treatments. Sometimes the best solution is a combination of both. This will be discussed in more detail in the Recommendations section.

Site visits took place on June 28th, August 31st and September 21st with the purpose of documenting existing conditions in the park and at the Shirley Bridge Road culvert, which is the downstream location where the park’s stream ultimately discharges into a slough on the south side of Lake Windward. There is approximately 1,360 linear feet of stream between the park property boundary and Shirley Bridge Road. During these visits, stream bank erosion, stream entrenchment, stormwater drainage structures, and the ponds were evaluated. Culverts and stream crossings along the park trails and roadways were surveyed to document size, condition, and overall hydraulic function.

Water quality sampling events took place on October 12th, October 19th, November 16th and November 28th. A macroinvertibrate bioassessment was conducted on November 15th. These sampling events are detailed further in the following section.

For a photo location map and photo log documentation of the field reconnaissance, please refer to Appendix A.

WATER QUALITY ASSESSMENT

Water quality sampling was completed at Webb Bridge Park in order to identify specific pollutants and existing sources of pollution; characterize the waters; and identify changes/trends over time. Water quality sampling helps link specific sources of pollution to a stream quality problem. Certain activities within a watershed generate certain pollutants; therefore, a tentative link can be made that would warrant further investigation or sampling efforts. Sampling for certain chemical constituents on a regular basis can be used to analyze stream and water resources trends over time.

The stream sampling stations were identified and selected to provide information on short-term ambient trends in waters that may be affected by point source discharges and nonpoint source impacts within, and downstream of, Webb Bridge Park. The water quality sampling point locations were based on surrounding land use, stream characteristics, point source, and stormwater discharges. Information gathered from the water quality sampling provided insight as to the ability of the stream to support a healthy aquatic community and to the presence of chemical and non-chemical stressors to the stream ecosystem.

Seventeen water quality sampling stations were identified within the Webb Bridge Park watershed. Refer to Figure 4: “Sampling Station Locations”. The water quality sampling stations included stream and culvert sampling stations. Six water quality sampling stations (Stations SS 1- SS 6) were located within the outfalls of the culverts and detention ponds. Eleven water quality sampling stations (Stations SS 7-SS 17) were located within the streams. The water quality sampling stations were sampled four times between October and November 2011 (Table 1).

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Webb Bridge Park Drainage Study
Figure 4: Sampling Station Locations

N W E S

-No Scale-

Table 1. Water Quality Sampling Events

Sampling Event	Date Conducted	Total Precipitation (inches)
1	October 12, 2011	0.75
2	October 19, 2011	0.73
3	November 16, 2011	1.45
4	November 28, 2011	0.62

Methodology

Water quality sampling was conducted in-situ using a multi-parameter instrument and a colorimeter. Both physiochemical and analytical parameters were gathered during the sampling events. The physiochemical parameters included temperature, dissolved oxygen, pH, and conductivity while the analytical parameters consisted of nitrate, phosphorous, turbidity, and potassium. Sampling was conducted between October and November 2011 and during rain events after 0.30 inches of rain had occurred. Additionally, each sampling effort was scheduled with at least 72 hours of dry weather between each event.

The Oakton Multi-parameter PCSTester 35 was used to sample temperature, conductivity, and pH. The multi-parameter instrument was placed in mid-channel at an area that had good vertical mixing, such as at the end of a riffle zone. The unit was left to stabilize, which was approximately 60 seconds, in order to allow the sensors to reach thermal equilibrium with the water temperature. For each parameter, the multi-parameter instrument was allowed to stabilize prior to recording the final measurement.

The Smart3 Colorimeter was used to sample nitrate, phosphorous, dissolved oxygen, potassium, and turbidity. Grab samples were taken in mid-channel in an area with cross-sectional homogeneity where the water is well mixed such as at the end of a riffle zones which

have good vertical mixing. All grab samples were taken from downstream to upstream within the stream channel. Samples within the stream were taken well below the surface to eliminate the chance of collecting surface film. For each sample taken within the channel the cap of the sample bottle was removed under water allowing the bottle to fill with water. The bottle was then inverted to allow water to fill to the rim of the bottle. Once the bottle was filled to the rim underwater, the cap was replaced while underwater. Reagents were then mixed with the grab samples in order to test for the nitrate, phosphorous, dissolved oxygen, and potassium parameters. Once the chemicals were mixed with the grab samples then the grab samples were placed within the colorimeter to produce an output in parts per million, which is equivalent to mg/L. The turbidity grab sample was placed within the colorimeter, without being mixed, with chemicals to produce an output in formazin turbidity units (FTU), which is directly equivalent to nephelometric turbidity units (NTU).

Water Quality Parameters

A combination of physiochemical and analytical parameters were tested for during the water quality sampling events. The physiochemical parameters included temperature, dissolved oxygen, conductivity, and pH while the analytical parameters consisted of nitrate, phosphorous, turbidity, and potassium.

Parameter: Water Temperature

Many of the physical, biological and chemical characteristics of surface water are dependent on temperature. In general, increased temperatures speed chemical reactions while lowered temperatures slow reaction time. If temperature is outside of the optimal range for a prolonged period of time, the health of aquatic organisms can be affected. Temperature also affects the oxygen content of the water, the rate of photosynthesis by aquatic plants, and the metabolic rates of aquatic organisms. Additionally, temperature can be affected by weather, discharging stormwater, construction of dams, and the removal of vegetation along streambanks.

State standards for water temperature cannot exceed 89.6 degrees Fahrenheit. Further, at no time can the temperature of the receiving waters be increased more than 5 degrees Fahrenheit above intake temperature, except that in estuarine waters the increase cannot exceed 1.5 degrees Fahrenheit. The amount of oxygen required by an aquatic organism varies according to species and stage of life. Macroinvertebrates (insects, crayfish, worms, clams and snails) will move within the streambed to find their optimal temperature within the channel. These macroinvertebrates increase their activity in warmer water temperatures thereby requiring more oxygen to support their metabolism. Respiring algae and decaying organic material usually causes low oxygen levels during the summer months when water temperatures have increased.

Parameter: Dissolved Oxygen (DO)

Dissolved oxygen refers to the amount of oxygen dissolved in water. Oxygen enters into water in two ways: 1) oxygen from the atmosphere diffuses into the water from the atmosphere, and 2) oxygen is introduced into water by algae and other aquatic plants through photosynthesis. Dissolved oxygen is elevated where water and oxygen is mixed easily such as riffle zones. Lower water temperatures hold more oxygen than warmer water temperatures.

Dissolved oxygen is an essential element for the maintenance of healthy lakes and streams. Fish and other aquatic organisms cannot survive without oxygen; therefore, dissolved oxygen is one of the most important water quality parameters. The atmosphere, algae, and vascular aquatic plants are sources of dissolved oxygen in lakes and streams. Conversely, an accumulation of organic wastes will deplete dissolved oxygen within these systems. **Aquatic**

life is under stress when the dissolved oxygen concentration falls below 5 mg/L while waters with good fishing have a dissolved oxygen concentration of approximately 9 mg/L. State standards for water supporting warm water species of fish consist of a daily average of 5.0 mg/L and no less than 4.0 mg/L at any point in time.

Human activity can affect dissolved oxygen levels within streams. During the summer months increases in the amount of nutrients can occur (phosphorus, nitrogen as ammonia, yard waste, nitrite and nitrate) from lawn and farm fertilizers in runoff and other discharges that can result in the increased growth of plants and algae. As they decompose the excess organic matter from the plants and algae, bacteria take up oxygen, which reduces the dissolved oxygen available in the water.

Because temperature in streams can vary hourly, this parameter is an important factor when analyzing the dissolved oxygen levels in water samples. For that reason, the saturation value is considered. Saturation is the maximum level of dissolved oxygen that would be present in the water at a specific temperature, but only in the absence of other influences. The percent saturation can be calculated by comparing the maximum saturation value to the measured dissolved oxygen result. **A healthy stream is considered to be between 90- and 100-percent saturated.**

Parameter: Conductivity

The conductivity of water is directly related to the concentration of dissolved solids in the water. Dissolved ions in water influence the ability of water to conduct an electrical current. Nitrates and phosphates anions (ions carrying a negative charge) can affect the conductivity in water. In general, the higher the water temperature, the higher the conductivity.

Conductivity in natural systems is affected by the geology of the area in which the stream flows. Streams that flow through areas with clay soils will tend to have higher conductivity because of the presence of materials that ionize when entering into the stream system. **Conductivity in Georgia streams can range from 0 to 1500 µs/cm, but most streams that support a mixture of fish will have a range of 50 to 500 µs/cm.**

Parameter: pH

The pH value of water, which can range from 0 to 14, measures the concentration of hydrogen ions. The pH represents the balance between hydrogen ions and hydroxide ions in water. Solutions that have more hydrogen than hydroxide ions will have a pH value lower than 7, which is considered to be acidic. Solutions that have more hydroxide than hydrogen ions will have a pH value higher than 7, which is considered to be basic. For every one unit change in pH then there is approximately a ten-fold change in how acidic or basic the sample is, which in turn means that each increment on the scale represents a ten-fold change in the hydrogen concentration. For example, water with a pH of 5 has ten times the number of hydrogen ions than water with a pH of 6 and is ten times more acidic.

The pH value affects many chemical and biological processes in the water. **Water with a pH of less than 4.8 or greater than 9.2 can be harmful to aquatic life.** State water quality standards for pH range from 6.0 to 8.5. The pH is also a valuable indicator of the chemical balance in water as a high or low pH will adversely affect the availability of certain chemicals or nutrients in the water for use by plants. If pH value is outside the 6.5 to 8.5 ranges, then the diversity in the stream is reduced because it stresses the physiological systems of most organisms, which can reduce reproduction. Changes in acidity can be caused by atmospheric deposition (acid rain), surrounding rock, and certain wastewater discharges.

Parameter: Nitrate

Nitrate is a source of nitrogen, which is an important nutrient for plants and algae. Nitrification is a process where ammonia is broken down by bacterial action in which nitrite is formed and is then converted to the more stable nitrate (less toxic). Nitrates are used in fertilizers and also occur in effluent discharges from wastewater treatment plants. Nitrate is regulated to protect human health as well as aquatic environments. Increased nitrate levels will adversely affect cold water fish more than warm water fish. Nitrate concentrations of 0.5 mg/L are toxic to rainbow trout. Unpolluted waters that contain warm water fish usually have nitrate concentration of 1 mg/L or less. The U.S. Environmental Protection Agency limits of 10 mg/L for nitrate in drinking water supplies.

The typically low natural levels of nitrate in surface water can be supplemented with nitrate from human sources. Nitrate from the fertilizer not taken up by grass in lawns can enter water bodies through runoff. **Once nitrates enter the water, the nitrates can stimulate excessive plant and algae growth. Decomposition of the plant and algal material by bacteria can deplete dissolved oxygen, which in turn will adversely impact fish and other aquatic animals.**

Parameter: Phosphorus

Phosphorus, like nitrogen, is an important nutrient for plants and algae. Total phosphorous consists of organic phosphorous and inorganic phosphate. Organic phosphorous is part of living plants and animals and is attached to particulate organic matter that is composed of once-living plants and animals. Inorganic phosphates comprise the ions bonded to soil particles and phosphates. Since phosphorus is in short supply in most fresh waters, even the slightest increase in phosphorus can cause excessive growth of plants and algae that deplete dissolved oxygen during their growth and as they decompose. **Algal blooms are a classic symptom of eutrophication and excessive growth can reduce the transparency of the water within detention ponds and lakes.** Much of the excess phosphorus available to plants in the environment comes from lawn fertilizers, runoff containing soil-bound phosphate, yard waste, and certain industrial wastewaters.

Organic phosphates and inorganic phosphates cannot be measured directly. The results from sampling the total phosphorus are expressed as phosphate. Sampling for phosphorus is difficult because it can involve measuring very low concentrations that are 0.01 milligram per liter (mg/L) or lower. Very low concentrations of phosphorus can have a significant impact on streams. Natural levels of phosphate usually range from 0.005 to 0.05 mg/L and phosphorus levels of 0.08 to 0.10 mg/L can contribute to the eutrophication process. The U.S. Environmental Protection Agency limits phosphates to 0.01 mg/L in streams in order for "maximum" diversity of aquatic life to be supported and 0.1 mg/L in streams for "moderate" diversity of aquatic life.

Parameter: Turbidity

Turbidity is a measure of water clarity or "how far" light can travel through water. Although the suspended particles that reduce clarity can include organics - such as algae and plant components - and inorganics - such as silt and clay particles - turbidity in streams is a measure of the inorganic particles that account for the total suspended solids. These particles typically range in size of 0.004 mm (clay) to 1.0 mm (sand).

High turbidity levels increase water temperatures since suspended particles absorb more heat, which will in turn reduce the concentration of dissolved oxygen. **When high turbidity reduces the amount of light that penetrates through water, photosynthesis and the production of dissolved oxygen are decreased.** Suspended solids can reduce growth rates and disease resistance in fish, as well as affect egg and larval development. Particles that are settled along the bottom of the channel can accumulate and smother fish eggs and aquatic insects, suffocate newly-hatched insect larvae and make stream bottom microhabitats unsuitable for mayfly nymphs, stonefly nymphs, caddisfly larvae and other aquatic insects.

Turbidity can be useful as an indicator of the effects of construction runoff, urban runoff, agricultural practices, eroding stream banks, excessive algal growth, illicit discharges, and other sources. Turbidity often increases sharply during a rainfall, particularly in developed watersheds, which typically have a relatively high percentage of impervious surfaces. Stormwater runoff from impervious surfaces increases in-stream velocities, which in turn increases erosion rates of streambanks. Turbidity can also rise sharply during dry weather if earth-disturbing activities are occurring in, or near, a stream without erosion control practices in place. **Regular monitoring of turbidity can aid in detecting trends that might indicate increasing erosion in developing watersheds**. Since turbidity is closely related to stream flow and velocity, it should be correlated with these factors. Monitoring turbidity should take place at the same sampling locations during each event in order to make accurate comparisons of the change in turbidity over time.

No absolute numerical standards exist for turbidity in Georgia streams. Georgia Environmental Protection Division has the following standards for the National Pollutant Discharge Elimination System permit in regards to turbidity: 1) discharge results in the turbidity of receiving waters cannot be increased by more than ten (10) nephelometric turbidity units for waters classified as trout streams and 2) receiving waters cannot be increased by more than twenty-five (25) nephelometric turbidity units for waters supporting warm water fisheries. Determining acceptable turbidity ranges is difficult since streams in different regions have varied natural levels of turbidity. **The State considers the following ranges for turbidity: turbidities of 10 NTU or less represent very clear waters, 50 NTU is cloudy, and 100—500 NTU or greater are very cloudy to muddy.** Certain fish species will become stressed at prolonged exposures of 25 NTU's or greater.

Parameter: Potassium

Potassium occurs naturally in water in small quantities. Freshwater streams usually carry 2 to 3 parts per million of potassium, a nutrient that aids in plant and animal growth. Potassium from dead plant material often will bind to clay minerals in the soil, enters the stream system as water washes across rocks and clays containing potassium and settles onto the channel bottom as sediment. Potassium also enters a stream system through stormwater runoff as a nonpoint source pollutant. Potassium is found in fertilizers and is often called "potash". Too much of this nutrient can cause overgrowth of vegetation or create algal blooms. As previously mentioned, algal blooms can result in low dissolved oxygen levels within a pond or stream system.

Results of Water Quality Sampling

Water chemistry sampling is a point-in-time measurement. The data from sampling water chemistry are highly accurate and reflect a sequence of collections during a relatively short time period. A limitation of this type of study is that water that flowed through the channel last week could be dramatically different in quality from the water quality data that were obtained during the sampling events. Therefore, a catastrophic event may take place within a stream, but no evidence may remain in the water column to qualify or quantify the event. However, sampling on a regular basis for a minimum of a year will yield better water quality data within stream systems and will provide reliable evidence of trends.

Parameters sampled and evaluated at Webb Bridge Park during the October and November events include: water temperature, conductivity, phosphate levels, nitrate concentrations, potassium levels, dissolved oxygen, and pH. **These data were collected and compared with standards commonly used in Georgia water bodies to discern the relative quality of water within the study area.**

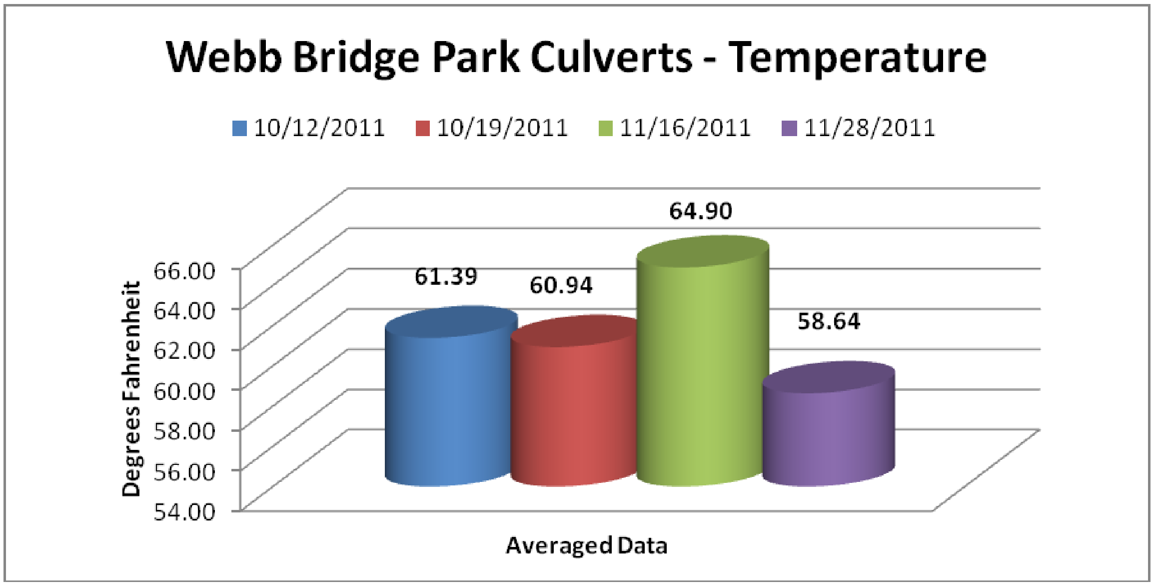
For ease of discussion, the following analysis is divided into four separate areas which were evaluated 1) Webb Bridge Park Culverts, 2) Thornbury Lake Culverts 3) Unnamed tributary of Lake Windward, and 4) Unnamed tributary of Thornbury Lake.

Area 1 - Webb Bridge Park Culverts

Three culverts and a detention pond within Webb Bridge Park were sampled. These culverts (Sample Stations 1-3) and pond (Sample Station 4) were identified as potential sources for contributing stormwater pollutants downstream to Thornbury Lake. All three culverts ultimately flow into the detention pond and drain areas within the park and adjacent private property. For each of the four sampling events, the parameters at each sample station were averaged. However, if the sampled data had notably higher than normal values, then the actual data is presented along with the averaged data.

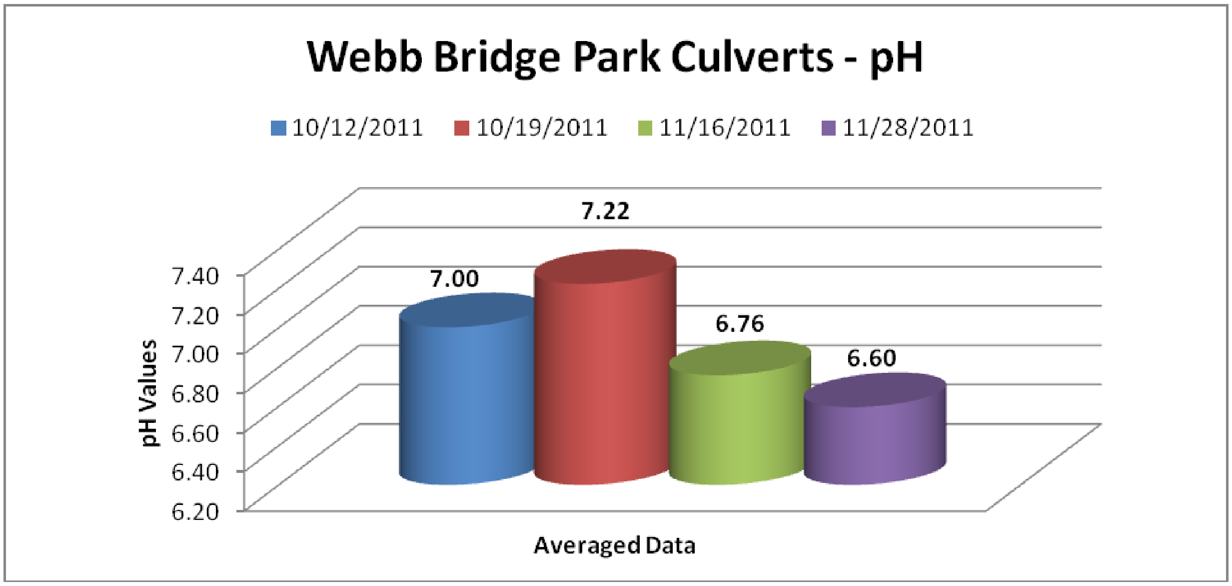
Temperature

The averaged temperatures ranged between 58.64 to 64.90 degrees Fahrenheit. Georgia standard for temperatures within streams cannot exceed 89.6 degrees Fahrenheit. The average water temperatures flowing from the culverts and detention pond were within the acceptable range.



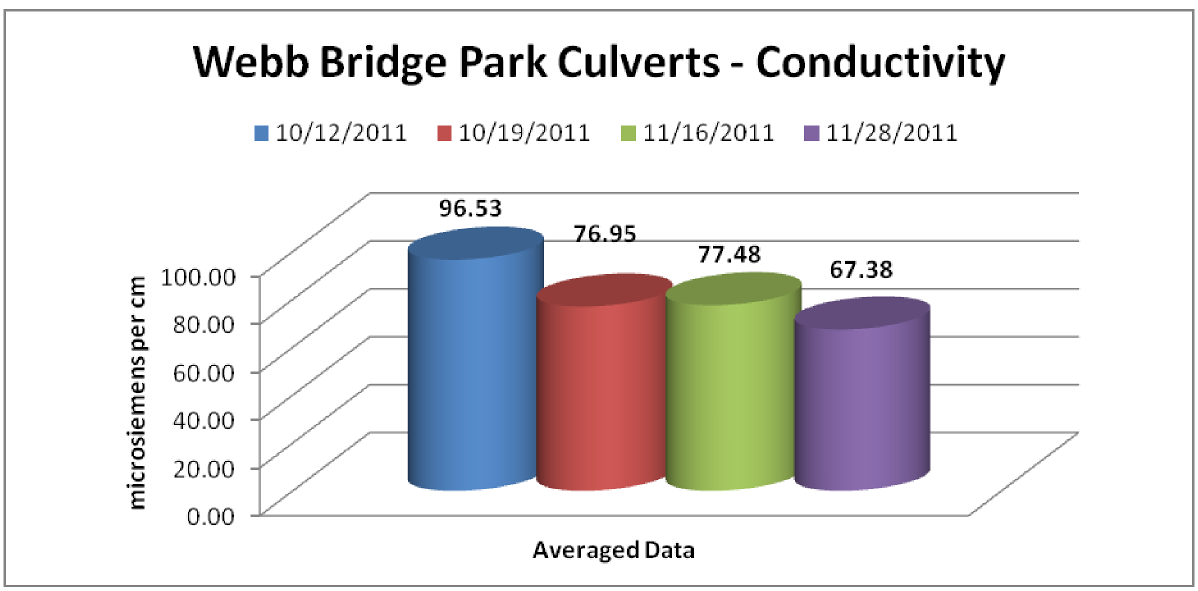
pH

Averaged values for pH ranged from 6.60 to 7.22. Standard acceptable values for pH in Georgia streams are from 6.0 to 8.5. The averaged pH values are well within the acceptable limits for stormwater entering into a stream system.



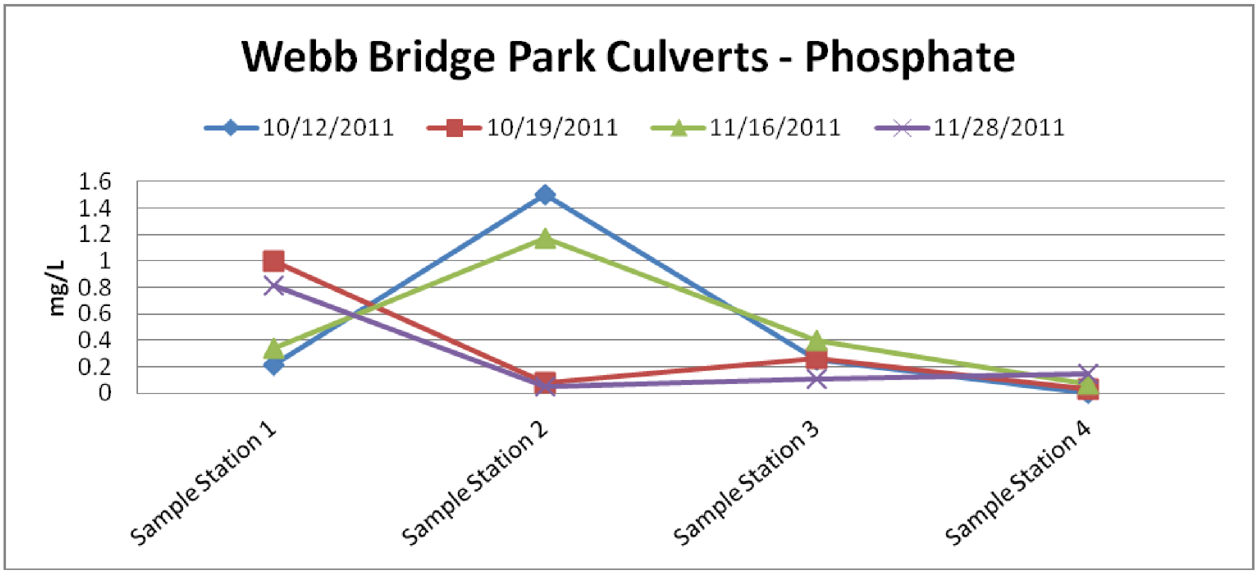
Conductivity

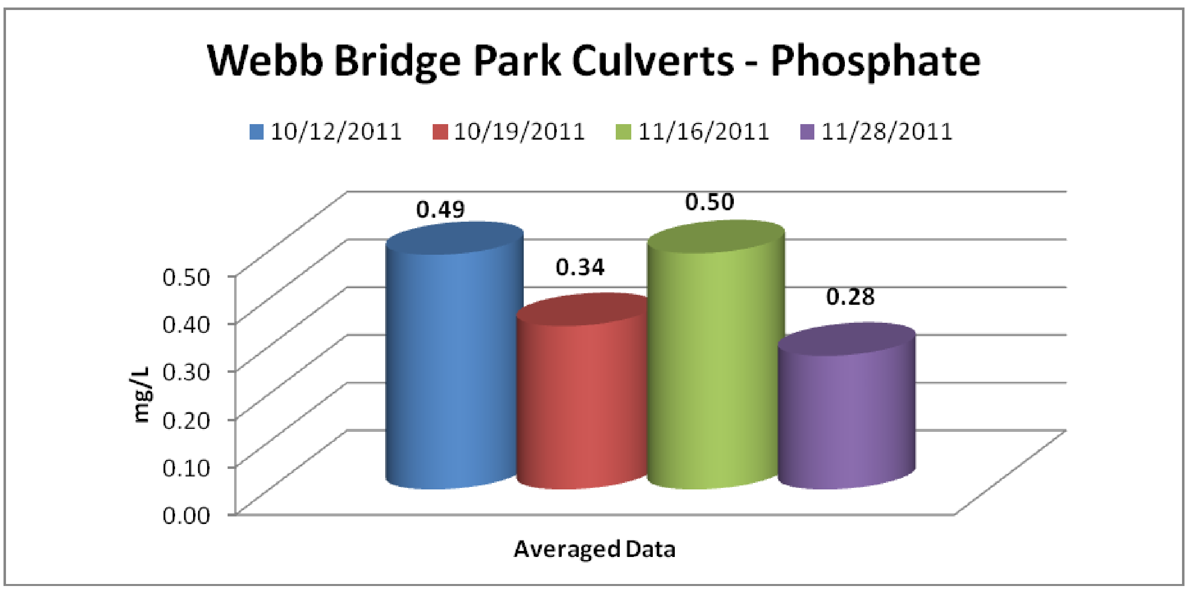
The averaged conductivity values varied between 67.38 µs/cm and 96.53 µs/cm. Streams in Georgia normally range from 0 – 1500 µs/cm; however, most streams in Georgia that better support mixed fisheries will have conductivity values between 50 – 500 µs/cm. All of the actual and averaged conductivity values that were sampled lie well within the normal range.



Phosphorus

Phosphate concentrations are normally less than 0.1 mg/L in natural stream systems. Stormwater entering into the detention pond (Sample Station 4) from Sample Station 2 (culvert) had two of the highest phosphate concentrations (1.5 and 1.17) during two of the monitoring events. Sample Station 2 flow comes primarily from a private detention pond, located adjacent to Webb Bridge Park. Sample Station 1, a culvert that drains stormwater from a parking lot within Webb Bridge Park, and Sample Station 3, a culvert that drains a portion of the athletic fields within the Park, had elevated phosphate levels during each sampling event, which ranged from 0.23 to 1 mg/L and 0.11 to 0.4 mg/L. Phosphate levels exiting the detention pond (Sample Station 4) ranged from 0 to 0.15 mg/L. Phosphate levels over 0.1 mg/L will accelerate eutrophication within detention ponds, lakes, and streams.

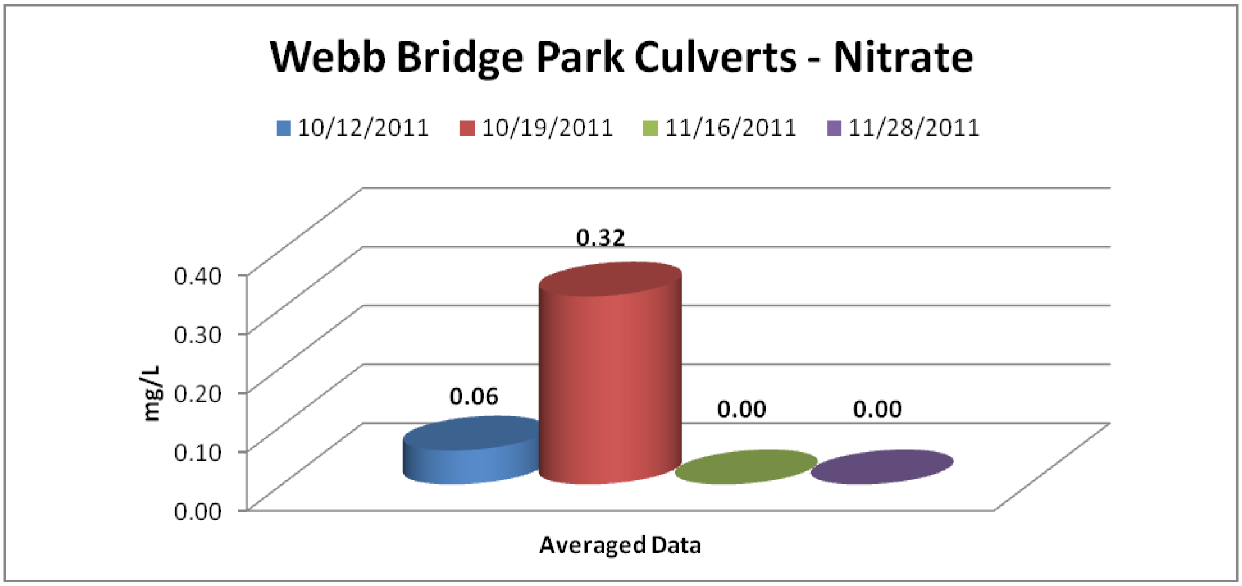




Nitrate

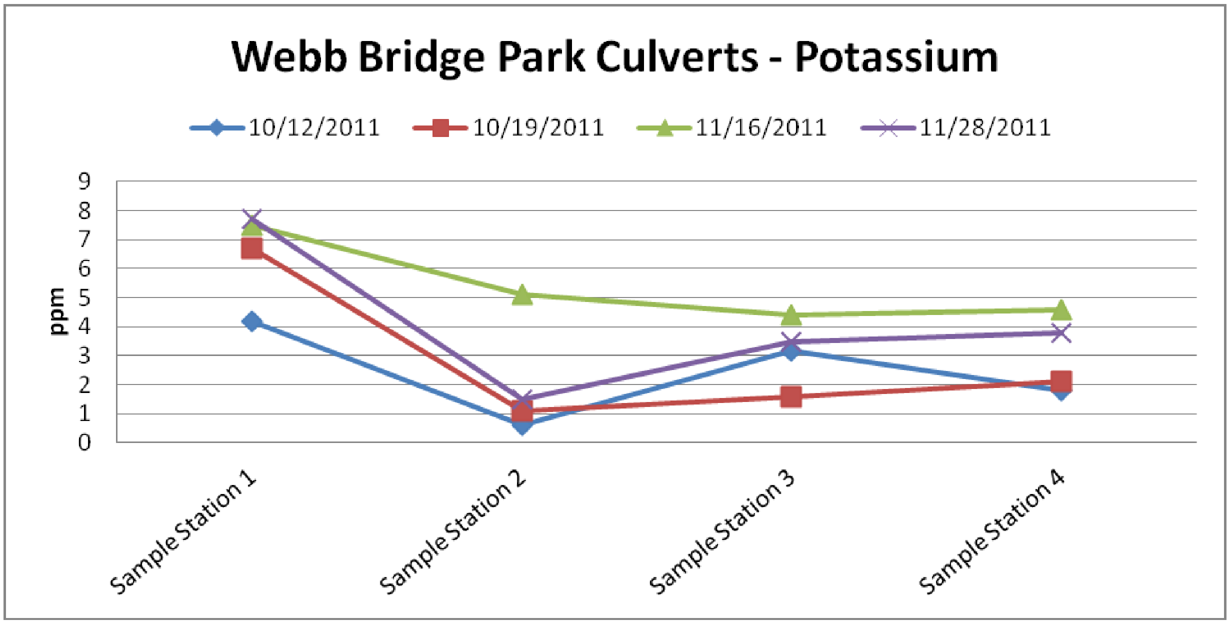
The averaged nitrate values sampled within the park were 0.32 mg/L or less. Nitrates were only detected during the first two sampling events, with the highest nitrate level measured at 1.07

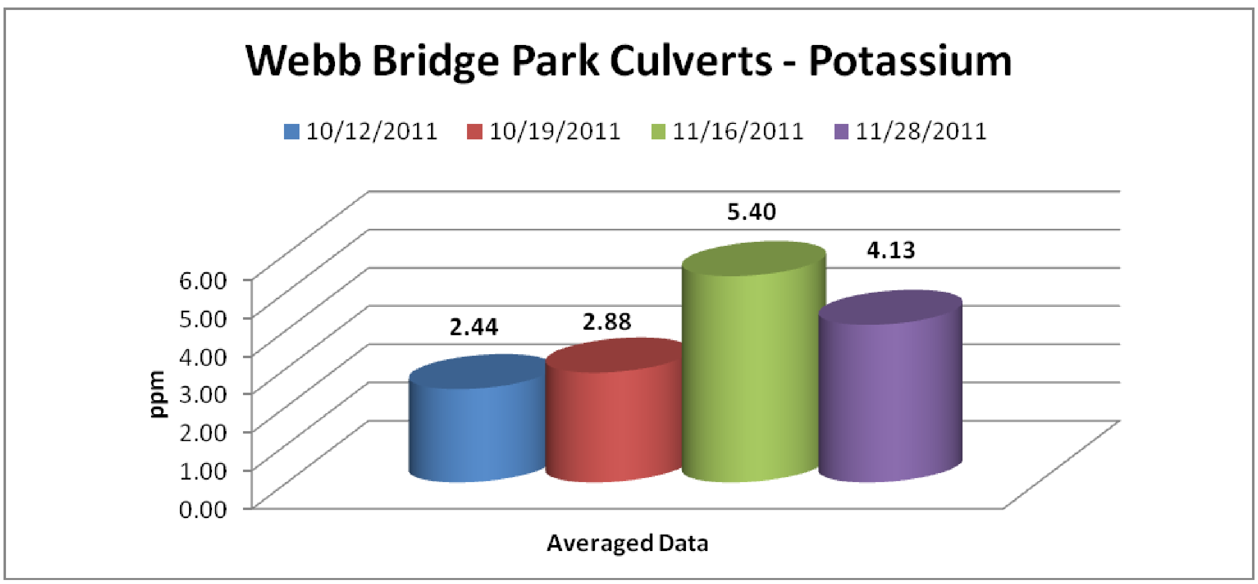
mg/L (Sample Station 2). Unpolluted waters that contain warm water fish usually have a nitrate concentration of 1 mg/L or less. Nitrates are highly soluble; therefore, dissolve quickly once the nutrient enters into a wet pond, stream, or lake.



Potassium

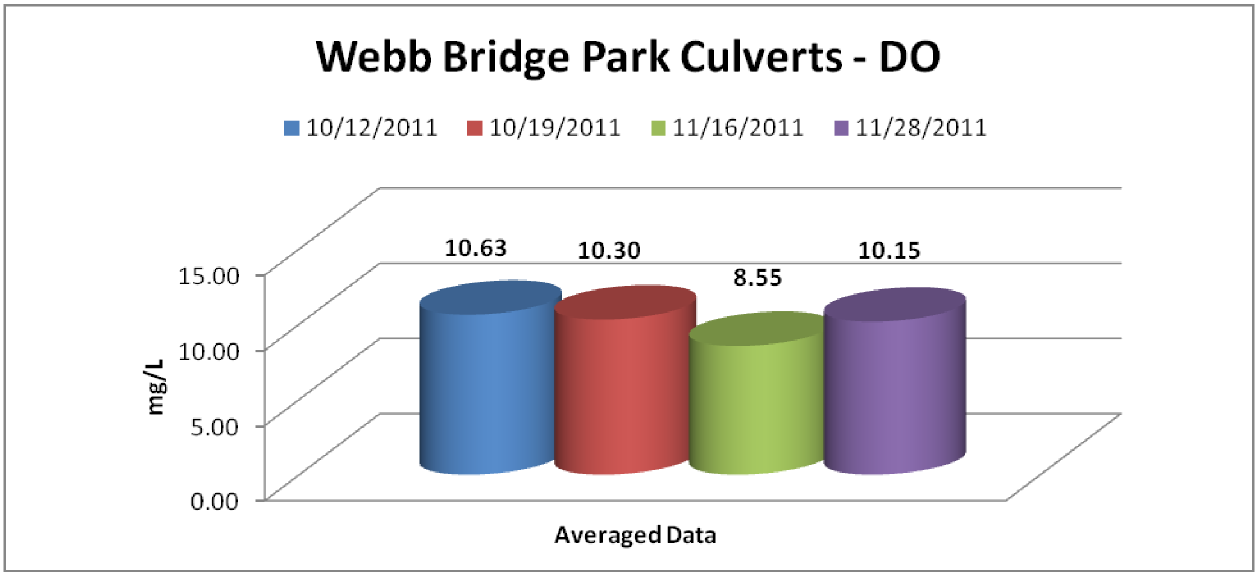
Potassium levels sampled ranged from 0.6 to 7.7 ppm. Natural levels of potassium within streams typically vary from 2 – 3 ppm. Sample Station 1 had the highest potassium readings during each sampling event, which was between 4.2 to 7.7 ppm. Except for the third and fourth sampling events, Sample Station 4 (detention pond) had potassium levels from 1 to 3 ppm exiting the pond into the stream system. The averaged potassium levels (5.40 ppm) were the highest during the third sampling event (November 16, 2011).





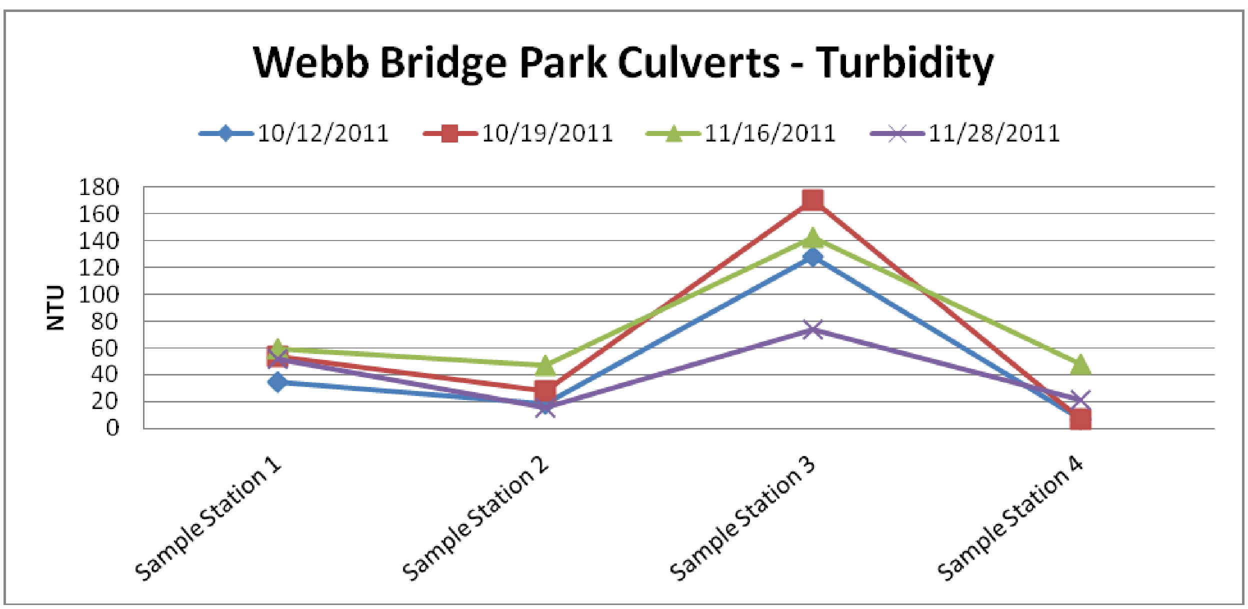
Dissolved Oxygen

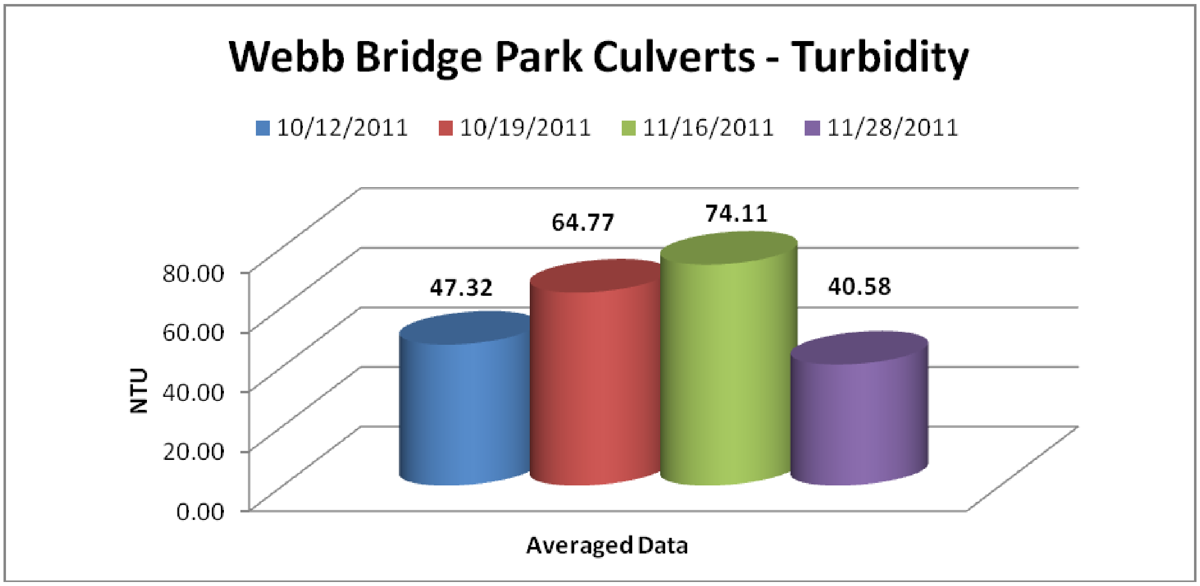
Averaged dissolved oxygen (DO) was recorded between 8.55 mg/L and 10.63 mg/L. Optimal DO concentration in streams is about 9 mg/L. Georgia standards for DO in streams cannot fall below 5 mg/L. All sampled stormwater had recorded DO levels within ranges near the optimal concentration values.



Turbidity

A majority of the turbidity values for stormwater flowing from the culverts were lower than 50 NTU, except for Sample Station 3. Sample Station 3 had turbidity values that ranged from 73 to 170.19 NTU's for all sampling events. The State considers waters that have 50 NTU's to be cloudy and 100- 500 NTU's or greater to be very cloudy to muddy. Water flowing from the detention pond had turbidity values from 7.1 to 48.01 NTU's, which is considered to fairly clear water. The averaged turbidity levels (74.11 NTU) were the highest during the third sampling event (November 16, 2011).



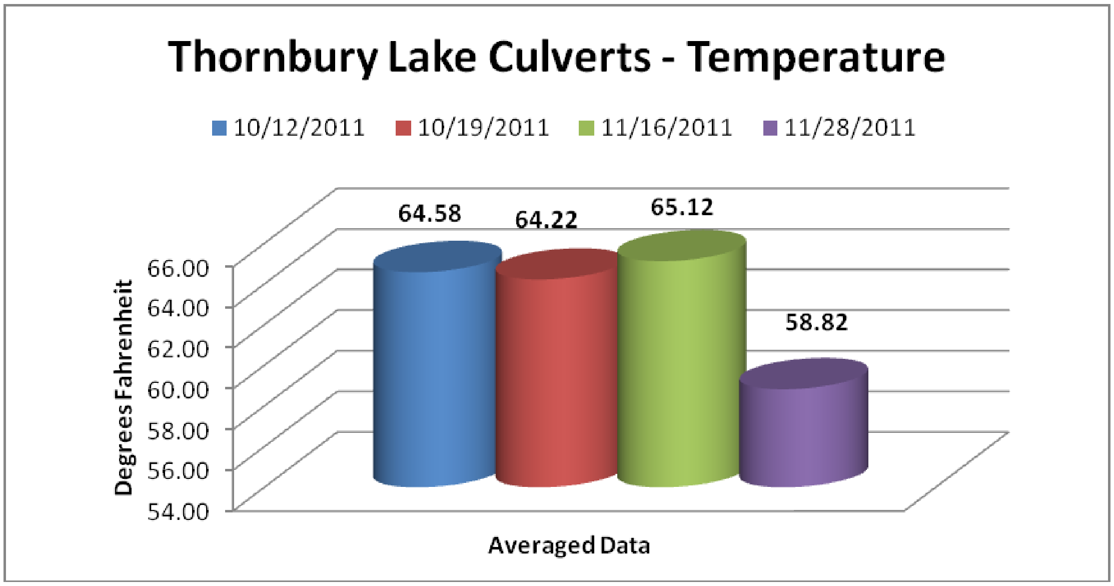


Area 2 - Thornbury Lake Culverts

Two culverts that outfall into Thornbury Lake were sampled to determine if pollutants were being discharged into the Lake from the Thornbury Parc subdivision. The two culverts (Sample Station 5 and 6) convey stormwater runoff from the subdivision. For each of the four sampling events, the parameters at each sample station were averaged. However, if the sampled data had notably higher than normal values, then the actual data is presented along with the averaged data.

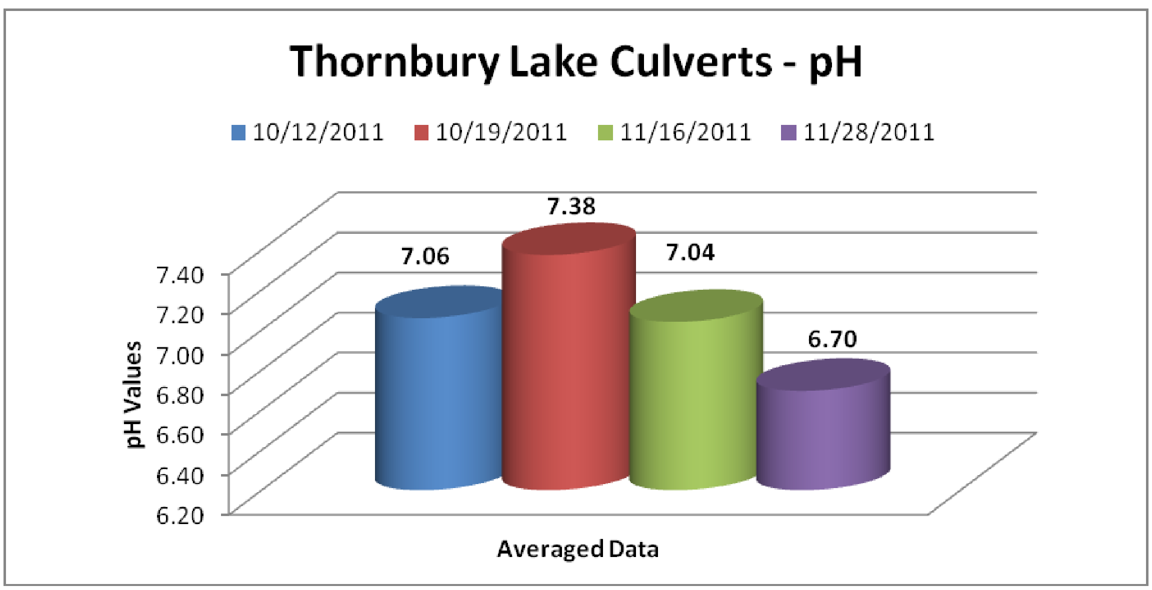
Temperature

The averaged temperatures of stormwater flowing from the culverts ranged between 58.82 to 65.12 degrees Fahrenheit. Georgia standard for temperatures within streams cannot exceed 89.6 degrees Fahrenheit. Sampled temperatures at the culverts, and ultimately flowing into the unnamed tributary of Thornbury Lake, are within the acceptable range.



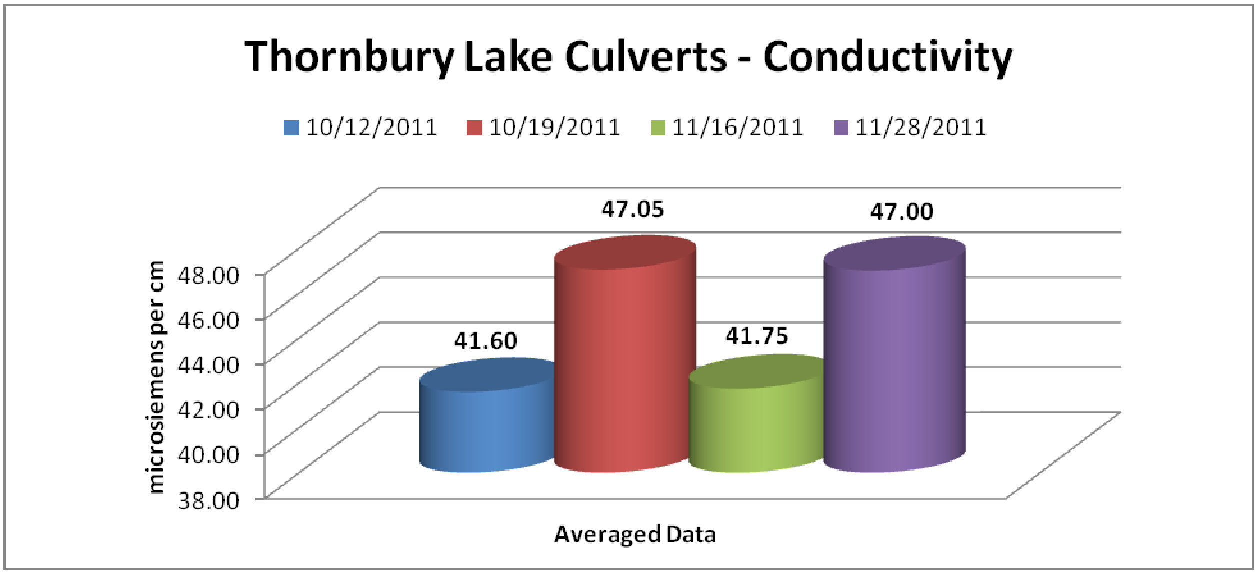
pH

Averaged values for pH within Thornbury Lake range from 6.70 to 7.38. The pH values for streams in Georgia are from 6.0 to 8.5. The averaged pH values are well within the acceptable limits for stormwater entering into a stream system.



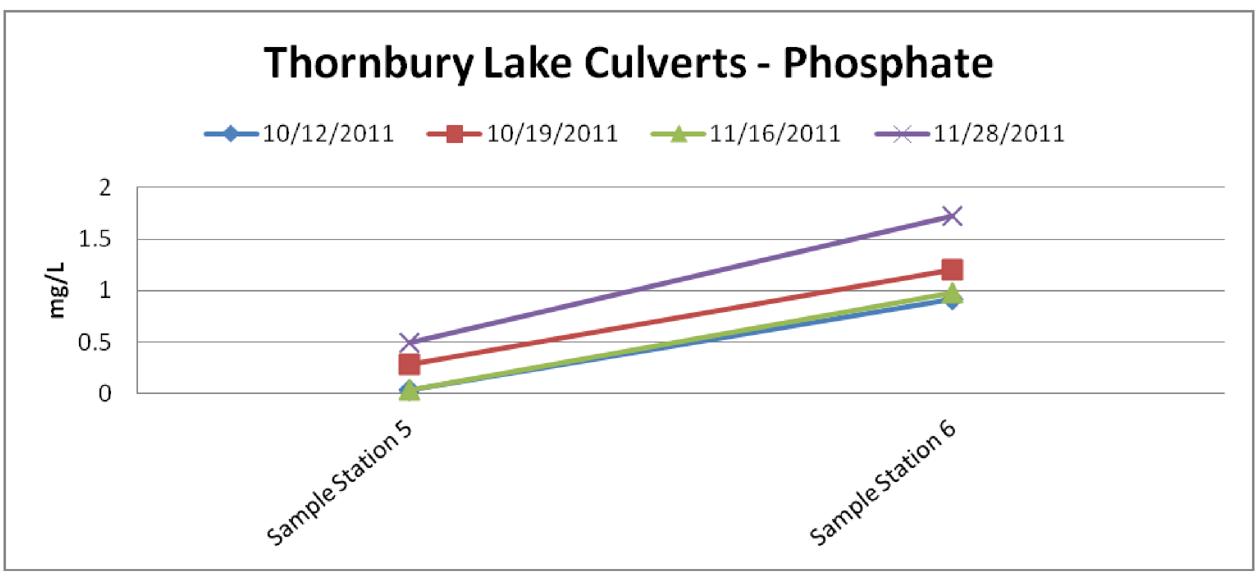
Conductivity

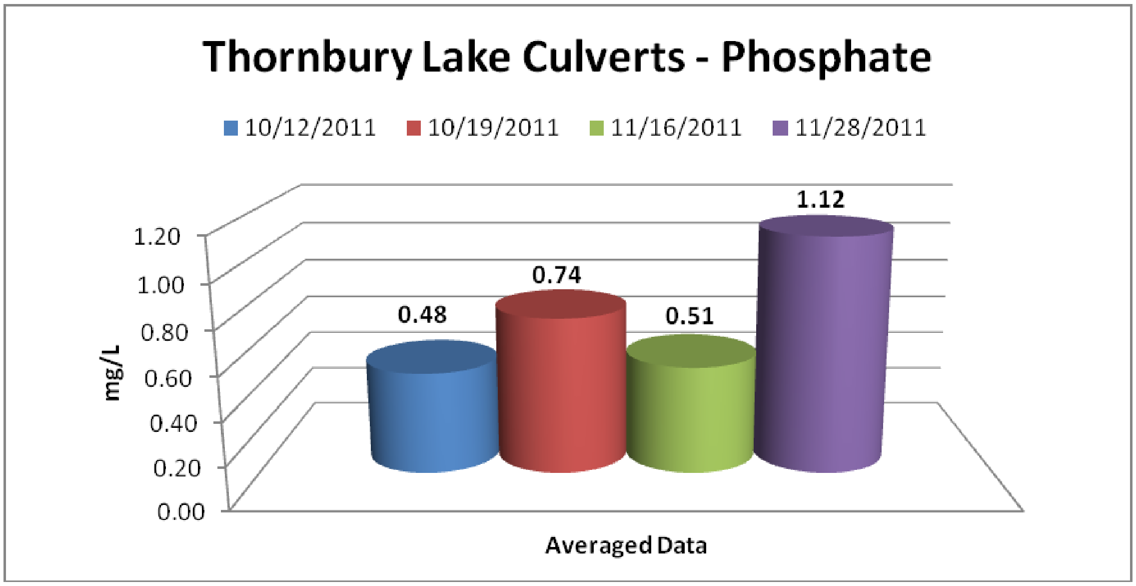
Conductivity values of stormwater entering into Thornbury Lake were averaged and ranged from 41.6 µs/cm to 47.05 µs/cm. Streams in Georgia normally range from 0 – 1500 µs/cm; however, most streams in Georgia that better support mixed fisheries will have conductivity values between 50 – 500 µs/cm. All of the actual and averaged data that were collected falls within the acceptable range for stormwater.



Phosphorus

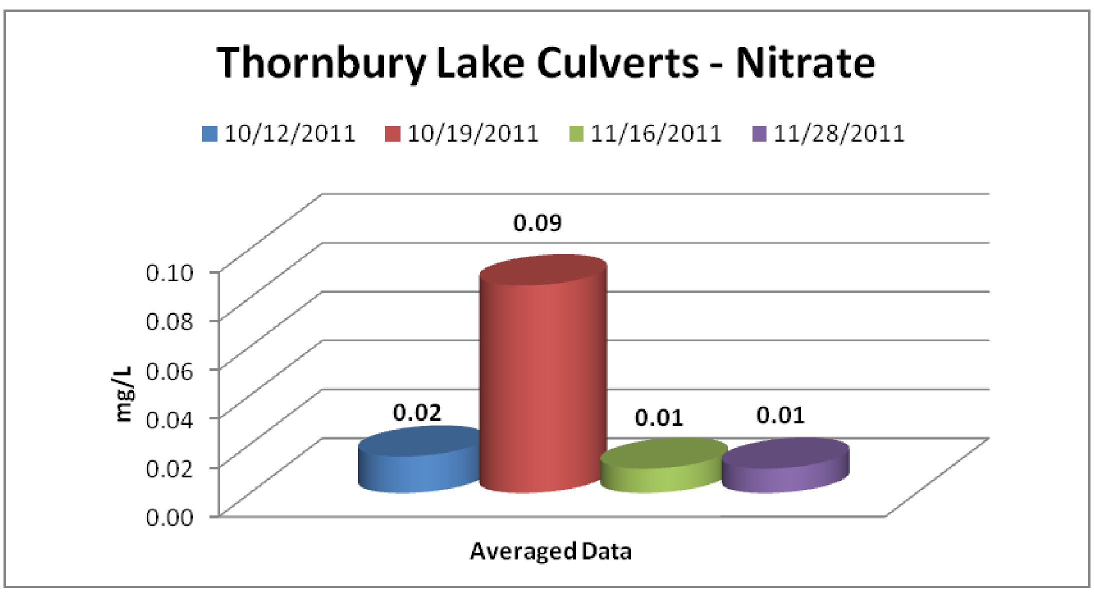
Phosphate concentrations are normally less than 0.1 mg/L in natural stream systems. Stormwater entering into Thornbury Lake from Sample Station 6 had two of the highest phosphate concentrations (1.2 and 1.73) during two of the sampling events. Sample Station 5 had elevated phosphate levels during two of the sampling events, which were 0.28 and 0.5 mg/L. All of the averaged phosphate levels in the stormwater flowing into Thornbury Lake are above 0.1 mg/L. Phosphate levels over 0.1 mg/L accelerates eutrophication within wet ponds, lakes, and streams.





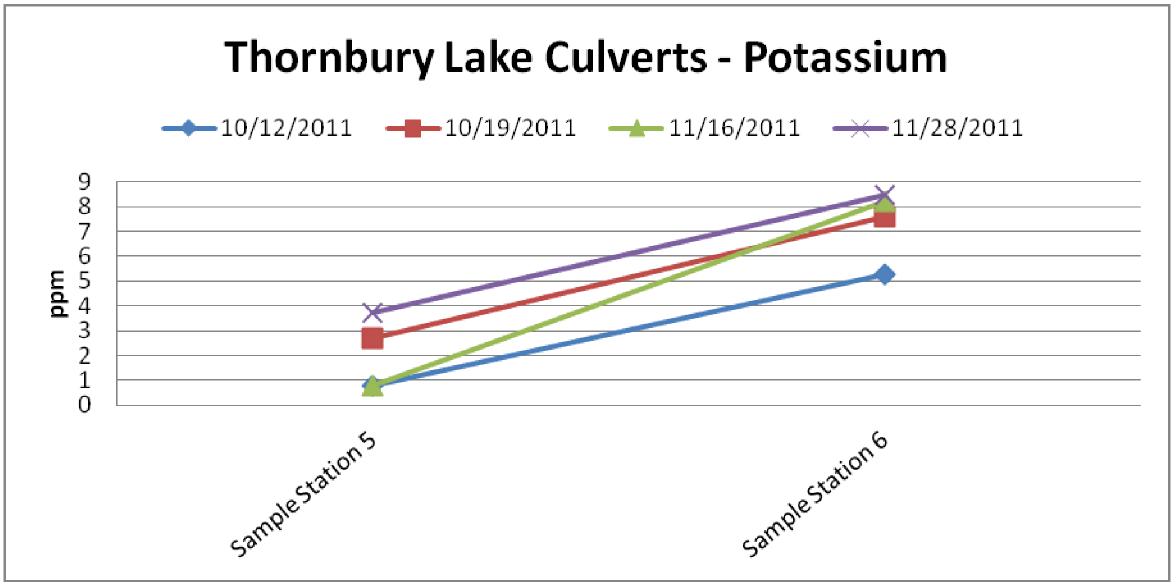
Nitrate

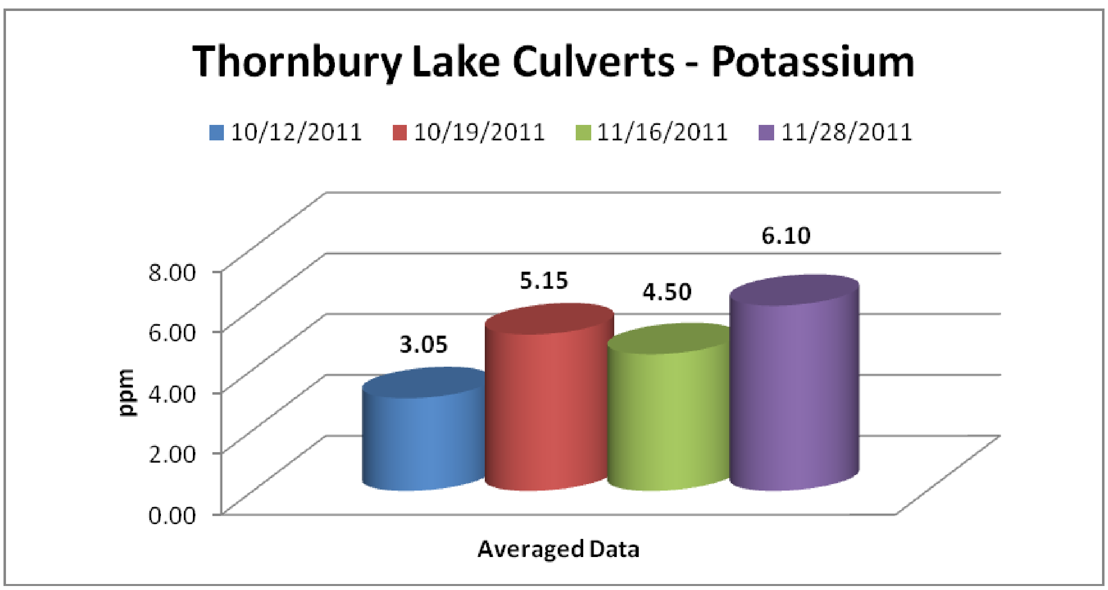
The averaged nitrate values sampled within the park were 0.09 mg/L or less. Nitrates were only detected during each sampling event at Sample Station 5, in which the highest nitrate level detected was 0.12 mg/L during the October 10, 2011 sampling event. Unpolluted waters that contain warm water fish usually have nitrate concentration of 1 mg/L or less. Nitrates are highly soluble; therefore, dissolve quickly once nitrates enter into a wet pond, stream, or lake. During the time of sampling, the nitrates entering Thornbury Lake were within the acceptable range.



Potassium

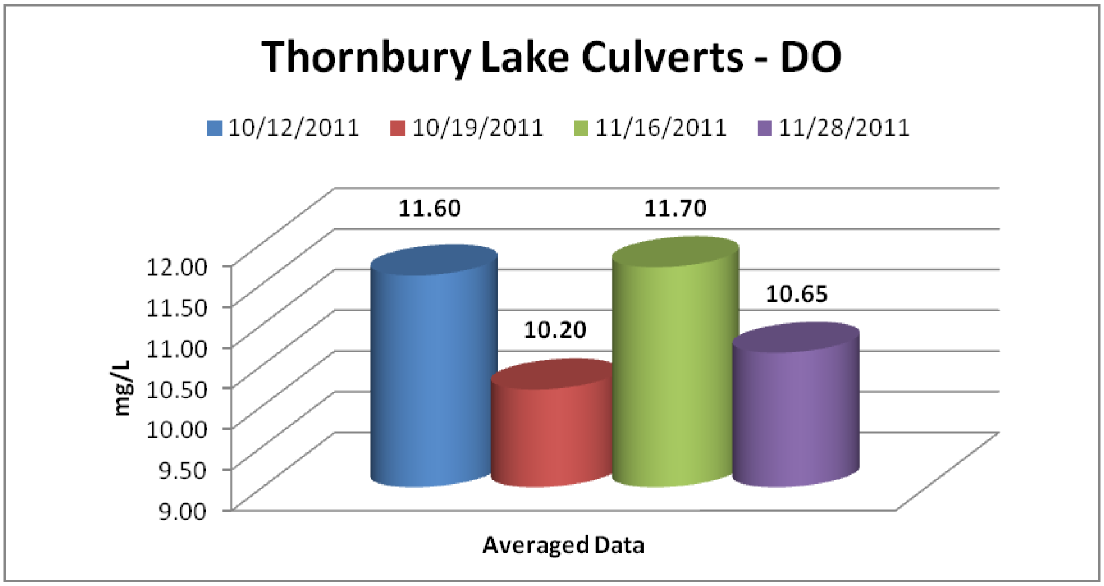
Potassium levels ranged from 0.8 to 8.5 ppm. Natural levels of potassium within streams typically vary from 2 – 3 ppm. Sample Station 6 had the highest readings for potassium during each sampling event, which was between 5.3 to 8.5 ppm. Except for the fourth sampling event, Sample Station 5 potassium levels fell between 0.8 to 3 ppm prior to entering Thornbury Lake. The averaged potassium levels (6.10 ppm) were the highest during the fourth sampling event (November 28, 2011).





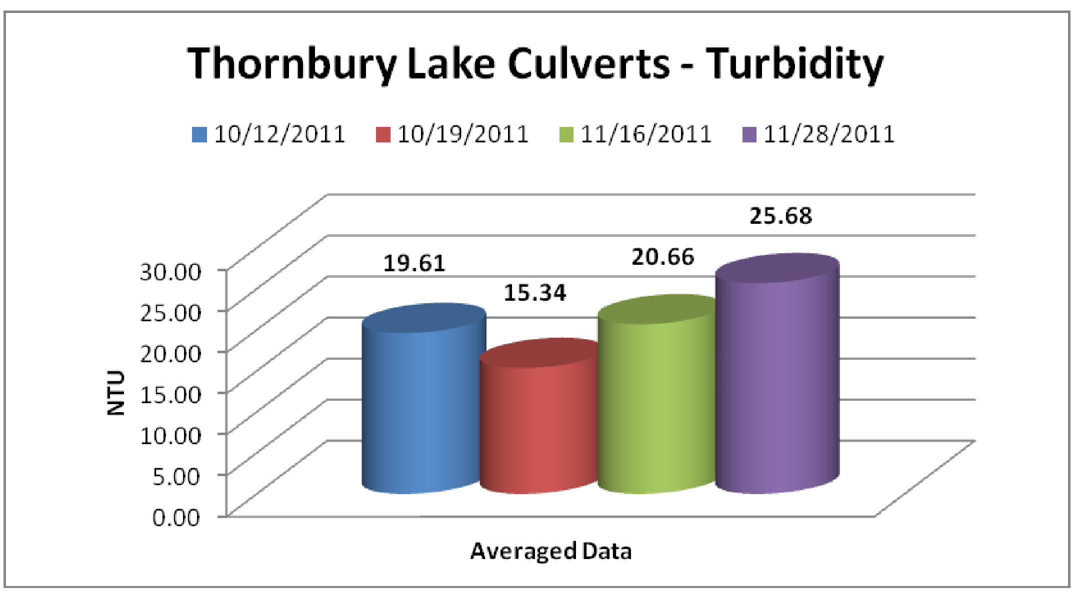
Dissolved Oxygen

Averaged dissolved oxygen (DO) was recorded between 10.20 mg/L and 11.70 mg/L. Optimal DO concentration in streams is about 9 mg/L. Georgia standards for DO in streams cannot fall below 5 mg/L. All sampled stormwater had recorded DO levels within ranges near the optimal concentration values.



Turbidity

All of the turbidity values for stormwater flowing from the culverts and into Thornbury Lake were lower than 50 NTU. The State considers waters that have 50 NTU's to be cloudy and 100-500 NTU's or greater to be very cloudy to muddy. Stormwater flowing into the lake had averaged turbidity values from 15.34 to 25.68 NTU's, which is considered to clear to fairly clear water. The averaged turbidity levels (25.68 NTU) were the highest during the fourth sampling event (November 28, 2011).

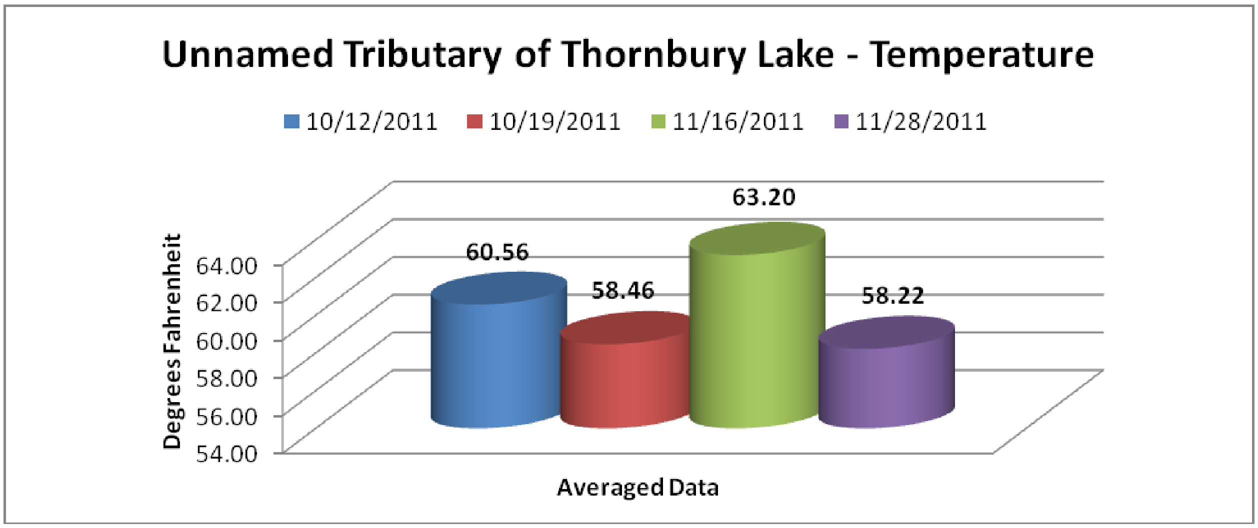


Area 3 - Unnamed Tributary of Thornbury Lake

Three sampling stations were selected along the unnamed tributary of Thornbury Lake. These include two stations - Sample Stations 7 and 8 - upstream of Thornbury Lake and Sample Station 9, which is located downstream of Thornbury Lake. For each of the four sampling events, the parameters at each sample station were averaged. However, if the sampled data had notably higher than normal values, then the actual data is presented along with the averaged data.

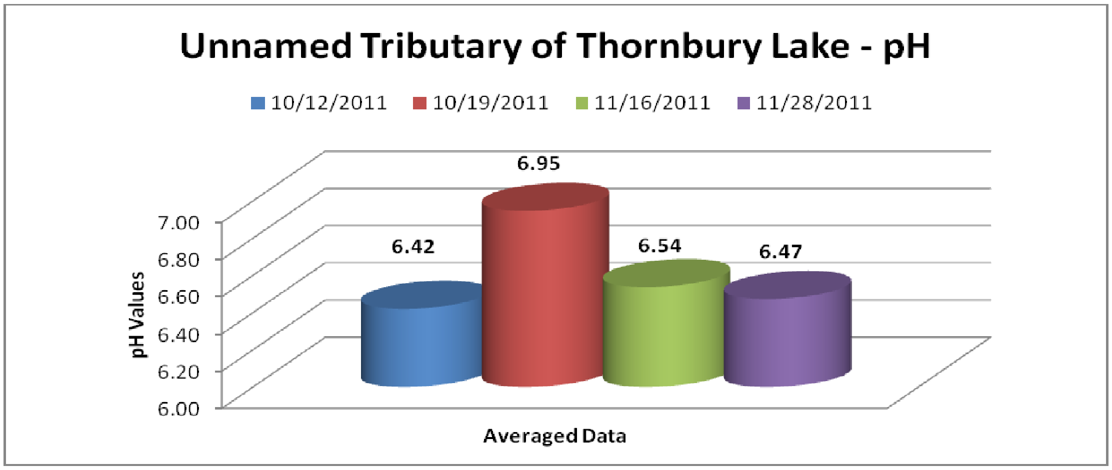
Temperature

The averaged temperatures within the stream ranged between 58.22 to 63.20 degrees Fahrenheit. Georgia standard for temperatures within streams cannot exceed 89.6 degrees Fahrenheit. Temperatures sampled at Stations 7-9 were all within the acceptable range.



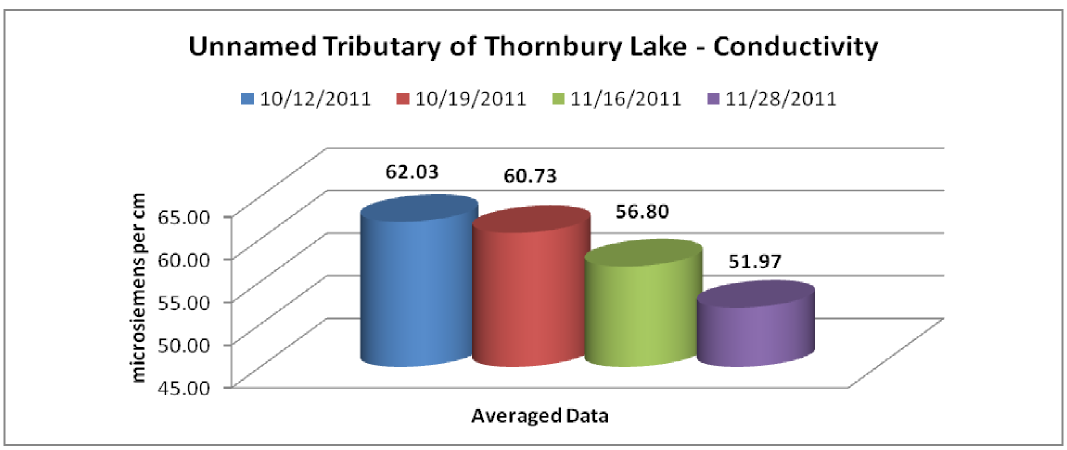
pH

Averaged values for pH within the unnamed tributary of Thornbury Lake fell between 6.42 and 6.95. The pH values for Piedmont streams in Georgia vary from 6.0 to 8.5. The averaged pH values are well within the acceptable limits within this stream system.



Conductivity

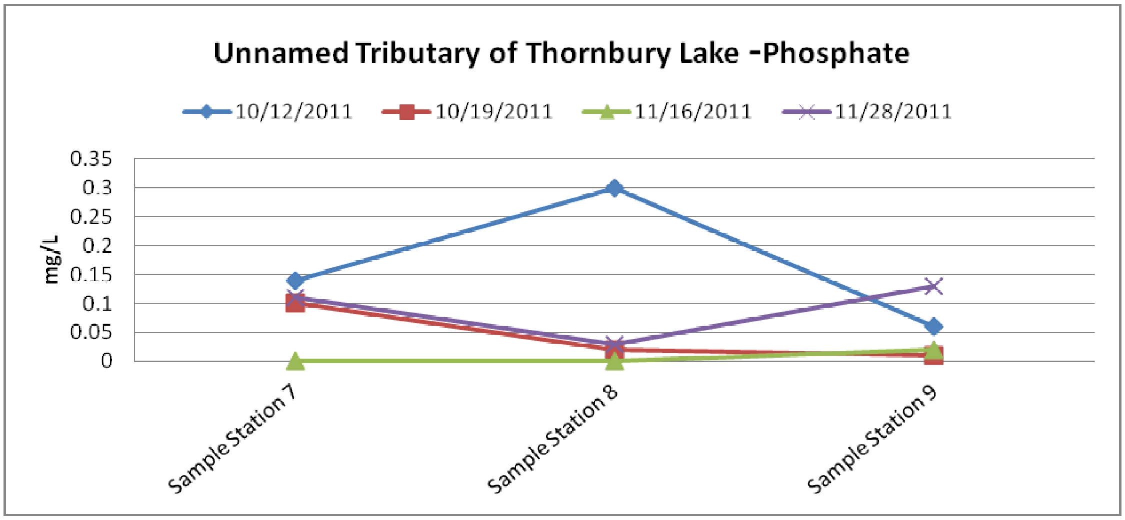
Conductivity values within the stream flowing through Thornbury Lake were averaged and ranged from 51.97 µs/cm to 62.03 µs/cm. Streams in Georgia normally range from 0 – 1500 µs/cm; however, most streams in Georgia that better support mixed fisheries will have conductivity values between 50 – 500 µs/cm. Sample Station 8 was below 50 µs/cm in the last three sampling events (36.2 to 44.2 µs/cm), which is below the normal conductivity range that better supports mixed fisheries within Georgia streams. All of the averaged data that was sampled falls within the acceptable range for streams in Georgia, but falls below the ranges that support mixed fisheries.

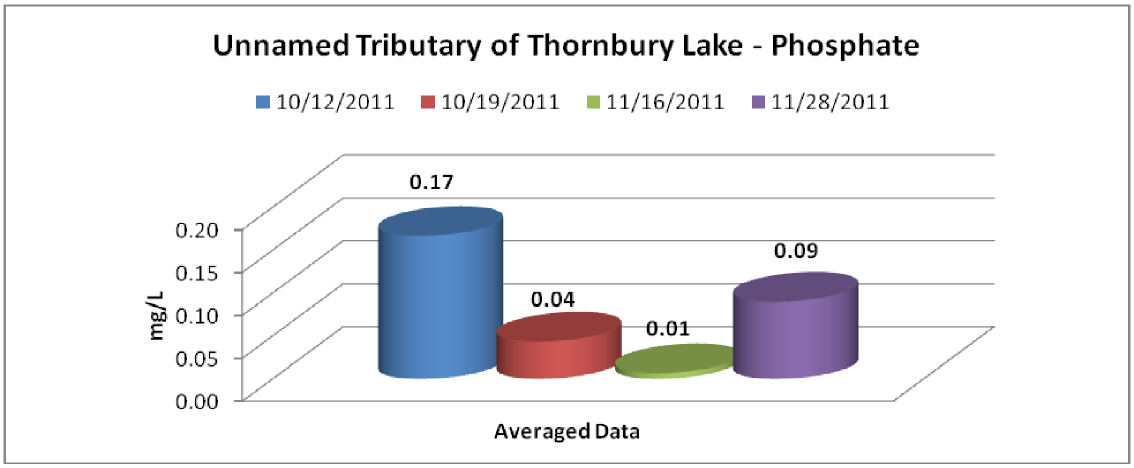


Phosphorus

Phosphate concentrations are normally less than 0.1 mg/L in natural stream systems. Headwaters flowing into Thornbury Lake from Sample Stations 7 and 8 had two of the highest phosphate concentrations (0.14 and 0.3) during the first sampling event. Sample Station 9 had elevated phosphate levels during the last sampling event, which was 0.13 mg/L. All of the averaged phosphate levels within the stream flowing through Thornbury Lake were within acceptable limits except for during the first sampling event, which yielded levels above 0.1

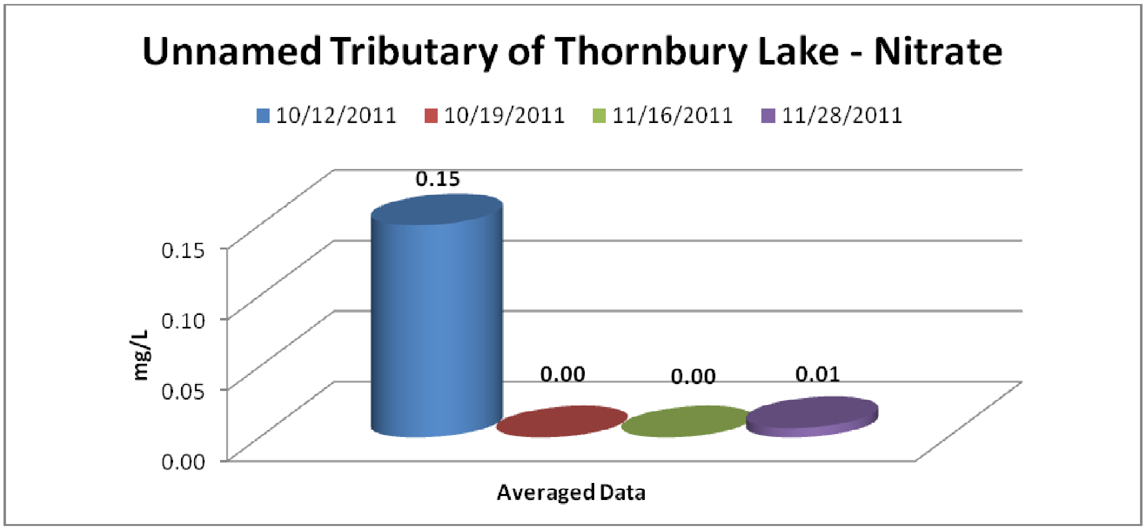
mg/L. Phosphate levels over 0.1 mg/L will accelerate eutrophication within wet ponds, lakes, and streams.





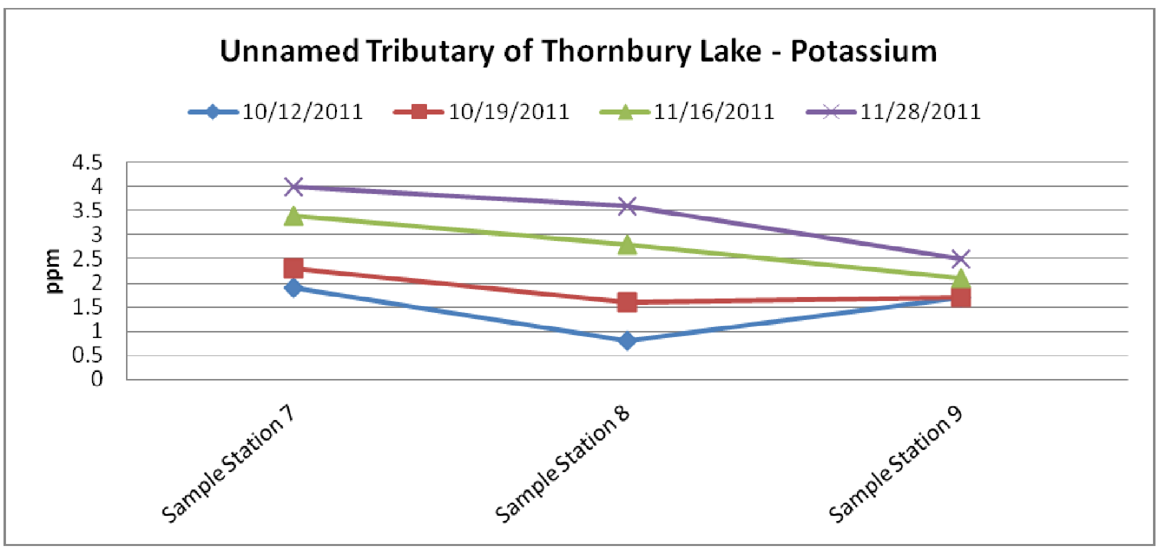
Nitrate

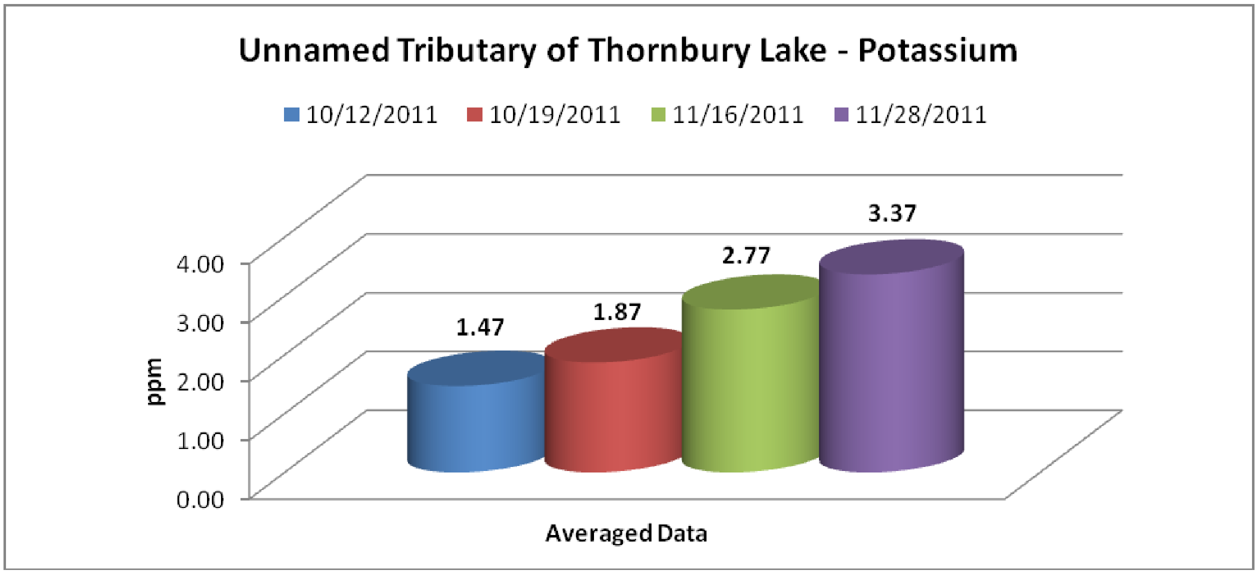
The averaged nitrate values sampled within the unnamed tributary were 0.15 mg/L or less. The highest nitrate value - 0.23 mg/L - was recorded during the first sampling event at Sample Station 9. Nitrates are highly soluble; therefore, dissolve quickly once nitrates enter into a wet pond, stream, or lake. During the time of sampling, the nitrates within the stream system were within the acceptable range (1.0 mg/L or less).



Potassium

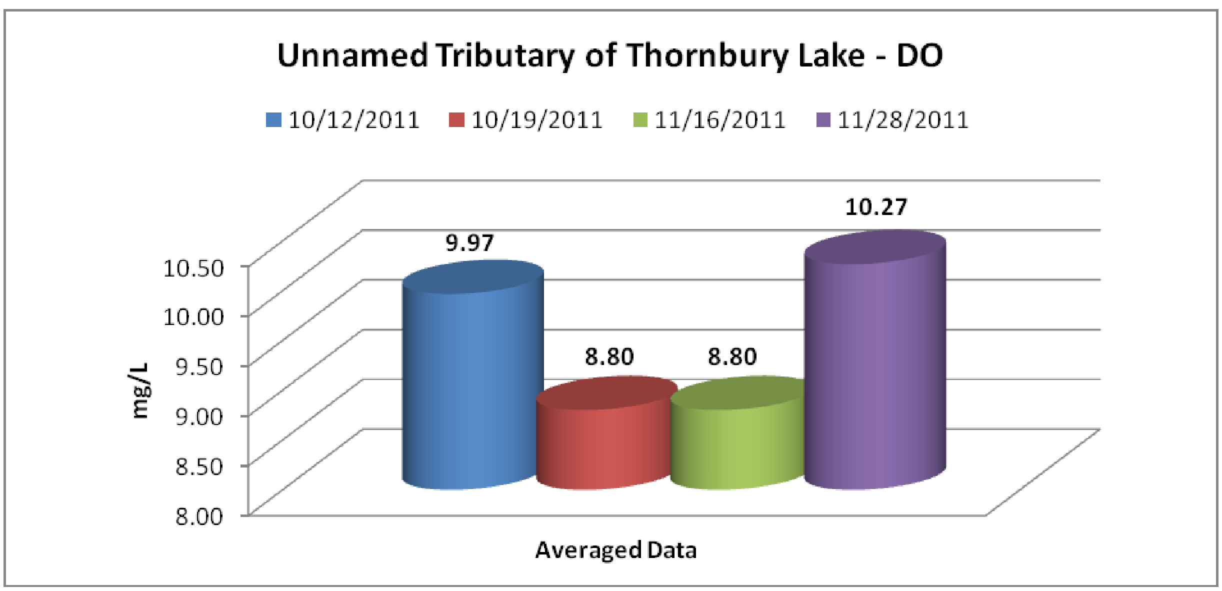
Potassium levels sampled ranged from 0.8 to 3.6 ppm. Natural levels of potassium within streams typically vary from 2 – 3 ppm. Sample Station 7 had the highest readings for potassium during each sampling event; however, this sampling station only had levels above acceptable ranges during the last two sampling events (3.4 and 4 ppm). Sample Station 8 had potassium levels of 3.6 ppm during the last sampling event. The averaged potassium levels (3.37 ppm) were the highest during the fourth sampling event (November 28, 2011).





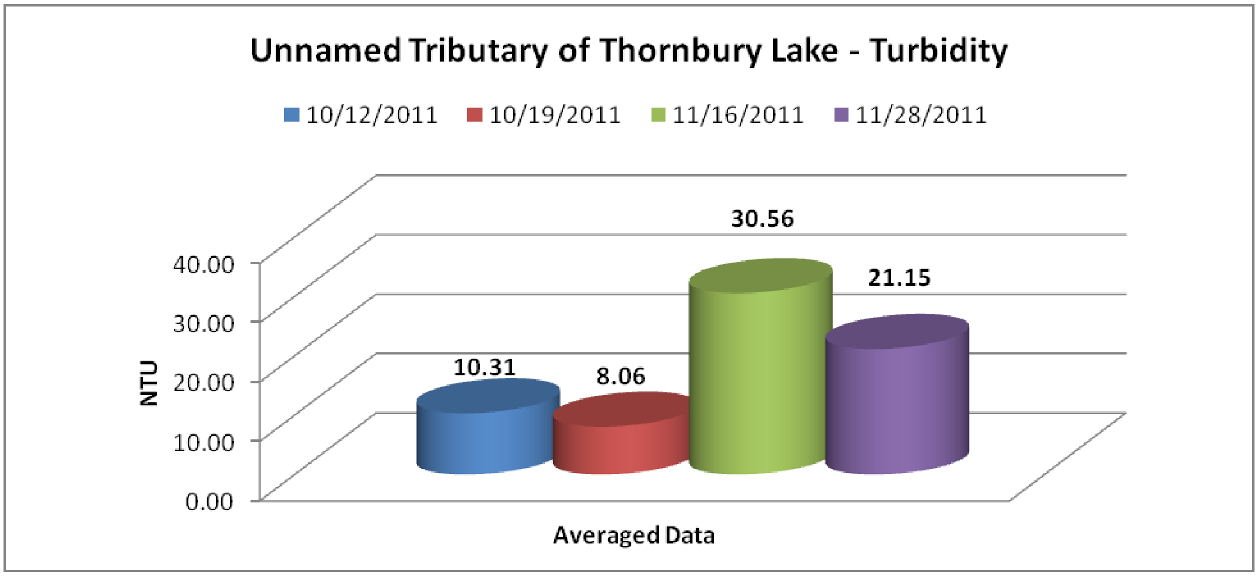
Dissolved Oxygen

Averaged dissolved oxygen (DO) was recorded between 8.80 mg/L and 10.27 mg/L. Optimal DO concentration in streams is approximately 9 mg/L. Georgia standards for DO in streams cannot fall below 5 mg/L. All sampling stations within the unnamed tributary had recorded DO levels within ranges near the optimal concentration of DO in streams.



Turbidity

All of the turbidity values for water flowing within the unnamed tributary of Thornbury Lake were lower than 50 NTU. The State considers waters that have 50 NTU's to be cloudy and 100-500 NTU's or greater to be very cloudy to muddy. Water flowing within the stream had averaged turbidity values from 8.06 to 30.56 NTU's, which is considered to clear to fairly clear water. The averaged turbidity levels (30.56 NTU) were the highest during the third sampling event (November 16, 2011).



Area 4 - Unnamed Tributary of Lake Windward

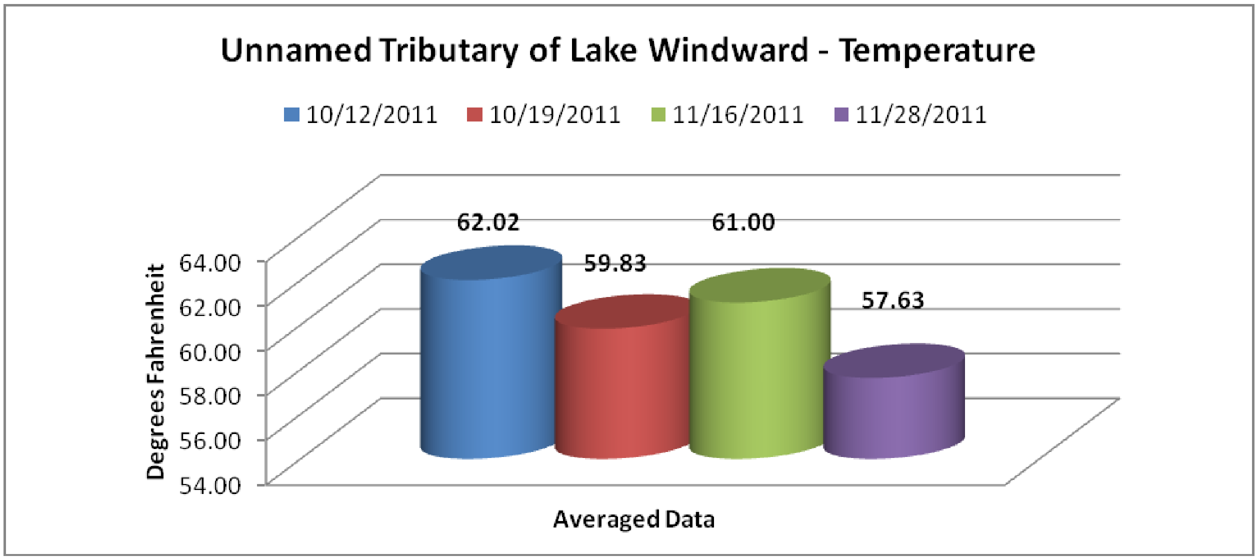
To establish if stormwater pollutants were being discharged into the Lake Windward tributary from the Webb Bridge Park property, eight sampling stations were selected. These include six stations - Sampling Stations 10 – 15 – set upstream of the confluence with the unnamed tributary of Thornbury Lake and two stations - Sampling Stations 16 and 17 - located downstream of the confluence of the unnamed tributary of Thornbury Lake.

Sampling Station 16 was set just downstream of the confluence with the unnamed tributary of Thornbury Lake. At this location, the stream conveys a majority of the Park's contributory drainage area, with 105 acres collecting from the western portion of the park and 73 acres that convey runoff from the eastern portion of the park. Sampling Station 17 was set just upstream of the Shirley Bridge Road culvert, a triple-barrel 54-inch CMP which discharges directly into Lake Windward.

For each of the four sampling events, the parameters at each sample station were averaged. However, if the sampled data had notably higher than normal values, then the actual data is presented along with the averaged data.

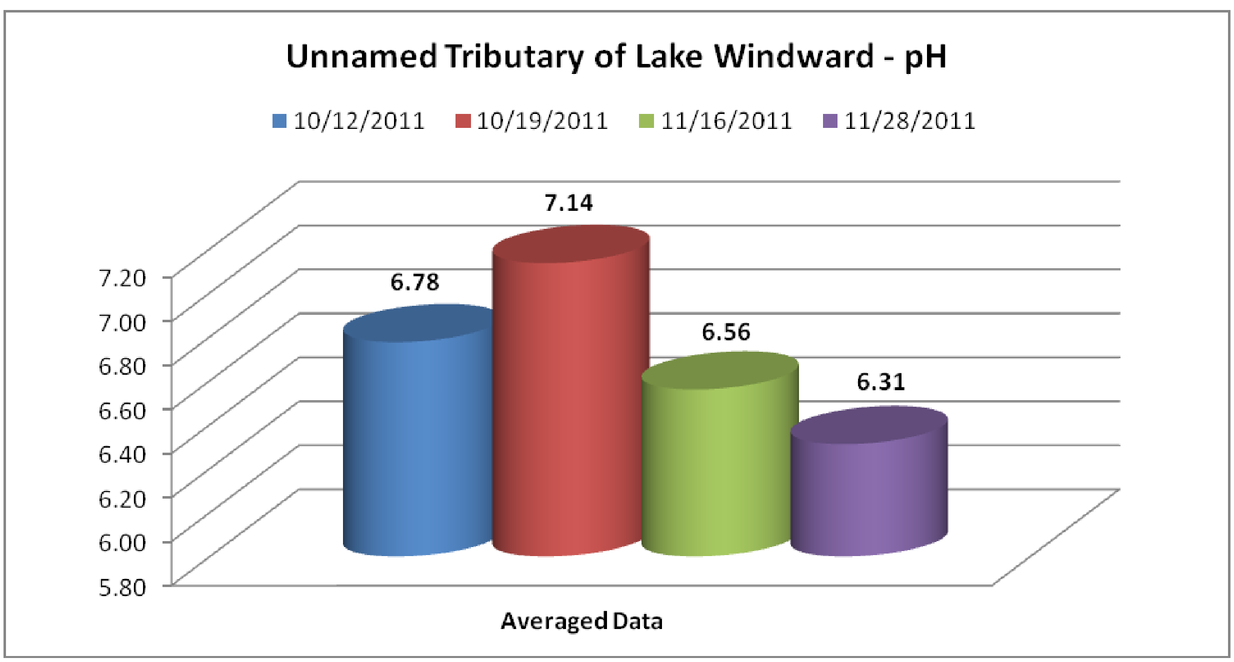
Temperature

The averaged temperatures within the stream ranged between 57.63 to 62.02 degrees Fahrenheit. Georgia standard for temperatures within streams cannot exceed 89.6 degrees Fahrenheit. Temperatures sampled at Stations 10 - 17 were all within the acceptable range.



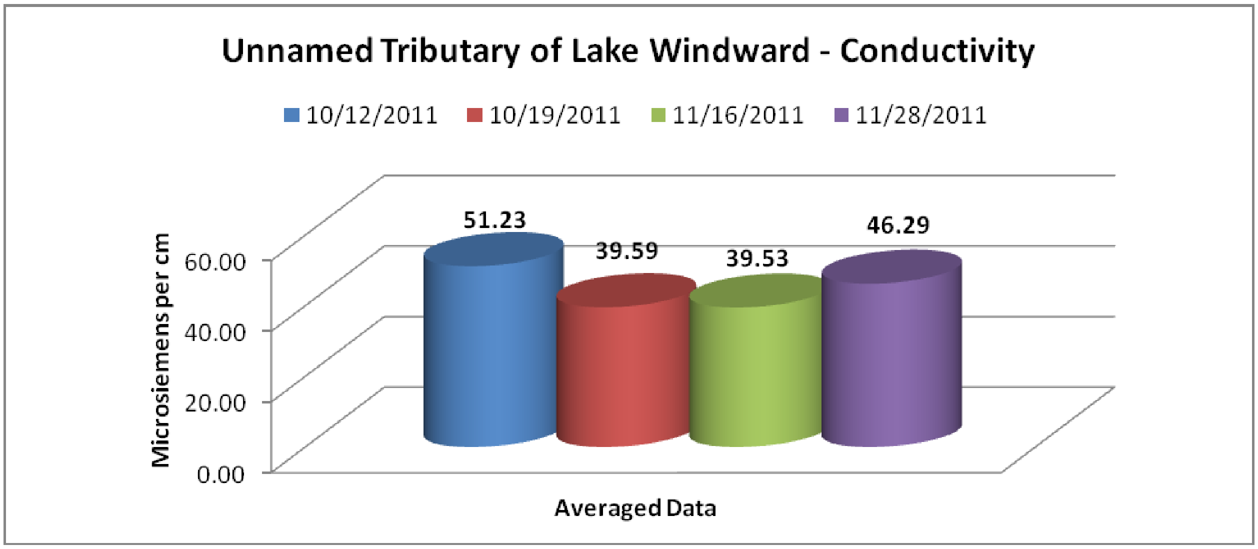
pH

Averaged values for pH within the unnamed tributary of Lake Windward ranged from 6.31 to 7.14. The pH values for Piedmont streams in Georgia range from 6.0 to 8.5. The averaged pH values are well within the acceptable limits within this stream system.



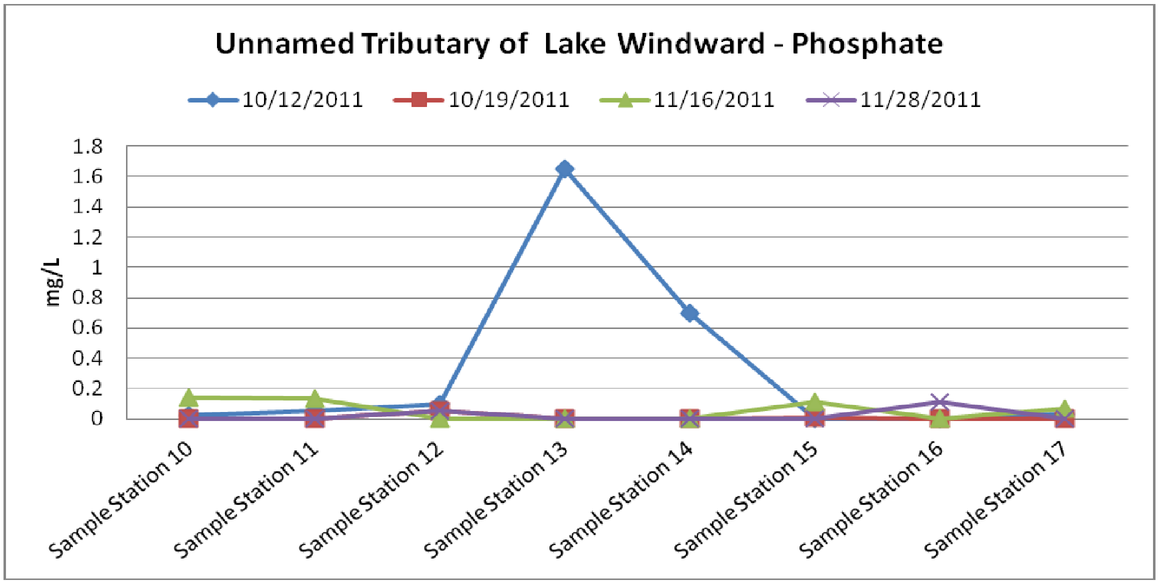
Conductivity

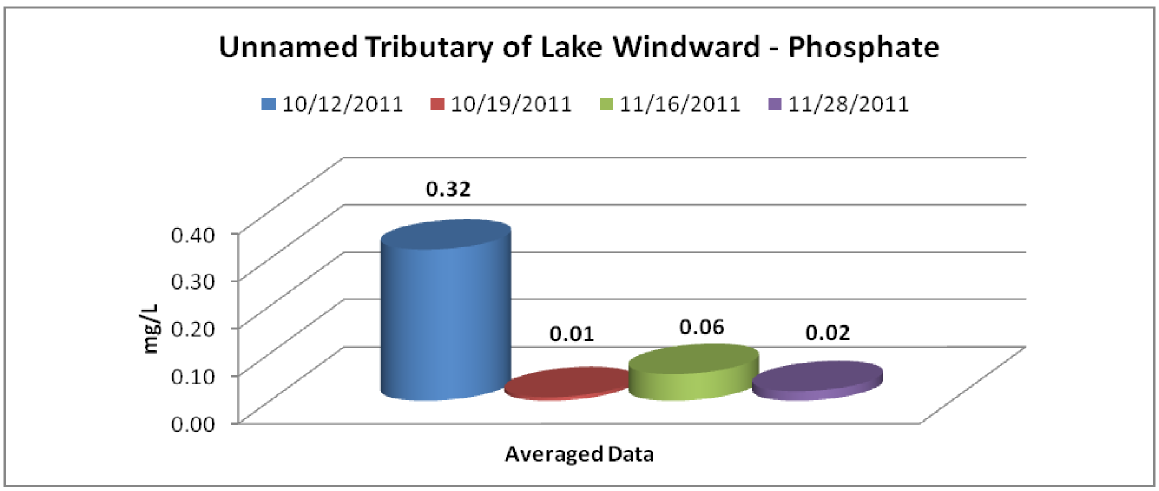
Conductivity values within the stream flowing into Lake Windward were averaged and ranged from 39.53 µs/cm to 51.23 µs/cm. Streams in Georgia normally range from 0 – 1500 µs/cm; however, streams in Georgia that support mixed fisheries will have conductivity values between 50 – 500 µs/cm. All of the averaged data that was sampled falls within the acceptable range for streams in Georgia, but is below the values that would support mixed fisheries within the stream.



Phosphorus

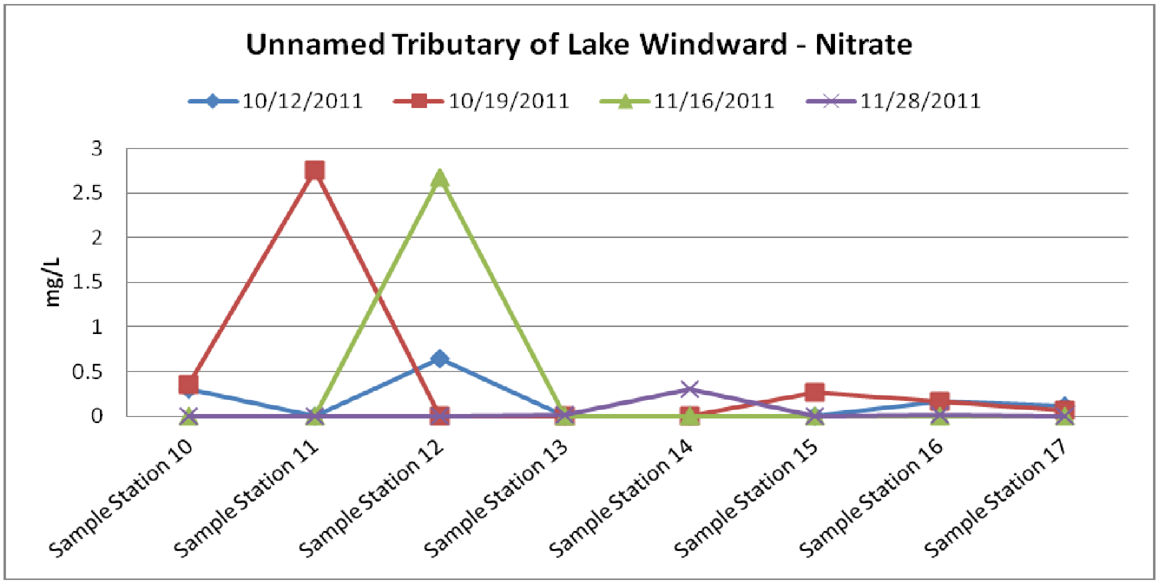
Phosphate concentrations are normally less than 0.1 mg/L in natural stream systems. Sample Stations 13 and 14 had the highest phosphate readings during the first sampling event, which were 1.65 and 0.7 mg/L respectively. Overall, the phosphate readings recorded for each sampling event ranged from 0 to 0.14 mg/L. Sample Stations 10 and 11 had elevated phosphate readings that were recorded during the third sampling event in which the phosphate levels were 0.14 and 0.13 mg/L. All of the averaged phosphate levels within the unnamed tributary flowing into Lake Windward were within acceptable limits except for the first sampling event, which was above 0.1 mg/L. Phosphate levels over 0.1 mg/L will accelerate eutrophication within wet ponds, lakes, and streams.

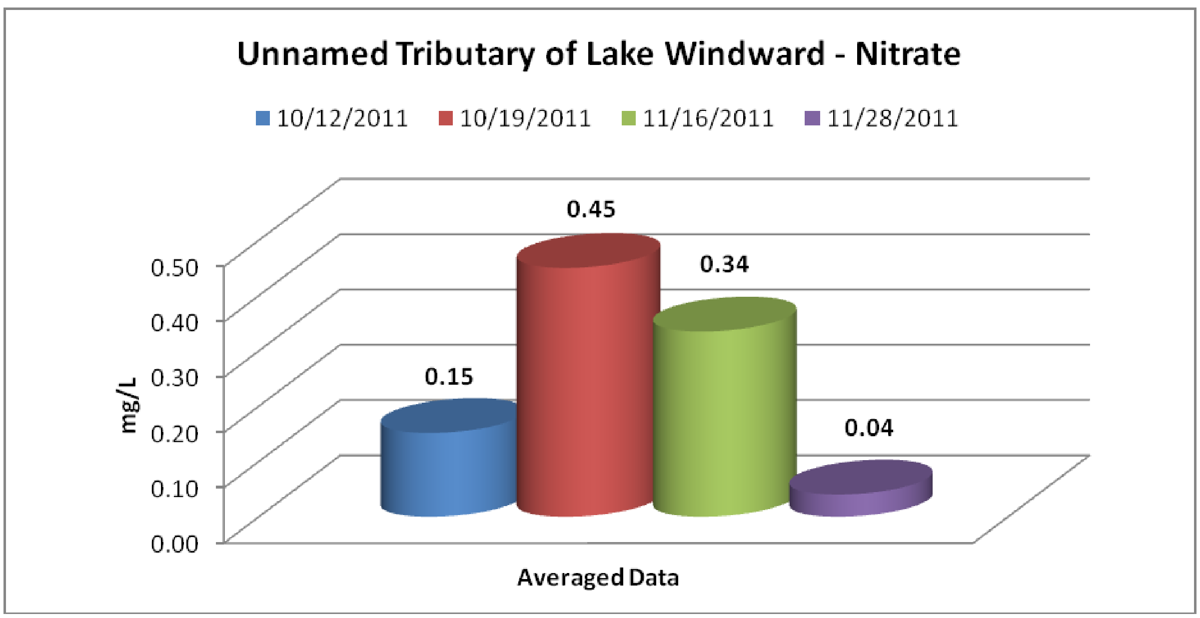




Nitrate

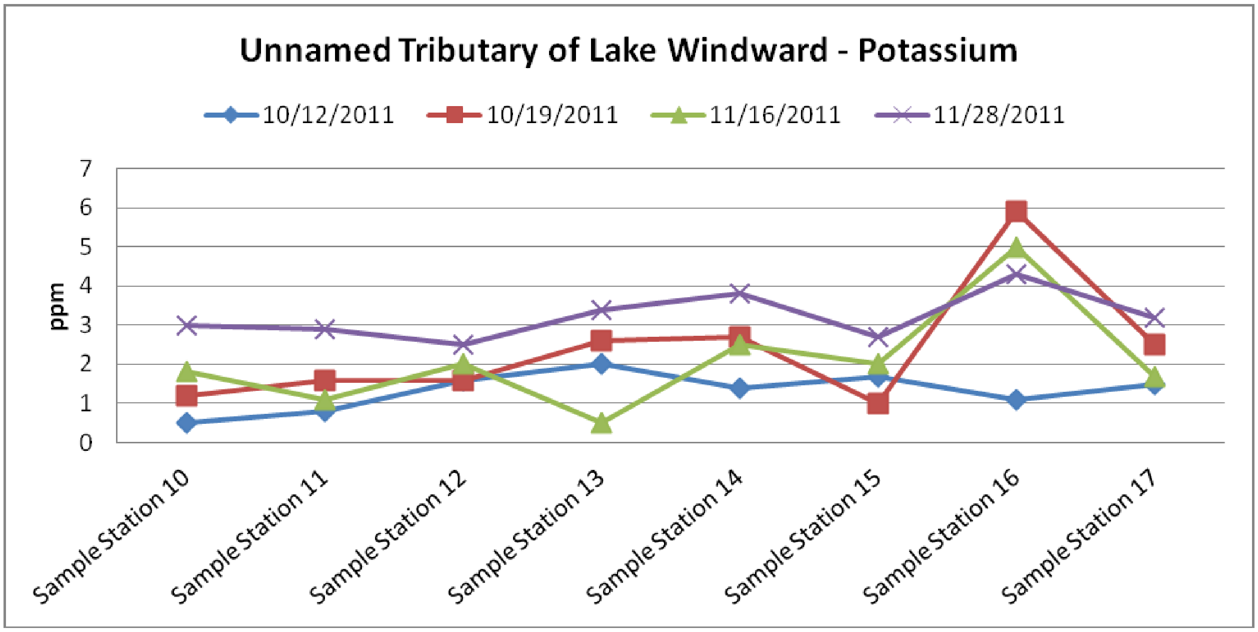
The averaged nitrate values sampled within the unnamed tributary were 0.45 mg/L or less. Nitrates were only detected in high values during the second sampling event at Sample Station 11, in which the nitrate levels recorded were 2.75 mg/L. The second highest nitrate value recorded was during the third sampling event at Sample Station 12, in which the nitrate level was 2.68 mg/L. Nitrates are highly soluble; therefore, dissolve quickly once nitrates enter into a wet pond, stream, or lake. Nitrates within the stream system were within acceptable ranges (1.0 mg/L or less), except for Sample Station 11 during the second sampling event and Sample Station 12 during the third sampling event.

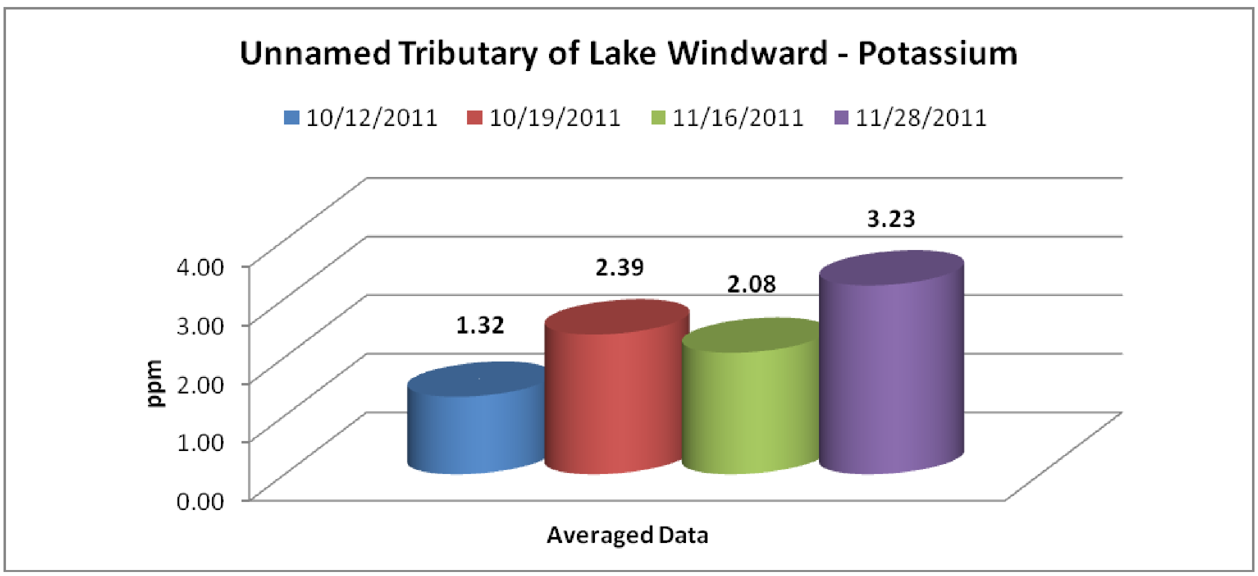




Potassium

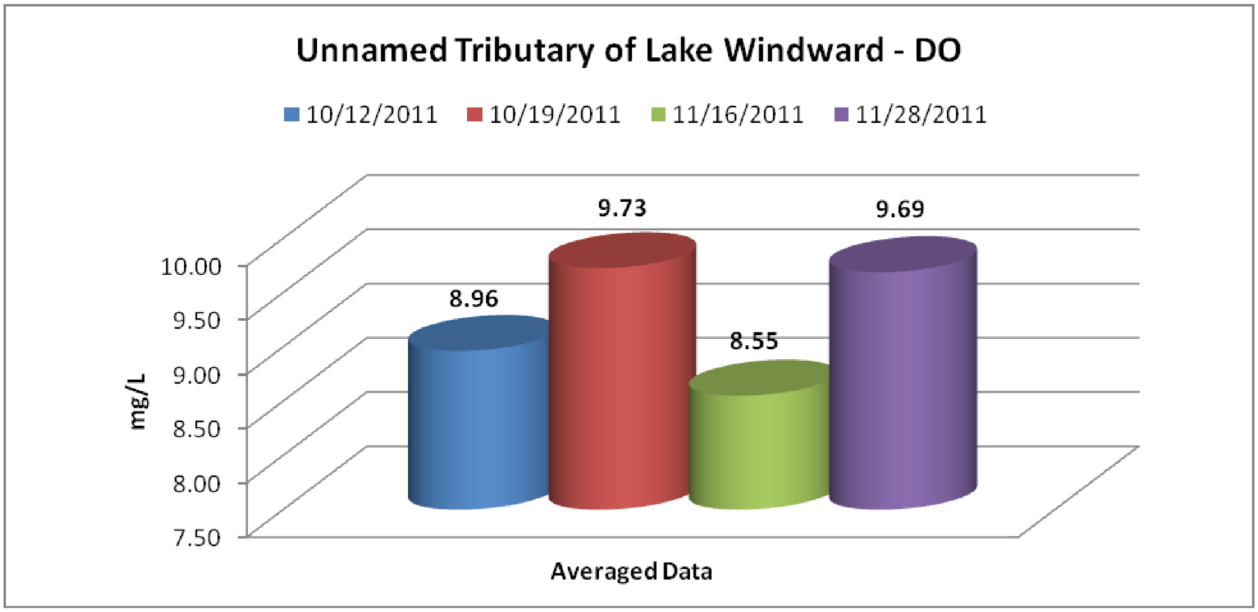
Potassium levels sampled ranged from 0.5 to 5.9 ppm. Natural levels of potassium within streams typically vary from 2 – 3 ppm. Sample Station 16 had the highest readings for potassium during sampling events 2 – 4, during which this sampling station had potassium readings of 5.9, 5.0, and 4.3 ppm, respectively. Sample Stations 13 and 14 had potassium levels of 3.4 and 3.8 ppm, respectively, during the last sampling event. The averaged potassium levels (3.23 ppm) were the highest during the fourth sampling event (November 28, 2011).





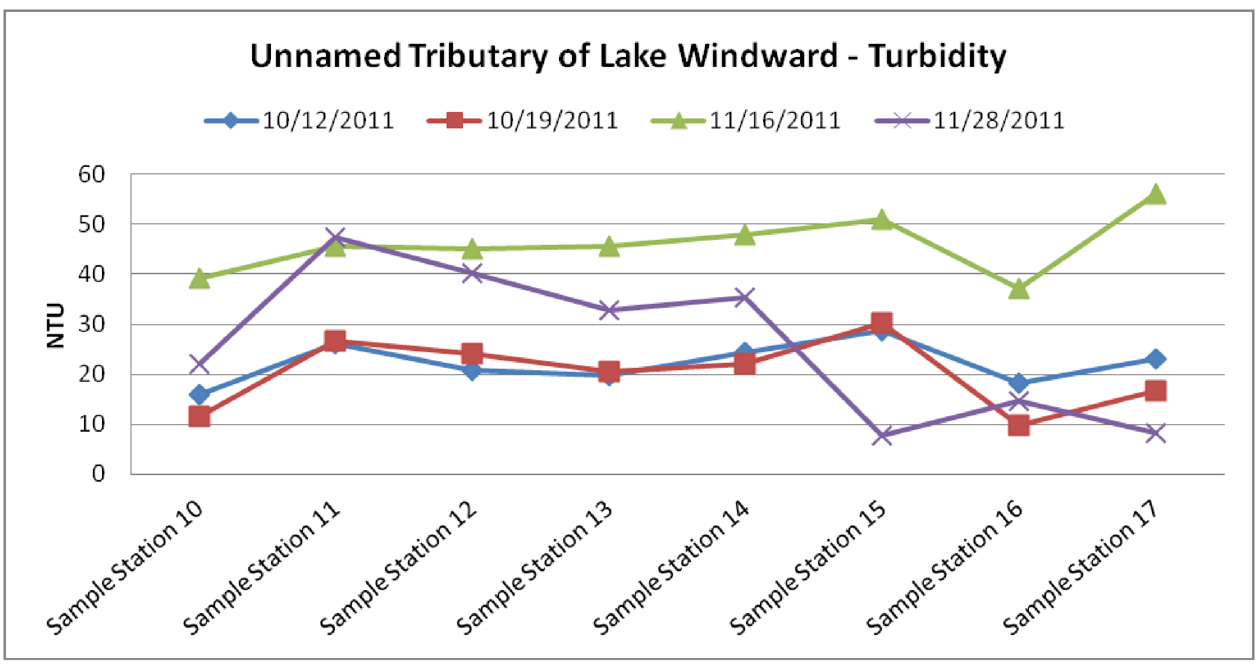
Dissolved Oxygen

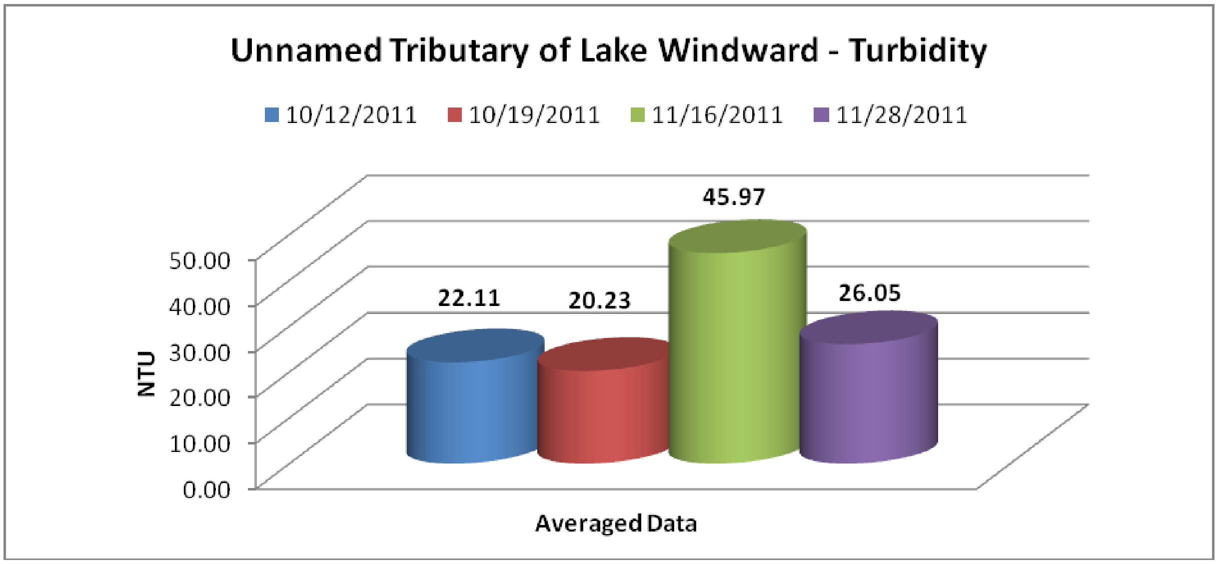
Averaged dissolved oxygen (DO) was recorded between 8.55 mg/L and 9.73 mg/L. Optimal DO concentration in streams is approximately 9 mg/L. Georgia standards for DO in streams cannot fall below 5 mg/L. All sampling stations within the tributary had recorded DO levels within ranges near the optimal concentration of DO in streams.



Turbidity

All of the turbidity values for water flowing within the unnamed tributary of Lake Windward were lower than 50 NTU except for Sample Stations 15 and 17. Sample Stations 15 and 17 had turbidity readings of 50.95 and 56.17, respectively, during the third sampling event. The State considers waters that have 50 NTU's to be cloudy and 100- 500 NTU's or greater to be very cloudy to muddy. Water flowing within the stream had averaged turbidity values from 20.23 to 45.97 NTU's, which is considered to fairly clear water to cloudy. The averaged turbidity levels (45.97 NTU) were the highest during the third sampling event (November 16, 2011).





Conclusions of Water Quality Sampling

The land surrounding Webb Bridge Park is developed and considered to be urbanized. Urban areas contain more impervious surfaces, which reduce the amount of rainfall that is absorbed into the ground. Stormwater runoff from heated roads and parking lots can create rapid increases in stream temperatures. Additionally, stormwater runoff from urbanized watersheds often contains elevated levels of pollutants, which ultimately impact the quality of streams and lakes.

Eight water quality parameters were sampled and evaluated in order to determine (1) if pollutants were entering the streams and lakes and (2) if these pollutant levels were within acceptable ranges. Four water quality parameters - temperature, pH, dissolved oxygen, conductivity - consistently exhibited readings within the acceptable ranges while four water quality parameters - nitrates, phosphate, potassium, and turbidity - resulted in readings that were above the acceptable ranges.

Although water quality parameters were sampled at seventeen locations within, and downstream of, Webb Bridge Park, the results of the sampling efforts were evaluated further at key locations to determine if the park was contributing to pollutant loading downstream. **Key locations that were evaluated include: 1) pollutants exiting the park from the wet pond, 2) pollutants entering Thornbury Lake through the unnamed tributary of Thornbury Lake, 3) pollutants entering Thornbury Lake through stormwater runoff from the Thornbury Parc subdivision, 4) pollutants exiting Thornbury Lake through the unnamed tributary of Thornbury Lake, and 5) pollutants entering into Lake Windward.**

Temperature

As urbanization occurs within a watershed, the thermal regime of the surrounding environment is altered. Heated stormwater runoff mixes with receiving waters, creating the potential to increase the surface water base temperature in streams and lakes. The amount of heat transferred and the degree of thermal pollution is important to the ecological integrity of receiving waters.

The increase in thermal energy within stormwater runoff is primarily due to the increase of impervious surfaces in the contributory watershed. Impervious surfaces absorb and emit heat, which creates air and surface temperatures that are significantly higher than those in rural areas. An increase of impervious surface within surrounding land also creates additional surface runoff. Increased air and surface temperatures combined with additional surface runoff will result in a larger volume of stormwater runoff that has increased temperatures.

The water temperatures exiting Webb Bridge Park, entering and exiting Thornbury Lake, and entering into Lake Windward fell within the acceptable temperature ranges (Table 2).

Table 2. Summary of water temperatures at key locations

Location	Sampling Events			
	10/12/2011	10/19/2011	11/16/2011	11/28/2011
Exiting Webb Bridge (SS – 4)	61.52°F	61.16°F	66.20°F	57.74°F
Entering Thornbury Lake (SS – 8)	60.62°F	58.82°F	65.30°F	57.56°F
Entering Thornbury Lake (SS – 5 and 6) Avg.	64.58°F	64.22°F	65.12°F	58.82°F
Exiting Thornbury Lake (SS – 9)	61.52°F	57.56°F	61.34°F	57.92°F
Entering Lake Windward (SS – 17)	62.42°F	62.42°F	58.64°F	61.34°F

pH

The pH values of stormwater runoff and water within streams are important because aquatic organisms have tolerances for very narrow pH ranges. An in-stream pH value higher or lower than the 6 to 8.5 range can decrease the survival of aquatic organisms and will lead to loss of stream ecosystem diversity. Several sources can contribute to pH change in stormwater runoff. These include industrial business that use acidic chemicals, cement used for paving concrete, and chemical cleaners used in residential homes. High pH levels can occur when algae and aquatic vegetation use carbon dioxide for photosynthesis. Low pH levels can be created when aquatic vegetation respires or from bacterial decay of organic matter in the water producing high levels of carbon dioxide. Low pH in waters can allow toxic chemicals to become mobile and taken up by aquatic plants and animals, which will produce conditions that are toxic to aquatic life.

The pH levels exiting Webb Bridge Park, entering and exiting into Thornbury Lake, and entering into Lake Windward fell within the acceptable pH value ranges (Table 3). This

indicates that pH values are optimal for aquatic organisms within the unnamed tributaries of Thornbury Lake and Lake Windward and within the two sampled lakes.

Table 3. Summary of pH at key locations

Location	Sampling Events			
	10/12/2011	10/19/2011	11/16/2011	11/28/2011
Exiting Webb Bridge (SS – 4)	7.08	7.08	6.67	6.60
Entering Thornbury Lake (SS – 8)	6.25	6.94	6.56	6.47
Entering Thornbury Lake (SS – 5 and 6) Avg.	7.06	7.38	7.04	6.70
Exiting Thornbury Lake (SS – 9)	6.42	6.95	6.54	6.47
Entering Lake Windward (SS – 17)	7.00	7.30	7.10	6.36

Conductivity

Conductivity in stormwater is affected by the presence of inorganic dissolved solids such as chloride, sulfate, sodium, calcium, nitrate, etc. Conductivity in streams is affected by the geology of the area in which the water flows through. Streams that run through granite bedrock will exhibit lower conductivity while streams that flow through limestone and clay soils will typically have higher conductivity values. High conductivity readings can also result from industrial pollution or stormwater runoff. Extended dry periods and low flow conditions can contribute to higher conductivity readings. Organic compounds, such as oil, do not conduct electric current well; therefore, an oil spill will lower the conductivity of the water.

The conductivity levels exiting Webb Bridge Park, entering and exiting into Thornbury Lake, and entering into Lake Windward fell within the acceptable conductivity ranges (Table 4). Streams in Georgia normally range from 0 – 1500 µs/cm; however, most streams in Georgia that better support mixed fisheries will have conductivity values between 50 – 500 µs/cm. These results indicate that conductivity values will support aquatic organisms and fish within the unnamed tributaries of Thornbury Lake and Lake Windward and within the two sampled lakes.

Table 4. Summary of conductivity at key locations

Location	Sampling Events			
	10/12/2011	10/19/2011	11/16/2011	11/28/2011
Exiting Webb Bridge (SS – 4)	115.8 µs/cm	108.2 µs/cm	65.8 µs/cm	79.5 µs/cm
Entering Thornbury Lake (SS – 8)	51.1 µs/cm	42.0 µs/cm	36.2 µs/cm	44.2 µs/cm
Entering Thornbury Lake (SS – 5 and 6) Avg.	41.6 µs/cm	47.1 µs/cm	41.7 µs/cm	47.0 µs/cm
Exiting Thornbury Lake (SS – 9)	58.9 µs/cm	54.8 µs/cm	50.4 µs/cm	59.7 µs/cm
Entering Lake Windward (SS – 17)	75.9 µs/cm	45.7 µs/cm	40.5 µs/cm	71.9 µs/cm

Phosphorus

Phosphorus is an essential nutrient for plants and animals, but phosphorus is a limiting nutrient in most fresh water streams. Excess phosphorus in stormwater runoff and streams can cause accelerated plant growth and algae blooms, which will lead to eutrophication in the water. High phosphorous levels can create low dissolved oxygen levels in water, resulting in conditions that cannot support aquatic life. Sources of phosphorus contamination entering stormwater include runoff from fertilized lawns and farmland, failing septic systems, and industrial discharges. Sources of phosphorus entering streams include runoff from disturbed land, drained wetlands, and water treatment plants.

The phosphates exiting Webb Bridge Park and entering and exiting into Thornbury Lake were above the acceptable phosphate ranges during certain sampling events and certain locations (Table 5). Natural levels of phosphorus usually range from 0.005 to 0.05 mg/L and phosphorus levels of 0.08 to 0.10 mg/L can contribute to the eutrophication process. Phosphorus levels greater than 0.10 mg/L can stimulate plant growth that surpasses natural eutrophication rates.

Table 5. Summary of phosphates at key locations

Location	Sampling Events			
	10/12/2011	10/19/2011	11/16/2011	11/28/2011
Exiting Webb Bridge (SS – 4)	0.00 mg/L	0.03 mg/L	0.07 mg/L	0.15 mg/L
Entering Thornbury Lake (SS – 8)	0.30 mg/L	0.02 mg/L	0.00 mg/L	0.03 mg/L
Entering Thornbury Lake (SS – 5 and 6) Avg.	0.48 mg/L	0.74 mg/L	0.51 mg/L	1.12 mg/L
Exiting Thornbury Lake (SS – 9)	0.06 mg/L	0.01 mg/L	0.02 mg/L	0.13 mg/L
Entering Lake Windward (SS – 17)	0.03 mg/L	0.00 mg/L	0.07 mg/L	0.00 mg/L

Based on the above data, phosphate levels exceeded 0.1 mg/L within the unnamed tributary of Thornbury Lake before entering Thornbury Lake during the first sampling event. The probable source appears to be stormwater runoff from Fox Road since phosphate levels exiting the detention pond in Webb Bridge Park during this event was 0.00 mg/L. Stormwater runoff from the Thornbury Parc subdivision had phosphate levels above 0.10 mg/L flowing into Thornbury Lake, but the phosphates appeared to dissolve and settle out becoming part of the sediments within the lake prior to flowing into the unnamed tributary of Lake Windward. **All phosphate levels within the unnamed tributary of Lake Windward (and prior to entering into Lake Windward) are within the acceptable ranges.**

Nitrate

Algae are very efficient users of nitrogen. Nutrients may not be measurable by the time algae are observed; however, nitrates still can continue to impact the ecosystem as a whole. Algal blooms were observed within the wet pond in Webb Bridge Park during the June 28, 2011 site visit, conducted prior to any sampling events. Since algal blooms were observed, stormwater was sampled upstream from detention pond to aid in identifying the source of excess nutrients. Algal blooms will usually be found in lakes and detention ponds, but if algal blooms are found in streams then the nutrient content is probably very high. Levels in excess of 1.0 mg/L indicate a potential source such as sewage, fertilizers, disturbance of soil, or animal waste.

The nitrates Webb Bridge Park, entering and exiting into Thornbury Lake, and entering into Lake Windward fell within the acceptable nitrate ranges (Table 6). Unpollutated waters will have nitrate levels at 1.0 mg/L or less.

Table 6. Summary of nitrates at key locations

Location	Sampling Events			
	10/12/2011	**10/19/2011**	**11/16/2011**	**11/28/2011**
Exiting Webb Bridge (SS – 4)	0.00 mg/L	0.21 mg/L	0.00 mg/L	0.00 mg/L
Entering Thornbury Lake (SS – 8)	0.14 mg/L	0.00 mg/L	0.00 mg/L	0.01 mg/L
Entering Thornbury Lake (SS – 5 and 6) Avg.	0.02 mg/L	0.09 mg/L	0.01 mg/L	0.01 mg/L
Exiting Thornbury Lake (SS – 9)	0.23 mg/L	0.00 mg/L	0.00 mg/L	0.00 mg/L
Entering Lake Windward (SS – 17)	0.16 mg/L	0.16 mg/L	0.00 mg/L	0.01 mg/L

Potassium

Potassium is a requirement for almost any organism, including a number of bacteria, because it plays a major role in nerve functions. Potassium is important for plant growth as potassium from dead plant and animal material will bind to clay minerals in soils before it dissolves in water. Plants contain approximately an average of two percent potassium (dry mass) while beetles average approximately 0.75 percent potassium (dry mass). A number of potassium compounds are found within synthetic fertilizers. A high percentage of commercially applied potassium is added to synthetic fertilizers in which potassium salts and mixtures of magnesium and calcium compounds are also applied regularly. In most cases potassium is the adjacent anion and not the active ingredient. Potassium hydroxide forms caustic potash, which is applied in detergents, fertilizers, and carbon dioxide absorbers.

The potassium exiting Webb Bridge Park, entering into Thornbury Lake, and entering into Lake Windward were above the acceptable potassium ranges (Table 7). Potassium is not very hazardous in water, but it does spread rapidly since it has a relatively high mobility potential. Potassium toxicity is usually caused by other components in a compound. Potassium tends to settle out along the channel bottom and ultimately ends up within the sediment. Streams typically will have approximately 2-3 ppm of potassium.

Table 7. Summary of potassium at key locations

Location	Sampling Events			
	10/12/2011	10/19/2011	11/16/2011	11/28/2011
Exiting Webb Bridge (SS – 4)	1.8 ppm	2.1 ppm	4.6 ppm	3.8 ppm
Entering Thornbury Lake (SS – 8)	0.8 ppm	1.6 ppm	2.8 ppm	3.6 ppm
Entering Thornbury Lake (SS – 5 and 6) Avg.	3.1 ppm	5.15 ppm	4.5 ppm	6.1 ppm
Exiting Thornbury Lake (SS – 9)	1.7 ppm	1.7 ppm	2.1 ppm	2.5 ppm
Entering Lake Windward (SS – 17)	1.5 ppm	2.5 ppm	1.7 ppm	3.2 ppm

Based on the above data, potassium levels exceeded 3 ppm exiting Webb Bridge Park during the third and fourth sampling events, but had settled out within the unnamed tributary of Thornbury Lake prior to entering Thornbury Lake except during the fourth sampling event. Potassium levels that entered Thornbury Lake through stormwater settled out within the lake before flowing into the unnamed tributary of Lake Windward. Potassium levels entering into Lake Windward were within the acceptable range except during the fourth sampling event. At this location, the probable source of potassium appears to be through stormwater runoff, which is likely carrying fertilizers into the streams and lakes. Fertilizers spread on the lawns during the late fall and winter months will contain potassium, but not nitrates or phosphates.

Dissolved Oxygen

Fish, macroinvertebrates, plants, and aerobic bacteria require oxygen for respiration. Oxygen dissolves readily into water from the atmosphere until the water is saturated. Once oxygen is dissolved in water, it will diffuse slowly and its distribution will depend on the movement of aerated water by turbulence (riffle zone). The dissolved oxygen capacity of water is limited by the temperature of the water and by the atmospheric pressure. Temperature and atmospheric pressure will determine the highest amount of oxygen that will dissolve in water. A low dissolved oxygen level indicates a demand on the oxygen within the stream. Pollutants that include sewage or decaying organic material can create low dissolved oxygen levels. Organic materials accumulate along the channel bottom in sediments and support microorganisms, which consume oxygen as they break down the materials.

The dissolved oxygen levels exiting Webb Bridge Park, entering and exiting into Thornbury Lake, and entering into Lake Windward fell within the acceptable dissolved oxygen ranges (Table 8). The State requires the DO to be above 5.0 mg/L while the optimal DO level within streams in Georgia is 9 mg/L. This indicates that the DO values will support aquatic organisms and fish within the unnamed tributaries of Thornbury Lake and Lake Windward and within the two sampled lakes.

Table 8. Summary of dissolved oxygen at key locations

Location	Sampling Events			
	10/12/2011	**10/19/2011**	**11/16/2011**	**11/28/2011**
Exiting Webb Bridge (SS – 4)	11.6 mg/L	10.4 mg/L	6.3 mg/L	8.3 mg/L
Entering Thornbury Lake (SS – 8)	10.3 mg/L	10.2 mg/L	10.3 mg/L	9.8 mg/L
Entering Thornbury Lake (SS – 5 and 6) Avg.	11.6 mg/L	10.2 mg/L	11.7 mg/L	10.65 mg/L
Exiting Thornbury Lake (SS – 9)	9.9 mg/L	9.3 mg/L	9.8 mg/L	10.8 mg/L
Entering Lake Windward (SS – 17)	7.9 mg/L	10.6 mg/L	8.3 mg/L	8.6 mg/L

Turbidity

Turbidity concentrations are influenced by the velocity within the stream. Higher velocities convey more particles and larger sized sediment, during which these sediments can be re-suspended and lead to increased turbidity concentrations. Large rain events transport sand, clay, and silts from adjacent lands through stormwater runoff and ultimately into stream systems. In additions to sediments being suspended during storm events, other factors that can increase turbidity within streams include septic system effluent, decaying plants and animals, and algal blooms.

The turbidity exiting Webb Bridge Park and entering into and exiting Thornbury Lake were within the acceptable turbidity ranges (Table 9). Determining acceptable turbidity ranges is difficult since streams in different regions have different natural levels of turbidity. The State considers the following ranges for turbidity: turbidities of 10 NTU or less represent very clear waters, 50 NTU is cloudy, and 100—500 NTU or greater are very cloudy to muddy. Certain fish species will become stressed at prolonged exposures of 25 NTU's or greater.

Table 9. Summary of turbidity at key locations

Location	Sampling Events			
	10/12/2011	**10/19/2011**	**11/16/2011**	**11/28/2011**
Exiting Webb Bridge (SS – 4)	7.10 NTU	7.28 NTU	48.01 NTU	20.93 NTU
Entering Thornbury Lake (SS – 8)	10.22 NTU	12.84 NTU	46.14 NTU	19.99 NTU
Entering Thornbury Lake (SS – 5 and 6) Avg.	19.61 NTU	15.34 NTU	20.66 NTU	26.68 NTU
Exiting Thornbury Lake (SS – 9)	7.97 NTU	3.67 NTU	18.06 NTU	16.33 NTU
Entering Lake Windward (SS – 17)	23.16 NTU	16.61 NTU	56.17 NTU	8.26 NTU

Based on the above data, turbidity levels exceeded 50 NTU entering into Lake Windward during the third sampling event. This can likely be attributed to the amount of precipitation, 1.65 inches within a 24-hour period, which occurred during the sampling event. Urbanization of the surrounding land also plays a role in the turbidity levels being higher following larger storm events as there is more stormwater runoff entering the stream system from impervious areas.

Overall, Webb Bridge Park is contributing very limited pollutants downstream based on the short-term sampling that was conducted. Pollutants are entering the park's wet pond from a private detention pond located just south of the park and from stormwater runoff within the park. The pollutant levels exiting the park (at the location just downstream of the wet pond, Sample Station 4) are within acceptable ranges or slightly above the acceptable range limits, thereby suggesting that majority of the pollutants are accumulating within the detention pond.

A number of pollutants were entering Thornbury Lake within runoff from the Thornbury Parc subdivision, however, the majority of the pollutant levels exiting Thornbury Lake were within acceptable ranges. Pollutants are entering the unnamed tributary of Lake Windward from a private detention pond (adjacent subdivision at the headwaters, southwest of Sample Stations 11 and 12) and from overland runoff. The pollutants exiting Thornbury Lake and the unnamed tributary of Lake Windward within the park had accumulated within the downstream reach of the channel prior to flowing into Lake Windward.

Although the short-term water quality sampling suggests that Webb Bridge Park is not contributing to excessive pollutant loading downstream, additional water quality sampling is recommended. The wet pond within the park had algal blooms during the June and August site visit, which indicates that excessive pollutants (possibly excessive nitrates) were entering into the detention pond. **A full year of water quality sampling will give an indication of the type and amount of pollutants that are entering and exiting the park.** Additionally, the sampling will provide further direction on specific locations or activities that need to be evaluated in more detail.

BENTHIC MACROINVERTEBRATE ASSESSMENT

Macroinvertebrate assemblages are good indicators of localized conditions within the watershed. Many benthic macroinvertebrates have limited migration patterns; therefore, conducting an assessment can typically determine if any site-specific impacts have occurred. Certain macroinvertebrates have sensitive life stages that respond quickly to a stress event, while the overall community will respond more slowly.

The unnamed tributary of Lake Windward within Webb Bridge Park was sampled for macroinvertebrates in order to determine the health and overall condition of the stream. Specific sampling locations were chosen to provide insight on potential problems within the contributory watershed. In addition, the sample sites were selected based on the knowledge that future stream restoration and installation of Best Management Practices may be implemented in order to improve water quality within the stream and watershed.

Methodology

Two sample reaches were selected in order to compare conditions in the upstream and downstream portions of the stream. Refer to Figure 5: “Benthic Sampling Reaches”. The reach with the greatest productive habitat availability constraints was first determined which then established the types of habitat to be sampled at both reaches. The assessment covered a 100-meter reach and was sampled using a D-frame net. Two biologists conducted the assessment in which one biologist collected the samples using the D-frame net while the other biologist tracked the number of "jabs", compiled the material in the sieve bucket, and checked large in-stream debris for organisms. The assessment of the sample reaches commenced at the downstream portion of the reach by jabbing the D-frame net into stable habitats at twenty different locations. A single "jab" consisted of thrusting the D-frame net into the stable habitat for a distance of one meter while a "kick" consisted of disturbing the substrate upstream of the D-frame net.

Benthic Sampling using the “jab” technique

Stable habitats that were sampled include riffles, snags, leaf packs, banks, and sediment/sandy material. Riffle areas, which consist of gravel and cobble substrates, were sampled by rubbing all loose debris off of the substrate so that the organisms could be captured. After the debris was rubbed off the gravel substrate, the streambed was kicked just upstream of the net to dislodge any burrowing organisms. The snags, which consisted of partially submerged woody debris, provide colonization habitat for organisms. Snags were sampled by jabbing into the woody debris over an approximate 1-meter section. Left and right banks were jabbed in several different locations. Banks that consisted of roots and plants were sampled as the snags were sampled and the bare banks were sampled by pushing the net along the substrate to

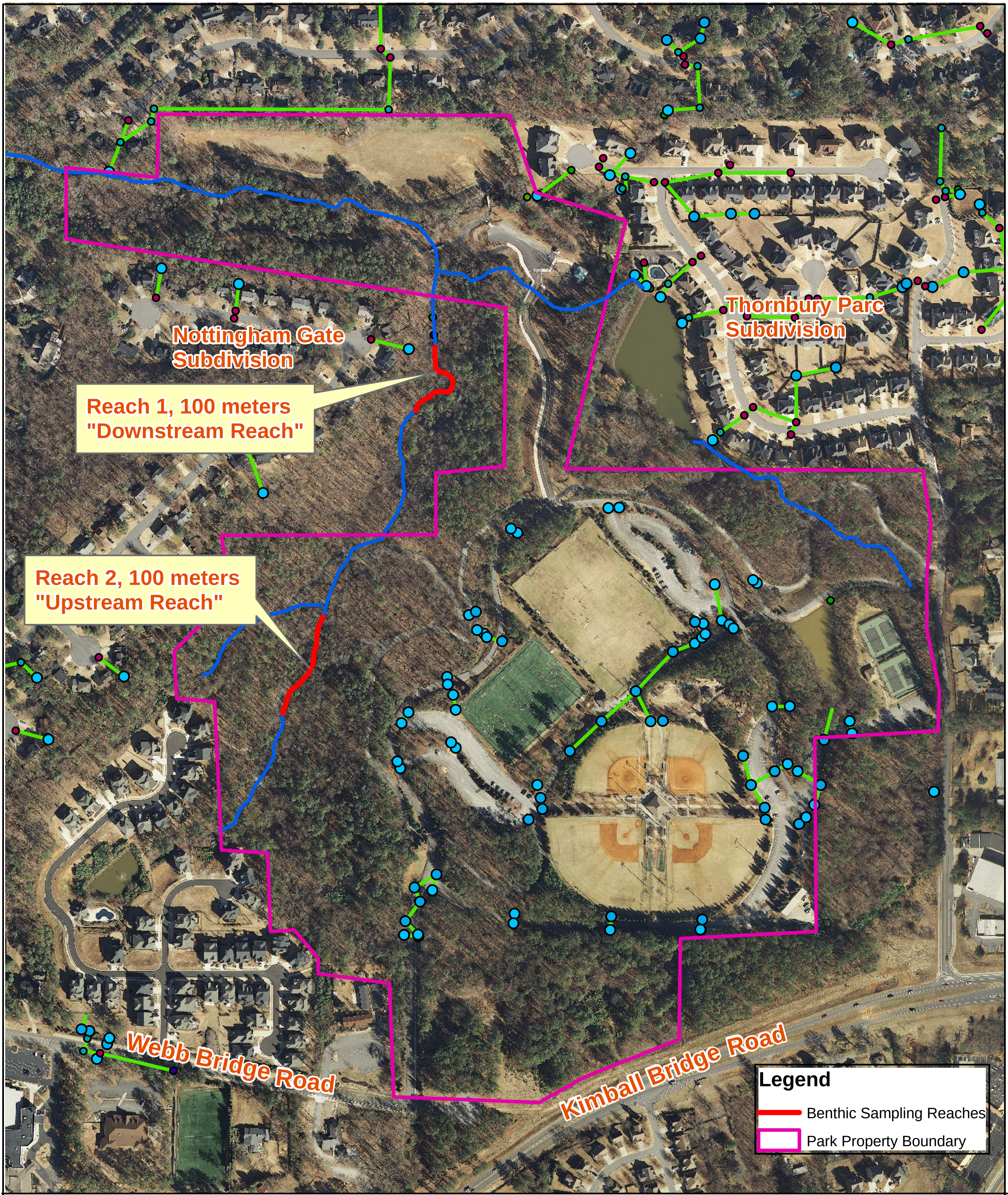


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Figure 5: Benthic Sampling Reaches

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dislodge the organisms. Leaf packs are deciduous leaf material that has accumulated within pool zones and on snags. These habitats were sampled by collecting and rubbing a large handful of leaf material to dislodge the organisms from the leaves. Sediment and sandy substrates were sampled by disturbing the substrate for approximately 0.3 square meters.

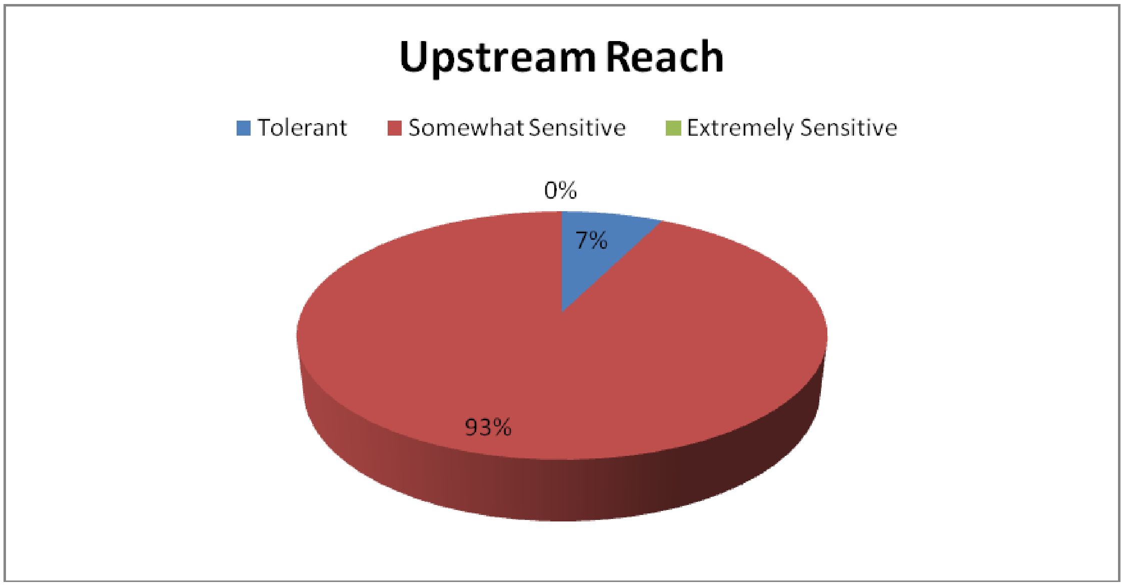
The collected samples were washed by running stream water through the net approximately three times. The samples were then transferred to the sieve bucket every three jabs. The sieve bucket was washed every six jabs in order to remove any fine material that had accumulated. All organisms were transferred from the sieve bucket to sample bottles that were filled with 95 percent ethanol for preservation. Once the sampling was completed, the sample bottles were shipped to a certified lab in order for the organisms to be identified.

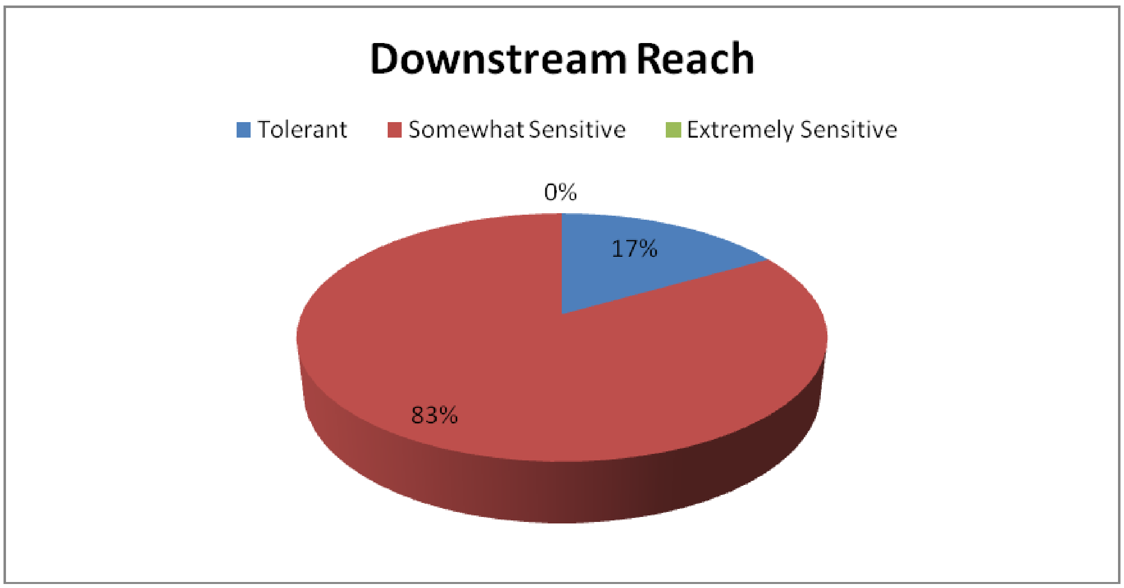
Results of Benthic Macroinvertebrate Assessment

Benthic studies are conducted to give a sense of water quality over a reasonably long chronology (in contrast to the point in time measurement of water chemistry). A single, catastrophic event can occur and profoundly affect the benthic organisms (bottom dwellers), as reflected in the relative numbers and diversity of the bottom dwelling species. Benthic organisms live in the stream, typically spending some or all of their life cycle on the bottom attached to, or very near, the substrate. Thus, benthic organisms are exposed on a daily basis to the changes in water quality over a good portion of their life cycle. Organisms that do not tolerate pollutants ("extremely sensitive species") of various sorts die or become severely weakened when exposed to pollutants. These species numbers will diminish in response to a polluted environment. Other benthic organisms tolerate pollutants ("somewhat sensitive species") and not only thrive under such circumstances, but perform much better because their competitors (for food and other resources) are wiped out, allowing their populations to increase to even greater proportions. Organisms that thrive in polluted environments are referred to as "tolerant species". Those organisms are found in high percentages where a longer history of pollution is evident.

Tolerance Value

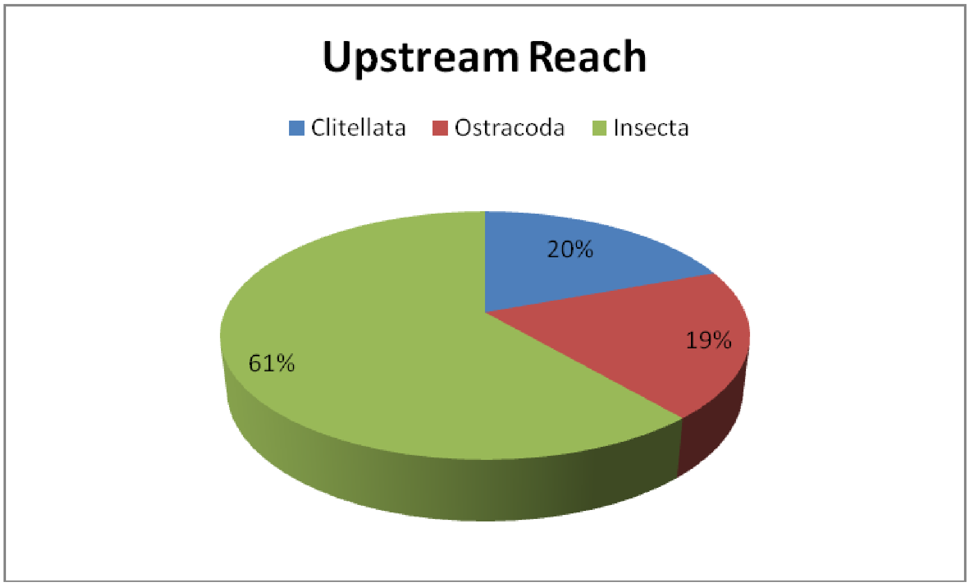
Two 100-meter reaches were sampled to provide an overall assessment of the stream using standardized criteria. Neither of the reaches contained extremely sensitive species, which is to be expected since the stream is within an urbanized watershed where pollutants are introduced on a regular basis. The downstream reach had an increased number of tolerant species (17 percent of those sampled) than the upstream reach (7 percent of those sampled). Data suggests that the pollutants are accumulating within the downstream reach, which has lead to a habitat loss within the downstream reach due to the higher percentage of tolerant species.

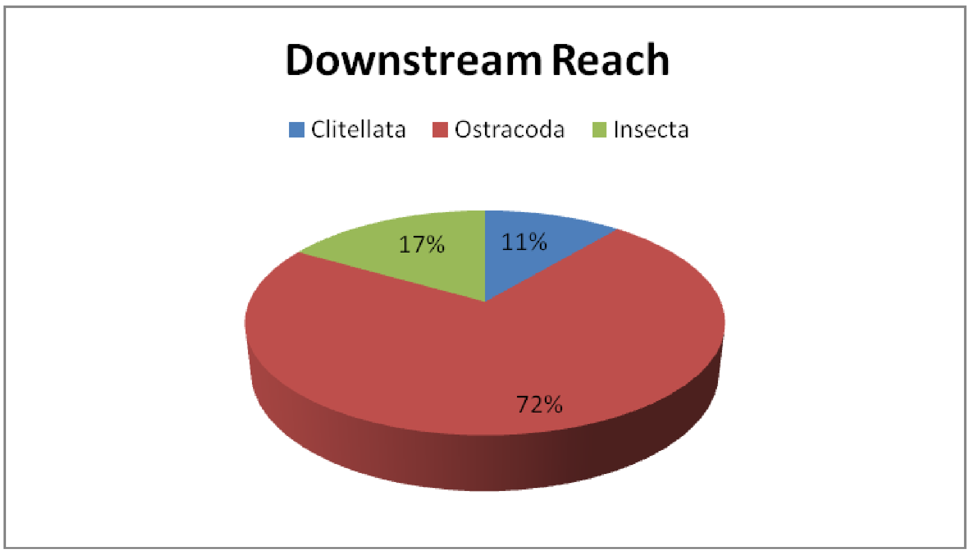




Type of Organisms

Macroinvertebrates collected within the upstream and downstream reaches of the unnamed tributary were identified, at a minimum, to class. The macroinvertebrates collected fell within three classes, which are Ostracoda, Clitellata, and Insecta. The upstream reach had more organisms that fell within the Insecta class (61 percent of those sampled) while the downstream reach was dominated by organisms within Ostracoda class (72 percent of those sampled).





Organisms were categorized within classes and then identified to family. The organisms collected belong to the following families: Lumbricidae, Branchiobdellidae, Cambaridae, Cordulegastridae, Corixidae, Notonectidae, Veliidae, Dytiscidae, and Tipulidae. Some organisms were identified to genus or species. An overview of the organisms identified within the two reaches is discussed below.

Lumbricidae Family

Lumbricidae family consists of blackworms and lies within the subclass Oligochaeta in phylum Annelida, which is made up of different types of aquatic and terrestrial worms. These worms usually have few setae (bristles) on the outer body surface and lack parapodia. The blackworms are usually smaller and more delicate than their terrestrial counterparts and are scavengers that feed on detritus and algae. These worms are usually found in the bottom of muck within freshwater streams. Many of the species within the family can tolerate low dissolved oxygen and large numbers of these worms in a stream with few other groups present indicate that severe nutrient pollution is present.

Branchiobdellidae Family

Branchiobdellidae family is comprised of crayfish worms that are within the subclass Oligochaeta in phylum Annelida. Crayfish worms are freshwater ectosymbionts, which live on the surface of crayfish. The crayfish worms usually do not cause harm to crayfish; however, large infestations may restrict the flow of oxygen rich water within the gills of the crayfish.

Ostracoda Class

Ostracoda is a class of the Order Crustacea and are usually referred to as seed or mussel shrimp. Ostracods are small and range in length from 0.1 to 32 mm in size. Ostracods have five pairs of appendages on their head and 1 to 3 pairs of appendages on the rest of their body. These crustaceans feed mostly on dead organic material and suspended organic particles. Most ostracods crawl on, or burrow in, the sediments along the stream bottom.

Cambaridae Family

Cambarus is the genus of crayfish, which is in the family Cambaridae. *Cambarus* species have ten legs and two chelae (claws). Crayfish are omnivorous meaning they eat both plants and animals. They are scavengers and will eat dead animals, such as worms, insects, salamanders, etc. Crayfish inhabit streams and are usually under rocks or within the banks at the toe of slope. A crayfish size depends on the availability of food, water quality and temperature.

Cordulegastridae Family

Cordulegaster maculata (Twin-spotted spiketail) is in the Cordulegastridae (Spiketails) family. This species has a brown body marked with a double row of pale yellow spots on the abdomen and yellow stripes on the thorax. The spiketail is approximately 7 mm in size and occupies clear freshwater streams.

Corixidae Family

Trichocorixa is the genus for water boatmen, which is in the Corixidae family. The water boatmen have transverse striations on the ventral shot and a clavus that does not extend past a pair of nodal furrows on the sides of the body. This genus mostly occurs in standing water and feed on small invertebrates.

Notonectidae Family

Notonecta is the genus backswimmers and is in the Notonectidae family. Backswimmers have a middle femur with a pointed spine before the distal end and the eyes are widely separated. The species within this genus range from 8 to 16 mm in length. Backswimmers swim upside down and propel themselves by rowing with their hind legs. They are good fliers but are found in slow-moving streams.

Veliidae Family

Microvelia species are the smaller water striders in the Veliidae (Water Striders) family. The small water striders are conical at the front and have granulated eyes. Legs are short and this genus consists of winged and wingless species. The front tarsi have two segments and the hind tarsi have three segments. These species are found in streams and ponds.

Dytiscidae Family

The genus *Hydroporus* includes water beetles in the Dytiscidae family. Water beetles are black and range from about 2 to 40 mm in length. The beetles are adapted to living in water as they rise to the water surface and take in air through their tracheal system. The adults will hibernate in sediment within the channel bottom for a good portion of the year.

Tupulidae Family

Tipula species are crane flies and are within the Tupulidae (Large Crane Flies) family. This genus consists of a wide variety of non-biting flies that have long antennas. The species within this genus range in size from 10 to 25 mm. The crane flies are detritus feeders in which they break down organic matter within streams.

Site Index Score

The upstream and downstream reaches were evaluated based on certain metrics. These metrics are combined to make up a multi-metric index that includes five categories: richness, composition, tolerance/intolerance, functional feeding group, and habit. Each metric is scored on a 100-point scale. A final site index score takes into account the individual scores of each metric. A site index score refers to the stream health rating in which the following percentiles include: above 95 (Very good); 75-95 (Good); 25-75 (Fair); 5-25 (Poor); and below 5 (Very poor). The upstream reach had a site index score of 34 while the downstream reach had a site index score of 22 (Tables 10 and 11). Based on the site index scores, the upstream reach within Webb Bridge Park is considered to have a stream quality that is “fair” while the downstream reach is considered to be “poor” quality.

Table 10. Upstream Reach Index Score

Metrics	Standardized Metric Scores/Index Score/Site Ranking
Coleoptera Taxa	11.36
% Oligochaeta	92.82
% Plecoptera	0.00
Shredder Taxa	0.00
Scraper Taxa	0.00
Swimmer Taxa	100.00
Site Index Score	34

Table 11. Downstream Reach Index Score

Metrics	Standardized Metric Scores/Index Score/Site Ranking
Coleoptera Taxa	11.36
% Oligochaeta	87.53
% Plecoptera	0.00
Shredder Taxa	9.09
Scraper Taxa	0.00
Swimmer Taxa	26.32
Site Index Score	22

Conclusions of Benthic Macroinvertebrate Assessment

The benthic macroinvertebrate assessment was conducted in order to determine if pollution or habitat loss has caused the stream system to become impaired. Changes over time in hydrology, land cover, and impervious surfaces alter the physical and chemical environments within streams. These changes can degrade the macroinvertebrate assemblages. Bank erosion, resulting from increased runoff within the watershed, will have a profound effect on ecological communities within streams as the organisms are forced to adapt to more frequent high flows and a decrease in habitat. Pollutants from fertilizers, oils and grease will bind to sediments within the streambed and can greatly impact the organisms within urban streams.

Different macroinvertebrates will occupy different ecological niches within an aquatic environment; therefore, a diverse array of macroinvertebrates that inhabit a stream implies that the stream system is a healthy and balanced ecosystem. The absence of sensitive species, such as stoneflies, indicates that there are excessive pollutants being discharged into the stream, water temperatures are too high, dissolved oxygen is too low, or habitat degradation along the streambed has destroyed the sheltering areas. **The macroinvertebrate population found within the downstream reach suggests that, over time, there has been a change in physical and chemical environments within the stream that has resulted in poor overall stream quality. The upstream reach data suggests that there has been a slight change in the**

physical and chemicals environments within the stream; the stream quality in this reach is categorized as fair.

This stream is considered an urban stream, classified by a developed watershed and physical activities (ie. fertilizing) that have contributed to the change in both the physical and chemical environments within the stream channel. The build-out of land use, reduction of natural and forested areas, and the overall increase of impervious area have contributed to stream bank erosion, which has lead to a decrease in ideal physical environments for macroinvertebrates. Further, the chemical environment within the stream has been altered by the increase in stormwater runoff from the surrounding subdivisions.

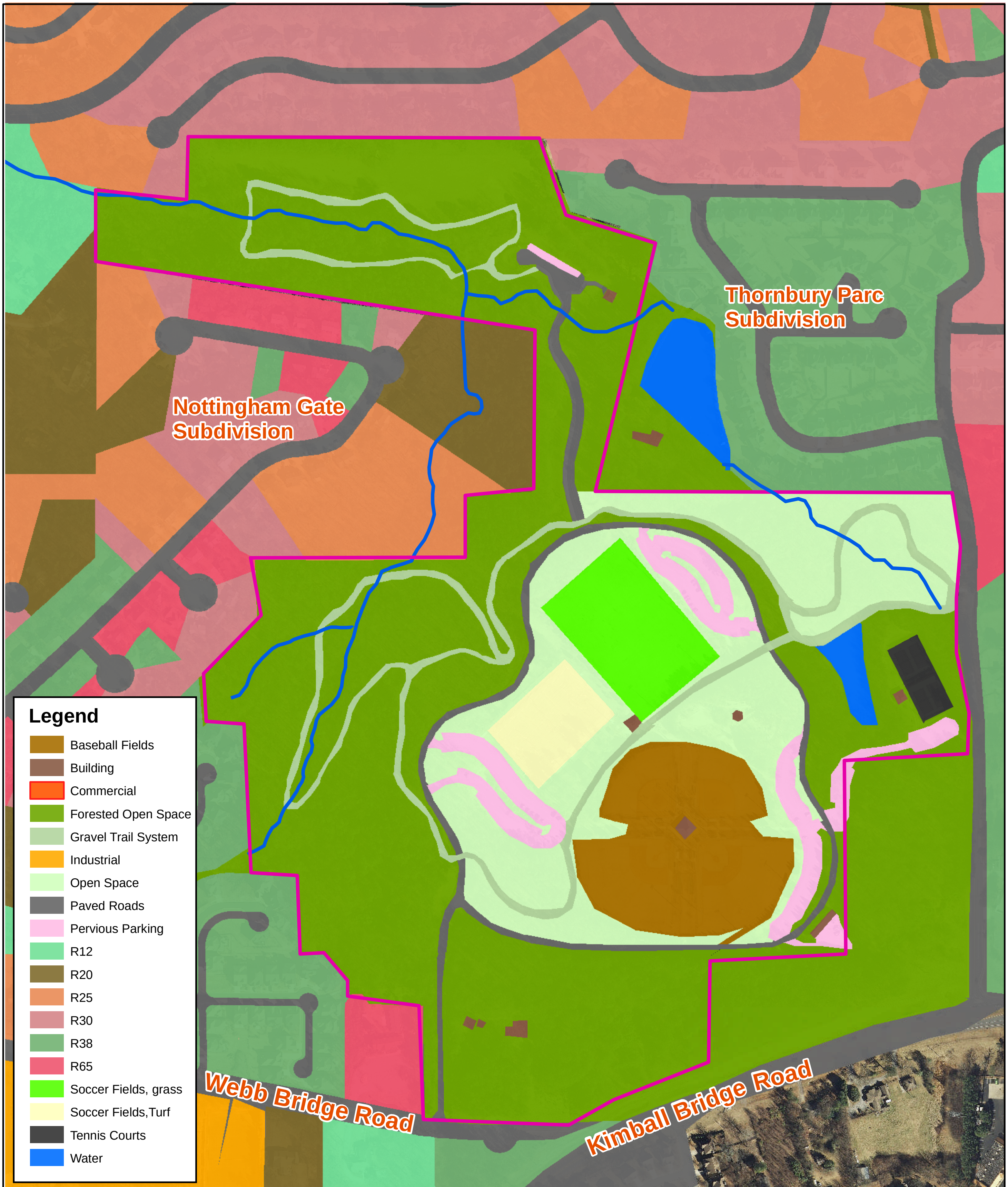
HYDROLOGIC AND HYDRAULIC MODELING

The City of Alpharetta provided Manhard with the existing hydrologic and hydraulic models. As a part of the Alpharetta's citywide flood study update, a comprehensive hydrologic and hydraulic analysis was recently completed in 2011. The hydrologic analysis included the determination of peak flows resulting from a hypothetical 100-year 24-hour storm event for all drainage basins with a contributory area of 100 acres or more. These calculated peak flows were then incorporated into a hydraulic model, which simulated the flood levels and floodplain extents that would occur along a given stream following the storm event. The USACE's HEC-HMS version 3.4 and HEC-RAS version 4.1 models were utilized for the hydrologic and hydraulic analyses, respectively. ESRI's ArcMap GIS software platform was used throughout this study to support all modeling and digitally-based analysis.

Hydrologic Analysis

Manhard reviewed the HEC-HMS hydrologic model and the City's existing conditions land use layer in ArcGIS. Based on discussions with City staff, no further development is anticipated within the park's contributory watershed (with the exception of resurfacing the parking areas and the potential installation of artificial turf on the north soccer field). We digitally modified the land use layer based on current aerial photography to include enhanced representative detail of the existing land cover within the park's watershed. For the purposes of this study, the parking areas that are currently covered in pervious pavement were assumed to be impervious in nature, as City staff have indicated that the pavement has not performed as anticipated with regards to runoff infiltration and will likely be resurfaced in the future. Refer to Figure 6: "Land Use Map".

Utilizing both the City's 2010 2-foot interval topography and current the stormwater infrastructure data, the model sub-basins were modified from the existing coverage to include additional detail on the park property. Refer to Figure 7: "HEC-HMS Connectivity". There are approximately 178 acres of contributory area at the confluence of the park's two primary drainage basins.



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Webb Bridge Park Drainage Study
Figure 6: Land Use Map

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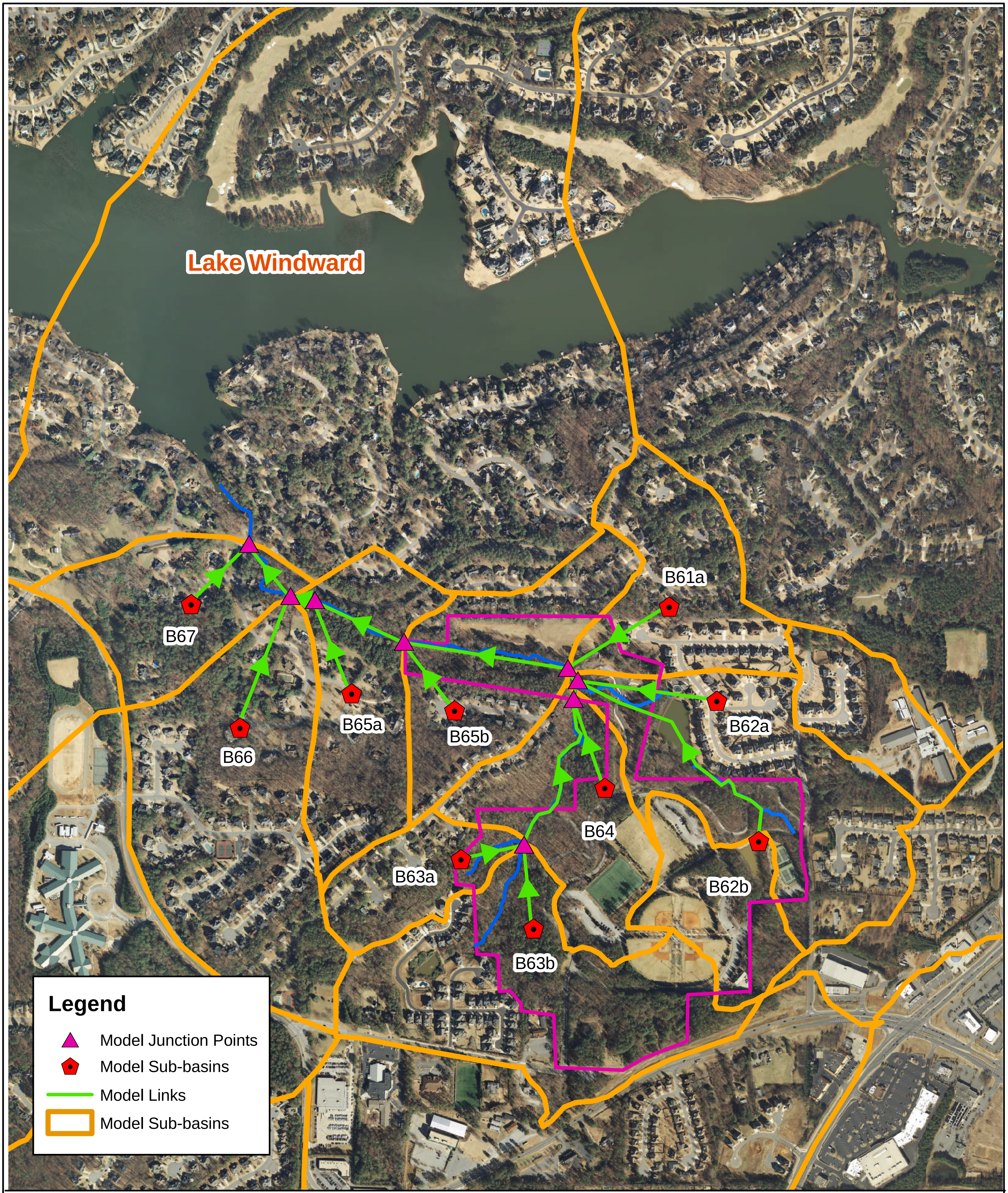

Webb Bridge Park Drainage Study
Figure 7: HEC-HMS Connectivity Diagram

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After sub-basins were delineated, weighted runoff curve numbers were calculated for each basin to represent “existing” and “future” conditions within the park. A curve number represents the surface runoff potential within a sub-basin. As mentioned previously, there is no further development planned within the park’s watershed; accordingly, existing and future landuse were considered to be one in the same. Sub-basin boundaries, soils data and landuse are all required to properly calculate curve numbers. A digital version of the Natural Resources Conservation Service (NRCS) Soil Survey, “SSURGO,” was used for this determination. The Survey includes information regarding each soil type’s hydrologic soil group (HSG), which is a measure of the rate at which water enters the soil surface and the rate at which it transmits through the soil. The majority of the soils at Webb Bridge Park are classified as “B” soils, with a small amount of “D” soils present along the stream beds. While “B” soils are generally well-draining soils, “D” soils have a permanently high water table and high swelling potential.

Lastly, lag times were calculated for the sub-basins. A lag time is defined as the time elapsed between the center of mass rainfall excess to the center of mass of the resulting runoff hydrograph. The lag time is computed as 0.6 multiplied by the time of concentration. The time of concentration represents the travel time required for stormwater runoff to travel through a basin, from the most hydraulically remote location to the point of discharge. Lag times were calculated for all project sub-basins. Table 12 illustrates the sub-basin parameters.

Table 12. Sub-basin Parameters

Sub-basin	Area (acres)	Curve Number	Lag Time (min)
B61a	31.5	75	13.3
B62a	52.1	78	13.3
B62b	20.5	73	7.9
B63a	16.3	75	8.7
B63b	58.6	71	25.6
B64	31.2	71	8.5
B65a	31.3	74	7.9
B65b	33.7	74	8.7
B66	63.9	72	21.0
B67	25.6	70	14.0

The HEC-HMS model simulations were run and the resultant peak flows determined for the 1- through 500-year 24-hour storm events. Refer to Table 13 for the model results.

Table 13: HEC-HMS Model Results, Peak Flows (cfs)

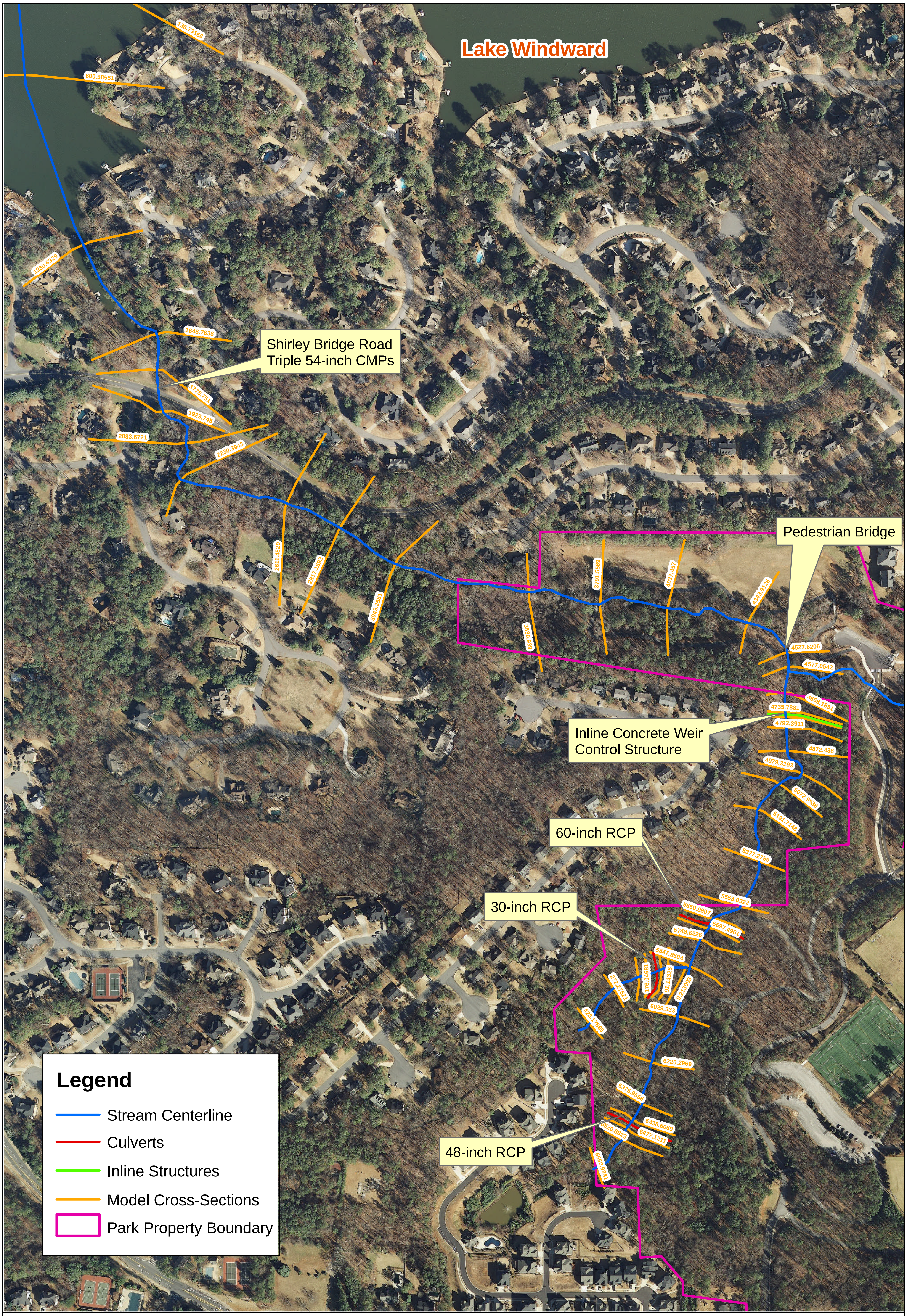
Modeled Sub-basin	1-year storm	2-year storm	5-year storm	10-year storm	25-year storm	50-year storm	100-year storm	500-year storm
B61a	39.8	58.3	77.9	98.3	126.4	147.9	169.5	223.0
B62a	77.5	109.9	143.8	178.8	226.3	262.3	298.6	387.5
B62b	29.4	43.8	59.2	75.2	97.4	114.5	131.8	174.5
B63a	25.2	36.6	48.8	61.5	78.9	92.1	105.5	138.4
B63b	37.3	58.3	81.2	105.5	139.3	165.6	192.4	259.1
B64	38.3	58.6	80.6	103.8	136.1	161.0	186.2	248.9
B65a	47.6	70.1	93.9	118.7	153.0	179.2	205.7	271.2
B65b	49.4	72.7	97.5	123.5	159.3	186.6	214.2	282.3
B66	50.2	77.0	106.1	136.8	179.4	212.2	245.5	328.8
B67	22.7	35.8	49.9	65.0	86.1	102.4	119.0	160.5

Hydraulic Analysis

The City had an existing HEC-RAS model that extended up through the park for approximately 1,300 feet, along the unnamed tributary of Lake Windward, and continued upstream for another 800 feet off of the park property. Manhard augmented this model with additional stream cross-section and structure data obtained from both field survey and digital topographic data. The new model was extended up to the edge of the park property along the tributary's mainstem and through a ditch that connects to the mainstem from the west. Refer to Figure 8, "HEC-RAS Model Extents".

Peak flows from the HEC-HMS hydrologic model were incorporated into the HEC-RAS model and plan simulations were run for the 1- through 500-year, 24-hour storm events. These simulations provide estimated water surface elevations and channel velocities along the modeled streams for each storm event.

Review of the model results indicate a general consensus with observations made in the field. Along the reaches that have the most severe bank erosion, the larger storm event simulations result in water surface elevations contained within the channel banks. This indicates that the stream channel is no longer connected to the floodplain in these locations. These reaches have downcut and are now actively widening. The sections that have experienced the most severe erosion are located on private property. Refer to Appendix B for summary tables and graphical cross-section representations of the model results.



Manhard CONSULTING LTD

Webb Bridge Park Drainage Study
Figure 8: HEC-RAS Model Extents

III. RECOMMENDATIONS

This section includes specific projects, activities and staff training recommended for Webb Bridge Park. Recommended projects include concepts intended to treat, repair, eliminate and prohibit stormwater-related issues in – and downstream of - the park. These issues include existing stream and slope erosion, sediment aggradation in the park's ditches and pond, and water quality concerns related to nutrient concentrations.

For certain projects, recommendations will be made on the phasing and scheduling of the project's implementation. For instance, projects that incorporate live plants should be constructed during specific times of year for the highest growth success rates to be achieved. Projects that incorporate chemical treatments or live animals also have ideal timeframes during the calendar year.

Many of the projects are considered "stand-alone" efforts that can be successfully implemented independently of other projects. Alternatively, this section will also include recommendations regarding projects that could provide the most benefit when constructed in conjunction with each other.

The projects are organized and presented in prioritized **"tiers"**:

- **Tier 1 projects** are considered to be the highest priority based on their relatively low cost, high need/benefit, or a combination of the two.

- **Tier 2 projects** are those that are recommended for implementation at some point within the next ten years, but are not currently considered to be a high priority.

- **Tier 3 projects** include those that would provide some benefit but are considered to be low priority due to their high cost and low need.

Some projects include multiple options: A project may have one option selected as Tier 1 and another option as Tier 2, based on variances in cost for proposed solutions. For the sake of thoroughness and at the request of the City, we have included all practicable recommendations for projects, including some Tier 3 projects that may be cost-prohibitive under current budgetary constraints.

The difference between options could be the type of treatment to be used (e.g. varying materials); the staffing for the project labor (vendor staff versus City staff); or the level of treatment provided for a given problem area. Each project option includes approximate implementation costs. These costs are estimates, intended to provide the City with a price range, and are not to be considered firm design or construction costs.

Prior to discussing the specific projects, a few general recommendations for Webb Bridge Park are mentioned below.

GENERAL RECOMMENDATIONS

- The City is considering resurfacing the upper soccer field with artificial turf. Prior to doing so, a drainage study should be conducted in order to ensure no problems associated with additional stormwater runoff are created downstream.
- It is recommended that the Thornbury Parc subdivision consider implementing the options presented in Project 12 for the Thornbury Parc pond to facilitate the elimination of algae and organic matter within the water body.
- It is recommended that the City conduct training and maintenance education for the park staff prior to the implementation of projects that involve new plantings in or around streams and ditches. This training is intended to inform staff on what plants should, and should not, be manicured/clipped/mowed.
- Sand and sediment removed from ditches, streams, and ponds in the park should be placed in designated locations outside the original drainage area, thereby eliminating the threat of re-entry into the park's waterways and drainage system.

PROJECT RECOMMENDATIONS

Table 14 presents the prioritized project options by tier. Specific discussion, elements and details of each project follow and project concept sheets can be located in Appendix C. Figure 9, “Project Locations”, illustrates the recommended project locations.

Table 14: Prioritized Project Options

TIER 1			
Project ID	Description	Option	Cost
1	Erosion Control	1, 2, or 3**	$1,700 - $2,600
3	Erosion Control	1	$1,200
4	Erosion Control	1	$1,500
5	Infrastructure Repair	1 or 2**	$1,400 - $1,800
6	Stream Restoration	1	$160,000
9	Parking Lot Paving	3	$55,000
10	Stormwater BMP	1	$54,000
11	Erosion Control	1	$1,100

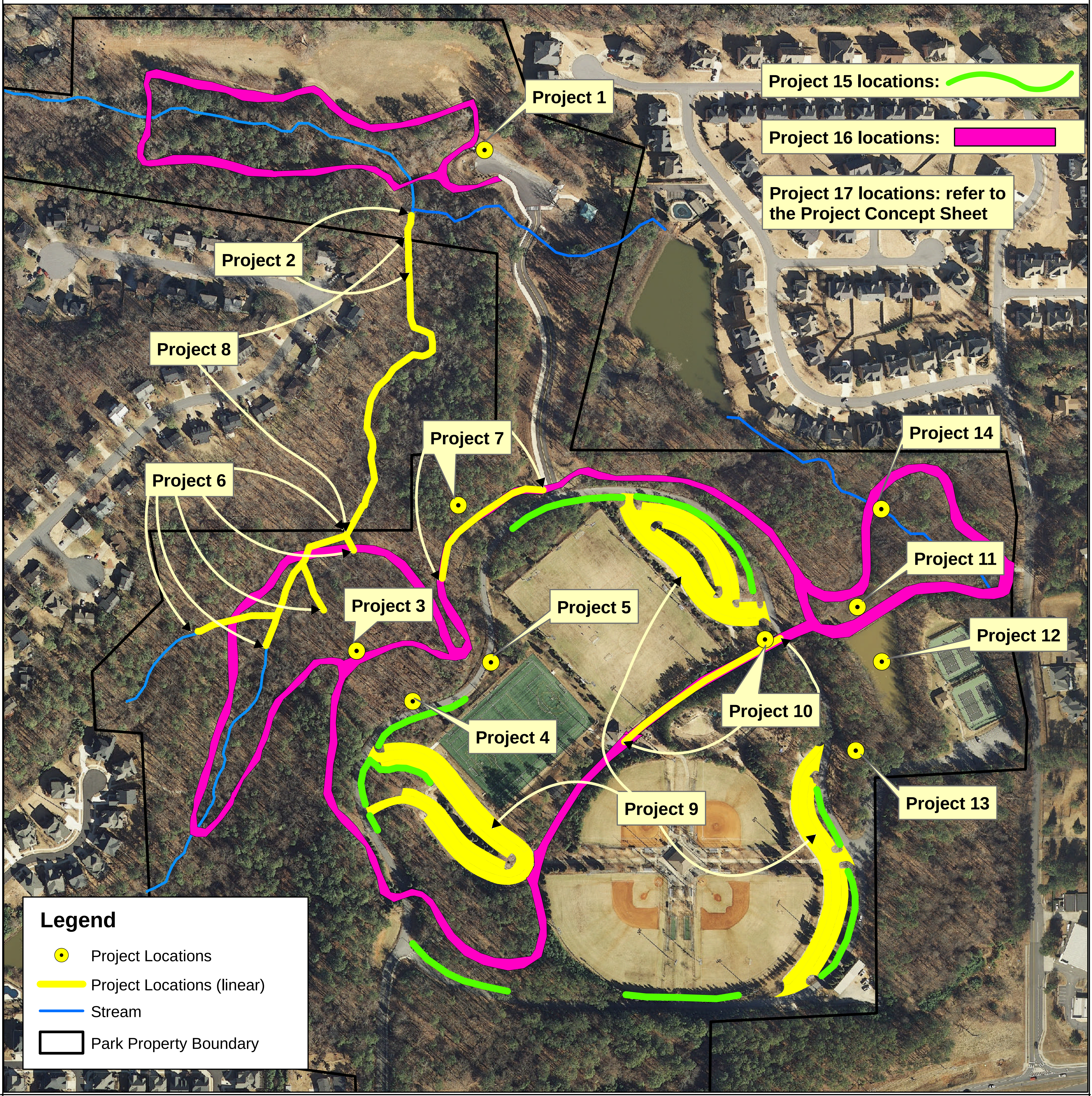
TIER 1 (continued)			
Project ID	Description	Option	Cost
12	Algae Reduction	1, 2	$500 - $1,200
14	Erosion Control	1	$1,700
15	Erosion Control	1	$180,000
17	Water Quality Sampling	2	$14,000
TIER 2			
Project ID	Description	Option	Cost
2	Stream Restoration	1	$130,000
6	Stream Restoration	2 or 3	$78,000 - $360,000
7	Stormwater BMP	1	$7,000
13	Stormwater BMP	1	$120,000
15	Erosion Control	2	$146,000
16	Trail Resurface	3	$200,000
17	Water Quality Sampling	1	$40,000
TIER 3			
Project ID	Description	Option	Cost
7	Stormwater BMP	2 or 3**	$64,000 - $80,000
8	Stream Restoration	1	$450,000
9	Parking Lot Paving	1 or 2**	$630,000-$830,000
10	Stormwater BMP	2 or 3**	$160,000-$190,000
15	Erosion Control	3 or 4**	$120,000-$260,000
16	Trail Resurface	1 or 2**	$1,700,000-$2,300,000

**Only one option necessary

Tier 1 Projects			
Project ID	**Description**	**Option**	**Cost**
1	Erosion Control	1, 2, or 3**	$1,700 - $2,600
3	Erosion Control	1	$1,200
4	Erosion Control	1	$1,500
5	Infrastructure Repair	1 or 2**	$1,400 - $1,800
6	Stream Restoration	1	$160,000
9	Parking Lot Paving	3	$55,000
10	Stormwater BMP	1	$54,000
11	Erosion Control	1	$1,100
12	Algae Reduction	1, 2	$500 - $1,200
14	Erosion Control	1	$1,700
15	Erosion Control	1	$180,000
17	Water Quality Sampling	2	$14,000

Tier 2 Projects			
Project ID	**Description**	**Option**	**Cost**
2	Stream Restoration	1	$130,000
6	Stream Restoration	2 or 3	$78,000 - $360,000
7	Stormwater BMP	1	$7,000
13	Stormwater BMP	1	$120,000
15	Erosion Control	2	$146,000
16	Trail Resurface	3	$200,000
17	Water Quality Sampling	1	$40,000

Tier 3 Projects			
Project ID	**Description**	**Option**	**Cost**
7	Stormwater BMP	2 or 3**	$64,000 - $80,000
8	Stream Restoration	1	$450,000
9	Parking Lot Paving	1 or 2**	$630,000-$830,000
10	Stormwater BMP	2 or 3**	$160,000-$190,000
15	Erosion Control	3 or 4**	$120,000-$260,000
16	Trail Resurface	1 or 2**	$1,700,000-$2,300,000



Webb Bridge Park Drainage Study
Figure 9: Project Locations

N W E S

-No Scale-

Project Concept No. 1

Existing Conditions

Runoff from north side of parking lot is discharged directly onto bare soil, which has led to the formation of rills and localized erosion.

Project Concept Description

This project involves the incorporation of a level spreader feature along the edge of pavement and the establishment of vegetation on the downstream earthen slope. By definition, a level spreader is a "storm flow outlet device constructed at zero grade across the slope whereby concentrated runoff may be discharged at non-erosive velocities onto undisturbed areas stabilized by vegetation". The purpose of the spreader is to dissipate the concentration and velocities of stormwater runoff by converting it into sheet flow, ultimately discharging the water onto areas stabilized by vegetation. An established vegetative cover on the areas below a level spreader is critical for maximizing pollutant removal efficiency and erosion prevention.

There are various types of level spreaders and their associated costs vary. Concrete, perforated pipes, earthen berms, as well as proprietary products that facilitate both infiltration and energy dissipation, are different types of materials that can serve effectively as level spreaders. The type of material chosen should be dictated on a case-by-case basis, depending on the application, site, and costs.

Project Costs

Option 1: This option includes the use of a non-erodible, highly pervious pavement as the level spreader and the placement of sod on the earthen slope. The vendor will provide staff to install the level spreader.

Approximate cost – $2,500

Option 2: This option includes the use of more traditional materials for the level spreader and the placement of sod on the earthen slope.

Approximate cost - $1,800

Option 3: Similar to Option 1, this option includes the use of a non-erodible, highly pervious pavement as the level spreader and the placement of sod on the earthen slope. In comparison to Option 1, this option uses City staff to install the level spreader.

Approximate cost – $2,600

Project Concept No. 2

Existing Conditions

The stream reach from the online concrete detention weir to the confluence of an unnamed tributary of Lake Windward and unnamed tributary of Thornbury Pond is downcutting and the banks are eroding in areas. A scour hole exists just downstream of the online detention weir structure. The metal trash rack (located on the property line) is no longer effective, as it is approximately five feet above the top of banks.

Project Concept Description

The concept plan for this reach includes restoring approximately 140 linear feet of channel. A stable cross-section will be created from the online concrete detention weir structure to the confluence of the unnamed tributary of Thornbury Pond. The metal trash rack should be removed, as it is no longer effectively preventing trash from flowing downstream. A rock cross vane, or equivalent structure with similar performance, should be constructed just downstream of the online detention weir structure to provide grade control within the channel.

Project Costs

Option 1: This option includes geomorphic assessment, pre-construction monitoring, permitting, easement coordination, design, and construction. Construction costs on stream restoration projects can vary greatly depending on the contractor.

Approximate cost – $130,000

Project Concept No. 3

Existing Conditions

Localized ditch erosion has occurred downstream of an 18-inch HDPE pipe located under the gravel trail system.

Project Concept Description

Approximately 14 square yards of Type 3 riprap should be placed at the pipe outfall to provide erosion control for the affected area. A synthetic filter fabric should be installed between the riprap and soil foundation.

Project Costs

Option 1: Approximate cost – $1,200

Project Concept No. 4

Existing Conditions

Localized ditch erosion has occurred downstream of a 24-inch reinforced concrete pipe (RCP) located under Webb Bridge Park Road.

Project Concept Description

Approximately 20 square yards of Type 3 riprap should be placed at pipe outfall to provide erosion control for the affected area. A synthetic filter fabric should be installed between the riprap and soil foundation.

Project Costs

Option 1: Approximate cost – $1,500

Project Concept No. 5

Existing Conditions

A concrete manhole lid has shifted from its original setting, creating an appearance of instability.

Project Concept Description

The manhole structure needs to be checked by City staff, and repaired as necessary, using the existing lid or a new lid (if warranted).

Project Costs

Option 1: This option involves the resetting of the existing lid.

Approximate cost – $1,400

Option 2: This option involves the replacement of the concrete manhole lid.

Approximate cost - $1,800

Project Concept No. 6

Existing Conditions

The total project includes three ephemeral streams (Reach 1 -3) that flow into the unnamed tributary of Lake Windward (Reach 4). Reach 1 is downcutting, causing large amounts of bank erosion within this channel downstream of the culvert. The severe bank erosion is undermining the culvert and trail. Ultimately, if this reach is not restored the trail will likely collapse. Upstream of the culvert, bank erosion has occurred and large woody debris is present within the channel. Reaches 2 and 3 have steep slopes and are downcutting. Reach 4 is a perennial stream that is downcutting, and bank erosion is occurring both upstream and downstream of the culvert. The culvert within the perennial stream is poorly aligned, causing bank erosion immediately upstream and downstream of the culvert.

Project Concept Description

All four reaches will need to be restored to fully stabilize the entire stream system in the project scope. If all four reaches are not restored concurrently, then Reaches 1-3 should be restored prior to restoring Reach 4. The concept plan for Reach 1 consists of removing the debris from the channel and constructing a rock step-pool system upstream of the culvert. Downstream of the culvert the channel should be raised to the invert of the culvert and a step-pool system should be constructed to provide a stepped longitudinal profile from the invert of the culvert to the confluence with the perennial stream. Reaches 2 and 3 should have rock step-pool systems constructed to provide a stepped longitudinal profile to the confluence with the perennial stream. Reach 4 will consist of bank shaping to provide a stable cross-section of the channel, in-stream structures (j-hooks or log vanes) to turn the water away from certain bends, grade control structures (cross-vanes) to prevent downcutting, and geolifts with bentonite and live stakes along the left bank immediately downstream of the culvert.

Recommendations on Construction Phasing

- Restoration of the tributaries (Reaches 1 – 3) should be performed prior to restoration of the mainstem (Reach 4);
- Should Option 3 be implemented, construction should ideally take place during the time of year when the trail system is least used;
- Should Options 2 and 3 both be implemented, Options 3 should be constructed before, or concurrent with, Option 2

Project Costs

Option 1: This option includes the completion of stream restoration along the tributaries (Reaches 1-3) only, totaling approximately 320 feet in length. A geomorphic assessment, pre-construction monitoring, permitting, design, and construction are included in the cost. Construction costs on stream restoration projects can vary greatly depending on the contractor.

Approximate cost – $160,000

Option 2: This option includes the completion of stream restoration along the mainstem and tributaries (Reaches 1-4), totaling approximately 715 feet in length. A geomorphic assessment, pre-construction monitoring, permitting, design, and construction are included in the cost. Construction costs on stream restoration projects can vary greatly depending on the contractor.

Approximate cost - $360,000

Option 3: This option includes a stand-alone cost for the replacement and realignment of the existing 60-inch reinforced concrete pipe located under the trail along the mainstem (Reach 4). For the sake of pricing, the assumption was made that a new section of pipe will be required and that the new pipe will need to be approximately 80 feet in length. Permitting, design, and construction are included in the cost.

Approximate cost - $78,000

Project Concept No. 7

Existing Conditions

A resident within the Nottingham Gate subdivision, whose property is located downslope from the park, has logged a complaint with the City regarding stormwater-related erosion. The issue was specific to rills and small gullies that have formed over time on the steep earthen slope on the north side of the trail.

Project Concept Description

This project would potentially involve two different activities. The first activity is the incorporation of structures that will provide energy dissipation at two locations where rills have formed on the earthen slope. A variety of materials can be used to serve this function; proper installation will be critical to the structures functioning successfully. The intent of these structures is to reduce both flow velocity and flow concentration on the earthen slope, to ultimately reduce future erosion potential. The second activity involves resurfacing a 740 square yard section of trail with a non-erodible highly porous pervious pavement, which will serve to infiltrate stormwater runoff along the trail and remove the future need for gravel maintenance. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products.

Recommendations on Construction Phasing

The implementation of Option 1 is not dependant on the construction of Options 2 or 3. Proper installation of Option 1 could potentially provide relatively more overall benefit for the respective cost than Options 2 and 3.

Project Costs

Option 1: This option involves the design and installation of structures that will provide energy dissipation along the earthen slope.

Approximate cost – $7,000

Option 2: This option combines Option 1 with the resurfacing a 740 square yard section of trail with a non-erodible highly porous pervious pavement. The vendor will provide staff to resurface the trail.

Approximate cost - $80,000

Option 3: Similar to Option 2, this option combines Option 1 with the resurfacing a 740 square yard section of trail with a non-erodible highly porous pervious pavement. In comparison to Option 2, this option uses City staff to resurface the trail.

Approximate cost - $64,000

Project Concept No. 8

Existing Conditions

This stream reach has experienced a large amount of bank erosion which has occurred over a period of time. The stream has downcut and is now actively widening. Furthermore, the stream channel is no longer connected to the floodplain. Benthic macroinvertebrate sampling conducted as a part of this drainage study determined there is not a wide variety of organisms occupying this reach. The macroinvertebrate population found suggests that over time there have been changes in the physical and chemical environments within the stream resulting in poor overall stream quality.

Project Concept Description

This project is located entirely on private property and covers a total of 8 parcels. The concept plan for this reach involves the design of a stable channel cross-section, with bankfull benches, that will be reconnected to the floodplain. In areas where the channel has a steep slope, a stepped longitudinal profile would be constructed by incorporation of a step-pool system. Riffle-pool sequences will be constructed within this reach, along with in-stream structures (j-hooks, cross vanes and rock vanes), to guide water away from the channel bends and to provide vertical grade control.

Project Costs

Option 1: This option includes geomorphic assessment, pre-construction monitoring, permitting, design, and construction. Construction costs on stream restoration projects can vary greatly depending on the contractor.

Approximate cost – $450,000

Project Concept No. 9

Existing Conditions

Three parking lots within the park were originally constructed with the intent of incorporating pervious pavement. Over the years, the pavement has not infiltrated runoff as designed and essentially performs as traditional impervious pavement. Additionally, the gravel on the top layers has loosened, ultimately contributing to the solids loading in the park's streams and wet pond.

Project Concept Description

The City has indicated a desire to pave the parking lots with traditional pavement at some point in the future. This project includes three options for repaving the lots. The first involves repaving only the parking space areas with a non-erodible, highly-porous pervious pavement, which will serve to infiltrate stormwater runoff and eliminate future gravel runoff from those areas. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products. The second option involves paving the same areas (only the parking spaces) as the first option, with the City staff performing the labor. The third option involves paving all three lots, in their entirety, with traditional asphalt pavement.

Project Costs

Option 1: This option involves repaving only the parking space areas with a non-erodible highly porous pervious pavement. The vendor will provide staff to resurface the lots.

Approximate cost – $830,000

Option 2: Similar to Option 1, this option includes repaving only the parking space areas with a non-erodible, highly porous pervious pavement. In comparison to Option 1, this option uses City staff to install the pavement.

Approximate cost - $630,000

Option 3: This option involves paving all three lots, in their entirety, with traditional asphalt pavement.

Approximate cost - $55,000

Project Concept No. 10

Existing Conditions

During the months of May through September, a well pump located at the northwest corner of the park pond is run daily and pumps water up to a small rock channel in the playground area. This channel discharges the water into a pipe system, then a short ditched system, and ultimately routes the water back to the pond. The playground includes a large sandbox area that the City replenishes every spring with approximately 18 tons of sand. Given the proximity of the sandbox to the rock channel, children routinely place sand in the channel. When the pump is running or a rain event occurs, this sand is conveyed into the downstream drainage system. The City has dredged the park pond, which was built during original park construction, once in the past fourteen years in spring 2011.

Project Concept Description

The sand loading from the playground area contributes to the reduction of storage volume in the pond. City staff would like a project solution that will reduce the need to dredge the pond in the future. This project includes two "constructed" activities and an ongoing maintenance component. The first of the constructed activities is the primary recommended solution for this project. This involves the design and construction of a permanent sediment basin, located within the ditch downstream of the playground. This open basin would serve to provide additional capacity to collect and store sand, prior to its discharge into the pond. *In order for this solution to be successful, it is critical that park staff continue to clean out this ditch system on a regular basis.* The second component to this project involves resurfacing a 1366-square yard section of trail with a non-erodible, highly porous pervious pavement, which will serve to infiltrate stormwater runoff along the trail and remove the future need for gravel maintenance. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications, and available product test results prior to the use of any pervious pavement products.

Project Costs

Option 1: This option involves the design and construction of a permanent sediment basin within the ditch downstream of the playground. A labor estimate for one year of ditch and basin maintenance is included in the cost.

Approximate cost – $54,000

Option 2: This option combines Option 1 with resurfacing a 1366 square yard section of trail with a non-erodible, highly porous pervious pavement. The vendor will provide staff to resurface the trail. Additionally, a labor estimate for one year of ditch and basin maintenance is included in the cost.

Approximate cost - $190,000

Option 3: This option is identical to Option 2, with the exception that City staff will be utilized to install the pavement on the trail.

Approximate cost - $160,000

Project Concept No. 11

Existing Conditions

A portion of the pond's dam embankment is bare of vegetation.

Project Concept Description

It is recommended that City staff replace the sod in areas that have become bare of vegetation. A good vegetative cover on the dam will reduce future erosion on the embankment and encourage better infiltration of stormwater runoff.

Project Costs

Option 1: Approximate cost – $1,100

Project Concept No. 12

Existing Conditions

Large algal blooms were observed in the park's pond during the site visits conducted over the summer months, which indicates that excessive pollutants were entering the pond. Sampling conducted in October and November 2011 indicated the majority of the incoming nutrients were accumulating within the pond, contributing to the algae. Other degradation indicators observed within the pond included turbid water and sedimentation. The turbidity results from sediments introduced by stormwater runoff and other particles suspended within the water. A nutrient-balanced pond ecosystem does not have a significant portion of the surface covered with algal mats.

Project Concept Description

This project involves two components that can be implemented together or as stand-alone options. The first component is the addition of Triploid Grass Carp to the pond. The carp, when incorporated into a waterbody at a population large enough to keep the fish 'hungry', will consume both surface algae and organic matter along the pond bottom. The recommended quantity of fish is based on pond surface area and vegetative cover. A rule of thumb often used is to determine the amount of fish via the area and cover formula, then add double that amount to the waterbody. Six carp, ranging 8 to 10 inches in length, are recommended here.

The second component of this project involves the addition of a non-toxic algaecide, Phycomycin. This is a granular product that works to eliminate existing algae, as well as prevent the formation of new algal blooms. Initial treatment should occur in the spring/early summer and maintenance treatments can take place every 2 - 4 weeks, as necessary. Phycomycin is EPA approved, works quickly, and is entirely non-toxic. Product information is included in Appendix D.

Recommendations on Project Phasing

This project involves 2 options, which can be implemented together or independently. We recommend that both options be implemented together for the highest probability of success. This initial treatment should be done during the spring or early summer months, ideally as the water temperature warms to 60 degrees Fahrenheit or above.

Project Costs

Option 1: This option involves the addition of six Triploid Grass Carp, ranging 8 to 10 inches in length, to the pond.

Approximate cost – $600

Option 2: This option involves the addition of a non-toxic algaecide, Phycomycin, to the pond. The pricing for two 50-pound bags is included in the cost.

Approximate cost - $520

Project Concept No. 13

Existing Conditions

Large algal blooms were observed in the park’s pond during the site visits conducted over the summer months, which indicates that excessive pollutants were entering the pond. Sampling conducted in October and November 2011 indicated the majority of the incoming nutrients were accumulating within the pond, contributing to the algal blooms. Algae can result from a combination of factors - unfiltered stagnant water, unbalanced oxygen levels from excessive nitrates and phosphates, sunlight, and humid weather being some of the common contributors.

Project Concept Description

The project would involve the design of a constructed wetland BMP that would incorporate different habitats and a wide array of plant species. The wetland would have a forested buffer, emergent and scrub-shrub areas, low flow channels, and pool zones. Additionally, the wetland would be hydrologically connected to the park's wet pond (i.e. the stormwater would flow through the wetland prior to reaching the pond.) The design will encourage nutrients and sediments to accumulate within the wetland vegetation, which is intended to absorb the nutrients prior to entering the pond. A variety of native herbaceous species, particularly evergreen species, would be planted to take up the excessive incoming nutrients year round.

Recommendations on Project Phasing

Prior to authorizing this project, it is recommended that the City conduct further water quality sampling at locations upstream of the wet pond, as presented in Project 17, Option 2.

Should the results of the sampling indicate that excessive nutrients are exiting the pond, this data can be used to determine the design specifications of a constructed wetland that would filter out pollutants/nutrients prior to entering the wet pond.

Project Costs

Option 1: This option includes permitting, design and construction. Construction costs on constructed wetland projects can vary greatly depending on the contractor.

Approximate cost – $120,000

Project Concept No. 14

Existing Conditions

Localized scour has occurred upstream of a culvert, located under the gravel trail system.

Project Concept Description

Approximately 22 square yards of Type 3 riprap should be placed just upstream of culvert inlet, to provide erosion control for the affected area. A synthetic filter fabric should be installed between the riprap and soil foundation.

Project Costs

Option 1: Approximate cost – $1,700

Project Concept No. 15

Existing Conditions

Park staff is tasked monthly with debris and sediment removal from roadside ditches that become obstructed following rain events. Along certain ditch sections lined only with bare clay, soil erosion is an ongoing problem.

Project Concept Description

Four different options are provided to address the erosion along the park's ditches. For the sake of overall comparison, the costs in Table 14, "Prioritized Project Options", are provided as a lump sum for the entire 2,350 linear feet of ditches determined to require some level of repair. Furthermore, some of these ditch sections show indication of only minor erosion while others are in more immediate need of stabilization.

The four options developed for the ditch improvements are: Option 1 – Install Type 3 riprap along the 2,350 feet of ditches; Option 2 – Install RootCarpet™, a biodegradable coconut fiber vegetated with specifically selected plant species; Option 3 - Line the ditches with a non-erodible highly porous pervious pavement; and Option 4 – Replace the open ditch system with HDPE or RCP piping.

Many of the park's ditches contain healthy, mature trees that would present a challenge for any mass-grading effort; therefore we highly recommend that a thorough field assessment be conducted prior to commencing design on any of these options. To reiterate, the options are presented and priced in order to provide an overall comparison for the City.

Following is further information on project Options 2 and 3: **Option 2** - Appendix E contains basic specification, application and contact data for RootCarpet™. The recommended plants should include dry-to-mesic species, which can survive without a constant source of water. Upon installation, it is estimated that the plants will need to be watered regularly for 2 to 4 weeks. Should this option be implemented, it is recommended that on-site training be conducted to educate park staff on this application and the plants, as the ditches should not be mowed following installation of the RootCarpet™. **Options 3** – The pervious pavement recommended for this application must be highly porous. This option not only includes the lining of the ditches but also the installation of small in-ditch check dams (formed out of the pavement material) to provide clean-out areas upstream of pipe inlets. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products.

Recommendations on Construction Phasing

- For Option 2 the recommended plants are intended to be "self-maintaining", but will require the park staff to keep them well hydrated for the first 2 - 4 weeks following installation. Installation should ideally take place in the early spring or fall.

Project Costs

Option 1: This option includes 2,350 linear feet of riprap, assuming a 10-foot wide ditch section. A synthetic filter fabric should be installed between the riprap and soil foundation.

Approximate cost - $180,000

Option 2: This option includes the installation of 2,350 linear feet of RootCarpet™. Pricing includes the coconut fiber material, the plant plugs, installation costs and labor for the initial watering of the plants.

Approximate cost - $146,000

Option 3 – This option includes the installation of a non-erodible, highly pervious pavement along 2,350 linear feet of ditches, assuming a 10-foot wide ditch section. The vendor will provide staff for the installation.

Approximate cost - $260,000

Option 4 – This option includes the replacement of 2,350 linear feet of open ditches with either HDPE or RCP piping. Pipe sections, fittings, headwalls, fill dirt and labor are included in the cost estimate.

Approximate cost - $120,000 (HDPE option), $190,000 (RCP option)

Project Concept No. 16

Existing Conditions

An extensive gravel trail system winds through the park property. The 2.2-mile trail system covers 4.7 acres of land. Approximately 54 tons of gravel is required annually to replenish areas that have become bare due to washoff.

Project Concept Description

The park's trail system is heavily used and enjoyed most of the year by local citizens. This project involves the resurfacing of the trails with a non-erodible, highly pervious pavement. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products.

Three options were developed. Options 1 and 2 include resurfacing the entire trail system and option 3 recommends resurfacing only the steepest sections of the trail, many of which have been previously reinforced with railroad ties.

Project Costs

Option 1: Install non-erodible, highly pervious pavement along the 2.2-mile-long trail system. Installation labor is provided by the vendor.

Approximate cost - $2,300,000

Option 2: Install non-erodible, highly pervious pavement along the 2.2-mile-long trail system. Installation labor is provided by City staff.

Approximate cost - $1,700,000

Option 3: Install non-erodible, highly pervious pavement along the steepest sections of trail, for approximately 1,000 feet in length. Installation labor is provided by the vendor.

Approximate cost - $200,000

Project Concept No. 17

Existing Conditions

Additional sampling activities will be conducted along the streams and ponds within and downstream of Webb Bridge Park. Specifically, the unnamed tributary to Lake Windward, the unnamed tributary to Thornbury Lake, the park pond, and the Thornbury Parc pond.

Project Concept Description

One year of additional sampling for nutrients, pollutants, and habitat assessments is recommended. Water quality sampling results provide baseline data for future water quality sampling, provide short-term trends, and suggest which areas may need improvement in regards to water quality. This project presents two options for the City, which offer two different levels of sampling. The first option includes an additional year of sampling at all original locations assessed during the Webb Bridge Park Drainage Study. Sampling will be conducted at multiple locations and reaches of stream, as illustrated in the Project Concept (refer to the corresponding project sheet), report Figures 4 and 5. The scope of the sampling efforts included in Option 1 will be identical to the efforts conducted for the Drainage Study, including both pollutant parameter sampling and benthic assessments.

The second option involves a focused effort on the park's wet pond. For Option 2, sampling results from four sampling stations will be assessed to determine if excessive nutrients are entering and exiting the pond. Three of the sampling stations (SS1 - SS3) will include stormwater flow from culverts into the pond and one sampling station (SS4) will test the water exiting the pond. The three culvert sampling stations (SS1 - SS3) would provide data as to what type and quantity of nutrients are entering the wet pond from the contributory watershed. The fourth sampling station (SS4) will provide information on type and quantity of nutrients leaving the pond and discharging into the unnamed tributary of Thornbury Parc. Should the results of the water quality sampling indicate that excessive nutrients are exiting the pond, this data can be used to determine the design specifications of a potential constructed wetland (Project 13) that would be constructed to filter out pollutants/nutrients prior to entering the wet pond.

Project Costs

Option 1: This option involves an additional year of sampling at all original locations assessed during the Webb Bridge Park Drainage Study. Fifteen water quality events, one benthic event and a brief summary report are included in the cost.

Approximate cost – $40,000

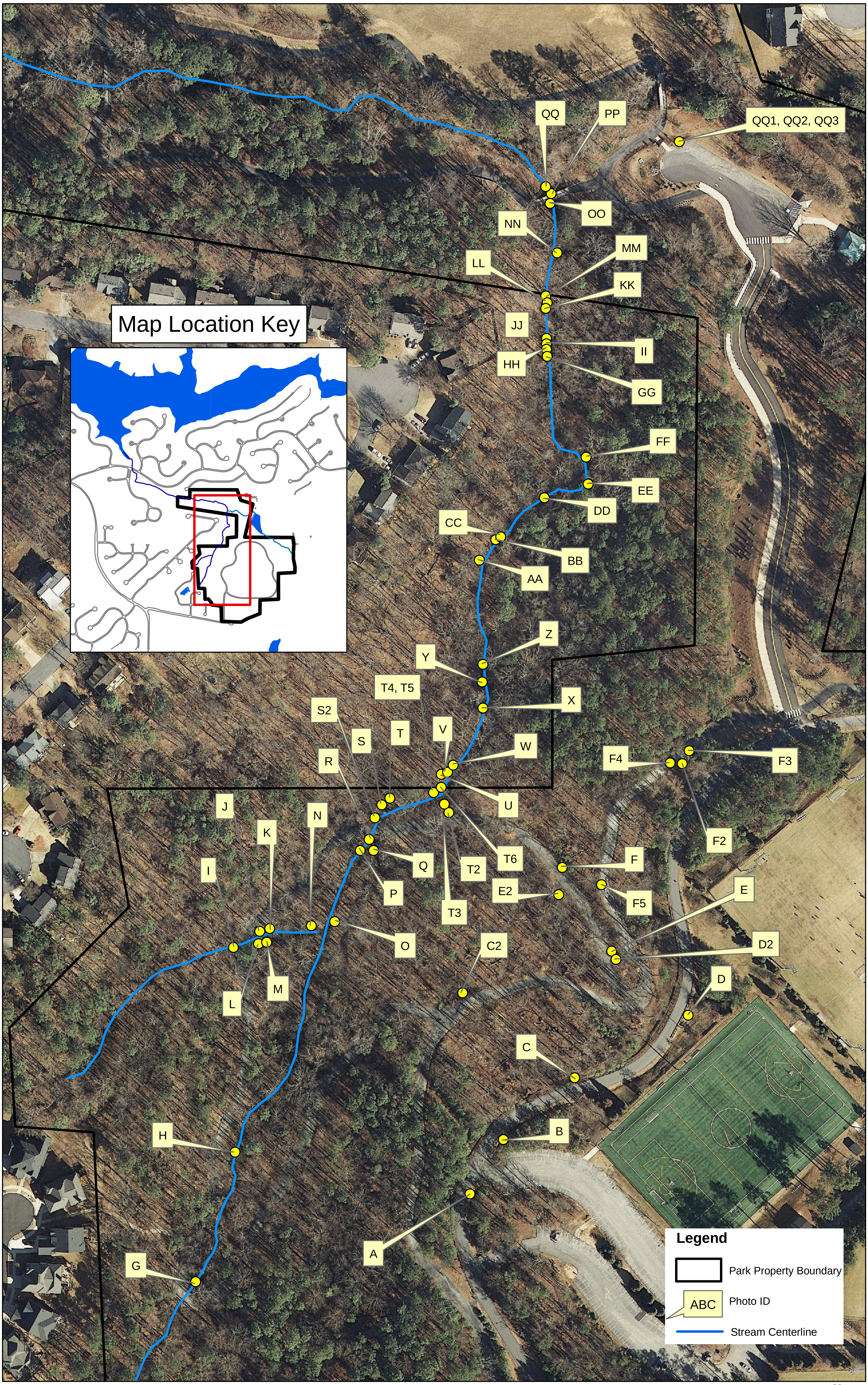
Option 2: This option involves an additional year of sampling at four sampling stations surrounding the park's wet pond. Fifteen water quality events and a brief summary report are included in the cost.

Approximate cost - $14,000

Webb Bridge Park Drainage Study

Appendix A

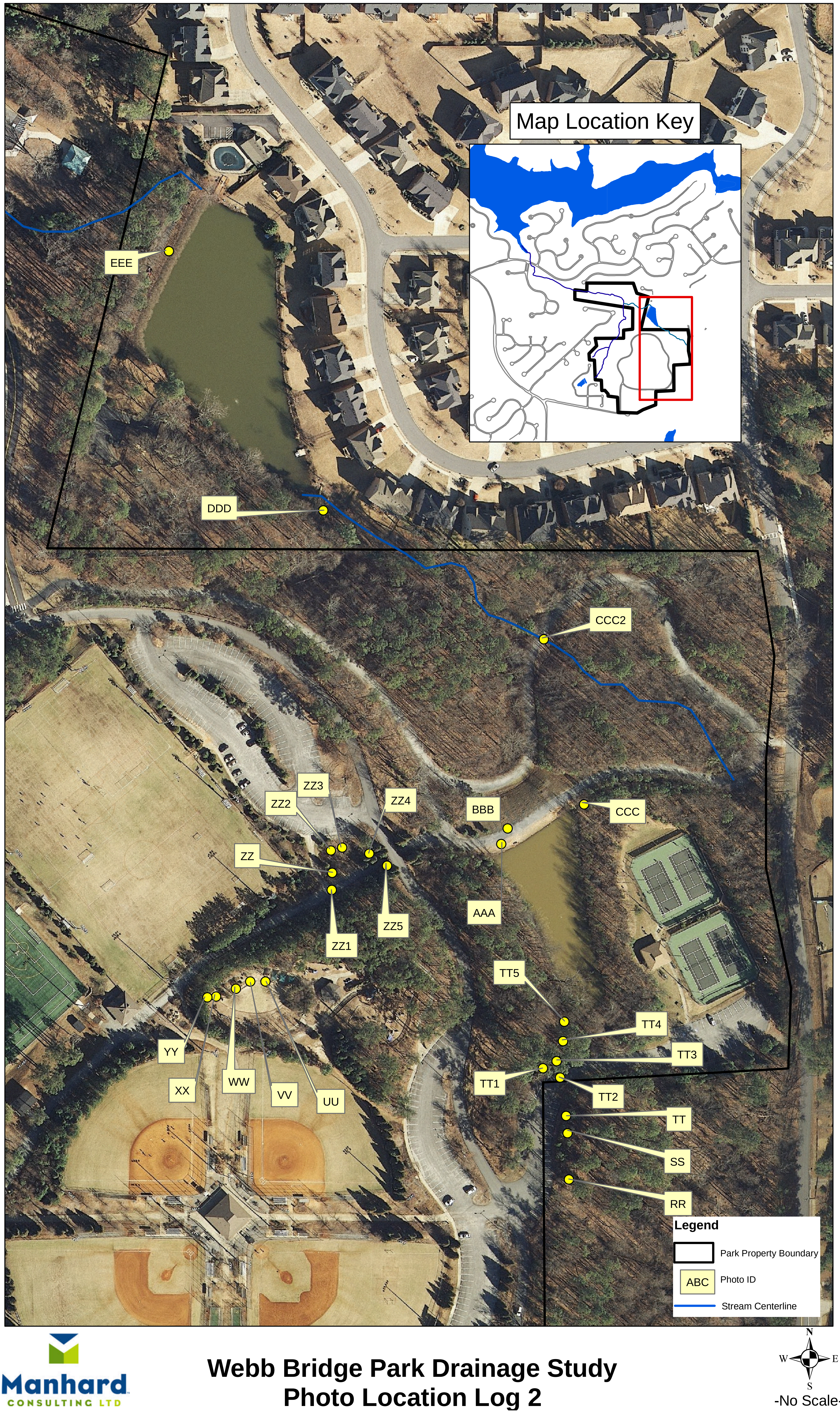
Photo Location Maps & Photo Logs



Manhard CONSULTING LTD

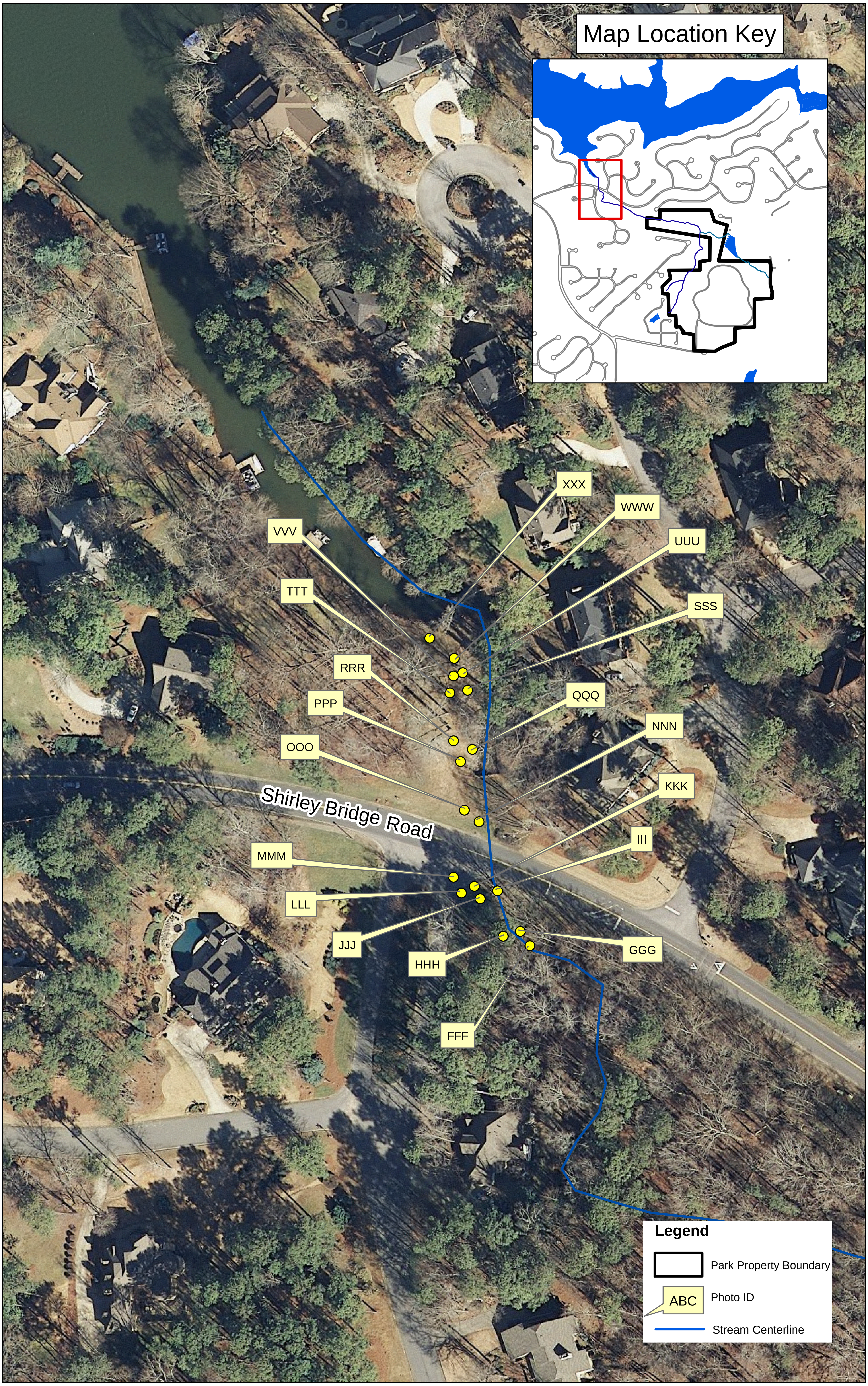
Webb Bridge Park Drainage Study
Photo Location Log 1

N W E S
-No Scale-



Manhard CONSULTING LTD

Webb Bridge Park Drainage Study
Photo Location Log 2



Manhard CONSULTING LTD

Webb Bridge Park Drainage Study
Photo Location Log 3

N W E S
-No Scale-

PHOTO A: drainage ditch along access road

PHOTO B: drainage ditch along access road

PHOTO C: erosion at outfall of 24-inch RCP

PHOTO C2: erosion at outfall of 18-inch HDPE pipe

PHOTO D: manhole in need of repair

PHOTO D2: at location of pipe outfall from eastern trail, looking downslope at rock-lined ditch

PHOTO E: rock-lined ditch along trail

PHOTO E2: downstream face of clogged 18-inch HDPE pipe

PHOTO F: rock-lined ditch along trail

PHOTO F2: upstream face of 18-inch HDPE pipe under trail

PHOTO F3: at location of Photo F2, looking upslope along trail to the east

PHOTO F4: at location of photo F2, looking downslope along trail to the west

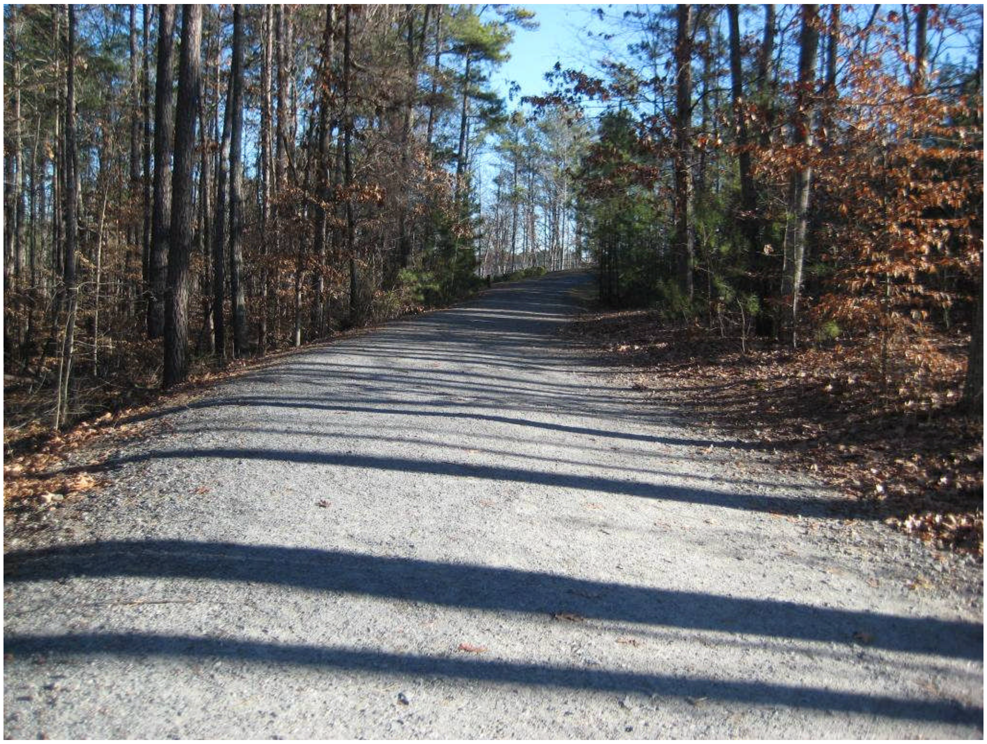


PHOTO F5: looking northeast along trail; location where runoff begins to drain away from private property (to the northwest) and back towards park (to the southeast)

PHOTO G: standing on left bank, looking downstream from 48-inch RCP crossing

PHOTO H: natural rock outcrop in channel; minor bank erosion

PHOTO I: looking upstream of 30-inch RCP at trees and woody debris in ditch

PHOTO J: outfall of 30-inch RCP under trail; erosion undermining headwall

PHOTO K: looking at eroded right bank, just downstream of pipe outfall in Photo J

PHOTO L: outfall of 30-inch RCP under trail following rain event; erosion undermining headwall (identical location as Photo J)

PHOTO M: looking at eroded right bank following rain event, just downstream of pipe outfall (identical location as Photo K)

PHOTO N: standing on left bank of mainstem, looking upstream at confluence with ditch

PHOTO O: standing on left bank of mainstem, looking at right bank immediately across from ditch outfall

PHOTO P: standing in channel, looking upstream from 60-inch RCP crossing

PHOTO Q: looking upstream at steep ditch, confluence just upstream of 60-inch RCP

PHOTO R: upstream face of poorly aligned 60-inch RCP

PHOTO S: looking at severely eroded left bank, just downstream of 60-inch RCP

PHOTO S2: standing at downstream face of 60-inch RCP, looking at left bank which makes a 90-degree turn immediately downstream of culvert

PHOTO T: looking at severely eroded left bank, downstream of 60-inch RCP (approx. 15 feet downstream of Photo S)

PHOTO T2: standing on headwall of 24-inch HDPE pipe, looking at steep, eroded ditch section between pipe outfall and stream

PHOTO T3: standing on headwall of 24-inch HDPE pipe, looking at steep, eroded ditch section between pipe outfall and stream

PHOTO T4: standing in stream, looking up at 24-inch HDPE pipe outfall

PHOTO T5: standing in stream, looking up at 24-inch HDPE pipe outfall

PHOTO T6: standing at location of Photo T5, looking downstream

PHOTO U: standing on left bank, looking at right bank and pipe under trail; At this location we have just crossed onto privately-owned property in the Nottingham Gate Subdivision.

PHOTO V: erosion undermining tree root systems on right bank

PHOTO W: standing in channel at location of Photo V, looking downstream

PHOTO X: standing in channel, looking at right bank

PHOTO Y: scour hole in channel

PHOTO Z: looking upstream at rock outcrops in channel

PHOTO AA: standing in channel, looking downstream at rock outcrops

PHOTO BB: wooden footbridge over channel located behind 6591 Maid Marion Close

PHOTO CC: channel under wooden footbridge located behind 6591 Maid Marion Close

PHOTO DD: a lot of bank erosion occurring in this area; located upstream of oxbow and second footbridge crossing

PHOTO EE: looking upstream at footbridge over channel; located along oxbow

PHOTO FF: standing on right bank of ditch at confluence with mainstem, looking at left bank of channel

PHOTO GG: standing at concrete weir control structure, looking upstream

PHOTO HH: upstream face of concrete weir control structure that spans channel

PHOTO II: upstream face of concrete weir control structure that spans channel

PHOTO JJ: upstream face of concrete weir control structure that spans channel

PHOTO KK: standing just upstream of park property limits at existing metal rack in channel, looking upstream towards concrete control structure (in background)

PHOTO LL: metal rack in channel, secured by cables; located at the property limits between the park and the Nottingham Gate subdivision

PHOTO MM: metal rack in channel, secured by cables; located at the property limits between the park and the Nottingham Gate subdivision

PHOTO NN: standing on right bank of park’s primary western channel, at confluence with park’s eastern channel; looking downstream

PHOTO – OO: channel under metal pedestrian bridge, which crosses channel approximately 75 feet downstream of confluence of park’s primary western and eastern streams

PHOTO – PP: metal pedestrian bridge, which crosses channel approximately 75 feet downstream of confluence of park's primary western and eastern streams

PHOTO – QQ: view of downstream channel from metal pedestrian bridge

PHOTO – QQ1: rills/ditches in bare soil at northwest edge of Park's Phase III parking lot

PHOTO – QQ2: rills/ditches in bare soil at northwest edge of Park's Phase III parking lot

PHOTO – QQ3: rills/ditches in bare soil at northwest edge of Park's Phase III parking lot

PHOTO – RR: concrete detention pond located behind residential development constructed in 2011; pond is located on private property, just upstream of the park's wet pond

PHOTO – SS: concrete detention pond located behind residential development constructed in 2011; pond is located on private property, just upstream of the park's wet pond; looking south towards homes

PHOTO – TT: concrete detention pond located behind residential development constructed in 2011; looking at pond outlet structure which discharges into pipe upstream of park's wet pond

PHOTO – TT1: looking west at lightly wooded area between parking lot and road

PHOTO – TT2: standing on parking lot, looking northwest at lightly wooded area

PHOTO – TT3: looking north at shallow berm along wooded area, upstream of pond

PHOTO – TT4: looking west at lightly wooded area between parking lot and road

PHOTO – TT5: standing at southern-most tip of pond, looking southwest

PHOTO – UU: rock channel in playground area, looking downstream (looking southwest); large sandbox area located on right of photo

PHOTO – VV: rock channel in playground area, looking downstream (looking southwest); large sandbox area located on right of photo

PHOTO – WW: rock channel in playground area, looking downstream (looking southwest) towards outlet, which discharges into pipe system and ultimately into park's wet pond

PHOTO – XX: outlet of rock channel in playground area

PHOTO – YY: outlet of rock channel in playground area; small metal grate visible under header rock

PHOTO – ZZ: 18-inch HDPE pipe outlet from pipe system that conveys runoff from playground area and the two northern baseball fields (June 2011)

PHOTO – ZZ1: looking downslope along trail, towards pond

PHOTO – ZZ2: 18-inch HDPE pipe outlet from pipe system that conveys runoff from playground area and the two northern baseball fields (January 2012); same location as Photo ZZ

PHOTO – ZZ3: channel filled with sand, downstream of Photo ZZ2

PHOTO – ZZ4: looking at upstream face of double 18-inch HDPE pipes that run under trail to ditch which discharges into pond

PHOTO – ZZ5: looking upslope at gravel ditch that drains south side of trail; outfall of double 18-inch HDPE pipes, shown in Photo ZZ4, enter ditch from right-hand side of photo; ditch continues downstream directly to pond

PHOTO – AAA: view of park pond from dam

PHOTO – BBB: standing on park pond earthen dam, looking down at gravel trail

PHOTO – CCC: downstream face of stone weir structure that serves as primary outlet from park pond

PHOTO – CCC2: localized scour upstream of pipe crossing under trail

PHOTO – DDD: channel flowing into Thornbury Parc pond, from park's property

PHOTO – EEE: Thornbury Parc pond, view from dam

PHOTO – FFF: standing in channel just upstream of Shirley Bridge Road culvert, looking upstream (looking south)

PHOTO – GGG: upstream face of Shirley Bridge Road culvert, triple 54-inch CMPs (taken in August 2011)

PHOTO – HHH: standing in channel just upstream of Shirley Bridge Road culvert, looking upstream (looking south)

PHOTO – III: standing on Shirley Bridge Road culvert, looking at woody debris that has accumulated in channel

PHOTO – JJJ: upstream face of Shirley Bridge Road culvert, triple 54-inch CMPs (taken in October 2011)

PHOTO – KKK: standing on Shirley Bridge Road culvert, looking at woody debris that has accumulated in channel

PHOTO – LLL: upstream face of Shirley Bridge Road culvert, triple 54-inch CMPs (taken in October 2011)

PHOTO – MMM: standing on Shirley Bridge Road culvert, looking upstream at clear water coming from park (and other upstream contributory drainage areas); taken in September 2011

PHOTO – NNN: standing on Shirley Bridge Road culvert, looking downstream where stream from park (and other upstream contributory drainage areas) enters Lake Windward (taken in September 2011)

PHOTO – OOO: standing on Shirley Bridge Road culvert, looking downstream where stream from park (and other upstream contributory drainage areas) enters Lake Windward (taken in August 2011); in-stream gabion structure in far background

PHOTO – PPP: downstream face of Shirley Bridge Road culvert; sediment has settled out where channel has been widened in the vicinity of the culvert

PHOTO – QQQ: downstream face of Shirley Bridge Road culvert; sediment has settled out where channel has been widened in the vicinity of the culvert

PHOTO – RRR: downstream face of Shirley Bridge Road culvert; sediment has settled out where channel has been widened in the vicinity of the culvert

PHOTO – SSS: in-stream gabion structure, located approximately 100 feet downstream of Shirley Bridge Road culvert; looking downstream (taken in August 2011)

PHOTO – TTT: in-stream gabion structure, located approximately 100 feet downstream of Shirley Bridge Road culvert; looking at downstream aspect of structure (taken in October 2011)

PHOTO – UUU: in-stream gabion structure, located approximately 100 feet downstream of Shirley Bridge Road culvert; looking at downstream aspect of structure (taken in August 2011)

PHOTO – VVV: in-stream gabion structure, located approximately 100 feet downstream of Shirley Bridge Road culvert; looking at downstream aspect of structure (taken in September 2011)

PHOTO – WWW: looking towards home located on right overbank, just downstream of in-stream gabion structure (taken in October 2011)

PHOTO – XXX: standing on left bank, approximately 120 feet downstream from Shirley Bridge Road culvert; looking towards Lake Windward

Webb Bridge Park Drainage Study

Appendix B

HEC-HMS and HEC-RAS Model Output

& Summary Tables

HEC-HMS MODEL RESULTS

Project: Webb Bridge Park Simulation Run: Exist 1_YR Event

Start of Run: 18Nov2005, 00:00 Basin Model: Existing Conditions
End of Run: 20Nov2005, 00:00 Meteorologic Model: 1-year Event
Compute Time: 29Feb2012, 10:00:22 Control Specifications: Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	37.3	18Nov2005, 12:20	0.98
B63a	0.0254	25.2	18Nov2005, 12:03	1.20
J63	0.1170	44.4	18Nov2005, 12:08	1.03
RB64	0.1170	44.4	18Nov2005, 12:12	1.03
B64	0.0487	38.3	18Nov2005, 12:03	0.98
J64	0.1657	74.9	18Nov2005, 12:06	1.01
B62a	0.0814	77.5	18Nov2005, 12:07	1.39
B62b	0.0321	29.4	18Nov2005, 12:02	1.09
J62b	0.0321	29.4	18Nov2005, 12:02	1.09
RB62a	0.0321	29.3	18Nov2005, 12:05	1.09
J62a	0.2792	181.1	18Nov2005, 12:06	1.13
B61a	0.0492	39.8	18Nov2005, 12:07	1.20
J61a	0.3284	220.6	18Nov2005, 12:06	1.14
RB65b	0.3284	217.2	18Nov2005, 12:11	1.14
B65b	0.0527	49.4	18Nov2005, 12:03	1.14
J65b	0.3811	248.2	18Nov2005, 12:09	1.14
RB65a	0.3811	247.9	18Nov2005, 12:11	1.14
B65a	0.0490	47.6	18Nov2005, 12:02	1.14
J65	0.4301	272.8	18Nov2005, 12:10	1.14
B66	0.1000	50.2	18Nov2005, 12:15	1.03
J66	0.5301	318.7	18Nov2005, 12:10	1.12
B67	0.0400	22.7	18Nov2005, 12:08	0.92
J67	0.5701	341.0	18Nov2005, 12:10	1.11

Project: Webb Bridge Park Simulation Run: EX_2 YR Event

Start of Run:	18Nov2005, 00:00	Basin Model:	Existing Conditions
End of Run:	20Nov2005, 00:00	Meteorologic Model:	2-year Event
Compute Time:	29Feb2012, 10:12:08	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	58.3	18Nov2005, 12:20	1.45
B63a	0.0254	36.6	18Nov2005, 12:03	1.73
J63	0.1170	69.2	18Nov2005, 12:08	1.51
RB64	0.1170	69.2	18Nov2005, 12:11	1.51
B64	0.0487	58.6	18Nov2005, 12:03	1.45
J64	0.1657	116.6	18Nov2005, 12:05	1.49
B62a	0.0814	109.9	18Nov2005, 12:07	1.95
B62b	0.0321	43.8	18Nov2005, 12:02	1.59
J62b	0.0321	43.8	18Nov2005, 12:02	1.59
RB62a	0.0321	43.6	18Nov2005, 12:04	1.59
J62a	0.2792	268.6	18Nov2005, 12:06	1.64
B61a	0.0492	58.3	18Nov2005, 12:07	1.73
J61a	0.3284	326.6	18Nov2005, 12:06	1.65
RB65b	0.3284	320.1	18Nov2005, 12:12	1.65
B65b	0.0527	72.7	18Nov2005, 12:03	1.66
J65b	0.3811	356.7	18Nov2005, 12:11	1.65
RB65a	0.3811	355.8	18Nov2005, 12:13	1.65
B65a	0.0490	70.1	18Nov2005, 12:02	1.66
J65	0.4301	384.6	18Nov2005, 12:12	1.65
B66	0.1000	77.0	18Nov2005, 12:15	1.52
J66	0.5301	460.0	18Nov2005, 12:12	1.63
B67	0.0400	35.8	18Nov2005, 12:08	1.38
J67	0.5701	492.6	18Nov2005, 12:12	1.61

Project: Webb Bridge Park Simulation Run: EX_5 YR Event

Start of Run: 18Nov2005, 00:00 Basin Model: Existing Conditions
End of Run: 20Nov2005, 00:00 Meteorologic Model: 5-year Event
Compute Time: 29Feb2012, 10:22:36 Control Specifications: Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	81.2	18Nov2005, 12:19	1.97
B63a	0.0254	48.8	18Nov2005, 12:02	2.29
J63	0.1170	96.1	18Nov2005, 12:08	2.04
RB64	0.1170	96.1	18Nov2005, 12:11	2.04
B64	0.0487	80.6	18Nov2005, 12:02	1.97
J64	0.1657	162.0	18Nov2005, 12:05	2.02
B62a	0.0814	143.8	18Nov2005, 12:06	2.54
B62b	0.0321	59.2	18Nov2005, 12:02	2.12
J62b	0.0321	59.2	18Nov2005, 12:02	2.12
RB62a	0.0321	59.1	18Nov2005, 12:04	2.12
J62a	0.2792	362.6	18Nov2005, 12:05	2.18
B61a	0.0492	77.9	18Nov2005, 12:07	2.29
J61a	0.3284	439.3	18Nov2005, 12:06	2.20
RB65b	0.3284	431.8	18Nov2005, 12:12	2.20
B65b	0.0527	97.5	18Nov2005, 12:02	2.21
J65b	0.3811	482.7	18Nov2005, 12:11	2.20
RB65a	0.3811	481.9	18Nov2005, 12:12	2.20
B65a	0.0490	93.9	18Nov2005, 12:02	2.21
J65	0.4301	522.7	18Nov2005, 12:11	2.20
B66	0.1000	106.1	18Nov2005, 12:14	2.05
J66	0.5301	625.3	18Nov2005, 12:11	2.17
B67	0.0400	49.9	18Nov2005, 12:08	1.89
J67	0.5701	672.2	18Nov2005, 12:11	2.15

Project: Webb Bridge Park Simulation Run: EX_10 YR Event

Start of Run: 18Nov2005, 00:00 Basin Model: Existing Conditions
End of Run: 20Nov2005, 00:00 Meteorologic Model: 10-year Event
Compute Time: 29Feb2012, 10:34:33 Control Specifications: Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	105.5	18Nov2005, 12:19	2.52
B63a	0.0254	61.5	18Nov2005, 12:02	2.88
J63	0.1170	124.6	18Nov2005, 12:08	2.60
RB64	0.1170	124.5	18Nov2005, 12:11	2.60
B64	0.0487	103.8	18Nov2005, 12:02	2.52
J64	0.1657	210.0	18Nov2005, 12:05	2.57
B62a	0.0814	178.8	18Nov2005, 12:06	3.16
B62b	0.0321	75.2	18Nov2005, 12:02	2.70
J62b	0.0321	75.2	18Nov2005, 12:02	2.70
RB62a	0.0321	75.1	18Nov2005, 12:04	2.70
J62a	0.2792	460.8	18Nov2005, 12:05	2.76
B61a	0.0492	98.3	18Nov2005, 12:06	2.88
J61a	0.3284	557.9	18Nov2005, 12:05	2.78
RB65b	0.3284	547.8	18Nov2005, 12:11	2.77
B65b	0.0527	123.5	18Nov2005, 12:02	2.79
J65b	0.3811	615.1	18Nov2005, 12:10	2.78
RB65a	0.3811	613.7	18Nov2005, 12:11	2.78
B65a	0.0490	118.7	18Nov2005, 12:02	2.79
J65	0.4301	669.4	18Nov2005, 12:10	2.78
B66	0.1000	136.8	18Nov2005, 12:14	2.61
J66	0.5301	800.9	18Nov2005, 12:11	2.74
B67	0.0400	65.0	18Nov2005, 12:07	2.43
J67	0.5701	862.0	18Nov2005, 12:10	2.72

Project: Webb Bridge Park Simulation Run: EX_25 YR Event

Start of Run: 18Nov2005, 00:00 Basin Model: Existing Conditions
End of Run: 20Nov2005, 00:00 Meteorologic Model: 25-year Event
Compute Time: 29Feb2012, 10:47:36 Control Specifications: Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	139.3	18Nov2005, 12:18	3.29
B63a	0.0254	78.9	18Nov2005, 12:02	3.69
J63	0.1170	164.2	18Nov2005, 12:08	3.38
RB64	0.1170	164.2	18Nov2005, 12:11	3.38
B64	0.0487	136.1	18Nov2005, 12:02	3.29
J64	0.1657	276.5	18Nov2005, 12:05	3.35
B62a	0.0814	226.3	18Nov2005, 12:06	4.01
B62b	0.0321	97.4	18Nov2005, 12:01	3.49
J62b	0.0321	97.4	18Nov2005, 12:01	3.49
RB62a	0.0321	97.2	18Nov2005, 12:03	3.49
J62a	0.2792	595.9	18Nov2005, 12:05	3.56
B61a	0.0492	126.4	18Nov2005, 12:06	3.69
J61a	0.3284	721.0	18Nov2005, 12:05	3.58
RB65b	0.3284	709.3	18Nov2005, 12:11	3.58
B65b	0.0527	159.3	18Nov2005, 12:02	3.59
J65b	0.3811	799.2	18Nov2005, 12:10	3.58
RB65a	0.3811	798.0	18Nov2005, 12:11	3.58
B65a	0.0490	153.0	18Nov2005, 12:01	3.59
J65	0.4301	873.8	18Nov2005, 12:10	3.58
B66	0.1000	179.4	18Nov2005, 12:14	3.39
J66	0.5301	1045.3	18Nov2005, 12:10	3.55
B67	0.0400	86.1	18Nov2005, 12:07	3.19
J67	0.5701	1127.9	18Nov2005, 12:10	3.52

Project: Webb Bridge Park Simulation Run: EX_50 YR Event

Start of Run:	18Nov2005, 00:00	Basin Model:	Existing Conditions
End of Run:	20Nov2005, 00:00	Meteorologic Model:	50-year Event
Compute Time:	29Feb2012, 10:58:09	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	165.6	18Nov2005, 12:18	3.89
B63a	0.0254	92.1	18Nov2005, 12:02	4.33
J63	0.1170	194.9	18Nov2005, 12:08	3.99
RB64	0.1170	194.8	18Nov2005, 12:11	3.99
B64	0.0487	161.0	18Nov2005, 12:02	3.89
J64	0.1657	328.0	18Nov2005, 12:04	3.96
B62a	0.0814	262.3	18Nov2005, 12:06	4.66
B62b	0.0321	114.5	18Nov2005, 12:01	4.11
J62b	0.0321	114.5	18Nov2005, 12:01	4.11
RB62a	0.0321	114.3	18Nov2005, 12:03	4.11
J62a	0.2792	699.3	18Nov2005, 12:05	4.18
B61a	0.0492	147.9	18Nov2005, 12:06	4.33
J61a	0.3284	845.8	18Nov2005, 12:05	4.20
RB65b	0.3284	831.6	18Nov2005, 12:11	4.20
B65b	0.0527	186.6	18Nov2005, 12:02	4.22
J65b	0.3811	940.4	18Nov2005, 12:09	4.20
RB65a	0.3811	939.1	18Nov2005, 12:10	4.20
B65a	0.0490	179.2	18Nov2005, 12:01	4.22
J65	0.4301	1033.3	18Nov2005, 12:09	4.20
B66	0.1000	212.2	18Nov2005, 12:14	4.00
J66	0.5301	1234.0	18Nov2005, 12:10	4.17
B67	0.0400	102.4	18Nov2005, 12:07	3.79
J67	0.5701	1331.9	18Nov2005, 12:09	4.14

Project: Webb Bridge Park Simulation Run: EX_100 YR Event

Start of Run:	18Nov2005, 00:00	Basin Model:	Existing Conditions
End of Run:	20Nov2005, 00:00	Meteorologic Model:	100-year Event
Compute Time:	29Feb2012, 11:11:20	Control Specifications:	Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	192.4	18Nov2005, 12:18	4.51
B63a	0.0254	105.5	18Nov2005, 12:02	4.97
J63	0.1170	226.1	18Nov2005, 12:08	4.61
RB64	0.1170	226.0	18Nov2005, 12:11	4.61
B64	0.0487	186.2	18Nov2005, 12:02	4.51
J64	0.1657	380.7	18Nov2005, 12:04	4.58
B62a	0.0814	298.6	18Nov2005, 12:06	5.32
B62b	0.0321	131.8	18Nov2005, 12:01	4.74
J62b	0.0321	131.8	18Nov2005, 12:01	4.74
RB62a	0.0321	131.5	18Nov2005, 12:03	4.74
J62a	0.2792	804.0	18Nov2005, 12:05	4.81
B61a	0.0492	169.5	18Nov2005, 12:06	4.97
J61a	0.3284	972.1	18Nov2005, 12:05	4.84
RB65b	0.3284	956.1	18Nov2005, 12:10	4.84
B65b	0.0527	214.2	18Nov2005, 12:02	4.85
J65b	0.3811	1085.1	18Nov2005, 12:09	4.84
RB65a	0.3811	1083.6	18Nov2005, 12:10	4.84
B65a	0.0490	205.7	18Nov2005, 12:01	4.85
J65	0.4301	1195.6	18Nov2005, 12:09	4.84
B66	0.1000	245.5	18Nov2005, 12:14	4.62
J66	0.5301	1425.7	18Nov2005, 12:09	4.80
B67	0.0400	119.0	18Nov2005, 12:07	4.40
J67	0.5701	1542.2	18Nov2005, 12:09	4.77

Project: Webb Bridge Park Simulation Run: EX_500 YR Event

Start of Run: 18Nov2005, 00:00 Basin Model: Existing Conditions
End of Run: 20Nov2005, 00:00 Meteorologic Model: 500-year Event
Compute Time: 29Feb2012, 11:24:48 Control Specifications: Control 1

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (IN)
B63b	0.0916	259.1	18Nov2005, 12:18	6.07
B63a	0.0254	138.4	18Nov2005, 12:02	6.58
J63	0.1170	303.9	18Nov2005, 12:08	6.18
RB64	0.1170	303.8	18Nov2005, 12:11	6.18
B64	0.0487	248.9	18Nov2005, 12:02	6.07
J64	0.1657	512.1	18Nov2005, 12:04	6.15
B62a	0.0814	387.5	18Nov2005, 12:06	6.96
B62b	0.0321	174.5	18Nov2005, 12:01	6.32
J62b	0.0321	174.5	18Nov2005, 12:01	6.32
RB62a	0.0321	174.2	18Nov2005, 12:03	6.32
J62a	0.2792	1063.0	18Nov2005, 12:04	6.40
B61a	0.0492	223.0	18Nov2005, 12:06	6.58
J61a	0.3284	1284.5	18Nov2005, 12:05	6.43
RB65b	0.3284	1265.4	18Nov2005, 12:10	6.43
B65b	0.0527	282.3	18Nov2005, 12:02	6.45
J65b	0.3811	1442.4	18Nov2005, 12:09	6.43
RB65a	0.3811	1439.2	18Nov2005, 12:09	6.43
B65a	0.0490	271.2	18Nov2005, 12:01	6.45
J65	0.4301	1598.3	18Nov2005, 12:08	6.43
B66	0.1000	328.8	18Nov2005, 12:13	6.20
J66	0.5301	1903.9	18Nov2005, 12:09	6.39
B67	0.0400	160.5	18Nov2005, 12:07	5.94
J67	0.5701	2060.5	18Nov2005, 12:09	6.36

HEC-RAS Plan: Existing River: CaneyCreek_Trib1 Reach: CaneyCreek_Trib1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CaneyCreek_Trib1	6661	EX002YR	58.30	1120.00	1121.31	1121.31	1121.70	0.033917	5.01	11.64	15.23	1.01
CaneyCreek_Trib1	6661	EX005YR	81.20	1120.00	1121.53	1121.53	1121.97	0.032436	5.35	15.17	17.36	1.01
CaneyCreek_Trib1	6661	EX010YR	105.50	1120.00	1121.72	1121.72	1122.22	0.031291	5.66	18.63	19.04	1.01
CaneyCreek_Trib1	6661	EX025YR	139.30	1120.00	1121.95	1121.95	1122.51	0.029982	6.00	23.20	21.01	1.01
CaneyCreek_Trib1	6661	EX050YR	165.60	1120.00	1122.08	1122.08	1122.71	0.029571	6.35	26.09	21.92	1.02
CaneyCreek_Trib1	6661	EX100YR	192.40	1120.00	1122.21	1122.21	1122.90	0.028348	6.66	29.02	22.67	1.01
CaneyCreek_Trib1	6661	EX500YR	259.10	1120.00	1122.53	1122.53	1123.34	0.025289	7.24	36.70	26.81	0.99
CaneyCreek_Trib1	6661	EX001YR	37.30	1120.00	1121.13	1121.06	1121.40	0.027399	4.13	9.03	13.44	0.89
CaneyCreek_Trib1	6521	EX002YR	58.30	1116.00	1117.21		1117.36	0.011227	3.05	19.08	23.17	0.59
CaneyCreek_Trib1	6521	EX005YR	81.20	1116.00	1118.04		1118.09	0.002257	1.92	45.93	49.58	0.29
CaneyCreek_Trib1	6521	EX010YR	105.50	1116.00	1118.29		1118.35	0.002071	2.05	58.76	51.91	0.28
CaneyCreek_Trib1	6521	EX025YR	139.30	1116.00	1118.51		1118.59	0.002258	2.34	70.59	53.96	0.30
CaneyCreek_Trib1	6521	EX050YR	165.60	1116.00	1118.64		1118.73	0.002514	2.58	77.38	55.11	0.32
CaneyCreek_Trib1	6521	EX100YR	192.40	1116.00	1118.77		1118.88	0.002655	2.77	85.00	56.36	0.34
CaneyCreek_Trib1	6521	EX500YR	259.10	1116.00	1119.05		1119.19	0.003081	3.24	100.74	58.86	0.37
CaneyCreek_Trib1	6521	EX001YR	37.30	1116.00	1116.69	1116.69	1116.96	0.036984	4.18	8.92	16.54	1.00
CaneyCreek_Trib1	6477	EX002YR	58.30	1113.52	1117.19	1114.95	1117.22	0.000723	1.27	46.22	28.03	0.17
CaneyCreek_Trib1	6477	EX005YR	81.20	1113.52	1118.02	1115.24	1118.04	0.000391	1.20	73.72	46.50	0.13
CaneyCreek_Trib1	6477	EX010YR	105.50	1113.52	1118.27	1115.49	1118.30	0.000477	1.41	85.82	50.90	0.15
CaneyCreek_Trib1	6477	EX025YR	139.30	1113.52	1118.48	1115.80	1118.53	0.000638	1.71	97.23	54.81	0.17
CaneyCreek_Trib1	6477	EX050YR	165.60	1113.52	1118.60	1116.02	1118.66	0.000785	1.94	103.80	56.93	0.19
CaneyCreek_Trib1	6477	EX100YR	192.40	1113.52	1118.73	1116.23	1118.80	0.000913	2.15	111.41	59.30	0.21
CaneyCreek_Trib1	6477	EX500YR	259.10	1113.52	1118.99	1116.81	1119.09	0.001248	2.64	127.26	63.82	0.24
CaneyCreek_Trib1	6477	EX001YR	37.30	1113.52	1116.34	1114.64	1116.37	0.000898	1.35	27.68	16.03	0.18
CaneyCreek_Trib1	6457		Culvert									
CaneyCreek_Trib1	6439	EX002YR	58.30	1113.00	1114.69		1114.89	0.007974	3.50	16.64	10.99	0.50
CaneyCreek_Trib1	6439	EX005YR	81.20	1113.00	1115.04		1115.28	0.008553	3.96	20.53	11.81	0.53
CaneyCreek_Trib1	6439	EX010YR	105.50	1113.00	1115.35		1115.64	0.008989	4.33	24.38	12.68	0.55
CaneyCreek_Trib1	6439	EX025YR	139.30	1113.00	1115.72		1116.07	0.009557	4.77	29.20	13.69	0.58
CaneyCreek_Trib1	6439	EX050YR	165.60	1113.00	1115.95		1116.35	0.010143	5.11	32.42	14.32	0.60
CaneyCreek_Trib1	6439	EX100YR	192.40	1113.00	1116.16		1116.62	0.010781	5.41	35.57	15.12	0.62
CaneyCreek_Trib1	6439	EX500YR	259.10	1113.00	1116.61		1117.18	0.012308	6.07	42.69	16.95	0.67
CaneyCreek_Trib1	6439	EX001YR	37.30	1113.00	1114.31		1114.45	0.007552	2.98	12.54	10.40	0.48
CaneyCreek_Trib1	6376	EX002YR	58.30	1112.00	1113.38	1113.38	1113.89	0.032616	5.75	10.14	10.03	1.01
CaneyCreek_Trib1	6376	EX005YR	81.20	1112.00	1113.66	1113.66	1114.26	0.030847	6.19	13.12	11.10	1.00
CaneyCreek_Trib1	6376	EX010YR	105.50	1112.00	1113.91	1113.91	1114.59	0.029894	6.59	16.00	12.04	1.01
CaneyCreek_Trib1	6376	EX025YR	139.30	1112.00	1114.20	1114.20	1114.99	0.027608	7.11	19.86	14.94	0.99
CaneyCreek_Trib1	6376	EX050YR	165.60	1112.00	1114.42	1114.42	1115.27	0.025227	7.40	23.41	17.74	0.97
CaneyCreek_Trib1	6376	EX100YR	192.40	1112.00	1114.63	1114.63	1115.53	0.023319	7.65	27.36	20.41	0.95
CaneyCreek_Trib1	6376	EX500YR	259.10	1112.00	1115.09	1115.09	1116.08	0.020104	8.15	38.14	26.36	0.91
CaneyCreek_Trib1	6376	EX001YR	37.30	1112.00	1113.07	1113.07	1113.49	0.034340	5.15	7.24	8.85	1.00
CaneyCreek_Trib1	6220	EX002YR	58.30	1103.72	1105.91	1105.75	1106.58	0.035538	6.60	8.83	5.17	0.89
CaneyCreek_Trib1	6220	EX005YR	81.20	1103.72	1106.37	1106.23	1107.15	0.036407	7.10	11.43	6.27	0.93
CaneyCreek_Trib1	6220	EX010YR	105.50	1103.72	1106.76	1106.67	1107.63	0.036742	7.48	14.10	7.44	0.96
CaneyCreek_Trib1	6220	EX025YR	139.30	1103.72	1107.21	1107.16	1108.16	0.036085	7.83	17.78	8.95	0.98
CaneyCreek_Trib1	6220	EX050YR	165.60	1103.72	1107.49	1107.46	1108.51	0.035797	8.10	20.45	9.91	0.99
CaneyCreek_Trib1	6220	EX100YR	192.40	1103.72	1107.74	1107.74	1108.82	0.035715	8.36	23.01	10.74	1.01
CaneyCreek_Trib1	6220	EX500YR	259.10	1103.72	1108.27	1108.27	1109.50	0.032160	8.88	29.51	14.21	0.99
CaneyCreek_Trib1	6220	EX001YR	37.30	1103.72	1105.42	1105.27	1105.94	0.034232	5.81	6.42	4.66	0.87
CaneyCreek_Trib1	6029	EX002YR	58.30	1097.04	1098.72	1098.72	1099.44	0.039357	6.81	8.56	6.01	1.01
CaneyCreek_Trib1	6029	EX005YR	81.20	1097.04	1099.10	1099.10	1099.96	0.038841	7.43	10.93	6.43	1.00
CaneyCreek_Trib1	6029	EX010YR	105.50	1097.04	1099.46	1099.46	1100.44	0.038470	7.94	13.28	6.82	1.00
CaneyCreek_Trib1	6029	EX025YR	139.30	1097.04	1099.88	1099.88	1101.02	0.038568	8.55	16.30	7.28	1.01
CaneyCreek_Trib1	6029	EX050YR	165.60	1097.04	1100.19	1100.19	1101.42	0.038229	8.89	18.62	7.68	1.01
CaneyCreek_Trib1	6029	EX100YR	192.40	1097.04	1100.49	1100.49	1101.80	0.037627	9.17	20.98	8.10	1.00
CaneyCreek_Trib1	6029	EX500YR	259.10	1097.04	1101.15	1101.15	1102.62	0.036578	9.76	26.56	8.99	1.00
CaneyCreek_Trib1	6029	EX001YR	37.30	1097.04	1098.31	1098.31	1098.87	0.040030	6.02	6.20	5.57	1.01
CaneyCreek_Trib1	5848	EX002YR	69.20	1093.97	1097.28		1097.35	0.001804	2.24	30.93	11.43	0.24
CaneyCreek_Trib1	5848	EX005YR	96.10	1093.97	1098.04		1098.13	0.001723	2.40	39.97	12.40	0.24
CaneyCreek_Trib1	5848	EX010YR	124.60	1093.97	1098.79		1098.89	0.001620	2.49	49.97	14.05	0.23
CaneyCreek_Trib1	5848	EX025YR	164.20	1093.97	1099.34		1099.47	0.001905	2.83	58.02	15.27	0.26
CaneyCreek_Trib1	5848	EX050YR	194.90	1093.97	1099.54		1099.70	0.002345	3.19	61.09	15.71	0.29
CaneyCreek_Trib1	5848	EX100YR	226.10	1093.97	1099.71		1099.90	0.002820	3.55	63.77	16.09	0.31
CaneyCreek_Trib1	5848	EX500YR	303.90	1093.97	1100.05		1100.34	0.004085	4.38	69.35	17.35	0.38
CaneyCreek_Trib1	5848	EX001YR	44.40	1093.97	1096.48		1096.54	0.001872	2.00	22.21	10.46	0.24
CaneyCreek_Trib1	5749	EX002YR	69.20	1093.37	1097.21		1097.24	0.000650	1.45	47.57	18.19	0.16
CaneyCreek_Trib1	5749	EX005YR	96.10	1093.37	1097.98		1098.02	0.000604	1.53	62.71	21.03	0.16
CaneyCreek_Trib1	5749	EX010YR	124.60	1093.37	1098.75		1098.78	0.000558	1.55	80.46	25.37	0.15
CaneyCreek_Trib1	5749	EX025YR	164.20	1093.37	1099.30		1099.34	0.000623	1.73	95.06	27.63	0.16
CaneyCreek_Trib1	5749	EX050YR	194.90	1093.37	1099.49		1099.55	0.000758	1.94	100.41	28.42	0.18
CaneyCreek_Trib1	5749	EX100YR	226.10	1093.37	1099.65		1099.72	0.000905	2.15	105.03	29.08	0.20
CaneyCreek_Trib1	5749	EX500YR	303.90	1093.37	1099.97		1100.08	0.001299	2.65	114.51	30.38	0.24
CaneyCreek_Trib1	5749	EX001YR	44.40	1093.37	1096.40		1096.43	0.000634	1.30	34.19	15.16	0.15
CaneyCreek_Trib1	5698	EX002YR	69.20	1093.46	1097.20	1094.71	1097.21	0.000303	0.90	76.86	37.86	0.11
CaneyCreek_Trib1	5698	EX005YR	96.10	1093.46	1097.97	1094.96	1097.99	0.000200	0.90	107.64	40.85	0.10
CaneyCreek_Trib1	5698	EX010YR	124.60	1093.46	1098.75	1095.19	1098.76	0.000147	0.91	141.18	46.31	0.09
CaneyCreek_Trib1	5698	EX025YR	164.20	1093.46	1099.30	1095.46	1099.31	0.000156	1.03	167.86	50.58	0.09
CaneyCreek_Trib1	5698	EX050YR	194.90	1093.46	1099.49	1095.69	1099.51	0.000188	1.16	178.01	55.20	0.10
CaneyCreek_Trib1	5698	EX100YR	226.10	1093.46	1099.65	1095.97	1099.68	0.000222	1.30	187.18	57.56	0.11
CaneyCreek_Trib1	5698	EX500YR	303.90	1093.46	1099.97	1096.27	1100.01	0.000314	1.62	206.39	62.37	0.13
CaneyCreek_Trib1	5698	EX001YR	44.40	1093.46	1096.38	1094.43	1096.40	0.000472	0.92	48.27	32.30	0.13
CaneyCreek_Trib1	5681		Culvert									
CaneyCreek_Trib1	5661	EX002YR	69.20	1093.02	1094.70		1094.88	0.008496	3.35	20.68	17.40	0.54
CaneyCreek_Trib1	5661	EX005YR	96.10	1093.02	1095.01		1095.22	0.008221	3.65	26.33	18.88	0.54
CaneyCreek_Trib1	5661	EX010YR	124.60	1093.02	1095.28		1095.52	0.008231	3.94	31.62	20.16	0.55
CaneyCreek_Trib1	5661	EX025YR	164.20	1093.02	1095.61		1095.89	0.008297	4.28	38.36	21.63	0.57
CaneyCreek_Trib1	5661	EX050YR	194.90	1093.02	1095.83		1096.14	0.008334	4.50	43.31	22.68	0.57

HEC-RAS Plan: Existing River: CaneyCreek_Trib1 Reach: CaneyCreek_Trib1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CaneyCreek_Trib1	5661	EX100YR	226.10	1093.02	1096.01		1096.36	0.008395	4.76	47.51	23.40	0.58
CaneyCreek_Trib1	5661	EX500YR	303.90	1093.02	1096.40		1096.85	0.008529	5.38	57.00	25.39	0.60
CaneyCreek_Trib1	5661	EX001YR	44.40	1093.02	1094.35		1094.49	0.008959	2.97	14.94	15.72	0.54
CaneyCreek_Trib1	5553.07	EX002YR	69.20	1091.14	1092.78	1092.76	1093.23	0.029775	5.39	12.84	13.51	0.97
CaneyCreek_Trib1	5553.07	EX005YR	96.10	1091.14	1093.01	1093.01	1093.57	0.030791	6.03	15.94	14.46	1.01
CaneyCreek_Trib1	5553.07	EX010YR	124.60	1091.14	1093.23	1093.23	1093.88	0.029878	6.45	19.33	15.42	1.01
CaneyCreek_Trib1	5553.07	EX025YR	164.20	1091.14	1093.53	1093.53	1094.25	0.028622	6.80	24.15	17.17	1.01
CaneyCreek_Trib1	5553.07	EX050YR	194.90	1091.14	1093.73	1093.73	1094.50	0.028077	7.02	27.75	18.49	1.01
CaneyCreek_Trib1	5553.07	EX100YR	226.10	1091.14	1093.92	1093.92	1094.73	0.027499	7.22	31.33	19.72	1.01
CaneyCreek_Trib1	5553.07	EX500YR	303.90	1091.14	1094.34	1094.34	1095.23	0.026477	7.53	40.35	23.14	1.01
CaneyCreek_Trib1	5553.07	EX001YR	44.40	1091.14	1092.53	1092.47	1092.86	0.027699	4.63	9.59	12.03	0.91
CaneyCreek_Trib1	5377.31	EX002YR	69.20	1088.13	1089.37	1089.14	1089.59	0.014818	3.70	18.72	20.98	0.69
CaneyCreek_Trib1	5377.31	EX005YR	96.10	1088.13	1089.61	1089.34	1089.86	0.014268	4.03	23.84	22.74	0.69
CaneyCreek_Trib1	5377.31	EX010YR	124.60	1088.13	1089.83	1089.52	1090.11	0.013785	4.30	28.96	24.37	0.70
CaneyCreek_Trib1	5377.31	EX025YR	164.20	1088.13	1090.10		1090.42	0.013189	4.58	35.83	26.48	0.69
CaneyCreek_Trib1	5377.31	EX050YR	194.90	1088.13	1090.29		1090.64	0.012937	4.75	41.02	28.27	0.70
CaneyCreek_Trib1	5377.31	EX100YR	226.10	1088.13	1090.47		1090.84	0.012438	4.86	46.51	30.06	0.69
CaneyCreek_Trib1	5377.31	EX500YR	303.90	1088.13	1090.90		1091.30	0.011588	5.04	60.31	35.00	0.68
CaneyCreek_Trib1	5377.31	EX001YR	44.40	1088.13	1089.11	1088.91	1089.28	0.015302	3.29	13.50	18.48	0.68
CaneyCreek_Trib1	5191.75	EX002YR	69.20	1083.13	1085.04	1085.04	1085.63	0.032622	6.17	11.22	9.68	1.01
CaneyCreek_Trib1	5191.75	EX005YR	96.10	1083.13	1085.35	1085.35	1086.04	0.031355	6.66	14.44	10.71	1.01
CaneyCreek_Trib1	5191.75	EX010YR	124.60	1083.13	1085.64	1085.64	1086.41	0.030282	7.05	17.68	11.66	1.01
CaneyCreek_Trib1	5191.75	EX025YR	164.20	1083.13	1085.99	1085.99	1086.86	0.029282	7.49	21.91	12.80	1.01
CaneyCreek_Trib1	5191.75	EX050YR	194.90	1083.13	1086.23	1086.23	1087.17	0.028196	7.74	25.17	13.54	1.00
CaneyCreek_Trib1	5191.75	EX100YR	226.10	1083.13	1086.44	1086.44	1087.45	0.028128	8.06	28.05	14.13	1.01
CaneyCreek_Trib1	5191.75	EX500YR	303.90	1083.13	1086.93	1086.93	1088.08	0.027005	8.61	35.30	15.51	1.01
CaneyCreek_Trib1	5191.75	EX001YR	44.40	1083.13	1084.68	1084.68	1085.16	0.034578	5.56	7.99	8.48	1.01
CaneyCreek_Trib1	5072.99	EX002YR	69.20	1077.06	1079.32		1079.50	0.007523	3.41	20.28	14.80	0.51
CaneyCreek_Trib1	5072.99	EX005YR	96.10	1077.06	1079.74		1079.94	0.006673	3.57	26.92	16.70	0.50
CaneyCreek_Trib1	5072.99	EX010YR	124.60	1077.06	1080.13		1080.34	0.006055	3.68	33.82	18.56	0.48
CaneyCreek_Trib1	5072.99	EX025YR	164.20	1077.06	1080.61		1080.84	0.005423	3.79	43.31	20.92	0.46
CaneyCreek_Trib1	5072.99	EX050YR	194.90	1077.06	1080.94		1081.17	0.005121	3.87	50.41	22.64	0.46
CaneyCreek_Trib1	5072.99	EX100YR	226.10	1077.06	1081.27		1081.50	0.004736	3.89	58.12	24.38	0.44
CaneyCreek_Trib1	5072.99	EX500YR	303.90	1077.06	1082.13		1082.35	0.003511	3.75	81.00	28.59	0.39
CaneyCreek_Trib1	5072.99	EX001YR	44.40	1077.06	1079.41		1079.47	0.002610	2.06	21.58	15.19	0.30
CaneyCreek_Trib1	4979	EX002YR	69.20	1075.72	1077.94		1078.40	0.019442	5.46	12.67	8.01	0.77
CaneyCreek_Trib1	4979	EX005YR	96.10	1075.72	1078.30		1078.88	0.020885	6.12	15.70	8.70	0.80
CaneyCreek_Trib1	4979	EX010YR	124.60	1075.72	1078.62		1079.32	0.022099	6.70	18.61	9.27	0.83
CaneyCreek_Trib1	4979	EX025YR	164.20	1075.72	1079.01	1078.76	1079.85	0.023350	7.35	22.33	9.92	0.86
CaneyCreek_Trib1	4979	EX050YR	194.90	1075.72	1079.40		1080.25	0.021128	7.41	26.29	10.56	0.83
CaneyCreek_Trib1	4979	EX100YR	226.10	1075.72	1079.91		1080.69	0.016860	7.08	31.92	11.40	0.75
CaneyCreek_Trib1	4979	EX500YR	303.90	1075.72	1081.19		1081.78	0.010740	6.15	49.45	16.12	0.62
CaneyCreek_Trib1	4979	EX001YR	44.40	1075.72	1079.25		1079.30	0.001293	1.79	24.74	10.31	0.20
CaneyCreek_Trib1	4943.49*	EX002YR	69.20	1075.13	1077.30		1077.72	0.018254	5.18	13.36	9.43	0.77
CaneyCreek_Trib1	4943.49*	EX005YR	96.10	1075.13	1077.69		1078.17	0.017553	5.59	17.19	10.36	0.76
CaneyCreek_Trib1	4943.49*	EX010YR	124.60	1075.13	1078.04		1078.59	0.016976	5.93	21.01	11.18	0.76
CaneyCreek_Trib1	4943.49*	EX025YR	164.20	1075.13	1078.50		1079.10	0.015893	6.24	26.33	12.21	0.75
CaneyCreek_Trib1	4943.49*	EX050YR	194.90	1075.13	1079.11		1079.61	0.011279	5.68	34.31	14.09	0.64
CaneyCreek_Trib1	4943.49*	EX100YR	226.10	1075.13	1079.78		1080.18	0.007649	5.07	44.60	16.23	0.54
CaneyCreek_Trib1	4943.49*	EX500YR	303.90	1075.13	1081.17		1081.46	0.004210	4.33	70.11	20.60	0.41
CaneyCreek_Trib1	4943.49*	EX001YR	44.40	1075.13	1079.24		1079.26	0.000509	1.23	36.23	14.53	0.14
CaneyCreek_Trib1	4907.98*	EX002YR	69.20	1074.55	1077.09		1077.28	0.006664	3.46	20.01	12.60	0.48
CaneyCreek_Trib1	4907.98*	EX005YR	96.10	1074.55	1077.51		1077.73	0.006557	3.76	25.57	13.92	0.49
CaneyCreek_Trib1	4907.98*	EX010YR	124.60	1074.55	1077.90		1078.14	0.006468	3.99	31.23	15.32	0.49
CaneyCreek_Trib1	4907.98*	EX025YR	164.20	1074.55	1078.40		1078.67	0.005952	4.17	39.36	16.83	0.48
CaneyCreek_Trib1	4907.98*	EX050YR	194.90	1074.55	1079.07		1079.30	0.004074	3.80	51.36	18.91	0.41
CaneyCreek_Trib1	4907.98*	EX100YR	226.10	1074.55	1079.78		1079.96	0.002854	3.46	65.41	21.09	0.35
CaneyCreek_Trib1	4907.98*	EX500YR	303.90	1074.55	1081.18		1081.33	0.001779	3.09	98.26	26.17	0.28
CaneyCreek_Trib1	4907.98*	EX001YR	44.40	1074.55	1079.24		1079.25	0.000180	0.81	54.52	19.42	0.09
CaneyCreek_Trib1	4872.47	EX002YR	116.60	1073.96	1076.04	1076.04	1076.70	0.029800	6.52	17.87	13.85	1.01
CaneyCreek_Trib1	4872.47	EX005YR	162.00	1073.96	1076.39	1076.39	1077.16	0.028332	7.04	23.01	15.21	1.01
CaneyCreek_Trib1	4872.47	EX010YR	210.00	1073.96	1076.71	1076.71	1077.58	0.027335	7.48	28.09	16.45	1.01
CaneyCreek_Trib1	4872.47	EX025YR	276.50	1073.96	1077.88		1078.37	0.009675	5.59	49.45	20.10	0.63
CaneyCreek_Trib1	4872.47	EX050YR	328.00	1073.96	1078.74		1079.11	0.005686	4.82	68.00	22.91	0.49
CaneyCreek_Trib1	4872.47	EX100YR	380.70	1073.96	1079.53		1079.83	0.003919	4.38	87.00	25.47	0.42
CaneyCreek_Trib1	4872.47	EX500YR	512.10	1073.96	1080.99		1081.24	0.002580	3.96	129.52	33.58	0.35
CaneyCreek_Trib1	4872.47	EX001YR	74.90	1073.96	1079.23		1079.24	0.000194	0.94	79.47	24.49	0.09
CaneyCreek_Trib1	4792	EX002YR	116.60	1071.22	1075.50	1073.21	1075.63	0.002857	2.93	39.74	13.99	0.31
CaneyCreek_Trib1	4792	EX005YR	162.00	1071.22	1075.90	1073.66	1076.09	0.003872	3.55	45.66	15.34	0.36
CaneyCreek_Trib1	4792	EX010YR	210.00	1071.22	1076.33	1074.12	1076.57	0.004221	4.01	53.64	24.29	0.39
CaneyCreek_Trib1	4792	EX025YR	276.50	1071.22	1077.85	1074.74	1078.00	0.001692	3.26	128.41	77.95	0.26
CaneyCreek_Trib1	4792	EX050YR	328.00	1071.22	1078.77	1075.14	1078.87	0.000987	2.79	203.95	93.55	0.20
CaneyCreek_Trib1	4792	EX100YR	380.70	1071.22	1079.58	1075.51	1079.65	0.000686	2.54	271.83	105.47	0.17
CaneyCreek_Trib1	4792	EX500YR	512.10	1071.22	1081.05	1076.25	1081.11	0.000461	2.38	400.11	123.44	0.15
CaneyCreek_Trib1	4792	EX001YR	74.90	1071.22	1079.23	1072.71	1079.23	0.000035	0.55	242.28	100.32	0.04
CaneyCreek_Trib1	4754	EX002YR	116.60	1071.22	1075.37	1073.79	1075.51	0.003233	3.00	43.37	27.81	0.34
CaneyCreek_Trib1	4754	EX005YR	162.00	1071.22	1075.76	1074.46	1075.94	0.003577	3.50	54.81	32.80	0.37
CaneyCreek_Trib1	4754	EX010YR	210.00	1071.22	1076.20	1074.76	1076.41	0.003448	3.79	68.54	64.98	0.37
CaneyCreek_Trib1	4754	EX025YR	276.50	1071.22	1077.80	1075.16	1077.93	0.001287	3.03	119.13	95.20	0.24
CaneyCreek_Trib1	4754	EX050YR	328.00	1071.22	1078.71	1075.45	1078.82	0.000951	2.93	147.86	106.79	0.22
CaneyCreek_Trib1	4754	EX100YR	380.70	1071.22	1079.50	1075.71	1079.61	0.000798	2.92	172.70	114.67	0.20
CaneyCreek_Trib1	4754	EX500YR	512.10	1071.22	1080.94	1076.22	1081.06	0.000698	3.12	218.20	127.39	0.20
CaneyCreek_Trib1	4754	EX001YR	74.90	1071.22	1079.23	1073.23	1079.23	0.000036	0.60	164.08	112.12	0.04
CaneyCreek_Trib1	4745		Inl Struct									
CaneyCreek_Trib1	4736	EX002YR	116.60	1071.02	1073.33	1072.65	1073.63	0.009116	4.44	26.27	13.41	0.56
CaneyCreek_Trib1	4736	EX005YR	162.00	1071.02	1073.83	1073.01	1074.20	0.008938	4.88	33.19	14.14	0.56
CaneyCreek_Trib1	4736	EX010YR	210.00	1071.02	1074.31	1073.33	1074.73	0.009104	5.21	40.31	15.81	0.58

HEC-RAS Plan: Existing River: CaneyCreek_Trib1 Reach: CaneyCreek_Trib1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CaneyCreek_Trib1	4736	EX025YR	276.50	1071.02	1074.89	1073.77	1075.36	0.009163	5.51	50.21	18.45	0.59
CaneyCreek_Trib1	4736	EX050YR	328.00	1071.02	1075.26	1074.07	1075.77	0.009154	5.72	57.32	19.95	0.59
CaneyCreek_Trib1	4736	EX100YR	380.70	1071.02	1075.60	1074.40	1076.14	0.009127	5.92	64.35	21.33	0.60
CaneyCreek_Trib1	4736	EX500YR	512.10	1071.02	1076.30	1075.10	1076.93	0.008666	6.37	81.77	61.97	0.60
CaneyCreek_Trib1	4736	EX001YR	74.90	1071.02	1072.78	1072.24	1073.02	0.009546	3.91	19.17	12.62	0.56
CaneyCreek_Trib1	4668.22	EX002YR	116.60	1069.39	1071.63	1071.63	1072.44	0.031209	7.25	16.09	10.02	1.01
CaneyCreek_Trib1	4668.22	EX005YR	162.00	1069.39	1072.07	1072.07	1073.02	0.029982	7.81	20.74	11.07	1.01
CaneyCreek_Trib1	4668.22	EX010YR	210.00	1069.39	1072.48	1072.48	1073.53	0.028844	8.25	25.45	12.04	1.00
CaneyCreek_Trib1	4668.22	EX025YR	276.50	1069.39	1072.97	1072.97	1074.14	0.028346	8.68	31.86	13.80	1.01
CaneyCreek_Trib1	4668.22	EX050YR	328.00	1069.39	1073.31	1073.31	1074.55	0.027790	8.93	36.73	15.04	1.01
CaneyCreek_Trib1	4668.22	EX100YR	380.70	1069.39	1073.62	1073.62	1074.92	0.027336	9.17	41.53	16.17	1.01
CaneyCreek_Trib1	4668.22	EX500YR	512.10	1069.39	1074.25	1074.25	1075.73	0.026941	9.75	52.54	19.06	1.02
CaneyCreek_Trib1	4668.22	EX001YR	74.90	1069.39	1071.14	1071.14	1071.80	0.032516	6.50	11.53	8.87	1.00
CaneyCreek_Trib1	4577.09	EX002YR	268.60	1064.64	1069.34	1068.18	1069.75	0.007178	5.13	52.33	18.52	0.54
CaneyCreek_Trib1	4577.09	EX005YR	362.60	1064.64	1069.94	1068.69	1070.44	0.007930	5.65	64.15	21.26	0.57
CaneyCreek_Trib1	4577.09	EX010YR	460.80	1064.64	1070.50	1069.17	1071.06	0.008245	5.99	76.93	24.22	0.59
CaneyCreek_Trib1	4577.09	EX025YR	595.90	1064.64	1071.17	1069.80	1071.79	0.008206	6.32	94.33	28.22	0.60
CaneyCreek_Trib1	4577.09	EX050YR	699.30	1064.64	1071.62	1070.19	1072.29	0.007769	6.54	108.30	37.54	0.59
CaneyCreek_Trib1	4577.09	EX100YR	804.00	1064.64	1072.02	1070.59	1072.71	0.007350	6.74	132.22	82.11	0.59
CaneyCreek_Trib1	4577.09	EX500YR	1063.00	1064.64	1073.35	1071.38	1073.82	0.003883	5.90	286.92	160.06	0.45
CaneyCreek_Trib1	4577.09	EX001YR	181.10	1064.64	1068.68	1067.60	1068.99	0.006475	4.45	40.69	16.65	0.50
CaneyCreek_Trib1	4554.49		Bridge									
CaneyCreek_Trib1	4527.66	EX002YR	268.60	1064.53	1068.58		1069.16	0.012604	6.13	43.97	20.37	0.71
CaneyCreek_Trib1	4527.66	EX005YR	362.60	1064.53	1069.03	1068.52	1069.77	0.012495	6.89	54.18	24.46	0.73
CaneyCreek_Trib1	4527.66	EX010YR	460.80	1064.53	1069.43	1068.92	1070.32	0.012682	7.59	64.74	28.92	0.75
CaneyCreek_Trib1	4527.66	EX025YR	595.90	1064.53	1069.63	1069.47	1070.92	0.017132	9.19	70.81	32.23	0.88
CaneyCreek_Trib1	4527.66	EX050YR	699.30	1064.53	1069.87	1069.87	1071.38	0.018440	9.98	79.01	36.05	0.93
CaneyCreek_Trib1	4527.66	EX100YR	804.00	1064.53	1070.24	1070.24	1071.81	0.017067	10.25	93.24	41.60	0.91
CaneyCreek_Trib1	4527.66	EX500YR	1063.00	1064.53	1071.02	1071.02	1072.71	0.015042	10.85	133.63	62.85	0.88
CaneyCreek_Trib1	4527.66	EX001YR	181.10	1064.53	1067.99		1068.46	0.012949	5.50	32.94	17.22	0.70
CaneyCreek_Trib1	4343.95	EX002YR	326.60	1060.93	1064.56	1064.56	1065.65	0.026190	8.40	38.90	18.11	1.01
CaneyCreek_Trib1	4343.95	EX005YR	439.30	1060.93	1065.06	1065.06	1066.34	0.025111	9.06	48.54	20.06	1.01
CaneyCreek_Trib1	4343.95	EX010YR	557.90	1060.93	1065.52	1065.52	1066.98	0.023123	9.72	58.05	22.42	1.00
CaneyCreek_Trib1	4343.95	EX025YR	721.00	1060.93	1066.31	1066.31	1067.75	0.016885	9.73	84.20	45.20	0.89
CaneyCreek_Trib1	4343.95	EX050YR	845.80	1060.93	1066.79	1066.79	1068.19	0.014428	9.75	112.00	70.19	0.84
CaneyCreek_Trib1	4343.95	EX100YR	972.10	1060.93	1067.37	1067.37	1068.56	0.010969	9.27	163.01	102.80	0.75
CaneyCreek_Trib1	4343.95	EX500YR	1284.50	1060.93	1068.07	1068.07	1069.21	0.009696	9.54	242.50	117.43	0.72
CaneyCreek_Trib1	4343.95	EX001YR	220.60	1060.93	1063.96	1063.96	1064.88	0.027036	7.67	28.78	15.80	1.00
CaneyCreek_Trib1	4037.49	EX002YR	326.60	1053.42	1056.96		1057.71	0.015294	6.92	47.43	21.48	0.80
CaneyCreek_Trib1	4037.49	EX005YR	439.30	1053.42	1057.42	1057.07	1058.36	0.015192	7.77	57.69	23.15	0.82
CaneyCreek_Trib1	4037.49	EX010YR	557.90	1053.42	1057.86	1057.52	1058.98	0.014924	8.49	68.19	24.24	0.83
CaneyCreek_Trib1	4037.49	EX025YR	721.00	1053.42	1058.42	1058.05	1059.75	0.014561	9.32	81.97	25.42	0.84
CaneyCreek_Trib1	4037.49	EX050YR	845.80	1053.42	1058.81	1058.44	1060.29	0.014360	9.87	92.00	26.24	0.85
CaneyCreek_Trib1	4037.49	EX100YR	972.10	1053.42	1059.17	1058.81	1060.81	0.014250	10.39	101.69	27.01	0.86
CaneyCreek_Trib1	4037.49	EX500YR	1284.50	1053.42	1059.77	1059.62	1061.96	0.016225	12.04	118.31	28.29	0.93
CaneyCreek_Trib1	4037.49	EX001YR	220.60	1053.42	1056.40		1056.98	0.016333	6.14	35.92	19.24	0.79
CaneyCreek_Trib1	3791.59	EX002YR	326.60	1049.27	1053.65		1054.33	0.012229	6.59	49.60	18.23	0.70
CaneyCreek_Trib1	3791.59	EX005YR	439.30	1049.27	1054.22		1055.06	0.011799	7.34	60.23	19.16	0.71
CaneyCreek_Trib1	3791.59	EX010YR	557.90	1049.27	1054.78		1055.76	0.011330	7.97	71.17	20.34	0.71
CaneyCreek_Trib1	3791.59	EX025YR	721.00	1049.27	1055.48		1056.64	0.010745	8.68	86.82	24.77	0.71
CaneyCreek_Trib1	3791.59	EX050YR	845.80	1049.27	1055.99	1055.01	1057.26	0.010291	9.11	101.16	33.73	0.71
CaneyCreek_Trib1	3791.59	EX100YR	972.10	1049.27	1056.45	1055.44	1057.82	0.010013	9.51	119.76	51.98	0.71
CaneyCreek_Trib1	3791.59	EX500YR	1284.50	1049.27	1057.40	1056.70	1058.82	0.009016	10.03	204.31	134.24	0.69
CaneyCreek_Trib1	3791.59	EX001YR	220.60	1049.27	1052.94		1053.48	0.012456	5.92	37.25	16.19	0.69
CaneyCreek_Trib1	3704.71*	EX002YR	326.60	1048.09	1052.64		1053.30	0.011293	6.53	50.04	17.56	0.67
CaneyCreek_Trib1	3704.71*	EX005YR	439.30	1048.09	1053.28		1054.08	0.010535	7.20	61.60	18.73	0.67
CaneyCreek_Trib1	3704.71*	EX010YR	557.90	1048.09	1053.89		1054.83	0.009931	7.78	73.58	20.48	0.67
CaneyCreek_Trib1	3704.71*	EX025YR	721.00	1048.09	1054.67		1055.76	0.009271	8.42	90.95	24.82	0.67
CaneyCreek_Trib1	3704.71*	EX050YR	845.80	1048.09	1055.22	1053.99	1056.41	0.008814	8.82	107.28	35.66	0.66
CaneyCreek_Trib1	3704.71*	EX100YR	972.10	1048.09	1055.73	1054.41	1056.99	0.008454	9.15	131.72	60.19	0.66
CaneyCreek_Trib1	3704.71*	EX500YR	1284.50	1048.09	1056.21	1056.21	1057.95	0.010791	10.89	168.89	93.48	0.75
CaneyCreek_Trib1	3704.71*	EX001YR	220.60	1048.09	1051.89		1052.43	0.011801	5.88	37.52	15.72	0.67
CaneyCreek_Trib1	3617.84*	EX002YR	326.60	1046.92	1051.89		1052.45	0.008027	5.98	54.96	17.47	0.58
CaneyCreek_Trib1	3617.84*	EX005YR	439.30	1046.92	1052.58		1053.26	0.007753	6.65	67.49	19.11	0.58
CaneyCreek_Trib1	3617.84*	EX010YR	557.90	1046.92	1053.23		1054.04	0.007493	7.23	80.70	21.11	0.59
CaneyCreek_Trib1	3617.84*	EX025YR	721.00	1046.92	1054.06		1055.01	0.007196	7.89	100.01	27.57	0.59
CaneyCreek_Trib1	3617.84*	EX050YR	845.80	1046.92	1054.66	1052.96	1055.69	0.006848	8.25	123.88	54.54	0.59
CaneyCreek_Trib1	3617.84*	EX100YR	972.10	1046.92	1055.33	1053.38	1056.29	0.005839	8.17	185.29	132.66	0.55
CaneyCreek_Trib1	3617.84*	EX500YR	1284.50	1046.92	1055.64	1055.64	1056.98	0.007978	9.84	228.77	144.14	0.65
CaneyCreek_Trib1	3617.84*	EX001YR	220.60	1046.92	1051.07		1051.51	0.008874	5.35	41.26	15.78	0.58
CaneyCreek_Trib1	3530.97	EX002YR	356.70	1045.74	1049.83	1049.83	1051.16	0.027386	9.26	38.52	14.70	1.01
CaneyCreek_Trib1	3530.97	EX005YR	482.70	1045.74	1050.47	1050.47	1052.02	0.025698	10.01	48.31	16.13	1.00
CaneyCreek_Trib1	3530.97	EX010YR	615.10	1045.74	1051.01	1051.01	1052.83	0.024311	10.84	57.42	17.35	1.00
CaneyCreek_Trib1	3530.97	EX025YR	799.20	1045.74	1051.75	1051.75	1053.85	0.022023	11.67	70.88	19.06	0.98
CaneyCreek_Trib1	3530.97	EX050YR	940.40	1045.74	1052.25	1052.25	1054.57	0.021168	12.28	80.64	20.24	0.98
CaneyCreek_Trib1	3530.97	EX100YR	1085.10	1045.74	1052.76	1052.76	1055.26	0.020018	12.77	91.59	22.63	0.97
CaneyCreek_Trib1	3530.97	EX500YR	1442.40	1045.74	1054.83	1054.83	1056.03	0.007729	9.85	311.16	166.27	0.63
CaneyCreek_Trib1	3530.97	EX001YR	248.20	1045.74	1049.43	1049.17	1050.32	0.020533	7.57	32.81	13.76	0.86
CaneyCreek_Trib1	3049.29	EX002YR	356.70	1040.83	1044.48		1044.80	0.006517	4.57	79.22	37.60	0.53
CaneyCreek_Trib1	3049.29	EX005YR	482.70	1040.83	1045.04		1045.42	0.005723	4.95	101.02	40.56	0.52
CaneyCreek_Trib1	3049.29	EX010YR	615.10	1040.83	1045.53		1045.97	0.005422	5.35	121.54	43.59	0.52
CaneyCreek_Trib1	3049.29	EX025YR	799.20	1040.83	1046.17		1046.68	0.005020	5.79	159.92	109.64	0.51
CaneyCreek_Trib1	3049.29	EX050YR	940.40	1040.83	1046.63		1047.13	0.004483	5.88	224.74	153.46	0.49
CaneyCreek_Trib1	3049.29	EX100YR	1085.10	1040.83	1047.06	1045.36	1047.54	0.003940	5.86	295.72	179.81	0.47
CaneyCreek_Trib1	3049.29	EX500YR	1442.40	1040.83	1047.14	1046.56	1047.93	0.006434	7.58	310.76	184.67	0.60
CaneyCreek_Trib1	3049.29	EX001YR	248.20	1040.83	1043.91		1044.19	0.008242	4.24	58.57	34.57	0.57
CaneyCreek_Trib1	2817.20	EX002YR	356.70	1038.02	1041.27	1041.17	1042.28	0.019904	8.11	45.27	21.78	0.92

HEC-RAS Plan: Existing River: CaneyCreek_Trib1 Reach: CaneyCreek_Trib1 (Continued)

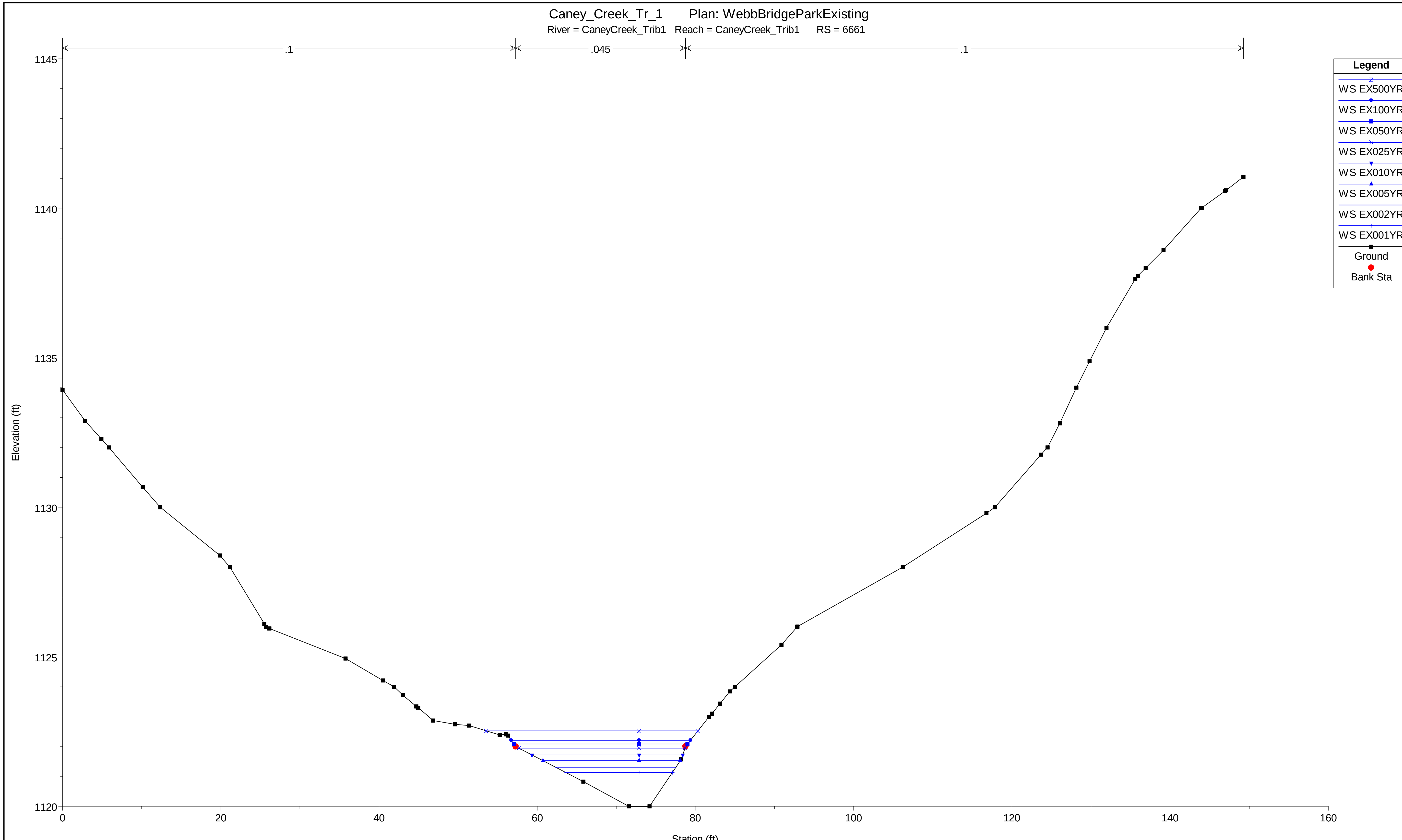
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CaneyCreek_Trib1	2817.20	EX005YR	482.70	1038.02	1041.68	1041.68	1043.01	0.021253	9.32	54.58	23.38	0.98
CaneyCreek_Trib1	2817.20	EX010YR	615.10	1038.02	1042.19	1042.19	1043.70	0.019440	9.96	67.09	25.51	0.96
CaneyCreek_Trib1	2817.20	EX025YR	799.20	1038.02	1042.82	1042.82	1044.56	0.017915	10.74	84.02	27.96	0.95
CaneyCreek_Trib1	2817.20	EX050YR	940.40	1038.02	1043.25	1043.25	1045.16	0.017355	11.31	96.50	30.68	0.95
CaneyCreek_Trib1	2817.20	EX100YR	1085.10	1038.02	1043.68	1043.68	1045.73	0.016535	11.76	110.44	33.54	0.94
CaneyCreek_Trib1	2817.20	EX500YR	1442.40	1038.02	1045.52	1045.52	1046.45	0.006178	8.91	391.57	281.60	0.61
CaneyCreek_Trib1	2817.20	EX001YR	248.20	1038.02	1040.97	1040.67	1041.62	0.015156	6.47	38.88	20.51	0.79
CaneyCreek_Trib1	2611.51	EX002YR	384.60	1035.99	1039.00	1038.76	1039.37	0.009715	5.27	114.82	115.00	0.64
CaneyCreek_Trib1	2611.51	EX005YR	522.70	1035.99	1039.35	1039.06	1039.74	0.009056	5.65	157.46	125.99	0.64
CaneyCreek_Trib1	2611.51	EX010YR	669.40	1035.99	1039.68	1039.31	1040.10	0.008528	5.97	201.73	154.82	0.63
CaneyCreek_Trib1	2611.51	EX025YR	873.80	1035.99	1040.09	1039.63	1040.53	0.008022	6.34	263.55	198.00	0.63
CaneyCreek_Trib1	2611.51	EX050YR	1033.30	1035.99	1040.37	1039.84	1040.82	0.007625	6.54	314.45	231.05	0.62
CaneyCreek_Trib1	2611.51	EX100YR	1195.60	1035.99	1040.62	1040.09	1041.11	0.007800	6.93	368.47	268.69	0.63
CaneyCreek_Trib1	2611.51	EX500YR	1598.30	1035.99	1041.21	1040.45	1041.67	0.006559	7.02	510.10	323.71	0.60
CaneyCreek_Trib1	2611.51	EX001YR	272.80	1035.99	1038.66	1038.40	1039.00	0.010362	4.84	78.14	102.78	0.65
CaneyCreek_Trib1	2516.23*	EX002YR	384.60	1034.76	1038.00	1037.66	1038.41	0.010503	5.27	90.35	82.45	0.66
CaneyCreek_Trib1	2516.23*	EX005YR	522.70	1034.76	1038.34		1038.83	0.010564	5.87	118.84	87.88	0.68
CaneyCreek_Trib1	2516.23*	EX010YR	669.40	1034.76	1038.64		1039.20	0.010722	6.42	145.96	93.54	0.70
CaneyCreek_Trib1	2516.23*	EX025YR	873.80	1034.76	1039.01	1038.67	1039.66	0.010770	7.02	185.16	116.90	0.72
CaneyCreek_Trib1	2516.23*	EX050YR	1033.30	1034.76	1039.27	1038.94	1039.97	0.010630	7.39	217.66	126.89	0.72
CaneyCreek_Trib1	2516.23*	EX100YR	1195.60	1034.76	1039.55	1039.18	1040.28	0.010233	7.65	253.72	138.24	0.72
CaneyCreek_Trib1	2516.23*	EX500YR	1598.30	1034.76	1040.12	1039.70	1040.92	0.009680	8.23	358.61	216.20	0.72
CaneyCreek_Trib1	2516.23*	EX001YR	272.80	1034.76	1037.66	1037.23	1038.00	0.010709	4.70	63.89	72.69	0.65
CaneyCreek_Trib1	2420.96*	EX002YR	384.60	1033.53	1037.00		1037.40	0.010872	5.11	82.98	79.40	0.66
CaneyCreek_Trib1	2420.96*	EX005YR	522.70	1033.53	1037.35		1037.82	0.010692	5.67	111.82	88.20	0.68
CaneyCreek_Trib1	2420.96*	EX010YR	669.40	1033.53	1037.64		1038.20	0.010778	6.20	138.66	92.70	0.69
CaneyCreek_Trib1	2420.96*	EX025YR	873.80	1033.53	1037.98	1037.66	1038.64	0.011159	6.87	173.05	117.95	0.72
CaneyCreek_Trib1	2420.96*	EX050YR	1033.30	1033.53	1038.20	1037.93	1038.94	0.011716	7.39	199.42	136.26	0.75
CaneyCreek_Trib1	2420.96*	EX100YR	1195.60	1033.53	1038.35	1038.15	1039.21	0.012939	8.02	222.29	170.07	0.79
CaneyCreek_Trib1	2420.96*	EX500YR	1598.30	1033.53	1038.67	1038.48	1039.80	0.015300	9.31	283.50	198.61	0.88
CaneyCreek_Trib1	2420.96*	EX001YR	272.80	1033.53	1036.64		1036.96	0.011177	4.58	59.62	38.98	0.65
CaneyCreek_Trib1	2325.69*	EX002YR	384.60	1032.31	1036.35		1036.61	0.006035	4.07	104.66	89.44	0.50
CaneyCreek_Trib1	2325.69*	EX005YR	522.70	1032.31	1036.53		1036.91	0.008255	5.02	121.12	99.28	0.59
CaneyCreek_Trib1	2325.69*	EX010YR	669.40	1032.31	1036.77	1036.26	1037.24	0.009090	5.65	149.64	130.71	0.63
CaneyCreek_Trib1	2325.69*	EX025YR	873.80	1032.31	1037.10	1036.69	1037.66	0.009505	6.27	201.26	192.15	0.66
CaneyCreek_Trib1	2325.69*	EX050YR	1033.30	1032.31	1037.33	1036.91	1037.93	0.009456	6.60	249.12	209.28	0.67
CaneyCreek_Trib1	2325.69*	EX100YR	1195.60	1032.31	1037.58	1037.34	1038.16	0.008774	6.69	300.62	211.52	0.65
CaneyCreek_Trib1	2325.69*	EX500YR	1598.30	1032.31	1038.13		1038.69	0.007531	6.88	418.41	215.86	0.62
CaneyCreek_Trib1	2325.69*	EX001YR	272.80	1032.31	1035.94		1036.15	0.006269	3.66	74.48	45.05	0.50
CaneyCreek_Trib1	2230.42	EX002YR	460.00	1031.08	1034.72	1034.68	1035.46	0.025199	6.91	66.59	42.79	0.98
CaneyCreek_Trib1	2230.42	EX005YR	625.30	1031.08	1035.74	1035.12	1036.12	0.008382	5.13	164.77	195.86	0.60
CaneyCreek_Trib1	2230.42	EX010YR	800.90	1031.08	1036.25		1036.55	0.005658	4.81	269.75	216.66	0.51
CaneyCreek_Trib1	2230.42	EX025YR	1045.30	1031.08	1036.71		1037.00	0.004746	4.88	371.50	221.41	0.48
CaneyCreek_Trib1	2230.42	EX050YR	1234.00	1031.08	1036.98		1037.28	0.004578	5.06	432.24	223.25	0.48
CaneyCreek_Trib1	2230.42	EX100YR	1425.70	1031.08	1037.25		1037.55	0.004418	5.21	491.23	225.04	0.47
CaneyCreek_Trib1	2230.42	EX500YR	1903.90	1031.08	1037.81		1038.14	0.004260	5.62	619.00	227.80	0.47
CaneyCreek_Trib1	2230.42	EX001YR	318.70	1031.08	1034.27	1034.27	1034.93	0.028127	6.52	48.87	37.21	1.00
CaneyCreek_Trib1	2083.69	EX002YR	460.00	1028.73	1035.04	1032.10	1035.07	0.000366	1.51	454.70	218.77	0.14
CaneyCreek_Trib1	2083.69	EX005YR	625.30	1028.73	1035.86	1032.40	1035.89	0.000297	1.55	638.40	226.64	0.13
CaneyCreek_Trib1	2083.69	EX010YR	800.90	1028.73	1036.31	1032.70	1036.35	0.000332	1.75	744.98	248.67	0.14
CaneyCreek_Trib1	2083.69	EX025YR	1045.30	1028.73	1036.74	1033.09	1036.78	0.000406	2.04	856.87	272.72	0.15
CaneyCreek_Trib1	2083.69	EX050YR	1234.00	1028.73	1036.99	1033.40	1037.05	0.000489	2.31	927.29	285.48	0.17
CaneyCreek_Trib1	2083.69	EX100YR	1425.70	1028.73	1037.24	1033.73	1037.31	0.000540	2.50	998.16	297.89	0.18
CaneyCreek_Trib1	2083.69	EX500YR	1903.90	1028.73	1037.78	1034.37	1037.88	0.000661	2.93	1152.30	311.36	0.20
CaneyCreek_Trib1	2083.69	EX001YR	318.70	1028.73	1032.32	1031.79	1032.55	0.008005	3.82	83.45	55.77	0.55
CaneyCreek_Trib1	1923.75	EX002YR	492.60	1026.55	1034.93	1030.08	1034.99	0.000480	1.94	266.97	85.39	0.16
CaneyCreek_Trib1	1923.75	EX005YR	672.20	1026.55	1035.74	1030.64	1035.81	0.000581	2.16	370.41	162.03	0.18
CaneyCreek_Trib1	1923.75	EX010YR	862.00	1026.55	1036.17	1031.15	1036.26	0.000683	2.48	440.06	168.34	0.19
CaneyCreek_Trib1	1923.75	EX025YR	1127.90	1026.55	1036.54	1031.76	1036.67	0.000879	2.96	505.14	177.51	0.22
CaneyCreek_Trib1	1923.75	EX050YR	1331.90	1026.55	1036.76	1032.17	1036.91	0.001053	3.32	543.97	187.02	0.24
CaneyCreek_Trib1	1923.75	EX100YR	1542.20	1026.55	1036.97	1032.57	1037.15	0.001220	3.66	584.59	207.43	0.27
CaneyCreek_Trib1	1923.75	EX500YR	2060.50	1026.55	1037.40	1033.46	1037.67	0.001623	4.43	680.33	228.76	0.31
CaneyCreek_Trib1	1923.75	EX001YR	341.00	1026.55	1031.84	1029.53	1031.98	0.001838	2.97	114.77	35.99	0.29
CaneyCreek_Trib1	1863.25		Culvert									
CaneyCreek_Trib1	1775.76	EX002YR	492.60	1025.25	1029.67		1029.96	0.004081	4.29	115.48	41.85	0.44
CaneyCreek_Trib1	1775.76	EX005YR	672.20	1025.25	1030.08		1030.49	0.004911	5.13	134.09	48.34	0.49
CaneyCreek_Trib1	1775.76	EX010YR	862.00	1025.25	1030.45		1030.99	0.005673	5.91	154.10	59.21	0.54
CaneyCreek_Trib1	1775.76	EX025YR	1127.90	1025.25	1030.90		1031.62	0.006532	6.84	182.32	66.10	0.59
CaneyCreek_Trib1	1775.76	EX050YR	1331.90	1025.25	1031.21		1032.05	0.007096	7.47	203.15	70.54	0.62
CaneyCreek_Trib1	1775.76	EX100YR	1542.20	1025.25	1031.50		1032.47	0.007599	8.05	224.44	76.29	0.65
CaneyCreek_Trib1	1775.76	EX500YR	2060.50	1025.25	1032.15	1031.28	1033.42	0.008542	9.29	284.86	114.37	0.70
CaneyCreek_Trib1	1775.76	EX001YR	341.00	1025.25	1029.24		1029.43	0.003284	3.47	98.21	38.53	0.38
CaneyCreek_Trib1	1648.77	EX002YR	492.60	1025.25	1029.28	1028.45	1029.44	0.003554	3.86	233.24	139.15	0.41
CaneyCreek_Trib1	1648.77	EX005YR	672.20	1025.25	1029.70	1028.73	1029.89	0.003612	4.27	292.70	143.00	0.42
CaneyCreek_Trib1	1648.77	EX010YR	862.00	1025.25	1030.09	1029.00	1030.30	0.003667	4.64	348.80	146.12	0.43
CaneyCreek_Trib1	1648.77	EX025YR	1127.90	1025.25	1030.58	1029.30	1030.82	0.003691	5.07	421.03	149.28	0.44
CaneyCreek_Trib1	1648.77	EX050YR	1331.90	1025.25	1030.91	1029.52	1031.18	0.003720	5.36	471.63	151.41	0.45
CaneyCreek_Trib1	1648.77	EX100YR	1542.20	1025.25	1031.24	1029.71	1031.53	0.003732	5.63	521.70	153.53	0.45
CaneyCreek_Trib1	1648.77	EX500YR	2060.50	1025.25	1031.98	1030.15	1032.32	0.003737	6.20	637.45	159.13	0.46
CaneyCreek_Trib1	1648.77	EX001YR	341.00	1025.25	1028.86	1028.14	1028.99	0.003471	3.43	175.91	133.63	0.39
CaneyCreek_Trib1	1230.63	EX002YR	492.60	1025.25	1027.23		1027.44	0.007046	3.68	133.87	87.06	0.52
CaneyCreek_Trib1	1230.63	EX005YR	672.20	1025.25	1027.48		1027.77	0.007856	4.30	156.38	87.91	0.57
CaneyCreek_Trib1	1230.63	EX010YR	862.00	1025.25	1027.72		1028.09	0.008570	4.88	177.15	88.68	0.60
CaneyCreek_Trib1	1230.63	EX025YR	1127.90	1025.25	1027.99		1028.48	0.009641	5.63	201.43	89.57	0.65
CaneyCreek_Trib1	1230.63	EX050YR	1331.90	1025.25	1028.17		1028.76	0.010509	6.17	217.27	90.15	0.69
CaneyCreek_Trib1	1230.63	EX100YR	1542.20	1025.25	1028.33		1029.03	0.011356	6.70	232.22	90.69	0.73
CaneyCreek_Trib1	1230.63	EX500YR	2060.50	1025.25	1028.68		1029.65	0.013456	7.91	263.69	91.94	0.81
CaneyCreek_Trib1	1230.63	EX001YR	341.00	1025.25	1026.96		1027.10	0.006324	3.09	110.49	86.10	0.48

HEC-RAS Plan: Existing River: CaneyCreek_Trib1 Reach: CaneyCreek_Trib1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CaneyCreek_Trib1	600.58	EX002YR	492.60	1025.25	1026.41		1026.43	0.000638	0.87	567.41	536.41	0.15
CaneyCreek_Trib1	600.58	EX005YR	672.20	1025.25	1026.57		1026.59	0.000747	1.03	652.93	538.07	0.16
CaneyCreek_Trib1	600.58	EX010YR	862.00	1025.25	1026.71		1026.73	0.000861	1.19	726.91	539.37	0.18
CaneyCreek_Trib1	600.58	EX025YR	1127.90	1025.25	1026.88		1026.91	0.000990	1.38	819.91	541.56	0.20
CaneyCreek_Trib1	600.58	EX050YR	1331.90	1025.25	1027.00		1027.04	0.001072	1.51	885.34	543.32	0.21
CaneyCreek_Trib1	600.58	EX100YR	1542.20	1025.25	1027.12		1027.16	0.001157	1.64	945.78	544.93	0.22
CaneyCreek_Trib1	600.58	EX500YR	2060.50	1025.25	1027.36		1027.41	0.001348	1.93	1077.60	553.51	0.24
CaneyCreek_Trib1	600.58	EX001YR	341.00	1025.25	1026.25		1026.26	0.000531	0.71	480.59	534.69	0.13
CaneyCreek_Trib1	136.73	EX002YR	492.60	1025.25	1025.73	1025.57	1025.76	0.005738	1.23	400.85	1164.06	0.37
CaneyCreek_Trib1	136.73	EX005YR	672.20	1025.25	1025.81	1025.61	1025.84	0.005743	1.39	483.00	1164.64	0.38
CaneyCreek_Trib1	136.73	EX010YR	862.00	1025.25	1025.87	1025.65	1025.91	0.005745	1.54	560.79	1165.18	0.39
CaneyCreek_Trib1	136.73	EX025YR	1127.90	1025.25	1025.96	1025.70	1026.00	0.005741	1.71	659.24	1165.87	0.40
CaneyCreek_Trib1	136.73	EX050YR	1331.90	1025.25	1026.02	1025.73	1026.07	0.005751	1.83	728.14	1166.35	0.41
CaneyCreek_Trib1	136.73	EX100YR	1542.20	1025.25	1026.07	1025.77	1026.13	0.005745	1.94	795.50	1166.82	0.41
CaneyCreek_Trib1	136.73	EX500YR	2060.50	1025.25	1026.20	1025.85	1026.28	0.005746	2.18	946.83	1167.88	0.43
CaneyCreek_Trib1	136.73	EX001YR	341.00	1025.25	1025.67	1025.53	1025.68	0.005737	1.06	321.44	1163.50	0.36

HEC-RAS Plan: Existing River: CaneyCrk Trib1b Reach: CaneyCrk Trib1b

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
CaneyCrk Trib1b	423	EX002YR	36.60	1124.00	1125.17	1125.17	1125.53	0.034220	4.84	7.62	11.61	1.00
CaneyCrk Trib1b	423	EX005YR	48.80	1124.00	1125.33	1125.33	1125.75	0.030840	5.25	9.68	13.86	0.98
CaneyCrk Trib1b	423	EX010YR	61.50	1124.00	1125.48	1125.48	1125.96	0.028122	5.58	11.99	16.02	0.96
CaneyCrk Trib1b	423	EX025YR	78.90	1124.00	1125.68	1125.68	1126.20	0.025200	5.92	15.39	18.74	0.94
CaneyCrk Trib1b	423	EX050YR	92.10	1124.00	1125.81	1125.81	1126.37	0.023802	6.15	17.96	20.26	0.93
CaneyCrk Trib1b	423	EX100YR	105.50	1124.00	1125.93	1125.93	1126.53	0.023006	6.39	20.43	21.36	0.92
CaneyCrk Trib1b	423	EX500YR	138.40	1124.00	1126.19	1126.19	1126.87	0.021681	6.91	26.33	23.86	0.92
CaneyCrk Trib1b	423	EX001YR	25.20	1124.00	1124.99	1124.99	1125.29	0.036822	4.39	5.74	9.67	1.00
CaneyCrk Trib1b	272	EX002YR	36.60	1116.00	1117.08	1117.08	1117.51	0.034624	5.27	6.95	8.11	1.00
CaneyCrk Trib1b	272	EX005YR	48.80	1116.00	1117.28	1117.28	1117.78	0.033627	5.69	8.58	8.66	1.01
CaneyCrk Trib1b	272	EX010YR	61.50	1116.00	1117.46	1117.46	1118.02	0.032688	6.03	10.20	9.17	1.01
CaneyCrk Trib1b	272	EX025YR	78.90	1116.00	1117.68	1117.68	1118.32	0.031610	6.40	12.32	9.80	1.01
CaneyCrk Trib1b	272	EX050YR	92.10	1116.00	1117.83	1117.83	1118.52	0.031448	6.67	13.82	10.26	1.01
CaneyCrk Trib1b	272	EX100YR	105.50	1116.00	1118.07	1118.07	1118.71	0.025205	6.44	17.21	24.58	0.92
CaneyCrk Trib1b	272	EX500YR	138.40	1116.00	1118.42	1118.42	1119.05	0.019627	6.53	27.22	32.56	0.84
CaneyCrk Trib1b	272	EX001YR	25.20	1116.00	1116.86	1116.86	1117.22	0.036619	4.80	5.25	7.43	1.01
CaneyCrk Trib1b	176	EX002YR	36.60	1112.00	1112.75	1112.75	1113.02	0.037363	4.14	8.84	16.75	1.00
CaneyCrk Trib1b	176	EX005YR	48.80	1112.00	1112.88	1112.88	1113.18	0.035877	4.42	11.04	18.42	1.01
CaneyCrk Trib1b	176	EX010YR	61.50	1112.00	1112.98	1112.98	1113.33	0.034629	4.70	13.10	20.10	1.01
CaneyCrk Trib1b	176	EX025YR	78.90	1112.00	1113.12	1113.12	1113.51	0.032246	5.02	15.92	22.52	1.00
CaneyCrk Trib1b	176	EX050YR	92.10	1112.00	1113.21	1113.21	1113.63	0.030706	5.23	18.10	24.22	0.99
CaneyCrk Trib1b	176	EX100YR	105.50	1112.00	1113.29	1113.29	1113.75	0.029493	5.44	20.19	25.79	0.98
CaneyCrk Trib1b	176	EX500YR	138.40	1112.00	1113.52	1113.52	1114.01	0.024442	5.70	27.29	41.40	0.93
CaneyCrk Trib1b	176	EX001YR	25.20	1112.00	1112.61	1112.61	1112.84	0.039522	3.80	6.63	14.89	1.00
CaneyCrk Trib1b	141	EX002YR	36.60	1106.55	1109.60	1107.91	1109.68	0.002819	2.26	16.17	7.36	0.27
CaneyCrk Trib1b	141	EX005YR	48.80	1106.55	1109.87	1108.17	1109.98	0.004431	2.66	18.35	10.54	0.35
CaneyCrk Trib1b	141	EX010YR	61.50	1106.55	1110.04	1108.41	1110.17	0.008363	2.96	21.50	33.84	0.48
CaneyCrk Trib1b	141	EX025YR	78.90	1106.55	1110.18	1108.72	1110.35	0.009207	3.34	26.40	36.75	0.51
CaneyCrk Trib1b	141	EX050YR	92.10	1106.55	1110.19	1108.93	1110.42	0.012054	3.85	26.93	37.05	0.59
CaneyCrk Trib1b	141	EX100YR	105.50	1106.55	1110.34	1109.13	1110.56	0.010681	3.89	32.57	40.11	0.56
CaneyCrk Trib1b	141	EX500YR	138.40	1106.55	1110.45	1109.62	1110.77	0.013669	4.63	37.44	42.58	0.64
CaneyCrk Trib1b	141	EX001YR	25.20	1106.55	1109.23	1107.63	1109.28	0.002030	1.85	13.65	6.54	0.23
CaneyCrk Trib1b	108		Culvert									
CaneyCrk Trib1b	91	EX002YR	36.60	1102.00	1103.00	1103.00	1103.42	0.035102	5.22	7.01	8.36	1.01
CaneyCrk Trib1b	91	EX005YR	48.80	1102.00	1103.26	1103.26	1103.68	0.034885	5.24	9.31	11.05	1.01
CaneyCrk Trib1b	91	EX010YR	61.50	1102.00	1103.42	1103.42	1103.89	0.033730	5.47	11.23	12.17	1.00
CaneyCrk Trib1b	91	EX025YR	78.90	1102.00	1103.61	1103.61	1104.13	0.033242	5.77	13.66	13.51	1.01
CaneyCrk Trib1b	91	EX050YR	92.10	1102.00	1103.73	1103.73	1104.29	0.032507	6.02	15.31	13.97	1.01
CaneyCrk Trib1b	91	EX100YR	105.50	1102.00	1103.85	1103.85	1104.45	0.031599	6.21	16.98	14.43	1.01
CaneyCrk Trib1b	91	EX500YR	138.40	1102.00	1104.10	1104.10	1104.79	0.030528	6.69	20.68	15.21	1.01
CaneyCrk Trib1b	91	EX001YR	25.20	1102.00	1102.79	1102.79	1103.14	0.036990	4.72	5.34	7.81	1.01
CaneyCrk Trib1b	64	EX002YR	36.60	1099.13	1100.54	1100.54	1101.10	0.038576	6.01	6.09	5.45	1.00
CaneyCrk Trib1b	64	EX005YR	48.80	1099.13	1100.79	1100.79	1101.44	0.037936	6.47	7.54	5.86	1.00
CaneyCrk Trib1b	64	EX010YR	61.50	1099.13	1101.03	1101.03	1101.76	0.037384	6.85	8.98	6.24	1.01
CaneyCrk Trib1b	64	EX025YR	78.90	1099.13	1101.32	1101.32	1102.14	0.036844	7.27	10.85	6.70	1.01
CaneyCrk Trib1b	64	EX050YR	92.10	1099.13	1101.52	1101.52	1102.40	0.036477	7.54	12.21	7.01	1.01
CaneyCrk Trib1b	64	EX100YR	105.50	1099.13	1101.71	1101.71	1102.65	0.036158	7.78	13.56	7.31	1.01
CaneyCrk Trib1b	64	EX500YR	138.40	1099.13	1102.13	1102.13	1103.18	0.035281	8.25	16.78	8.05	1.01
CaneyCrk Trib1b	64	EX001YR	25.20	1099.13	1100.25	1100.25	1100.72	0.039626	5.46	4.62	5.00	1.00
CaneyCrk Trib1b	9	EX002YR	36.60	1097.03	1098.80	1098.65	1099.24	0.029036	5.31	6.90	5.83	0.86
CaneyCrk Trib1b	9	EX005YR	48.80	1097.03	1099.07	1098.93	1099.57	0.029021	5.69	8.58	6.56	0.88
CaneyCrk Trib1b	9	EX010YR	61.50	1097.03	1099.31	1099.17	1099.87	0.029014	6.01	10.23	7.21	0.89
CaneyCrk Trib1b	9	EX025YR	78.90	1097.03	1099.59	1099.46	1100.22	0.029011	6.39	12.35	7.97	0.90
CaneyCrk Trib1b	9	EX050YR	92.10	1097.03	1099.78	1099.65	1100.46	0.029008	6.64	13.88	8.48	0.91
CaneyCrk Trib1b	9	EX100YR	105.50	1097.03	1099.95	1099.82	1100.68	0.029056	6.87	15.36	8.94	0.92
CaneyCrk Trib1b	9	EX500YR	138.40	1097.03	1100.32	1100.21	1101.15	0.029035	7.34	18.85	9.94	0.94
CaneyCrk Trib1b	9	EX001YR	25.20	1097.03	1098.49	1098.34	1098.85	0.029056	4.85	5.20	5.02	0.84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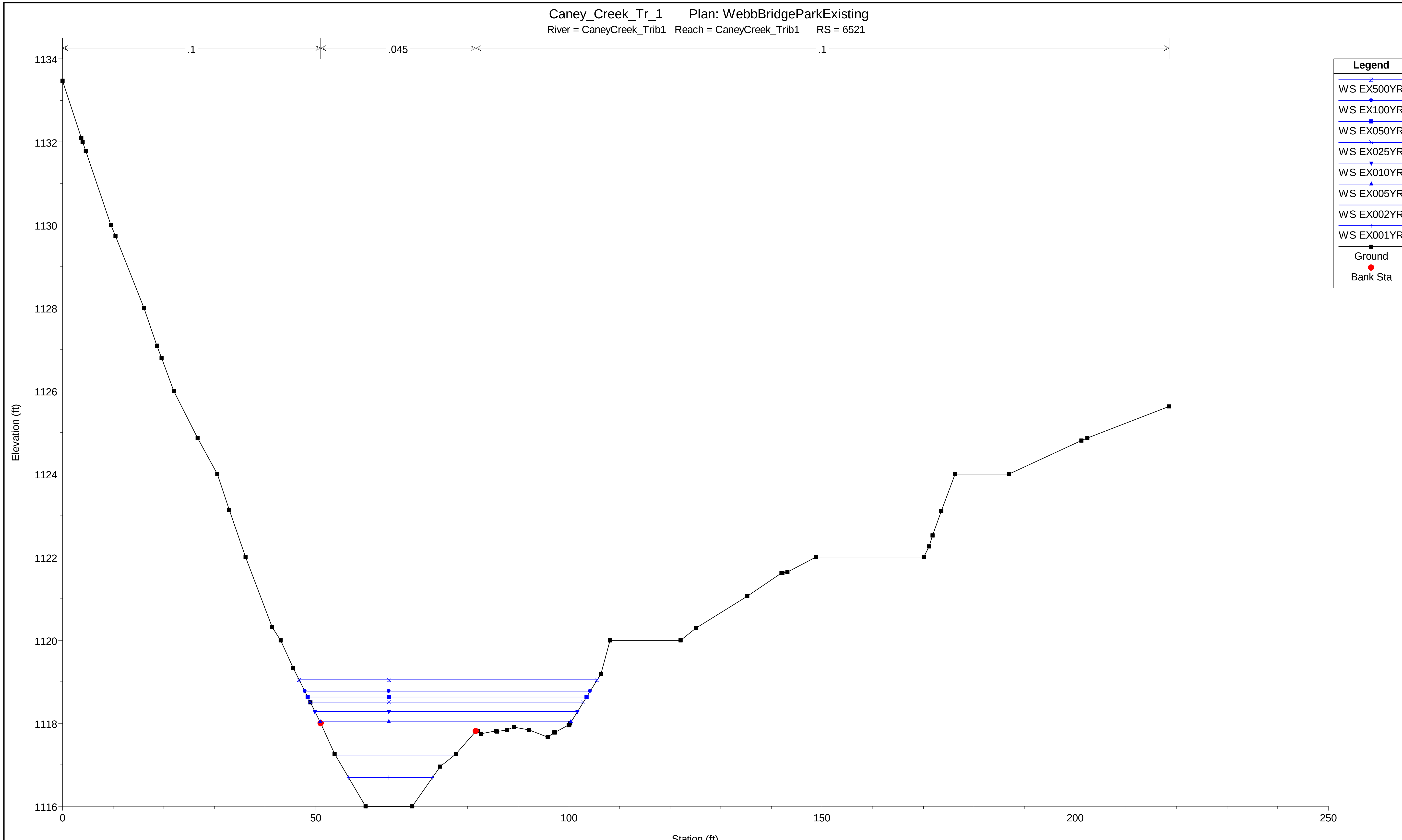
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6661
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1145
1140
1135
1130
1125
1120
0
20
40
60
80
100
120
140
160
Station (ft)



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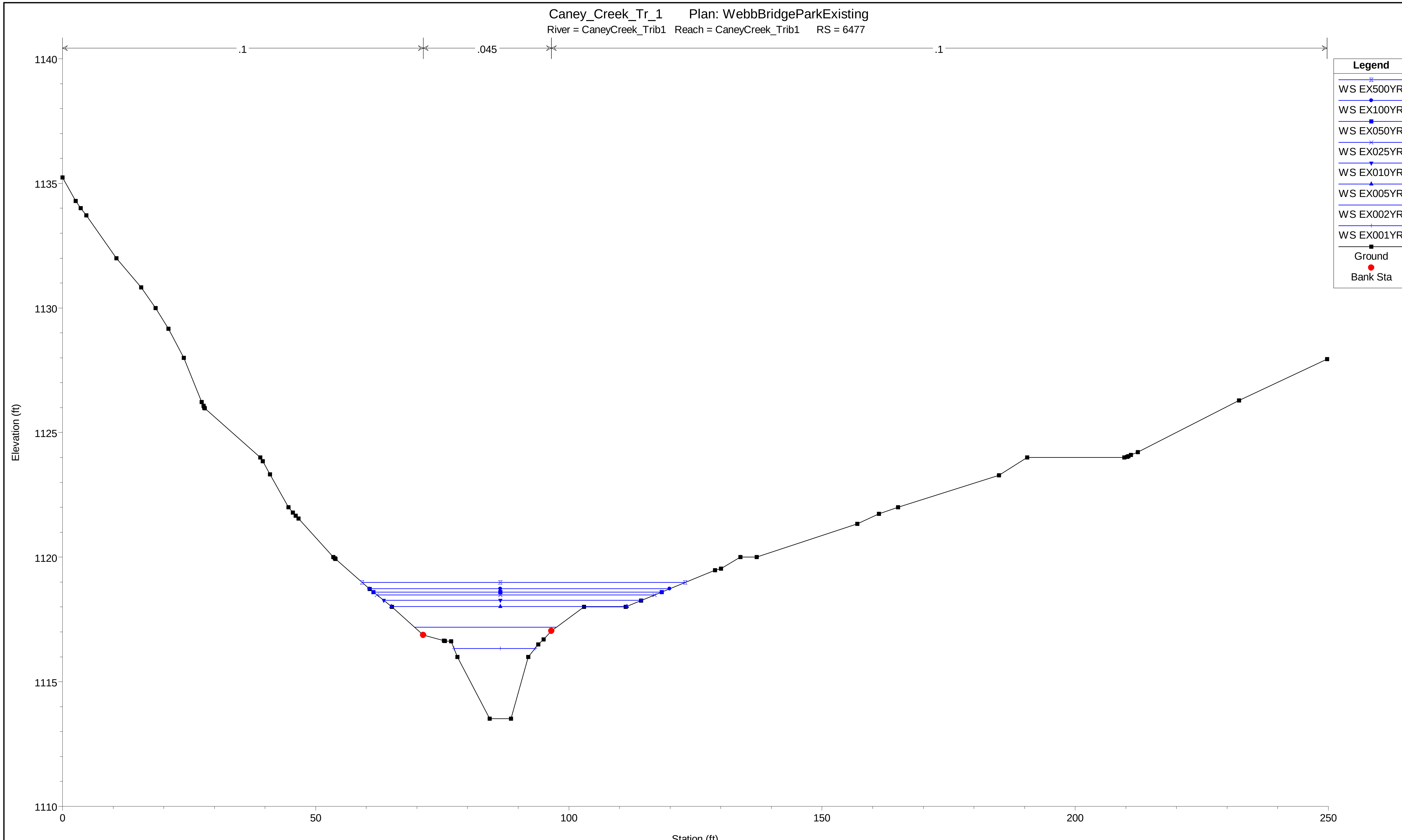
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6521
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1134
1132
1130
1128
1126
1124
1122
1120
1118
1116
Station (ft)
0
50
100
150
200
250



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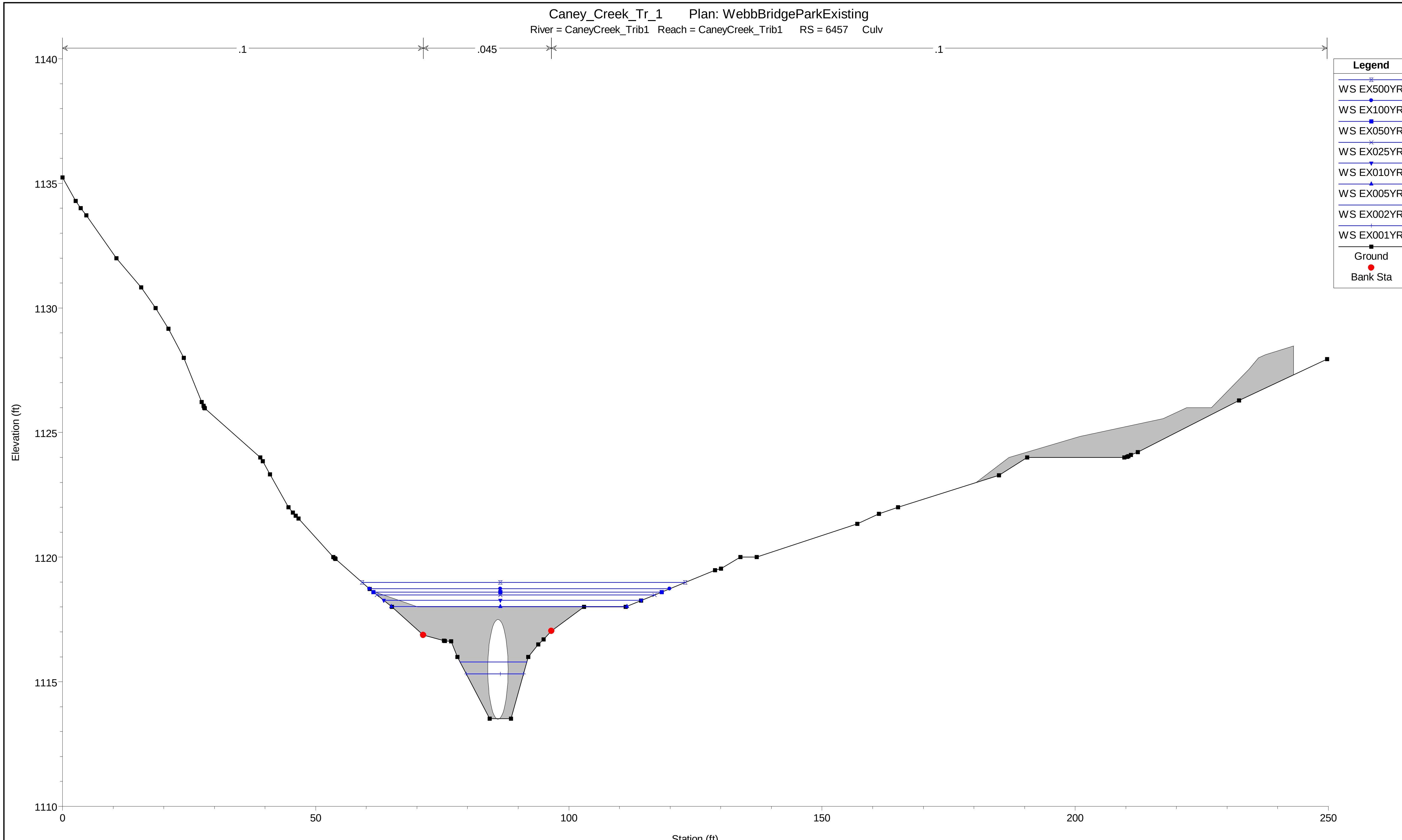
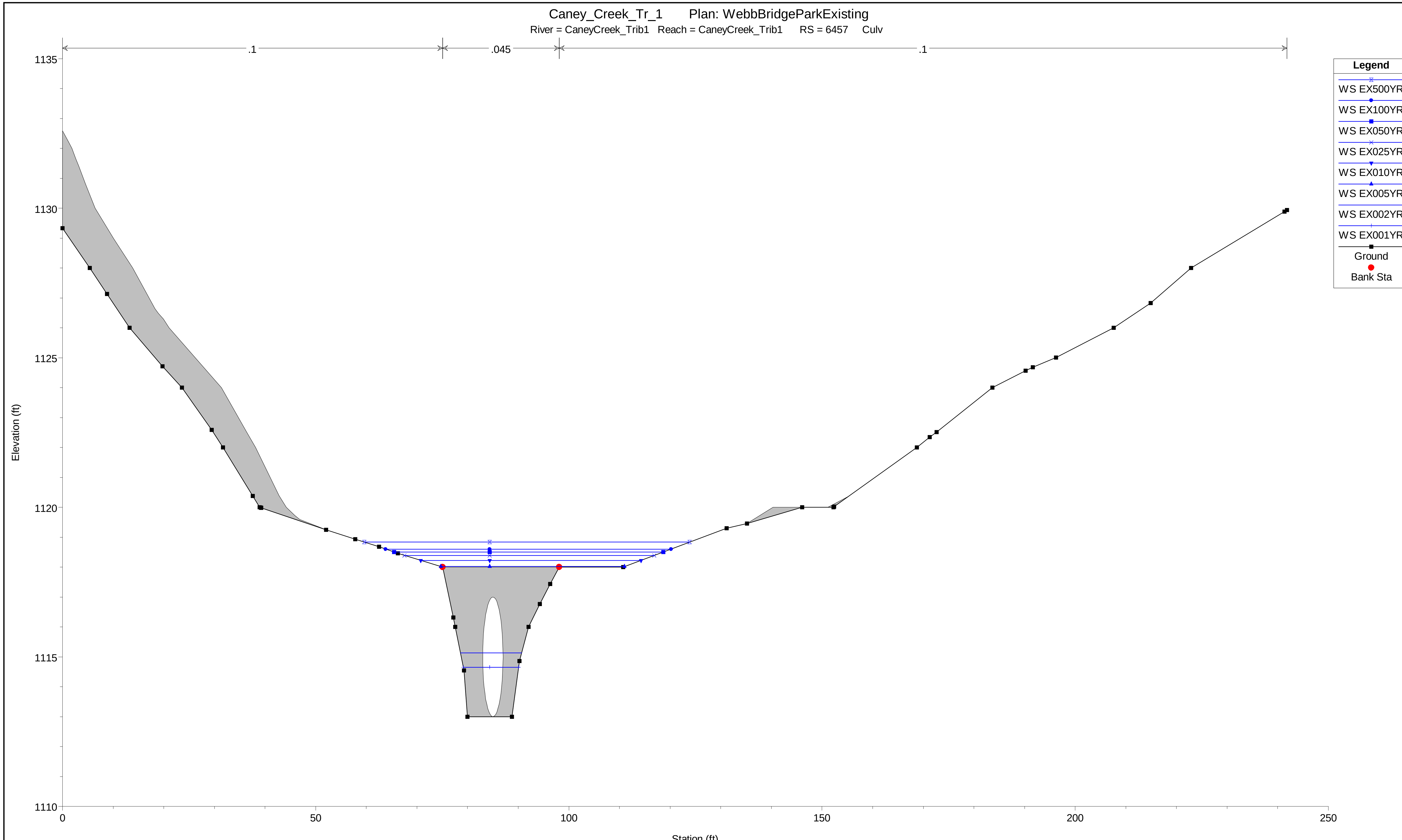
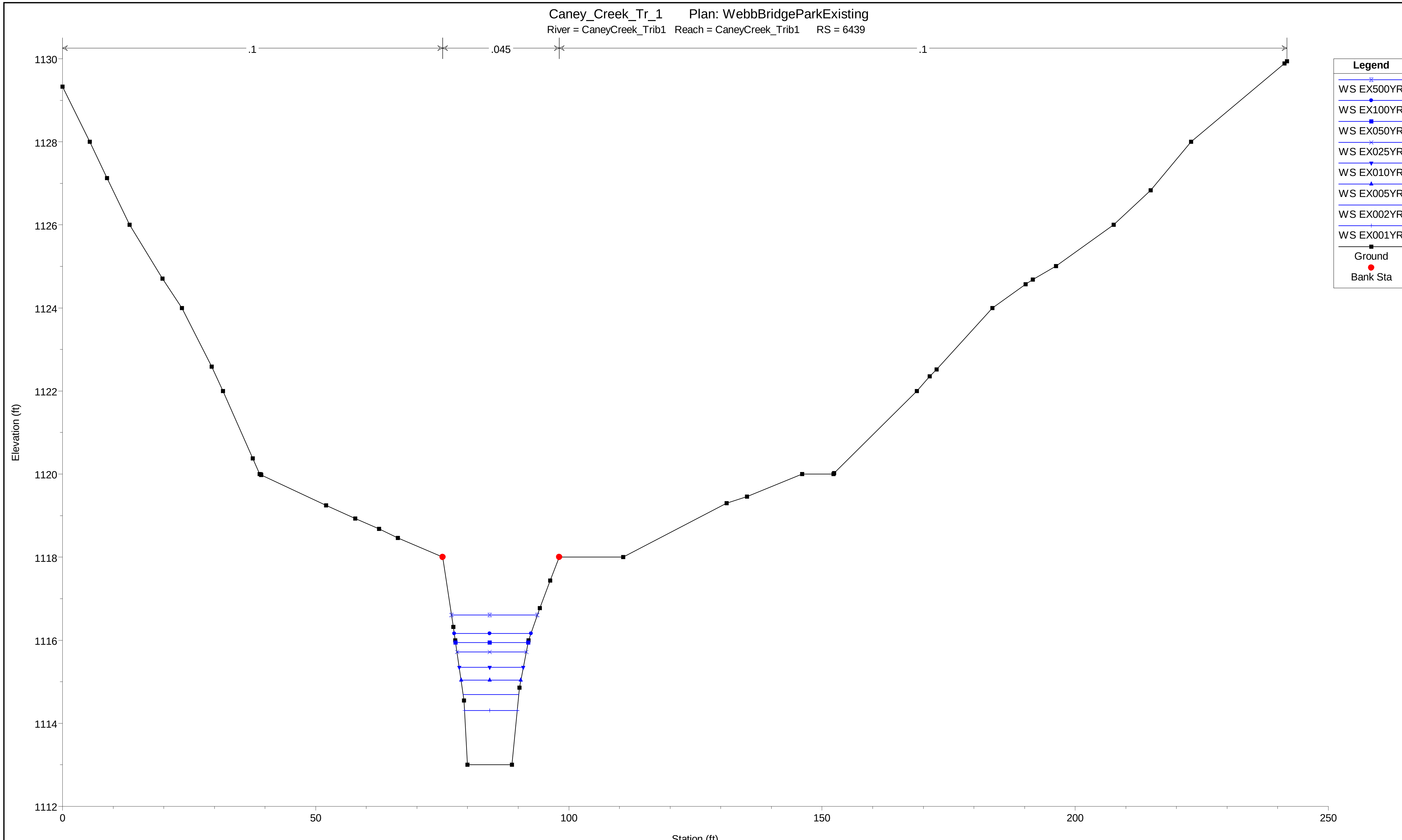
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6477
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1140
1135
1130
1125
1120
1115
1110
Station (ft)
0
50
100
150
200
250

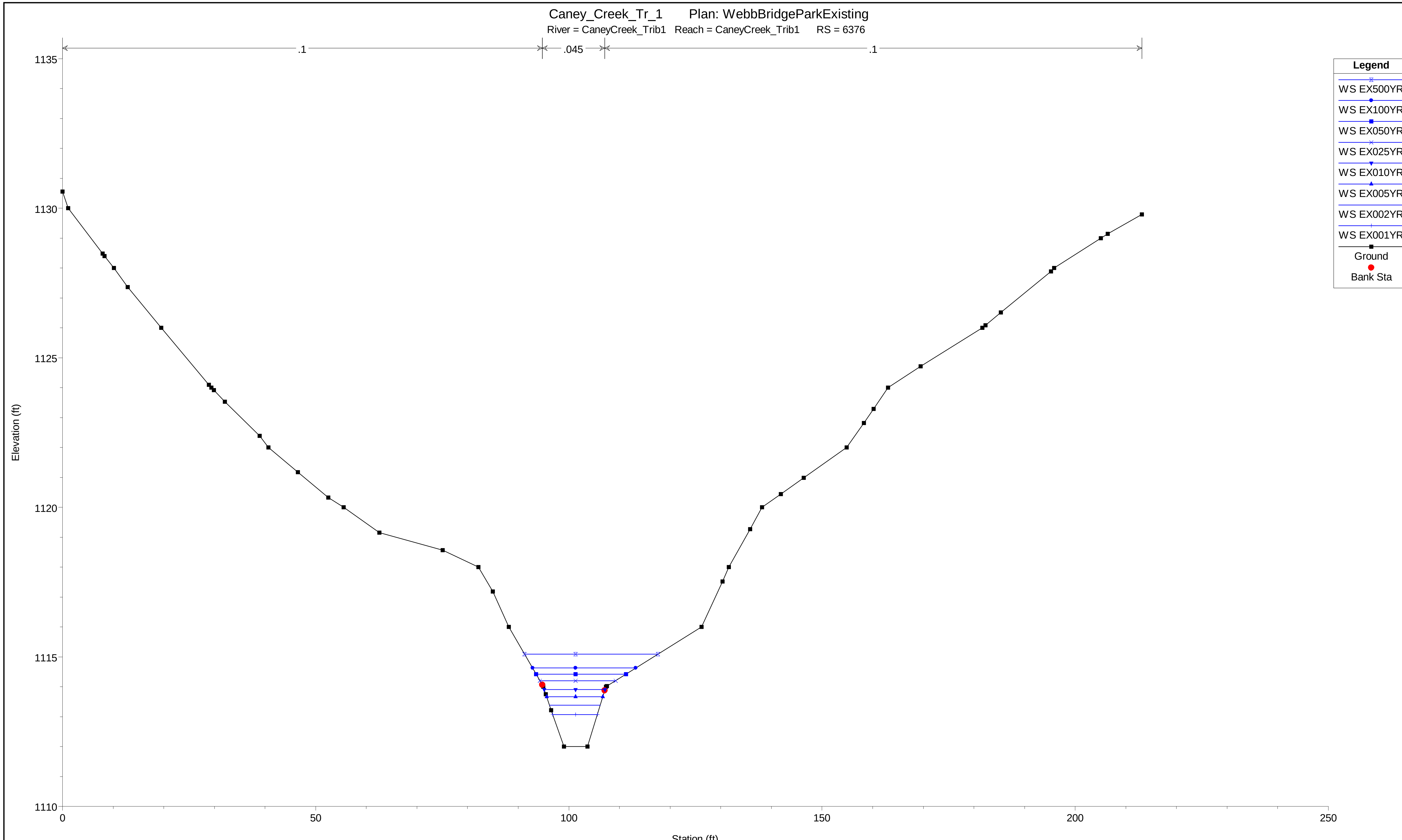

Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6457 Culv
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1140
1135
1130
1125
1120
1115
1110
0
50
100
150
200
250
Station (ft)



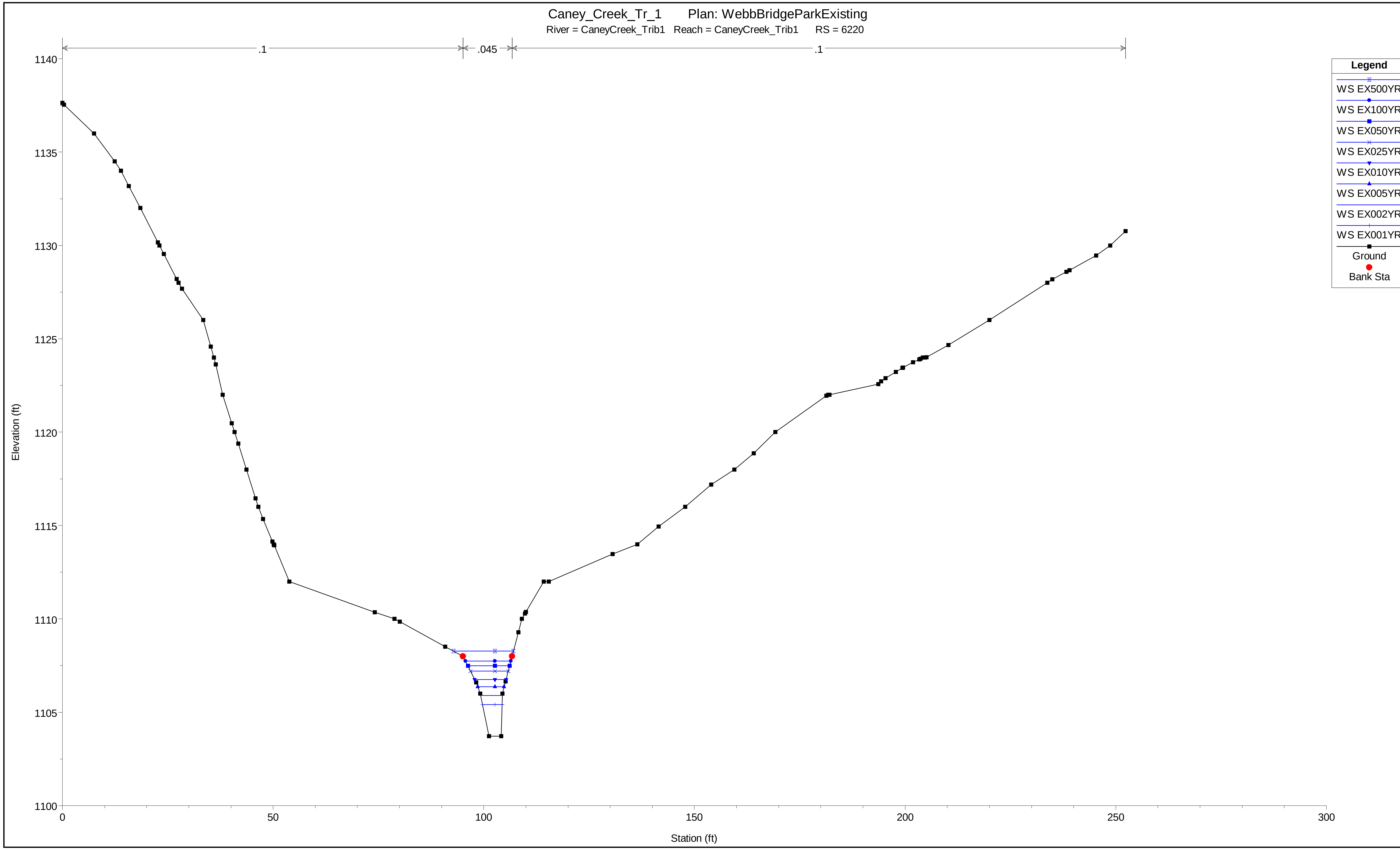
Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6457 Culv
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1135
1130
1125
1120
1115
1110
Station (ft)
0
50
100
150
200
250

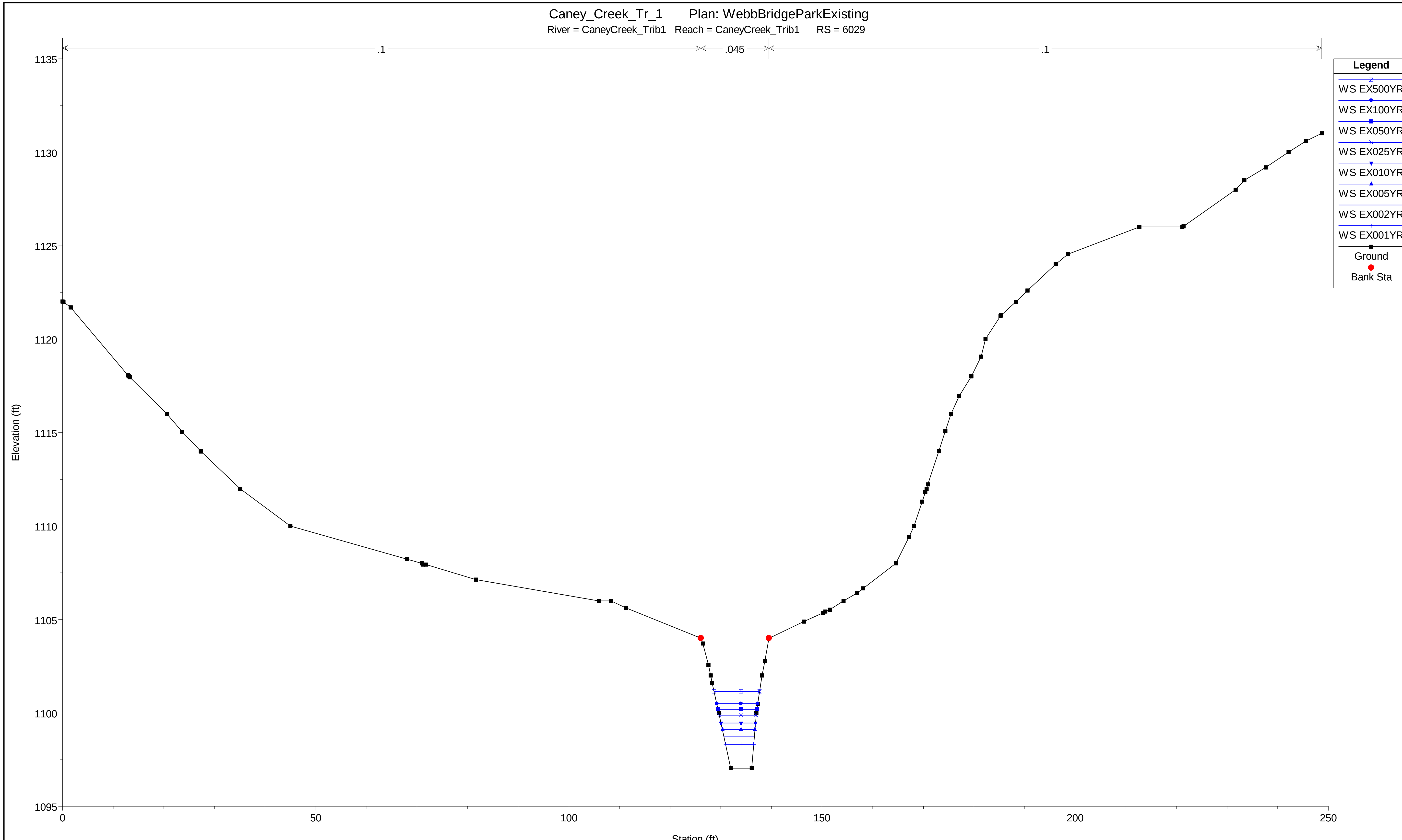


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6439
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1130
1128
1126
1124
1122
1120
1118
1116
1114
1112
0
50
100
150
200
250
Station (ft)

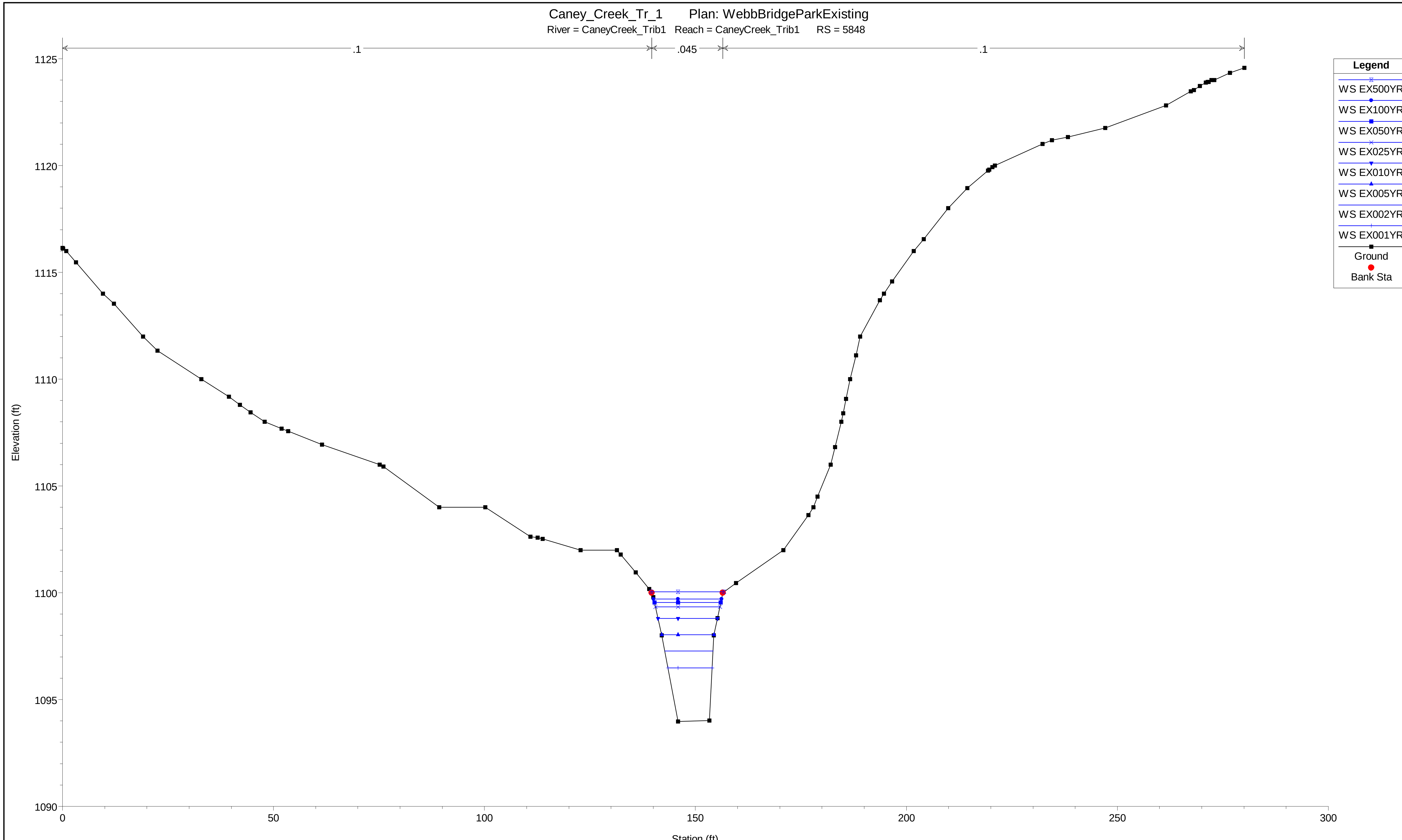


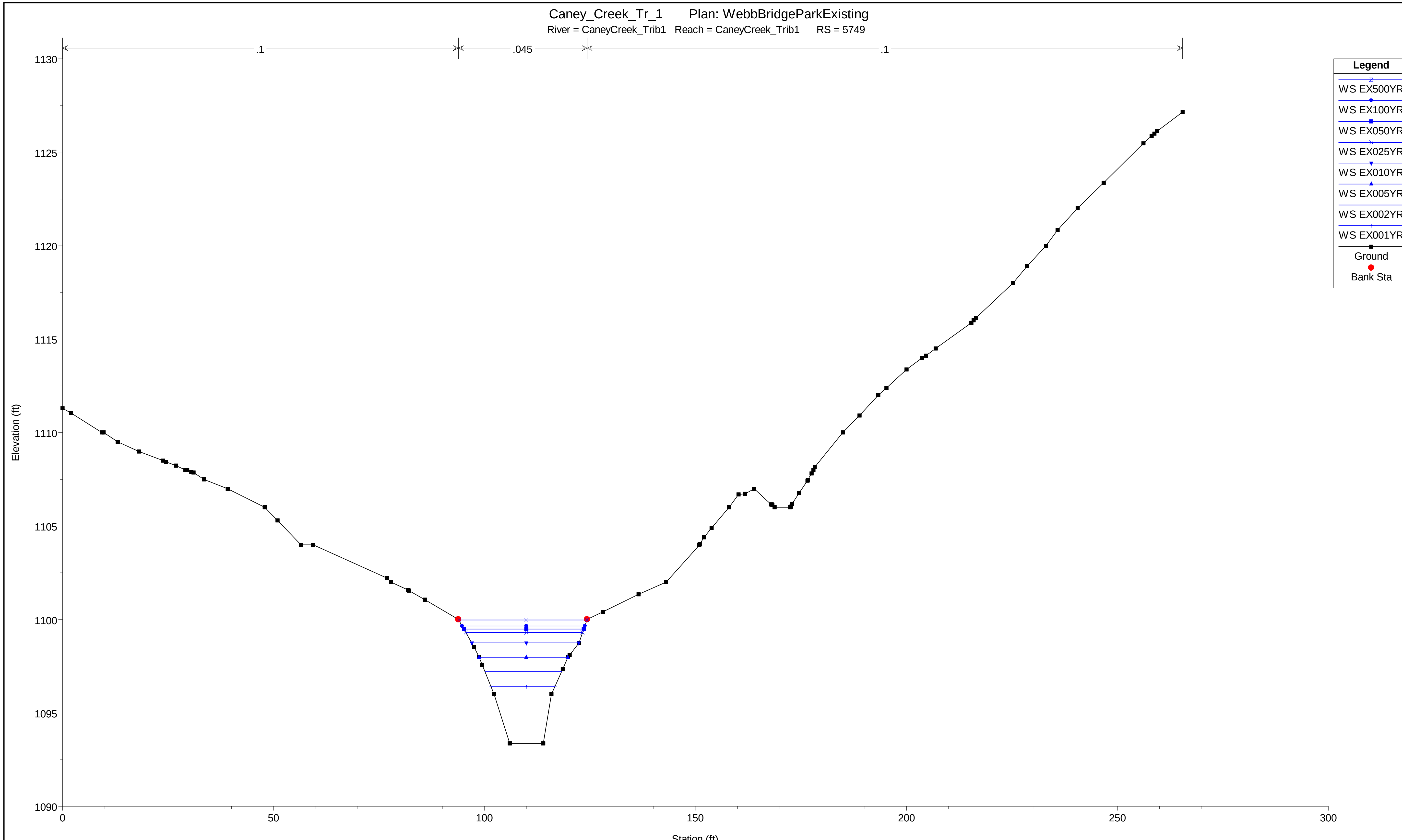
Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6376
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1135
1130
1125
1120
1115
1110
0
50
100
150
200
250
Station (ft)


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6220
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1140
1135
1130
1125
1120
1115
1110
1105
1100
0
50
100
150
200
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 6029
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1135
1130
1125
1120
1115
1110
1105
1100
1095
Station (ft)
0
50
100
150
200
250


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5848
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1125
1120
1115
1110
1105
1100
1095
1090
0
50
100
150
200
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5749
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1130
1125
1120
1115
1110
1105
1100
1095
1090
Station (ft)
0
50
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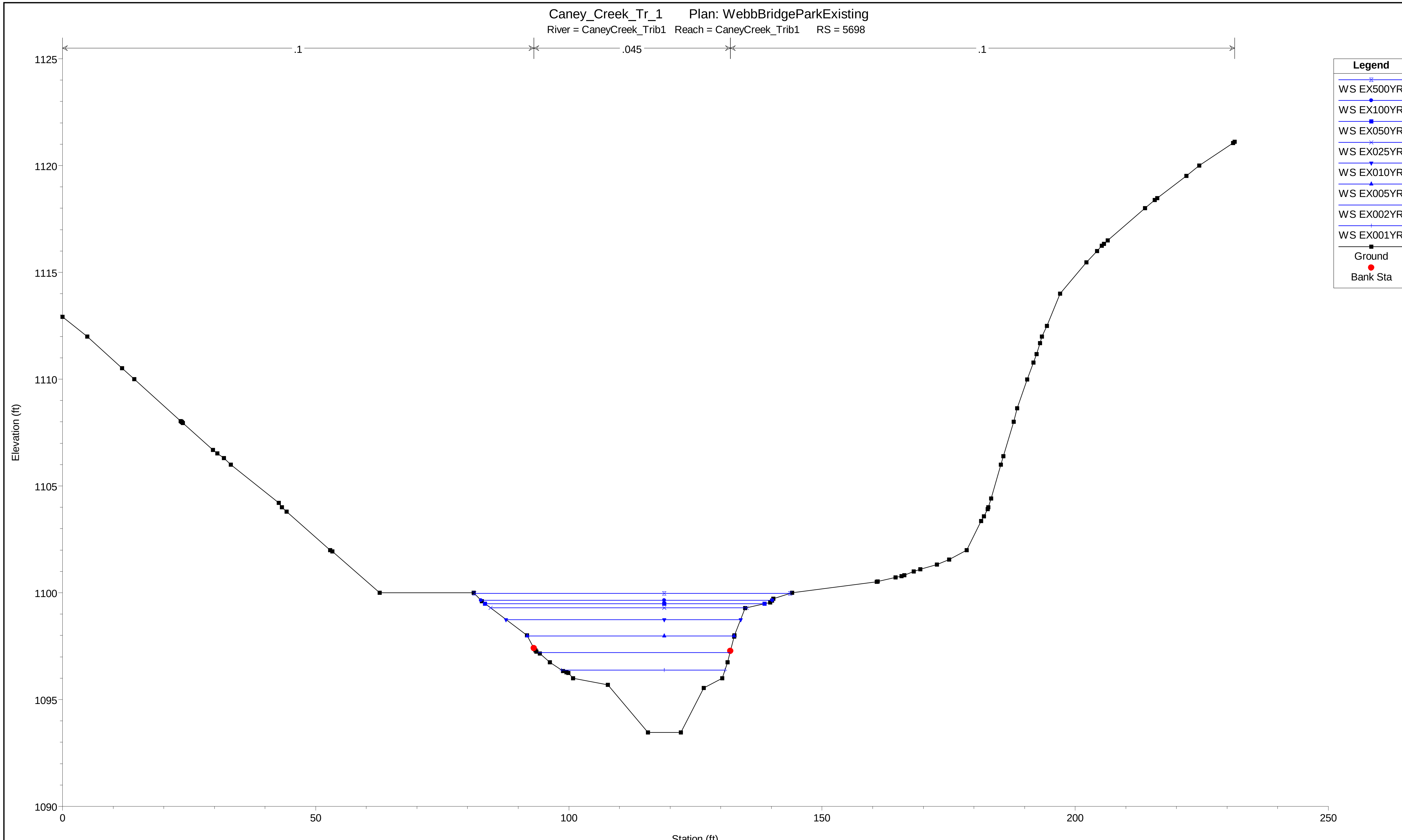
200
250
300



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5698
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1125
1120
1115
1110
1105
1100
1095
1090
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200
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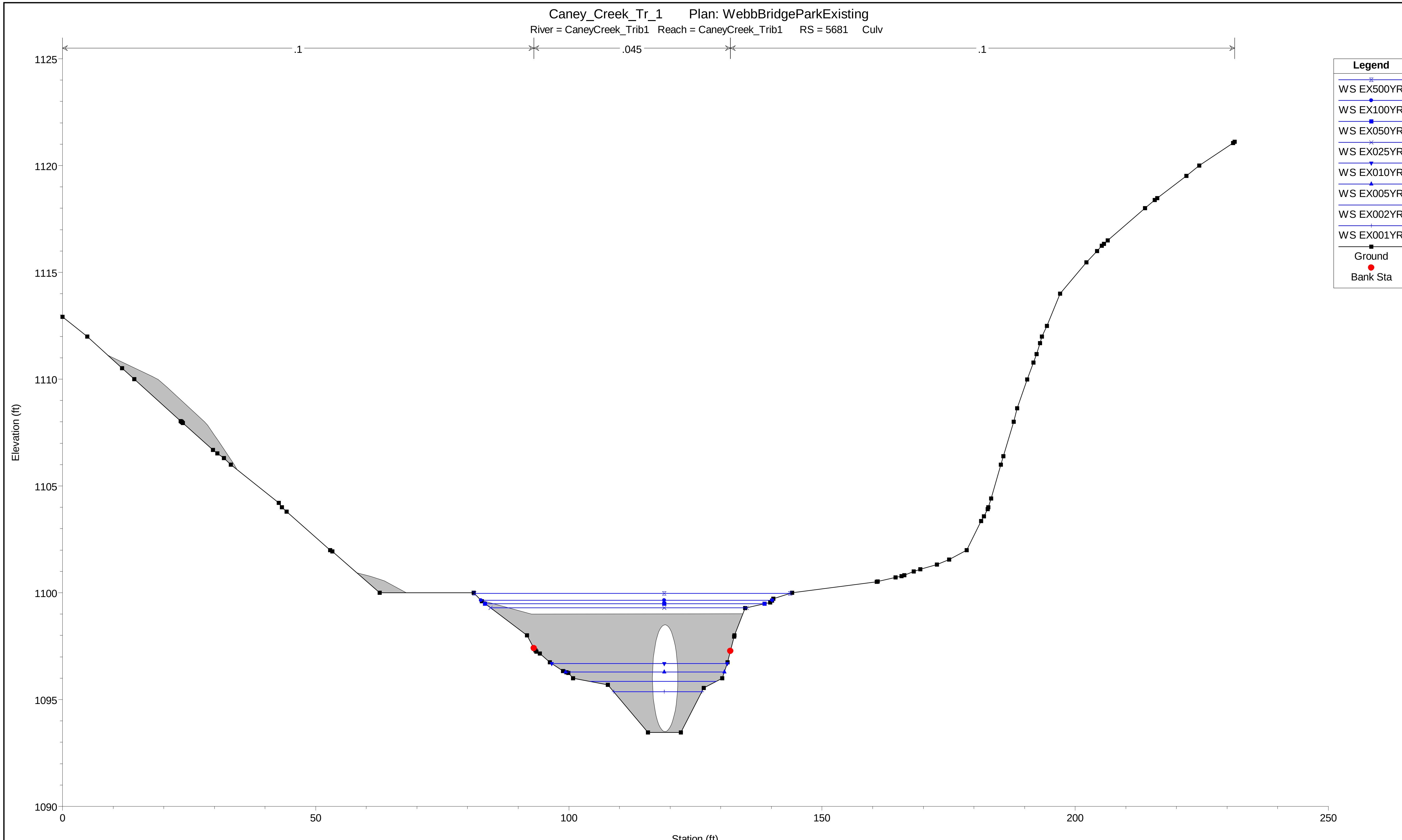
Station (ft)


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5681 Culv
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1125
1120
1115
1110
1105
1100
1095
1090
Station (ft)
0
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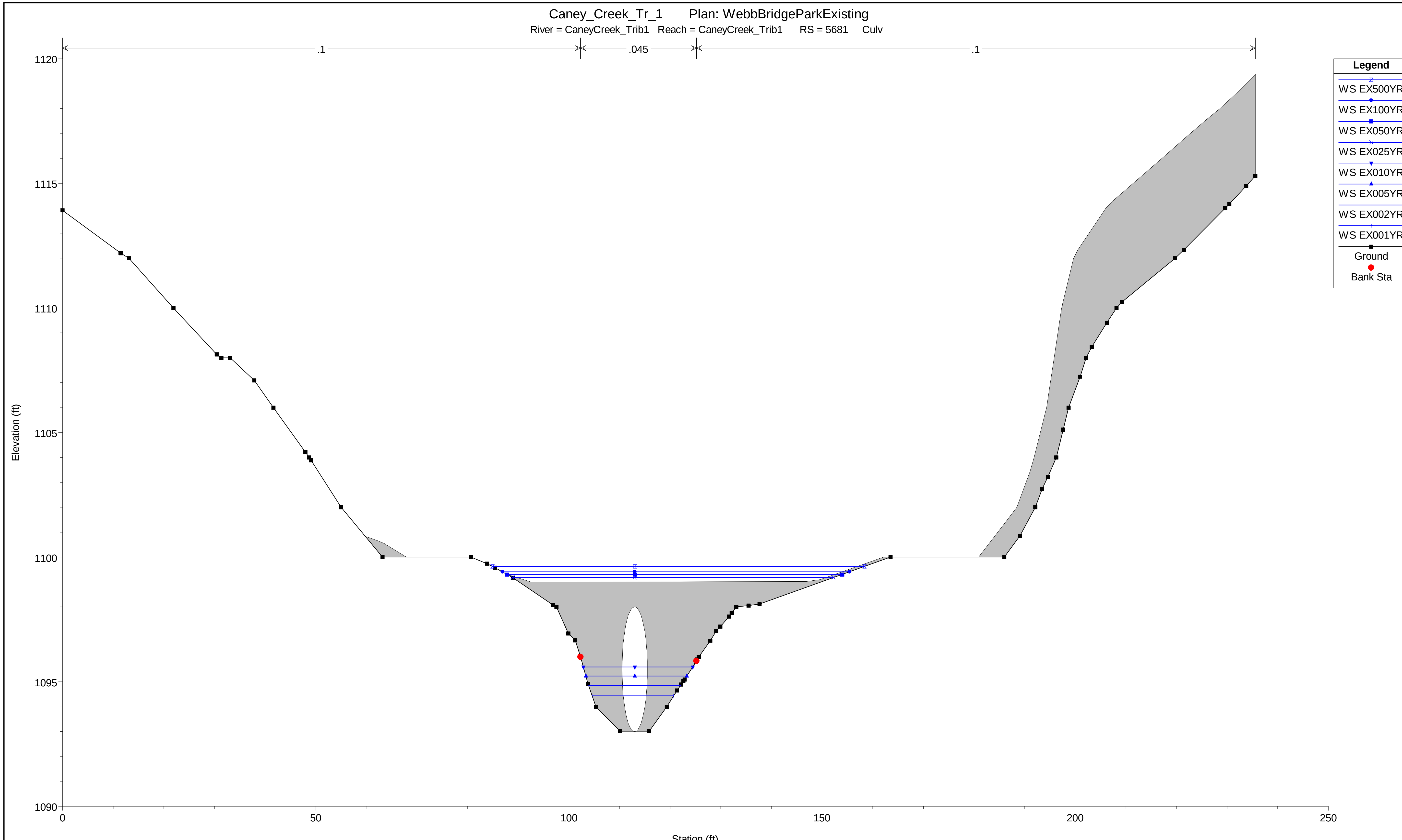
100
150
200
250



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5681 Culv
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1120
1115
1110
1105
1100
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200
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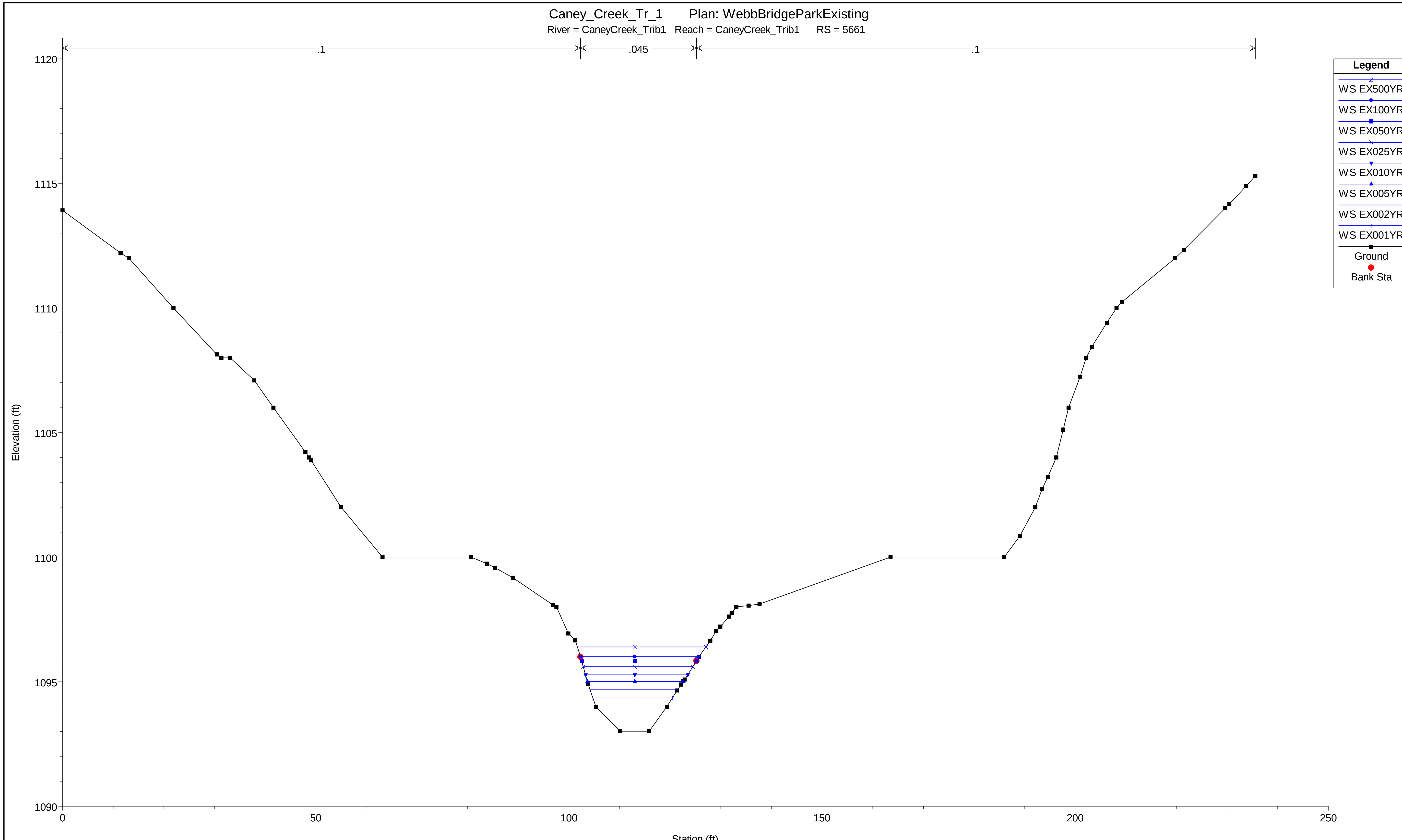
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5661
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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1110
1105
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200
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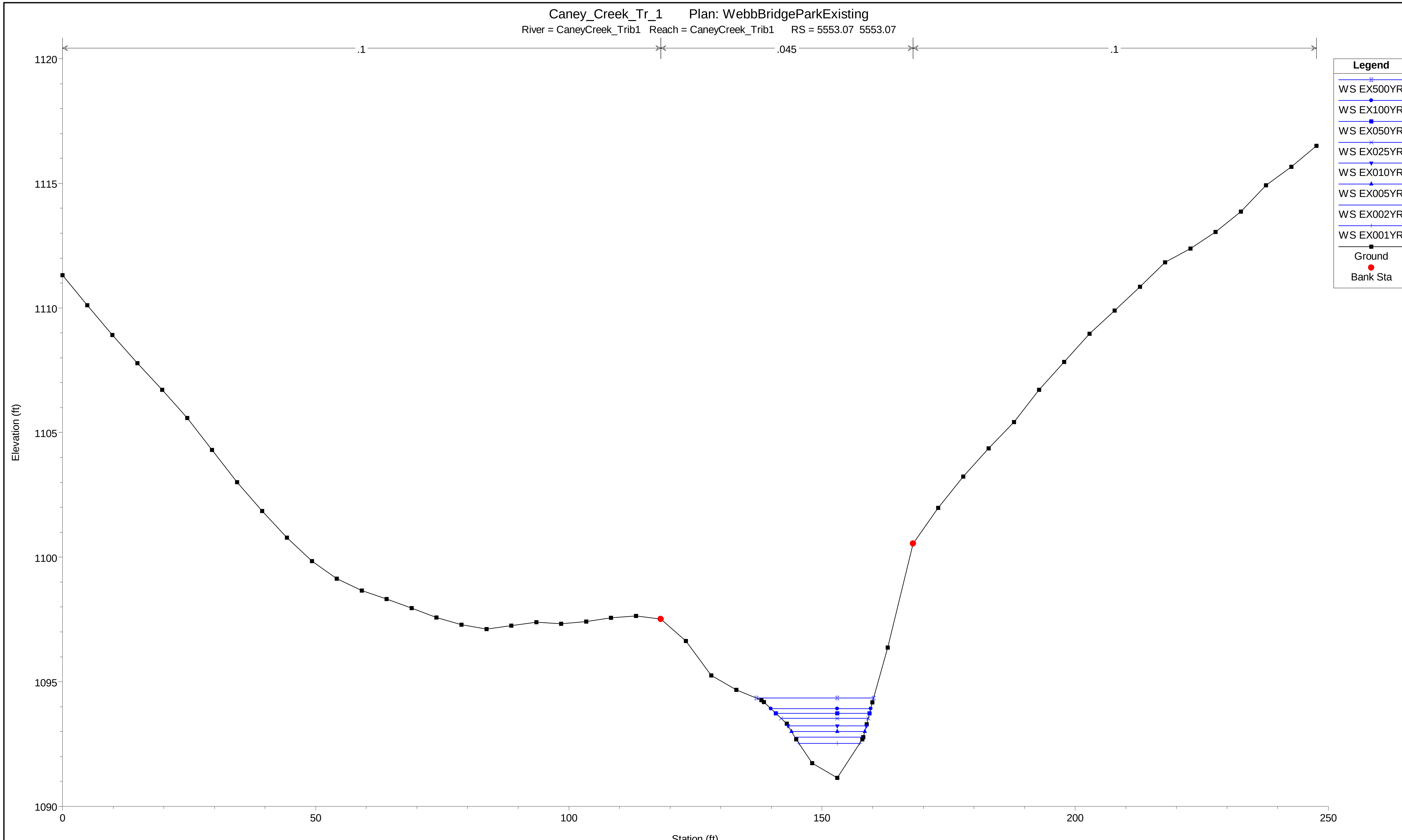
Station (ft)


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5553.07 5553.07
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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1115
1110
1105
1100
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0
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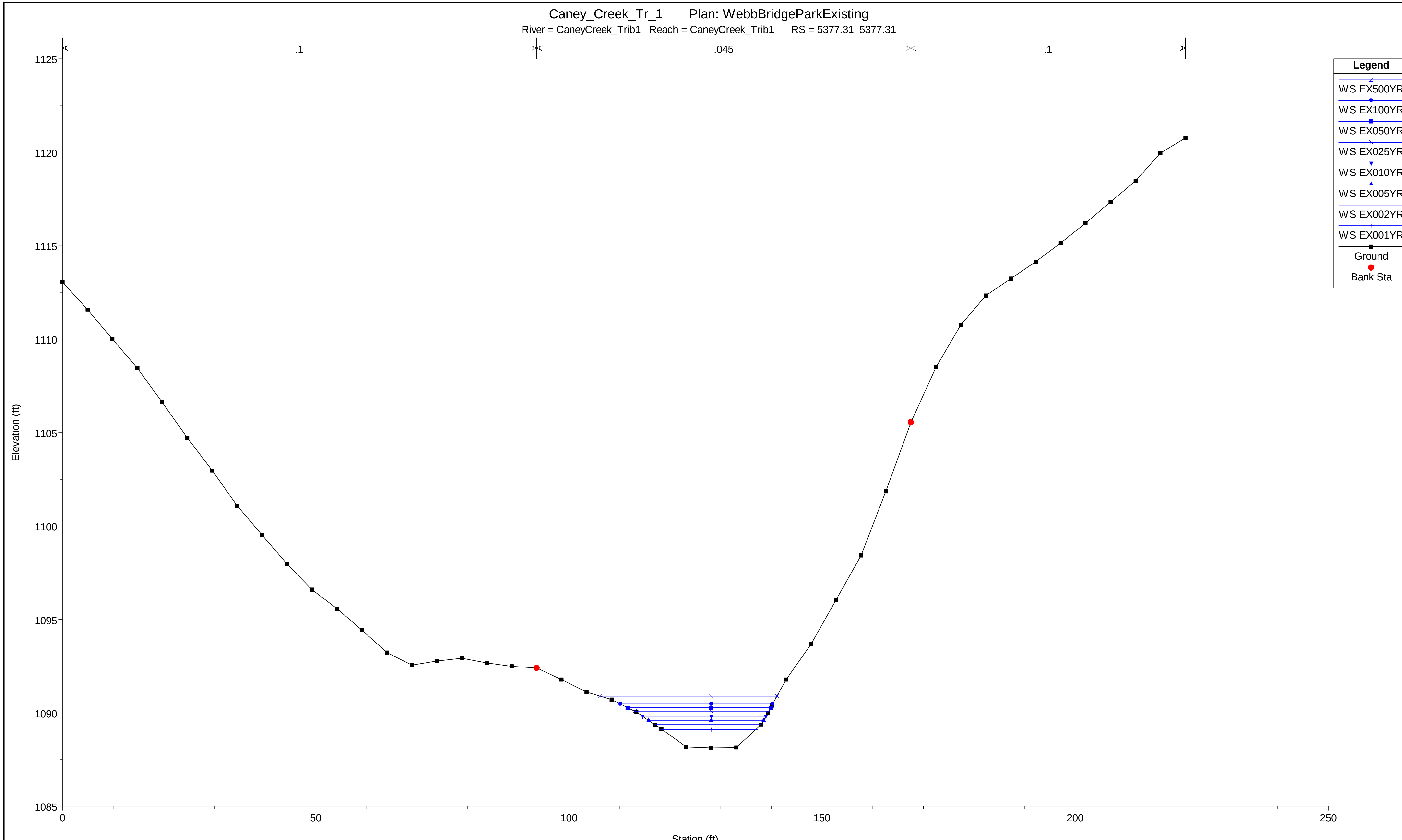
200
250
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5377.31 5377.31
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1125
1120
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1110
1105
1100
1095
1090
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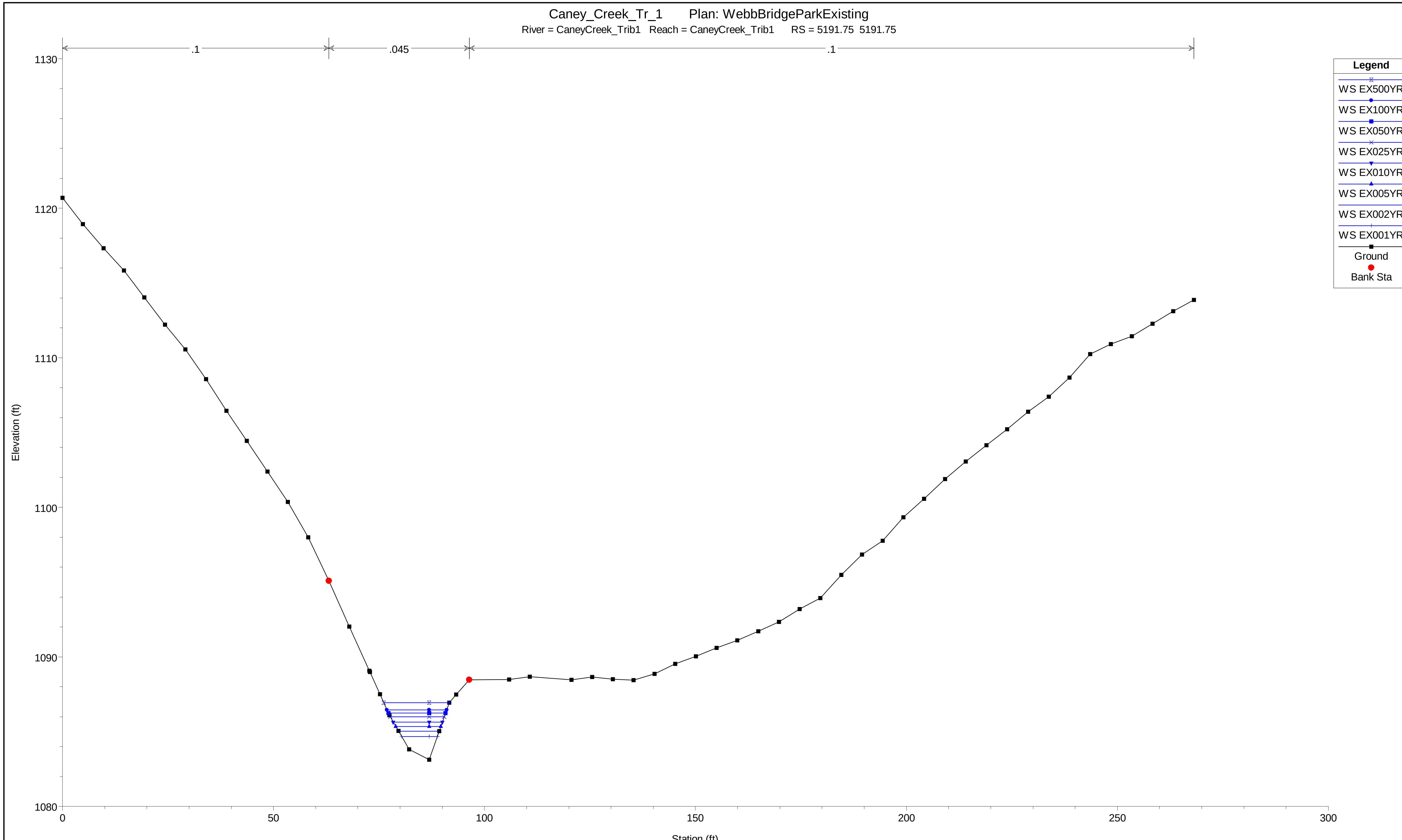
50
100
150
200
250
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5191.75 5191.75
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1130
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1110
1100
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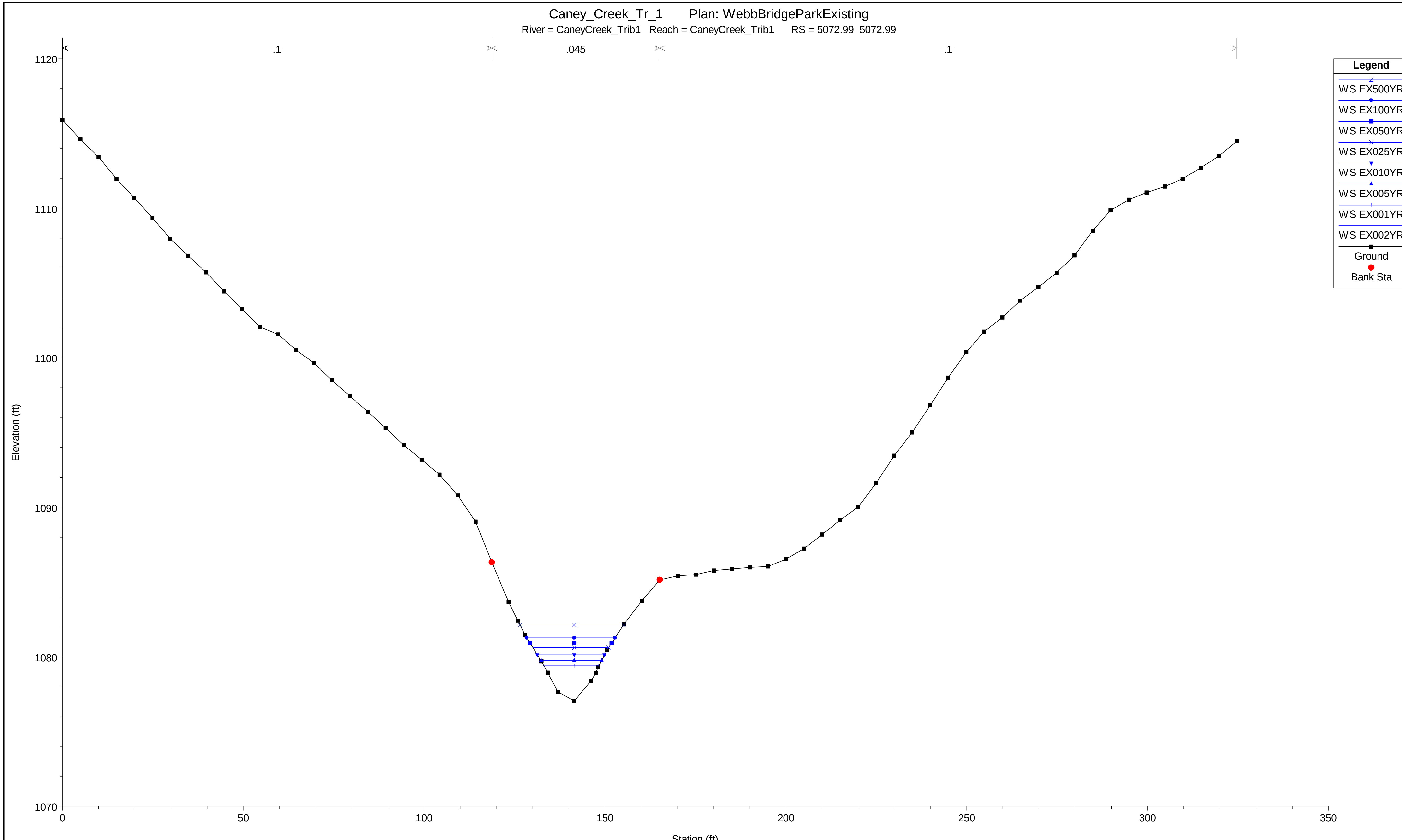
50
100
150
200
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 5072.99 5072.99
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX001YR
WS EX002YR
Ground
Bank Sta
Elevation (ft)
1120
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1100
1090
1080
1070
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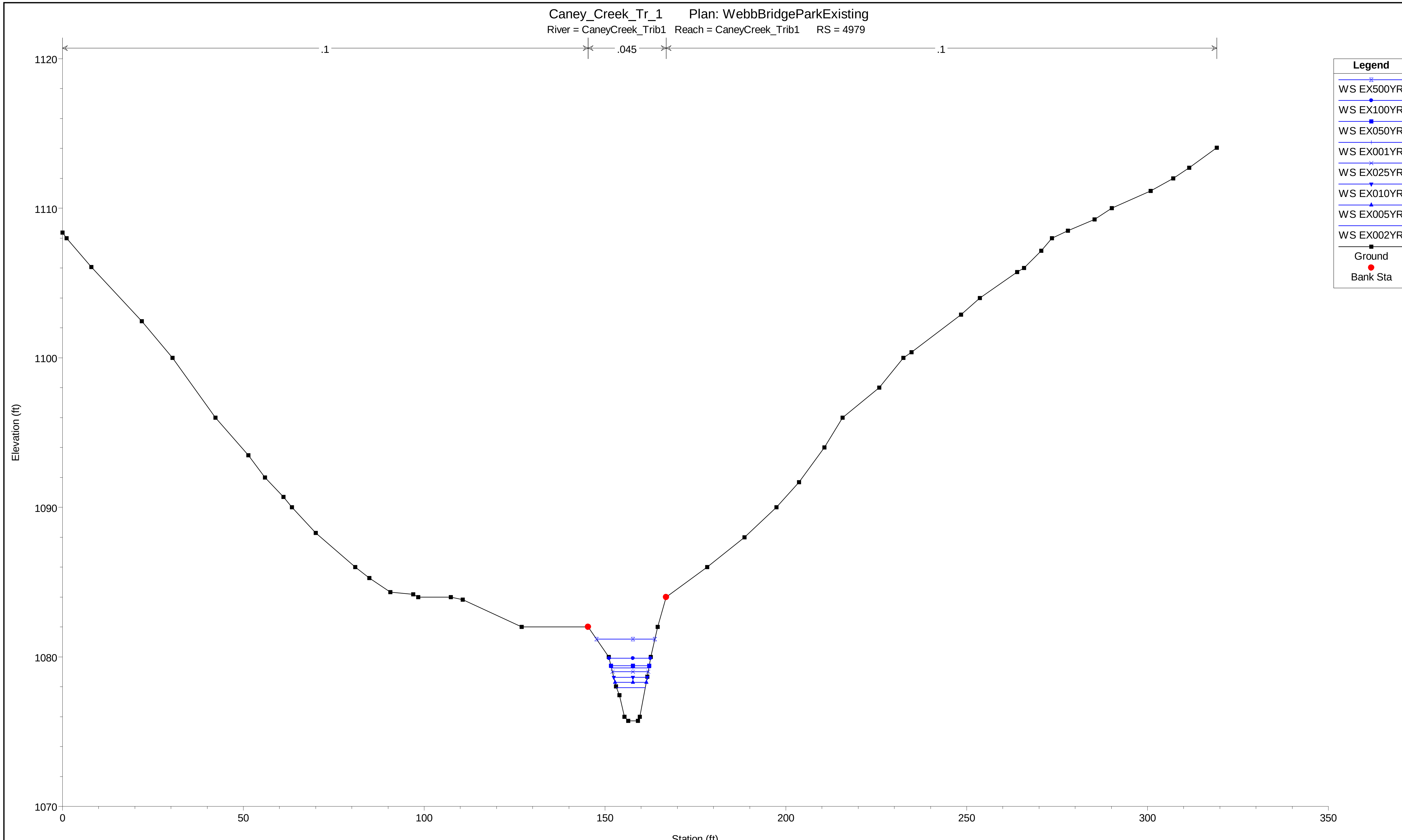
100
150
200
250
300
350
Station (ft)


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4979
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX001YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Bank Sta
Elevation (ft)
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1110
1100
1090
1080
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100
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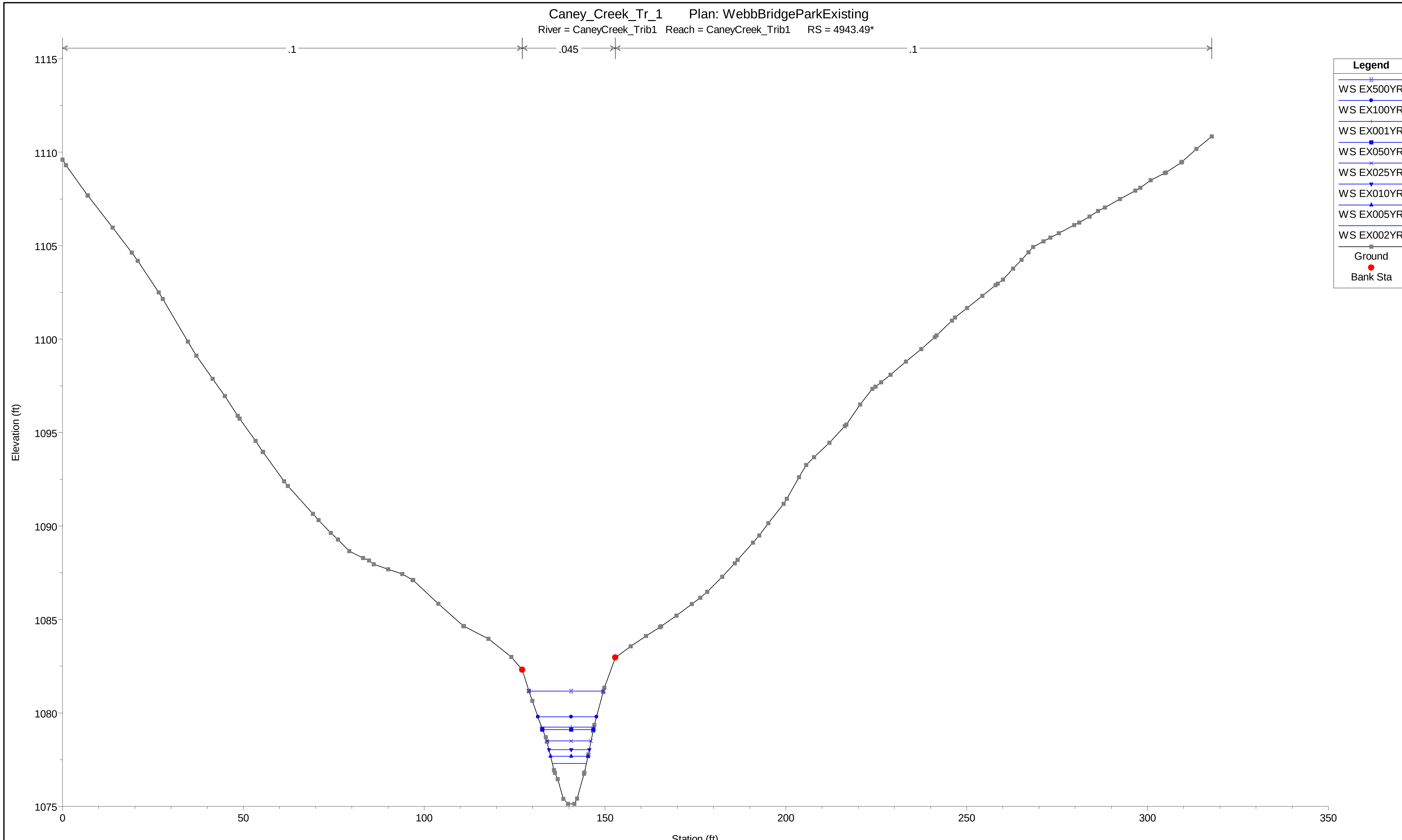
200
250
300
350
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4943.49*
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX001YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Bank Sta
Elevation (ft)
1115
1110
1105
1100
1095
1090
1085
1080
1075
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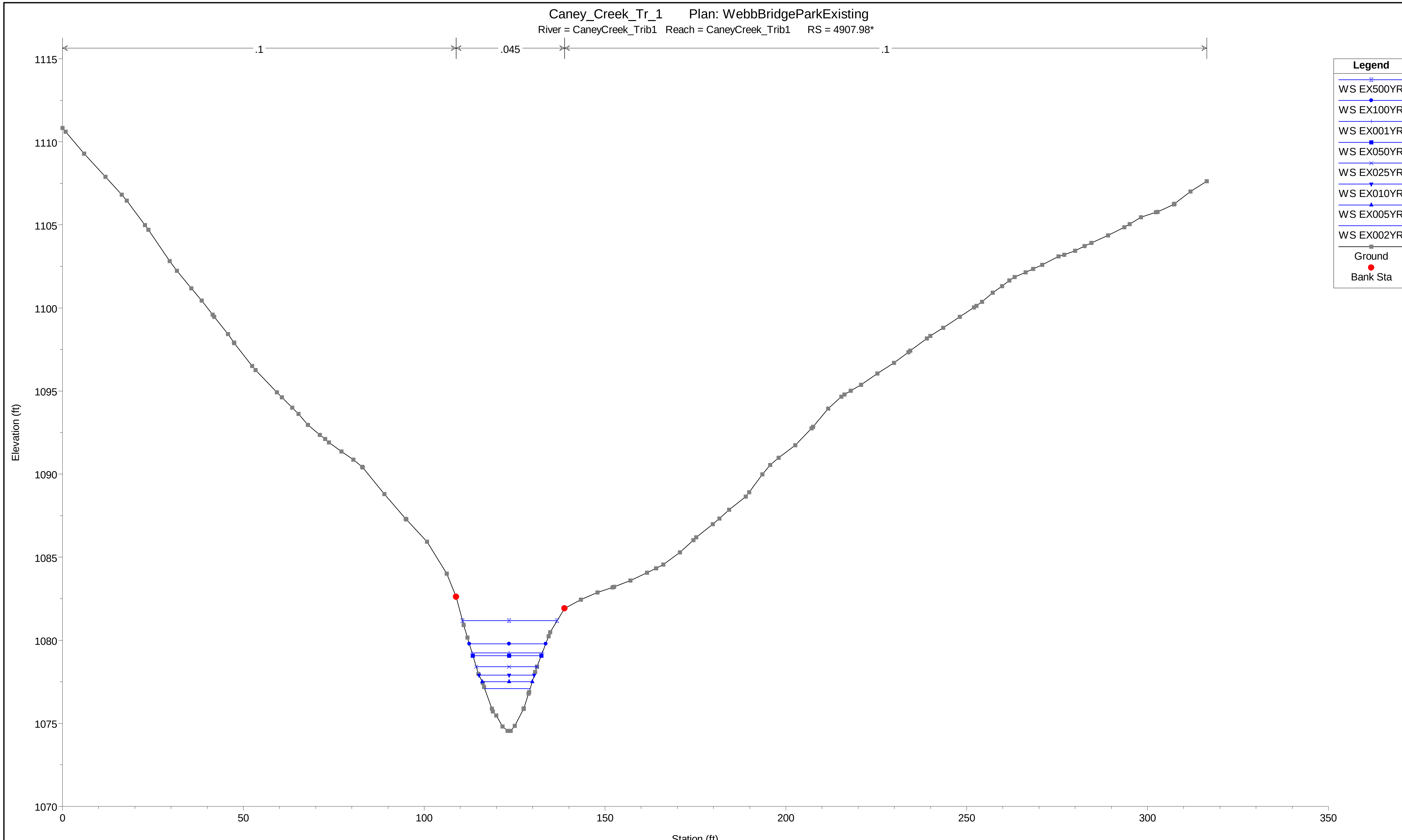
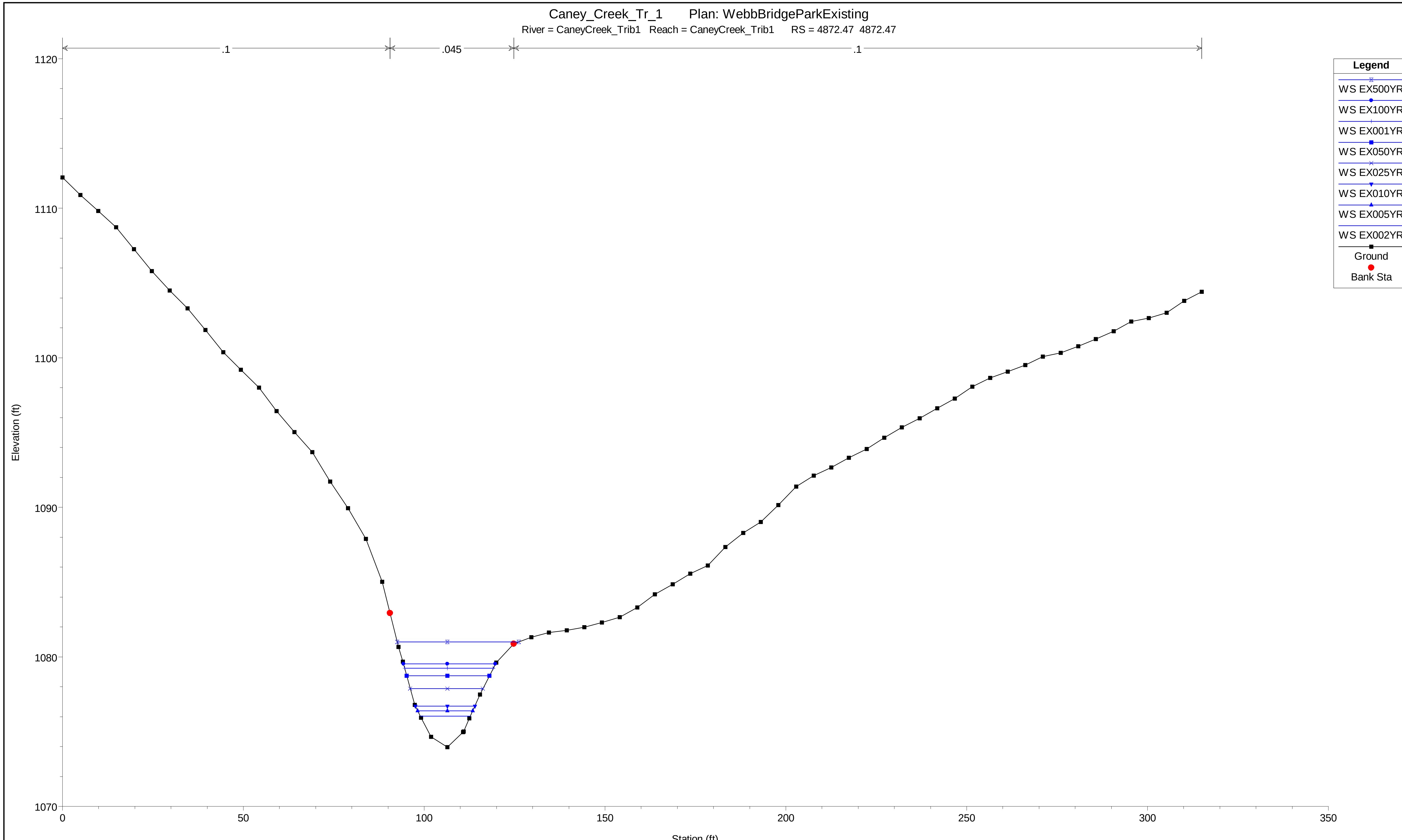
100
150
200
250
300
350
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4907.98*
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX001YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
1115
1110
1105
1100
1095
1090
1085
1080
1075
1070
0
50
100
150
200
250
300
350



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4872.47 4872.47
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX001YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Bank Sta
Elevation (ft)
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1110
1100
1090
1080
1070
Station (ft)
0
50
100
150
200
250
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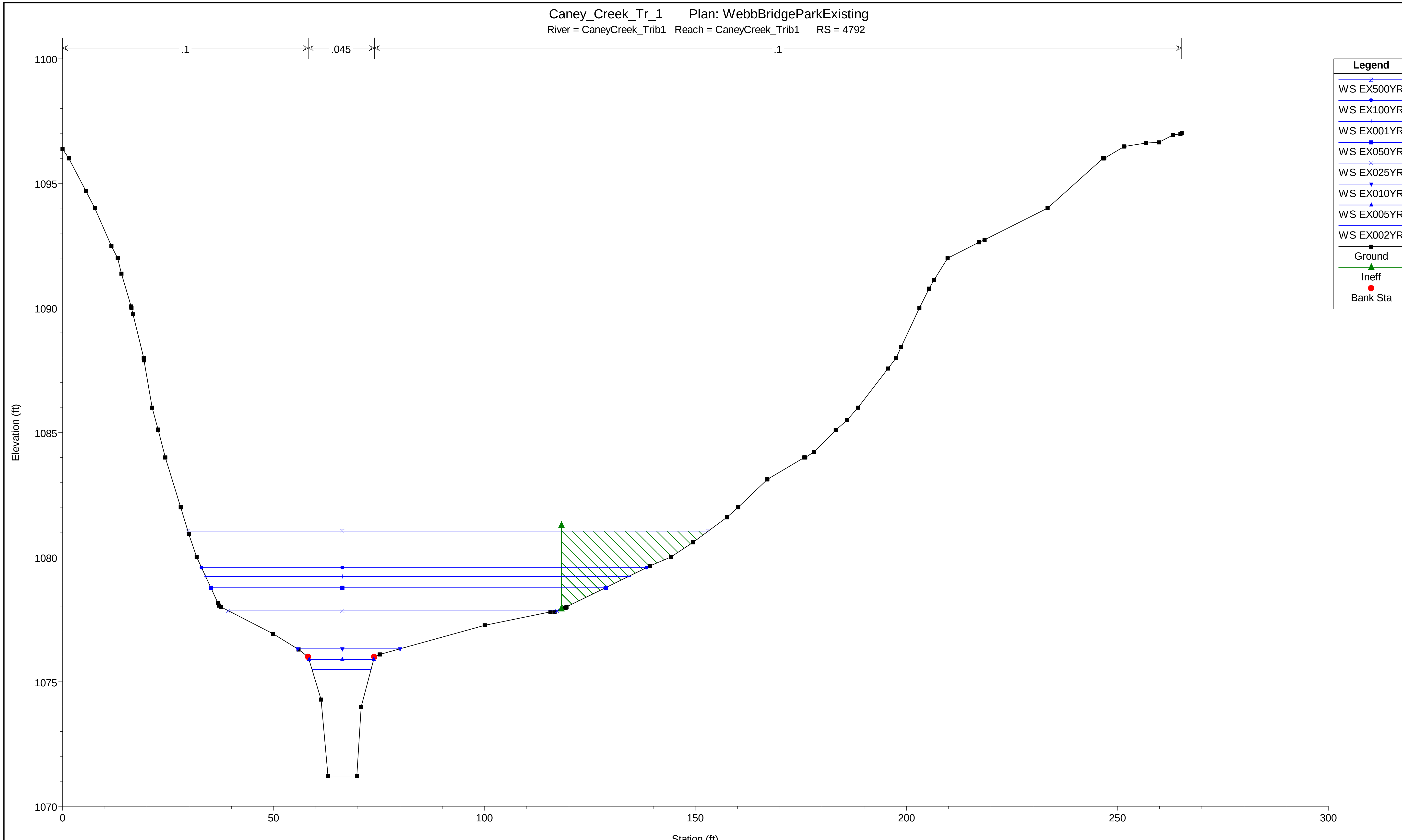
350



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4792
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX001YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Ineff
Bank Sta
Elevation (ft)
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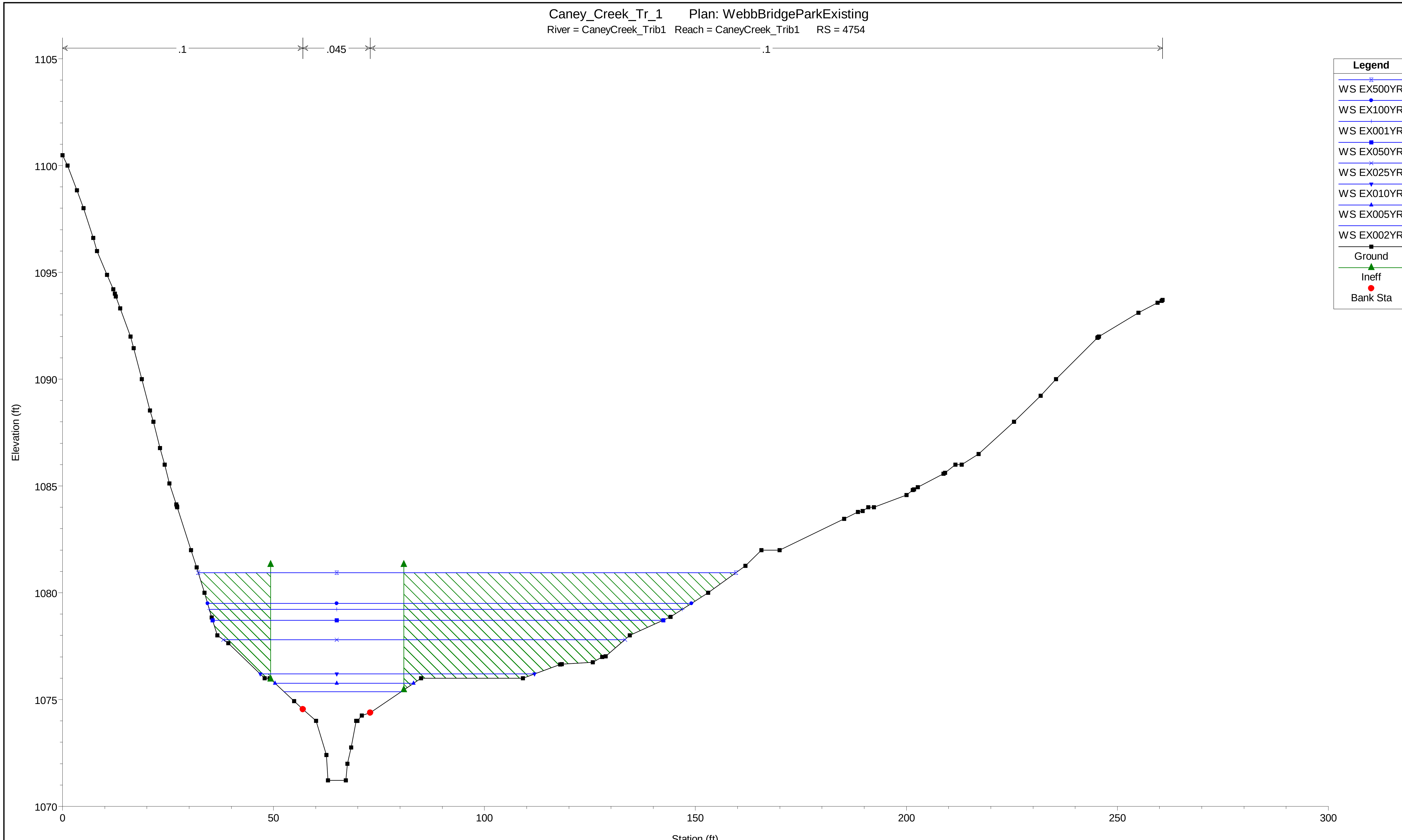
1095
1090
1085
1080
1075
1070
0
50
100
150
200
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4754
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX001YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1070
1075
1080
1085
1090
1095
1100
1105
0
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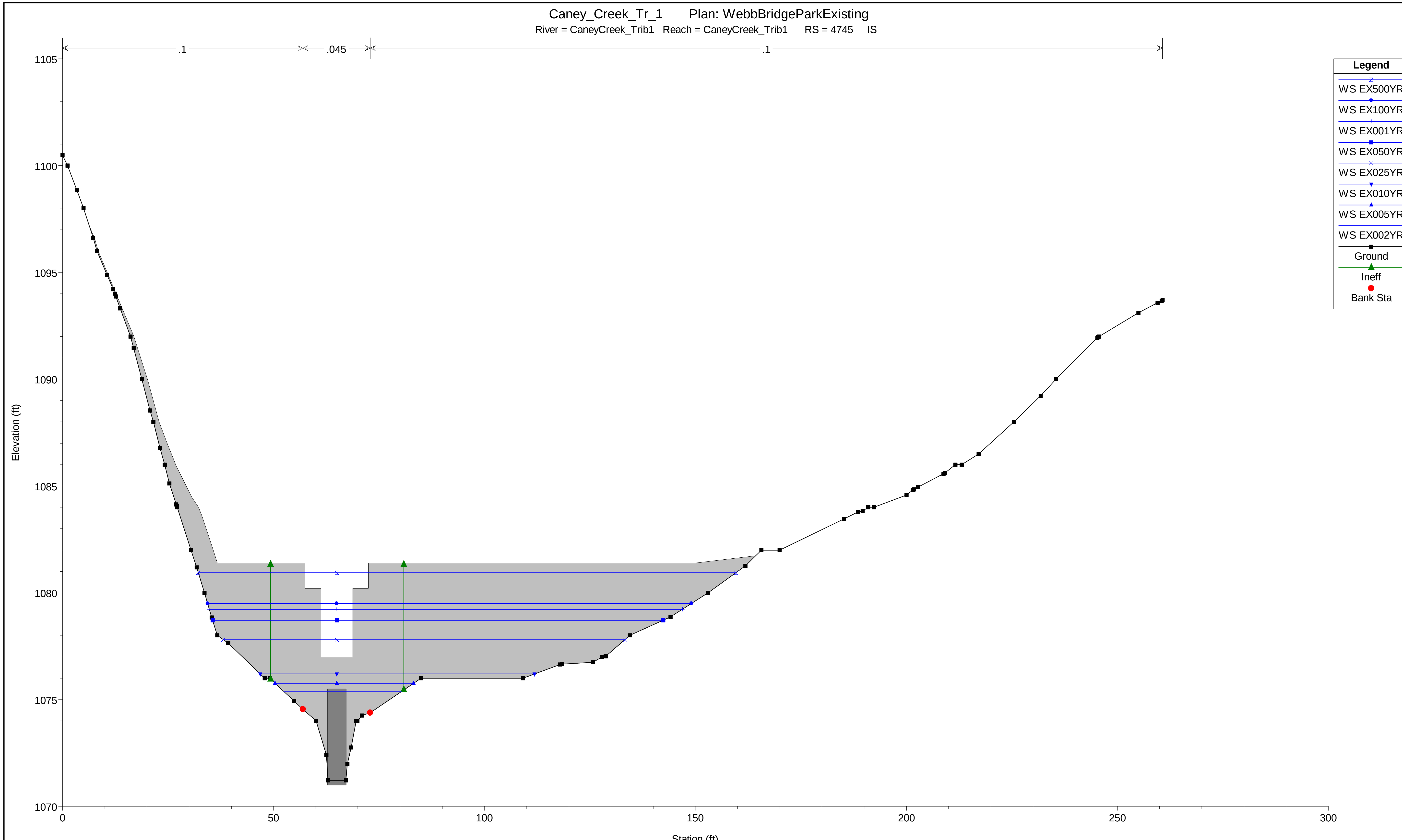
100
150
200
250
300


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4745 IS
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX001YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
1105
1100
1095
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1085
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1070
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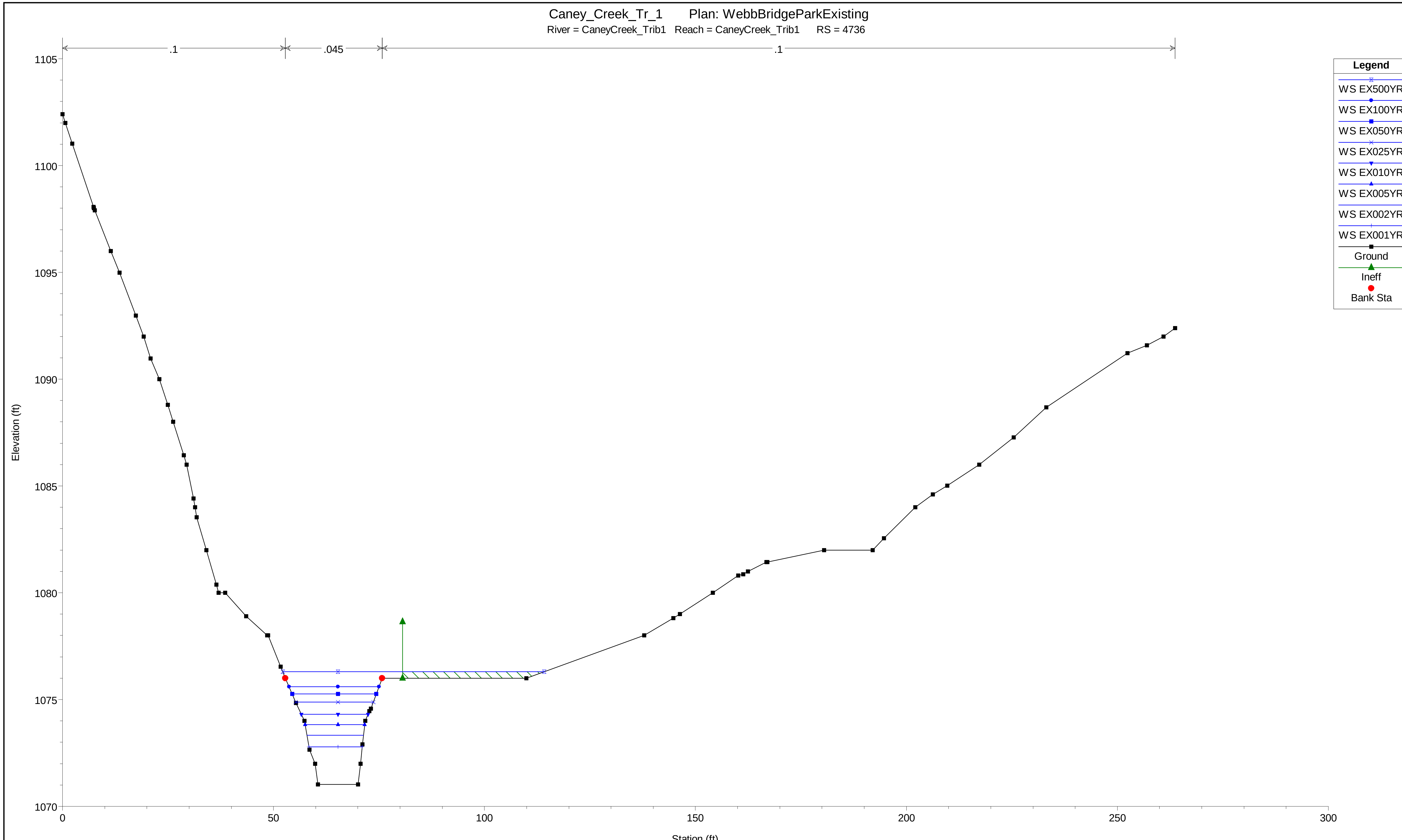
250
300



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4736
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Ineff
Bank Sta
Elevation (ft)
1105
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1095
1090
1085
1080
1075
1070
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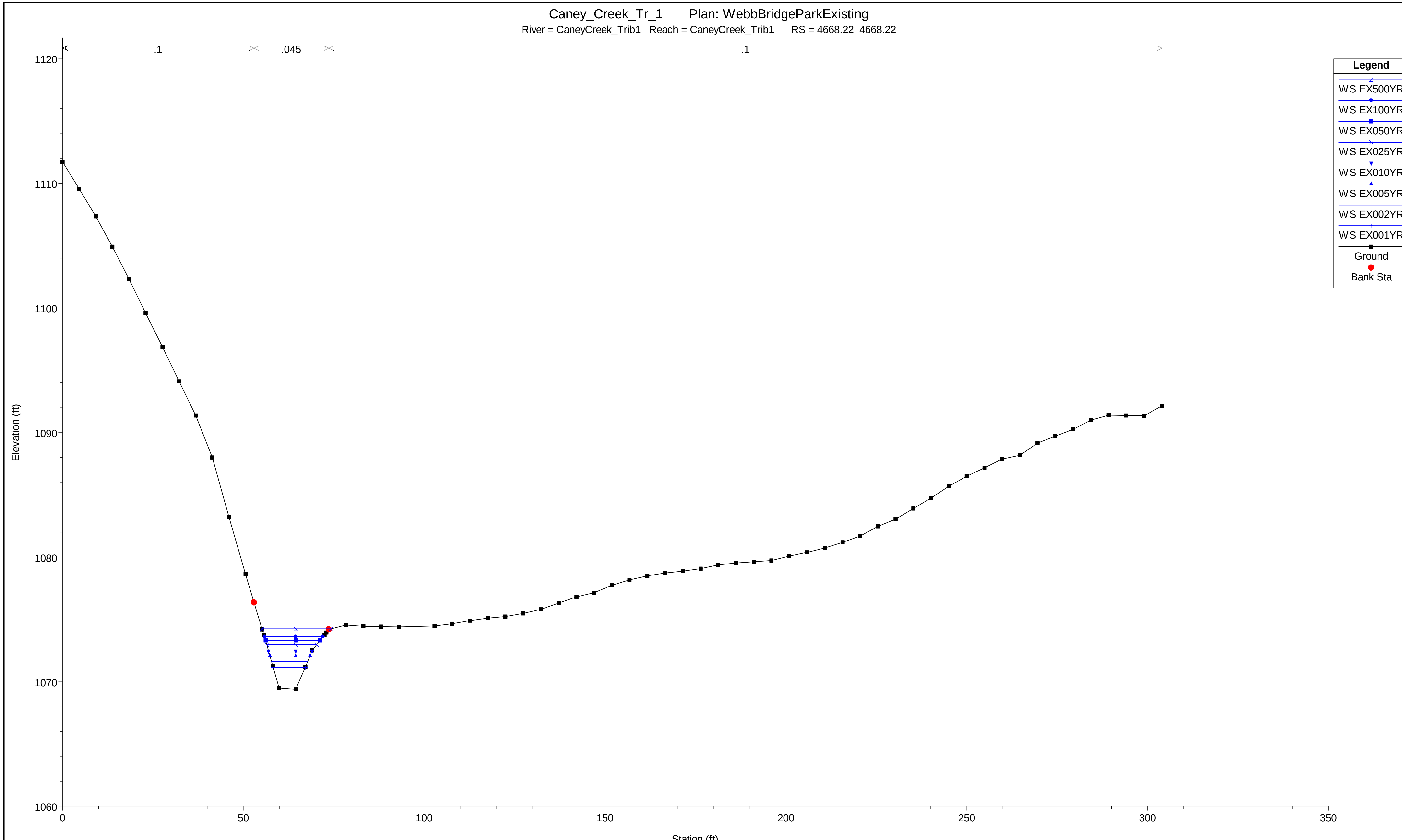
50
100
150
200
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4668.22 4668.22
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1120
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1090
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1070
1060
Station (ft)
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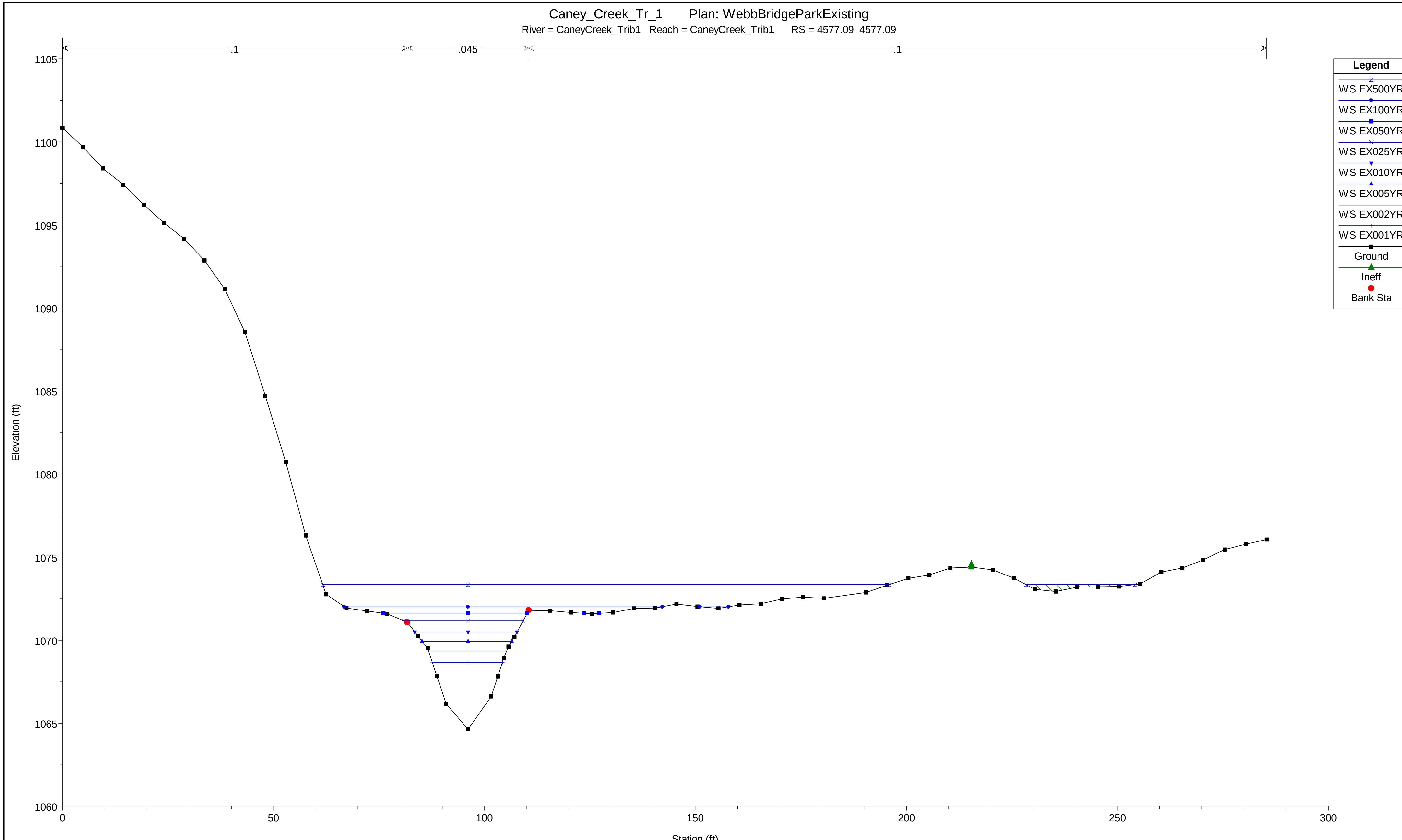
350



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4577.09 4577.09
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Ineff
Bank Sta
Elevation (ft)
1105
1100
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1075
1070
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50
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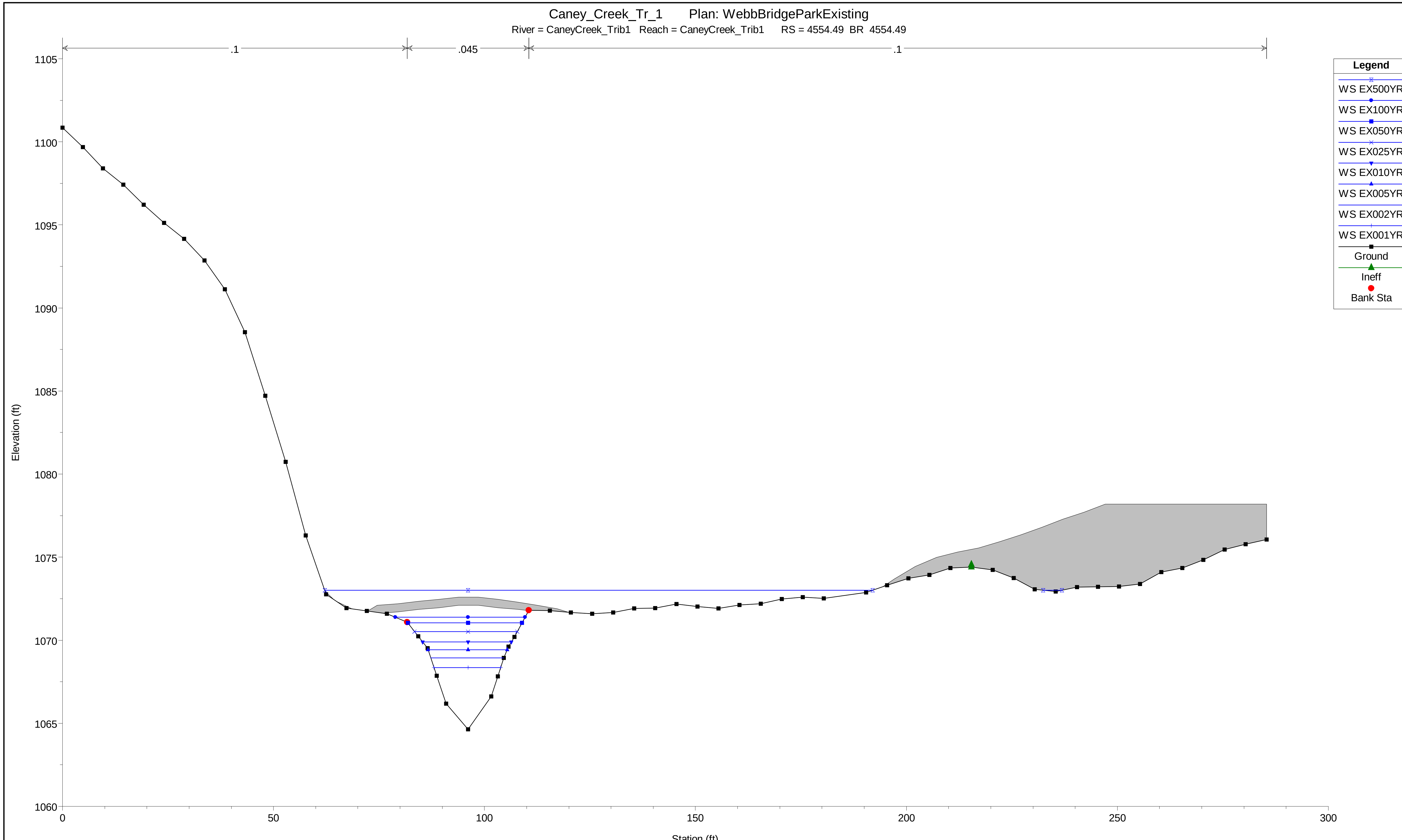
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4554.49 BR 4554.49
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Ineff
Bank Sta
Elevation (ft)
1105
1100
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1080
1075
1070
1065
1060
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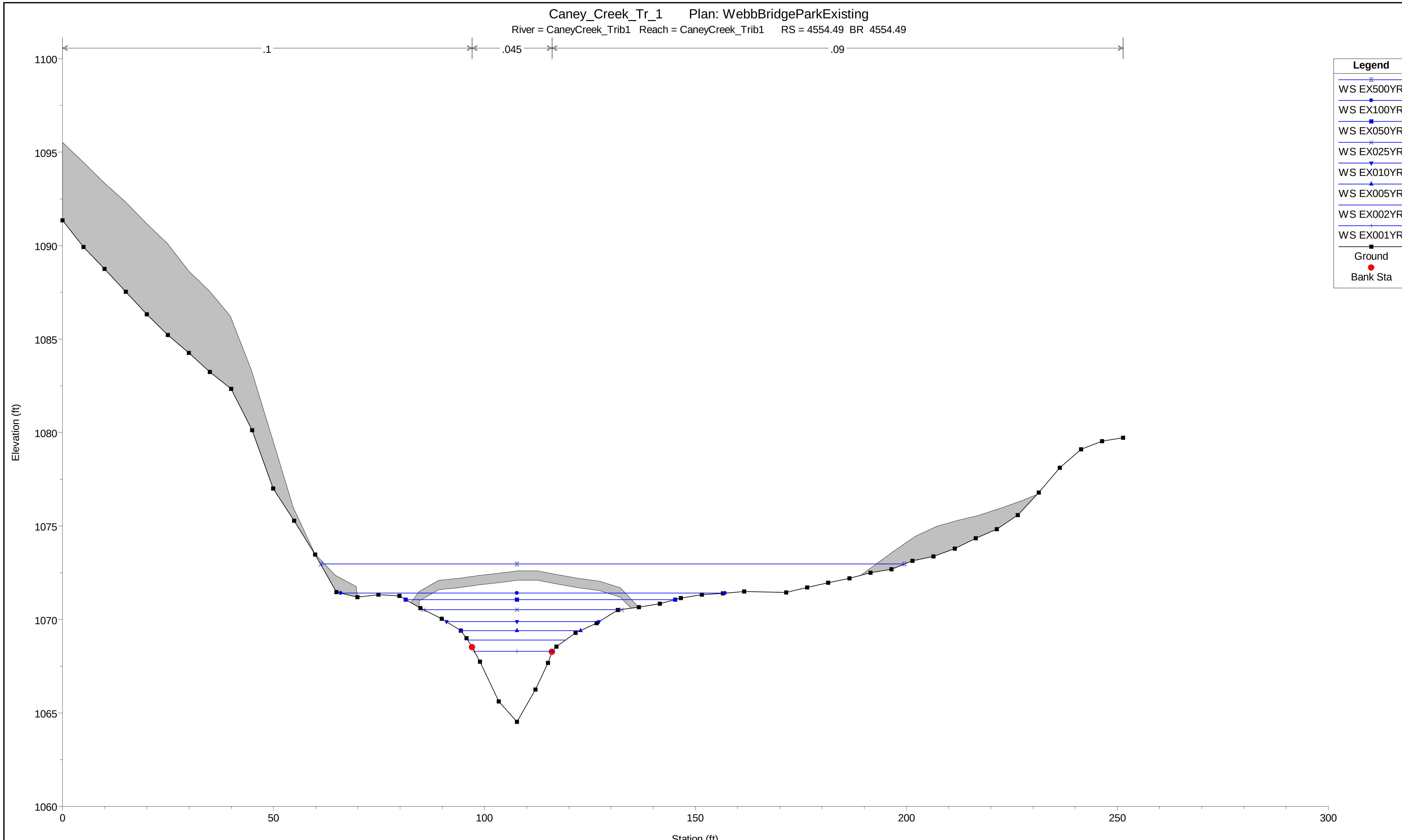
50
100
150
200
250
300
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4554.49 BR 4554.49
.1
.045
.09
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1100
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1085
1080
1075
1070
1065
1060
Station (ft)
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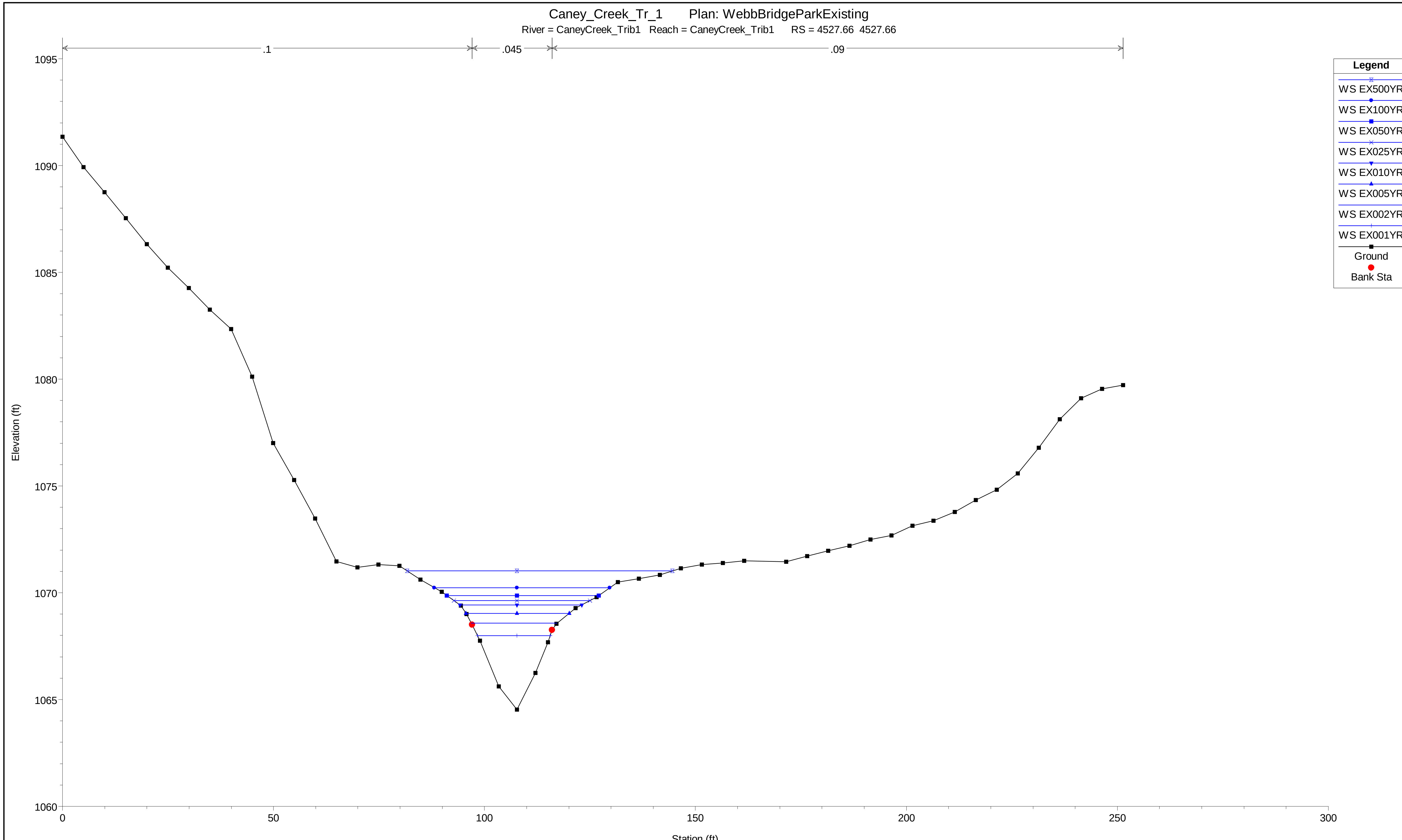
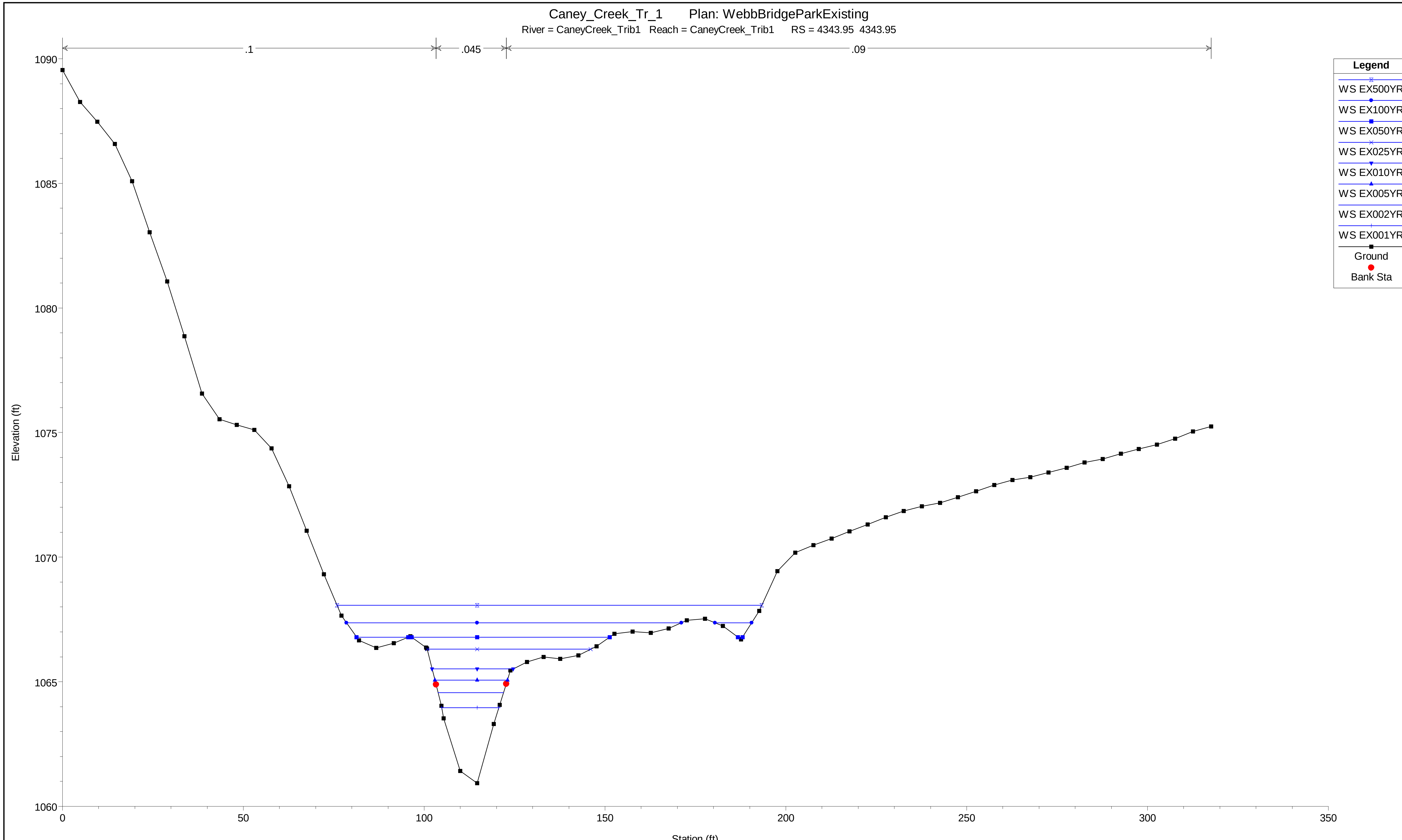
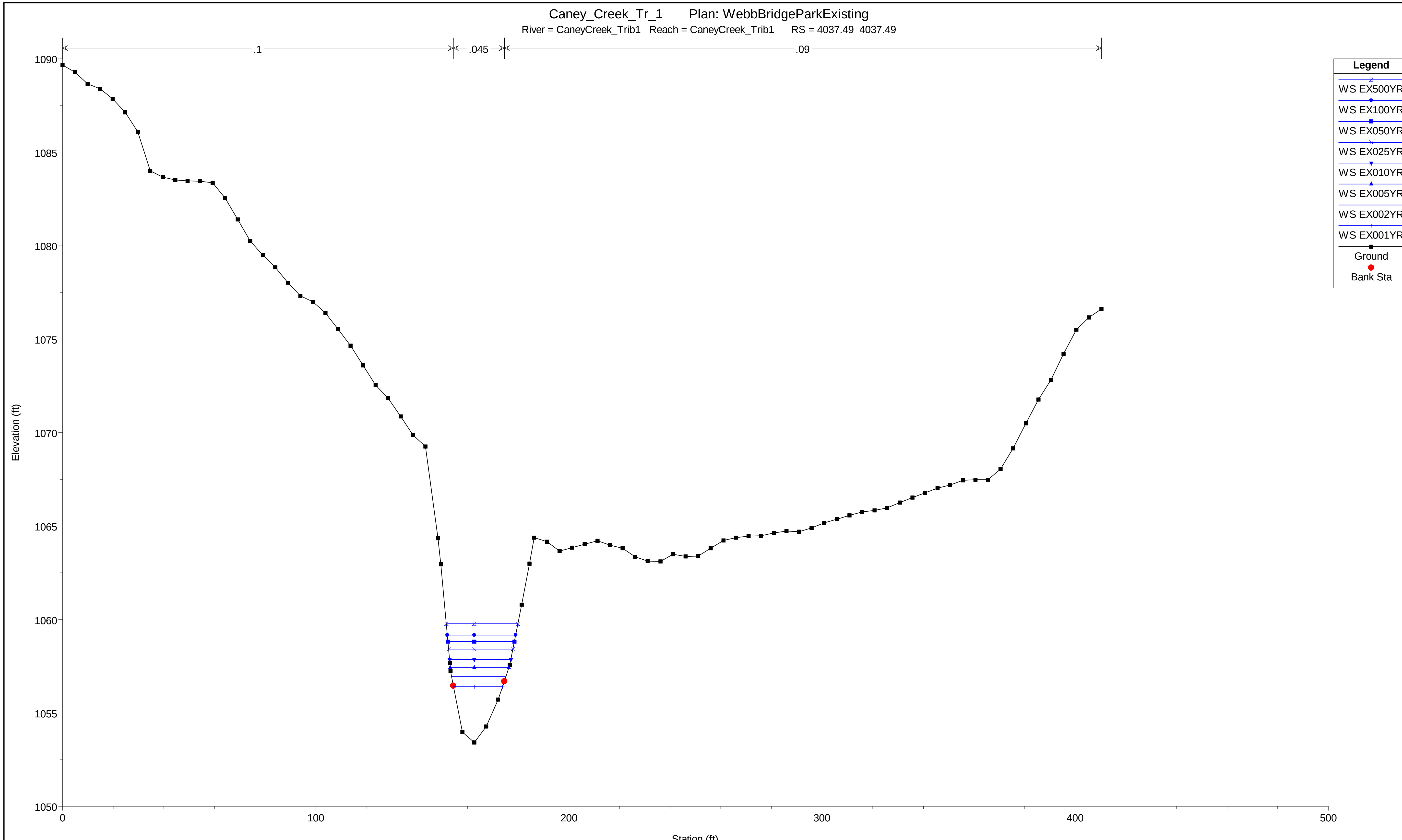
100
150
200
250
300



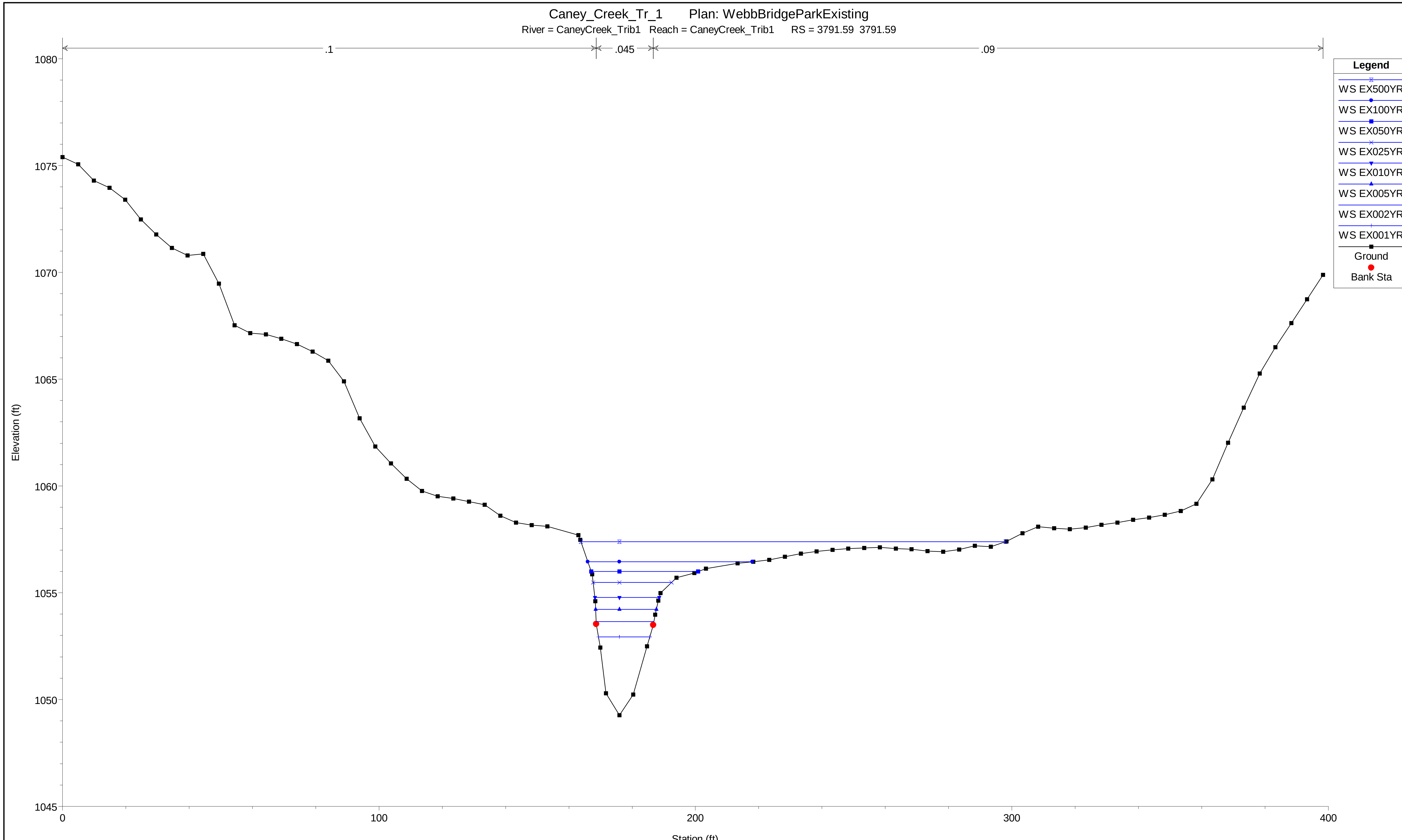
Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4527.66 4527.66
.1
.045
.09
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1095
1090
1085
1080
1075
1070
1065
1060
0
50
100
150
200
250
300
Station (ft)



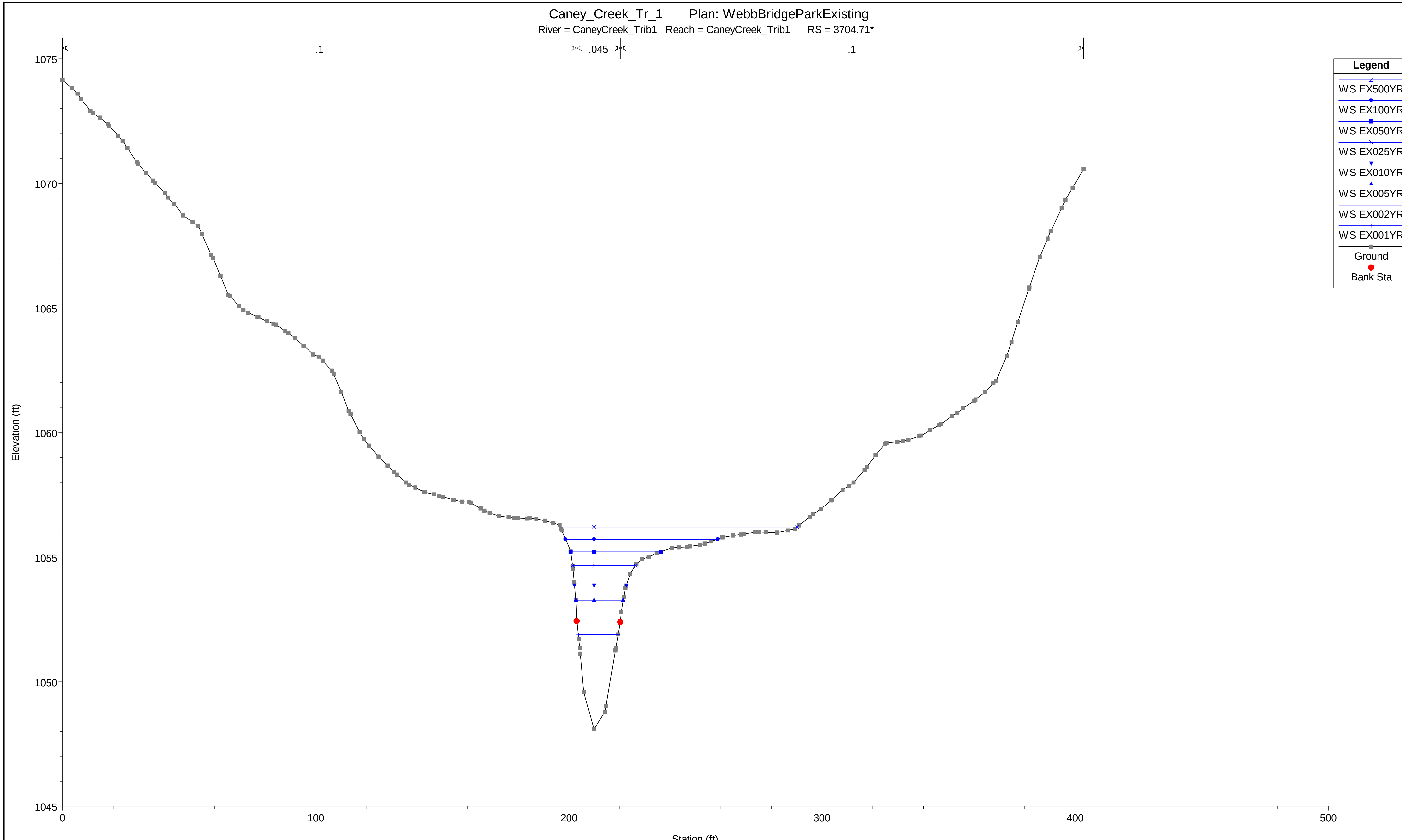
Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4343.95 4343.95
.1
.045
.09
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
1060
1065
1070
1075
1080
1085
1090
0
50
100
150
200
250
300
350



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 4037.49 4037.49
.1
.045
.09
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1090
1085
1080
1075
1070
1065
1060
1055
1050
0
100
200
300
400
500
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 3791.59 3791.59
.1
.045
.09
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1045
1050
1055
1060
1065
1070
1075
1080
0
100
200
300
400
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 3704.71*
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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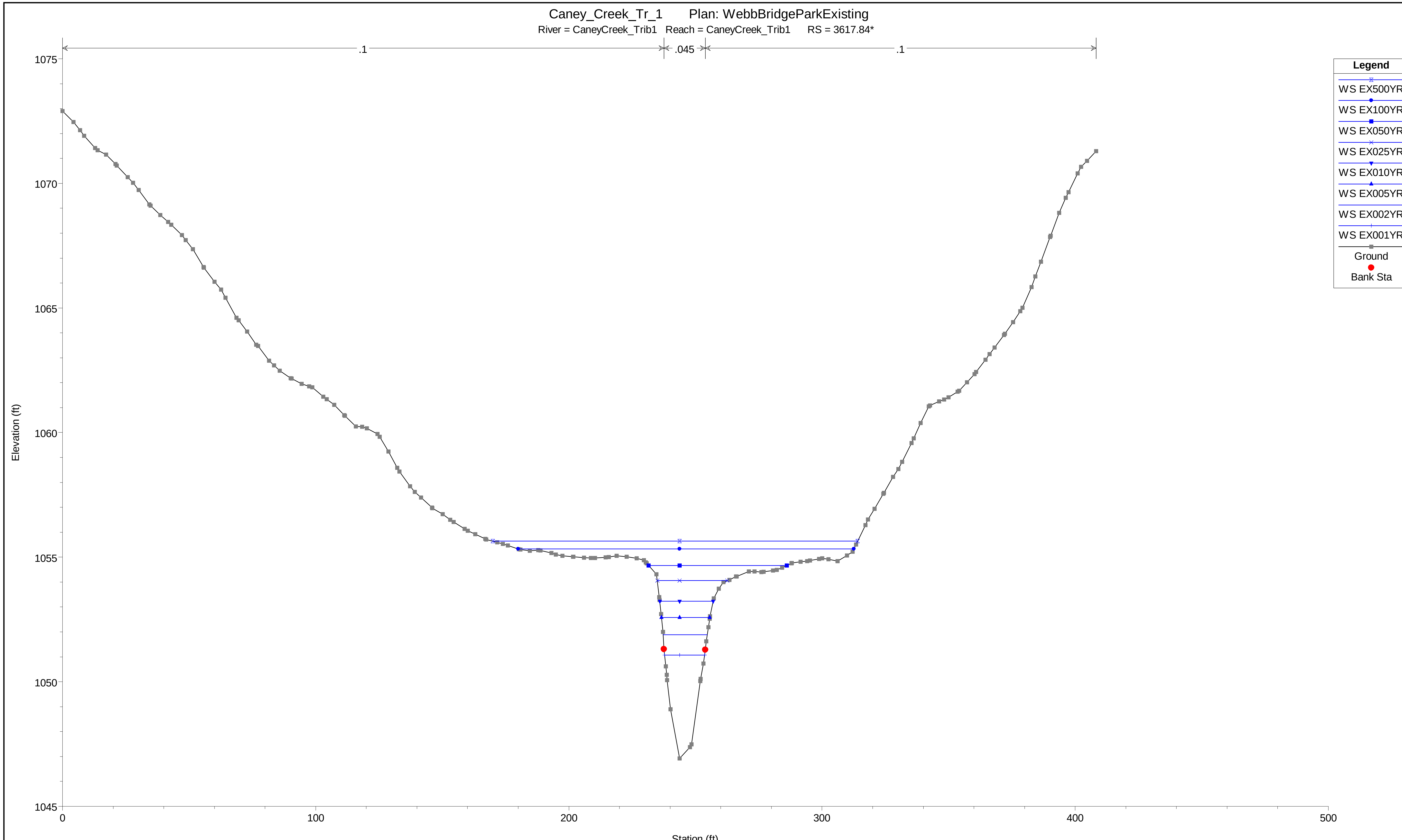
1070
1065
1060
1055
1050
1045
0
100
200
300
400
500
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 3617.84*
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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1065
1060
1055
1050
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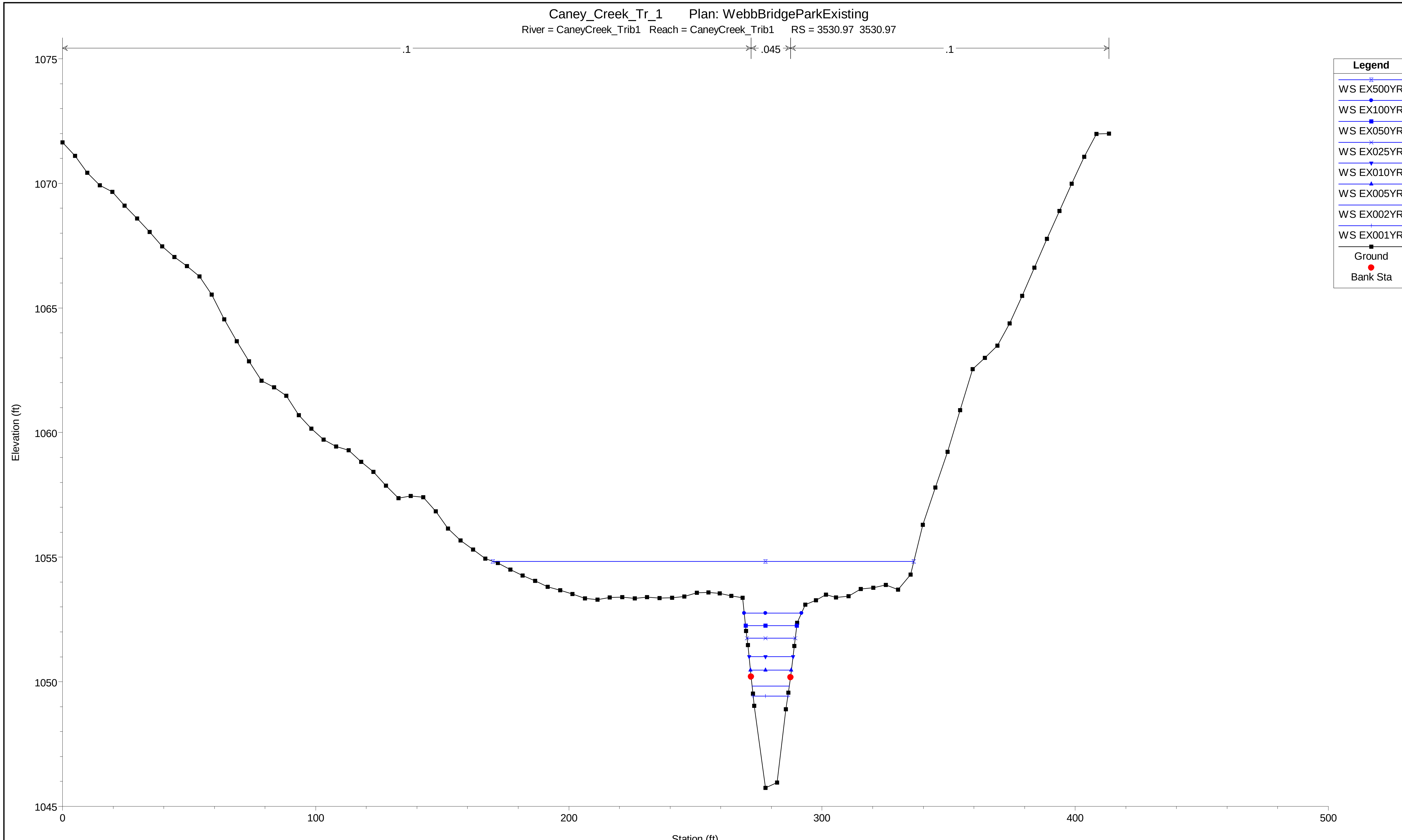
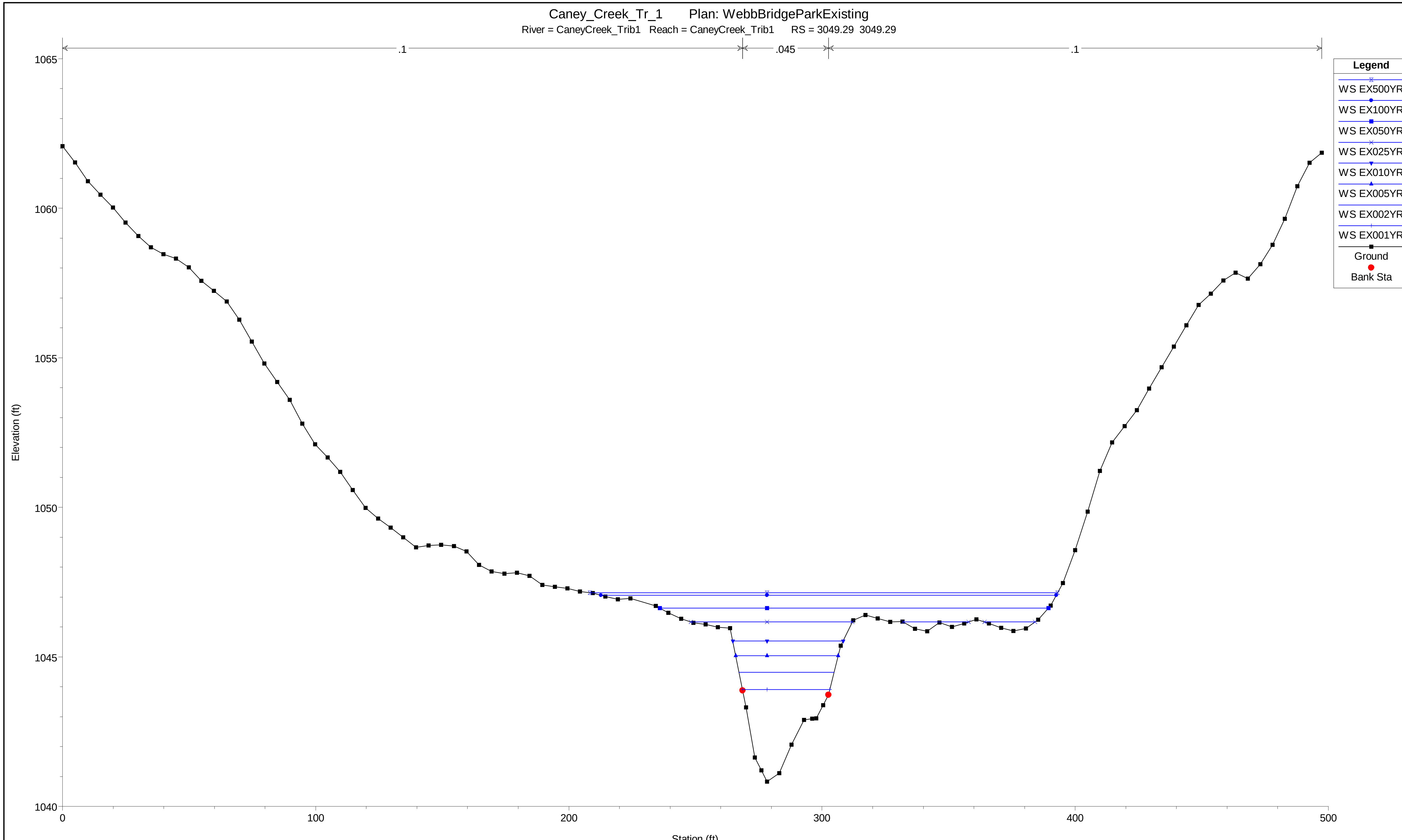
0
100
200
300
400
500
Station (ft)


Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 3530.97 3530.97
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1075
1070
1065
1060
1055
1050
1045
0
100
200
300
400
500
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCreek_Trib1 Reach = CaneyCreek_Trib1 RS = 3049.29 3049.29
.1
.045
.1
Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1065
1060
1055
1050
1045
1040
0
100
200
300
400
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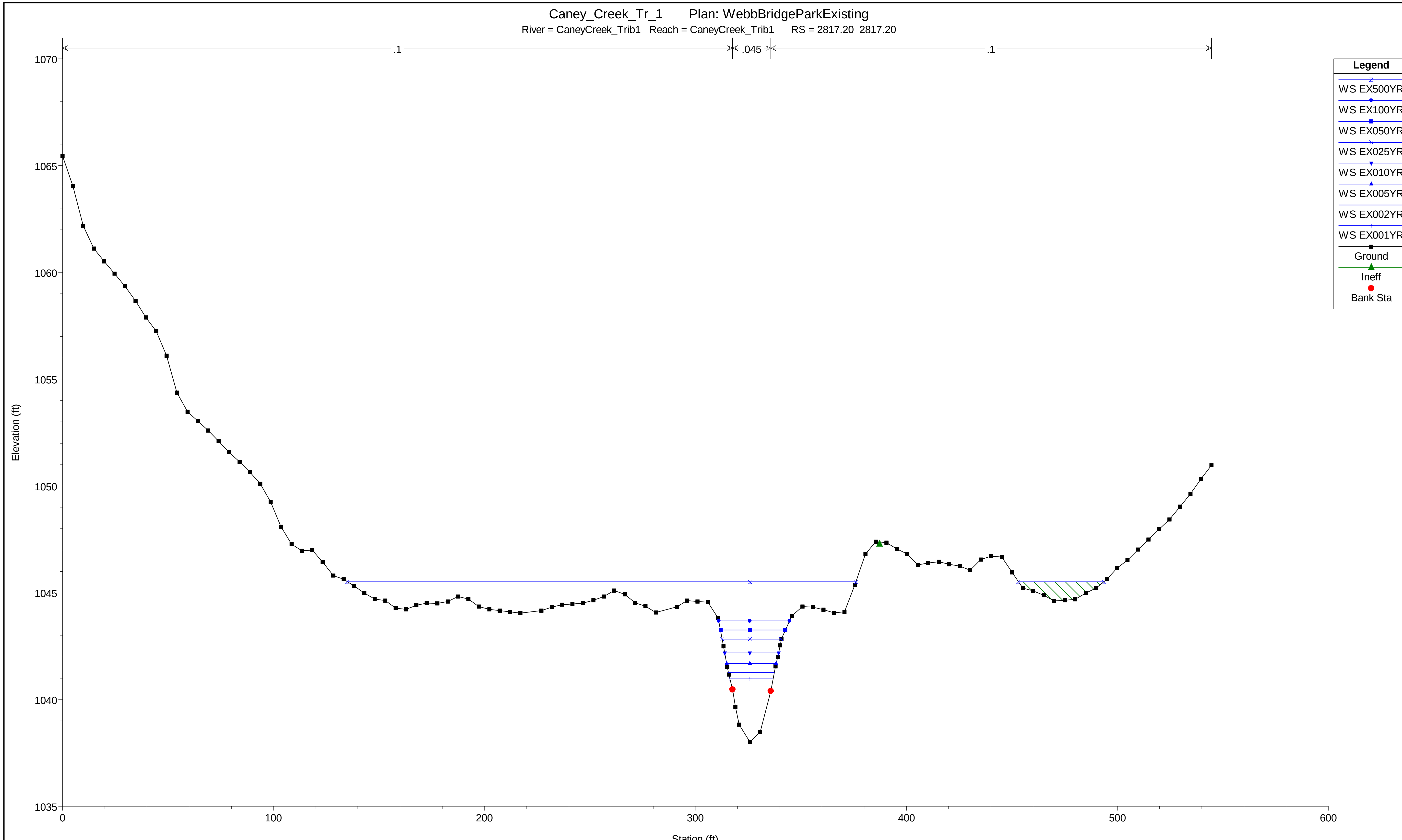
Station (ft)



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.045
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Legend
WS EX500YR
WS EX100YR
WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Ineff
Bank Sta
Elevation (ft)
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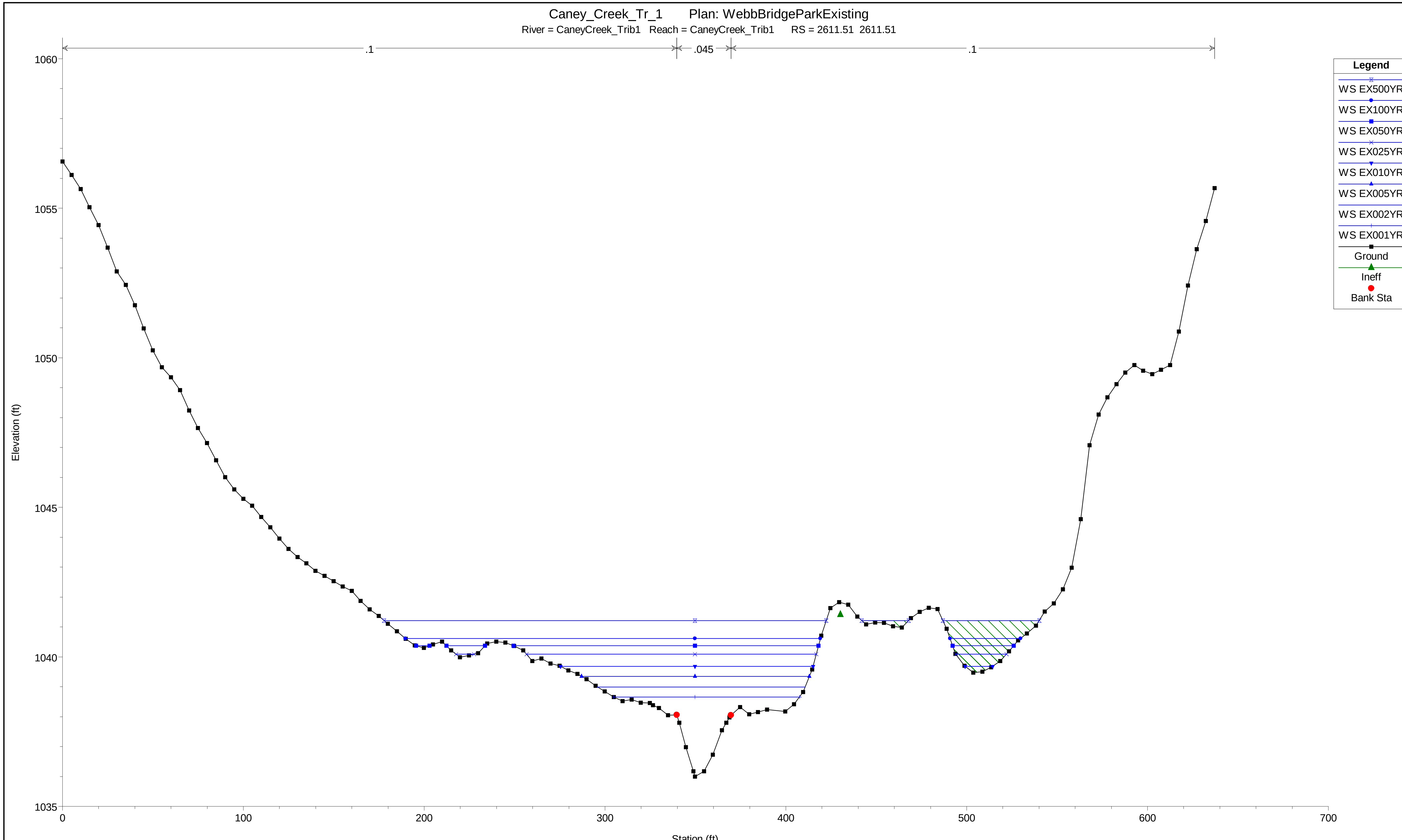
Station (ft)



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WS EX100YR
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WS EX001YR
Ground
Ineff
Bank Sta
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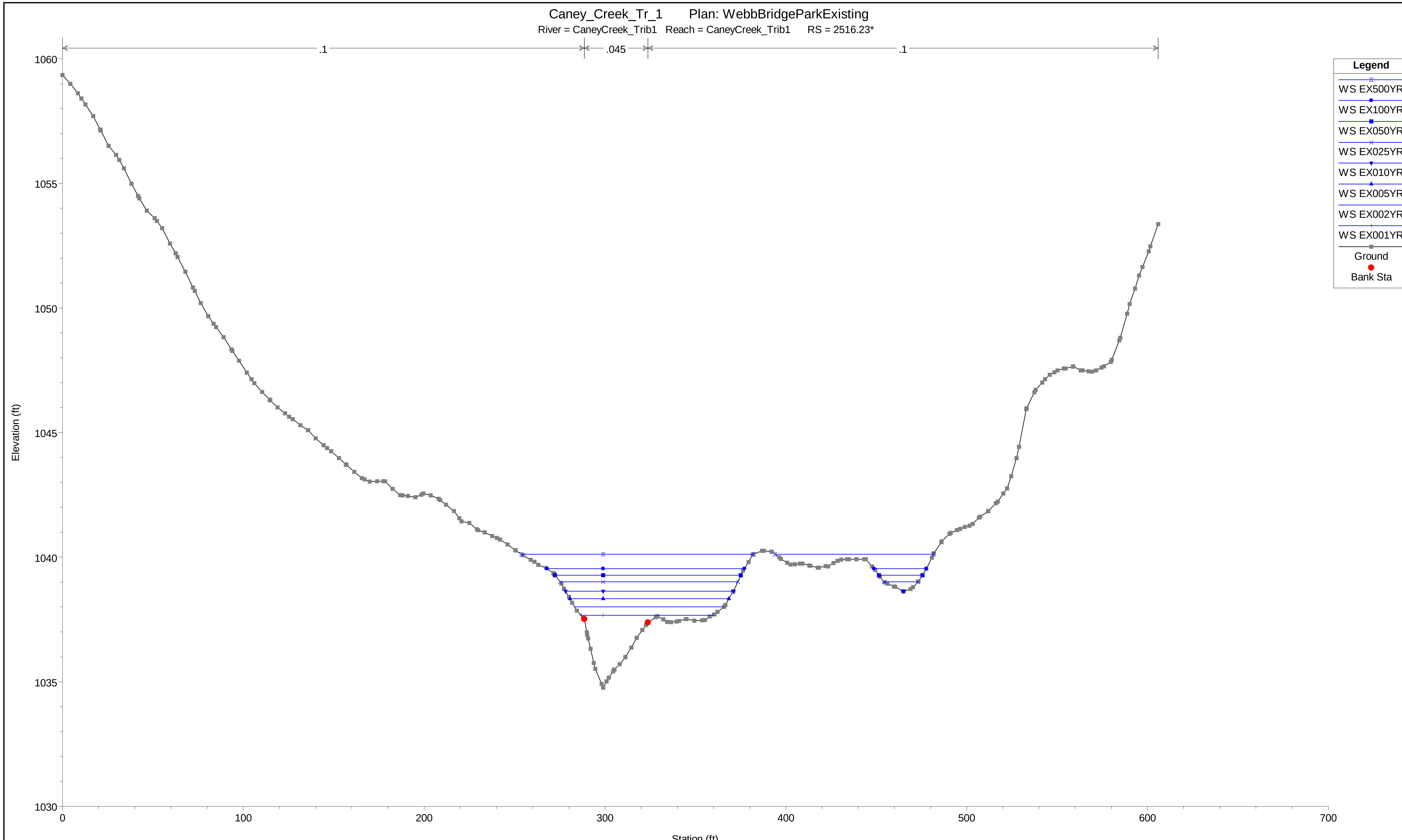
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Bank Sta
Elevation (ft)
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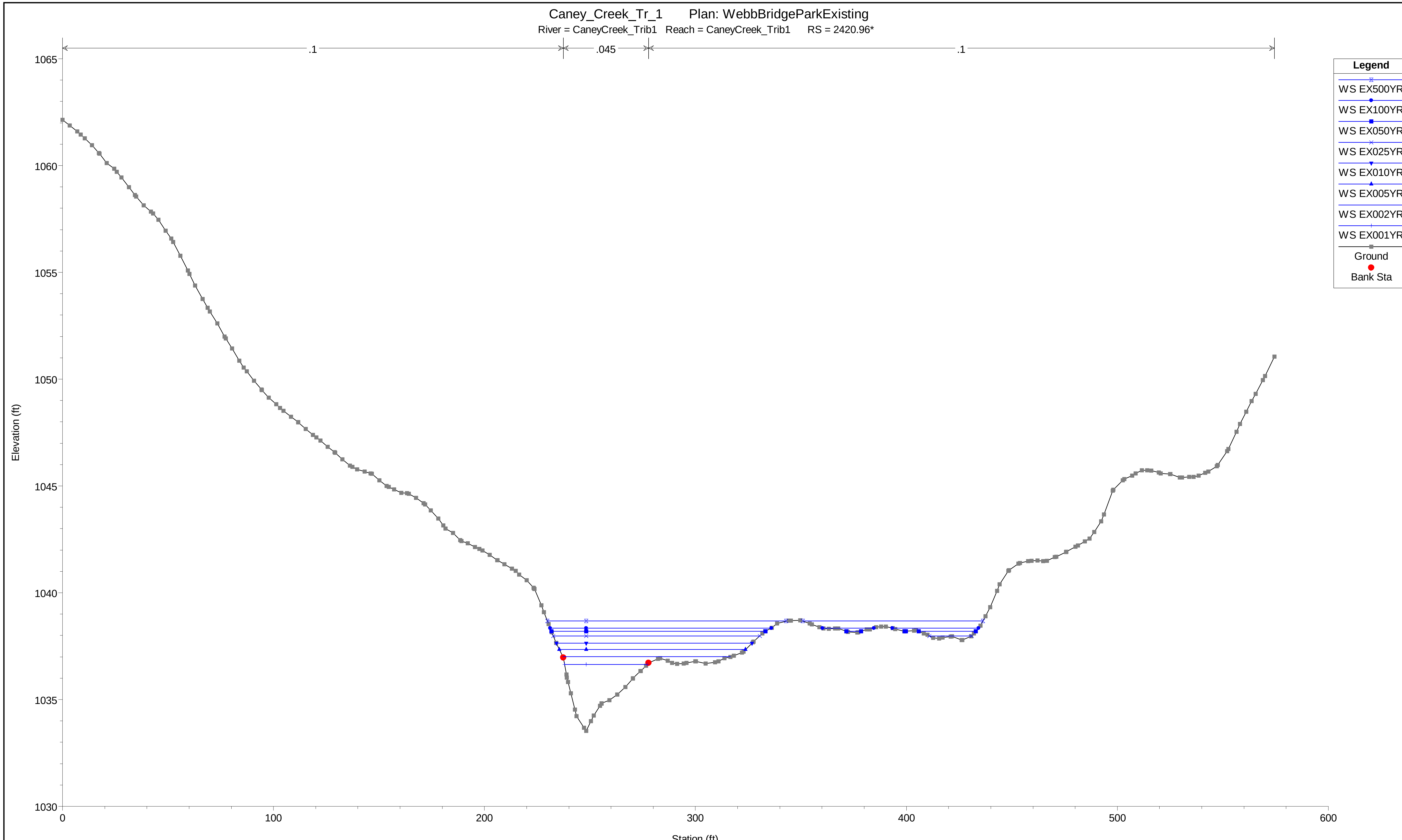
Station (ft)



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Ground
Bank Sta
Elevation (ft)
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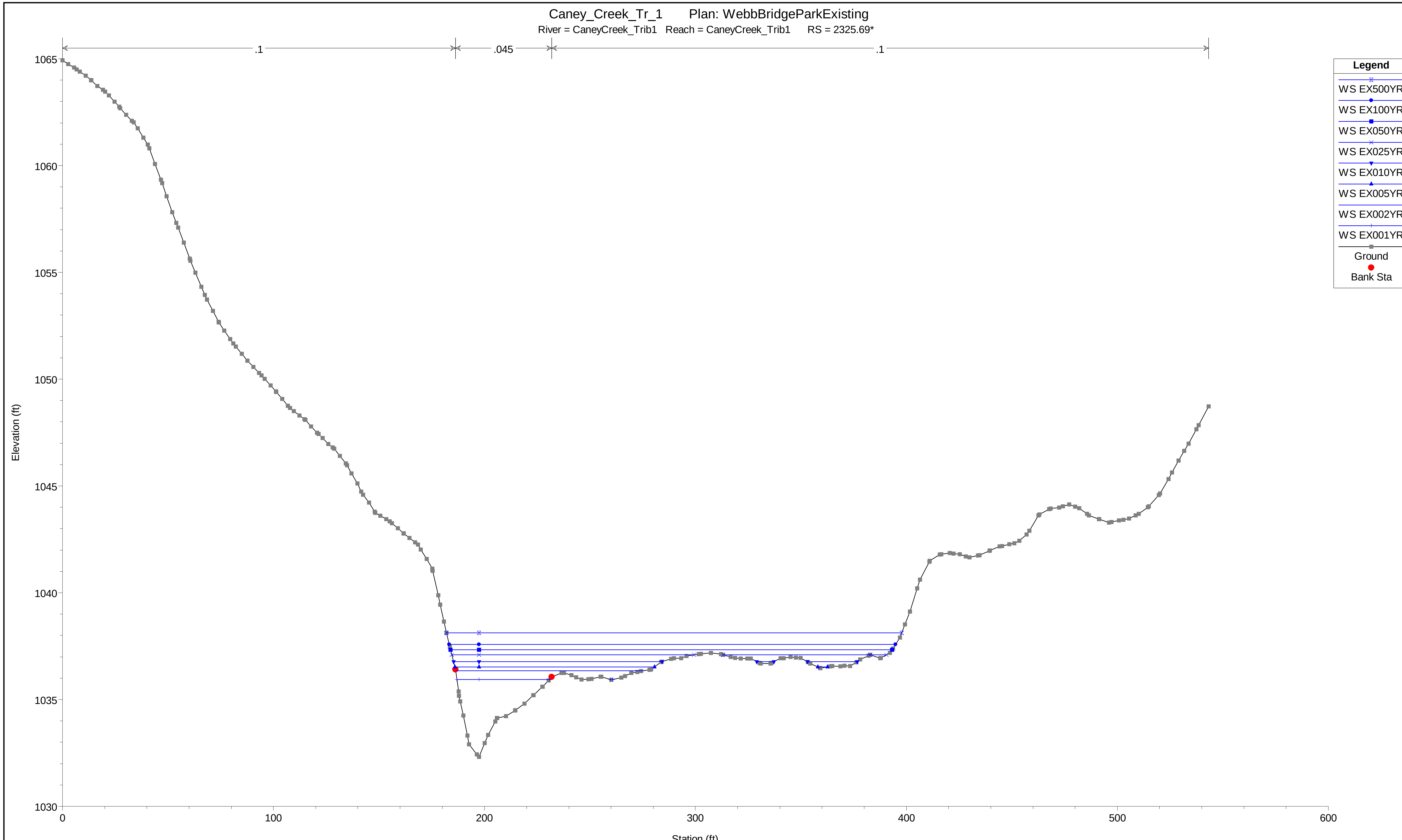
Station (ft)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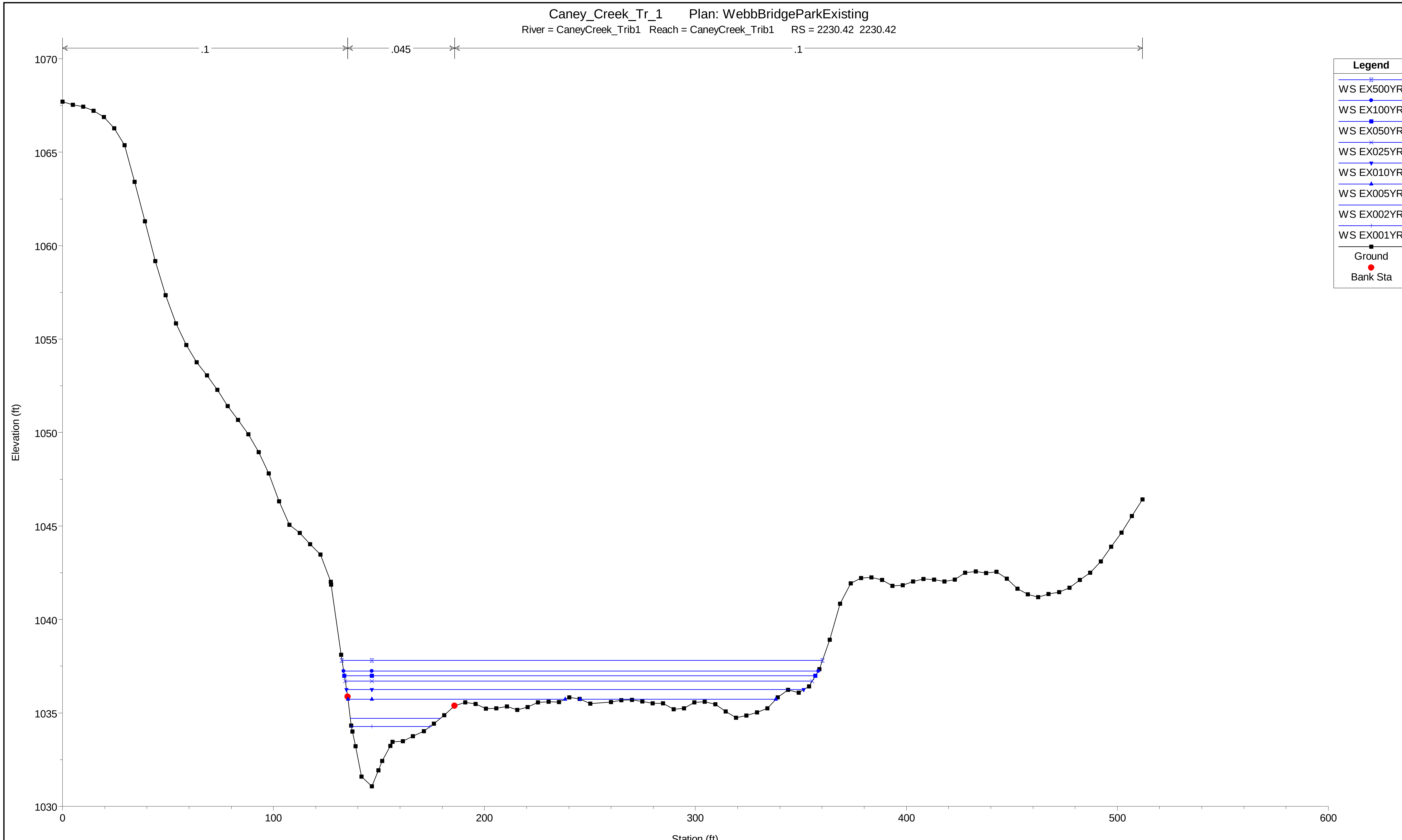

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.045
.1
Legend
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WS EX010YR
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WS EX001YR
Ground
Bank Sta
Elevation (ft)
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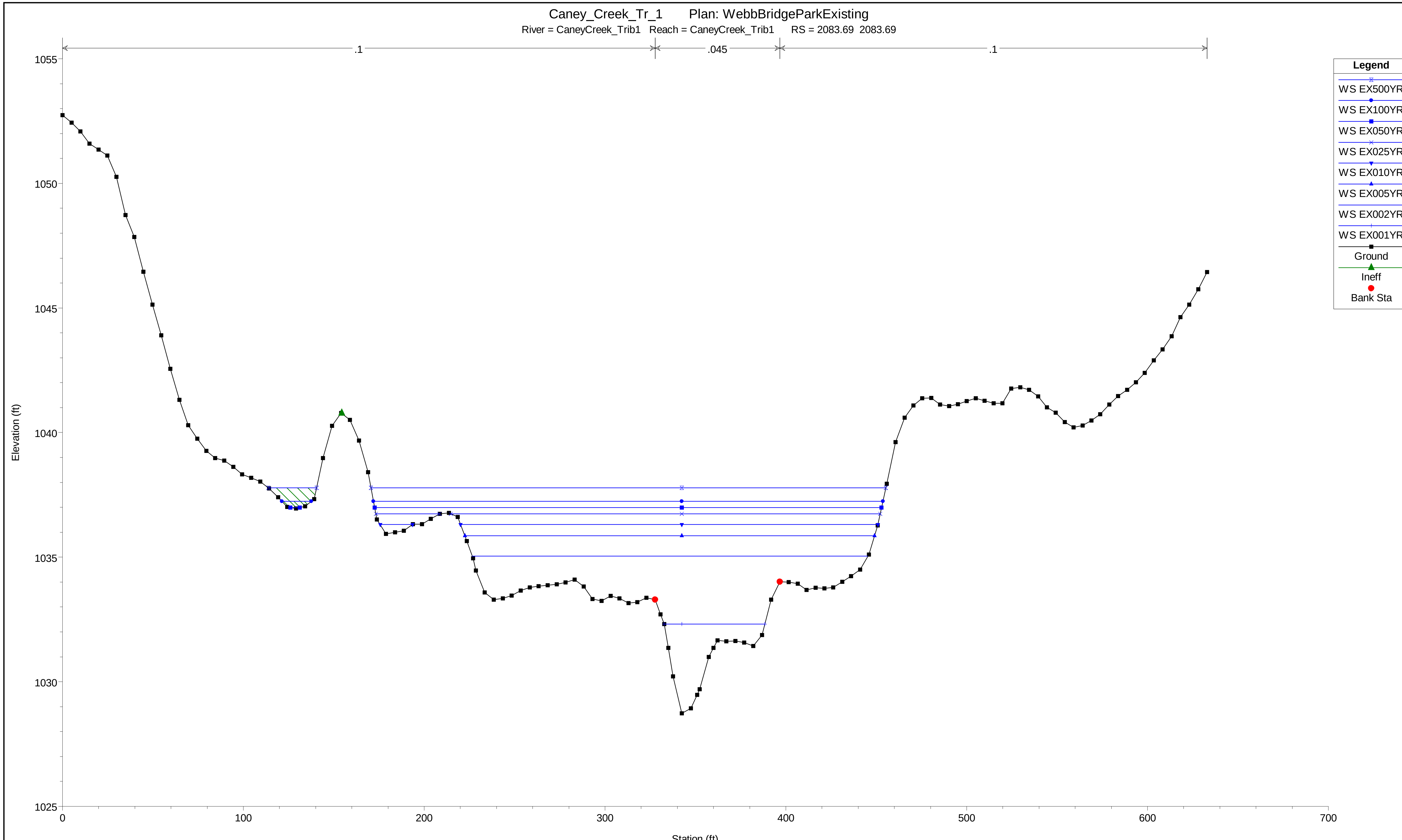
Station (ft)



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Legend
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Ineff
Bank Sta
Elevation (ft)
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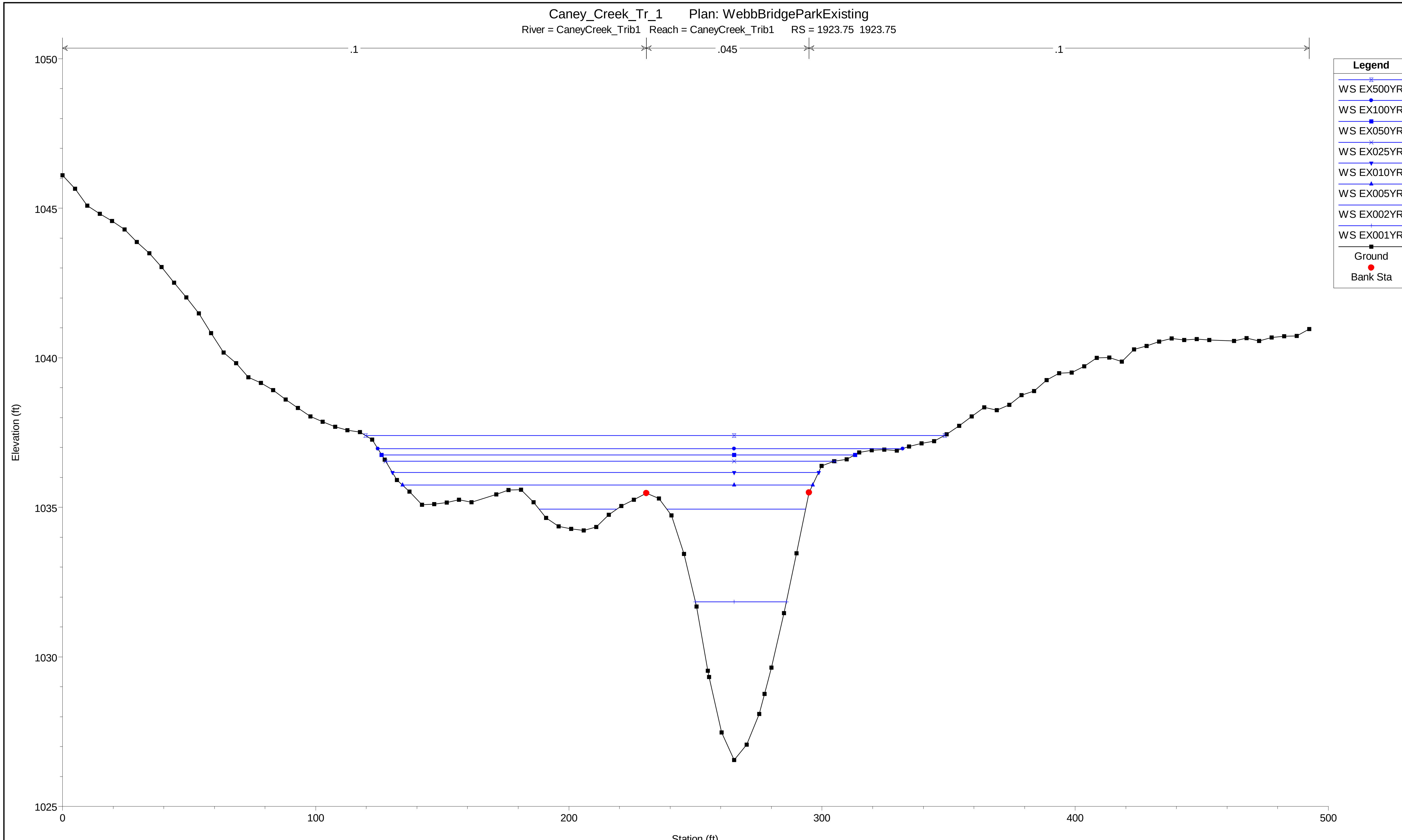
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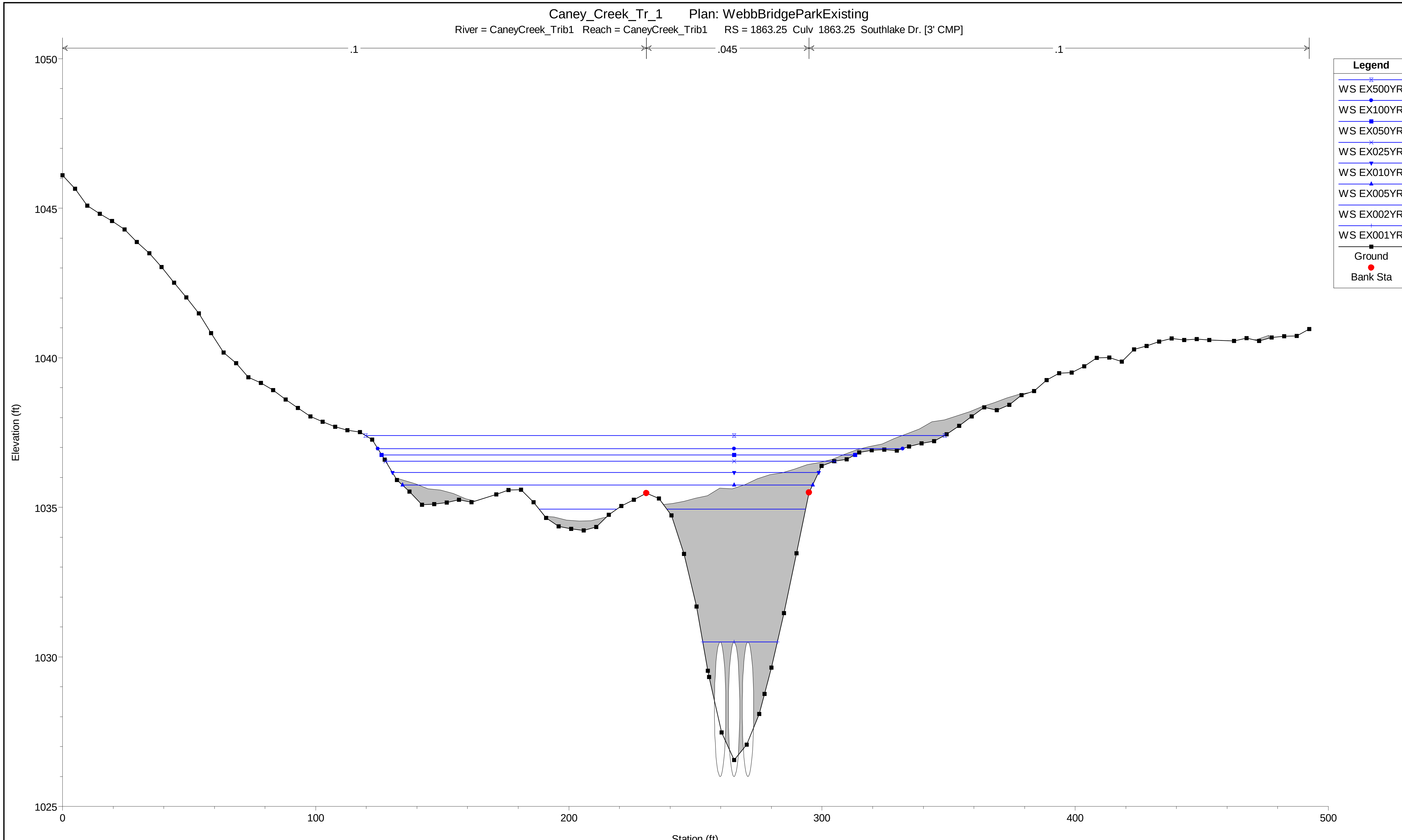
Station (ft)



Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
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.1
.045
.1
Legend
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
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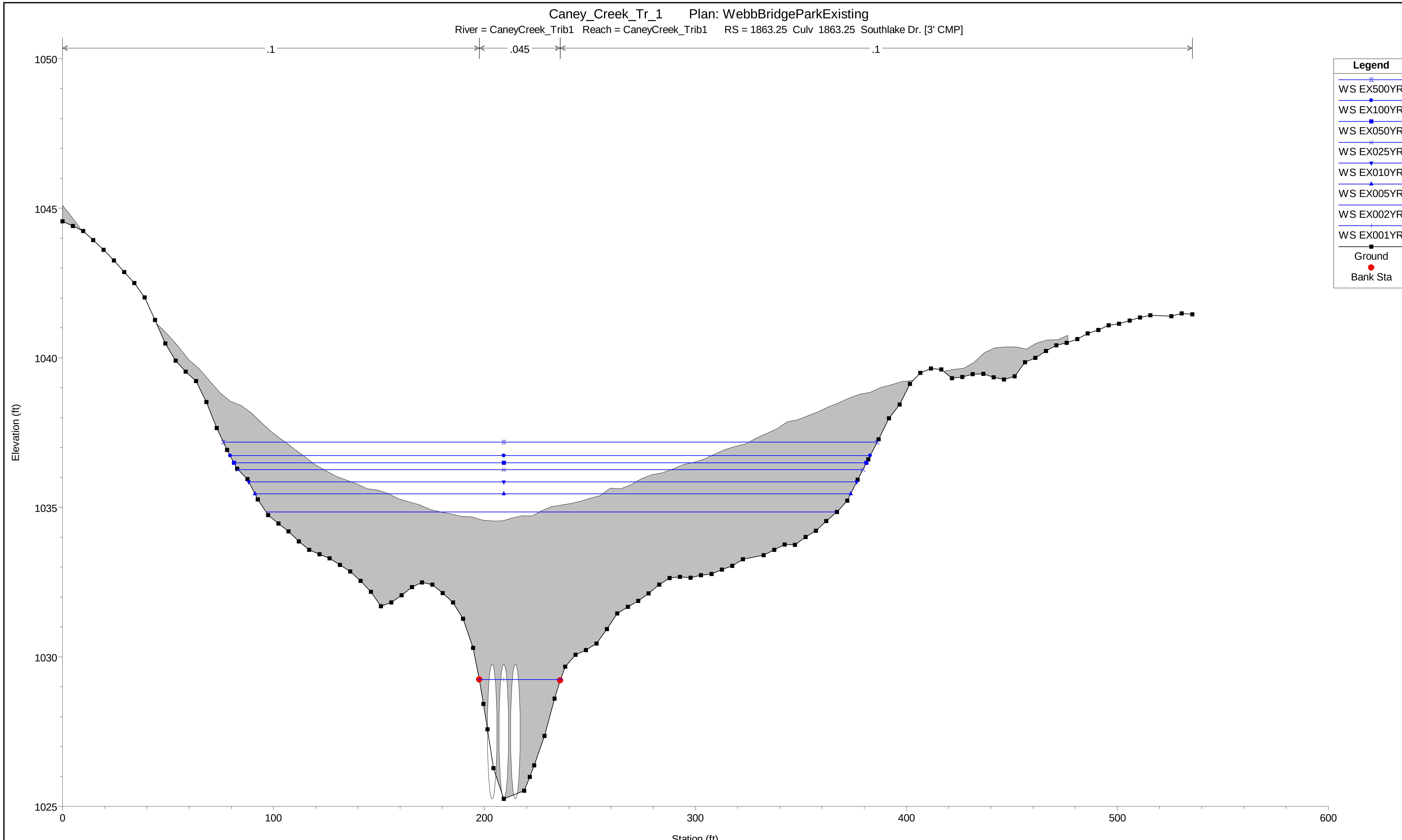
Station (ft)



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Legend
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
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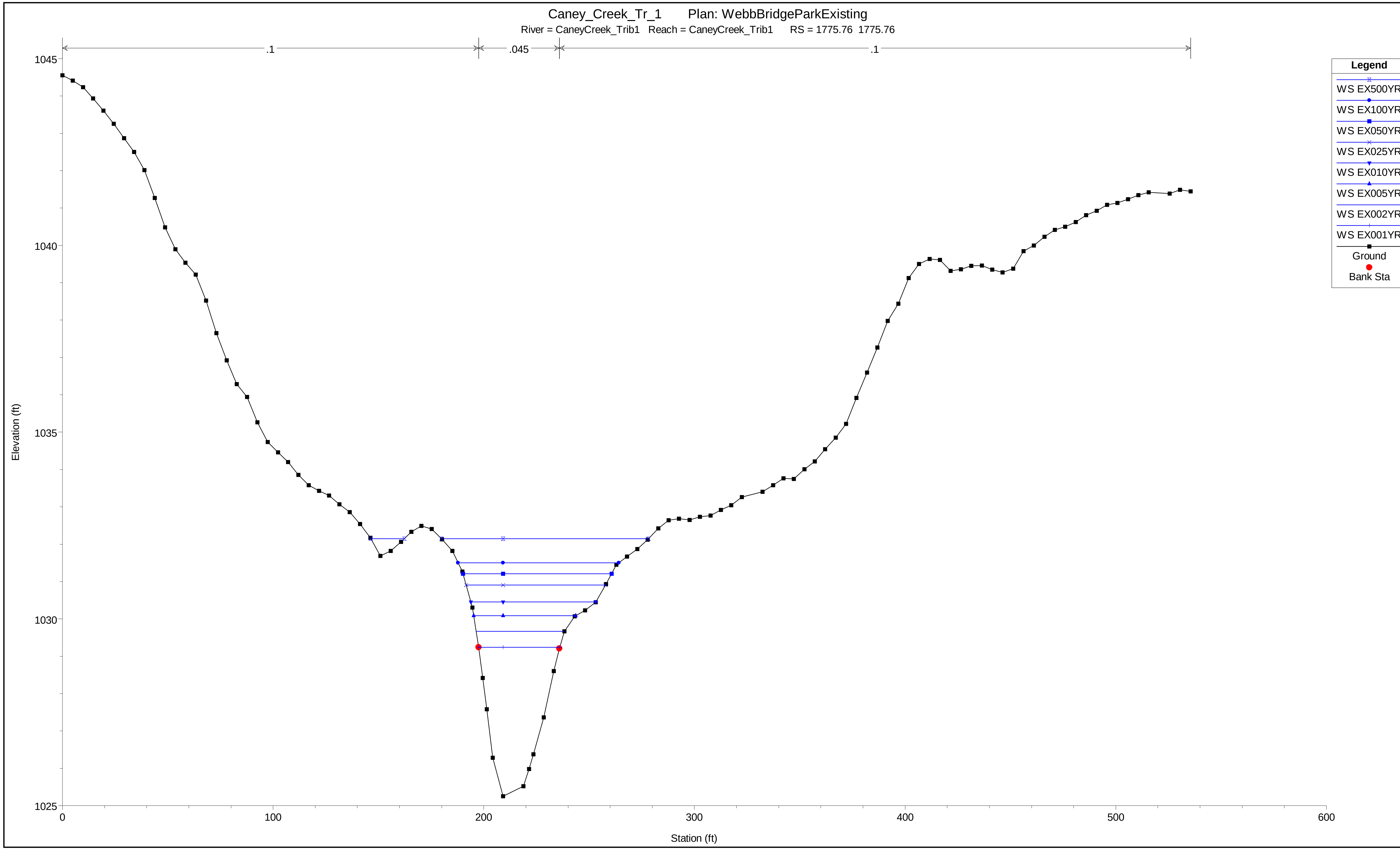
Station (ft)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Legend
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
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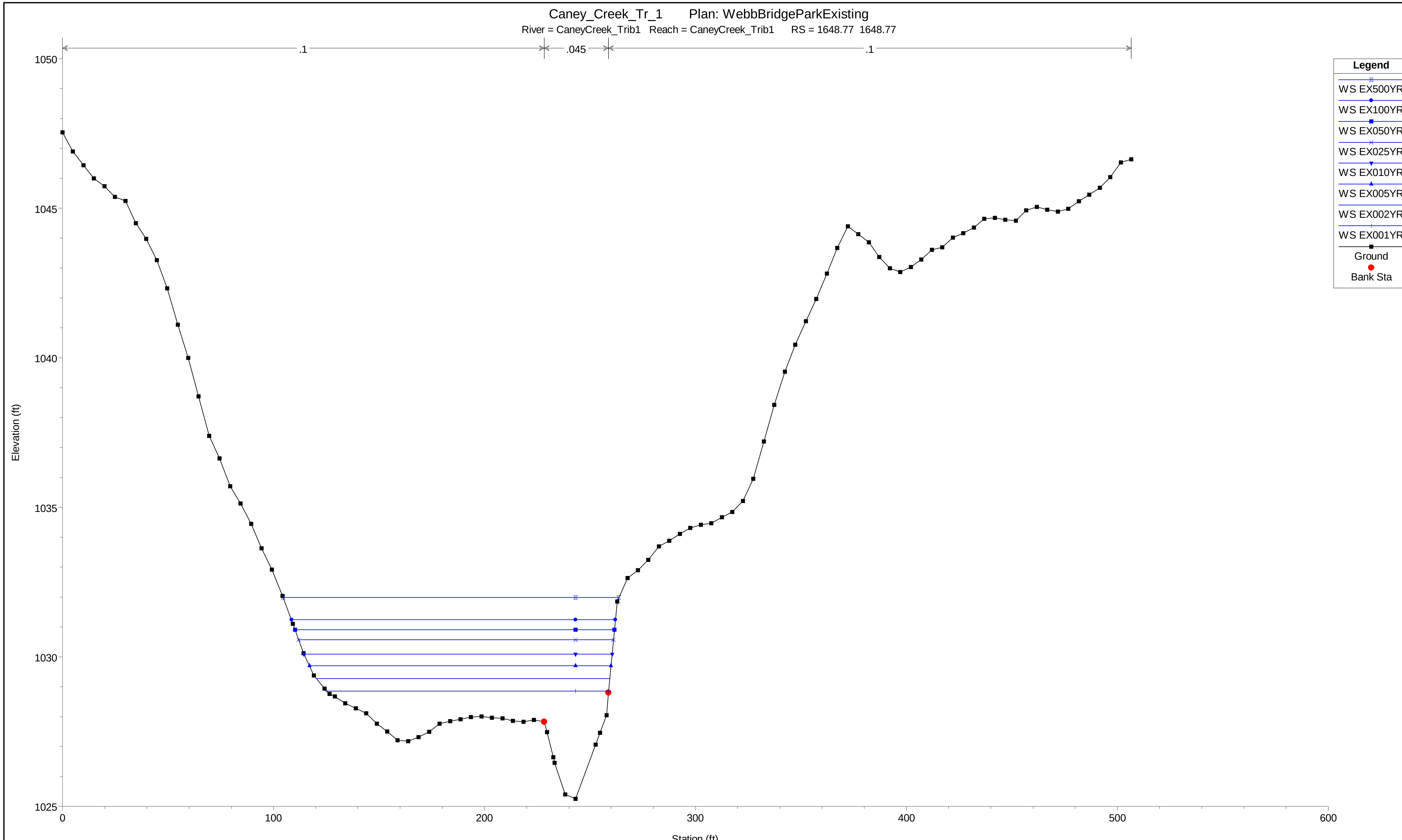
Station (ft)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.1
Legend
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
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100
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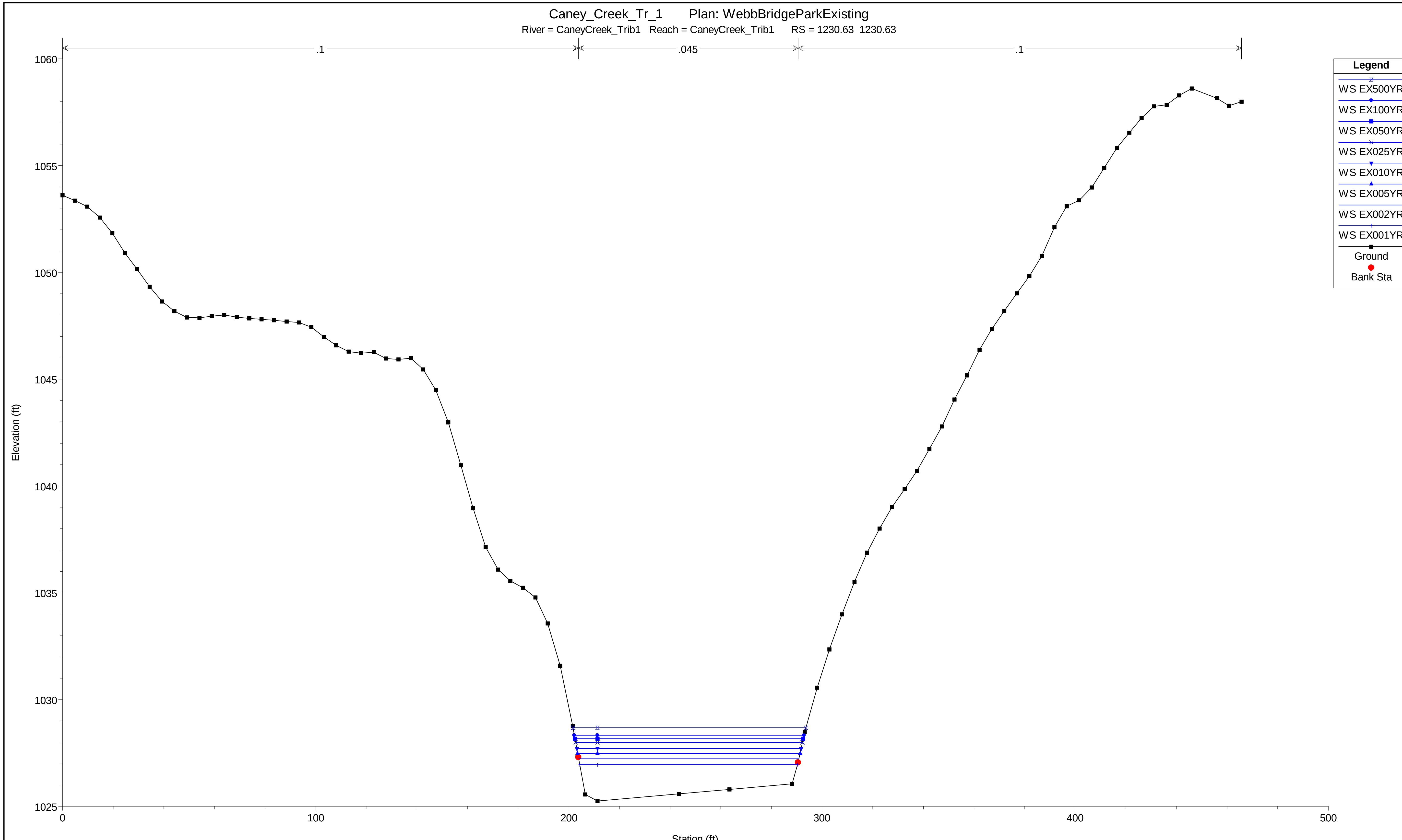
Station (ft)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Legend
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WS EX001YR
Ground
Bank Sta
Elevation (ft)
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Station (ft)
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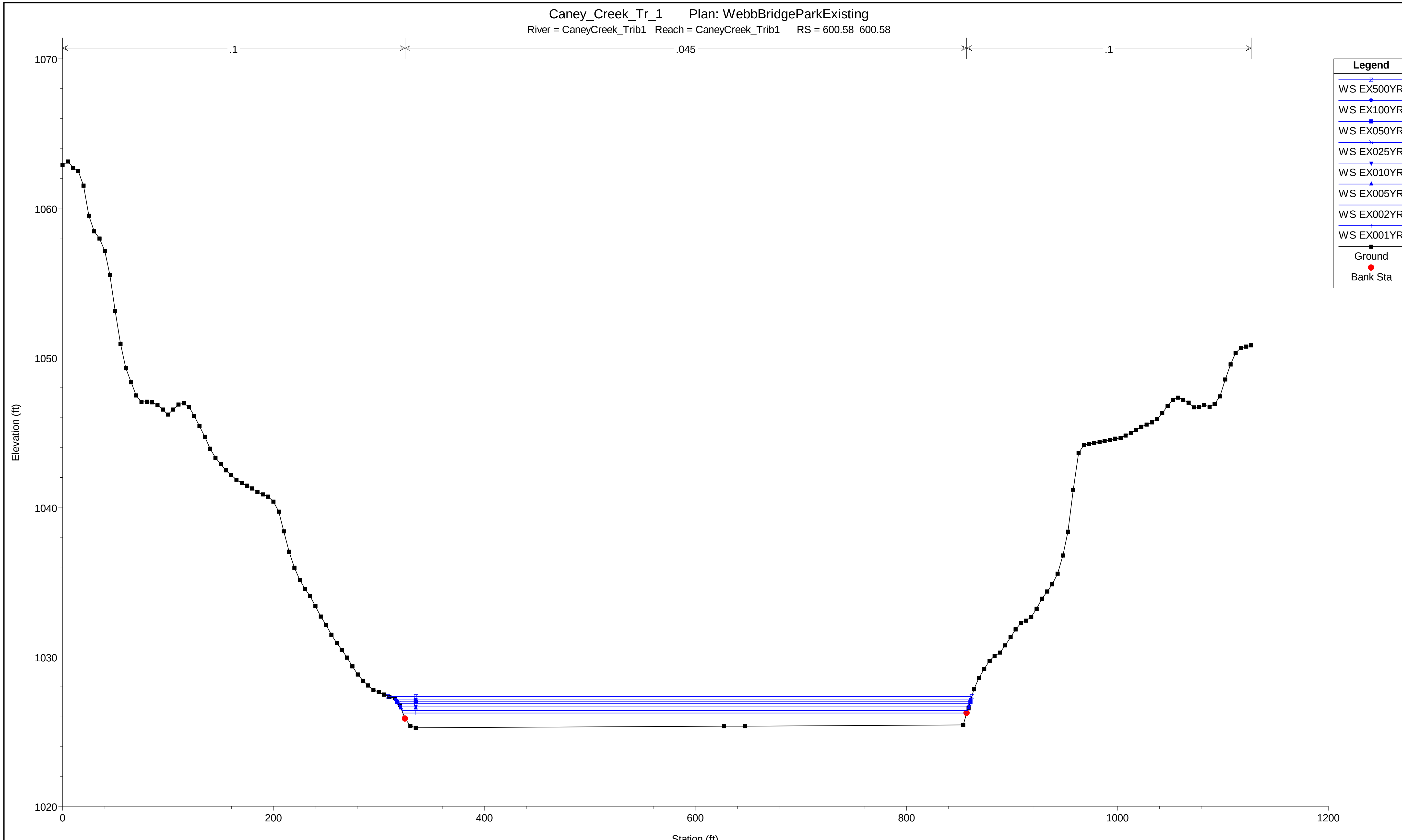
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.045
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Legend
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WS EX050YR
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WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
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600
800
1000
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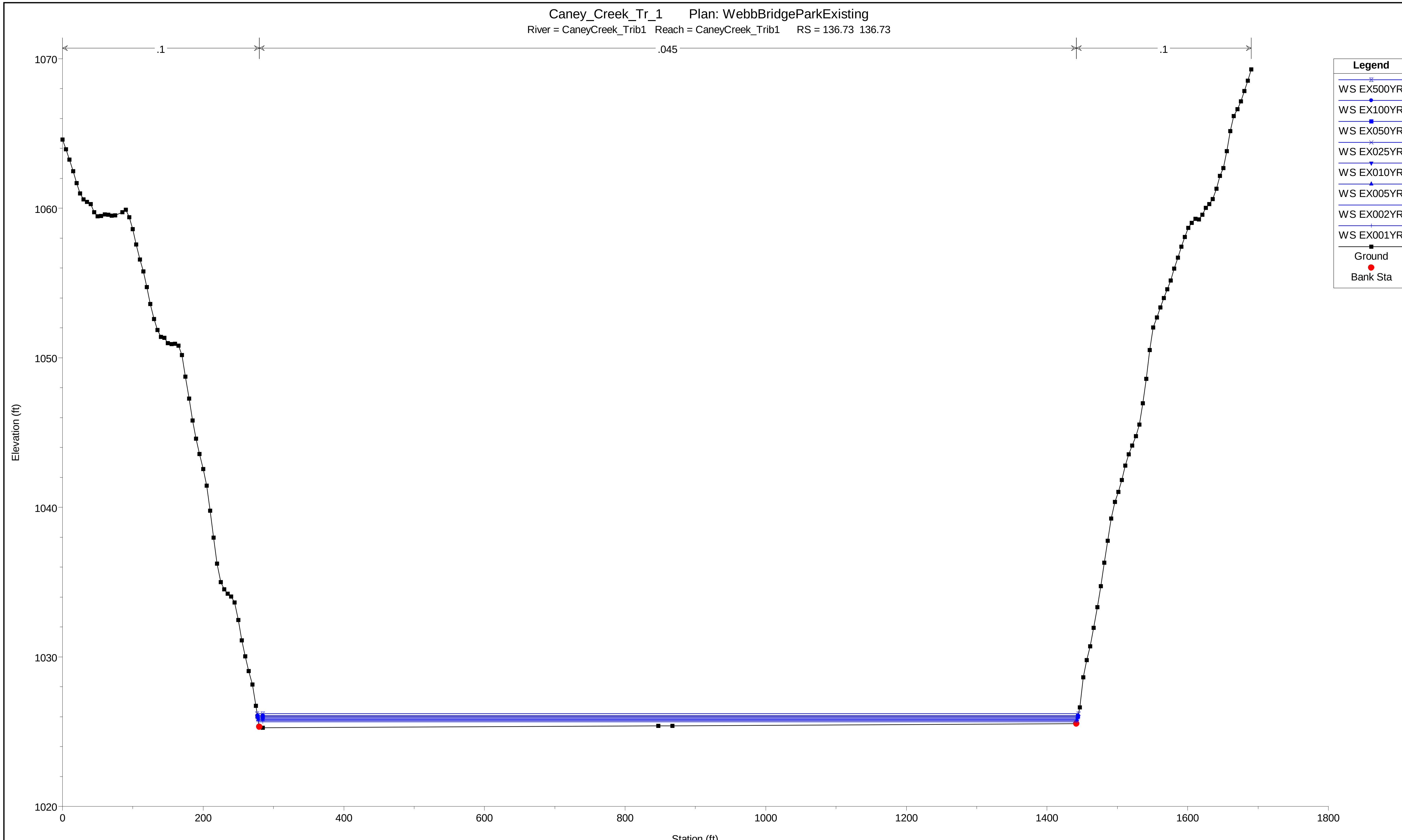
Station (ft)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.045
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Legend
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WS EX050YR
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WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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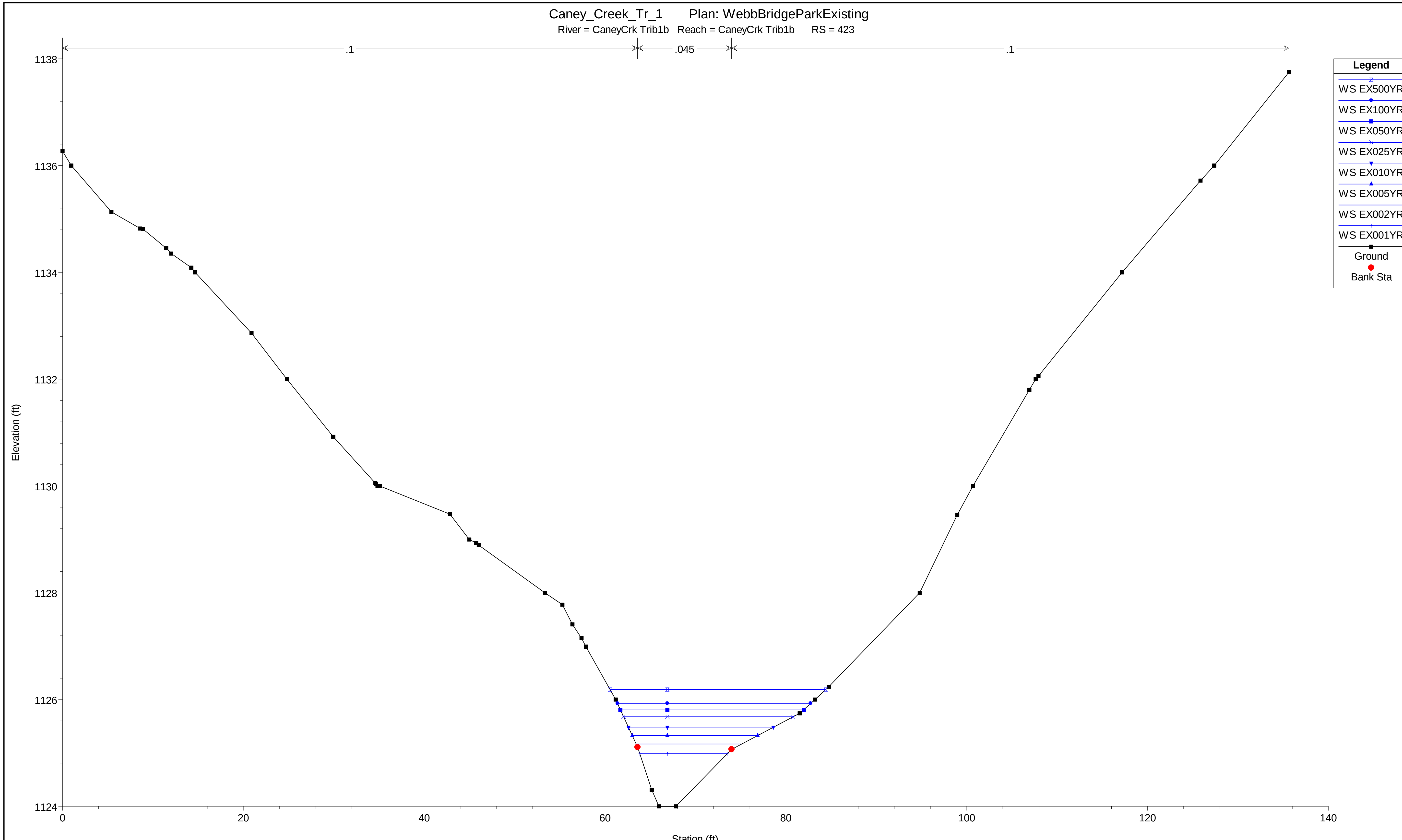
Station (ft)



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.045
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Legend
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WS EX050YR
WS EX025YR
WS EX010YR
WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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Station (ft)
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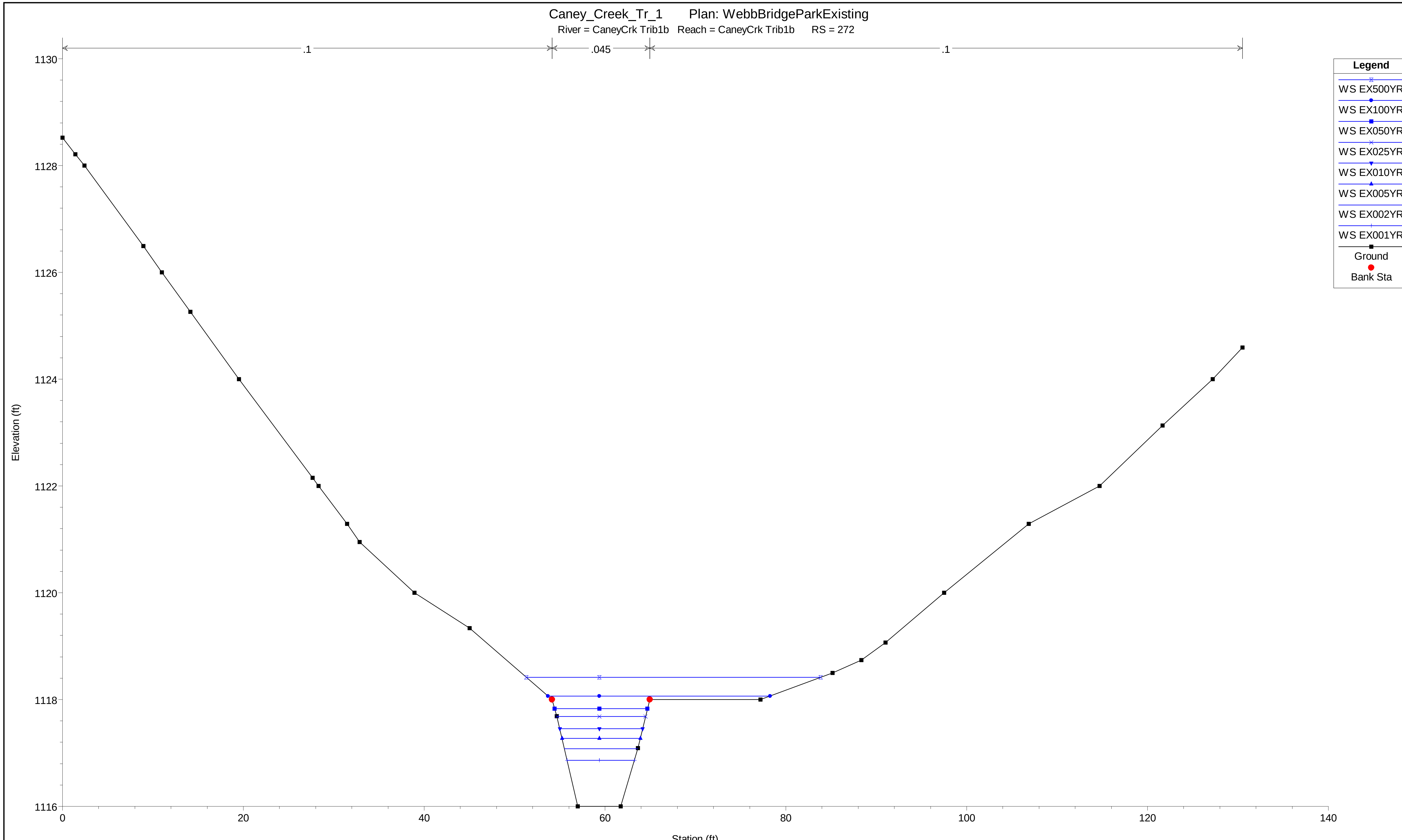

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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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120
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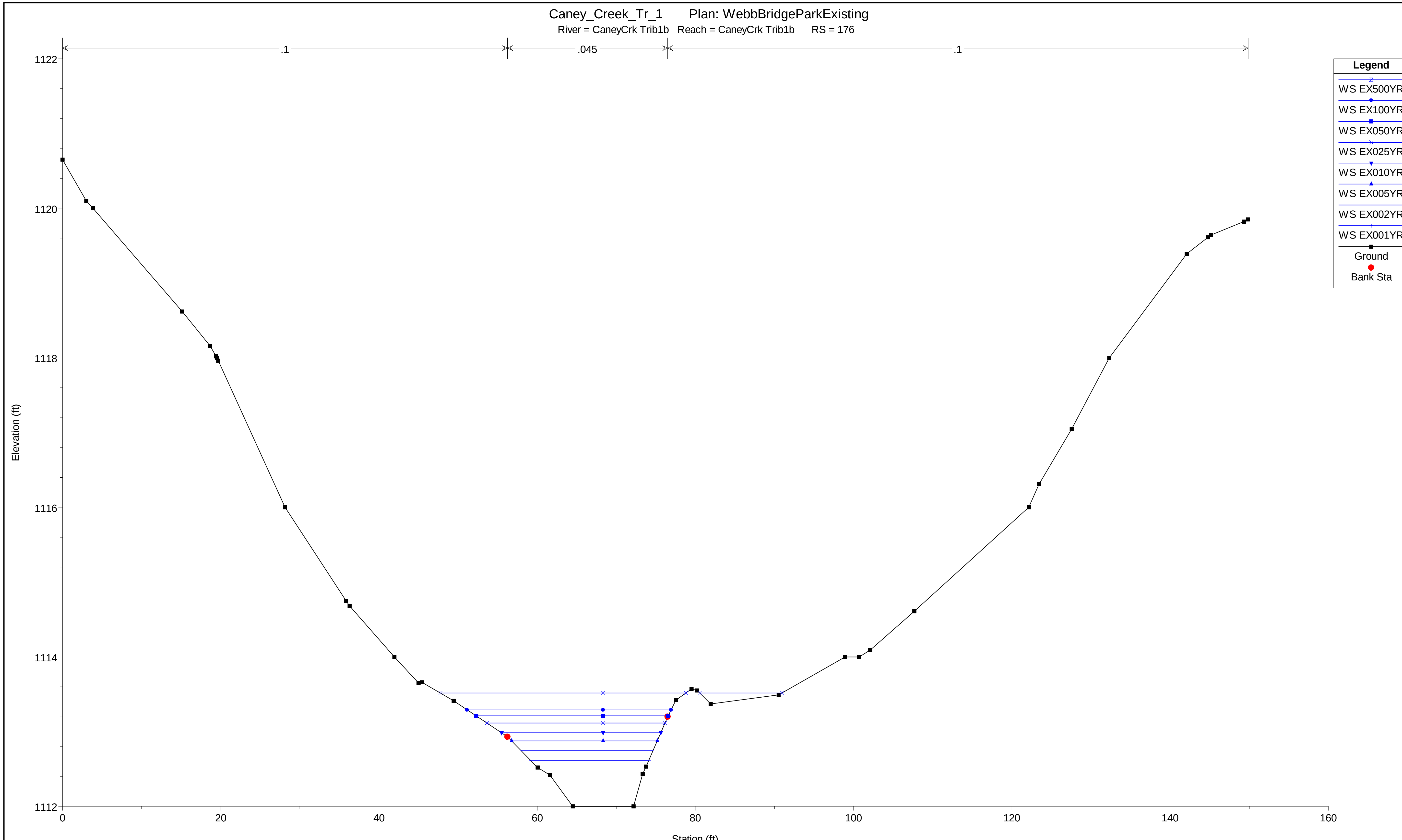
Station (ft)



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Legend
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WS EX050YR
WS EX025YR
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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Station (ft)
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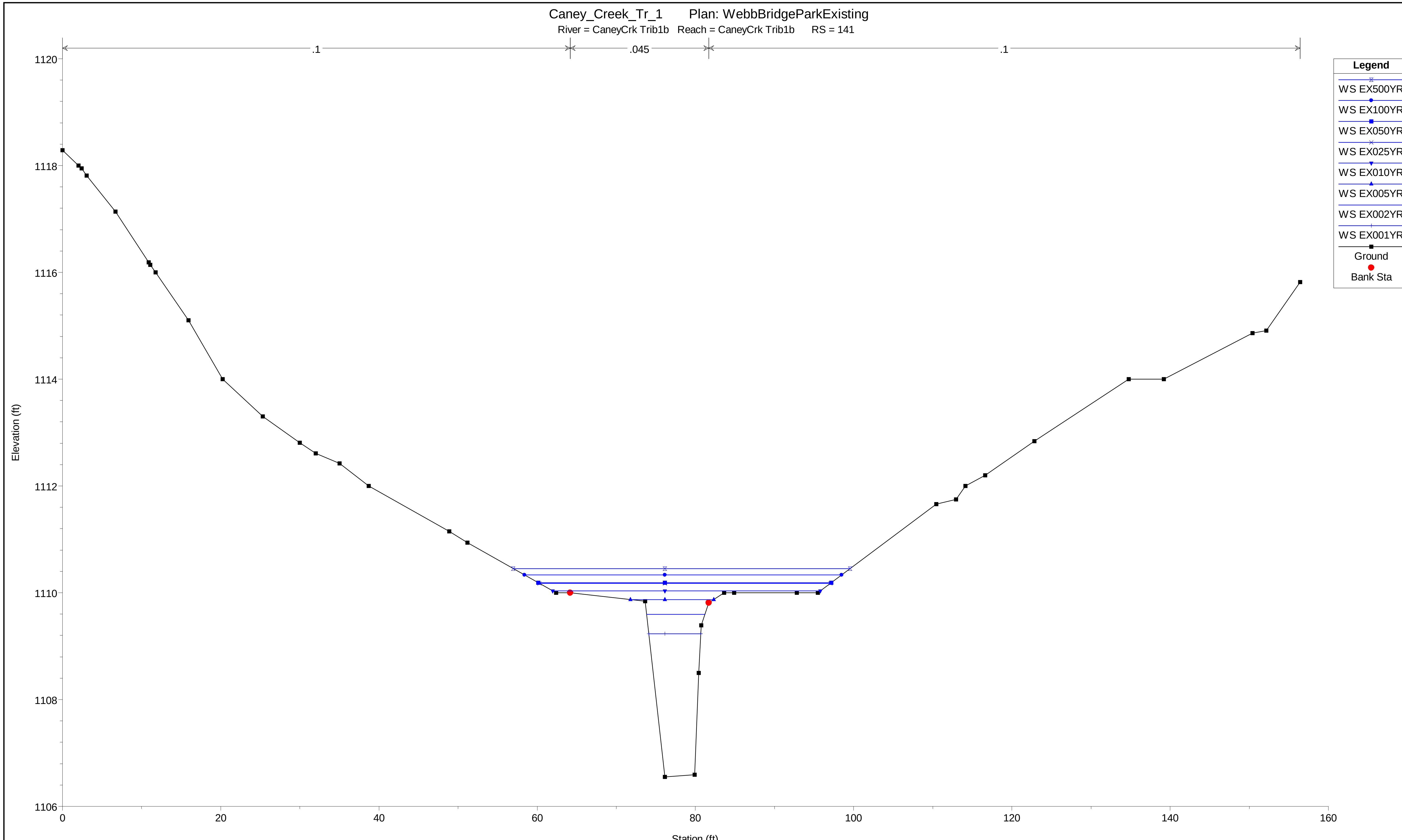
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Legend
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WS EX001YR
Ground
Bank Sta
Elevation (ft)
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Station (ft)
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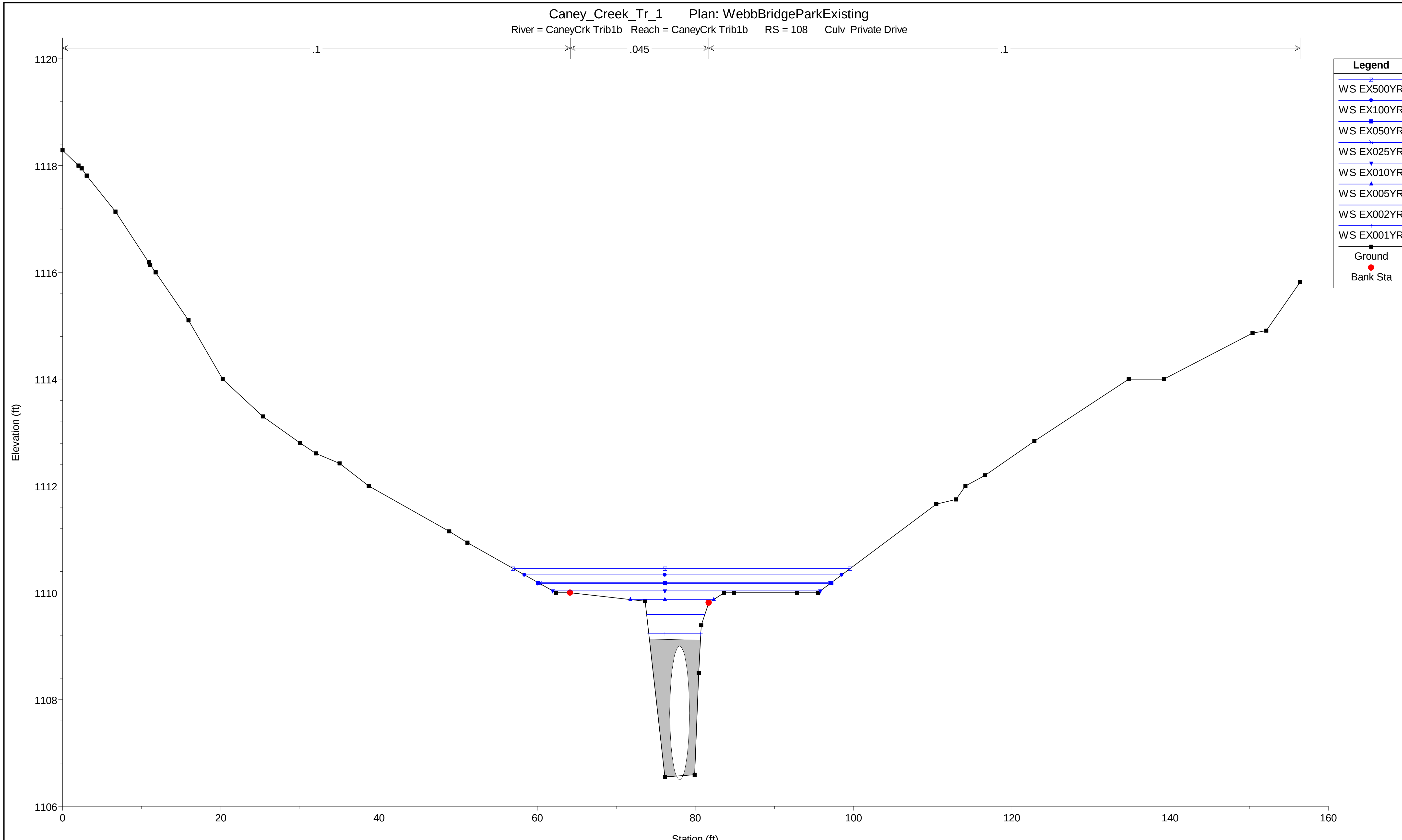

Caney_Creek_Tr_1 Plan: WebbBridgeParkExisting
River = CaneyCrk Trib1b Reach = CaneyCrk Trib1b RS = 108 Culv Private Drive
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Legend
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WS EX100YR
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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Station (ft)
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140
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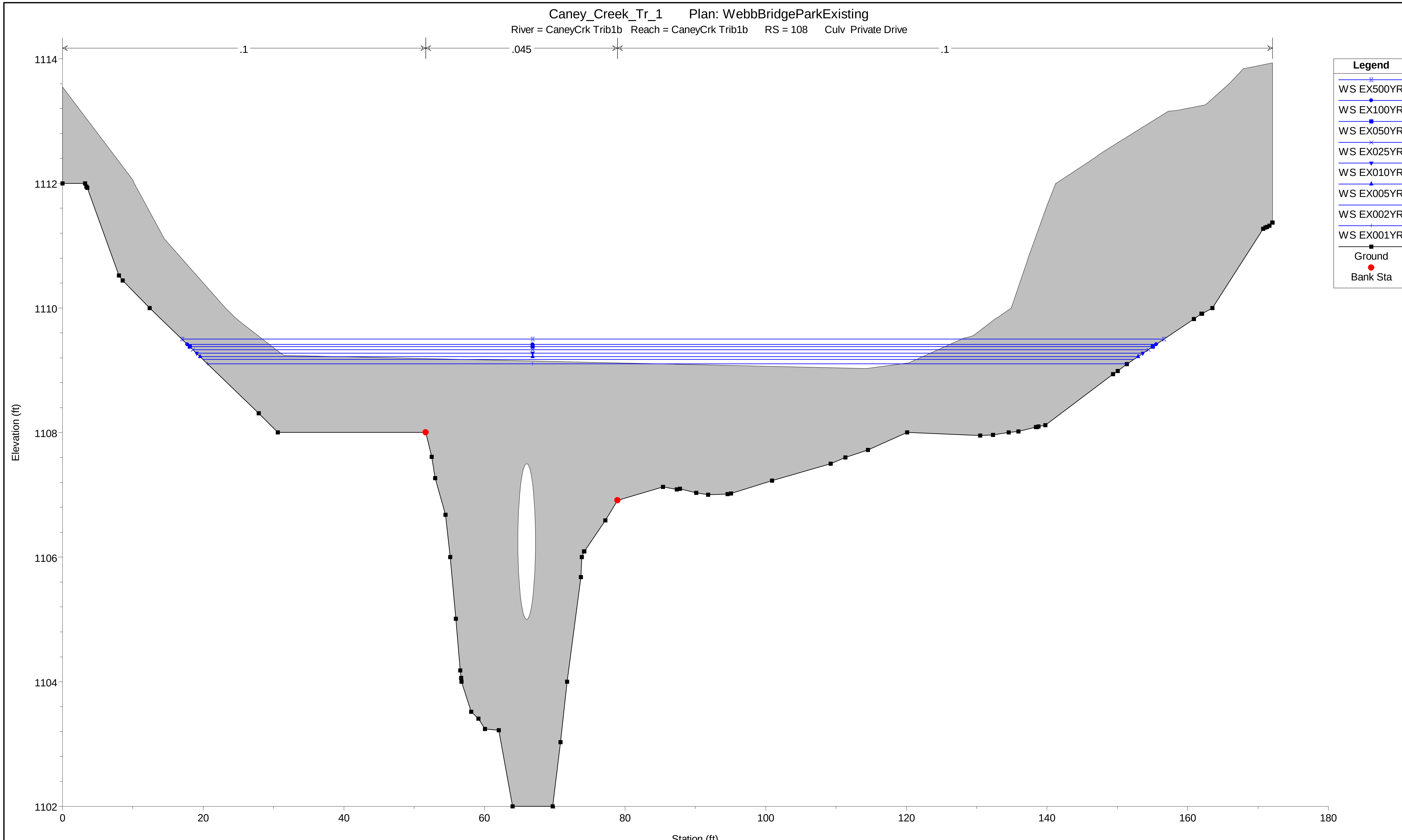

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River = CaneyCrk Trib1b Reach = CaneyCrk Trib1b RS = 108 Culv Private Drive
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.045
.1
Legend
WS EX500YR
WS EX100YR
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
1114
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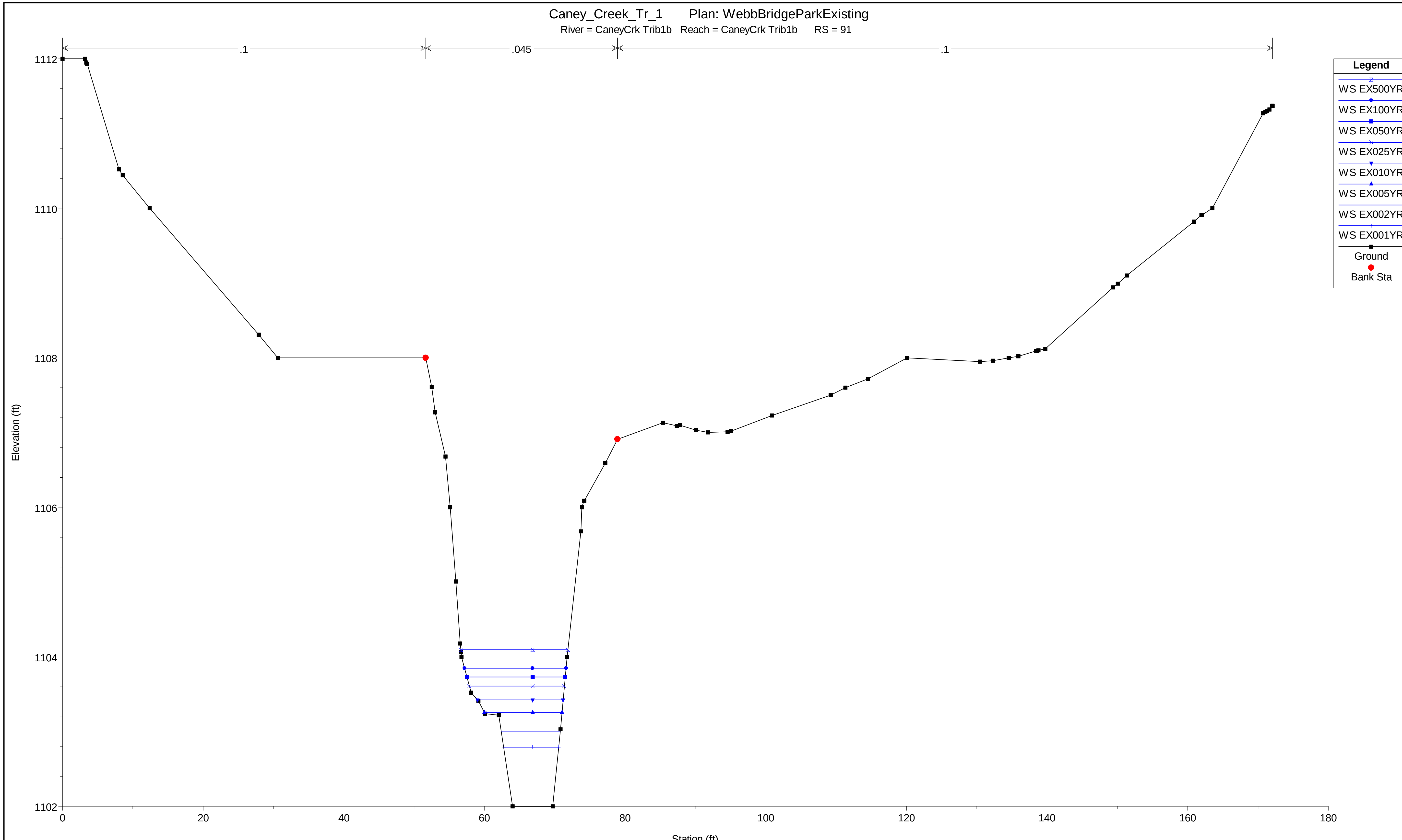
Station (ft)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.045
.1
Legend
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WS EX100YR
WS EX050YR
WS EX025YR
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WS EX005YR
WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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Station (ft)
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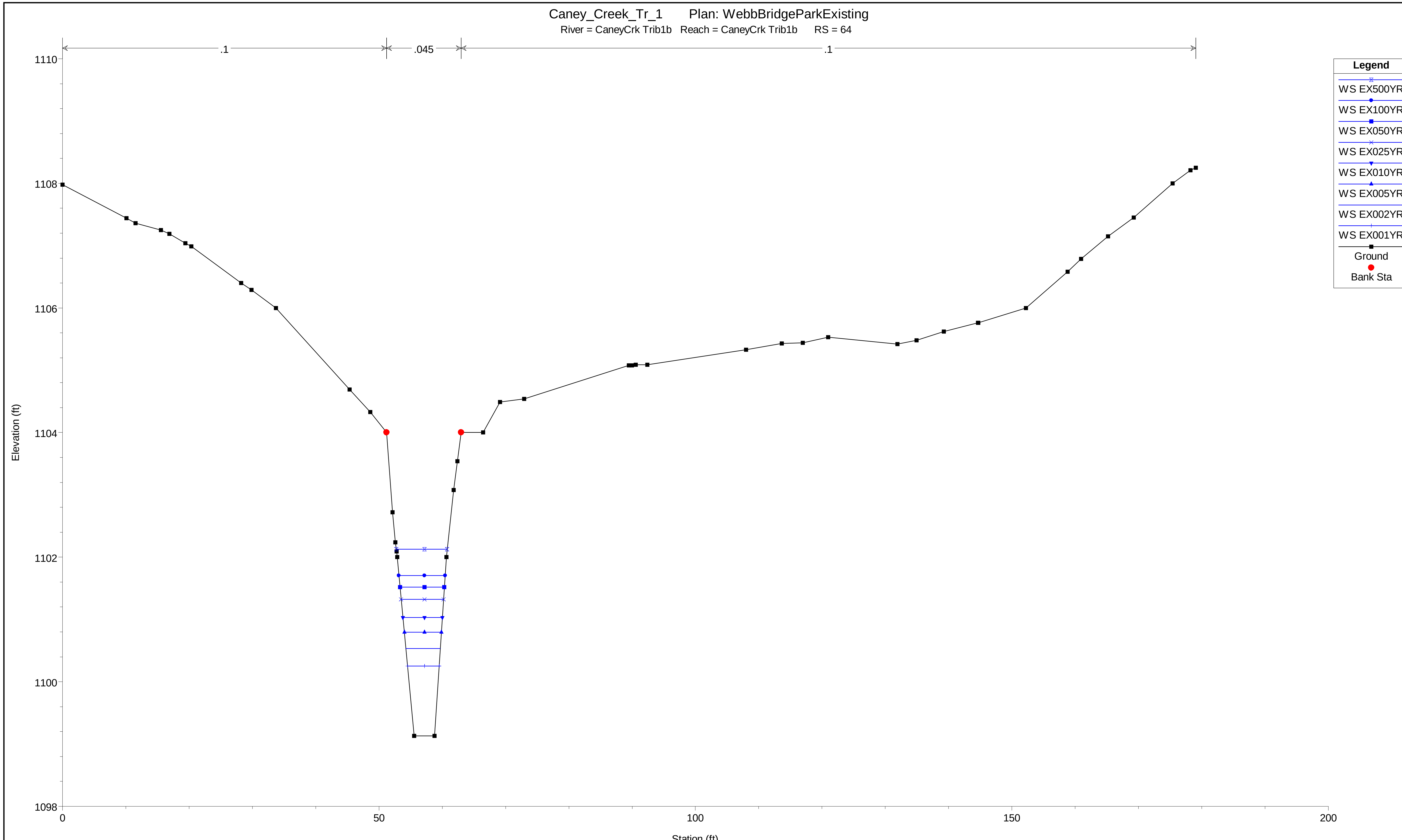

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.1
Legend
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WS EX100YR
WS EX050YR
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WS EX002YR
WS EX001YR
Ground
Bank Sta
Elevation (ft)
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1106
1104
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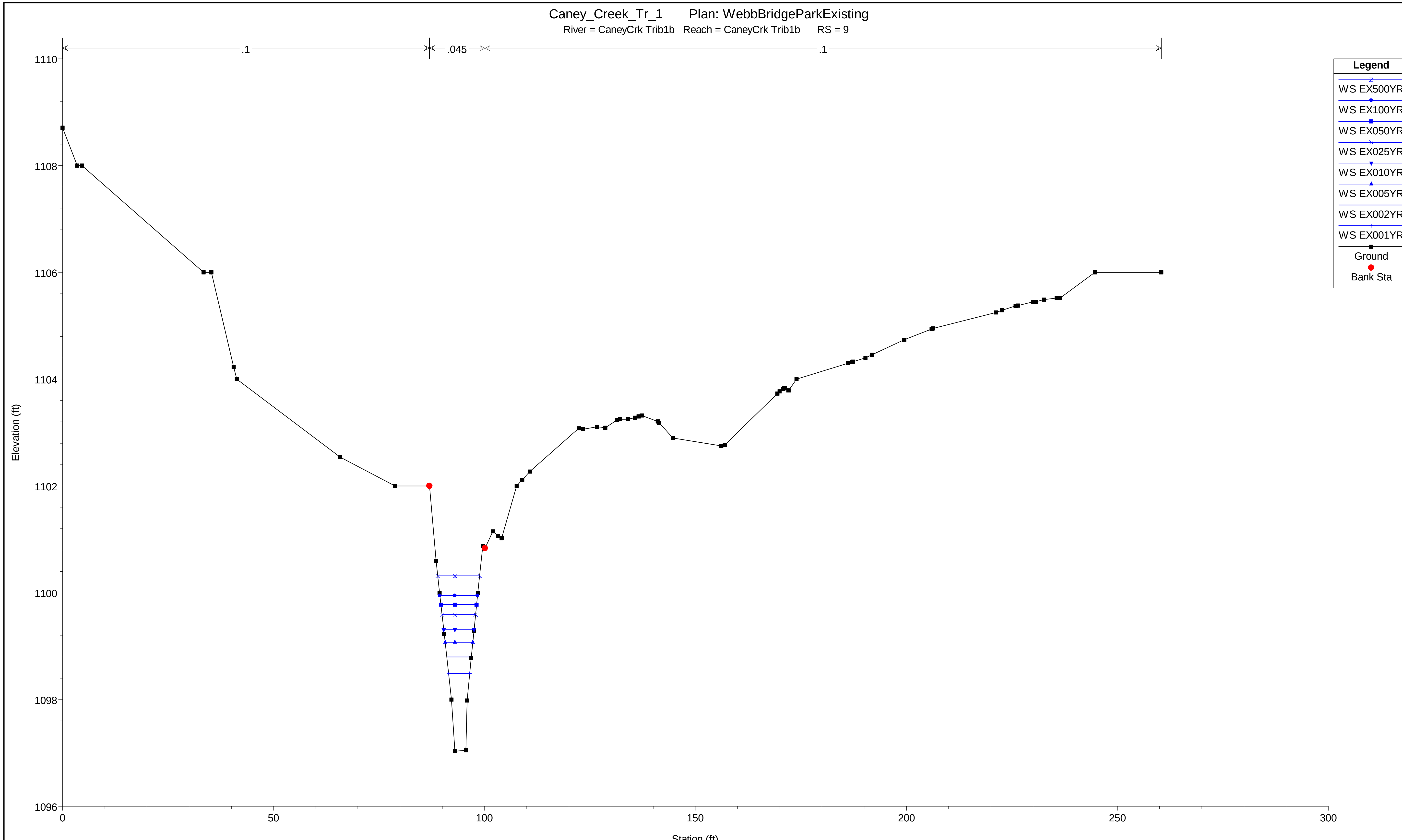
150
200
Station (ft)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Legend
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WS EX001YR
Ground
Bank Sta
Elevation (ft)
Station (ft)
1096
1098
1100
1102
1104
1106
1108
1110
0
50
100
150
200
250
300

Webb Bridge Park Drainage Study

Appendix C

Project Concept Sheets

PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	SW BMP	***MAP ID***	**1**
Project Location:	Parking lot	***Project ID***	**1**
Property Ownership:	____ *Private* X *City Owned*		
If Private, Associated Parcels:	*n/a*		
Description:	Level Spreader feature at edge of parking lot; Establish vegetation on downstream slope		

EXISTING CONDITIONS

Key photos associated with project: QQ1, QQ2, QQ3

Visible Impairment: X Yes ____ No

Visible Impairment Description: Rills and soil erosion downstream of parking lot

Measured Impairment: ____ Yes X No

Measured Impairment Description:

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Paved parking lot

Existing Conditions: Runoff from north side of parking lot is discharged directly onto bare soil, which has lead to the formation of rills and localized erosion.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N

MAP ID 1

Project Type: SW BMP ***Project ID*** 1

PROJECT DETAILS

This project involves the incorporation of a level spreader feature along the edge of pavement and the establishment of vegetation on the downstream earthen slope. By definition, a level spreader is a "storm flow outlet device constructed at zero grade across the slope whereby concentrated runoff may be discharged at non-erosive velocities onto undisturbed areas stabilized by vegetation". The purpose of the spreader is to dissipate the concentration and velocites of stormwater runoff by converting it into sheet flow, ultimately discharging the water onto areas stabilized by existing vegetation. An established vegetative cover on the areas below a level spreader is critical for maximizing pollutant removal efficiency and erosion prevention.
There are various types of level spreaders and their associated costs vary. Concrete, perforated pipes, berms, as well as proprietary products that facilitate both infiltration and energy dissipation, are different types of materials that can serve effectively in level spreaders. The type of material chosen should be dictated on a case-by-case basis, depending on the application, site and costs.

PROJECT CONCEPT

PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	Stream restoration activities	***MAP ID***	**2**
Project Location:	In-stream	***Project ID***	**2**
Property Ownership:	X *Private* X *City Owned*		
If Private, Associated Parcels:	1 TAXPIN 11 04410161027		
Description:	Removal of trash rack; Regrade streambanks; In-stream structures		

EXISTING CONDITIONS

Key photos associated with project: HH through NN

Visible Impairment: X Yes ___ No

Visible Impairment Description: Stream erosion exacerbated by online detention weir

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

Measured Impairment: X Yes ___ No

Measured Impairment Description: Benthic Macroinvertebrate Sampling

**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Perennial stream

Existing Conditions: The stream reach from the online concrete detention weir to the confluence of an unnamed tributary of Lake Windward and unnamed tributary of Thornbury Pond is downcutting and the banks are eroding in areas. A scour hole exists just downstream of the online detention weir structure. The trash rack is no longer effective, as it is approximately five feet above the top of banks.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID 2

Project Type: Stream restoration activities ***Project ID*** 2

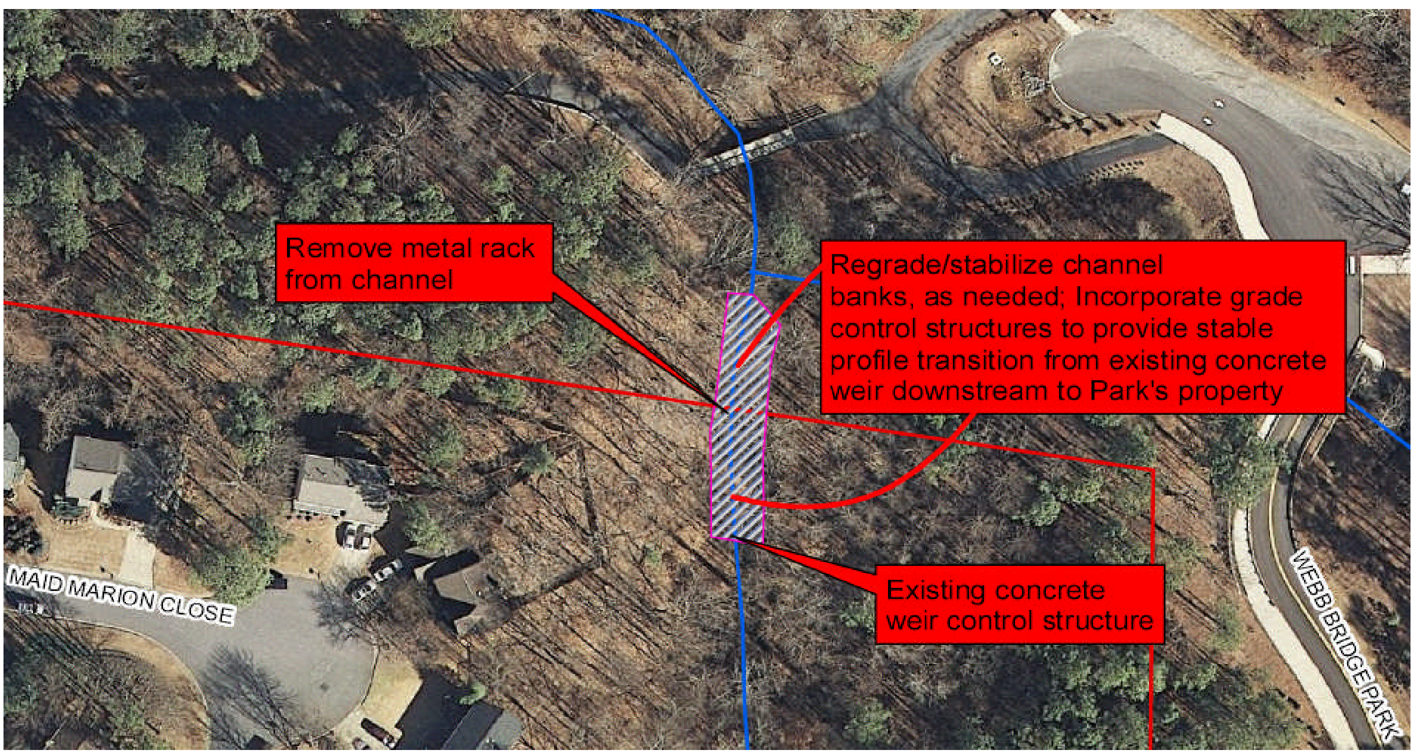
PROJECT DETAILS

The concept plan for this reach includes restoring the channel so that a stable cross-section exists from the online concrete detention weir structure to the confluence of the unnamed tributary of Thornbury Pond. The trash rack should be removed, as it is no longer effectively catching trash from flowing downstream. A stable cross-section of the channel should be constructed from the online weir structure to the confluence of the unnamed tributary of Thornbury Pond. A rock cross vane should be constructed just downstream of the online detention weir structure to provide grade control within the channel.

Rock Cross Vane

Stable Cross-Section

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Erosion Control treatment — ***MAP ID*** 3
Project Location: Pipe outfall — ***Project ID*** 3
Property Ownership: ____ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Install riprap (or similar) to provide erosion control at pipe outfall

EXISTING CONDITIONS

Key photos associated with project: C2

Visible Impairment: X Yes ____ No

Visible Impairment Description: Active erosion in ditch at outfall of 18-inch HDPE pipe

Measured Impairment: ____ Yes X No

Measured Impairment Description:

Current Land Use: Stormwater ditch

Existing Conditions: Localized erosion has occurred downstream of pipe outfall.

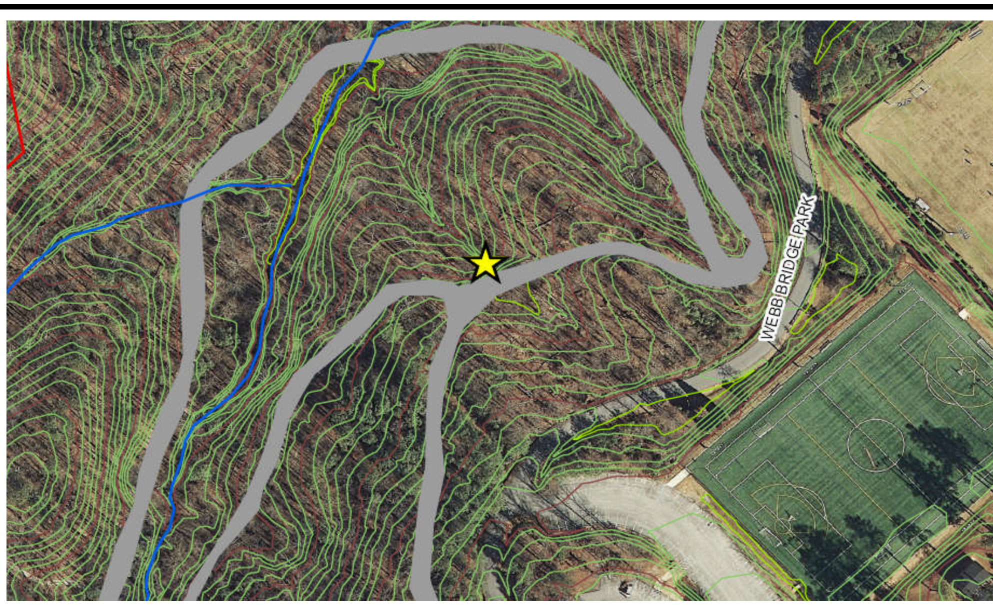
**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N



CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

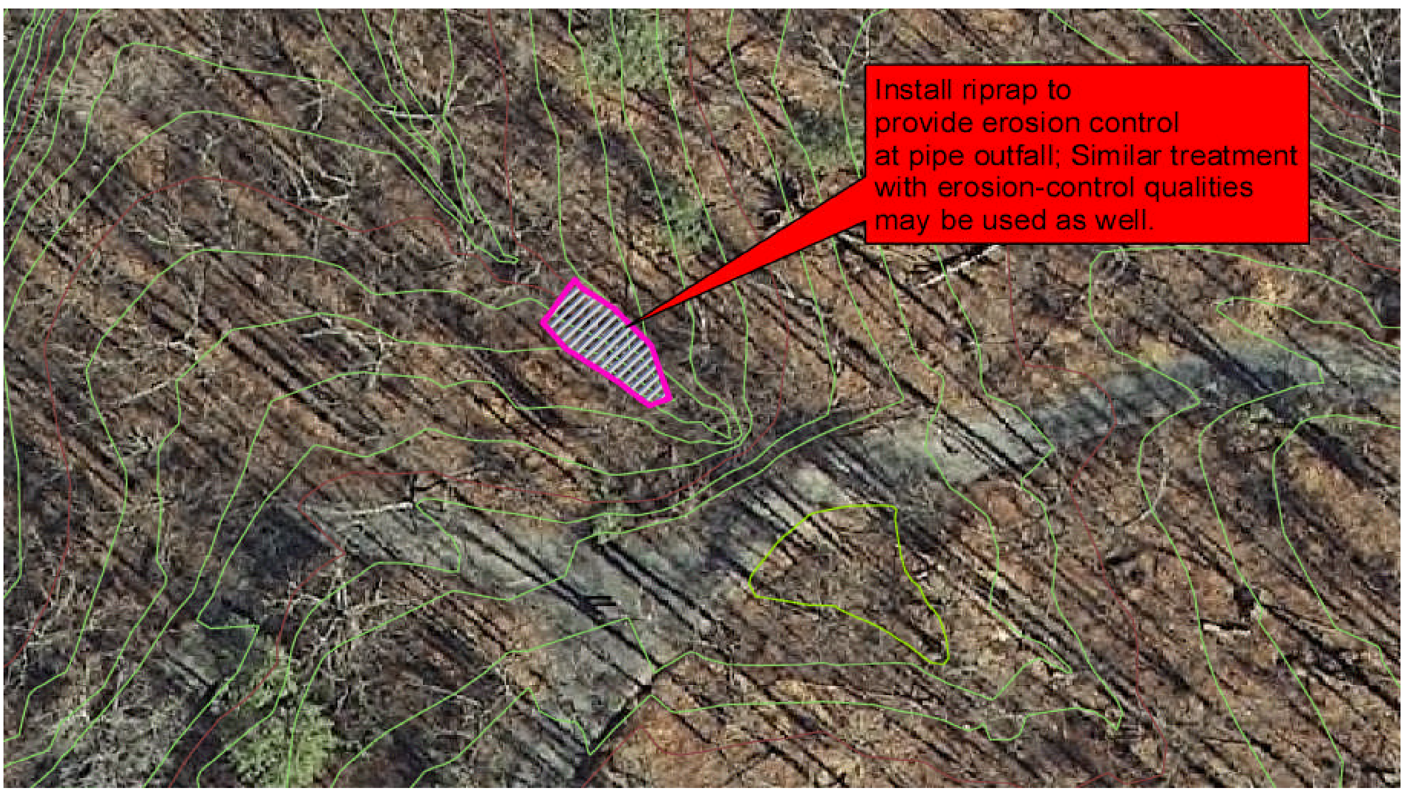
MAP ID **3**

Project Type: Erosion Control treatment ***Project ID*** **3**

PROJECT DETAILS

Approximately 14 square yards of Type 3 riprap should be placed at pipe outfall, to provide erosion control for the area. A synthetic filter fabric should be installed between the riprap and soil foundation.

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	Erosion Control treatment	***MAP ID***	**4**
Project Location:	Pipe outfall	***Project ID***	**4**
Property Ownership:	____ *Private* X *City Owned*		
If Private, Associated Parcels:	n/a		
Description:	Install riprap (or similar) to provide erosion control at pipe outfall		

EXISTING CONDITIONS

Key photos associated with project: C

Visible Impairment: X Yes ____ No

Visible Impairment Description: Active erosion in ditch at outfall of 24-inch RCP

Measured Impairment: ____ Yes X No

Measured Impairment Description:

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Stormwater ditch

Existing Conditions: Localized erosion has occurred downstream of pipe outfall.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N

CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID **4**

Project Type: Erosion Control treatment ***Project ID*** **4**

PROJECT DETAILS

Approximately 20 square yards of Type 3 riprap should be placed at pipe outfall, to provide erosion control for the area. A synthetic filter fabric should be installed between the riprap and soil foundation.

PROJECT CONCEPT

PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Infrastructure repair
Project Location: Stormwater manhole
Property Ownership: ___ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Repair manhole lid

MAP ID **5**
Project ID **5**

EXISTING CONDITIONS

Key photos associated with project: D

Visible Impairment: X Yes ___ No

Visible Impairment Description: Manhole lid needs to be checked for potential repair or reset

Measured Impairment: ___ Yes X No

Measured Impairment Description:

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Stormwater manhole

Existing Conditions: Concrete manhole lid has shifted from original setting, such that the structure appears unstable.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

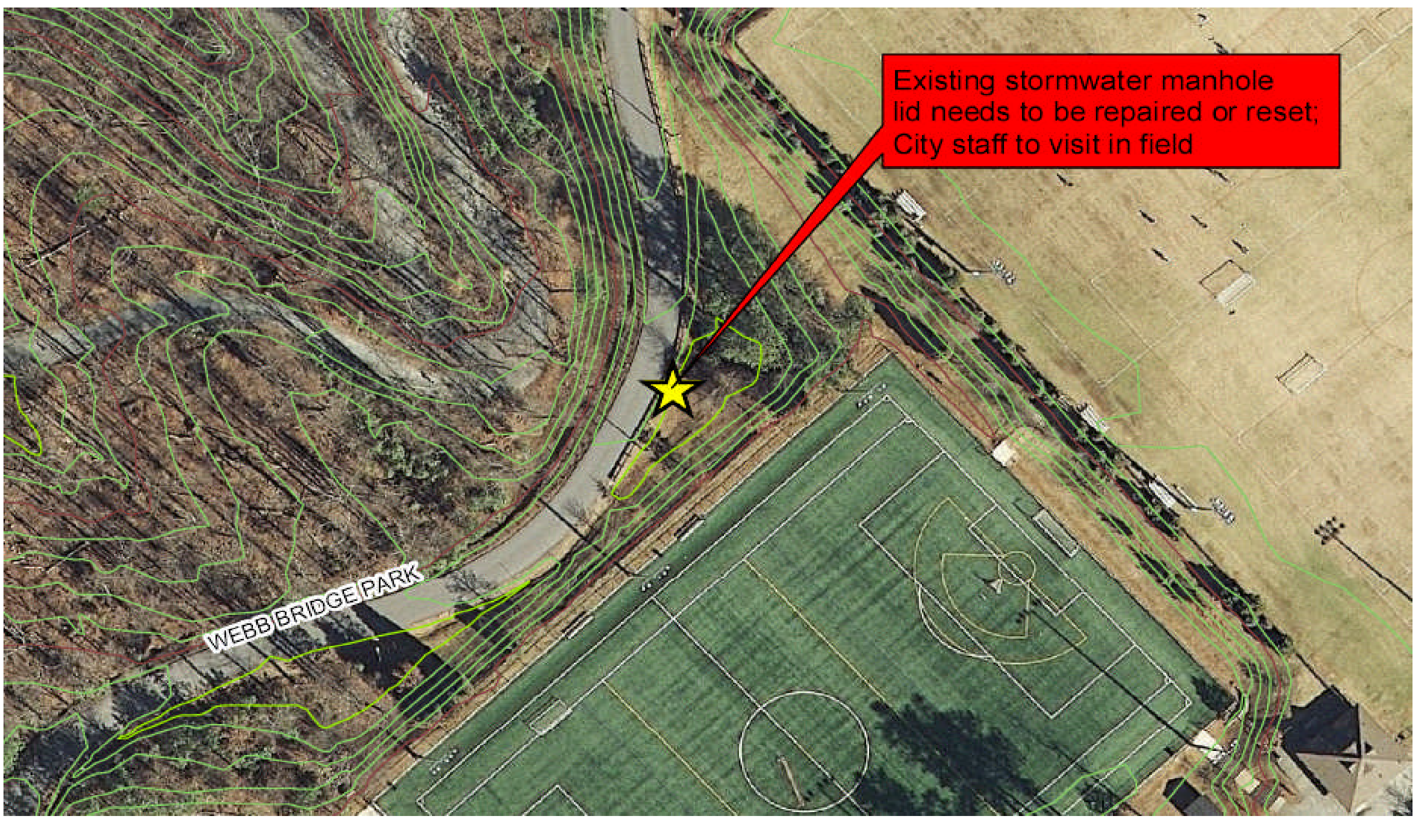
MAP ID **5**

Project Type: Infrastructure repair ***Project ID*** **5**

PROJECT DETAILS

The manhole structure needs to be checked and repaired as necessary, using the existing lid or a new lid (if warranted).

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Stream restoration activities — ***MAP ID*** **6**
Project Location: In-stream — ***Project ID*** **6**
Property Ownership: X *Private* X *City Owned*
If Private, Associated Parcels: 2 TAXPIN 11 04410161034, TAXPIN 11 04410161033
Description: Stable cross-sections and longitudinal profile, bank stabilization, step-pool system, and in-stream structures

EXISTING CONDITIONS

Key photos associated with project: I through W
Visible Impairment: X Yes ___ No
Visible Impairment Description: Bank erosion, downcutting, debris, and poorly-aligned culvert
Measured Impairment: X Yes ___ No
Measured Impairment Description: Benthic macroinvertebrate sampling

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

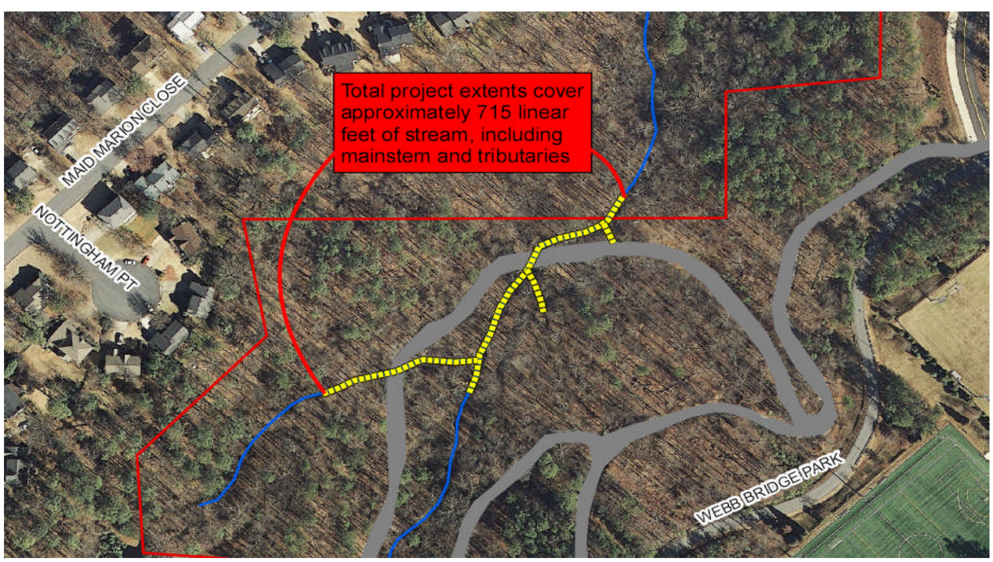
Current Land Use: Perennial and ephemeral streams

Existing Conditions: The total project includes three ephemeral streams (Reach 1 -3) that flow into the unnamed tributary of Lake Windward (Reach 4). Reach 1 is downcutting and large amounts of bank erosion has occurred within this channel downstream of the culvert. The severe bank erosion is undermining the culvert and trail. Ultimately, if this reach is not restored the trail will likely collapse. Upstream of the culvert, bank erosion has occurred and large woody debris exist within the channel. Reaches 2 and 3 have steep slopes and are downcutting. Reach 4 is a perennial stream that is downcutting and bank erosion is occurring both upstream and downstream of the culvert. The culvert within the perennial stream is poorly-aligned which has caused bank erosion immediately upstream and downstream of the culvert.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N



MAP ID 6

Project Type: Stream restoration activities ***Project ID*** 6

PROJECT DETAILS

All four reaches will need to be restored in order to fully stabilize the entire stream system in the project scope. If all four reaches are not restored concurrently, then Reaches 1-3 should be restored prior to restoring Reach 4. The concept plan for Reach 1 consists of removing the debris from the channel and constructing a rock step-pool system upstream of the culvert. Downstream of the culvert the channel should be raised to the invert of the culvert and a step-pool system would be constructed to provide a stepped longitudinal profile from the invert of the culvert to the confluence with the perennial stream. Reaches 2 and 3 should have rock step-pool systems constructed in order to provide a stepped longitudinal profile to the confluence with the perennial stream. Reach 4 will consist of bank shaping to provide a stable cross-section of the channel, in-stream structures (j-hooks or log vanes) to turn the water away from certain bends, grade control structures (cross-vanes) to prevent downcutting, and geolifts with bentonite and live stakes along the left bank immediately downstream of the culvert.

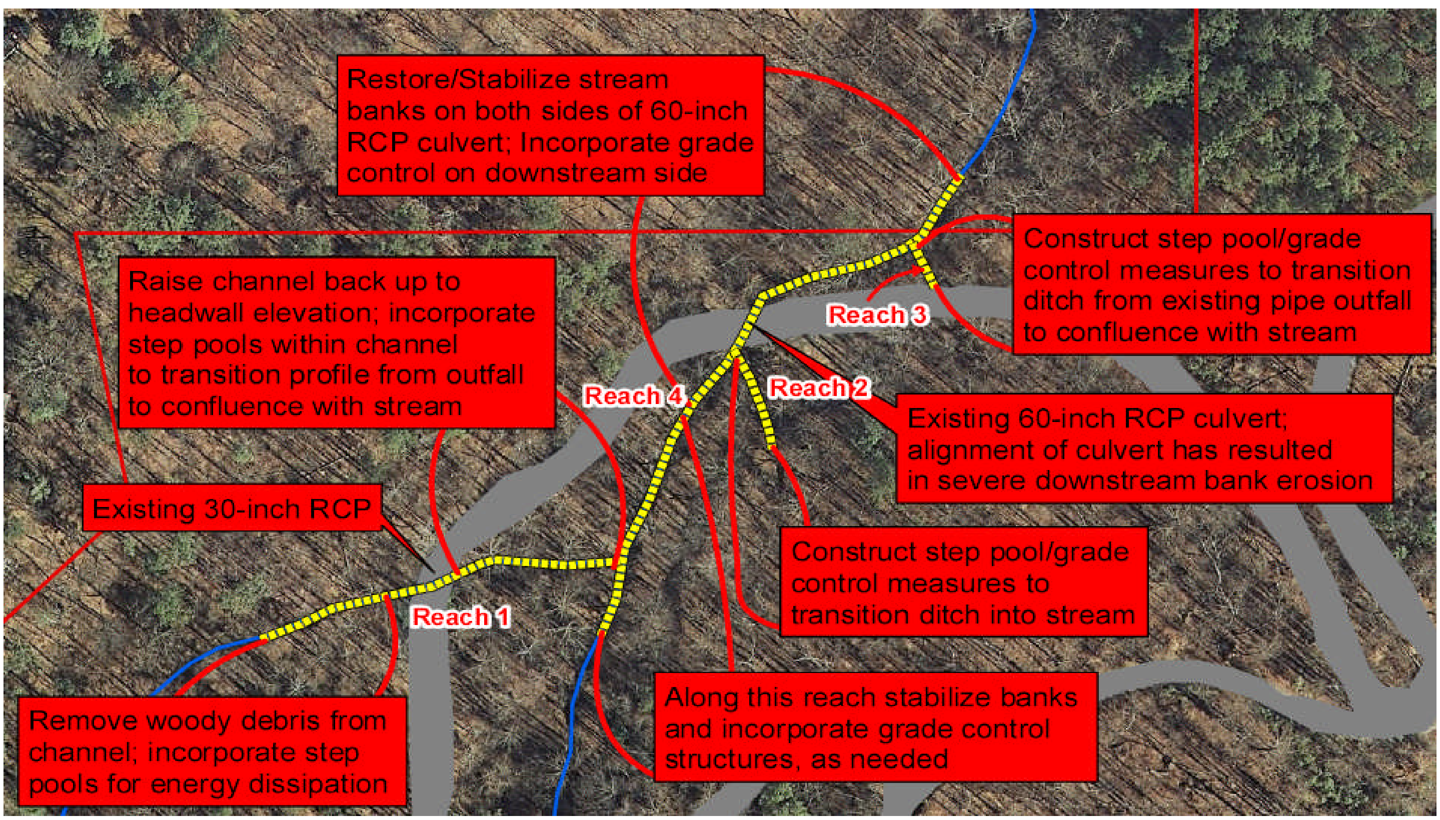

Step-pool


J-hook


Cross Vane


Geolift, Post-Construction

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	Trail resurface and SW BMP	***MAP ID***	7
Project Location:	Along trail and at pipe outfall	***Project ID***	7
Property Ownership:	____ *Private* X *City Owned*		
If Private, Associated Parcels:	n/a		
Description:	Resurface trail with pervious pavement; incorporate energy dissipation at pipe outfall		

EXISTING CONDITIONS

Key photos associated with project: F2 through F5

Visible Impairment: ____ Yes X No

Visible Impairment Description: ____

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

Measured Impairment: ____ Yes X No

Measured Impairment Description: ____

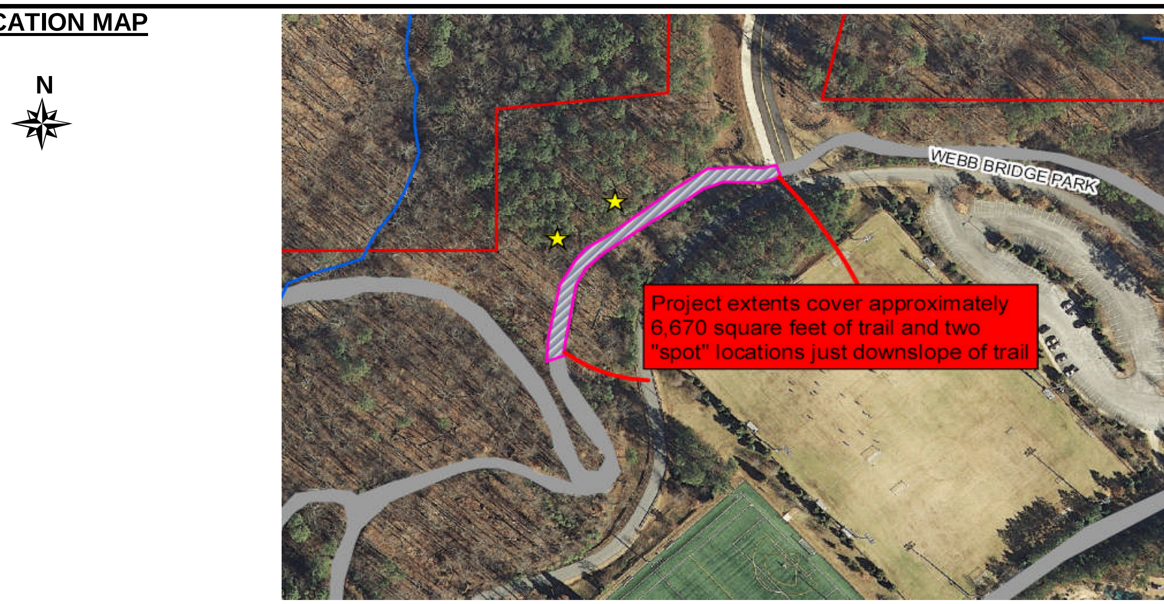
**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Gravel Trail, lighted wooded slope

Existing Conditions: A resident in the Nottingham Gate subdivision, whose property is located downslope from the park, has logged a complaint with the City regarding stormwater-related erosion. The issue was specific to rills and small gullies that have formed over time on the steep earthen slope, on the north side of the trail.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP



CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

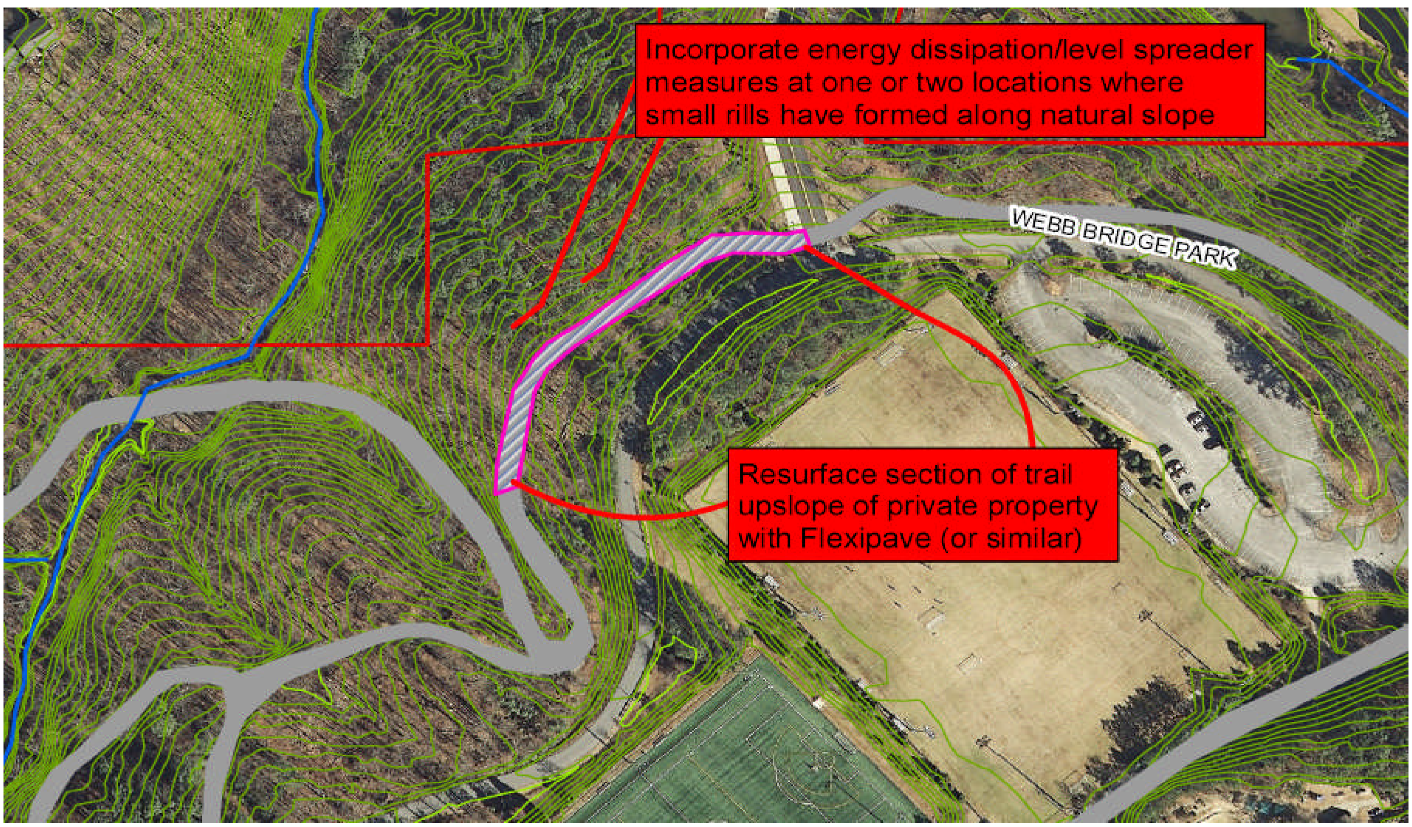
MAP ID **7**

Project Type: Trail resurface and SW BMP ***Project ID*** **7**

PROJECT DETAILS

This project would involve two different activities. The first activity is the incorporation of structures that will provide energy dissipation at two locations where rills have formed. A variety of materials can be used to serve this function; proper installation will be critical to the structures functioning successfully. The intent of these structures is to reduce both flow velocity and flow concentration on the earthen slope, to reduce future erosion potential. The second activity involves resurfacing a section of trail (740 square yards) with a highly-porous pervious pavement, which will serve to infiltrate stormwater runoff along the trail and remove the future need for gravel maintenance. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products.

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Stream restoration activities — ***MAP ID*** **8**
Project Location: In-stream, behind Nottingham Gate Subdivision — ***Project ID*** **8**
Property Ownership: X *Private* ____ *City Owned*
If Private, Associated Parcels: 8 *Affected parcels listed under "Existing Conditions"
Description: Stable cross-sections and longitudinal profile, step-pool system, and in-stream structures

EXISTING CONDITIONS

Key photos associated with project: W through KK

Visible Impairment: X Yes ____ No

Visible Impairment Description: Bank erosion, downcutting, and stream is not connected to the floodplain

Measured Impairment: X Yes ____ No

Measured Impairment Description: Benthic Macroinvertebrate Sampling

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

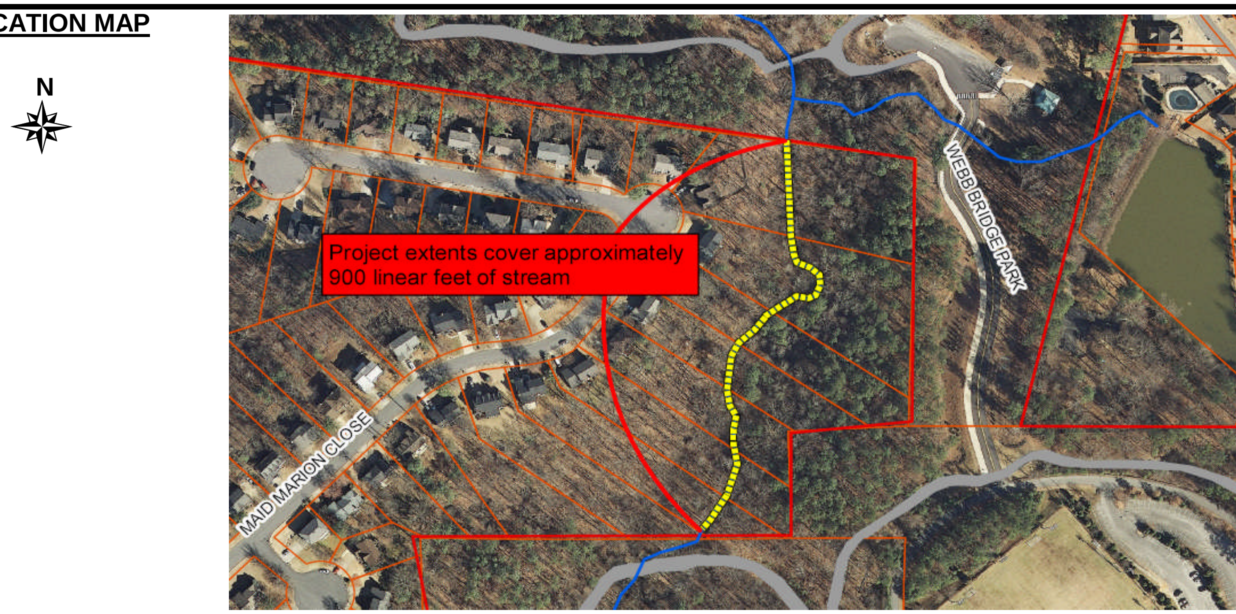
**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Perennial Stream

Existing Conditions: This stream reach has experienced a large amount of bank erosion, which has occurred over a period of time. The reach has downcut and is now actively widening. Further, the stream channel is no longer connected to the floodplain; benthic macroinvertebrate sampling (conducted as a part of this drainage study) determined there is not a wide variety of organisms occupying this stream reach.
The impaired stream flows through the following parcels: TAX PINs:11 04410161027, 11 04410161028, 11 04410161029, 11 04410161030, 11 04410161031, 11 04410161032, 11 04410161033, and 11 04410161034.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP



CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID 8

Project Type: Stream restoration activities ***Project ID*** 8

PROJECT DETAILS

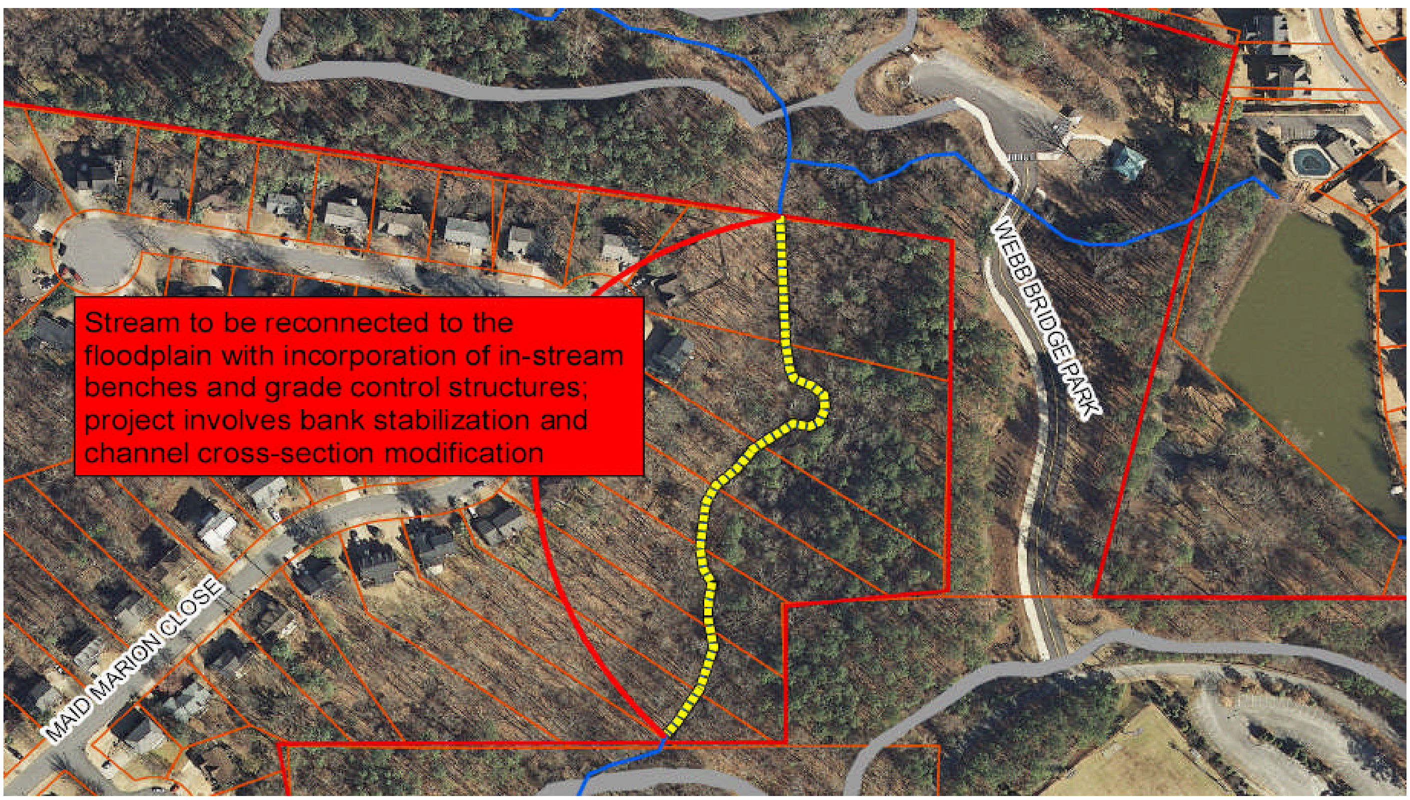
The concept plan for this reach is to design a stream channel that it is reconnected to the floodplain. A stable cross-section with bankfull benches would be constructed within this reach. In areas where the channel has a steep slope, a stepped longitudinal profile would be constructed by incorporating a step-pool system. Riffle-pool sequences will be constructed within this reach along with in-stream structures (j-hooks, cross vanes, and rock vanes) to guide water away from the channel bends and to provide grade control.

Constructed Riffle

Step-pool System (in stream)

Stable Cross-Section

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Alternative pavement measures — ***MAP ID*** 9
Project Location: Existing parking lots — ***Project ID*** 9
Property Ownership: ___ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Resurface existing parking spaces in three parking lots with pervious pavement (or similar)

EXISTING CONDITIONS

Key photos associated with project: n/a

Visible Impairment: X Yes ___ No

Visible Impairment Description: Surface of parking areas has become loose, contributing to solids runoff

Measured Impairment: ___ Yes X No

Measured Impairment Description: ___

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

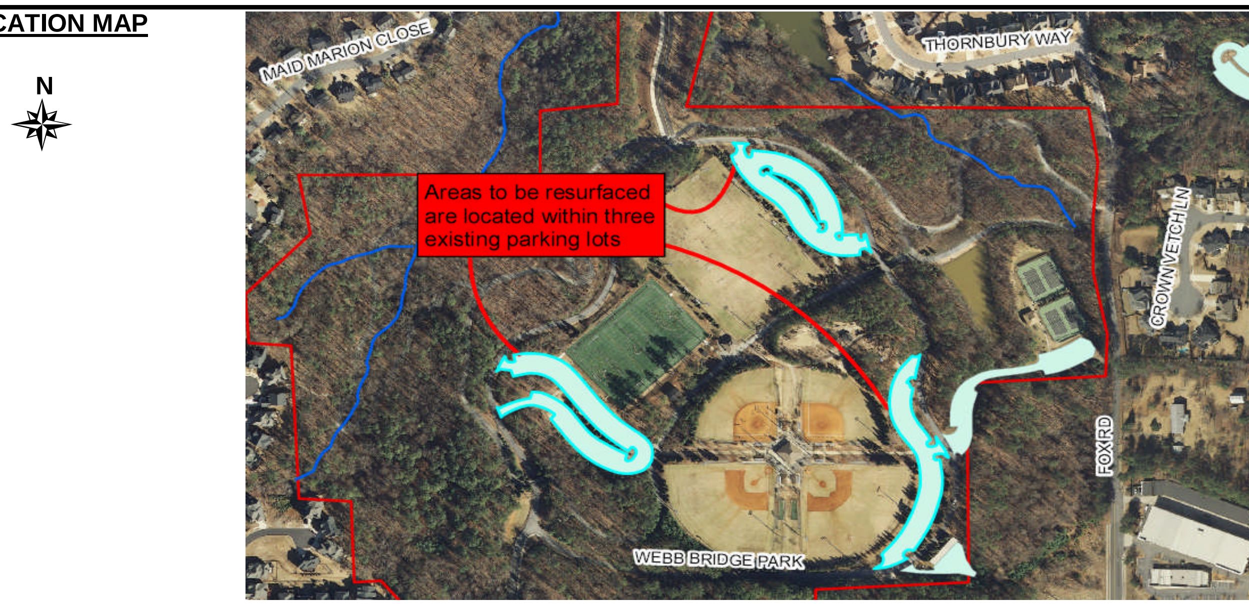
**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Parking lot

Existing Conditions: Three parking lots within the park were originally constructed with the intent of incorporating pervious pavement. The pavement has not infiltrated runoff as designed and essentially performs as traditional impervious pavement. Additionally, the gravel on the top layers has become loose, contributing to the solids loading in the park's streams and pond.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP



CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

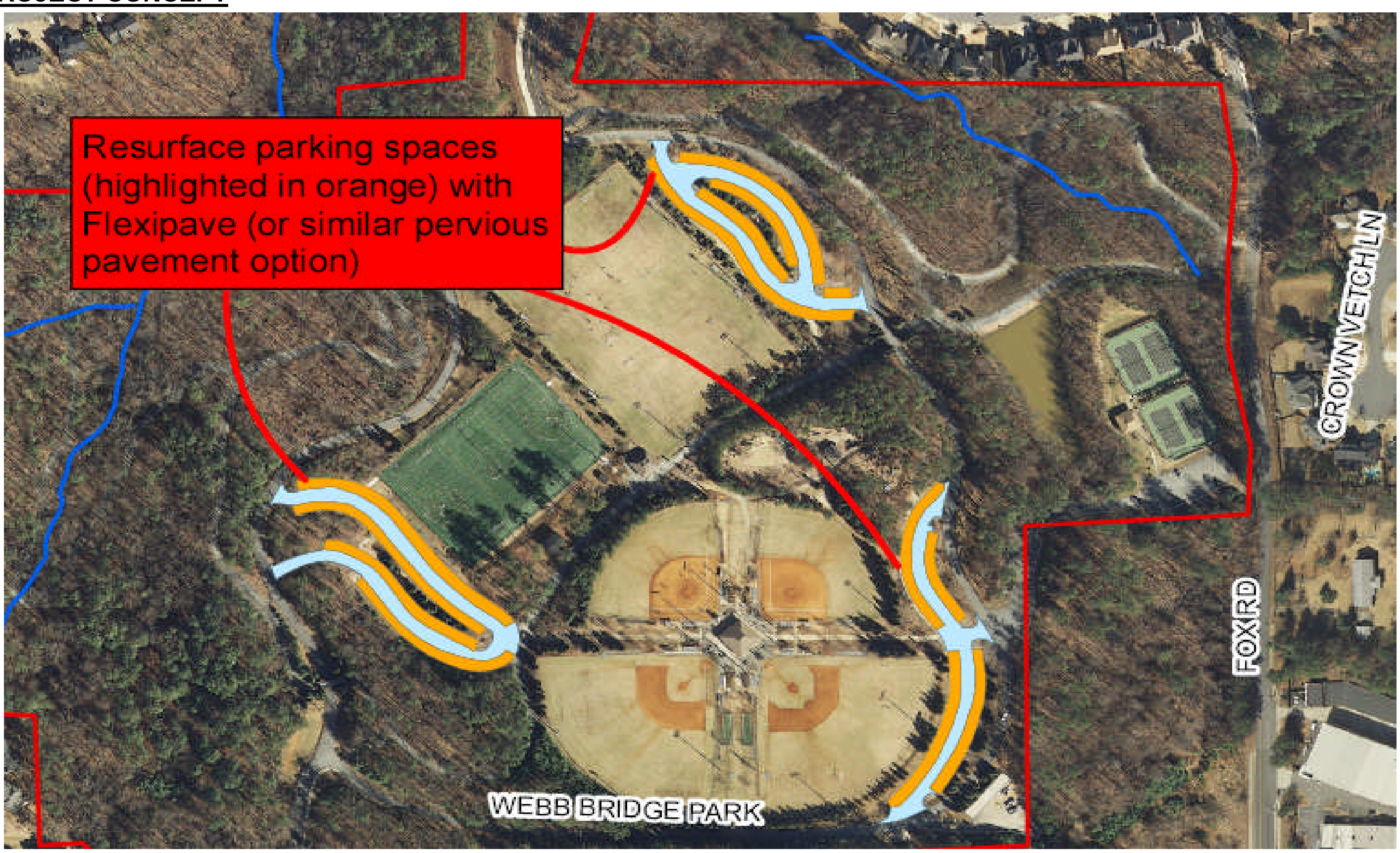
MAP ID **9**

Project Type: Alternative pavement measures ***Project ID*** **9**

PROJECT DETAILS

The City has indicated a desire to pave the parking lots with traditional pavement at some point in the future. This project includes three options for repaving the lots. The first involves repaving only the parking spaces with a highly porous pervious pavement, which will serve to infiltrate stormwater runoff and eliminate future gravel runoff from those areas. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products. The second option involves paving the same areas as the first option, with the City staff performing the labor. The third option involves paving all three lots, in their entirety, with traditional asphalt pavement.

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: SW BMP, Trail resurface — ***MAP ID*** **10**
Project Location: Ditch and trail downstream of playground area — ***Project ID*** **10**
Property Ownership: ____ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Resurface section of trail with pervious pavement; construct open "catch basin" within ditch

EXISTING CONDITIONS

Key photos associated with project: UU through ZZ5
Visible Impairment: X Yes ____ No
Visible Impairment Description: Large amounts of sand accumulation in ditch, downstream of playground
Measured Impairment: X Yes ____ No
Measured Impairment Description: Relatively high turbidity readings sampled at outfall d/s of playground
Current Land Use: Gravel Trail, SW Ditch

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

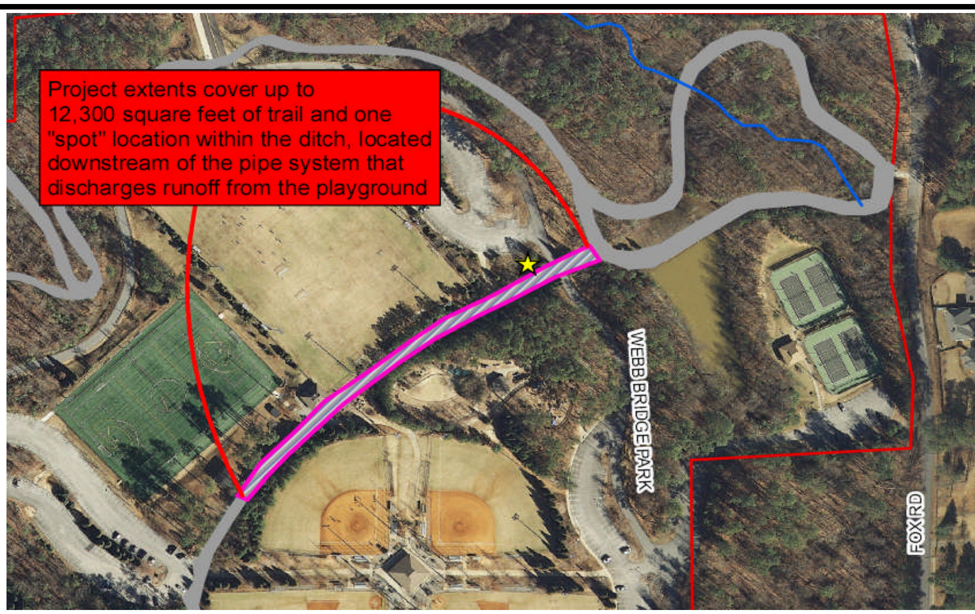
**Measured impairment denotes degradation or pollution detected by sampling*

Existing Conditions: During the months of May through September, a well pump located at the northwest corner of the park pond is run daily and pumps water up to a small rock channel in the playground area. This channel discharges the water into a pipe system, then a short ditched system, and ultimately routes the water back to the pond. The playground includes a large sandbox area that the City replenishes every spring with approximately 18 tons of sand. Given the proximity of the sandbox to the rock channel, children routinely place sand in the channel. When the pump is running or a rain event occurs, this sand is conveyed into the downstream drainage system. The City has dredged the park pond, which was built during original park construction, once in the past fourteen years in spring 2011.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N



CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID **10**

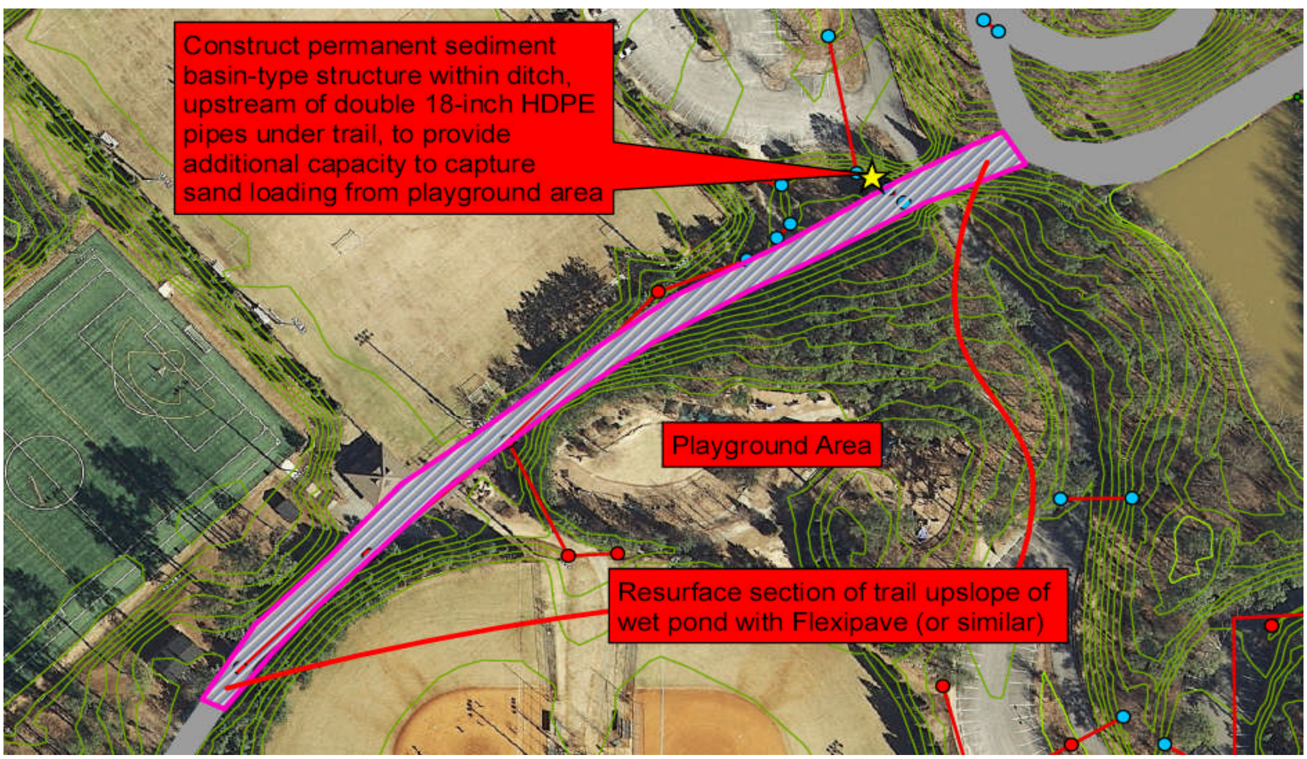
Project Type: SW BMP, Trail resurface ***Project ID*** **10**

PROJECT DETAILS

The sand loading from the playground area contributes to the reduction of storage volume in the pond. The City has dredged the park pond, which was built during original park construction, once in the past fourteen years in spring 2011. City staff would like a project solution that will reduce the need to dredge the pond in the future. This project includes two "constructed" activities and an ongoing maintenance component. The first of the constructed activities is the primary recommended solution for this project. This involves the design and construction of a permanent sediment basin, located within the ditch downstream of the playground. This open basin would serve to provide additional capacity to collect and store sand, prior to its discharge into the pond. In order for this solution to be successful, it is critical that park staff continue to clean out this ditch system on a regular basis. The second component to this project involves resurfacing a section of trail (1366 square yards) with a highly-porous pervious pavement, which will serve to infiltrate stormwater runoff along the trail and remove the future need for gravel maintenance.

For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products.

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	Vegetative measures	***MAP ID***	**11**
Project Location:	Park wet pond	***Project ID***	**11**
Property Ownership:	______ *Private* __X__ *City Owned*		
If Private, Associated Parcels:	n/a		
Description:	Placement of sod on dam embankment, in areas that have become bare of vegetation		

EXISTING CONDITIONS

Key photos associated with project: BBB

Visible Impairment: __X__ Yes ____ No

Visible Impairment Description: Areas on dam have become bare and soil is exposed

Measured Impairment: ____ Yes __X__ No

Measured Impairment Description:

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Earthen dam embankment

Existing Conditions: A portion of the pond's dam embankment is bare of vegetation.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID **11**

Project Type: Vegetative measures ***Project ID*** **11**

PROJECT DETAILS

It is recommended that City staff replace the sod in areas that have become bare of vegetation. A good vegetative cover on the dam will reduce future erosion on the embankment and encourage better infiltration of stormwater runoff.

PROJECT CONCEPT

PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Live animal feature and chemical agent — ***MAP ID*** 12
Project Location: Park wet pond — ***Project ID*** 12
Property Ownership: ____ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Addition of grass carp and algaecide to pond, to assist with reduction of algae and organic matter

EXISTING CONDITIONS

Key photos associated with project: AAA

Visible Impairment: X Yes ____ No

Visible Impairment Description: Large amounts of algal blooms present during warmer months

Measured Impairment: X Yes ____ No

Measured Impairment Description: Sampling detected moderate amounts of nutrients being accomodated by pond

Current Land Use: Wet pond

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

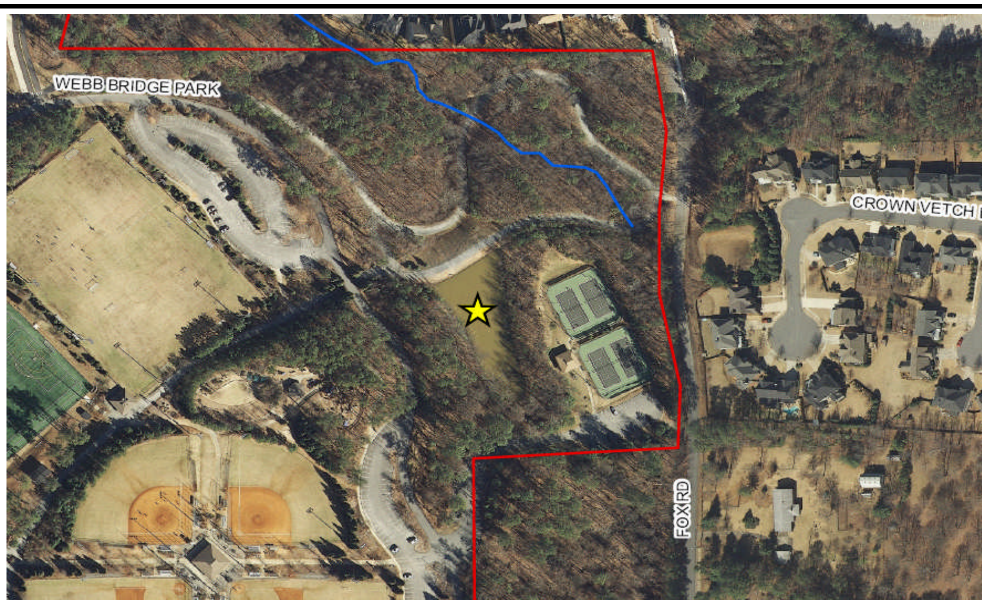
**Measured impairment denotes degradation or pollution detected by sampling*

Existing Conditions: The 0.3-acre wet pond had algal blooms during the site visits conducted over the summer months, which indicates that excessive pollutants were entering the pond. Sampling conducted in October and November 2011 indicated the majority of the incoming nutrients were accumulating within the pond, contributing to the algal blooms. Other degradation indicators observed within the pond included turbid water and sedimentation. The turbidity results from sediments introduced by stormwater runoff and other particles suspended within the water. A nutrient balanced pond ecosystem does not have a significant portion of the surface covered with algal mats.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N



MAP ID 12

Project Type: Live animal feature and chemical agent **Project ID** 12

PROJECT DETAILS

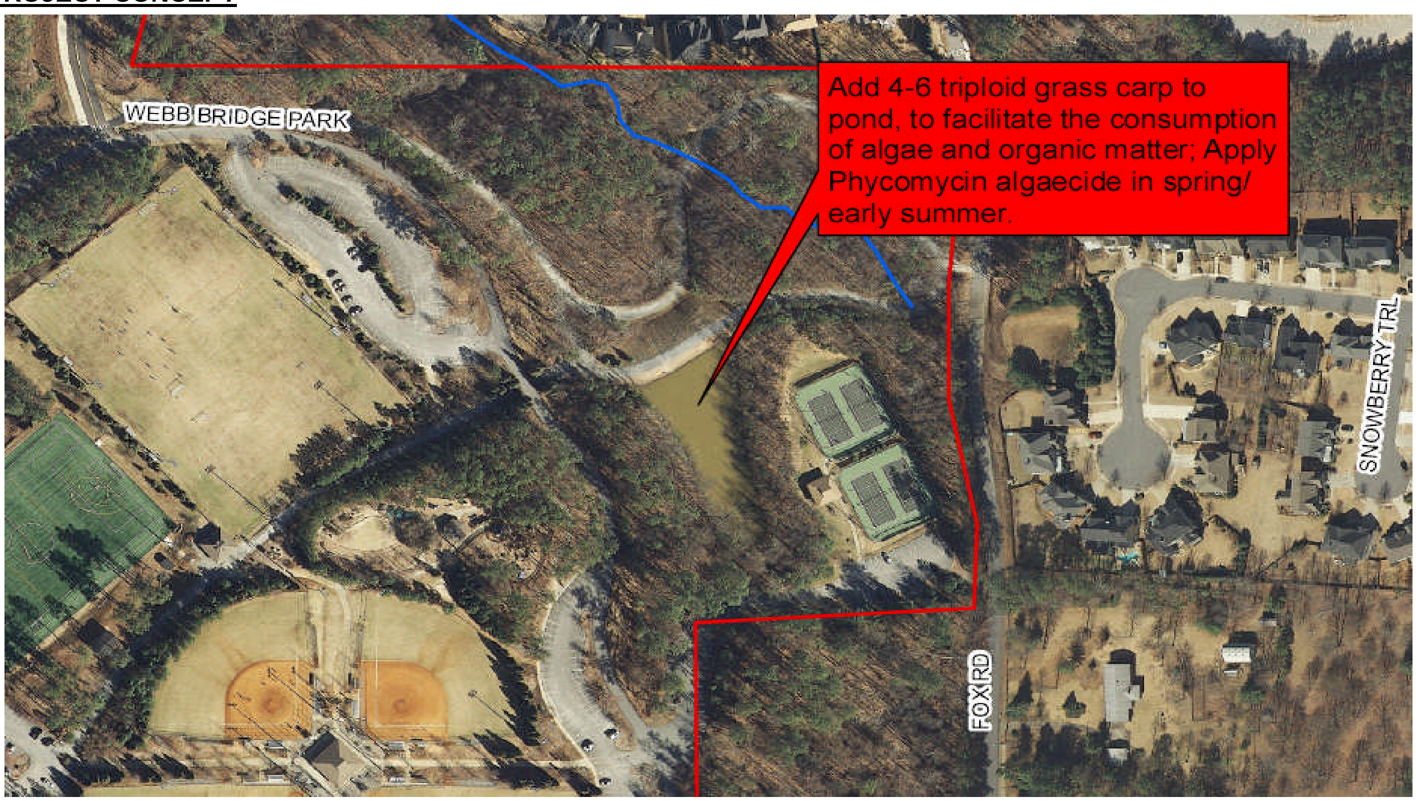
This project involves 2 components, which can be used in conjunction with each other or as stand-alone options. The first component is the addition of Triploid Grass Carp to the pond. The carp, when incorporated into a waterbody at a population large enough to keep the fish 'hungry', will consume both surface algae and organic matter along the pond's bottom. The recommended amount of fish is based on pond surface area and vegetative cover. A rule of thumb often used is to determine the amount of fish via the area and cover formula, then add double that amount to the waterbody. Six carp, ranging 8 to 10 inches in length, are recommended here.

The second component of this project involves the addition of a non-toxic algaecide, Phycomycin. This is a granular product that works to eliminate existing algae, as well as prevent the formation of new algal blooms. Initial treatment should occur in the spring/early summer and maintenance treatments can take place every 2 - 4 weeks, as necessary. Phycomycin is EPA approved, works quickly and is entirely non-toxic. Product information is included on following pages.

Triploid Grass Carp

Triploid Grass Carp

PROJECT CONCEPT



Phycomycin - Product Info

Phycomycin is a granular product that attacks planktonic and filamentous algae on contact. You can actually see it working as you apply. Fast-acting, it leaves behind no harmful residues and adds bio-available oxygen to the water.

Phycomycin is effective both as an *algaecide* (eliminating existing blue-green algae infestations) and as an *algaestat* (i.e., retarding and preventing new growth). It works quickly, and neither it nor its byproducts (hydrogen peroxide and oxygen) linger in the ecosystem.

Water Use Restrictions	
Active Ingredients: **Sodium Carbonate Peroxyhydrate***	
Weight % Active Ingredient: **85**	
EPA Reg.No.	**8959-10**
	Number of Days
Human Drinking	**0**
Human Swimming	**0**
Human Fish Consumption	**0**
Animal Drinking	**0**
Irrigation Turf	**0**
Irrigation Forage	**0**
Irrigation Food Crops	**0**

Can also be applied as a spot or perimeter treatment. EPA approved and NSF/ANSI Standard 60 certified for drinking water application.

Begin application in spring as water temperature warms to 60º F and above. Early treatment when growth first appears or begins to create a nuisance will reduce the amount of Phycomycin you will need. Early treatment will also reduce the amount of dead growth.

Heavy, out of control growth may require more than one application or physical removal to gain control. For best results, use under conditions of minimal water flow. Apply early on the morning of a calm, sunny day.

Phycomycin can be applied either manually, or by using most existing broadcast spreaders.

No water use restrictions.

The product is applied at 3.0 to 100.0 lbs/acre-ft.

ALGAECIDE AND OXIDIZER Application Rates				
Seasonal Program			**Rates for Specific Algae Problems**	
Step One	Shock Treatment Spring/Early Summer.	Apply 15-40 lbs./acre-foot of water	Spot Treatments*	20-50 lbs./acre-foot of water
Step Two	Maintenance Treatments Every 2-4 weeks.	Apply 8-25 lbs./acre-foot of water	Planktonic Blue-Green Algae Blooms	9-30 lbs./acre-foot of water
Step Three	Spot Treatment As needed. Can be applied to perimeter only.	Apply 20-50 lbs./acre-foot of water	Filamentous Algae Blooms	50-100 lbs./acre-foot of water

PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	Stormwater BMP	***MAP ID***	**13**
Project Location:	Southwest of park's pond	***Project ID***	**13**
Property Ownership:	____ *Private* X *City Owned*		
If Private, Associated Parcels:	n/a		
Description:	Constructed wetland		

EXISTING CONDITIONS

Key photos associated with project: TT1 through TT5

Visible Impairment: ____ Yes X No

Visible Impairment Description: ____

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

Measured Impairment: X** Yes ____ No

Measured Impairment Description: **Potential impairment, to be determined during future sampling efforts

**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Lightly wooded area

Existing Conditions: The 0.3-acre wet pond exhibited large algal blooms during the summer months. Sampling conducted in October and November 2011 indicated the majority of the incoming nutrients were accumulating within the pond, contributing to the algal blooms. The algae within the pond is a result of a combination of factors - unfiltered stagnant water, unbalanced oxygen levels from excessive levels of nitrates and phosphates, sunlight, and humid weather.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N

PROJECT CONCEPT

WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID 13

Project Type: Stormwater BMP ***Project ID*** 13

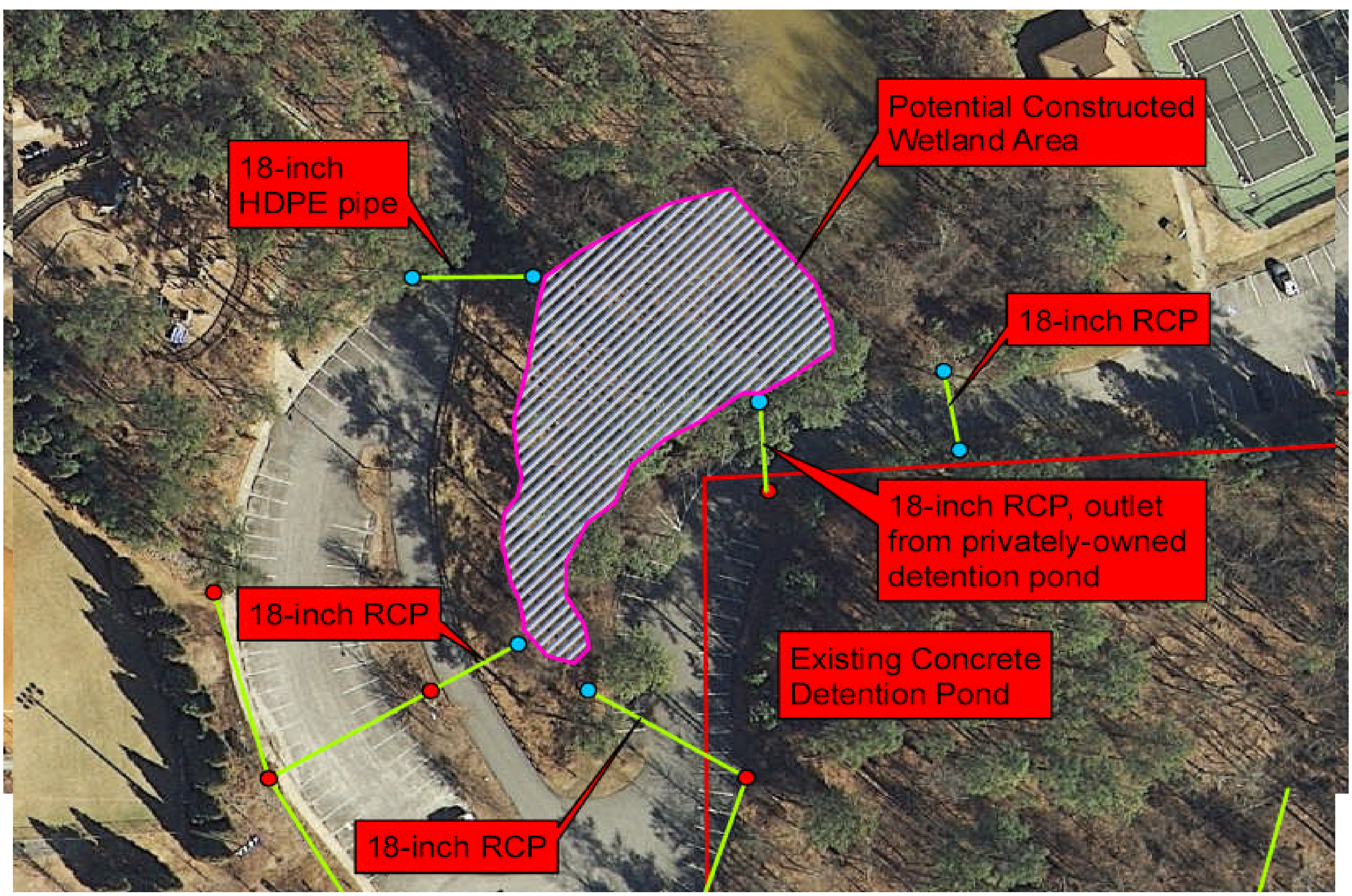
PROJECT DETAILS

The conceptual design of the constructed wetland BMP would include different habitats and a wide array of plant species that take up nutrients year round. The wetland would have a forested buffer, emergent and scrub-shrub areas, low flow channels, and pool zones. The wetland would be hydrologically connected to the park's wet pond, in which the stormwater would flow through the wetland prior to reaching the pond. This design will allow nutrients to accumulate within the wetland vegetation, which is intended to absorb the nutrients prior to entering the wet pond. A variety of native herbaceous species, particularly evergreen species, would be planted (again, intended to take the excessive incoming nutrients year round).


Emergent Area


Pool Zone

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type:	Erosion Control treatment	***MAP ID***	14
Project Location:	In-stream, at upstream culvert headwall	***Project ID***	14
Property Ownership:	____ *Private* X *City Owned*		
If Private, Associated Parcels:	n/a		
Description:	Install riprap (or similar) to provide erosion control at pipe inlet		

EXISTING CONDITIONS

Key photos associated with project: CCC2

Visible Impairment: X Yes ____ No

Visible Impairment Description: Localized erosion/scour upstream of culvert crossing under trail

Measured Impairment: ____ Yes X No

Measured Impairment Description: ____

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

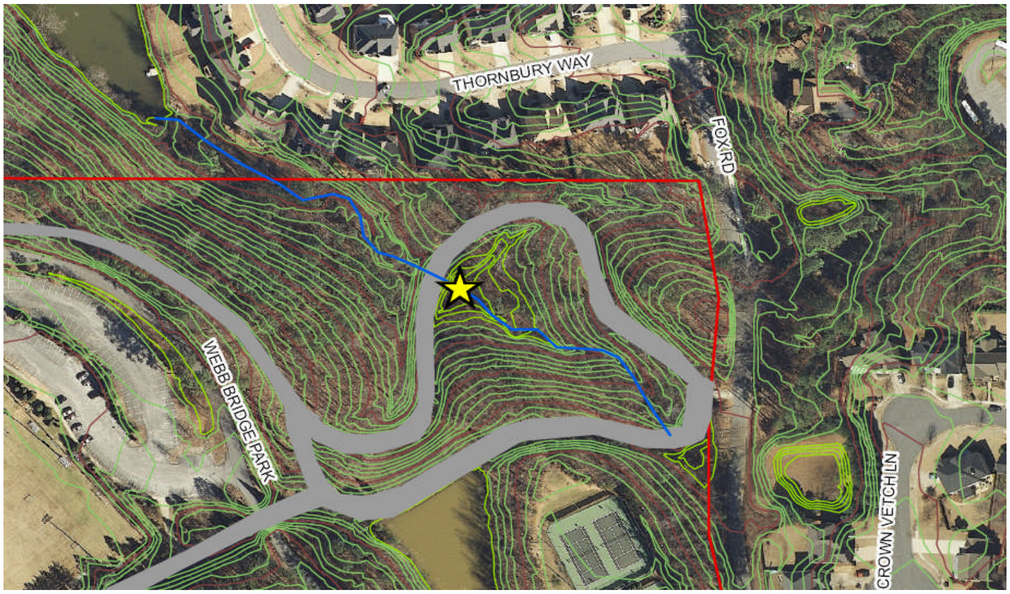
Current Land Use: Perennial stream

Existing Conditions: Localized erosion/scour has occurred upstream of culvert headwall.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N



CONTINUED
PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

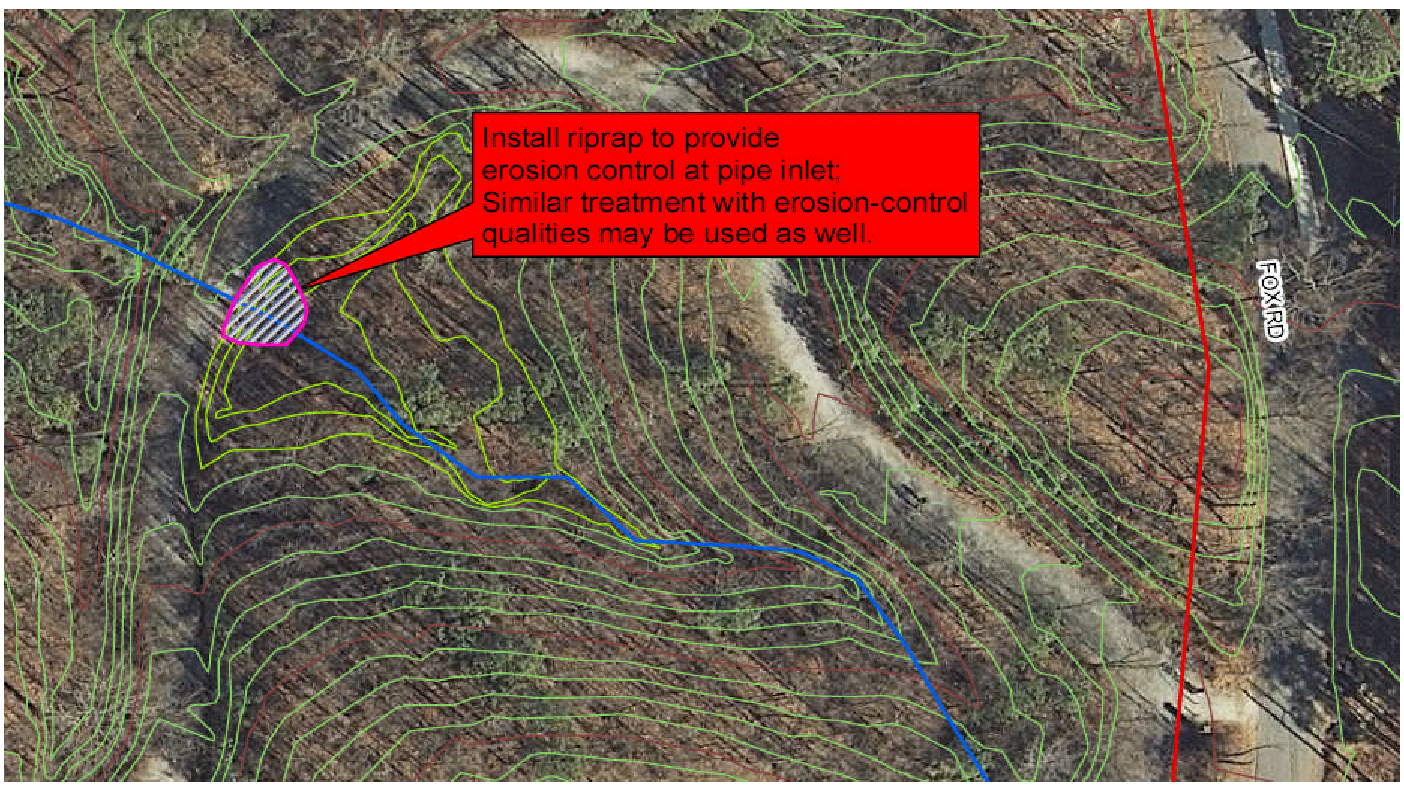
MAP ID **14**

Project Type: Erosion Control treatment ***Project ID*** **14**

PROJECT DETAILS

Approximately 22 square yards of Type 3 riprap should be placed just upstream of culvert inlet, to provide erosion control for the area. A synthetic filter fabric should be installed between the riprap and soil foundation.

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Erosion Control treatment — ***MAP ID*** **15**
Project Location: Stormwater ditches within park property — ***Project ID*** **15**
Property Ownership: ____ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Various erosion control options for ditches along park trails and Webb Bridge Park Rd

EXISTING CONDITIONS

Key photos associated with project: A, B
Visible Impairment: X Yes ____ No
Visible Impairment Description: Evidence of erosion and ongoing maintenance efforts by Parks Dept
Measured Impairment: ____ Yes X No
Measured Impairment Description: ____
Current Land Use: Stormwater ditches

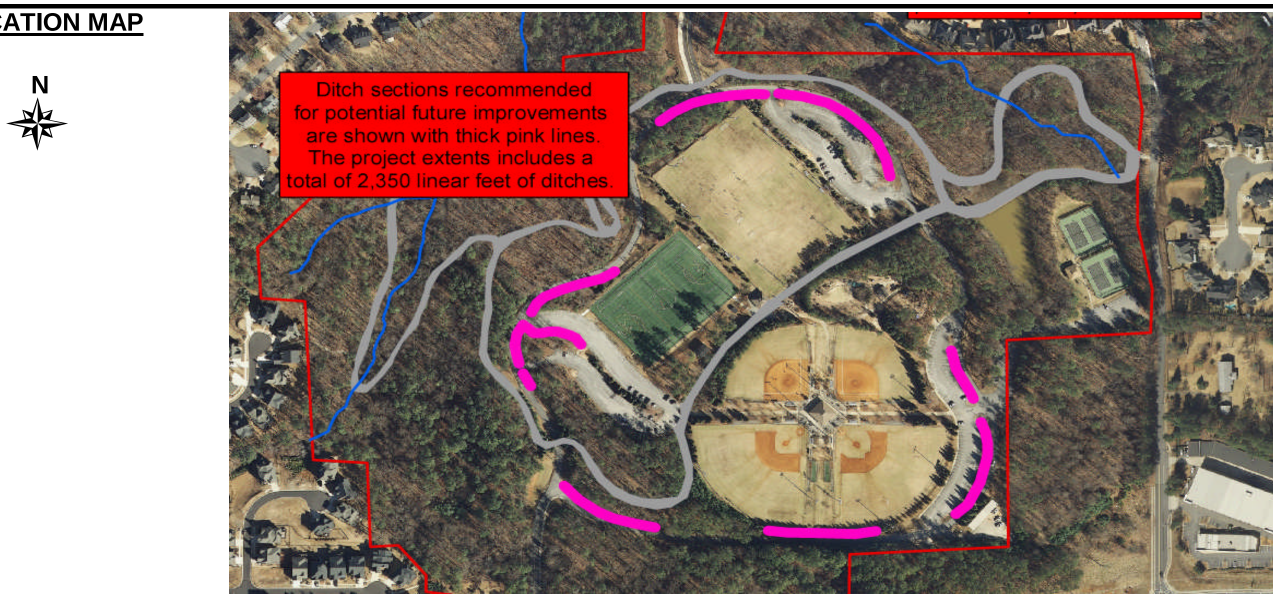
**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

Existing Conditions: Park staff is tasked monthly with debris and sediment removal from roadside ditches that become obstructed following rain events. Along certain ditch sections lined only with bare clay, soil erosion is an ongoing problem. Some of these ditch sections show indication of only minor erosion while others are in more immediate need of stabilization.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP



MAP ID **15**

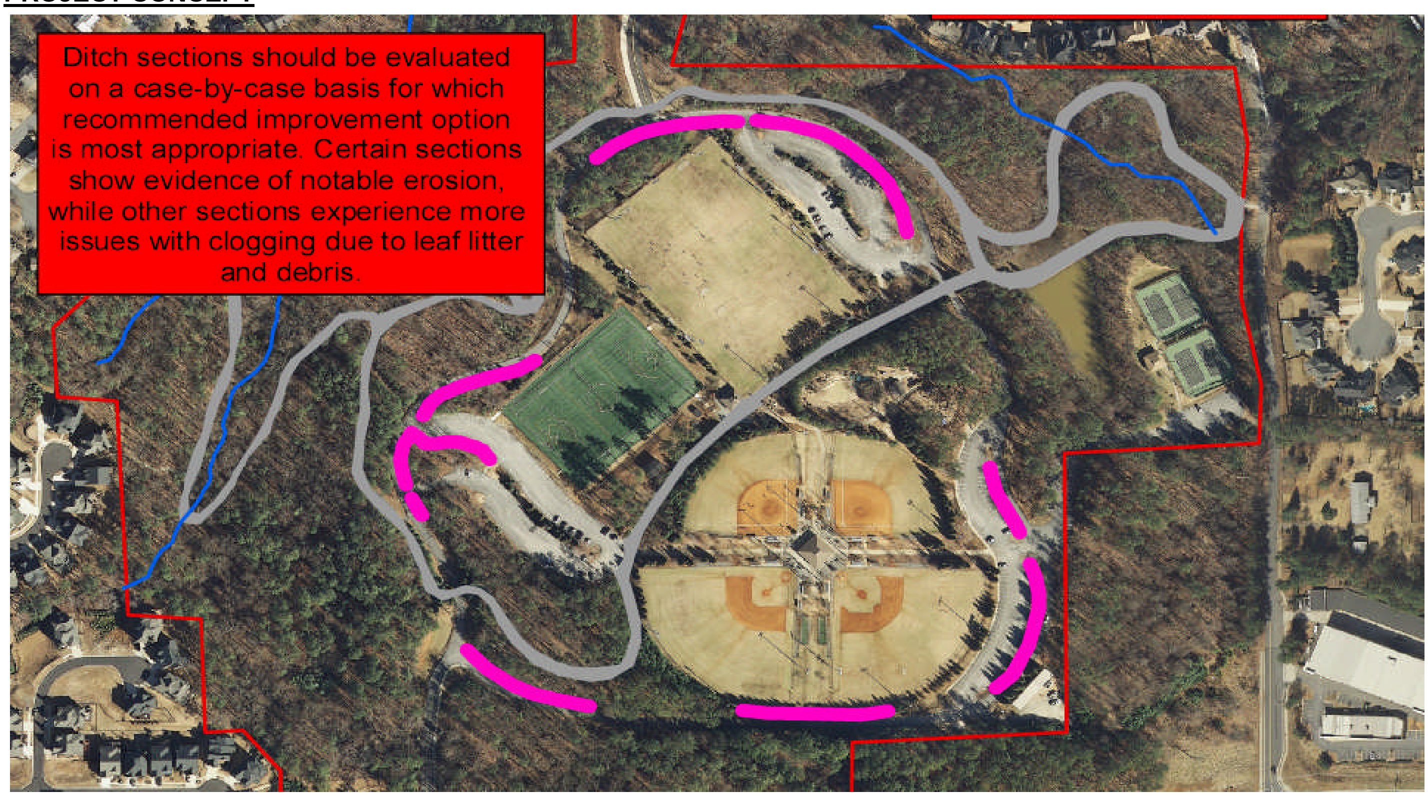
Project Type: Erosion Control treatment ***Project ID*** **15**

PROJECT DETAILS

Four different options are provided to address the erosion along the park's ditches. For the sake of overall comparison, the costs stated within the Drainage Study are provided as a lump sum for the entire 2,350 linear feet of ditches that were determined to require some level of repair. The four options developed for the ditch improvements are: Option 1 – Install Type 3 riprap along the 2,350 feet of ditches; Option 2 – Install RootCarpet™, a biodegradable coconut fiber vegetated with specifically selected plant species; Option 3 - Line the ditches with a non-erodible highly porous pervious pavement; and Option 4 – Replace the open ditch system with HDPE or RCP piping.

It bears noting that many of the park's ditches contain healthy, mature trees that would present a challenge for any mass-grading effort and it is highly recommended that a thorough field assessment be conducted prior to commencing design on any of these options.

PROJECT CONCEPT



RootCarpet™

native wetland vegetated mat

specifications

Carpet material: 100% biodegradable coconut fiber, vegetated with native wetland plants.

Custom orders: RootCarpet™ can be custom grown to your specific needs based on your site conditions. Please allow 8 weeks lead time.

Native wetland plants are installed 10” to 12” on center (approximately 45-65 plants per blanket).

Length: 15 ft (4.6 m)

Width: 3 ft (.92 m)

Area: 45 ft² (4.23 m²)

Coir mat thickness: 2.75" (7 cm)

Coir fiber density: 3' x 15' - 1.022 lbs/sqf

Exterior net structure: Square patterned coir net

Net mesh size: 0.75" x 0.75" (20 mm x 20 mm)

Net thickness: 0.16" (4 mm)

applications

RootCarpet™ can be used for installation along pond edges, bio-swales, golf course water features - anywhere instant native vegetation is needed. RootCarpet™ vegetated mats are especially helpful in establishing vegetation in moving water situations and along newly graded wetland banks. The coir mattress material will provide short-term stabilization while allowing the native vegetation to root into the substrate, eventually stabilizing the bank with an intensive native root structure.

Applications include:

- Golf Course
- Tidal Zone
- Wetland Restoration
- Stormwater Treatment
- Stream and Lake Banks
- Rain Gardens

Cardno JFNew

RootCarpet™

native wetland vegetated mat

handling and storage

Because RootCarpet™ contains live plants, delivery must coincide with the installation date.

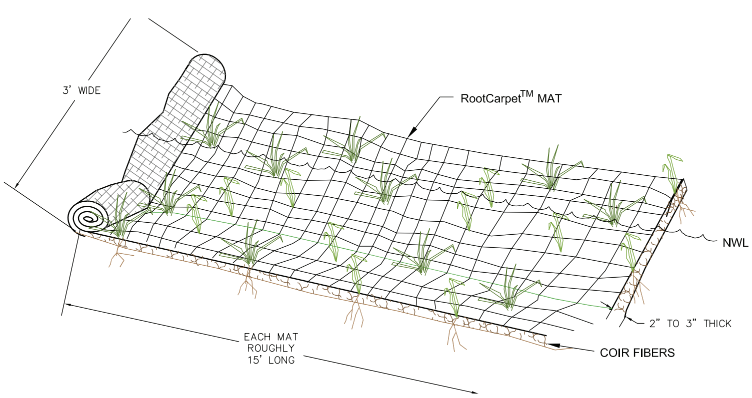
RootCarpet™ will be delivered to the site in loose rolls, tied with twine.

If not installing immediately, unroll and stage in a shaded area on site. RootCarpet™ must be kept moist at all times.

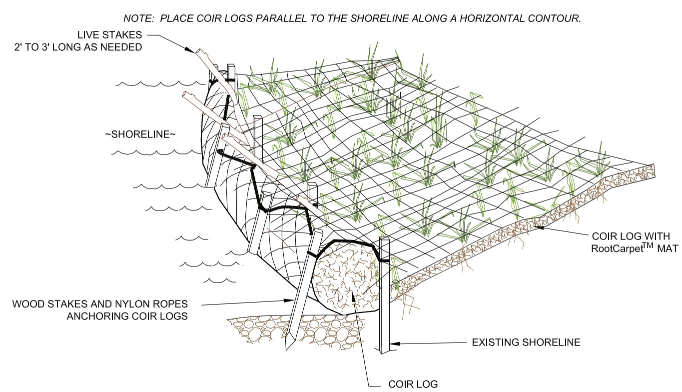
installation

1. Final grade should be smooth, free of rocks, sticks, and existing vegetation.
2. Do not install RootCarpet™ mats on hard, compacted soil.
3. RootCarpet™ mats must have good soil contact and be in contact with water (at the normal water level).
4. If installing in a stream channel, unroll RootCarpet™ mats starting downstream, working upstream. Lay mats loosely and DO NOT stretch. Overlap RootCarpet™ mats similarly to roof shingles, 6" on ends, 4" on sides.
5. If installing in conjunction with vegetated coir logs, RootCarpet™ should be in direct contact with coir logs.
6. Securely anchor with 8" to 12" steel turf staples or hardwood stakes as needed to maintain direct contact with soil.

guides



RootCarpet™ MAT DETAIL
NOT TO SCALE



COIR LOG WITH RootCarpet™ MAT
NOT TO SCALE

Cardno JFNew Native Plant Nursery
128 Sunset Drive
Walkerton, IN 46574
574.586.2412 jfnew.nursery.sales@cardno.com www.cardnojfnew.com/nursery

PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Trail resurface — ***MAP ID*** **16**
Project Location: Existing trail system in park — ***Project ID*** **16**
Property Ownership: ____ *Private* X *City Owned*
If Private, Associated Parcels: n/a
Description: Resurface entire trail system with pervious pavement

EXISTING CONDITIONS

Key photos associated with project: Multiple, refer to photo log in Appendix

Visible Impairment: X Yes ____ No

Visible Impairment Description: Parks replenishes trails with 54 tons of gravel annually

Measured Impairment: ____ Yes X No

Measured Impairment Description: ____

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

**Measured impairment denotes degradation or pollution detected by sampling*

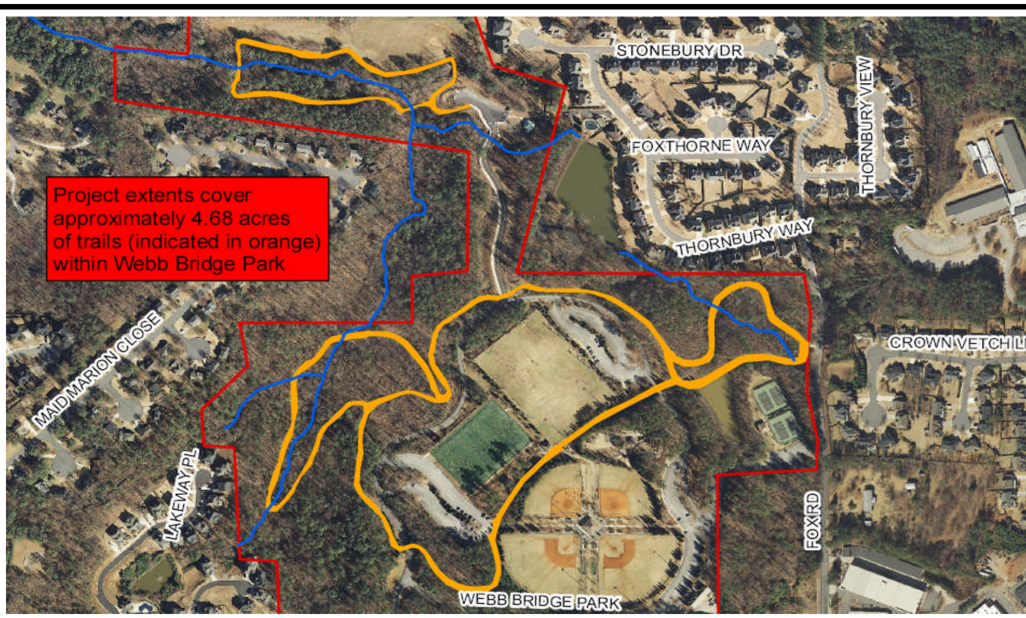
Current Land Use: Gravel Trail

Existing Conditions: An extensive gravel trail system winds through the park property. The 2.2-mile trail system covers 4.7 acres of land. Approximately 54 tons of gravel is required annually to replenish areas that have become bare due to washoff.

ADDITIONAL PROJECT INFORMATION

LOCATION MAP

N



PROJECT CONCEPT

WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID 16

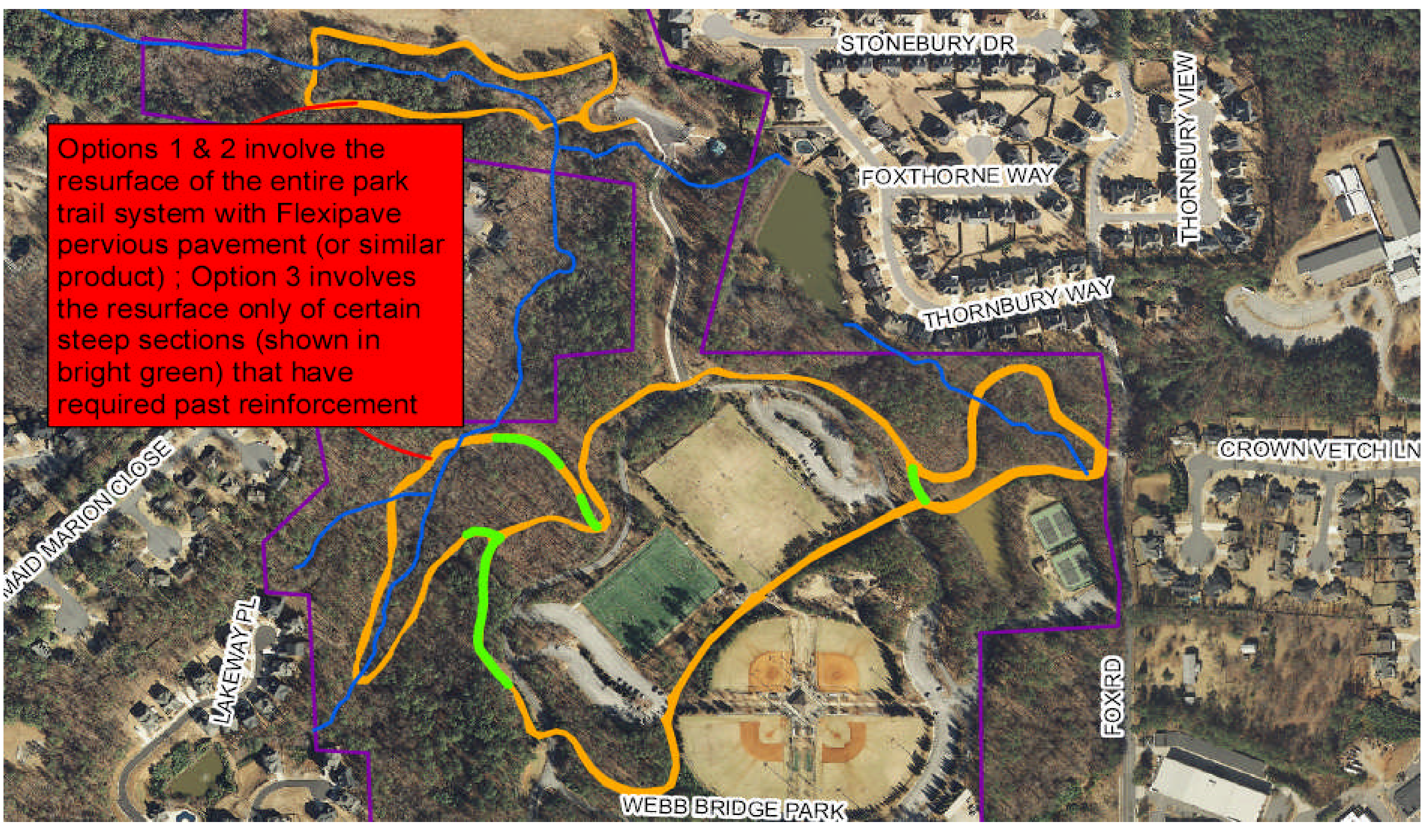
Project Type: Trail resurface ***Project ID*** 16

PROJECT DETAILS

The park's trail system is heavily used and enjoyed most of the year by the local citizens. This project involves the resurfacing of the trails with a non-erodible, highly pervious pavement. For the sake of pricing, Flexipave (www.kbius.com) was used for this scope. It is highly recommended that the City ascertain the applicability, performance specifications and available product test results prior to the use of any pervious pavement products.

Three options were developed. Options 1 and 2 include resurfacing the entire trail system and option 3 recommends resurfacing only the steepest sections of the trail (which total approximately 1,000 feet in length), many of which have been previously reinforced with railroad ties.

PROJECT CONCEPT



PROJECT CONCEPT
WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

Project Type: Water Quality Sampling Activities — ***MAP ID*** **17**

Project Location: Various locations in streams and ponds — ***Project ID*** **17**

Property Ownership: X *Private* X *City Owned*

If Private, Associated Parcels: in-stream sampling behind Nottingham Gate and Thornbury Parc subdivisions

Description: One year of additional sampling for nutrients, pollutants and habitat assessments

EXISTING CONDITIONS

Key photos associated with project: Multiple, refer to photo log in Appendix

Visible Impairment: X Yes ____ No

Visible Impairment Description: Algal blooms in park pond present during warmer months

**Visible impairment denotes a physical sign of damage, degradation, erosion or pollution*

Measured Impairment: X Yes ____ No

Measured Impairment Description: Benthic sampling indicated degradation in tributary to Lake Windward; moderate amounts of nutrients being accomodated by park pond

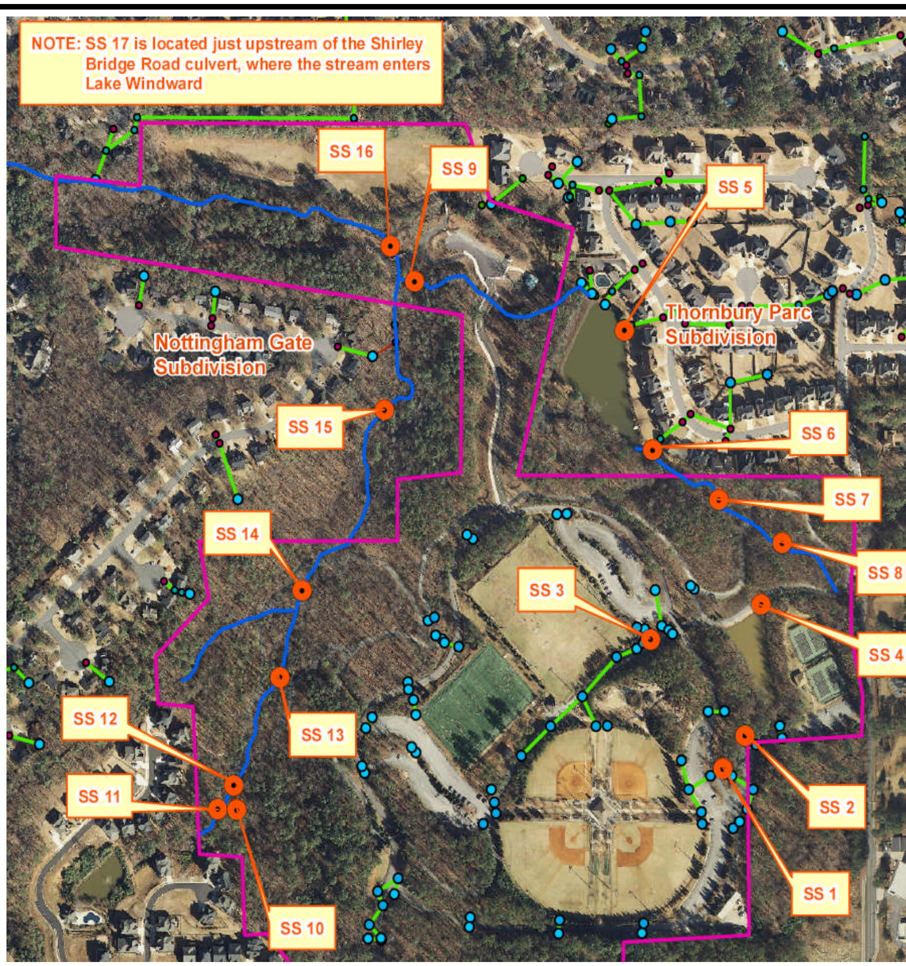
**Measured impairment denotes degradation or pollution detected by sampling*

Current Land Use: Streams and ponds

Existing Conditions: These sampling activities will be conducted along the streams and ponds within, and downstream of, Webb Bridge Park. Specifically, the unnamed tributary to Lake Windward, the unnamed tributary to Thornbury Lake, the park pond and the Thornbury Parc pond.

LOCATION MAP

N



PROJECT CONCEPT

WEBB BRIDGE PARK, ALPHARETTA, GEORGIA

MAP ID **17**

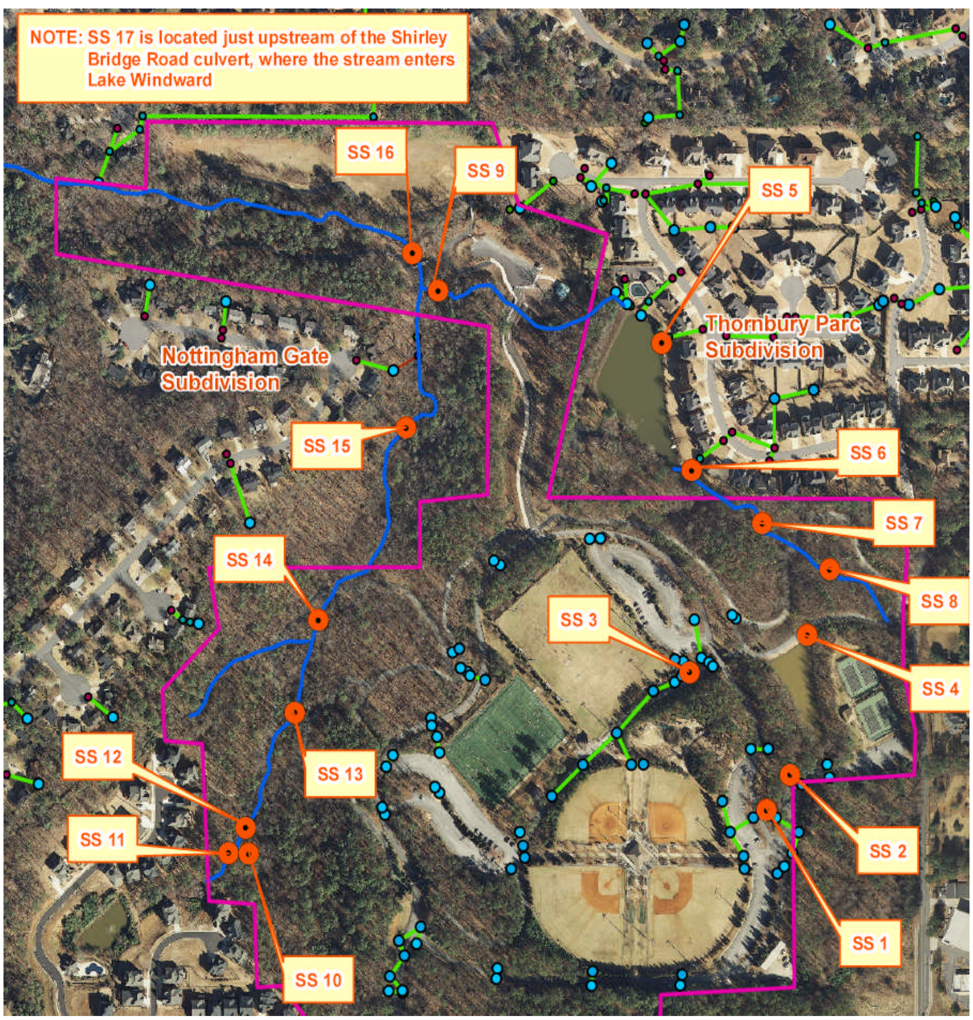
Project Type: Water Quality Sampling Activities ***Project ID*** **17**

PROJECT DETAILS

Water quality sampling results provide baseline data for future water quality sampling, provide short-term trends, and suggest which areas may need improvement in regards to water quality. This project presents two options for the City, which provide two different levels of sampling. The first option includes an additional year of sampling at all original locations assessed during the Webb Bridge Park Drainage Study. Sampling will be conducted at multiple locations and reaches of stream, as illustrated in the Project Concept (below), report Figures 4 and 5. The scope of the sampling efforts included in option 1 will be identical to the efforts conducted for the Drainage Study, including both pollutant parameter sampling and benthic assessments.

The second option involves a focused effort on the park's wet pond. For option 2, sampling results from four sampling stations will be assessed to determine if excessive nutrients are entering and exiting the pond. Three of the sampling stations (SS1 - SS3) will include stormwater flow from culverts into the pond and one sampling station (SS4) will test the water exiting the pond. The three culvert sampling stations (SS1 - SS3) would provide data as to what type and quantity of nutrients are entering the wet pond from the contributory watershed. The fourth sampling station (SS4) will provide information on type and quantity of nutrients leaving the pond and discharging into the unnamed tributary of Thornbury Parc. Should the results of the water quality sampling indicate that excessive nutrients are exiting the pond, this data can be used to determine the design specifications of a potential constructed wetland (Project 13) that could be constructed to filter out pollutants/nutrients prior to entering the wet pond.

PROJECT CONCEPT



Webb Bridge Park Drainage Study

Appendix D

Phycomycin Data Sheet and Information

Phycomycin - Product Info

Phycomycin is a granular product that attacks planktonic and filamentous algae on contact. You can actually see it working as you apply. Fast-acting, it leaves behind no harmful residues and adds bio-available oxygen to the water.

Phycomycin is effective both as an *algaecide* (eliminating existing blue-green algae infestations) and as an *algaestat* (i.e., retarding and preventing new growth). It works quickly, and neither it nor its byproducts (hydrogen peroxide and oxygen) linger in the ecosystem.

Water Use Restrictions	
Active Ingredients: **Sodium Carbonate Peroxyhydrate***	
Weight % Active Ingredient: **85**	
EPA Reg.No.	**8959-10**
	Number of Days
Human Drinking	**0**
Human Swimming	**0**
Human Fish Consumption	**0**
Animal Drinking	**0**
Irrigation Turf	**0**
Irrigation Forage	**0**
Irrigation Food Crops	**0**

Can also be applied as a spot or perimeter treatment. EPA approved and NSF/ANSI Standard 60 certified for drinking water application.

Begin application in spring as water temperature warms to 60º F and above. Early treatment when growth first appears or begins to create a nuisance will reduce the amount of Phycomycin you will need. Early treatment will also reduce the amount of dead growth.

Heavy, out of control growth may require more than one application or physical removal to gain control. For best results, use under conditions of minimal water flow. Apply early on the morning of a calm, sunny day.

Phycomycin can be applied either manually, or by using most existing broadcast spreaders.

No water use restrictions.

The product is applied at 3.0 to 100.0 lbs/acre-ft.

ALGAECIDE AND OXIDIZER Application Rates				
Seasonal Program			**Rates for Specific Algae Problems**	
Step One	Shock Treatment Spring/Early Summer.	Apply 15-40 lbs./acre-foot of water	Spot Treatments*	20-50 lbs./acre-foot of water
Step Two	Maintenance Treatments Every 2-4 weeks.	Apply 8-25 lbs./acre-foot of water	Planktonic Blue-Green Algae Blooms	9-30 lbs./acre-foot of water
Step Three	Spot Treatment As needed. Can be applied to perimeter only.	Apply 20-50 lbs./acre-foot of water	Filamentous Algae Blooms	50-100 lbs./acre-foot of water

Webb Bridge Park Drainage Study

Appendix E

RootCarpet™ Data Sheet and Information

RootCarpet™

native wetland vegetated mat

specifications

Carpet material: 100% biodegradable coconut fiber, vegetated with native wetland plants.

Custom orders: RootCarpet™ can be custom grown to your specific needs based on your site conditions. Please allow 8 weeks lead time.

Native wetland plants are installed 10” to 12” on center (approximately 45-65 plants per blanket).

Length: 15 ft (4.6 m)

Width: 3 ft (.92 m)

Area: 45 ft² (4.23 m²)

Coir mat thickness: 2.75" (7 cm)

Coir fiber density: 3' x 15' - 1.022 lbs/sqf

Exterior net structure: Square patterned coir net

Net mesh size: 0.75" x 0.75" (20 mm x 20 mm)

Net thickness: 0.16" (4 mm)

applications

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Applications include:

- Golf Course
- Wetland Restoration
- Stream and Lake Banks
- Tidal Zone
- Stormwater Treatment
- Rain Gardens

Cardno JFNew

RootCarpet™

native wetland vegetated mat

handling and storage

Because RootCarpet™ contains live plants, delivery must coincide with the installation date.

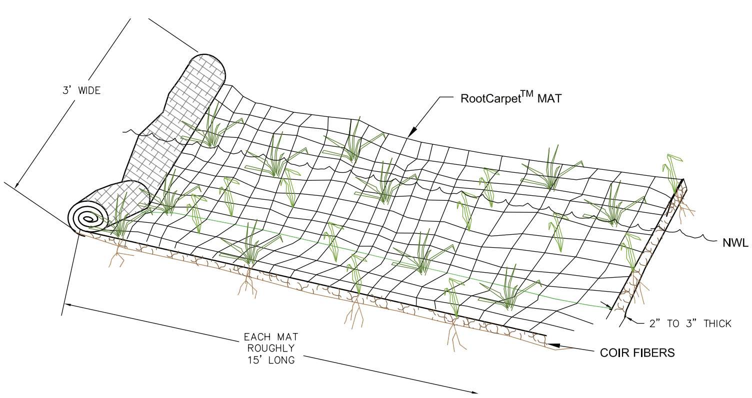
RootCarpet™ will be delivered to the site in loose rolls, tied with twine.

If not installing immediately, unroll and stage in a shaded area on site. RootCarpet™ must be kept moist at all times.

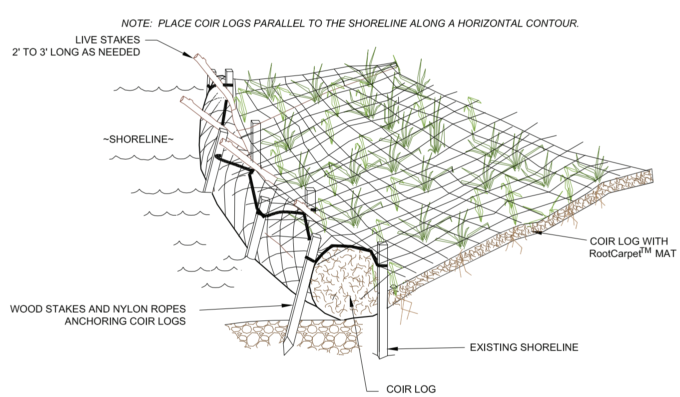
installation

1. Final grade should be smooth, free of rocks, sticks, and existing vegetation.
2. Do not install RootCarpet™ mats on hard, compacted soil.
3. RootCarpet™ mats must have good soil contact and be in contact with water (at the normal water level).
4. If installing in a stream channel, unroll RootCarpet™ mats starting downstream, working upstream. Lay mats loosely and DO NOT stretch. Overlap RootCarpet™ mats similarly to roof shingles, 6" on ends, 4" on sides.
5. If installing in conjunction with vegetated coir logs, RootCarpet™ should be in direct contact with coir logs.
6. Securely anchor with 8" to 12" steel turf staples or hardwood stakes as needed to maintain direct contact with soil.

guides



RootCarpet™ MAT DETAIL
NOT TO SCALE



COIR LOG WITH RootCarpet™ MAT
NOT TO SCALE

Cardno JFNew Native Plant Nursery

128 Sunset Drive
Walkerton, IN 46574
574.586.2412 jfnew.nursery.sales@cardno.com www.cardnojfnew.com/nursery

Cardno JFNew