Sink Hole Creek Restoration Project

Baseline Monitoring Document and As-built Baseline Report

Mitchell County, North Carolina

Monitoring Firm: Michael Baker Engineering, Inc. (Baker)

Monitoring Firm POC: Carmen McIntyre

Prepared for: North Carolina Ecosystem Enhancement Program (NCEEP)

NCEEP Project Manager: Guy Pearce

Report Prepared By: Michael Baker Engineering, Inc., NC Professional Engineering License #F-1084

797 Haywood Road, Suite 201

Asheville, NC 28806

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DRAFT

EXECUTIVE SUMMARY

The Sink Hole Creek site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents base-line, as-built monitoring data for the five-year monitoring period. The goals for the restoration project were as follows:

- To create geomorphically stable conditions on the Sink Hole Creek project site;
- The reduction of sediment and nutrient loading through restoration of riparian areas and stream banks and the exclusion of livestock from the streams corridors;
- To improve and restore hydrologic connections between the creek and floodplain;
- The restoration and preservation of headwater tributaries to the North Toe River, French Broad River Basin; and
- To improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Restoration of incised, eroding, and channelized streams by creating stable channels that have access to its floodplain;
- Improvement of water quality by establishing buffers for nutrient removal from runoff and by stabilizing streambanks to reduce bank erosion;
- Improvement of in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools, developing areas that increase oxygenation, providing woody debris for habitat, and reducing bank erosion;
- Improvement of terrestrial habitat by planting riparian areas with native vegetation and protection of these areas with a permanent conservation easement and fencing, so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature and improve wildlife habitat.

Sink Hole Creek and its tributaries were impaired by historical and recent land management practices, which included timber harvesting, pasture conversion, channelization, and livestock grazing. During development of the land for agricultural use, most woody riparian vegetation was removed. Prior to the restoration project, livestock had open access to portions of Sink Hole Creek, the section of UT1below Hwy. 80, UT2, and UT3. Past dredging activities had cut Sink Hole Creek off from its floodplain resulting in a deeply incised channel; while in other sections, stream banks were trampled down, creating over widened channel conditions. Over time, these land disturbances have contributed additional sediment and nutrient loading to Sink Hole Creek and ultimately to the North Toe River.

This Baseline Monitoring Document presents data on as-built stream geometry, stem count data from vegetation monitoring stations, and crest gauge installation. In addition, this report and subsequent monitoring reports will note any deviances relating to stream stability, site planting and the monitoring schedule established for the Sink Hole Creek mitigation project. The design proposed for the Sink Hole Creek mitigation project involved both Priority Level 1 and 2 approaches. The resulting design should ultimately yield primarily a B-type channel for Sink Hole Creek and Reach 2 of UT1. Unnamed tributaries 2 and 3 should become stable A and B-type channels. Based on geomorphic and vegetation data collected, this Site is currently on track to meet the hydrologic, vegetative, and stream success criteria specified in the Sink Hole Creek Mitigation Plan.

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1.0 PROJECT GOALS, BACKGROUND, AND ATTRIBUTES

The Sink Hole Creek mitigation site is located approximately four miles southwest of Bakersville, in Mitchell County, North Carolina (Figure 1 in Appendix A). The project site is situated in the French Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 04-03-06 and United States Geologic Survey (USGS) hydrologic unit 06010108040010. The Sink Hole Creek mitigation project is located in a watershed that is predominantly forested that also contains a small number of residences near Sink Hole Creek and its tributaries. While a majority of the watershed is in forested cover, a quarter of the drainage is in some form of pasture land or hay production. Sink Hole Creek and its tributaries have been impaired by historical and recent land management practices that include timber harvesting, pasture conversion, channelization, and livestock grazing. In addition, a historic mica mine is located 1000 feet north of the intersection of NC Highway 80 and Water Street (SR 1182). Prior to restoration, stream channelization and channel dredging were evident through much of the project site. Over time, these practices have contributed excessive sediment and nutrient loading to Sink Hole Creek and ultimately to the North Toe River which is home to the endangered Appalachian elktoe mussel. A significant loss of woody streambank vegetation occurred during the development of the land for agricultural use. Livestock had open access to portions of Sink Hole Creek, the section of UT1below NC Hwy. 80, UT2, and UT3. Past dredging activities had cut Sink Hole Creek off from its floodplain resulting in an incised channel; while in other sections, stream banks were trampled down, creating over widened channel conditions that contributed to additional sediment and nutrient loading. Land immediately surrounding the preservation reach of UT1 above Hwy. 80 is in forested cover.

The project involved restoration or enhancement of 4,703 linear feet (LF) along four on-site streams: Sink Hole Creek and three smaller unnamed tributaries (UT1, UT2 and UT3). In addition, 1,076 LF of the headwaters of UT 1 were preserved. Sink Hole Creek and UT1 are shown on the USGS topographic quadrangle for the site as being perennial and intermittent streams, respectively. Based on field evaluation, Sink Hole Creek and the restoration reach of UT1, as well as both UT2 and UT3 were determined to all be perennial features using the NCDWQ stream assessment protocol.

1.1 Restoration Summary

1.1.1 Location and Setting

The Sink Hole Creek project site is located approximately four miles southwest of Bakersville in the small community of Bandana, Mitchell County, North Carolina. To reach the project site, follow US Highway 19/23 north from Asheville for approximately 20 miles and take US Highway 19N (Exit 9) towards Burnsville and Spruce Pine. Continue along US Highway 19 (which becomes US-19E), for 25 miles. At Spruce Pine, turn left onto NC Highway 226 and continue for approximately 6.5 miles to State Road 1191. Turn left onto 1191, continue for approximately 1.7 miles, turn left onto NC Highway 80 and travel another 6.5 miles to Water Street (State Road 1182). Part of the project area is adjacent to the intersection of Water Street and NC Highway 80; UT 2 and UT3 are located in a pasture approximately .6 miles east on Water Street, on the left side of the road.

Sink Hole Creek is shown as a solid (perennial) blue-line stream throughout the site on the USGS topographic quadrangle map. UT1 is shown as a dashed blue-line (intermittent) stream on the USGS map. It originates in a forested area upstream of NC Highway 80 and is fed by five springs upstream of a small pond. Short feeder channels emanate from the springs and connect to UT1 within 50 to 100 feet of the individual springheads. UT2 and UT3 are first order perennial tributaries to Sink Hole Creek located at the eastern end of the watershed, approximately 2,300 feet upstream of the beginning of restoration reach 1 on Sink Hole Creek. This gap in the project is unavoidable because of structural and property constraints (houses, farm buildings, roads, and

multiple small parcels). Unnamed Tributary 2 is a perennial tributary that is spring fed and has one tributary, UT3, another spring-fed branch. Despite scoring as perennial, UT3 recently went dry during drought conditions. This was likely exacerbated by the recent restoration, which raised the streambed; it typically takes time after this type of effort for the water table to reach a new equilibrium.

1.1.2 Project Goals and Objectives

The goals for the Sink Hole Creek restoration project are as follows:

- To create geomorphically stable conditions on the Sink Hole Creek project site;
- The reduction of sediment and nutrient loading through restoration of riparian areas and stream banks and the exclusion of livestock from the streams corridors;
- To improve and restore hydrologic connections between the creek and floodplain;
- The restoration and preservation of headwater tributaries to the North Toe River, French Broad River Basin; and
- To improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were fulfilled:

- Restoration of incised, eroding, and channelized streams by creating stable channels that have access to its floodplain;
- Improvement of water quality by establishing buffers for nutrient removal from runoff and by stabilizing streambanks to reduce bank erosion;
- Improvement of in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools, developing areas that increase oxygenation, providing woody debris for habitat, and reducing bank erosion;
- Improvement of terrestrial habitat by planting riparian areas with native vegetation and protection of these areas with a permanent conservation easement and fencing, so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature and improve wildlife habitat.

1.1.3 Project Structure, Restoration Type, and Approach

1.1.3.1 Project Structure

Please refer to Table A1 in Appendix A for a summarization of the project structure of Sink Hole Creek. Figure 2, also in Appendix A, illustrates restoration approaches by project reach.

1.1.3.2 Restoration Type and Approach

<u>Sink Hole Creek (Reach 1)</u>

A Priority II Restoration approach was used on Reach 1 of Sink Hole Creek to re-establish a slightly more sinuous channel and step-pool morphology to this segment of channel that had experienced prior manipulation. The reconstruction of the stream remedied headcuts that were propagating up the channel, improved floodplain connectivity and eliminated the presence of vertical and eroding banks. Vertical and lateral stability was achieved by constructing drop-pool sequences with a series of grade control structures. Structures dissipate energy through vertical drops inducing high quality pool habitat at an acceptable spacing to achieve channel stability and habitat goals; this spacing is often observed to decrease over time as the project evolves naturally. In some areas, it was necessary to modify the existing channel alignment to achieve the aforementioned goals. A vegetated riparian buffer was also restored along this reach.

Sink Hole Creek (Reach 2)

In Reach 2 of Sink Hole Creek, the stream had been impacted by channelization and manmade levy creation. The valley is narrow and grade is controlled by bedrock outcroppings. This reach was restored using a Priority II approach. Modifications to the cross-sectional dimension, and removal of manmade levies were pursued to restore proper channel dimension and restore floodplain connectivity. Minor pattern adjustments were made in areas not heavily influenced by bedrock. Over most of the reach, a step-pool morphology approach achieved energy dissipation and habitat goals. Vertical drops over step-pool structures enhance pool depth by scouring fine sediments and creating a self-maintaining habitat feature. Throughout the reach, patches of invasive species were removed physically or treated chemically, and a wide buffer zone of native vegetation was re-established.

UT1 (Reach 1)

This reach, located southeast of NC Highway 80 and upstream of an in-line pond, was preserved within a conservation easement that has a one hundred-foot (100') wide buffer. Reach 1 is forested and is stable with good access to its floodplain. There are multiple springs within the easement area that form UT1.

UT1 (Reach 2)

A Priority II Restoration approach was used to address head-cutting and a lack of grade control in this section of UT1. Grade control structures as well as constructed riffle sequences were installed to improve the profile. Modifications to the cross-sectional dimension were also made to replicate reference conditions and design parameters. The lack of a more defined riffle – pool sequence prior to construction can be mostly attributed to the historical straightening of the stream. Riparian restoration consisted of invasive vegetation removal and planting of the buffer with native species.

UT 2 (Reach 1)

Reach 1 of the headwater tributary UT2, previously had no buffer and was heavily impacted by high runoff and cattle access from adjacent pasture. As a result, sloughing banks and a lack of grade control were contributing high sediment loads into receiving waters. The reach begins at two springs at the upstream limit of the project reach. A Priority 1 restoration approach was used in this reach to raise the channel elevation and provide floodplain relief out onto the existing valley floor. Restoration measures replaced what was essentially an unstable and severely incised ditch with a stable, A-type, step-pool channel that will effectively dissipate energy and maintain diverse habitat. Over time, fencing and the establishment of a well vegetated riparian buffer will also significantly reduce erosion impacts from the adjacent pasture land.

UT2 (Reach 2)

The Priority I Restoration approach used upstream was continued to reconstruct Reach 2 of UT2 downstream of its confluence with UT3. This approach entailed creation of a new channel alignment away from the toe of the valley with stable dimensions. The old channel, which was a highly incised, vertical, channelized, and eroding feature, was abandoned. The new step-pool channel was designed to provide floodplain access at the existing elevation of valley, with abundant grade control incorporated to provide vertical stability. Structures provide stability in the form of energy dissipation, and pool habitat below each drop. Pasture and associated exotic invasive vegetation has been removed and replaced with a native riparian buffer. The new stable channel and buffer will significantly reduce the siltation that had been plaguing the lower stream reach by restoring grade control and lateral stability. New

habitat features complement the improved health and function of the restored system, and that of the downstream system.

UT3

This tributary was located in the same setting on the landscape as UT2-Reach 1, and was subject to the same prior and on-going impacts. Prior channelization appears likely, and the impacts of high runoff rates and livestock access had resulted in a deeply incised and eroding channel with no stable morphology or flood relief. The same Priority I techniques described for UT2 were used to transform this tributary into a stable A-type headwater channel. Dimension adjustments and the implementation of a series of grade control structures to form a step-pool configuration effectively dissipate energy and maintain scour pools for habitat in the new channel. In addition, restoration of the riparian buffer to a more natural state and exclusion of cattle with fencing will significantly reduce the impacts from the adjacent pasture land.

Some modifications were made during construction, including changes to the construction sequence to reduce risk and increase efficiency during wet, or high flow, conditions, and alteration of the location and structure-types used to compensate for the presence of bedrock. Changes are documented in the attached as-built drawings. Additionally, it was necessary to undertake repair on this reach following an intense rain event that occurred during the final days of construction. Although water topped Hwy. 80, Reach 1 of Sink Hole Creek only required minor repairs and the tributaries did not sustain any damage. Repairs were made to structures that were damaged and the banks had to be reestablished, reseeded and re-matted No additional repairs were required between the construction and baseline monitoring phases. The final as-built stream length for the project, as indicated in Table A1, Appendix A, is 5,779 LF.

1.1.4 Project History, Contacts and Attribute Data

The general area in which the project is located is rural in character, and is not likely to change significantly in the foreseeable future. The project area primarily drains agricultural and forested land. The largest percentage of land in the watershed is currently forested (60%), which serves as cover for wildlife as well as providing for timber production. Agricultural lands make up 27% of the watershed with these lands supporting hay production, Christmas tree farming, grazing lands and row crops. The project watershed also supports a low density of residential sites (< 6%).

Anthropogenic land use alteration, such as channelization of streams for agricultural purposes, in the Sink Hole Creek watershed has resulted in various stream corridor impairments. Incision, bank destabilization, erosion, and other ongoing stream processes typical of streams adjusting to modification, were found along various reaches of Sink Hole Creek and the unnamed tributaries within the project area.

In accordance with the approved mitigation plan for the site, construction activities began in May 2010. Project activity on Sink Hole Creek and UT1-Reach 2, consisted of making adjustments to channel dimension, pattern, and profile. A Priority II Restoration approach was used on these stream reaches to restore floodplain connectivity. In addition, some sinuosity was incorporated based on the valley shape and the channel profile was stabilized by creating a step-pool morphology using grade control structures, including constructed riffles. The dimension was improved by eliminating the presence of vertical banks, improving floodplain connectivity by the removal of manmade levies, and correcting prior channelization by making slight adjustments to channel pattern where feasible.

A Priority I Restoration approach was implemented on UT2 and UT3 to raise the channel bed elevation, create a more stable profile, adjust channel alignment and to re-establish a riparian buffer to stabilize the streambanks. Both channels required extensive work as both had been essentially reduced to functioning as severely incised ditches with vertical, eroding banks and an unstable profile that had been cut off from the surrounding floodplain and had multiple headcuts.

Throughout the project, vertical stability was the most important project objective to achieve stability, water quality, and habitat goals. In-stream structures (constructed riffles, boulder steps, log vanes, and log rollers) were used to control streambed grade, reduce stresses on streambanks, and promote diversity of bedform and habitat. Reach-wide grade control was provided by the aforementioned in-stream structures and by bedrock where present. Structures were spaced at a distance that resulted in the downstream header protecting the upstream footer to create a redundancy that will ensure long term vertical stability.

Stream dimensions were adjusted to eliminate vertical banks and erosion resulting from excessive shear stress and lack of floodplain relief. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and live staking. Transplants will provide living root mass quickly to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

The chronology of the Sink Hole Creek mitigation project is presented in Table A2, located in Appendix A which also includes Tables A3 and A4. The contact information for designers, contractors and plant material suppliers is presented in Table A3. Relevant project background information is presented in Table A4. Total stream length across the project increased from approximately 5,707 LF to 5,779 LF (excluding easement breaks).

2.0 SUCCESS CRITERIA

The five-year monitoring plan for the Sink Hole Creek mitigation project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, reference photo stations and crest gauges are shown on the as-built plan sheets.

2.1.1 Morphologic Parameters and Channel Stability

Geomorphic monitoring of restored stream reaches will be conducted over the next five years to evaluate the effectiveness of the restoration practices installed. Monitored stream parameters include bankfull flows, stream dimension, profile, pattern (to a lesser degree for reasons noted below), and photographic documentation. The methods used and any related success criteria are described below for each parameter. For monitoring stream success criteria, fifteen permanent cross-sections, four longitudinal profile sections and two crest gauges were installed.

2.1.1.1 Dimension

Fifteen permanent cross-sections were installed to help evaluate the success of the mitigation project. Permanent cross-sections were established throughout the project site as follows: six cross-sections were located on Sink Hole Creek, two cross-sections were located on both UT1 and UT3 and five cross-sections were located on UT2. Cross-sections selected for monitoring were located in representative riffle and pool reaches and each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in the as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). At this time, cross-sectional measurements do not indicate any streambank or channel stability issues.

2.1.1.2 Pattern and Longitudinal Profile

A longitudinal profile was completed for the restored streams to provide a baseline for evaluating changes in channel bed conditions over time. A longitudinal profile was conducted for the entire project length on Sink Hole Creek, UT2, UT3 and Reach 2 of UT1. Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, bankfull, and top of low bank, if the features are present. The pools should remain relatively deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type. Profile data collected reflect stable channel bedform and a diverse range of riffle and pool complexes.

All measurements will be taken at the head of each feature (e.g., riffle, run, pool, glide) and the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. Surveys will be tied to a permanent benchmark. Permanent cross-section and longitudinal profile data are provided in Appendix B. Although pattern adjustments were made in each reach for channel alignment considerations such as following the low point of the valley, pattern adjustments were not made with the intent to increase sinuosity. Sink Hole Creek and its tributaries are A and B-type streams primarily characterized by step-pool sequences. Consequently, pattern information is not provided in Appendix B as the parameters present are generally associated with meandering, riffle-pool channels. However, as the site is monitored, reaches will be evaluated for significant changes in pattern. Any changes that occur which warrants repair will be discussed in future monitoring reports.

The longitudinal profiles show that the bed features are largely stable. There are some signs of profile adjustment in Reach 1 of UT2 and UT3 where the Aa^{+}-type channels are on a much greater slope. These adjustments most likely occurred in July 2010 when a heavy downpour resulted in a brief flash flood event in the project area approximately one month after construction of these channels. Head-water systems are naturally degradational and the reconfiguration of bedform following extreme events (such as the July 2010 event in which over 4" of rain fell within one hour) is a natural occurrence. Adjustments are not of concern, unless they result in a loss of grade control in the channel, or severe erosion that cannot be repaired by natural vegetation processes. The results of that event do not appear to be threatening overall stability of these channels and do not present a concern at this time. Closely-spaced grade control structures should help maintain the overall profile desired, and there was no significant bank erosion observed as a result of the channel profile adjustments.

2.1.1.3 Substrate and Sediment Transport

Bed material analysis will consist of a pebble count taken in the same constructed riffle during annual geomorphic surveys of the project site. This sample, combined with evidence provided by changes in cross-sectional and profile data will reveal changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and

watershed changes. As-built surveys do not reveal any significant areas of aggradation or degradation within the project area at this time.

2.1.2 Vegetation

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, eight vegetation monitoring quadrants were installed across the restoration site. The size of individual quadrants vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred, or in the fall prior to leaf fall. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between June and November.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of Year 3 of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of Year 5 of the monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided good ground coverage. Live stakes and bare root trees planted are also providing streambank stability. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A minimum 30-foot buffer was established along all restored stream reaches. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in the winter of 2011. Species planted are listed below.

Riparian Buffer Plantings (Bare-Root and Live Stake Species)

Trees	
Sycamore	*(Platanus occidentalis)*
Red Oak	*(Quercus rubra)*
River birch	*(Betula nigra)*
Yellow birch	*(Betula alleghaniensis)*
White Oak	*(Quercus alba)*
Tulip Poplar	*(Liriodendron tulipifera)*
Understory Trees	
Ninebark	*(Physocarpus opulifolius)*
Tag Alder	*(Alnus serrulata)*
Flowering Dogwood	*(Cornus florida)*
Shrubs/small trees	
Sweetshrub	*(Cercis canadensis)*
Witch-hazel	*(Hamamelis virginiana)*
Deerberry	*(Vaccinium stamineum)*

Blackhaw	*(Viburnum prunifolium)*

Woody Vegetation for Live Stakes

Silky willow	*(Salix sericea)*
Ninebark	*(Physocarpus opulifolia)*
Elderberry	*(Sambucus canadensis)*
Silky Dogwood	*(Cornus amomum)*
Buttonbush	*(Cephalanthus occidentalis)*

The restoration plan for the Sink Hole Creek Site specifies that the number of quadrants required will be based on the species/area curve method, as described in NCEEP monitoring guidance documents. The size of individual quadrants is 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of eight vegetation plots, each 10 by 10 meters or 5 by 20 meters in size, were established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table C6, Appendix C. The average density of planted bare root stems, based on the data from the eight monitoring plots, is 754 stems per acre which indicates that the Site is on track for meeting the minimum success interim criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5. The locations of the vegetation plots are shown on the as-built plan sheets.

2.1.3 Hydrology

2.1.3.1 Streams

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. Crest gauges were installed on the floodplain at bankfull elevation. One crest gauge was placed on Reach 1 of Sink Hole Creek near Hwy. 80 below the confluence of UT2, while another gauge was set up near the end of the project area on Reach 2 of Sink Hole Creek. The crest gauges will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented on each crest gauge within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

2.1.4 Photographic Documentation of Site

Photographs will be used to document restoration success visually. Reference stations will be photographed during the as-built survey and for at least five years following construction. Reference photos will be taken once a year, from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) on the site are monitored during each monitoring period. Selected site photographs are shown in Appendix B.

2.1.4.1 Lateral Reference Photos

Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. A survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will be included in each photo. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.4.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored streams are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures subjectively. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.2 Areas of Concern

At this time the only area of concern is the upper sections of UT2 and UT3 where some channel profile adjustments have occurred since construction. These areas will be monitored and if necessary, additional grade control will be installed to maintain a stable a channel profile and dimension.

3.0 MAINTENANCE AND CONTINGENCY PLANS

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels
- Wet weather during construction can make accurate channel and floodplain excavations difficult
- Extreme and/or frequent flooding can cause floodplain and channel erosion
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed
- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in this and future monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. NCEEP approval will be obtained prior to any remedial action.

APPENDIX A
GENERAL TABLES AND FIGURES

LOCATION MAP AND PROJECT COMPONENT MAP
TABLES 1-4

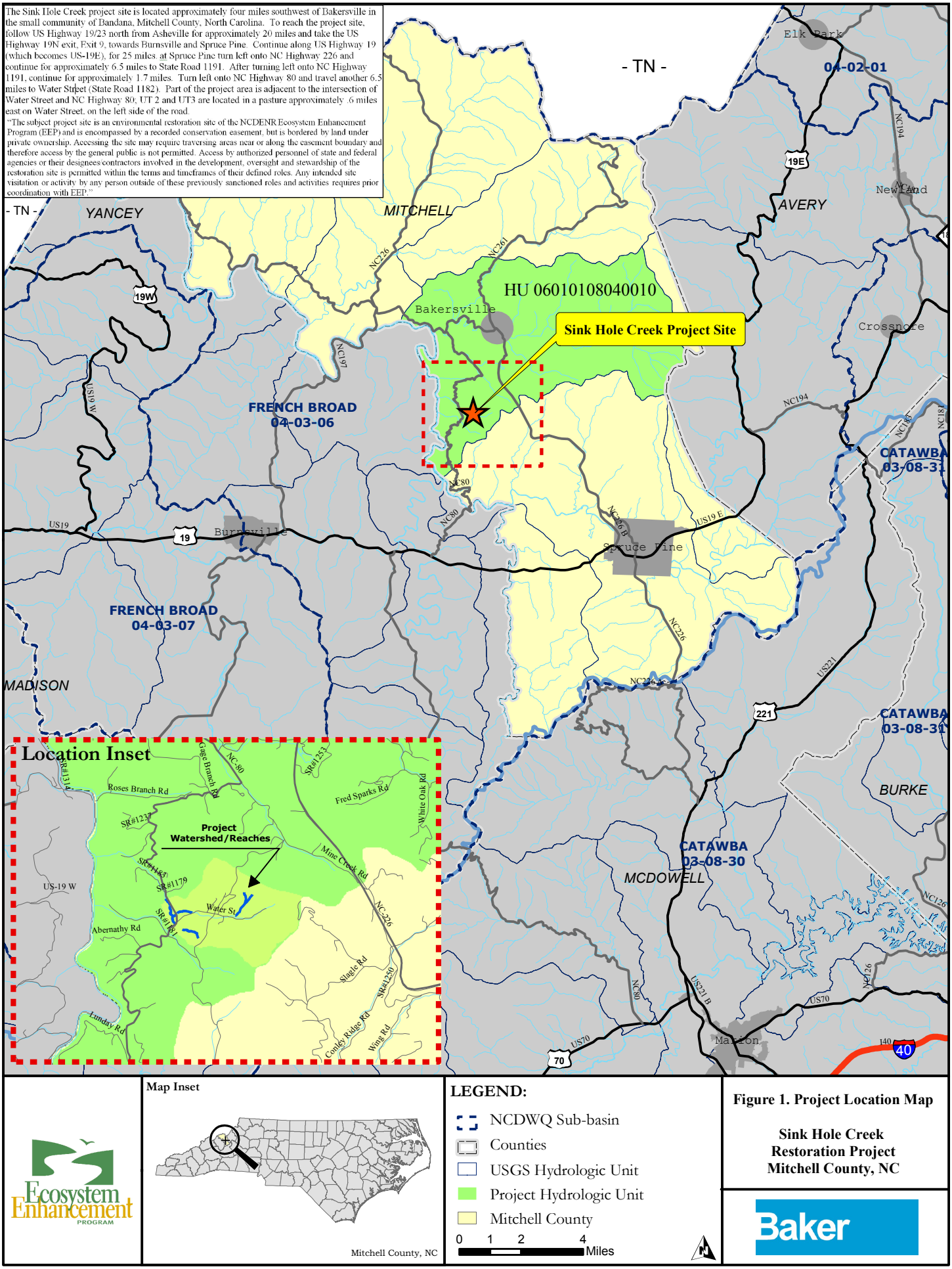


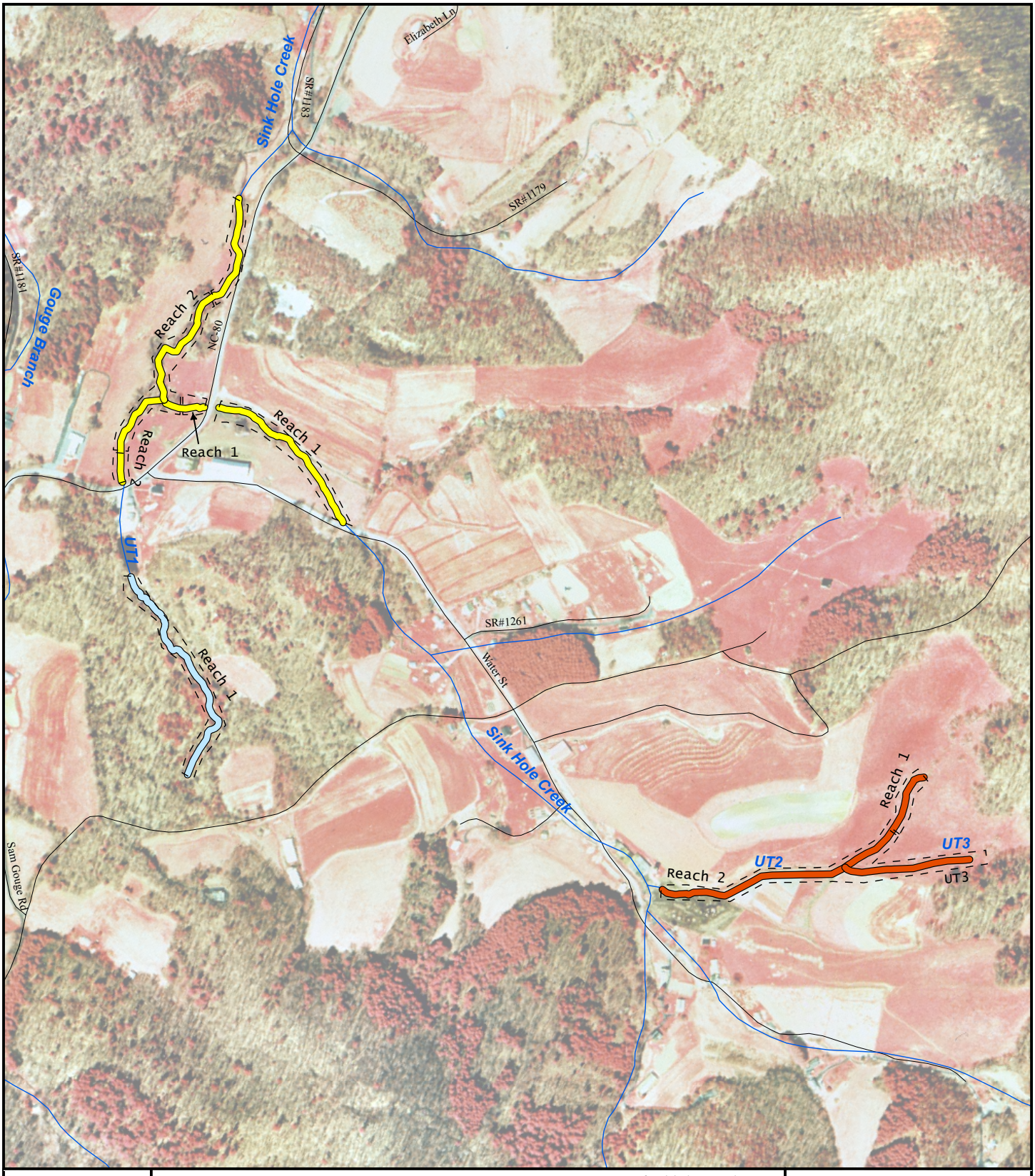
Figure 1. Project Location Map

Sink Hole Creek Restoration Project Mitchell County, NC

Figure 1. Notes

The Sink Hole Creek project site is located approximately four miles southwest of Bakersville in the small community of Bandana, Mitchell County, North Carolina. To reach the project site, follow US Highway 19/23 north from Asheville for approximately 20 miles and take US Highway 19N (Exit 9) towards Burnsville and Spruce Pine. Continue along US Highway 19 (which becomes US-19E), for 25 miles. At Spruce Pine, turn left onto NC Highway 226 and continue for approximately 6.5 miles to State Road 1191. Turn left onto 1191, continue for approximately 1.7 miles, turn left onto NC Highway 80 and travel another 6.5 miles to Water Street (State Road 1182). Part of the project area is adjacent to the intersection of Water Street and NC Highway 80; UT 2 and UT3 are located in a pasture approximately .6 miles east on Water Street, on the left side of the road.

The subject project site is an environmental restoration site of the NCDENR Ecosystem Enhancement Program (EEP) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with EEP.



LEGEND:

Proposed Project Component
- Preservation
- Priority I Restoration
- Priority II Restoration

Proposed Easement

Streams

0 200 400 800 Feet

*Date of aerial photography: 1998

Figure 2. Restoration Approach by Project Reach

Sink Hole Creek Restoration Project Mitchell County, NC

Ecosystem Enhancement Program

Baker

Table A1. Project Components

Sink Hole Creek Mitigation Project-NCEEP Project #D06125-C

Project Segment or Reach ID	Existing Feet/ Acres	Mitigation Type	Approach	Target Stream Type	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Sink Hole Creek									
Reach 1	1,036 LF	R	PII	B/C	1,019 LF	1.0:1	1,019	0+13 to 11+23	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
Reach 2	1,062 LF	R	PII		1,073 LF	1.0:1	1,073	11+23 to 22+08	Pattern adjustment, removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
UT1									
Reach 1	1,076 LF	P			1,076 LF	5.0:1	215	-	Preservation reach-no adjustments made.
Reach 2	489 LF	R	PII	B/C	489 LF	1.0:1	489	0+13 to 5+14	Slight pattern adjustment, removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
UT 2									
Reach 1	579 LF	R	PI	Aa^{+}/B	596 LF	1.0:1	596	0+22 to 6+30	Minor pattern adjustment, extensive improvements to dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via multiple grade control structures and constructed riffles.
Reach 2	879 LF	R	PI	C-B/A	885 LF	1.0:1	885	6+30 to 15+12	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
UT 3									
Reach 1	586 LF	R	PI	Aa^{+}/B	641 LF	1.0:1	641	0+00 to 6+41	Minor pattern adjustment, extensive improvements to dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via multiple grade control structures and constructed riffles.

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
4,918	NA	NA	NA		

Notes:

Table A2. Project Activity and Reporting History
Sink Hole Creek Mitigation Project-NCEEP Project #D06125-C

Activity or Report	Data Collection Complete	Completion or Delivery
Restoration Plan		May 2009
Final Design-90%		June 2009
Construction		August 2010
Temporary S&E mix applied to entire project area		May-July 2010
Permanent seed mix applied to project site		August 2010
Containerized and B&B plantings set out		April 2011
Flood Event		July 2010
Installation of crest gauges		January 2011
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	April 2011 (Vegetation Monitoring) November-December 2010 (Geomorphic Monitoring)	May 2011 (last of plantings completed in April)
Year 1 Monitoring		
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

Table A3. Project Contacts Table
Sink Hole Creek Mitigation Project-NCEEP Project #D06125-C

Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200, Cary, NC 27511 Contact: Will Pedersen, Tel. 919.459.9001
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200, Cary, NC 27511 Contact: George Morris, Tel. 919.459.9001
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Carmen McIntyre, Tel. 828.350.1408 x2010

Table A4. Project Attribute Table **Sink Hole Creek Mitigation Project-NCEEP Project #D06125-C**	
Project County	Mitchell County, NC
Physiograhic Region	Blue Ridge
Ecoregion	Blue Ridge Mountains-Southern Crystalline Ridges and Mountains
Project River Basin	French Broad
USGS HUC for Project	6010108040010
NCDWQ Sub-basin for Project	04-03-06
Within extent of EEP Watershed Plan?	In a TLW (French Broad River Basin Priorities Report-2009)
WRC Class	Cold Water
% of Project Easement Fenced or Demarcated	100% (post-construction)
Beaver Activity Observed During Design Phase?	No
Drainage Area (Square Miles)	
Sink Hole Creek Reach 1	.72 mi^2
Sink Hole Creek Reach 2	.84 mi^2
UT1Reach 1	.07 mi^2
UT1 Reach2	.09 mi^2
UT2 Reach 1	.02 mi^2
UT2 Reach 2	.08 mi^2
UT3	.02 mi^2
Stream Order	Sink Hole-3rd , UT1-1st, UT2-2nd, UT3-1st
Restored Length	
Sink Hole Creek Reach 1	1,019 LF
Sink Hole Creek Reach 2	1,073 LF
UT1Reach 1	1,076 LF
UT1Reach 2	489 LF
UT2 Reach 1	596 LF
UT2 Reach 2	885 LF
UT3	641 LF
Perennial or Intermittent	Perennial except Reach 1 of UT1 (intermittent)
Watershed Type	Rural (Predominantly Forested)
Watershed LULC Distribution (Percent area)	
Forest	66%

Table A4. Project Attribute Table **Sink Hole Creek Mitigation Project-NCEEP Project #D06125-C**				
Developed Open Space	6%			
Drainage Impervious Cover Estimate (%)	<10%			
NCDWQ AU/Index #	7-2-56			
303d Listed	No			
Upstream of 303d Listed Segment	No			
Reasons for 303d Listing or Stressor	-			
Total Acreage of Easement	9.46			
Total Vegetated Acreage w/in Easement	n/a (Easement vegetated with exception of stream channel)			
Total Planted Acreage within the Easement	~9.46 Acres			
Rosgen Classification (Pre-existing)				
Sink Hole Creek Reach 1	Eb/Cb			
Sink Hole Creek Reach 2	G/Eb			
UT1 Reach2	Cb/B			
UT2 Reach 1	Aa^{+}			
UT2 Reach 2	A			
UT3	A			
Rosgen Classification of As-built				
Sink Hole Creek Reach 1	B/Cb			
Sink Hole Creek Reach 2	B			
UT1 Reach2	B			
UT2 Reach 1	Aa+/B			
UT2 Reach 2	A/B			
UT3	Aa+/B			
Valley Type	II			
Valley Slope	.028-.03 (Sink Hole), .028 (UT1), .1-.055 (UT2), .1 (UT3)			
Valley Side Slope Range	n/a			
Valley Toe Slope Range	n/a			
Trout Waters Designation	Yes (Supporting Waters, Trib. to designated TW)			
Species of Concern	No			
Dominant Soil Series and Characteristics	Bandana/ Dillsboro/Saunook-Thunder/Dellwood-Reddies			
	Depth (in.)	% Clay	K Factor	T Factor
Sink Hole Creek Reach 1	>80”	10-20	.15	4
Sink Hole Creek Reach 2	>80”	10-20	.15	4
UT1Reach 1	~87”	27-35	.1	5

Table A4. Project Attribute Table **Sink Hole Creek Mitigation Project-NCEEP Project #D06125-C**				
UT1 Reach2	>80”	10-20	.15	4
UT2 Reach 1	>80”	7-20/ 15-28	.05/.02	5
UT2 Reach 2	>80”	5-15/ 5-18	.05	3
UT3	>80”	7-20/ 15-28	.05/.02	5

APPENDIX B
MORPHOLOGICAL SUMMARY DATA AND PLOTS, AND REFERENCE PHOTOGRAPHS

TABLES 1-2
EXHIBITS 1-2
LONGITUDINAL PROFILE PLOTS
CROSS-SECTION PLOTS

Table B1. Morphology and Hydraulic Monitoring Summary - Baseline Monitoring
Sink Hole Creek Mitigation Project #D06125-C

	Sink Hole Creek Reach 1																	
Parameter	Cross Section 1						Cross Section 2						Cross Section 3					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	14.14						12.86						14.22					
Floodprone Width (ft)	64.04						69.40						57.98					
BF Cross Sectional Area (ft2)	18.59						12.20						17.43					
BF Mean Depth (ft)	1.31						0.95						1.23					
BF Max Depth (ft)	2.51						1.48						1.96					
Width/Depth Ratio	10.80						13.60						11.60					
Entrenchment Ratio	>4.5						>5.4						>4.1					
Wetted Perimeter (ft)	16.76						14.76						16.68					
Hydraulic Radius (ft)	1.1						0.8						1.0					
Substrate																		
d50 (mm)																		
d84 (mm)																		

	Sink Hole Creek Reach 2																	
Parameter	Cross Section 4						Cross Section 5						Cross Section 6					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	13.12						16.67						13.06					
Floodprone Width (ft)	80.41						70.08						54.34					
BF Cross Sectional Area (ft2)	14.19						23.30						15.45					
BF Mean Depth (ft)	1.08						1.40						1.18					
BF Max Depth (ft)	1.67						2.36						1.88					
Width/Depth Ratio	12.10						11.90						11.00					
Entrenchment Ratio	6.10						4.20						>4.2					
Wetted Perimeter (ft)	15.28						19.47						15.42					
Hydraulic Radius (ft)	0.9						1.2						1.0					

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	30.30	70.18	51.30															
Radius of Curvature (ft)	31.66	51.20	39.35															
Meander Wavelength (ft)	134.84	331.16	227.38															
Meander Width Ratio	1.82	5.46	3.76															
Profile																		
Riffle length (ft)	9.01	55.63	22.46															
Riffle Slope (ft/ft)	0.01	0.05	0.02															
Pool Length (ft)	6.92	20.86	13.80															
Pool Spacing (ft)	12.21	65.89	39.36															
Substrate																		
d50 (mm)	31.16(R1) / 26.12(R2)																	
d84 (mm)	93.23(R1) / 78.53(R2)																	
Additional Reach Parameters																		
Valley Length (ft)	2006.00																	
Channel Length (ft)	2207.00																	
Sinuosity	1.10																	
Water Surface Slope (ft/ft)	0.025																	
BF Slope (ft/ft)	0.025																	
Rosgen Classification	B/Eb/Cb4																	

UT1 Reach 2												
Parameter	Cross Section 1						Cross Section 2					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	12.70						9.47					
Floodprone Width (ft)	44.80						36.86					
BF Cross Sectional Area (ft2)	12.27						4.25					
BF Mean Depth (ft)	0.97						0.45					
BF Max Depth (ft)	1.55						0.83					
Width/Depth Ratio	13.10						21.10					
Entrenchment Ratio	3.50						3.90					
Wetted Perimeter (ft)	14.64						10.37					
Hydraulic Radius (ft)	0.8						0.4					
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	5.19	19.76	13.43															
Riffle Slope (ft/ft)	0.03	0.06	0.04															
Pool Length (ft)	4.81	10.95	7.95															
Pool Spacing (ft)	10.96	34.42	15.09															
Substrate																		
d50 (mm)		-																
d84 (mm)		-																
Additional Reach Parameters																		
Valley Length (ft)		422.00																
Channel Length (ft)		489.00																
Sinuosity		1.16																
Water Surface Slope (ft/ft)		0.040																
BF Slope (ft/ft)		0.042																
Rosgen Classification		B																

UT2 Reach 1												
Parameter	Cross Section 1 Riffle						Cross Section 2 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	4.22						7.04					
Floodprone Width (ft)	30.55						30.16					
BF Cross Sectional Area (ft2)	1.09						5.26					
BF Mean Depth (ft)	0.26						0.75					
BF Max Depth (ft)	0.53						1.40					
Width/Depth Ratio	16.32						9.41					
Entrenchment Ratio	7.23						4.29					
Wetted Perimeter (ft)	4.74						8.54					
Hydraulic Radius (ft)	0.23						0.62					
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	4.37	17.86	11.47															
Riffle Slope (ft/ft)	0.05	0.15	0.12															
Pool Length (ft)	3.17	9.57	6.83															
Pool Spacing (ft)	9.77	21.51	13.49															
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)	527.00																	
Channel Length (ft)	596																	
Sinuosity	1.13																	
Water Surface Slope (ft/ft)	0.107																	
BF Slope (ft/ft)	0.107																	
Rosgen Classification	Aa+/B																	

UT2 Reach 2																		
Parameter	Cross Section 3						Cross Section 4						Cross Section 5					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension	Riffle						Riffle						Pool					
BF Width (ft)	4.89						6.02						8.41					
Floodprone Width (ft)	38.28						49.10						67.44					
BF Cross Sectional Area (ft2)	2.53						4.87						8.07					
BF Mean Depth (ft)	0.52						0.81						0.96					
BF Max Depth (ft)	0.86						1.50						1.67					
Width/Depth Ratio	9.47						7.43						8.76					
Entrenchment Ratio	7.82						8.16						8.02					
Wetted Perimeter (ft)	5.93						7.64						10.33					
Hydraulic Radius (ft)	0.43						0.64						0.78					
Substrate																		
d50 (mm)																		
d84 (mm)																		

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	13.06	27.11	18.08															
Riffle Slope (ft/ft)	0.05	0.09	0.08															
Pool Length (ft)	5.46	11.07	8.00															
Pool Spacing (ft)	9.02	42.80	26.23															
Substrate																		
d50 (mm)		-																
d84 (mm)		-																
Additional Reach Parameters																		
Valley Length (ft)		781.00																
Channel Length (ft)		885.00																
Sinuosity		1.13																
Water Surface Slope (ft/ft)		0.058																
BF Slope (ft/ft)		0.055																
Rosgen Classification		A/B																

UT3												
Parameter	Cross Section 1						Cross Section 2					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	5.22						6.18					
Floodprone Width (ft)	25.15						44.51					
BF Cross Sectional Area (ft2)	2.1						4.24					
BF Mean Depth (ft)	0.41						0.69					
BF Max Depth (ft)	0.76						1.28					
Width/Depth Ratio	12.71						9.01					
Entrenchment Ratio	4.8						7.20					
Wetted Perimeter (ft)	6.04						7.56					
Hydraulic Radius (ft)	0.35						0.56					
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	10.43	26.64	14.46															
Riffle Slope (ft/ft)	0.06	0.17	0.11															
Pool Length (ft)	2.89	5.83	5.34															
Pool Spacing (ft)	9.70	21.22	16.83															
Substrate																		
d50 (mm)		-																
d84 (mm)		-																
Additional Reach Parameters																		
Valley Length (ft)		622.00																
Channel Length (ft)		641.00																
Sinuosity		1.03																
Water Surface Slope (ft/ft)		0.105																
BF Slope (ft/ft)		0.111																
Rosgen Classification		Aa+/B																

Table B2. Baseline Stream Summary - As-Built Monitoring

Sink Hole Creek Mitigation Project #D06125-C

Baseline Stream Summary
Sink Hole Creek: Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	16.90	11.70	19.65	27.60	12.30	12.65	13.00	12.86	13.54	14.22															
Floodprone Width (ft)	-----	20.00	30.50	41.00	70.00	85.00	100.00	57.98	63.69	69.40															
Bankfull Mean Depth (ft)	1.00	0.60	0.85	1.10	1.00	1.05	1.10	0.95	1.09	1.23															
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	1.40	-----	1.48	1.72	1.96															
Bankfull Cross Sectional Area (ft2)	17.70	18.30	19.35	20.40	12.60	13.30	14.00	12.20	14.82	17.43															
Width/Depth Ratio	-----	8.60	12.00	15.40	11.80	11.90	12.00	11.60	12.60	13.60															
Entrenchment Ratio	-----	1.60	2.00	2.40	5.40	6.75	8.10	4.10	4.75	5.40															
Bank Height Ratio	-----	1.00	1.40	1.80	-----	1.00	-----	1.00	1.00	1.00															
Bankfull Velocity (fps)	-----	-----	8.32	-----	-----	6.32	-----	----	5.67	---															
Pattern																									
Channel Beltwidth (ft)*	-----	16.00	35.50	55.00	45.00	59.50	74.00	30.30	47.43	70.18															
Radius of Curvature (ft)*	-----	28.00	37.50	47.00	31.00	38.00	45.00	31.66	39.46	46.77															
Meander Wavelength (ft)*	-----	70.00	165.00	260.00	138.00	141.50	145.00	134.84	140.31	145.77															
Meander Width Ratio*	-----	1.10	2.60	4.10	3.66	4.70	5.69	2.36	3.50	4.94															
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	9.01	20.81	32.34															
Riffle Slope (ft/ft)	-----	0.036	0.045	0.055	0.038	0.044	0.050	0.010	0.023	0.053															
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	6.92	14.55	20.86															
Pool Spacing (ft)	-----	42.00	136.50	231.00	18.00	40.00	62.00	17.23	34.69	65.89															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	0.063/6.56/13.8/71.3/110			.3/8/10/50/95			8/20.38/31.16/93.23/151.79			-----			-----			-----			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.90	-----	-----	1.54	-----															
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	12.00	-----	-----	8.73	-----															
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	1036.00	-----	-----	1019.00	-----															
Drainage Area (SM)	-----	0.72	0.78	0.84	-----	0.72	-----	-----	0.72	-----															
Rosgen Classification	-----	-----	B4c	-----	-----	B4c/C4	-----	-----	Cb4/Eb4	-----															
Bankfull Discharge (cfs)	78.00	-----	161.00	-----	-----	84.00	-----	-----	84.00	-----															
Sinuosity	-----	1.08	1.09	1.09	1.10	1.15	1.20	-----	1.10	-----															
BF slope (ft/ft)	-----	0.024	0.026	0.028	0.025	0.025	0.026	-----	0.026	-----															

Notes: Pattern data generated from subreach of Reach 1, directly upstream of the NC Hwy. 80 culvert, where channel slope decreases.

Table B2. Baseline Stream Summary - As-Built Monitoring
Sink Hole Creek Mitigation Project #D06125-C

Baseline Stream Summary
Sink Hole Creek: Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	17.70	11.70	19.65	27.60	12.30	12.65	13.00	13.06	14.87	16.67															
Floodprone Width (ft)	-----	20.00	30.50	41.00	70.00	85.00	100.00	54.34	62.21	70.08															
Bankfull Mean Depth (ft)	1.04	0.60	0.85	1.10	1.00	1.05	1.10	1.18	1.29	1.40															
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	1.40	-----	1.88	2.12	2.36															
Bankfull Cross Sectional Area (ft2)	19.20	18.30	19.35	20.40	12.60	13.30	14.00	15.45	19.38	23.30															
Width/Depth Ratio	-----	8.60	12.00	15.40	11.80	11.90	12.00	11.00	11.45	11.90															
Entrenchment Ratio	-----	1.60	2.00	2.40	5.40	6.75	8.10	4.20	4.20	4.20															
Bank Height Ratio	-----	1.00	1.40	1.80	-----	1.00	-----	1.00	1.00	1.00															
Bankfull Velocity (fps)	-----	-----	7.18	-----	-----	6.39	-----	----	4.39	----															
Pattern																									
Channel Beltwidth (ft)	-----	16.00	35.50	55.00	-----	-----	-----	-----	-----	-----															
Radius of Curvature (ft)	-----	28.00	37.50	47.00	-----	-----	-----	-----	-----	-----															
Meander Wavelength (ft)	-----	70.00	165.00	260.00	-----	-----	-----	-----	-----	-----															
Meander Width Ratio	-----	1.10	2.60	4.10	-----	-----	-----	-----	-----	-----															
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	9.79	23.77	55.63															
Riffle Slope (ft/ft)	-----	0.036	0.045	0.055	0.038	0.044	0.050	0.017	0.023	0.046															
Pool Length (ft)	-----	13.00	14.50	16.00	-----	-----	-----	8.71	12.86	17.67															
Pool Spacing (ft)	-----	42.00	136.50	231.00	18.00	41.50	65.00	12.21	41.77	62.48															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	0.063/6.56/13.8/71.3/110			.3/8/10/50/95			8/17.95/26.12/78.53/135.48			-----			-----			-----			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.50	-----	-----	1.62	-----															
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	9.59	-----	-----	7.11	-----															
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	1062.00	-----	-----	1073.00	-----															
Drainage Area (SM)	-----	0.72	0.78	0.84	-----	0.84	-----	-----	0.84	-----															
Rosgen Classification	-----	-----	B4c	-----	-----	B4c	-----	-----	Cb/Eb/B	-----															
Bankfull Discharge (cfs)	88.00	-----	139.00	-----	----	85.00	----	----	85.00	----															
Sinuosity	-----	-----	1.16	-----	1.10	1.15	1.20	-----	1.10	-----															
BF slope (ft/ft)	-----	0.024	0.026	0.028	0.025	0.025	0.026	-----	0.023	-----															

Table B2. Baseline Stream Summary - As-Built Monitoring

Sink Hole Creek Mitigation Project #D06125-C

Baseline Stream Summary: UT1 Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	7.80	11.70	19.65	27.60	6.00	6.70	7.40	-----	9.47	-----															
Floodprone Width (ft)	-----	20.00	30.50	41.00	20.00	30.50	41.00	-----	36.86	-----															
Bankfull Mean Depth (ft)	0.53	0.60	0.85	1.10	0.50	0.55	0.60	-----	0.45	-----															
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	0.70	0.75	0.80	-----	0.83	-----															
Bankfull Cross Sectional Area (ft2)	5.10	10.20	21.60	33.00	3.20	3.90	4.60	-----	4.25	-----															
Width/Depth Ratio	-----	10.70	18.85	27.00	11.40	11.70	12.00	-----	21.12	-----															
Entrenchment Ratio	-----	1.30	16.65	32.00	9.50	13.10	16.70	-----	3.89	-----															
Bank Height Ratio	-----	-----	1.00	-----	-----	1.00	-----	-----	1.00	-----															
Bankfull Velocity (fps)	-----	-----	1.02	-----	-----	5.13	-----	-----	4.71	-----															
Pattern																									
Channel Beltwidth (ft)	-----	16.00	35.50	55.00	-----	-----	-----	-----	-----	-----															
Radius of Curvature (ft)	-----	28.00	37.50	47.00	-----	-----	-----	-----	-----	-----															
Meander Wavelength (ft)	-----	70.00	165.00	260.00	-----	-----	-----	-----	-----	-----															
Meander Width Ratio	-----	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----															
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	5.19	12.64	19.76															
Riffle Slope (ft/ft)	-----	0.0400	0.0430	0.0460	0.0382	0.07	0.0983	0.0252	0.0426	0.0620															
Pool Length (ft)	-----	13.00	14.50	16.00	9.00	23.00	37.00	4.81	7.82	10.95															
Pool Spacing (ft)	-----	42.00	136.50	231.00	9.00	23.00	37.00	10.96	18.67	34.42															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.2/11.7/32/81.1/155.3			.2/11.7/32/81.1/155.3			-----																	
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.50	-----	-----	1.50	-----															
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	7.69	-----	-----	7.06	-----															
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	489.00	-----	-----	489.00	-----															
Drainage Area (SM)	-----	-----	0.09	-----	-----	0.09	----	-----	0.09	----															
Rosgen Classification	-----	-----	A6a+/B4c	-----	-----	B4-C4	-----	-----	B4	-----															
Bankfull Discharge (cfs)	16.00	-----	22.00	-----	----	20.00	----	----	20.00	----															
Sinuosity	-----	-----	1.16	----	1.10	1.15	1.20	-----	1.16	-----															
BF slope (ft/ft)	-----	0.038	0.047	0.057	0.038	0.046	0.055	-----	0.042	-----															

Note:

Table B2. Baseline Stream Summary - As-Built Monitoring

Sink Hole Creek Mitigation Project #D06125-C

Baseline Stream Summary: UT2 Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	4.50	11.70	19.65	27.60	-----	4.00	-----	-----	4.22	-----															
Floodprone Width (ft)	-----	20.00	30.50	41.00	70.00	85.00	100.00	-----	30.55	-----															
Bankfull Mean Depth (ft)	0.33	0.60	0.85	1.10	----	0.40	----	-----	0.26	-----															
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	0.50	-----	-----	0.53	-----															
Bankfull Cross Sectional Area (ft2)	2.10	10.20	21.60	33.00	----	1.50	----	-----	1.09	-----															
Width/Depth Ratio	-----	10.70	18.85	27.00	----	10.80	----	-----	16.32	-----															
Entrenchment Ratio	-----	1.30	16.65	32.00	17.40	21.10	24.80	-----	7.23	-----															
Bank Height Ratio	-----	-----	1.00	-----	-----	1.00	-----	-----	1.00	-----															
Bankfull Velocity (fps)	-----	-----	1.11	-----	-----	3.30	-----	-----	4.59	-----															
Pattern																									
Channel Beltwidth (ft)	-----	16.00	35.50	55.00	-----	-----	-----	-----	-----	-----															
Radius of Curvature (ft)	-----	28.00	37.50	47.00	-----	-----	-----	-----	-----	-----															
Meander Wavelength (ft)	-----	70.00	165.00	260.00	-----	-----	-----	-----	-----	-----															
Meander Width Ratio	-----	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----															
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	4.37	11.98	17.86															
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.136	0.152	0.167	0.046	0.107	0.149															
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3.17	6.26	9.57															
Pool Spacing (ft)	-----	-----	-----	-----	6.00	13.50	21.00	9.77	14.44	21.51															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----		-----			-----			-----																
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----															
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----															
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	579.00	-----	-----	596.00	-----															
Drainage Area (SM)	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----															
Rosgen Classification	-----	-----	Aa+	-----	-----	Aa+4	-----	-----	Aa+/B	-----															
Bankfull Discharge (cfs)	5.00	-----	24.00	-----	----	5.00	----	----	5.00	----															
Sinuosity	-----	-----	1.07	----	1.10	1.15	1.20	-----	1.13	-----															
BF slope (ft/ft)	-----	0.105	0.106	0.108	0.105	0.106	0.108	-----	0.107	-----															

Note: No sediment data was collected for UT2 and UT3 during the design phase due to the extremely poor substrate present. For UT1, UT2 and UT3, no sediment capacity check was performed as these steep headwater tributaries are degradational systems by nature and they are being built primarily out of colluvial material that is designed to be immobile.

Table B2. Baseline Stream Summary - As-Built Monitoring

Sink Hole Creek Mitigation Project #D06125-C

Baseline Stream Summary: UT2 Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	7.50	11.70	19.65	27.60	6.00	6.70	7.40	4.89	5.46	6.02															
Floodprone Width (ft)	-----	20.00	30.50	41.00	70.00	85.00	100.00	38.28	43.69	49.10															
Bankfull Mean Depth (ft)	0.51	0.60	0.85	1.10	0.50	0.55	0.60	0.52	0.67	0.81															
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	0.70	0.75	0.80	0.86	1.18	1.50															
Bankfull Cross Sectional Area (ft2)	4.70	10.20	21.60	33.00	3.20	3.90	4.60	2.53	3.70	4.87															
Width/Depth Ratio	-----	10.70	18.85	27.00	11.40	11.70	12.00	7.43	8.45	9.47															
Entrenchment Ratio	-----	1.30	16.65	32.00	9.50	13.10	16.70	7.82	7.99	8.16															
Bank Height Ratio	-----	-----	1.00	-----	-----	1.00	-----	1.00	1.00	1.00															
Bankfull Velocity (fps)	-----	-----	0.65	-----	-----	4.87	-----	3.90	5.14	7.51															
Pattern																									
Channel Beltwidth (ft)	-----	16.00	35.50	55.00	-----	-----	-----	-----	-----	-----															
Radius of Curvature (ft)	-----	28.00	37.50	47.00	-----	-----	-----	-----	-----	-----															
Meander Wavelength (ft)	-----	70.00	165.00	260.00	-----	-----	-----	-----	-----	-----															
Meander Width Ratio	-----	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----															
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	13.06	18.44	27.11															
Riffle Slope (ft/ft)	-----	0.0400	0.0430	0.0460	0.081	0.089	0.098	0.052	0.072	0.091															
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	5.46	8.05	11.07															
Pool Spacing (ft)	-----	-----	21.00	-----	9.00	23.00	37.00	9.02	24.97	42.80															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.2/11.7/32/81.1/155.3			.2/11.7/32/81.1/155.3			-----																	
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----															
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----															
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	879.00	-----	-----	885.00	-----															
Drainage Area (SM)	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----															
Rosgen Classification	-----	-----	Aa+	-----	-----	A4	-----	-----	A/B	-----															
Bankfull Discharge (cfs)	15.00	-----	14.00	-----	----	19.00	----	----	19.00	----															
Sinuosity	-----	-----	1.04	----	-----	1.13	-----	-----	1.13	-----															
BF slope (ft/ft)	-----	0.038	0.047	0.057	0.038	0.046	0.055	-----	0.055	-----															

Note: No sediment data was collected for UT2 and UT3 during the design phase due to the extremely poor substrate present. For UT1, UT2 and UT3, no sediment capacity check was performed as these steep headwater tributaries are degradational systems by nature and they are being built primarily out of colluvial material that is designed to be immobile.

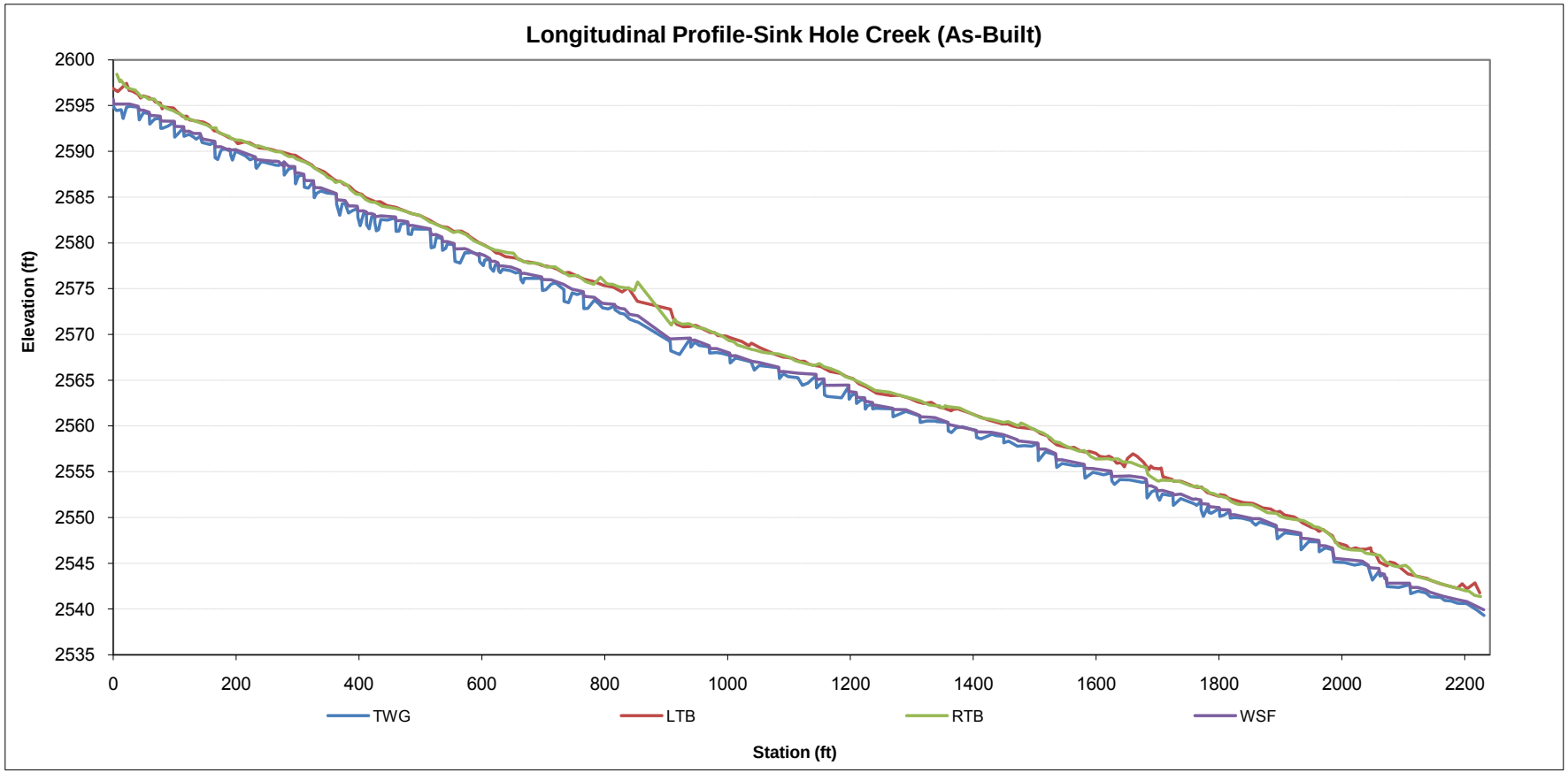
Table B2. Baseline Stream Summary - As-Built Monitoring

Sink Hole Creek Mitigation Project #D06125-C

Baseline Stream Summary: UT3

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	4.50	11.70	19.65	27.60	-----	4.00	-----	-----	5.22	-----															
Floodprone Width (ft)	-----	20.00	30.50	41.00	69.60	84.40	99.20	-----	25.15	-----															
Bankfull Mean Depth (ft)	0.33	0.60	0.85	1.10	----	0.40	----	-----	0.41	-----															
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	0.50	-----	-----	0.76	-----															
Bankfull Cross Sectional Area (ft2)	2.10	10.20	21.60	33.00	----	1.50	----	-----	2.14	-----															
Width/Depth Ratio	-----	10.70	18.85	27.00	----	10.80	----	-----	12.7	-----															
Entrenchment Ratio	-----	1.30	16.65	32.00	17.40	21.10	24.80	-----	4.8	-----															
Bank Height Ratio	-----	-----	1.00	-----	-----	1.00	-----	-----	1	-----															
Bankfull Velocity (fps)	-----	-----	0.51	-----	-----	3.30	-----	-----	2.34	-----															
Pattern																									
Channel Beltwidth (ft)	-----	16.00	35.50	55.00	-----	-----	-----	-----	-----	-----															
Radius of Curvature (ft)	-----	28.00	37.50	47.00	-----	-----	-----	-----	-----	-----															
Meander Wavelength (ft)	-----	70.00	165.00	260.00	-----	-----	-----	-----	-----	-----															
Meander Width Ratio	-----	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----															
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	10.43	16.82	26.64															
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.1364	0.152	0.1667	0.0602	0.1128	0.1682															
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	2.89	4.80	5.83															
Pool Spacing (ft)	-----	-----	-----	-----	6.00	13.000	20.00	9.70	15.41	21.22															
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----		-----			-----			-----																
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----															
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----															
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	586.00	-----	-----	641.00	-----															
Drainage Area (SM)	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----															
Rosgen Classification	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----															
Bankfull Discharge (cfs)	5.00	-----	11.00	-----	----	5.00	----	----	5.00	----															
Sinuosity	-----	-----	1.02	----	1.10	1.15	1.20	-----	1.03	-----															
BF slope (ft/ft)	-----	0.105	0.106	0.108	0.105	0.106	0.108	-----	0.111	-----															

Note: Reach Shear Stress and Stream Power were unable to be calculated correctly for UT3 during the As-built Survey due to inadequate surface flow in the channel.


Longitudinal Profile-Sink Hole Creek (As-Built)
Elevation (ft)
2600
2595
2590
2585
2580
2575
2570
2565
2560
2555
2550
2545
2540
2535
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
TWG
LTB
RTB
WSF
Station (ft)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Cb	18.59	14.14	1.31	2.51	10.76	0.9	4.53	2595	2594.63

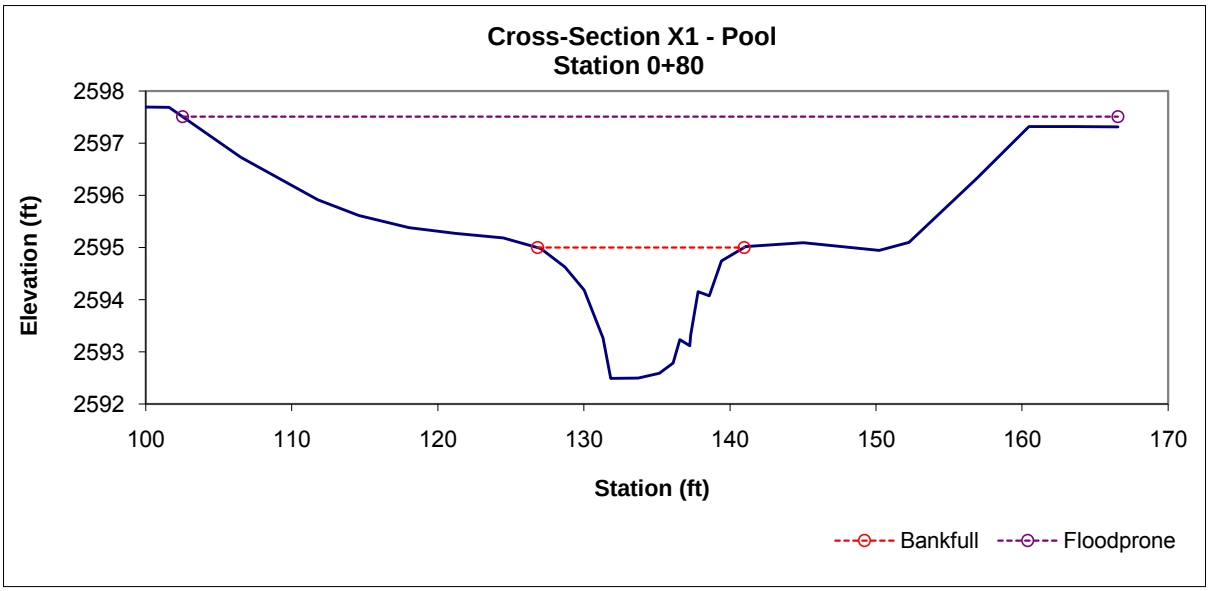


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	12.2	12.86	0.95	1.48	13.55	1	5.4	2589.98	2589.99

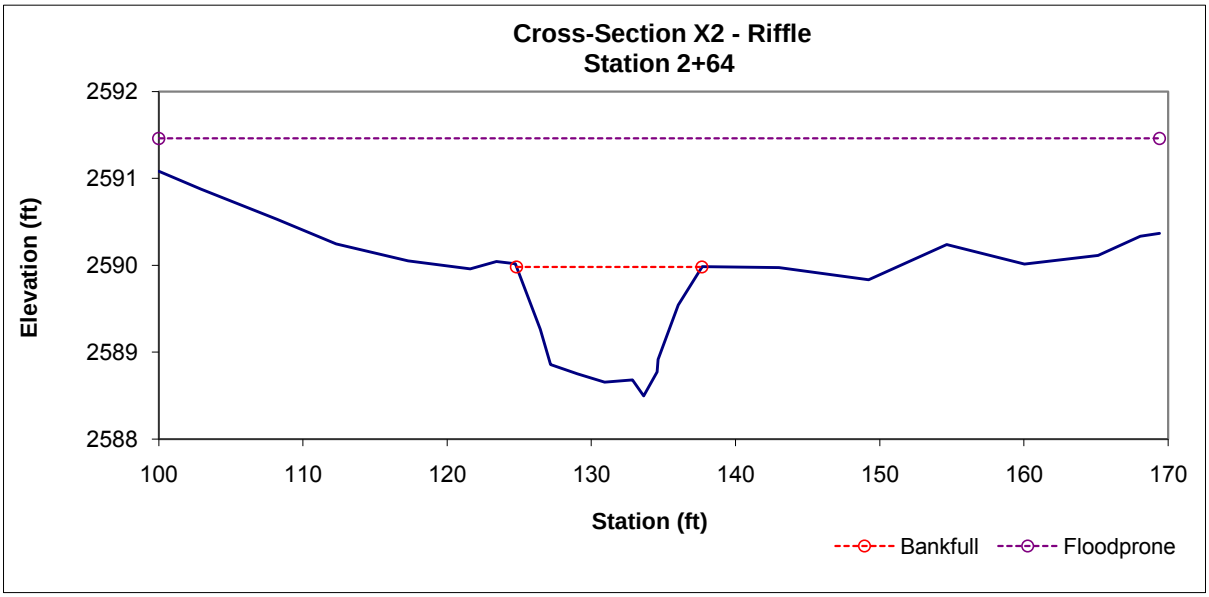


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	17.43	14.22	1.23	1.96	11.6	1	4.08	2580.63	2580.63

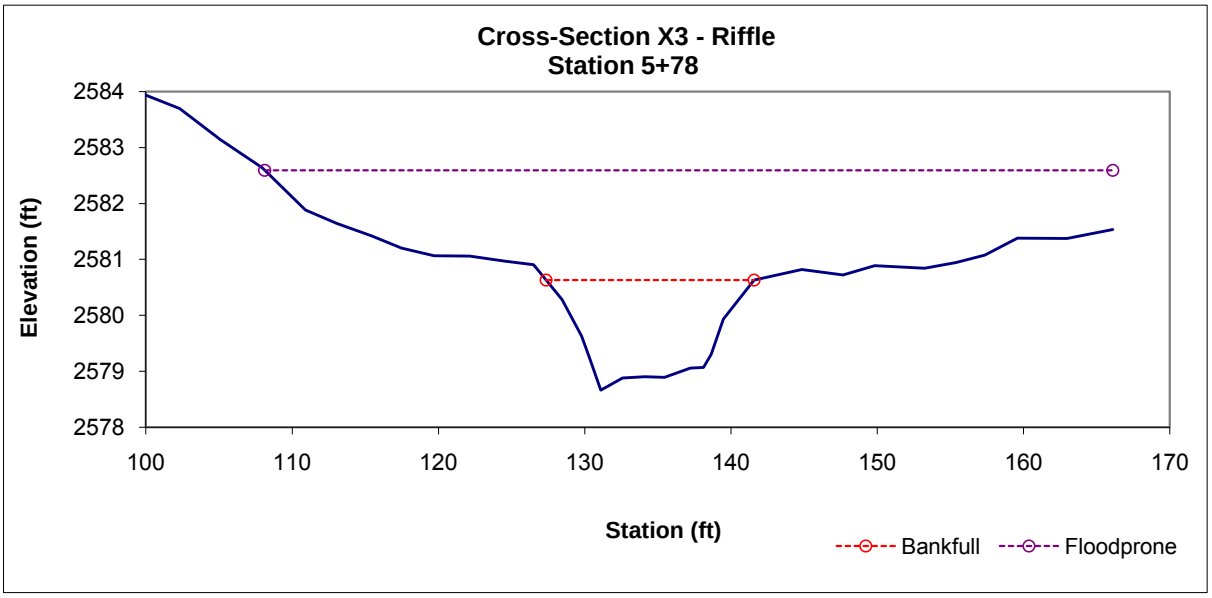


Photo 8: XS-3 facing right bank

Photo 9: XS-3 facing left bank

Photo 10: XS-3 facing upstream

Photo 11: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Cb	14.19	13.12	1.08	1.67	12.14	1	6.13	2562.19	2562.19

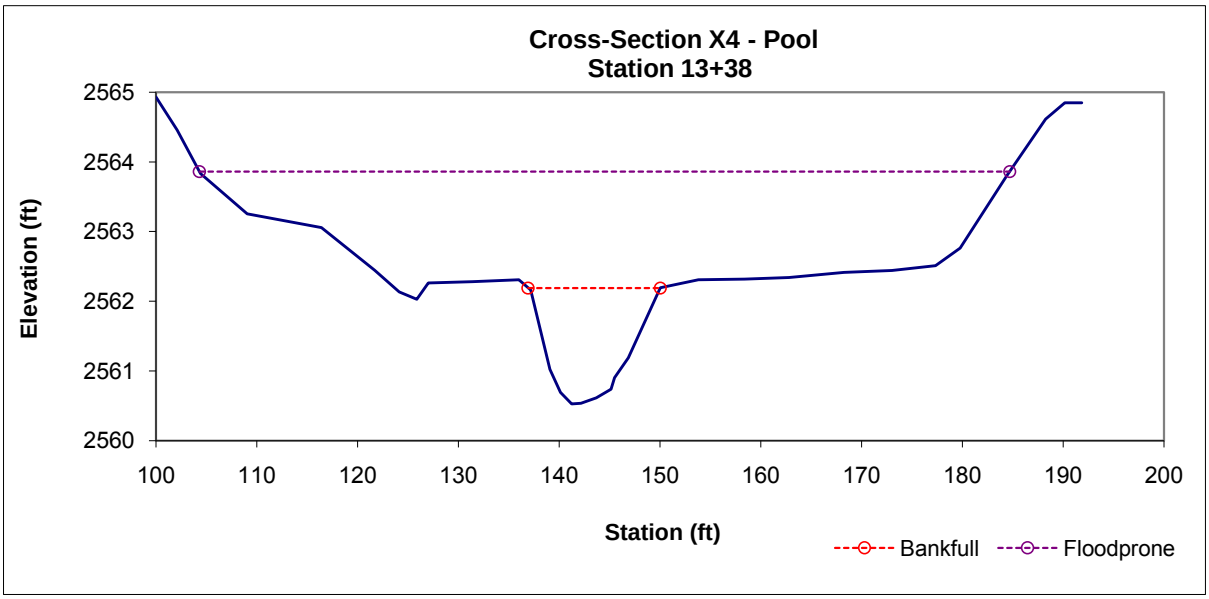


Photo 12: XS-4 facing right bank

Photo 13: XS-4 facing left bank

Photo 14: XS-4 facing upstream

Photo 15: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	23.3	16.67	1.4	2.36	11.92	1	4.2	2561.64	2561.64

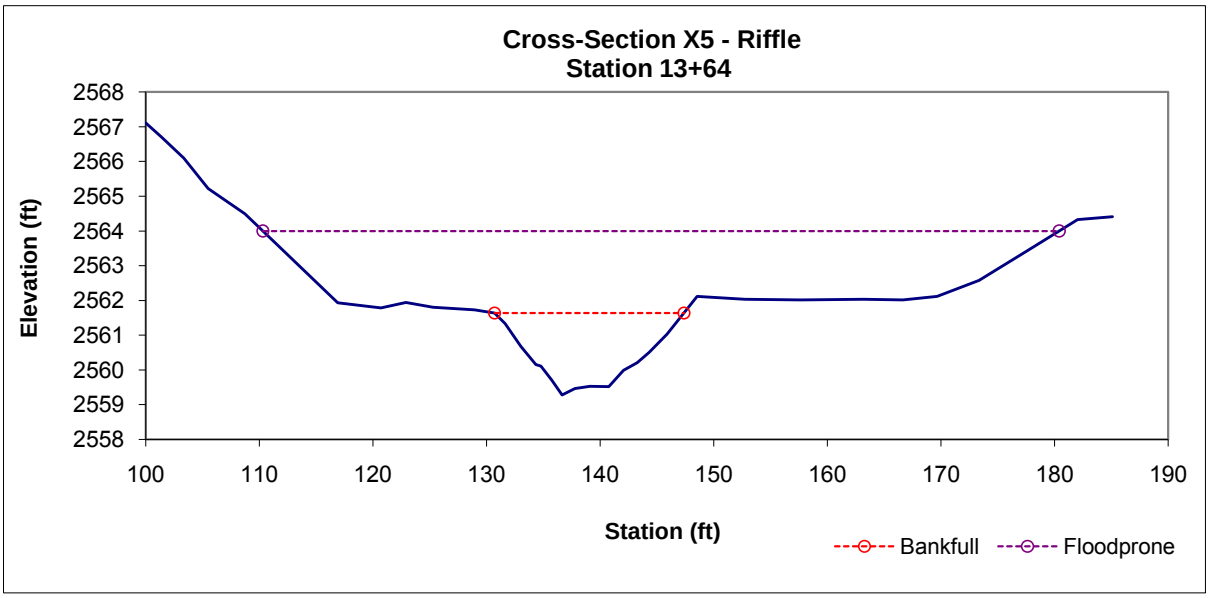


Photo 16: XS-5 facing right bank

Photo 17: XS-5 facing left bank

Photo 18: XS-5 facing upstream

Photo 19: XS-5 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	15.45	13.06	1.18	1.88	11.04	1	4.16	2553.34	2553.34

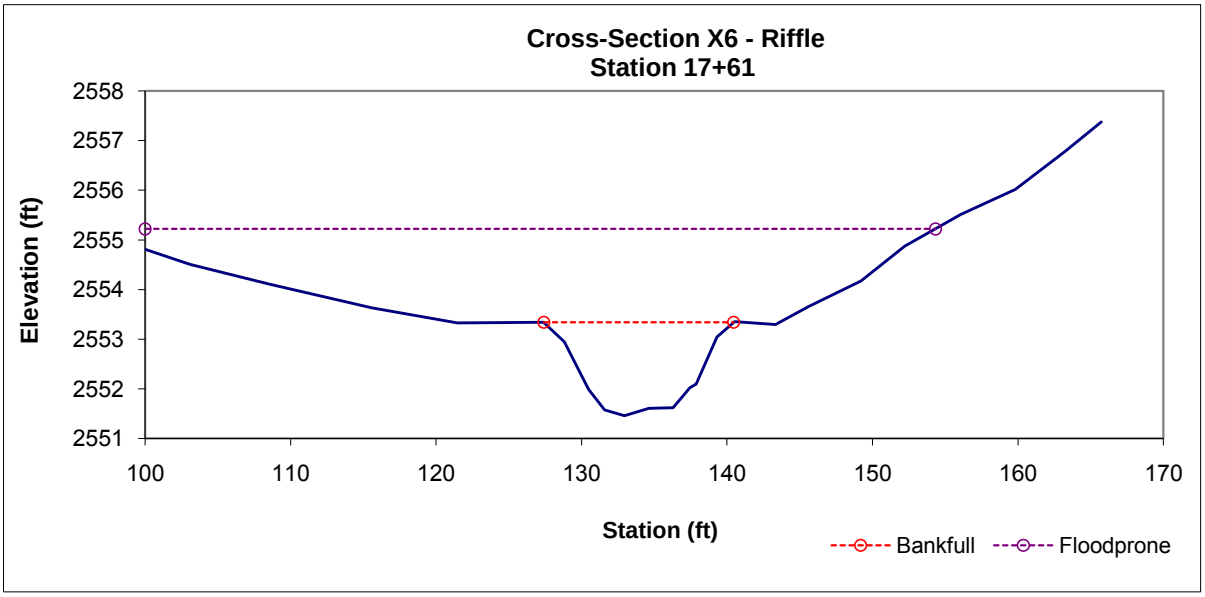
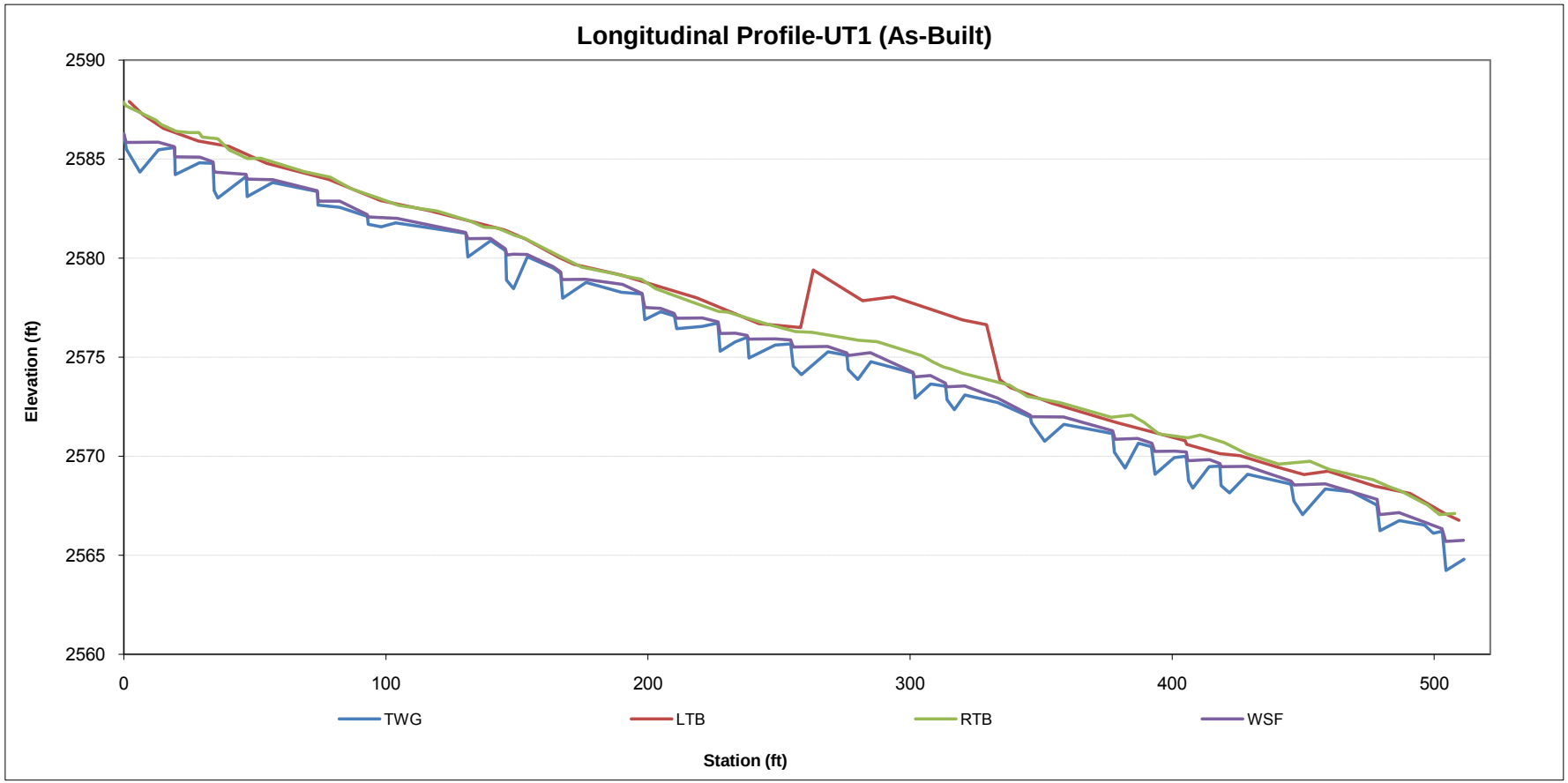


Photo 20: XS-6 facing right bank

Photo 21: XS-6 facing left bank

Photo 22: XS-6 facing upstream

Photo 23: XS-6 facing downstream


Longitudinal Profile-UT1 (As-Built)
Elevation (ft)
2590
2585
2580
2575
2570
2565
2560
0
100
200
300
400
500
TWG
LTB
RTB
WSF
Station (ft)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	B	12.27	12.7	0.97	1.55	13.13	0.9	3.53	2582.99	2582.99

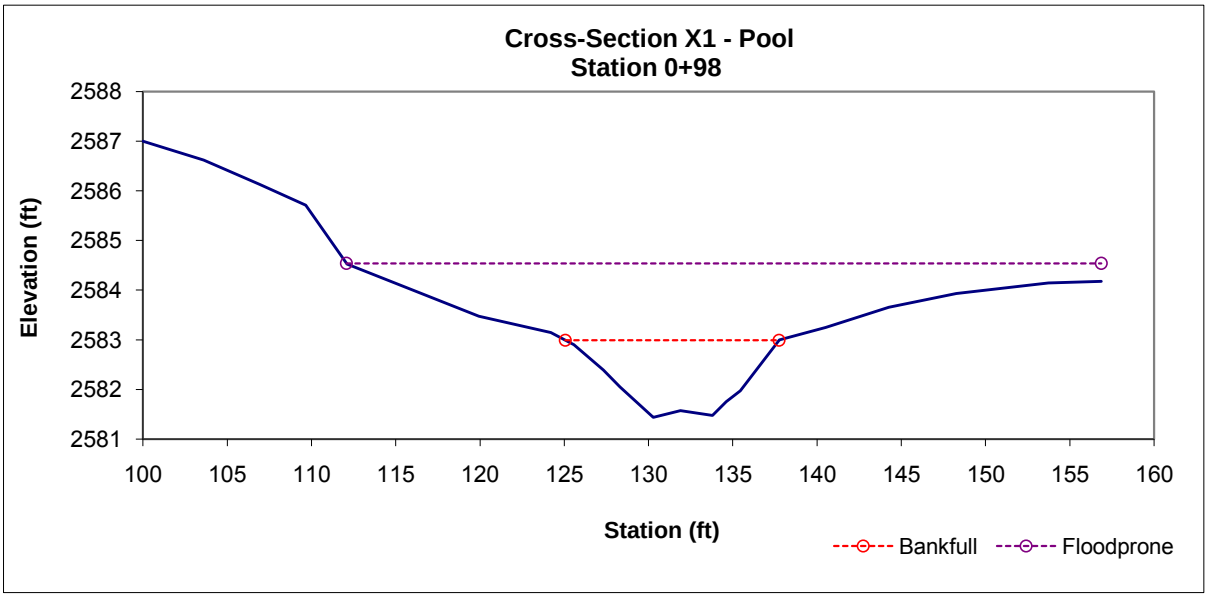


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	4.2	9.47	0.45	0.83	21.12	1	3.9	2579.1	2579.1

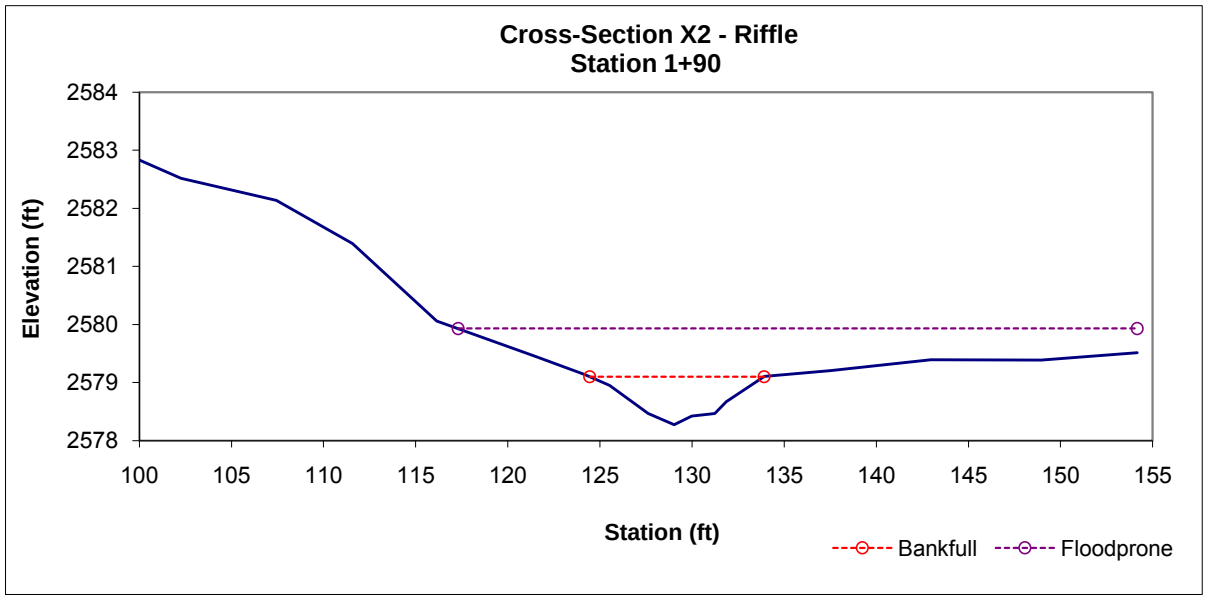
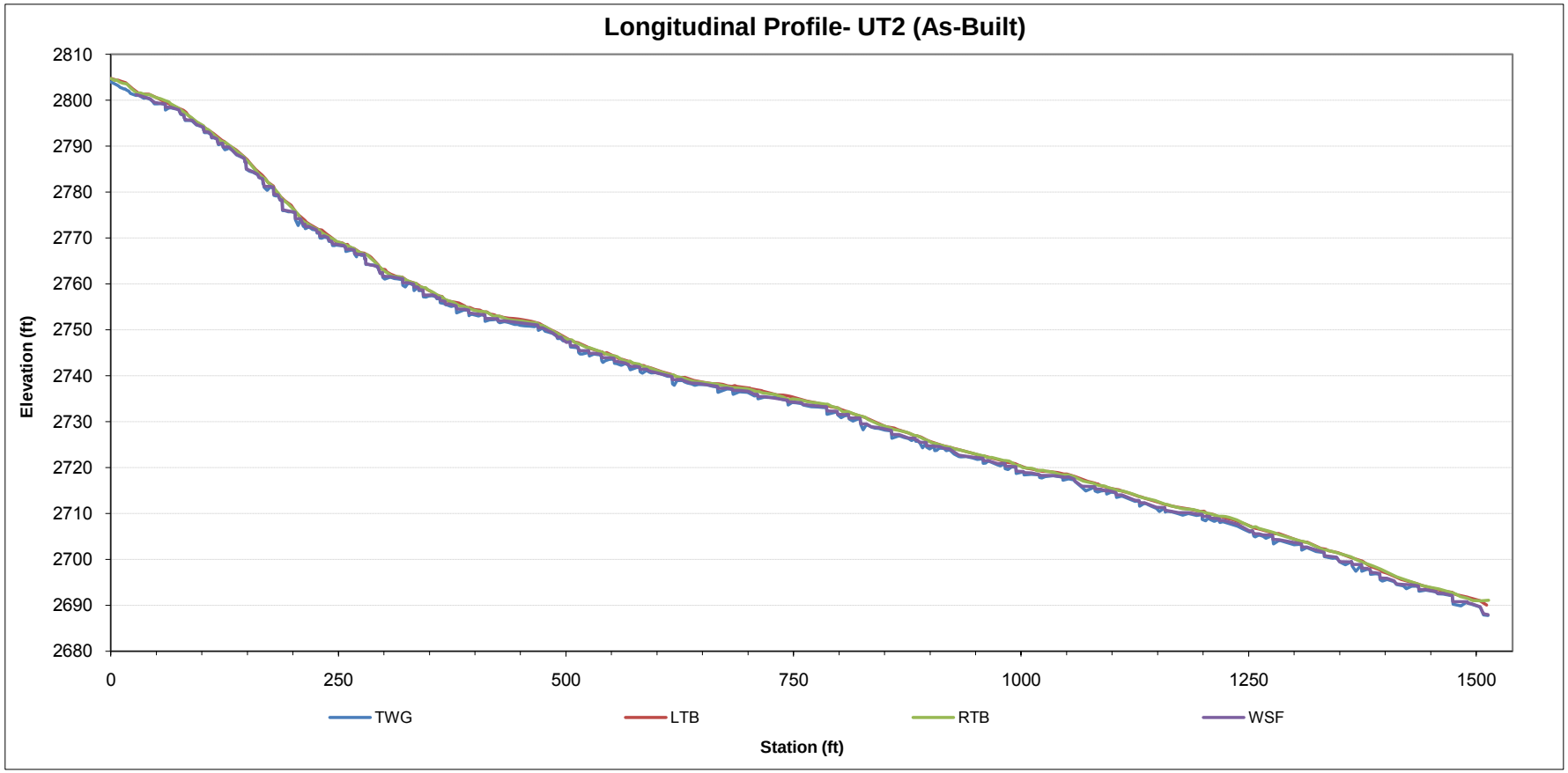


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream


Longitudinal Profile- UT2 (As-Built)
Elevation (ft)
2810
2800
2790
2780
2770
2760
2750
2740
2730
2720
2710
2700
2690
2680
0
250
500
750
1000
1250
1500
TWG
LTB
RTB
WSF
Station (ft)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	1.1	4.22	0.26	0.53	16.32	1	7.2	2768.83	2768.83

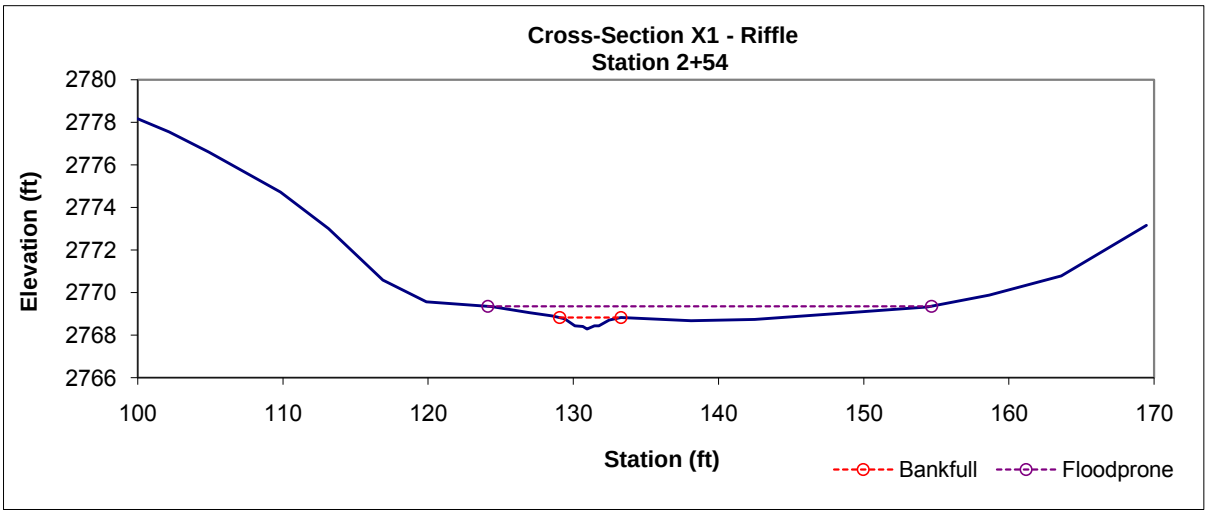


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	B	5.3	7.04	0.75	1.4	9.41	1	4.3	2752.95	2752.95

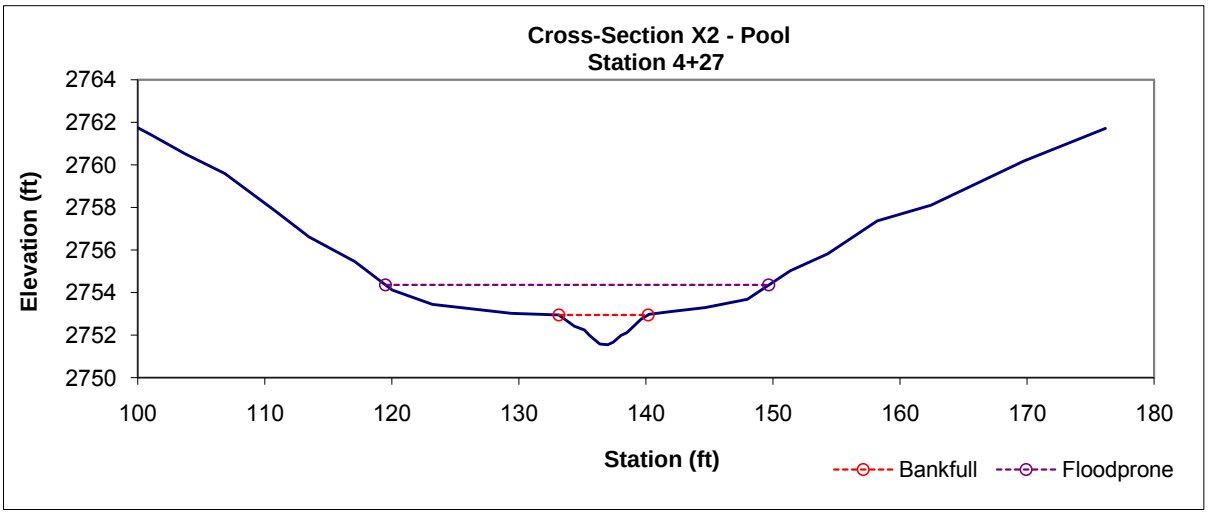


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	A	2.5	4.89	0.52	0.86	9.47	1	7.8	2737.05	2737.05

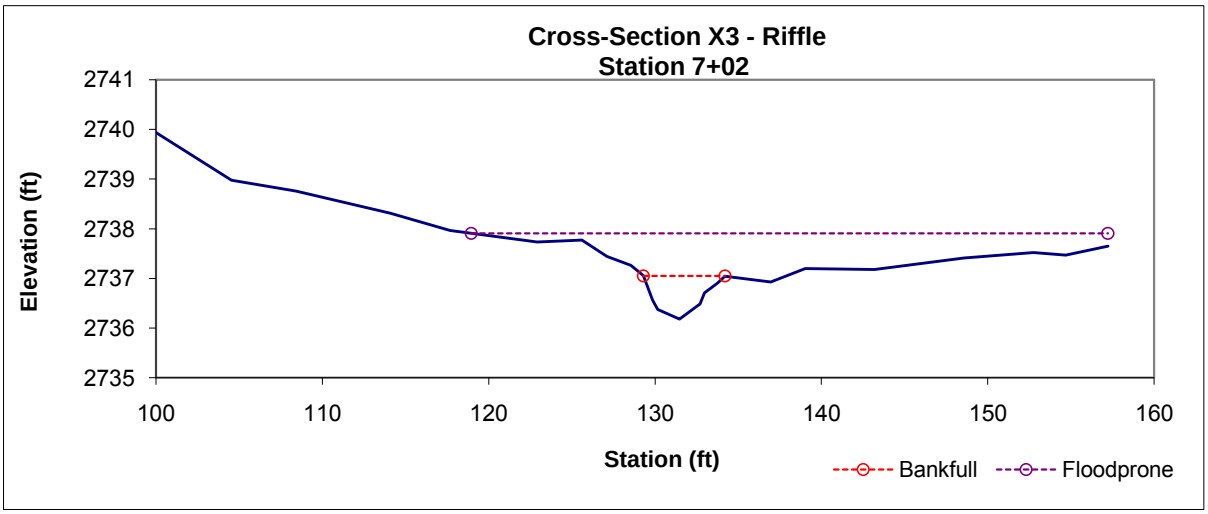


Photo 9: XS-3 facing right bank

Photo 10: XS-3 facing left bank

Photo 11: XS-3 facing upstream

Photo 12: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	A	4.9	6.02	0.81	1.5	7.43	1	8.2	2723.86	2723.86

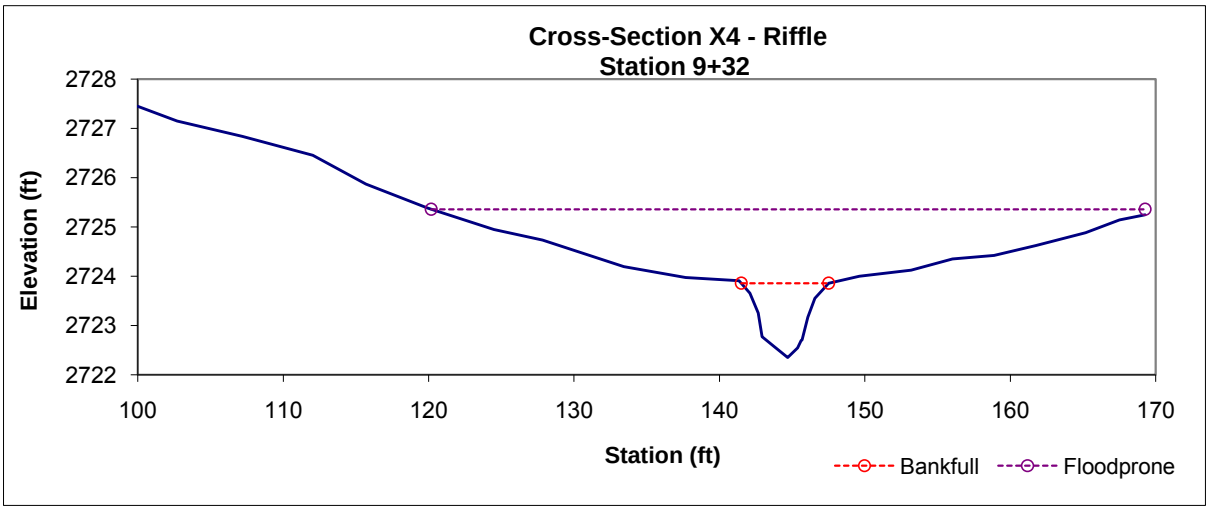


Photo 13: XS-4 facing right bank

Photo 14: XS-4 facing left bank

Photo 15: XS-4 facing upstream

Photo 16: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	A	8.1	8.41	0.96	1.67	8.76	1	8	2716.25	2716.25

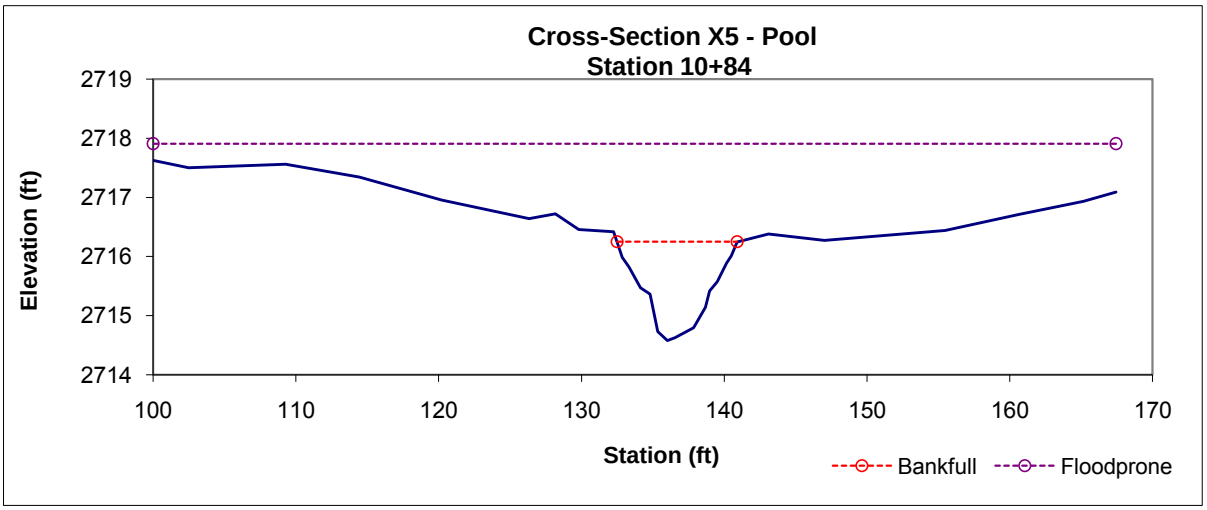
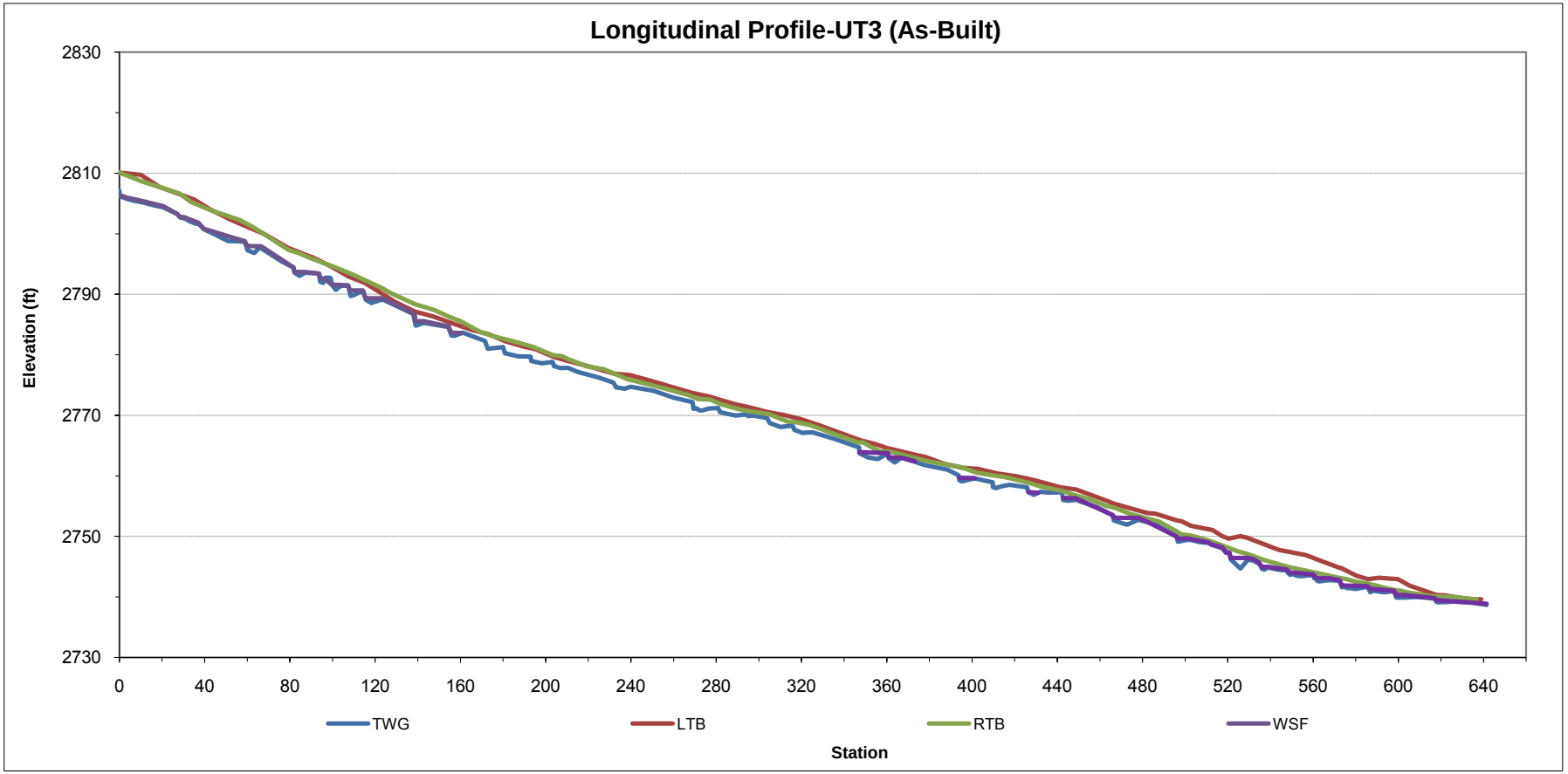


Photo 17: XS-5 facing right bank

Photo 18: XS-5 facing left bank

Photo 19: XS-5 facing upstream

Photo 20: XS-5 facing downstream


Longitudinal Profile-UT3 (As-Built)
Elevation (ft)
2830
2810
2790
2770
2750
2730
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
TWG
LTB
RTB
WSF
Station

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	2.14	5.22	0.41	0.76	12.7	1	4.8	2762.5	2762.83

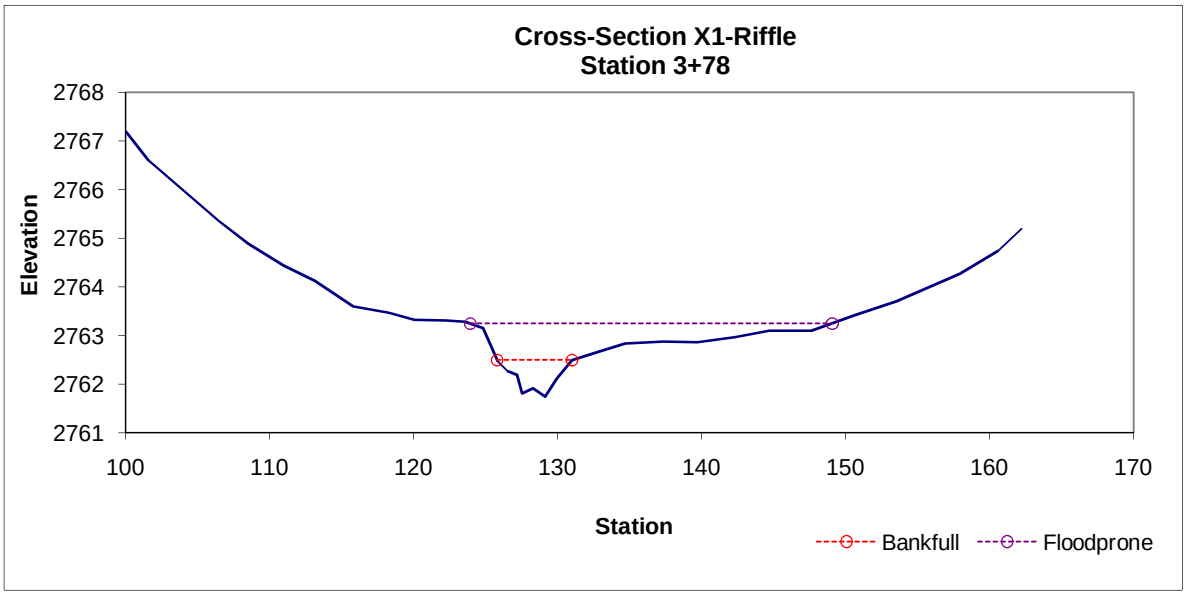


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	B	4.2	6.18	0.69	1.28	9.01	2	7.2	2757.37	2758.65

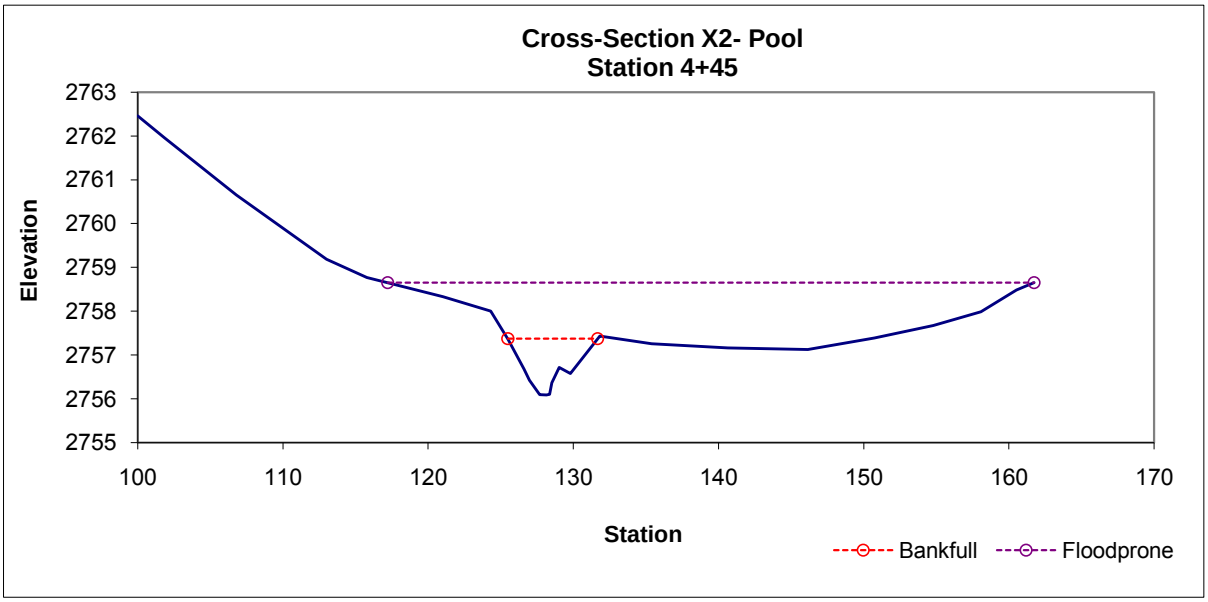


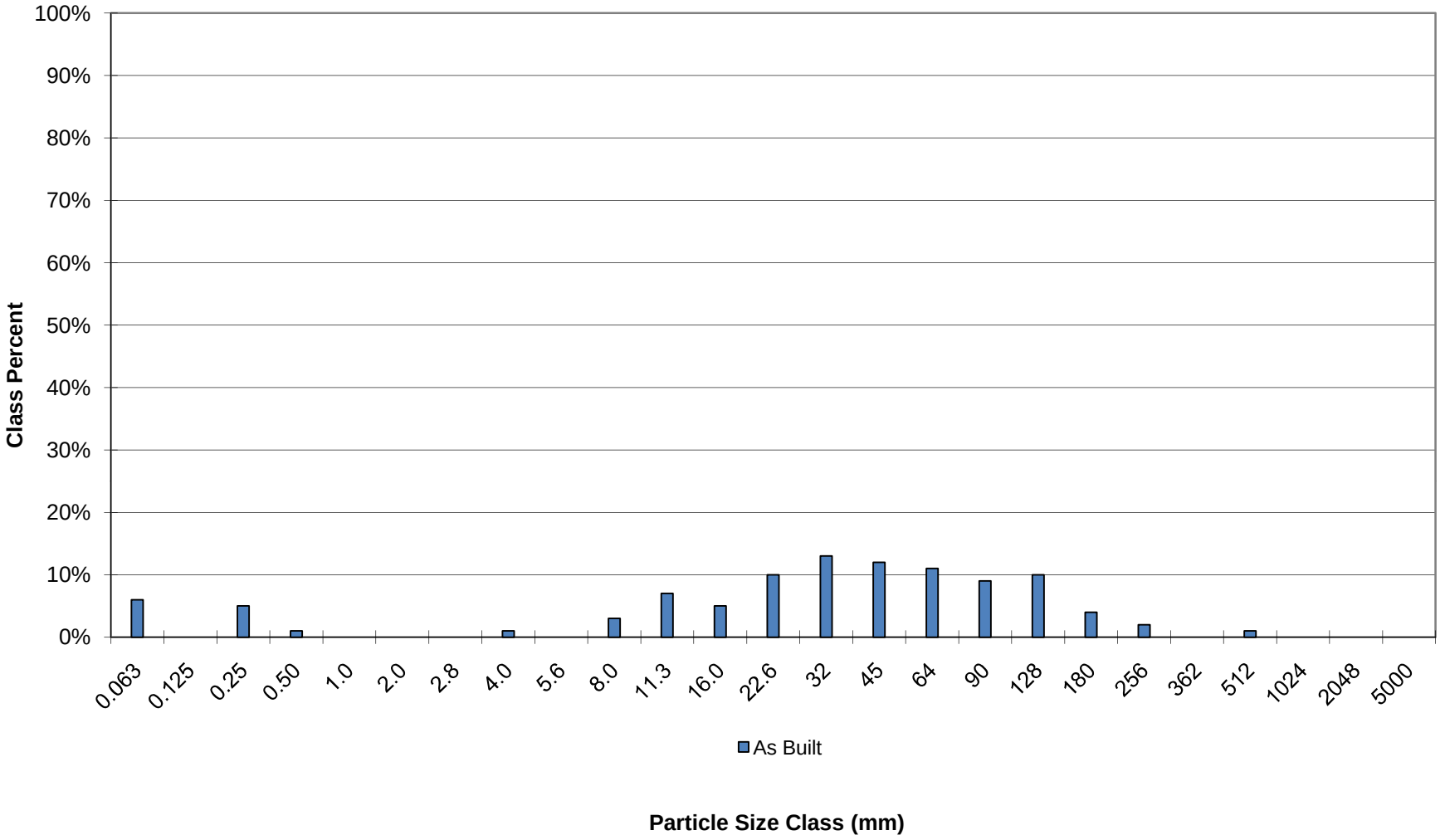
Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

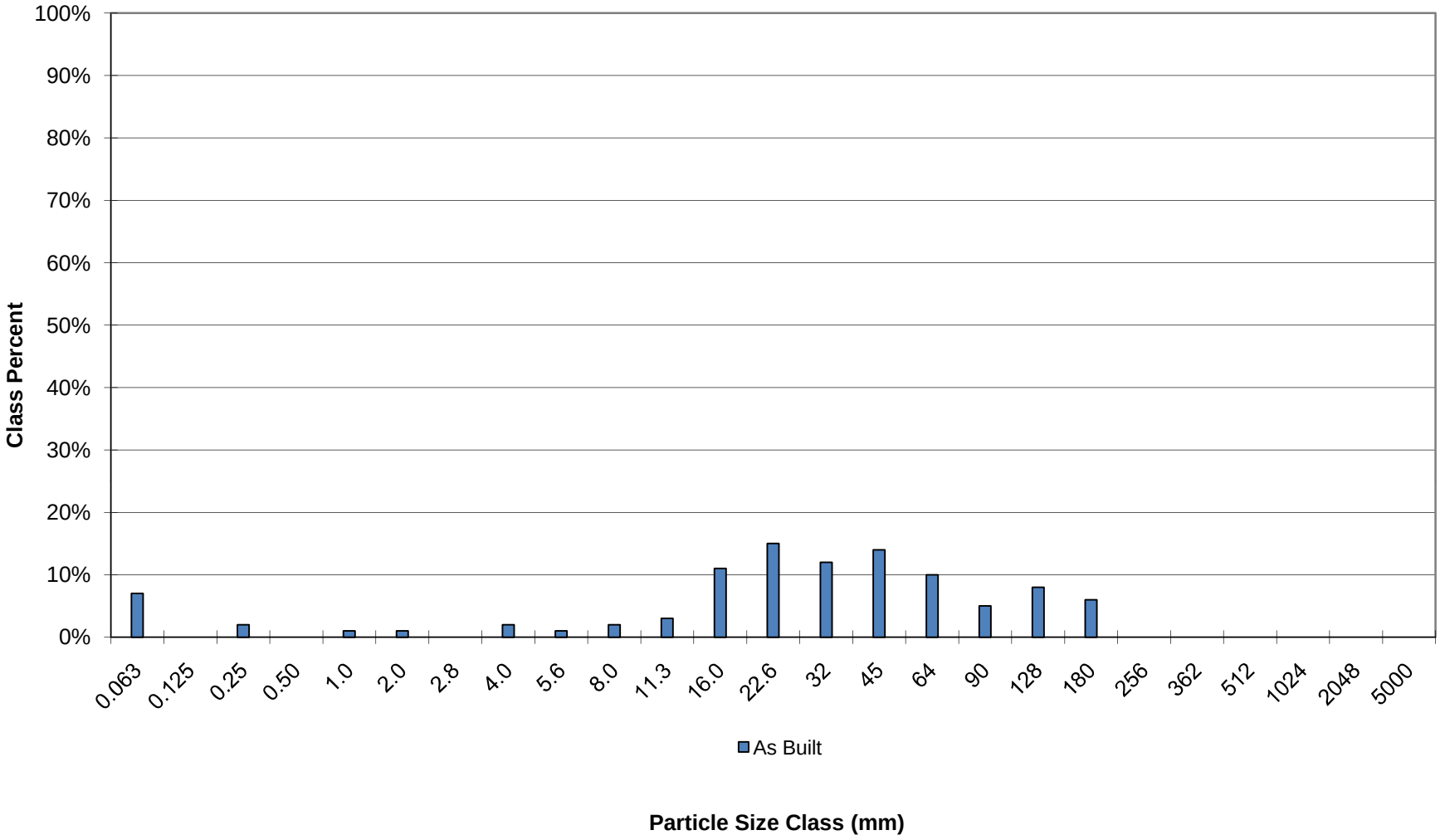
Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Sink Hole Creek
Reach 1
Riffle Pebble Count Size Class Distribution



Sink Hole Creek
Reach 2
Riffle Pebble Count Size Class Distribution



Sink Hole Creek
Photo Log - Reference Photo Points

Notes: Photos for Sink Hole Creek were taken November 2010.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream

Photo Point 7: looking upstream

Photo Point 7: looking downstream

Photo Point 8: looking upstream

Photo Point 8: looking downstream

Photo Point 9: looking upstream

Photo Point 9: looking downstream

Photo Point 10: looking upstream

Photo Point 10: looking downstream

Photo Point 11: looking upstream

Photo Point 12: looking upstream

Photo Point 12: looking downstream

Photo Point 13: looking upstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

UT 1 to Sink Hole Creek-Reach 2
Photo Log - Reference Photo Points

Notes: Photos for UT1-Reach 2 were taken in November 2010.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

UT1 Photo Point 1: looking upstream

UT1 Photo Point 1: looking downstream

UT1 Photo Point 2: looking upstream

UT1 Photo Point 2: looking downstream

UT1 Photo Point 3: looking upstream

UT1 Photo Point 3: looking downstream

UT1 Photo Point 4: looking upstream

Sink Hole Creek – UT2
Photo Log - Reference Photo Points

Notes: Photos for UT2 were taken December 2010.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 7: looking upstream

Photo Point 7: view of confluence with UT3

Photo Point 7: looking downstream

Photo Point 8: looking upstream

Photo Point 8: looking downstream

Photo Point 9: looking upstream

Photo Point 9: looking downstream

Photo Point 10: looking upstream

Photo Point 10: looking downstream

Photo Point 11: looking upstream

Photo Point 11: looking downstream

Photo Point 12: looking downstream

Photo Point 13: looking upstream

Photo Point 13: looking downstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

Sink Hole Creek – UT3
Photo Log - Reference Photo Points

Notes: Photos for UT3 were taken December 2010.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream

Sink Hole Creek - UT2 Reach 1 Preservation Reach
Photo Log - Reference Photo Points

Notes: Photos for UT2 Reach 1 Preservation Reach were taken February 2011.

1. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking downstream

Photo Point 1: looking upstream

Photo Point 2: looking downstream

Photo Point 2: looking upstream

Photo Point 3: looking upstream

Photo Point 4: looking upstream

Photo Point 5: looking upstream

Photo Point 6: looking upstream

Photo Point 7: looking upstream

Photo Point 8: looking upstream

APPENDIX C
VEGETATION SUMMARY DATA
PHOTO LOG
TABLES 1-6

Table C1. Vegetation Metadata

Sink Hole Creek Mitigation Project-#D-06125-C

Report Prepared By	Carmen Horne-McIntyre
Date Prepared	5/6/2011 13:35
database name	cvs-eep-entrytool-v2.2.7.mdb
database location	L:\Monitoring\Monitoring Guidance\Vegetation\CVS EEP Entrytool V2.2.7
computer name	ASHEWCMCINTYR
file size	89882624

DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------

Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.

PROJECT SUMMARY----------

Project Code	92663
project Name	Sink Hole Creek Mitigation Project
Description	The project involved restoration or enhancement of 4,631 linear feet (LF) of four on-site streams: Sink Hole Creek and three smaller unnamed tributaries (UT1, UT2 and UT3). In addition, 1,076 LF of the headwaters of UT 1 was preserved.
River Basin	French Broad
length(ft)	4631
stream-to-edge width (ft)	30
area (sq m)	25811.43
Required Plots (calculated)	8
Sampled Plots	8

Table C2. Vegetation Vigor by Species

Sink Hole Creek Mitigation Project-#D-06125-C

	Species	CommonName	4	3	2	1	0	Missing	Unknown
	Acer saccharum	sugar maple	1						
	Alnus serrulata	hazel alder	5	1					
	Betula alleghaniensis	yellow birch	5			1			
	Betula nigra	river birch	30	1		1			
	Carya alba	mockernut hickory	10	1		1			
	Cornus florida	flowering dogwood	1						
	Quercus alba	white oak	1						
	Viburnum prunifolium	blackhaw	7						
	Betula lenta	sweet birch	7	1					
	Calycanthus	sweetshrub	2						
	Vaccinium stamineum	deerberry	3						
	Cercis canadensis	eastern redbud	25	6	1	1			
	Quercus rubra	northern red oak	11		2				
	Hamamelis virginiana	American witchhazel	1						
	Liriodendron tulipifera	tuliptree	9	1					
	Platanus occidentalis	American sycamore	8						
	Physocarpus opulifolius	common ninebark	1						
	Acer rubrum	red maple	4						
TOT:	**18**	**18**	**131**	**11**	**3**	**4**			

Table C3. Vegetation Damage by Species

Sink Hole Creek Mitigation Project-#D-06125-C

	Species	CommonName	Count of Damage Categories	(no damage)	Site Too Wet	Unknown
	Acer rubrum	red maple	0	4		
	Acer saccharum	sugar maple	0	1		
	Alnus serrulata	hazel alder	0	6		
	Betula alleghaniensis	yellow birch	0	6		
	Betula lenta	sweet birch	0	8		
	Betula nigra	river birch	0	32		
	Calycanthus	sweetshrub	0	2		
	Carya alba	mockernut hickory	1	11		1
	Cercis canadensis	eastern redbud	1	32	1	
	Cornus florida	flowering dogwood	0	1		
	Hamamelis virginiana	American witchhazel	0	1		
	Liriodendron tulipifera	tuliptree	0	10		
	Physocarpus opulifolius	common ninebark	0	1		
	Platanus occidentalis	American sycamore	0	8		
	Quercus alba	white oak	0	1		
	Quercus rubra	northern red oak	2	11		2
	Vaccinium stamineum	deerberry	0	3		
	Viburnum prunifolium	blackhaw	0	7		
TOT:	**18**	**18**	**4**	**145**	**1**	**3**

Table C4. Vegetation Damage by Plot
Sink Hole Creek Mitigation Project-#D-06125-C

	plot	Count of Damage Categories	(no damage)	Site Too Wet	Unknown
	92663-MR/CHM-0001	0	12		
	92663-MR/CHM-0002	3	17	1	2
	92663-MR/CHM-0003	0	21		
	92663-MR/CHM-0004	0	18		
	92663-MR/CHM-0005	0	23		
	92663-MR/CHM-0006	0	19		
	92663-MR/CHM-0007	1	19		1
	92663-MR/CHM-0008	0	16		
TOT:	**8**	**4**	**145**	**1**	**3**

Table C5. Vegetation Damage by Plot and Species
Sink Hole Creek Mitigation Project-#D-06125-C

	Species	Common Name	Total Planted Stems	# plots	avg# stems	plot 92663-MR/CHM-0001	plot 92663-MR/CHM-0002	plot 92663-MR/CHM-0003	plot 92663-MR/CHM-0004	plot 92663-MR/CHM-0005	plot 92663-MR/CHM-0006	plot 92663-MR/CHM-0007	plot 92663-MR/CHM-0008
	Acer rubrum	red maple	4	3	1.3		1		1			2	
	Acer saccharum	sugar maple	1	1	1		1						
	Alnus serrulata	hazel alder	6	3	2		2		3		1		
	Betula alleghaniensis	yellow birch	6	2	3	5	1						
	Betula lenta	sweet birch	8	4	2		3	3	1				1
	Betula nigra	river birch	32	8	4	1	2	8	5	4	5	5	2
	Calycanthus	sweetshrub	2	1	2								2
	Carya alba	mockernut hickory	12	7	1.7	1	3	1	2	2	2	1	
	Cercis canadensis	eastern redbud	33	8	4.1	1	2	3	1	6	6	9	5
	Cornus florida	flowering dogwood	1	1	1		1						
	Hamamelis virginiana	American witchhazel	1	1	1								1
	Liriodendron tulipifera	tuliptree	10	7	1.4	1	1	1	3	1	1	2	
	Physocarpus opulifolius	common ninebark	1	1	1	1							
	Platanus occidentalis	American sycamore	8	4	2			2		3	1		2
	Quercus alba	white oak	1	1	1	1							
	Quercus rubra	northern red oak	13	7	1.9	1	3	2	2	3	1	1	
	Vaccinium stamineum	deerberry	3	2	1.5			1		2			
	Viburnum prunifolium	blackhaw	7	3	2.3					2	2		3
TOT:	**18**	**18**	**149**	**18**		**12**	**20**	**21**	**18**	**23**	**19**	**20**	**16**

Table C6. Stem Count Arranged by Plot (As-Built)
Sink Hole Creek Mitigation Project#D-06125-C

			Current Data (AB 2010)																Annual Means									
			Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Current Mean		MY1 (2011)		MY2 (2012		MY3 (2013)		MY4 (2014		MY5 (2015)	
Tree Species	**Common Name**	**Type**	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T
Acer rubrum	Red Maple	Tree			1	1			1	1					2	2			1.3	1.3										
Acer saccahrum	Sugar Maple	Tree			1	1													1.0	1.0										
Betula alleghaniensis	Yellow Birch	Tree	5	5	1	1													3.0	3.0										
Betula lenta	Sweet Birch	Tree			3	3	3	3	1	1							1	1	2.0	2.0										
Betula nigra	River Birch	Tree	1	1	2	2	8	8	5	5	4	4	5	5	5	5	2	2	4.0	4.0										
Carya alba	Mockernut Hickory	Tree	1	1	3	3	1	1	2	2	2	2	2	2	1	1			1.7	1.7										
Liriodendron tulipfera	Tulip Poplar	Tree	1	1	1	1	1	1	3	3	1	1	1	1	2	2			1.4	1.4										
Quercus alba	White Oak	Tree	1	1															1.0	1.0										
Quercus rubra	Red Oak	Tree	1	1	3	3	2	2	2	2	3	3	1	1	1	1			1.9	1.9										
Physocarpus opulifolius	Ninebark	Tree	1	1															1.0	1.0										
Platanus occidentalis	Sycamore	Tree					2	2			3	3	1	1			2	2	2.0	2.0										
Shrub Species																														
Alnus serrulata	Tag Alder	Tree			2	2			3	3			1	1					2.0	2.0										
Calycanthus	Sweetshrub	Shrub															2	2	2.0	2.0										
Cercis canadensis	Redbud	Tree	1	1	2	2	3	3	1	1	6	6	6	6	9	9	5	5	4.1	4.1										
Cornus florida	Flowering Dogwood	Tree			1	1													1.0	1.0										
Hamamelis virginiana	Witch Hazel	Shrub															1	1	1.0	1.0										
Viburnum prunifolium	Blackhaw	Shrub									2	2	2	2			3	3	2.3	2.3										
Vaccinium stamineum	Deerberry	Shrub					1	1			2	2							1.5	1.5										
		Plot area (acres)	0.025		0.025		0.025		0.025		0.025		0.025		0.025		0.025													
		Species Count	8	8	11	11	8	8	8	8	8	8	8	8	6	6	7	7	8.0	8.0										
P=Planted		Stem Count	12	12	20	20	21	21	18	18	23	23	19	19	20	20	16	16	18.6	18.6										
T=Total		Stems Per Acre	486	486	809	809	850	850	728	728	931	931	769	769	809	809	647	647	753.7	753.7										

Sink Hole Creek Mitigation Project
Photo Log - Vegetation Plot Photo Points

Notes:

1. Vegetation plots marked by t-posts at corners; herbaceous plot marked by stake within larger plot.
2. Planted vegetation flagged and tagged for future identification.

4/26/2011

Photo 1: Veg Plot 1

4/26/2011

Photo 2: Veg Plot 1: Herbaceous Plot

4/26/2011

Photo 3: Veg Plot 2

4/26/2011

Photo 4: Veg Plot 2: Herbaceous Plot

4/26/2011

Photo 5: Veg Plot 3

4/26/2011

Photo 6: Veg Plot 3: Herbaceous Plot

4/26/2011

Photo 7: Veg Plot 4

4/26/2011

Photo 8: Veg Plot 4: Herbaceous Plot

4/26/2011

Photo 9: Veg Plot 5

4/26/2011

Photo 10: Veg Plot 5: Herbaceous Plot

4/26/2011

Photo 11: Veg Plot 6

4/26/2011

Photo 12: Veg Plot 6: Herbaceous Plot

4/26/2011

Photo 13: Veg Plot 7

4/26/2011

Photo 14: Veg Plot 7: Herbaceous Plot

4/26/2011

Photo 15: Veg Plot 8

4/26/2011

Photo 16: Veg Plot 8: Herbaceous Plot