LITTLE TROUBLESOME CREEK MITIGATION SITE

Rockingham County, NC
DENR Contract 003267
EEP Project Number 94640

Baseline Monitoring Document and As-Built Baseline Report
FINAL
Data Collection Period: April-May 2012
Draft Submission Date: July 9, 2012
Final Submission Date: September 5, 2012

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EXECUTIVE SUMMARY

The Little Troublesome Creek Mitigation Site is located in Rockingham County, NC. The stream area, hereafter referred to as the Stream Site, is located on the southeastern side of Reidsville along Irvin and Little Troublesome Creeks. The wetland area, hereafter referred to as the Wetland Site, is located approximately four miles southeast of the Stream Site and is also adjacent to Little Troublesome Creek. The project streams ultimately flow into the Haw River which is part of the Cape Fear River Basin (United States Geological Survey (USGS) Hydrologic Unit 03030002). The primary objectives of the project were to stabilize highly eroding stream banks, reconnect streams to their historic floodplain, improve wetland hydrology and function, reduce nutrient levels, sediment input, and water temperature, increase dissolved oxygen concentrations, create appropriate in-stream and terrestrial habitat, and decrease channel velocities. These objectives were achieved by restoring 4,988 linear feet (LF) of perennial stream channel, and restoring, enhancing, and creating 18.0 acres of riparian wetland. The Stream Site and Wetland Site riparian areas were also planted to stabilize streambanks, improve habitat, and protect water quality.

Pre-Construction Site Conditions

The Stream Site and Wetland Site are located in the Inner Piedmont Belt of the Piedmont Physiographic Province (USGS, 1998). Approximately 28% of the land in the project watershed has been developed and approximately 17% of the land surface is impervious. Land uses within the watershed include: forested land (55%), developed (28%), and cultivated land (17%). The Stream Site consists of Little Troublesome Creek, Irvin Creek, and one unnamed tributary to Little Troublesome Creek. At the downstream limits of the Stream Site, the drainage area is 3,245 acres (5.1 square miles).

The Upper Cape Fear Basin Local Watershed Plan (LWP) identified urbanization and morphological stream alteration as having profound impacts on the health of Little Troublesome Creek. The LWP identified the Stream Site as the top recommended site for stream restoration in the Upper Cape Fear Basin Local Watershed Plan - Targeting Management Report (http://www.nceep.net/services/lwps/Troublesome_Creek/target .pdf). In addition, Little Troublesome Creek is included on the NC Division of Water Quality (NCDWQ) 303d list of impaired water bodies for to habitat degradation and turbidity.

Prior to construction activities, the most significant watershed stressors identified during the technical assessment were stream bank erosion and instability. Others included declining aquatic habitat, loss of forest, degraded riparian buffers, loss of wetlands, lack of urban stormwater detention, and water quality problems related to increased sediment and nutrient loadings. As a result of the aforementioned stressors, the Stream Site and Wetland Site had poor water quality due to sediment pollution and poor habitat due to lack of riparian and wetland vegetation; the Stream Site was surrounded by mature vegetation, but lacked stable streambank vegetation. The Stream Site also lacked in-stream bed diversity and exhibited unstable geomorphic conditions. Tables 5a and 5b in Appendix 2 present the pre-restoration conditions in detail for the Stream Site.

Restoration Approach and Implementation

Project implementation at the Stream and Wetland Sites restored a high quality of riparian function to the streams, wetlands, and riparian corridors. The ecological uplift can be summarized as starting from urban-impacted, incised streams and drained wetlands and moving to stable channels in a protected riparian corridor and functional wetlands. Restoration of dimension, pattern, and profile was implemented for Little Troublesome Creek, Irvin Creek Reaches 1 and 2, and UT1. The Wetland Site was improved by removing drainage ditches, grading the upland fringe along Little Troublesome Creek to a lower elevation, and planting the site with wetland vegetation. Figure 2 and Table 1 present the restoration, creation, and enhancement mitigation components for the Sites.

The final restoration plan was submitted and accepted by the North Carolina Ecosystem Enhancement Program (NCEEP) in June of 2011. Construction activities were completed by Fluvial Solutions in May 2012. The baseline monitoring and as-built survey were completed between April and May of 2012. There were no significant deviations reported in the project elements in comparison to the design plans. A few structures were either eliminated or adjusted slightly based on field conditions. Field adjustments made during construction are described in detail in section 5.1. Appendix 1 provides more detailed project activity, history, contact information, and watershed/site background information for this project.

Monitoring

Baseline monitoring (Year 0) was conducted in April and May of 2012. The first annual monitoring assessment (Year 1) will be completed in the fall of 2012. The Stream Site will be monitored for a total of five years, with the final monitoring activities conducted in 2016. The Wetland Site will be monitored for a total of seven years, with the final monitoring activities conducted in 2018. The close-out for both the Stream Site and Wetland Site will be conducted in 2019. Monitoring will consist of collecting morphological, vegetative, and hydrological data on an annual basis to assess the project success based on the restoration goals and objectives. The success of the Stream Site will be assessed using measurements of the stream channel's dimension, pattern, profile, substrate composition, permanent photographs, vegetation, and surface water hydrology. The success of the Wetland Site will be assessed using measurements of groundwater hydrology and vegetation. Any areas with identified high priority problems, such as streambank instability, aggradation/degradation, insufficient groundwater hydroperiod, or lack of vegetation establishment will be evaluated on a case-by-case basis. The problem areas will be visually noted and remedial actions will be discussed with NCEEP staff to determine a plan of action. A proposal of work will be submitted if remediation of an area is required.

1.0 Project Goals, Background and Attributes

1.1 Project Location and Setting

The Stream Site is located south of Turner Road, east of the intersection of Turner Road and Way Street in the City of Reidsville, North Carolina. The Wetland Site is located approximately 3,000 feet southwest of the intersection of NC Highway 150 and Mizpah Church Road, south of the City of Reidsville. Little Troublesome Creek is located within the Haw River watershed (NCDWQ Subbasin 03-06-01) of the Cape Fear River Basin (Hydrologic Unit 03030002010030). The Stream Site is located in a mature bottomland hardwood forest within a 34.5-acre tract owned by Wildlands Little Troublesome Creek Holdings, LLC. A conservation easement has been recorded on 33 acres of the tract (Deed Book 1411, Page Number 2458). The wetland portion of the Little Troublesome Creek project is located within a tract of land owned by Jerry Apple, south of Reidsville, NC. A conservation easement has been recorded on the 19-acre project area within the Apple tract (Deed Book 1412, Page Number 1685). Little Troublesome Creek (NCDWQ Index No. 16-7), which is the main creek on the project site, has been classified as Class C; NSW waters. Class C waters are protected for secondary recreation, fishing, wildlife, fish and aquatic life propagation and survival, agriculture, and other uses. The Nutrient Sensitive Waters (NSW) classification is a supplemental classification for waters that are subject to excessive growth of microscopic or macroscopic vegetation and therefore need nutrient management. Directions and a map of the Site are provided in Figure 1.

1.2 Project Goals and Objectives

The following primary project goals (measured) were established in the mitigation plan (2011) to address the effects listed above in the executive summary from watershed and project site stressors:

- Stabilize stream dimensions;
- Stabilize stream pattern and profile;
- Establish proper substrate distribution throughout stream;
- Establish wetland hydrology for restored wetlands; and
- Restore native vegetation throughout wetlands and buffer zones.

The following secondary project goals (unmeasured) were established in the mitigation plan (2011) to address the effects listed above in the executive summary from watershed and project site stressors:

- Decrease nutrient and urban runoff pollutant levels;
- Decrease sediment input;
- Decrease water temperature and increase dissolved oxygen levels;
- Create appropriate in-stream habitat;
- Create appropriate terrestrial habitat; and
- Decrease channel velocities.

The project objectives to meet these primary and secondary goals are to:

- Riffle cross-sections of the restoration and enhancement reaches will be constructed to remain stable and will show little change in bankfull area, maximum depth ratio and width-to-depth ratio over time.
- The project will be constructed so that the bedform features of the restoration reaches will remain stable overtime. This will include riffles that remain steeper and shallower than the pools and pools that are deep with flat water surface slopes. The relative percentage of riffles and pools will not change significantly over time. Banks will be constructed so that bank height ratios will remain very near to 1.0 for nearly all of the restoration reaches.
- Stream substrate will remain coarse in the riffles and finer in the pools.
- A free groundwater surface be present within 12 inches of the ground surface for 7 percent of the growing season measured on consecutive days under typical precipitation conditions.
- Native vegetation appropriate for the wetland and riparian buffer zones on the site will be planted throughout. The planted trees will become well established and survival criteria will be met.
- Off-site nutrient input will be absorbed on-site by filtering flood flows through restored floodplain areas and wetlands, where flood flows can disperse through native vegetation and be captured in vernal pools. Increased surface water residency time will provide contact treatment time and groundwater recharge potential.
- Sediment input from eroding stream banks will be reduced by installing bioengineering and in-stream structures while creating a stable channel form using geomorphic design principles. Sediment from off-site sources will be captured by deposition on restored floodplain areas where native vegetation will slow overland flow velocities.
- Restored riffle/step-pool sequences where distinct points of re-aeration can occur will allow for oxygen levels to be maintained in the perennial reaches. Creation of deep pool zones will lower temperature, helping to maintain dissolved oxygen concentrations. Establishment and maintenance of riparian buffers will create long-term shading of the channel flow to minimize thermal heating.
- Creating a channel form that includes riffle -pool sequences and gravel and cobble zones of macroinvertebrate habitat for fish. Introduction of large woody debris, rock structures, root wads, and native stream bank vegetation will substantially increase habitat value.
- Adjacent buffer areas will be restored by removing invasive vegetation and planting native vegetation. These areas will be allowed to receive more regular and inundating flows. Riparian wetland areas will be restored and enhanced to provide wetland habitat.
- By allowing for more overbank flooding and by increasing channel roughness, local channel velocities can be reduced. This will allow for less bank shear stress, formation of refuge zones during large storm events and zonal sorting of depositional material.

1.3 Project Structure, Restoration Type and Approach

1.3.1 Project Structure

Please refer to Figure 2 for the project component/asset map for the monitoring and restoration feature exhibits on Little Troublesome Creek and its tributaries and Table 1 for the project component and mitigation credit information for the Stream and Wetland Sites.

1.3.2 Restoration Type and Approach

Project implementation at the Stream and Wetland Sites restored a high quality of riparian function to the streams, wetlands, and riparian corridors. The ecological uplift can be summarized as starting from urban-impacted, incised streams and drained wetlands and moving to stable channels in a protected riparian corridor and functional wetlands. Restoration of dimension, pattern, and profile was implemented for Little Troublesome Creek, Irvin Creek Reaches 1 and 2, and UT1.

Little Troublesome Creek, Irvin Creek, and UT1 were improved to provide a stable, protected aquatic and terrestrial habitat. A Rosgen Priority 1 type restoration (Rosgen, 1997) was utilized on Little Troublesome Creek and Irvin Creek to create a new stable, functional stream channel based on reference reach and sediment transport analysis. The channel beds were raised and meandering channels were constructed with stable cross-sections. UT1 was restored using a Rosgen Priority 2 restoration approach to create a stable stream channel with a floodplain excavated to an elevation lower than the surrounding floodplain of Little Troublesome Creek. Rosgen C channel types were constructed for all reaches with width/depth ratios near 12, at the low end of the range for Rosgen C channels. The channel will be allowed to narrow over time as bank vegetation is established to approach a Rosgen E channel type. Gradual bank slopes of 2.5:1 were designed to provide adequate rooting area and stability for plant establishment. By using gradual bank slopes and keeping the top widths of the channels narrow, the width of the channel bottom will be effectively narrowed allowing for a minimal base flow and will improve in-stream habitat. Tables 5a and 5b provide a summary of the design geomorphic values for the restoration reaches.

As a final stage of construction, riparian stream buffers were planted and restored to the dominant natural plant community that exists within the project watershed. This natural community within and adjacent to the project easement was classified as Piedmont Bottomland Forest and was determined based on existing canopy and herbaceous species (Schafale and Weakley, 1990). Proposed plant and seed materials were placed on stream banks and bench areas as well as from the tops of banks out to the project easement limits. These areas were planted with bare root trees, live stakes, and a seed mixture of temporary herbaceous vegetation ground cover.

A permanent seed mixture of native herbaceous and grass species was also applied to all disturbed areas within the project easement. The herbaceous seed mixture was chosen that would provide quick stabilization of constructed stream banks, benches, and side slopes. These species will also provide early habitat value through rapid growth of ground cover to the tops of banks and floodplain areas.

The Wetland Site involved restoration, enhancement, and creation through grading portions of the site to improve or create wetland hydrology and planting the site with native wetland vegetation. The pre-restoration wetland hydrology of the lower elevation portions of the site was restored by filling one main drainage ditch to slow drainage from the site. The upland areas around the perimeter of the site were graded to a lower elevation so that wetland hydrology will become established. In these areas, the ground surface was lowered by approximately 4 inches in the restoration zone and up to 24 inches in the creation zone, depending on the pre-restoration elevation. In addition to these activities, a berm that runs along Little Troublesome Creek on the eastern edge of the site was notched to allow more frequent flooding of the site during storm flow events in the stream.

1.4 Project History, Contacts and Attribute Data

Little Troublesome Creek was restored by Wildlands Engineering, Inc. (WEI) through a full-delivery contract with NCEEP. Tables 2, 3, and 4 provide detailed information regarding the Project Activity and Reporting History, Project Contacts, and Project Baseline Information and Attributes.

2.0 Success Criteria

The stream restoration success criteria for the project site follow the approved success criteria presented in the Little Troublesome Creek Mitigation Plan approved by NCEEP in June of 2011. The success criteria were developed in compliance with the NCEEP Mitigation Plan Template (version 1.0, 11/20/09) and the Stream Mitigation Guidelines issued in April 2003 by the United States Army Corps of Engineers (USACE) and NCDWQ. Annual monitoring and quarterly site visits will be conducted to assess the condition of the finished project. The stream restoration sections of the project were assigned specific success criteria components for stream morphology, vegetation, and hydrology. The wetland restoration, enhancement, and creation sections were assigned specific performance criteria for hydrology and vegetation. An outline of the performance criteria follows.

2.1 Streams

2.1.1 Dimension

Riffle cross-sections on the restoration reaches should be stable and should show little change in bankfull area, maximum depth ratio and width-to-depth ratio. Riffle cross-sections should fall within the parameters defined for channels of the appropriate Rosgen stream type. If any changes do occur, these changes will be evaluated to assess whether the stream channel is showing signs of instability. Indicators of instability include a vertically incising thalweg or eroding channel banks. Changes in the channel that indicate a movement toward stability or enhanced habitat include a decrease in the width-to-depth ratio in meandering channels or an increase in pool depth. Remedial action would not be taken if channel changes indicate a movement toward stability.

2.1.2 Pattern and Profile

Longitudinal profile data for the stream restoration reaches should show that the bedform features are remaining stable. Although the project reaches are naturally gravel and small cobble bed channels, the bedload currently includes a large percentage of finer channel material. We anticipate this fine material to create transient bar features that will migrate

with each large flow event throughout the project reaches. Overall, the riffles should remain steeper and shallower than the pools, while the pools should remain deeper with flat water surface slopes. Due to the fines in the bedload in all reaches, some filling of the pools is expected to occur over time. The relative percentage of riffles and pools should not change significantly from the design parameters. The longitudinal profile should show that the bank height ratio remains very near to 1.0 for nearly all of the restoration reaches.

2.1.3 Substrate

Substrate materials in the restoration reaches should indicate a progression toward or the maintenance of coarser materials in the riffle features and smaller particles in the pool features.

2.1.4 Photo Documentation

Photographs should illustrate the site's vegetation and morphological stability on an annual basis. Lateral reference photos should show a stable cross-section with no excessive erosion or degradation of the banks. Longitudinal photos should indicate the absence of developing bars within the channel or vertical incision. Grade control structures should remain stable. Deposition of sediment on the bank side of vane arms is preferable. Maintenance of scour pools on the channel side of vane arms is expected.

2.1.5 Bankfull Events

Stream hydrology attainment will be monitored in accordance to the USACE (2003) standards. At the end of the five year monitoring period, two or more bankfull events must occur in separate years within the restoration reach.

2.2 Vegetation

The final vegetative success criteria will be the survival of 260 planted stems per acre in the riparian corridor of the Stream Site at the end of year five monitoring, and 200 planted stems per acre within the wetland Site at the end of year seven monitoring. The interim measure of vegetative success for the entire site will be the survival of at least 320 planted stems per acre at the end of the third monitoring year. The extent of invasive species coverage will also be monitored and controlled as necessary throughout the five-year monitoring period for streams and seven-year monitoring period for wetlands.

2.3 Wetlands

The final success criterion for wetland hydrology is a free groundwater surface within twelve inches of the ground surface for seven percent of the growing season which is measured on consecutive days under typical precipitation conditions. This success criterion was determined through model simulations of post restoration conditions and comparison to an immediately adjacent existing wetland system. If a particular gage does not meet the criterion for a given monitoring year, rainfall patterns will be analyzed and the hydrograph will be compared to that of the reference gage to assess whether atypical weather conditions occurred during the monitoring period.

2.4 Schedule and Reporting

Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCEEP. Based on the NCEEP Monitoring Report Template (version 1.2.1, 12/01/2009), the monitoring reports will include the following:

1. Project background which includes project objectives, project structure, restoration type and approach, location and setting, history and background;
2. As-built topographic plans of major project elements including such items as grade control structures, vegetation plots, permanent cross-sections, groundwater gages, and crest gages;
3. Photographs showing views of the restored Stream Site taken from fixed point stations.
4. Assessment of the stability of the Stream Site based on the cross-sections and longitudinal profile, where applicable;
5. Assessment of the stability of the Wetland Site based on groundwater gages and vegetation plots;
6. Vegetative data as described above including the identification of any invasion by undesirable plant species;
7. A description of damage by animals or vandalism;
8. Maintenance issues and recommended remediation measures will be detailed and documented; and
9. Wildlife observations.

3.0 Monitoring Plan

Annual Monitoring will be conducted for the monitoring parameters as noted below for five years for the Stream Site and seven years for Wetland Site assessments beyond completion of construction or until performance criteria have been met.

3.1 Stream

In order to ensure the Stream Site meets regulatory stream success criteria, stream dimension, pattern, and profile will be monitored annually for five years for restoration reaches (Little Troublesome, Irvin Creek, and UT1). Geomorphic assessments should be performed following guidelines outlined in the Stream Channel Reference Sites: An Illustrated Guide to Field Techniques (Harrelson et al., 1994), methodologies utilized in the Rosgen stream assessment and classification document (Rosgen, 1994 and 1996), and in the Stream Restoration a Natural Channel Design Handbook (Doll et al, 2003). Little Troublesome Creek's hydraulic and geomorphic data for existing condition, reference reaches, design, and as-built conditions are presented in Tables 5a, 5b, and 6.

3.1.1 Dimension

In order to monitor the channel dimension, a total of 13 permanent cross-sections were established within the Stream Site to represent the restored reach stream types and capture the variability in the dimensional features along the reaches. Three cross-sections were established on Little Troublesome Creek (two riffle and one pool). Eight cross-sections were established on Irvin Creek; two riffle and two pool cross sections were established on Reach 1 and two riffle and two pool cross sections were established on Reach 2. Two cross-sections were established on UT1 (one riffle and one pool).

3.1.2 Pattern and Profile

Four separate longitudinal profiles were conducted along Little Troublesome Creek (1,171 LF), Irvin Creek Reach 1 (2,095 LF), Irvin Creek Reach 2 (1,931 LF), and UT1 (233 LF). The longitudinal profile lengths total are greater than the linear footage of stream claimed for restoration due to the fact that several sections of channel on Irvin Creek Reaches 1 and 2 and Little Troublesome Creek do not generate credit due to easement crossings or property line constraints. The beginning and end of each longitudinal profile have been established such that are recoverable either through field identification or with the use of a GPS unit. Each longitudinal profile survey following the initial as-built survey will include re-surveying the same profile. The location of bedform features, in-stream structures, water surface, bankfull, top of bank, and permanent benchmarks will be collected at each survey. Data will be processed in CAD and analyzed using RiverMorph and Microsoft Excel.

Stream pattern was assessed and ranges were defined for Little Troublesome Creek, Irvin Creek Reaches 1 and 2, and UT1. Stream pattern assessment not be conducted unless issues in the profile and dimension indicate that pattern might be changed.

3.1.3 Substrate

A reach-wide pebble count was conducted in each restoration reach (Irvin Creek Reaches 1 and 2, Little Troublesome Creek, and UT1) for classification purposes. A wetted pebble count was conducted at each permanent surveyed riffle cross-section to characterize the pavement. Subsequent sampling will be performed annually at the same locations for the duration of the Stream Site monitoring.

3.1.4 Photo Reference Points

A total of 25 permanent photographs were established within the project stream and wetland areas after construction. Photographs will be taken once a year to visually document stability for five years following construction. Permanent markers were established so that the same locations and view directions on the site are monitored each year. Photographs will be used to monitor restoration, enhancement and creation stream and wetland areas as well as vegetation plots. The photographer will make every effort to maintain the same area in each photo over time. The representative digital photo(s) will be taken on the same day the surveys are conducted.

3.1.5 Bankfull Events

Three crest gages were installed within the Stream Site; one on Irvin Creek, one on Little Troublesome Creek, and one on UT1. The crest gages were installed onsite in a surveyed riffle cross-section of the restored channels at a central site location. The gages 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.

3.1.6 Visual Assessment

Visual assessments will be conducted along all reaches each year to obtain qualitative geomorphic data. Each visual assessment evaluation after the baseline survey will include re-evaluation along the same profile.

3.2 Vegetation

Planted woody vegetation were monitored in accordance with the guidelines and procedures developed by the Carolina Vegetation Survey-NCEEP Level 2 Protocol (Lee et al., 2006) to monitor and assess the planted woody vegetation. A total of 35 vegetation plots were established within the project easement areas (twenty-two at the Wetland Site; thirteen at the Stream Site) using standard 10 meter by 10 meter vegetation monitoring plots. The Stream Site included three plots along Little Troublesome Creek; five plots along Irvin Creek Reach 1; and five plots along Irvin Creek Reach 2. Due to the narrow planted corridor along UT1, vegetation plots were not established. A visual assessment of the planted corridor will be used to evaluate vegetation growth success.

Vegetation plots were randomly established within the planted corridor of the stream and wetland restoration areas to capture the heterogeneity of the designed vegetative communities. The vegetation plot corners have been marked and are recoverable either through field identification or with the use of a GPS unit. Reference photographs at the origin looking diagonally across the plot to the opposite corner were taken with the as-built. Subsequent assessments following baseline survey will capture the same reference photograph locations. Species composition, density and survival rates will be evaluated on an annual basis by plot and for the entire site. Individual plot data will be provided and will include diameter, height, density, vigor, damage (if any) and percent survival. Planted woody stems will be marked annually as needed, based off of a known origin, so they can be found in succeeding monitoring years. Mortality will be determined from the difference between the baseline year's living planted stems and the current year's living planted stems.

3.3 Wetlands

Eight groundwater monitoring gages were established throughout the wetland restoration, creation, and enhancement zones. The gages were installed at appropriate locations so that the data collected will provide an indication of groundwater levels throughout the Wetland Site. A total of eight groundwater gages were installed within the wetland areas. To determine the growing season for the Wetland Site, two soil temperature loggers were also installed. A barrotroll logger and a rain gage were also installed within the wetland site. All monitoring gages will be downloaded on a quarterly basis and will be maintained on an as needed basis. Refer to the as-built plans in Appendix 4 for the monitoring gage locations within the Wetland Site.

4.0 Maintenance and Contingency Plans

Any identified high priority problem areas, such as streambank instability, aggradation/degradation, lack of vegetation establishment, or failure to meet groundwater hydrology success criteria will be evaluated on a case-by-case basis. The problem areas will be visually noted and remedial actions will be discussed with NCEEP staff to determine a plan of action. A proposal of work will be submitted if remediation of an area is required.

4.1 Stream

Stream problem areas will be mapped and included in the CCPV as part of the annual stream assessment. Stream problems areas may include bank erosion, structure failure, beaver dams,

aggradation/degradation, etc. Appropriate remedial actions will be determined with NCEEP correspondence. A proposal of work will be submitted if remediation of an area is required.

4.2 Vegetation

Vegetative problem areas will be mapped and included in the Current Condition Plan View (CCPV) as part of the annual vegetation assessment. Vegetation problems areas may include planted vegetation not meeting success criteria, persistent invasive species, barren areas with little to no herbaceous cover, or grass suffocation/crowding of planted stems. Appropriate remedial actions will be determined with NCEEP correspondence. A proposal of work will be submitted if remediation of an area is required.

Prior to restoration, multiflora rose (*Rosa multiflora*) was noted throughout the Stream Site easement area, along with sporadic occurrences of Chinese privet (*Ligustrum sinense)*, Japanese honeysuckle (*Lonicera japonica.*), and kudzu (*Peuraria montana*). Mechanical extraction of all invasive species was performed in tandem with stream restoration activities. Long term management of these species with herbicide will be applied during the summer months to achieve optimum eradication. No invasive species were observed on the Wetland Site.

4.3 Wetlands

Wetland problem areas will be mapped and included in the CCPV as part of the annual wetland assessment. Wetland problems areas may include planted vegetation not meeting success criteria, persistent invasive species, barren areas with little to no herbaceous cover, grass suffocation/crowding of planted stems, or wetland hydrology not meeting success criteria. Appropriate remedial actions will be determined with NCEEP correspondence. A proposal of work will be submitted if remediation of an area is required.

A maintenance plans has been established for the Wetland Site that includes annual applications of a pre-emergent herbicide at the base of all planted trees and annual mowing in between the rows of trees for the first three growing seasons.

5.0 As-Built Condition (Baseline)

The Stream and Wetland Site construction and as-built surveys were completed between March and May 2012. The survey included developing an as-built topographic surface on both the Stream and Wetland Sites. The survey also involved locating the channel boundaries, structures, cross-sections, and monitoring features such as photo points, vegetation plots, groundwater gages, and crest gages. For comparison purposes, the baseline monitoring divided the reach assessments in the same way they were established for design parameters: Little Troublesome Creek, Irvin Creek Reach 1 and Reach 2, and UT1.

5.1 As-Built/Record Drawings

A half size as-built plan is located in Appendix 4 with the post-construction locations and alignments for the project. A record drawing has also been provided to NCEEP as a separate document that notates any significant field adjustments made during construction that were different from the design plans.

Field adjustments made to the design plans during construction include constructing pools deeper than designed throughout Irvin Creek Reaches 1 and 2. Originally, shallower pools were designed based on the sand fraction in the system, however during construction, pool depths were increased based on observed bed scour in the pools, determination that larger bed material controlled stream dynamics, and past experience of greater pool depths in similar systems provided better habitat and long term stability. Root wads were used in place of brush toe throughout the project due to the availability of large, high quality root balls. On Irvin Creek Reach 1, a constructed riffle at station 102+25 was designed to provide grade control at the beginning of the new channel. However during construction, this constructed riffle was eliminated since bedrock was located at the same elevation in the new channel. At station 107+75 along Irvin Creek Reach 1 a constructed riffle was designed on a small ditch draining into Irvin Creek. After Irvin Creek was built, it was determined in the field that this constructed riffle was unnecessary due to water backing up into the ditch. On Little Troublesome Creek a constructed riffle at station 200+00 was eliminated due to existing rip rap that held the correct grade around the sewer line easement. Brush toe at station 210+50 was eliminated during construction because it was determined not to be necessary. A vernal pool was eliminated at 208+00 due to concern that it would be too close to the newly constructed channel. During construction, brush toe was eliminated on UT1 at stations 400+20, 400+50, and 401+50 because it was determined to not be necessary in the field. Also, on UT1 a J-hook at station 401+90 was designed in combination with a constructed riffle. During construction, it was determined that the J-hook was not necessary in conjunction with the constructed riffle.

As part of the stream restoration project, Wildlands Engineering, Inc. (WEI) worked with Piedmont Natural Gas (PNG) to relocate the gas line on the site to a safer location to protect its integrity. Prior to this project, PNG had a blanket easement on the site with no defined easement boundaries. WEI proposed a location to move the gas line and new boundaries for the gas line easement. This proposed easement boundary was shown on the Little Troublesome stream restoration construction plans. However, when the gas line was reconstructed, PNG chose to keep the original alignment of the line rather than that proposed by WEI but to reconstruct the new line at a deeper elevation than the original elevation. Therefore, the alignment of the gas line did not change. The easement proposed by WEI and shown on the Little Troublesome construction plans is not the location of the final easement. The final easement was agreed to by PNG and is along the original gas line easement as shown in the Record Drawing (Appendix 4). Please refer to Appendix 5 for the recorded easement (Deed Book 1409, page 1478). The following sections further detail the as-built conditions in comparison to the design plans.

5.2 Baseline Data Assessment

5.2.1 Morphological State of the Channel

Morphological data for the as-built profile was collected in April and May of 2012. Please refer to Appendix 2 for summary data tables, morphological plots, and stream photographs.

Profile

The baseline (MY-0) profile numbers are closely matched to the design parameters. The plotted longitudinal profile and related summary data can be found in Appendix 2.

Riffles were depicted as a straight line, consistent slope in the design profile with rock and log riffle features to be installed during construction for habitat variability. The as-built profile reflects the installation of log and rock sills with micro-pools interspersed in the riffle.

During construction, pools were excavated deeper than the design profile throughout Irvin Creek. Deeper pools are generally considered to have better habitat characteristics in gravel bed systems. Where a J-hook structure was used to set the tail of riffle elevation, a scour pool was typically excavated immediately downstream of the J-hook. This excavation shifted the deepest part of the pool closer to the upstream end of the pool, rather than closer to the apex of the pool as shown in the design profile.

Dimension

The baseline (MY-0) dimension numbers are closely matched to the design parameters. Summary data and cross-section plots can be found in Appendix 2.

The main design variation concerns the floodprone width on UT1. Several large trees that were not identified in the original survey were encountered in the vicinity of UT1. Field adjustments were made to decrease the excavated floodplain width in order to save numerous trees. Even with the decrease in floodprone width, UT1 has a calculated entrenchment ratio of 4.2 which falls within the parameters typical of C stream types.

Pattern

The baseline (MY-0) pattern metrics are identical to the design parameters for all four reaches. No design changes were made to any alignments during construction. Pattern data will be completed in monitoring year five if there are any indicators through the profile or dimensions that significant geomorphic adjustments have occurred.

Sediment Transport

As-built shear stresses and velocities are similar to design parameters and should reduce the risk of further erosion along all three restoration reaches.

Prior to and following restoration, both reach 1 and 2 along Irvin Creek classified as gavel bed streams. Little Troublesome Creek was classified was a sand bed channel with a significant gravel component as well. UT 1 was almost entirely comprised of sand. Following construction, Little Troublesome Creek was classified as a medium gravel channel and UT1 was classified as a sand bed channel.

The results from Irvin Creek (Table 5a) were compared to the design shear stress parameters to assess the potential for bed degradation. Little Troublesome Creek and UT1 (Table 5b) were compared to the permissible velocities noted in the mitigation plan and to the design parameters to assess the potential for bed degradation. The shear stress and velocities calculated are generally within the allowable range, which indicate that the channel is not at risk to trend toward channel degradation.

5.2.2 Vegetation

The baseline monitoring (MY-0) vegetative survey was completed in April and May of 2012. The baseline vegetation monitoring on the Stream Site resulted in an average survivability of

953 stems per acre, which is greater than the design density required. There was an average of 24 stems per plot. The baseline vegetation monitoring on the Wetland Site resulted in an average survivability of 701 stems per acre, which is greater than the design density required. There was an average of 17 stems per plot. Please refer to Appendix 3 for vegetation summary tables, raw data tables, and vegetation plot photographs.

5.2.3 Photo Documentation

A total of 25 permanent photographs locations were surveyed by Turner Land Surveying and photographed by WEI. These photographs can be found in Appendix 2.

5.2.4 Hydrology

Two bankfull events have been observed on the Stream Site following completion of construction. The first event was prior to installation of crest gages but was evidenced by wrack lines on trees. The second event was captured by the crest gages and water levels above bankfull ranged from 1.1 ft to 1.8 ft. Crest gage data logs will be included in the Year one monitoring report.

6.0 References

Doll, B.A., Grabow, G.L., Hall, K.A., Halley, J., Harman, W.A., Jennings, G.D., and Wise, D.E., 2003. Stream Restoration A Natural Channel Design Handbook.

Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.

Lee, Michael T., Peet, Robert K., Steven D., Wentworth, Thomas R. (2006). CVS-EEP Protocol for Recording Vegetation Version 4.0. Retrieved from http://www.nceep.net/business/monitoring/veg/datasheets.htm.

Rosgen, D. L. 1994. A classification of natural rivers. *Catena* 22:169-199.

Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.

Rosgen, D.L. 1997. A Geomorphological Approach to Restoration of Incised Rivers. Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. Center For Computational Hydroscience and Bioengineering, Oxford Campus, University of Mississippi, Pages 12-22.

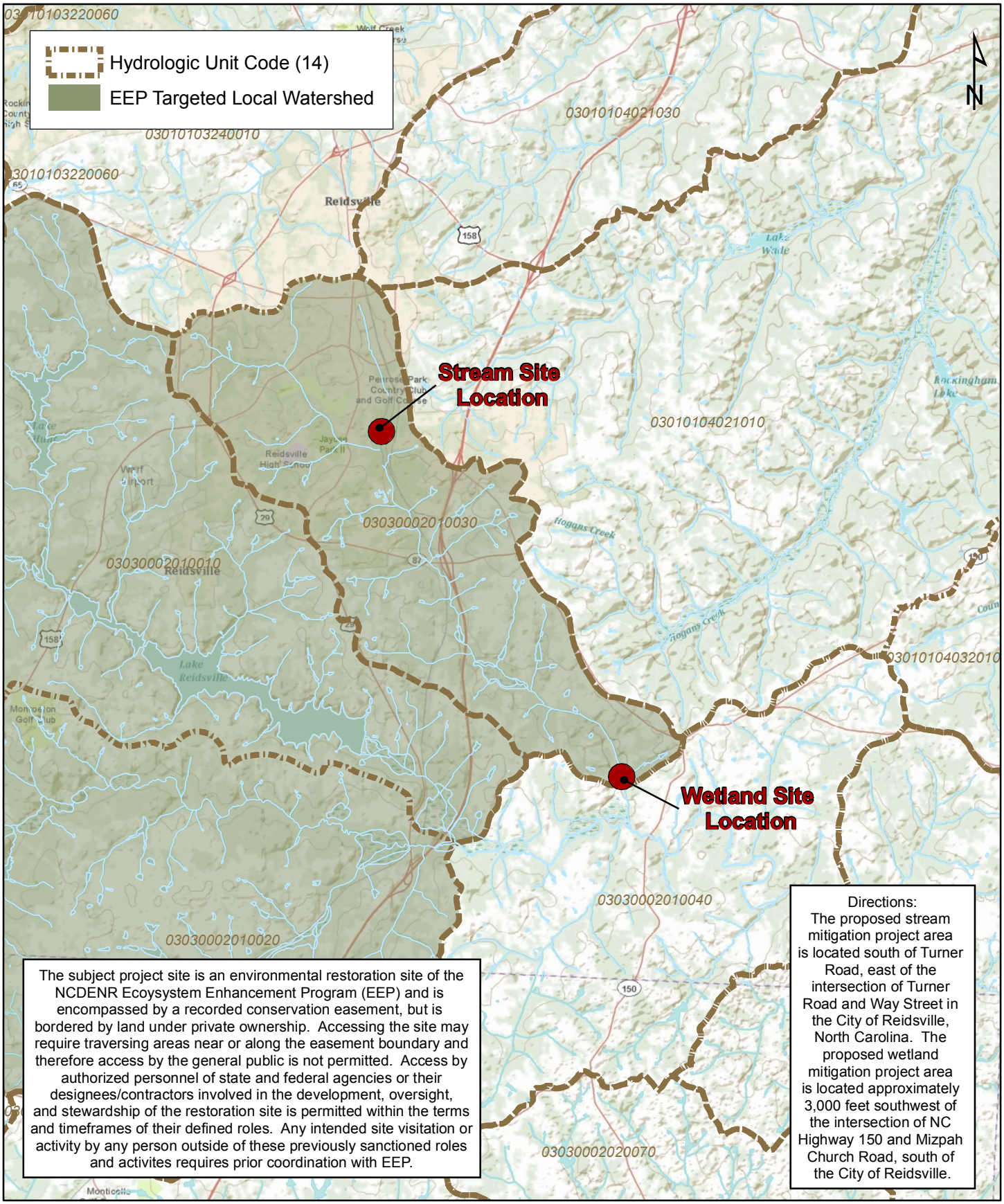
Schafale, M.P. and A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina, 3rd approx. North Carolina Natural Heritage Program, Raleigh, North Carolina.

United States Army Corps of Engineers (USACE), 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.

United States Geological Survey (USGS), 1998. North Carolina Geology. http:// http://www.geology.enr.state.nc.us/usgs/carolina.htm

Wildlands Engineering, Inc (2011). Little Troublesome Mitigation Site Mitigation Plan. NCEEP, Raleigh, NC.

APPENDIX 1. General Tables and Figures

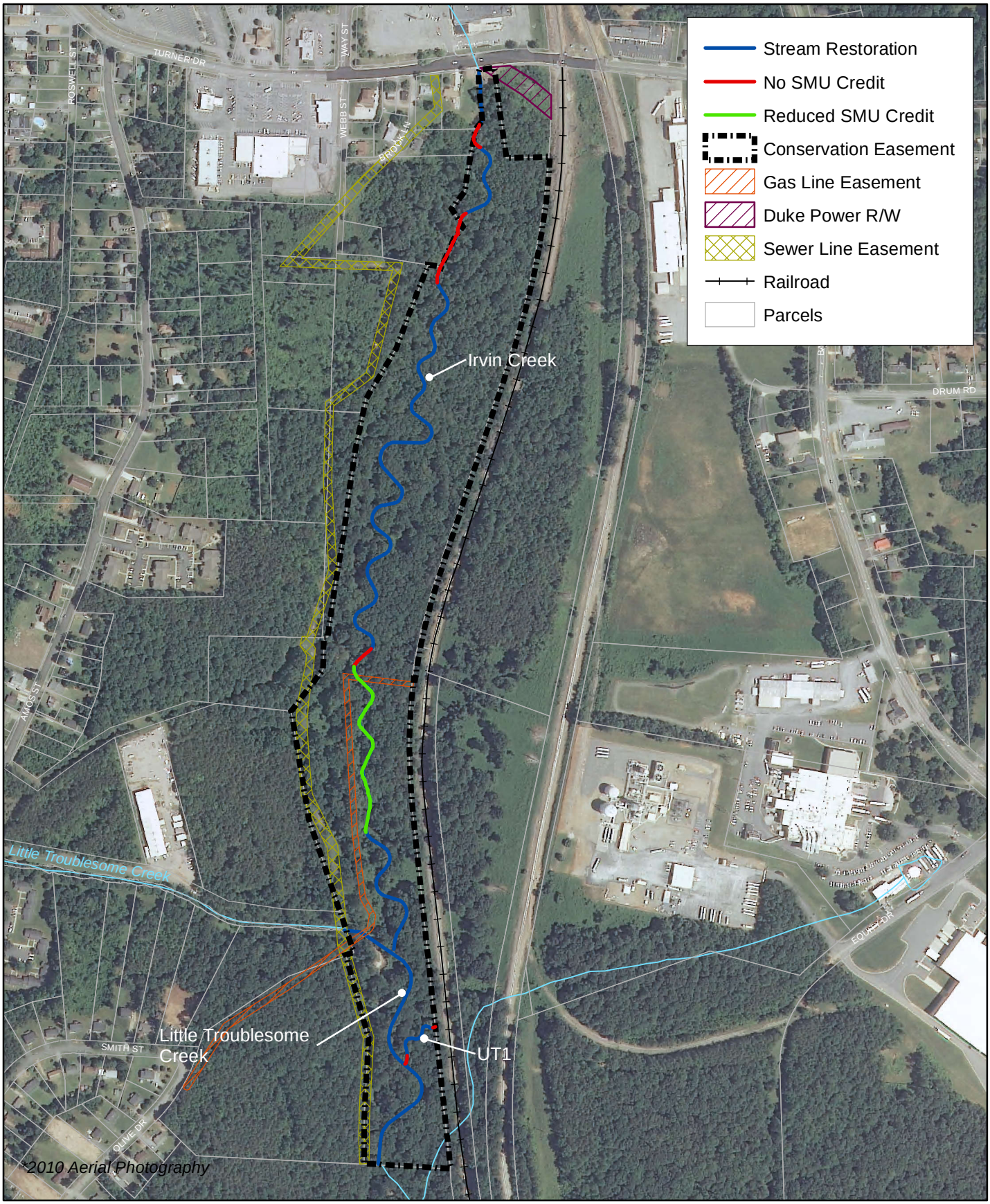


WILDLANDS ENGINEERING

0 0.75 1.5 Miles

Figure 1. Project Vicinity Map
Little Troublesome Creek Mitigation Site
NCEEP Project Number 94640
Monitoring Year 0

Rockingham County, NC



WILDLANDS ENGINEERING

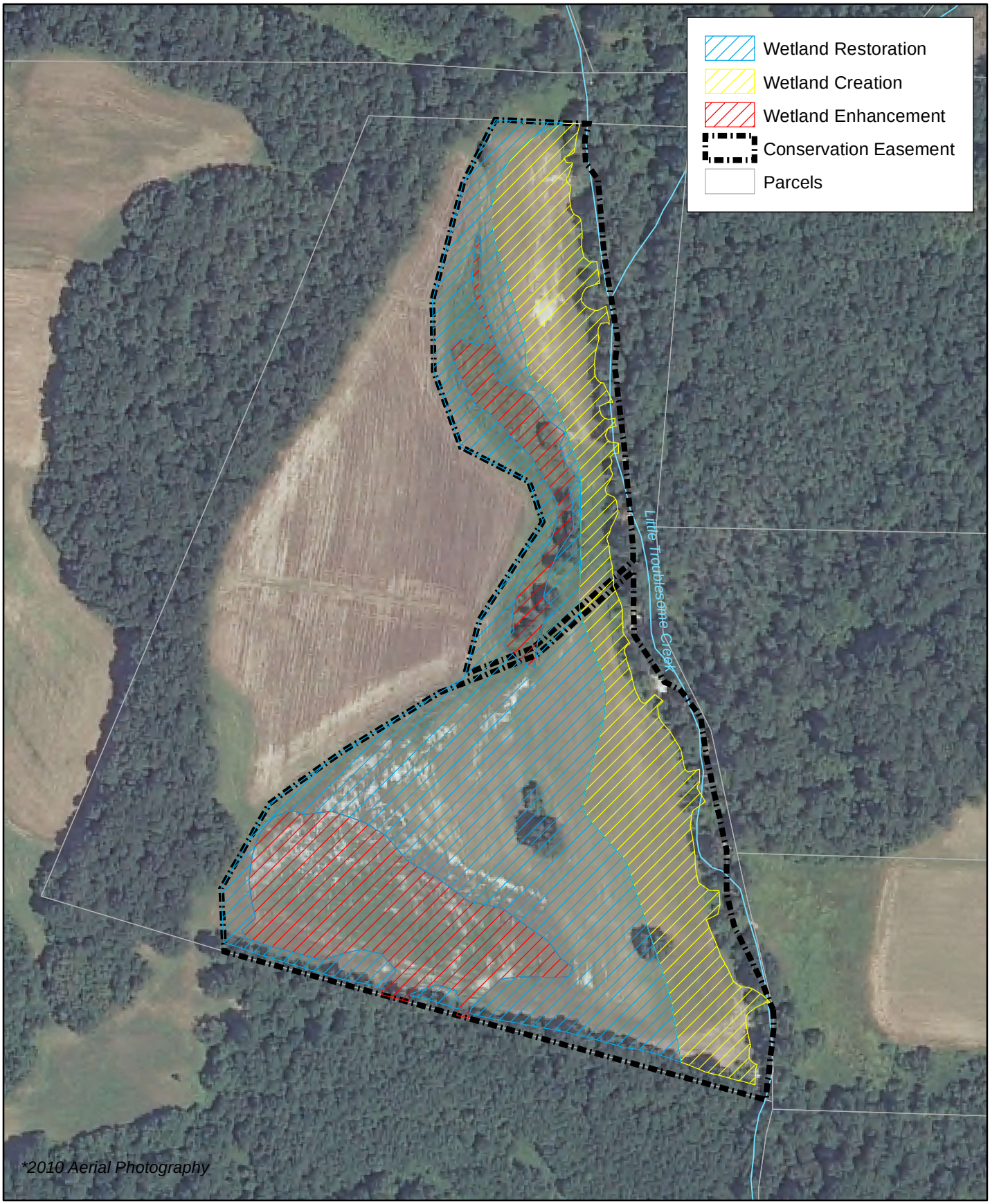
Ecosystem Enhancement PROGRAM

0 250 500 Feet

1

Figure 2a. Project Component/Asset Map
Little Troublesome Creek Mitigation Site
Stream Site
NCEEP Project Number 94640
Monitoring Year 0

Rockingham County, NC



WILDLANDS ENGINEERING

Ecosystem Enhancement PROGRAM

0 125 250 Feet

1

Figure 2b. Project Component/Asset Map
Little Troublesome Creek Mitigation Site
Wetland Site
NCEEP Project Number 94640
Monitoring Year 0

Rockingham County, NC

Appendix 1. General Tables and Figures
Table 1. Project Components and Mitigation Credits
Little Troublesome Creek Mitigation Site (NCEEP Project No.94640)
Monitoring Year 0

Mitigation Credits									
	Stream		Riparian Wetland		Non-Riparian Wetland		Buffer	Nitrogen Nutrient Offet	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE			
Totals	5,052	N/A	10.3	2.8	N/A	N/A	N/A	N/A	N/A

Project Components						
Reach ID	As-Built Stationing/ Location	Existing Footage (LF)	Approach	Restoration or Restoration Equivalent	Restoration Footage (LF) / Acreage (Ac)*	Mitigation Ratio
Irvin Creek - Reach 1	102+10 to 123+05	1,640	Priority 1	Restoration	1,793	1:1
Irvin Creek - Reach 2	123+05 to 142+37	1,505	Priority 1	Restoration	1,882	1:1
Little Troublesome Creek	200+00 to 211+71	1,080	Priority 1	Restoration	1,080	1:1
UT1	400+00 to 402+33	184	Priority 1/2	Restoration	233	1:1
RW1	N/A	N/A	Restoration	Restoration	8.7	1:1
RW1	N/A	N/A	Creation	Restoration Equivalent	4.9	3:1
RW1	N/A	3.7	Enhancement	Restoration Equivalent	3.7	1.3:1**

Component Summation						
Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-Riparian Wetland (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	4,988	8.7	-	-	-	-
Enhancement		2.8	-	-	-	-
Enhancement I	-					
Enhancement II	-					
Creation		1.9	-	-		
Preservation	-	-	-	-		-
High Quality Preservation	-	-	-	-		-

BMP Elements									
Elements		Location		Purpose/Function		Notes			
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-

BR = Bioretention Cell; S F= Sand Filter; SW = Stormwater Wetland; WDP = Wet Detention Pond; DDP = Dry Detention Pond; FS = Filter Strip; S = Grassed Swale; LS = Level Spreader; NI = Natural Infiltration Area; FB = Forested Buffer

* Note that lengths do not match stationing because channel sections that do not generate credit have been removed from length calculations.

**The higher enhancement ratio was agreed to with Todd Tugwell during a March 9, 2011 meeting for the following reasons. The higher ratio is warranted because of the low quality of the existing wetland enhancement zone. Currently the enhancement zone, like the restoration and creation zones, is being used for farming. The hydrology of the site has been altered by a drainage ditch and a berm along Little Troublesome Creek. There is no vegetation on the site except for some areas of grasses and cultivated crops. Enhancement activities performed on the site will include improving the hydrology of the enhancement zone (as well as the creation and restoration zones) and restoring the native vegetation. Therefore the functional uplift of the enhancement portion of the project will be nearly the same as that of the restoration zone and, thus, a high ratio for enhancement is appropriate.

Appendix 1. General Tables and Figures
Table 2. Project Activity and Reporting History
Little Troublesome Creek Mitigation Site (NCEEP Project No.94640)
Monitoring Year 0

Activity or Report	Date Collection Complete	Completion or Scheduled Delivery
Mitigation Plan	June 2011	June 2011
Final Design - Construction Plans	August 2011	August 2011
Construction	April 2012	May 2012
Temporary S&E mix applied to entire project area[1]	April 2012	May 2012
Permanent seed mix applied to reach/segments	April 2012	May 2012
Containerized and B&B plantings for reach/segments	April 2012	May 2012
Baseline Monitoring Document (Year 0 Monitoring - baseline)	April/May 2012	June 2012
Year 1 Monitoring	2012	December 2012
Year 2 Monitoring	2013	December 2013
Year 3 Monitoring	2014	December 2014
Year 4 Monitoring	2015	December 2015
Year 5 Monitoring	2016	December 2016
Year 6 Monitoring[2]	2017	December 2017
Year 7 Monitoring[2]	2018	December 2018

[1]Seed and mulch is added as each section of construction is completed.

Appendix 1. General Tables and Figures
Table 3. Project Contact Table
Little Troublesome Creek Mitigation Site (NCEEP Project No.94640)
Monitoring Year 0

Designer	**Wildlands Engineering, Inc.**
Jeff Keaton, PE	5605 Chapel Hill Road, Suite 122 Raleigh, NC 27604 919.851.9986
Construction Contractor	**Fluvial Solutions**
Peter Jelenevsky	PO Box 28749 Raleigh, NC 28749
Planting Contractor - Stream Site	**Fluvial Solutions**
Peter Jelenevsky	PO Box 28749 Raleigh, NC 28749
Planting Contractor - Wetland Site	**Bruton Natural Systems, Inc.**
Charlie Bruton	PO Box 1197 Freemont, NC 27830 919.242.6555
Seeding Contractor - Stream and Wetland Site	**Fluvial Solutions**
Peter Jelenevsky	PO Box 28749 Raleigh, NC 28749
Seed Mix Sources	**Mellow Marsh Farm**
Nursery Stock Suppliers	**Arborgen** **Dykes and Son Nursery** **NC Forestry Service, Claridge Nursery**
Monitoring Performers	**Wildlands Engineering, Inc.**
Stream, Vegetation, and Wetland Monitoring, POC	Kirsten Y. Gimbert 704.332.7754, ext. 110

Appendix 1. General Tables and Figures
Table 4. Project Baseline Information and Attributes
Little Troublesome Creek Mitigation Site (NCEEP Project No.94640)
Monitoring Year 0

Project Information					
Project Name	Little Troublesome Creek Mitigation Site				
County	Rockingham				
Project Area (acres)	Stream Site: 33 acres, Wetland Site: 19 acres				
Project Coordinates (latitude and longitude)	36° 20' 96"N, 79° 39' 31"W				
Project Watershed Summary Information					
Physiographic Province	Inner Piedmont Belt of the Piedmont				
River Basin	Cape Fear				
USGS Hydrologic Unit 8-digit	03030002				
USGS Hydrologic Unit 14-digit	03030002010030				
DWQ Sub-basin	03-06-01				
Project Drainiage Area (acres)	3,254				
Project Drainage Area Percentage of Impervious Area	17%				
CGIA Land Use Classification	55% Forest Land,17% Cultivated Land, 28% Developed				
Reach Summary Information					
Parameters	**Irvin Creek Reach 1**	**Irvin Creek Reach 2**	**Little Troublesome Creek**	**UT1**	**RW1**
Length of reach (linear feet) - Post-Restoration	2,095	1,932	1,171	233	N/A
Drainage area (acres)	525	584	3,245	62	N/A
NCDWQ stream identification score	45	45	45.5	26.5	N/A
NCDWQ Water Quality Classification	C	C	C; NSW	C	C; NSW
Morphological Desription (stream type)	Perennial	Perennial	Perennial	Intermittent	N/A
Evolutionary trend (Simon's Model) - Pre- Restoration	Stage IV	Stage IV	Stage IV	Stage IV	N/A
Underlying mapped soils	CsA	CsA	CsA	CsA	CsA / HcA
Drainage class	Somewhat Poorly-drained	Somewhat Poorly-drained	Somewhat Poorly-drained	Somewhat Poorly-drained	Somewhat Poorly-drained / Poorly Drained
Soil Hydric status	No	No	No	No	No / Yes
Slope	0-2%	0-2%	0-2%	0-2%	0-2%
FEMA classification	Zone AE				
Native vegetation community	Bottom-land forest				
Percent composition of exotic invasive vegetation - Post-Restoration	0%				
Regulatory Considerations					
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**		
Waters of the United States - Section 404	X	X	USACE Nationwide Permit No.27 and DWQ 401 Water Quality Certification No. 3689		
Waters of the United States - Section 401	X	X			
Division of Land Quality (Dam Safety)	N/A	N/A	N/A		
Endangered Species Act	X	X	Little Troublesome Creek Mitigation Plan; studies found "no effect" (letter from USFWS)		
Historic Preservation Act	X	X	No historic resources were found to be impacted (letter from SHPO)		
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	N/A	N/A	N/A		
FEMA Floodplain Compliance	X	X	Approved CLOMR		
Essential Fisheries Habitat	N/A	N/A	N/A		

*LF provided included portions of the stream that will be monitoring and have been reconstructed, but for which mitigation credit will not be claimed. Please refer to Table 1 for the credit summary lengths.

APPENDIX 2. Morphological Summary and Data Plots

Appendix 2. Morphological Summary Data and Plots
Table 5a. Baseline Stream Data Summary
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reaches 1 and 2
Monitoring Year 0

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data								Design[1]				As-Built/Baseline			
		Irvin Creek Reach 1		Irvin Creek Reach 2		Collins Creek		UT to Belews Creed		UT to Rocky Creek		Spencer Creek		Irvin Creek Reach 1		Irvin Creek Reach 2		Irvin Creek Reach 1		Irvin Creek Reach 2	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle																					
Bankfull Width (ft)	n/a	17.7		15.2	17.2	11.9	20.1	14.4		12.2		8.7		19.0		19.0		18.6	19.7	18.1	20.9
Floodprone Width (ft)		21.0		18.0	21.0	60.0		200.0		72.0		229.0		80+		200+		200+	200+	200+	200+
Bankfull Mean Depth		1.5		1.9	2.0	1.6	2.7	2.0		1.3		1.2		1.6		1.6		1.6	1.7	1.6	1.6
Bankfull Max Depth		1.8		2.4	2.6	3.3	4.2	2.7		1.8		1.9		2.2		2.2		2.4	2.6	2.4	2.4
Bankfull Cross-sectional Area (ft^2)		27.3		30.6	32.8	32.9		27.4		16.3		10.6		29.7		29.7		29.3	33.7	29.0	32.7
Width/Depth Ratio		11.5		8.0	8.6	4.4	12.1	7.6		9.1		7.3		12.0		12.0		11.5	11.8	11.3	13.3
Entrenchment Ratio		1.2		1.2	1.2	2.0	3.0	34.7		6.0		26.3		2.2+		2.2+		2.2+	2.2+	2.2+	2.2+
Bank Height Ratio		1.9	3.3	2.3	2.5	1.0	1.1	1.0		1.0		1.0		1.0		1.0		1.0	1.0	1.0	1.0
D50 (mm)		32.8		24.2														22.6		18.6	
Profile																					
Riffle Length (ft)	n/a					-		-		-		-		-	-	-	-	7	23	10	75
Riffle Slope (ft/ft)		0.001	0.0250	0.0019	0.017	0.0030	0.0080	-		0.0606	0.0892	0.0100	0.0670	0.0060	0.0080	0.0070	0.0147	0.0045	0.0116	0.0052	0.0160
Pool Length (ft)						-		-		-		-		-		-		10	39	6	81
Pool Max Depth (ft)		2.09	3.65	2.27	3.33	2.4		4.6		2.2		2.5		2.8	4.0	2.9	4.0	3.7	4.2	3.6	4.0
Pool Spacing (ft)^		39	60	27	76	32	80	75		26	81	13	47	76	133	77	135	57	236	91	142
Pool Volume (ft^3)																					
Pattern																					
Channel Beltwidth (ft)	n/a	39	81	46	94	-		31	32	-		24	52	57	152	58	154	52	151	49	86
Radius of Curvature (ft)		57	114	100	251	-		16	27	-		5	22	38	57	38	58	38	59	38	62
Rc:Bankfull Width (ft/ft)		3.2	6.4	6.6	14.6	-		2.2	4.1	-		1.5	2.8	2	3	2	3	2.0	3.1	2	3
Meander Wave Length (ft)		86	175	175	348	-		71	101	-		54	196	152	228	154	231	150	235	166	229
Meander Width Ratio		2.2	4.6	3	5.5	-		2.15	2.22	-		2.8	6	3	8	3	8	2.7	7.9	3	5
Substrate, Bed and Transport Parameters																					
Ri%/Ru%/P%/G%/S%	n/a																				
SC%/Sa%/G%/C%/B%/Be%																					
d16/d35/d50/d84/d95/d100		0.1/0.6/14.8/56.1/98.3/>2048		0.1/0.3/4.5/24.7/31.3/45.0		N/A		N/A		N/A		N/A						<0.062/<0.062/22.6/48.53/64.0/128		<0.062/<0.062/18.55/48.28/78.53/180.0	
Reach Shear Stress (Competency) lb/ft^2		0.88		0.42										0.38		0.43		0.38	0.41	0.40	
Max part size (mm) mobilized at bankfull																					
Stream Power (Capacity) W/m^2																					
Additional Reach Parameters																					
Drainage Area (SM)	n/a	0.67	0.82	0.82	0.91	1.68		3.40		1.1		0.5		0.82		0.91		0.82		0.91	
Watershed Impervious Cover Estimate (%)		17		17		-		-		-		-		17		17		17		17	
Rosgen Classification		G4c		G4c		E4		E5		E4b		E4/C4		C4		C4		C		C	
Bankfull Velocity (fps)		3.3		3.00	3.30									3.0		3.3		2.7	3.1	3.1	3.4
Bankfull Discharge (cfs)		90		100		115	150	125		85		N/A		90		100		90		100	
Q-NFF regression		110		126																	
Q-USGS extrapolation		-		-																	
Q-Mannings		122		99	102	-															
Valley Length (ft)		1490.9		1505.0		-		-		-		-		-		-					
Channel Thalweg Length (ft)		1640.0		1505.0		-		-		-		-		2057*		1919*		2095*		1932*	
Sinuosity (ft)		1.1		1.0		-		1.2		1.1		1.05		1.3		1.2		1.3		1.2	
Water Surface Slope (ft/ft)		-		-		0.003		0.007		0.0235		0.0132		-		-		N/A[1]		N/A[1]	
Bankfull Slope (ft/ft)		0.0107		0.0043		-		-		-		-		0.0045		0.0049		0.0045		0.0047	

(-): Data was not provided
N/A: Not Applicable

[1]Design parameters were expanded during the final design phase.
*LF provided included portions of the stream that will be monitoring and have been reconstructed, but for which mitigation credit will not be claimed. Please refer to Table 1 in Appendix 1 for the credit summary lengths.
^Pool to pool spacing calculations were measured using the most downstream pool in the meander for the as-built compared to the design pool to pool spacing, which included pools and plunge pools in the min and max values.

Appendix 2. Morphological Summary Data and Plots
Table 5b. Baseline Stream Data Summary
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek and UT1
Monitoring Year 0

Parameter	Gage	Pre-Restoration Condition[1]				Reference Reach Data		Design[1]				As-Built / Baseline			
		Little Troublesome Creek		UT1				UT1		Little Troublesome		UT1[2]		Little Troublesome Creek	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle															
Bankfull Width (ft)	n/a	28.7		5.2		refer to table 5a		7.8		32.3		10.9		32.6	48.8
Floodprone Width (ft)		93.0		8.0				100+		285+		36.7		200+	
Bankfull Mean Depth		2.6		1.2				0.6		2.7		0.5		1.6	2.7
Bankfull Max Depth		3.3		1.9				0.9		3.8		1		4.1	4.2
Bankfull Cross-sectional Area (ft^2)		73.6		6.4				5.0		86.6		5.1		79.6	87.1
Width/Depth Ratio		11.2		4.3				12.0		12.0		23		12.2	30
Entrenchment Ratio		3.2		1.5				2.2+		2.2+		2.2+		2.2+	
Bank Height Ratio		1.6	2.8	1.2	2.5			1.0		1.0		1.0		1.0	
D50 (mm)		0.8		9.7								0.4		20.7	
Profile															
Riffle Length (ft)	n/a					refer to table 5a		-		-		20	28	19	31
Riffle Slope (ft/ft)[1]		0.0007	0.0110	0.0072	0.05			0.0185	0.0369	0.0066	0.0088	0.0238	0.0263	0.0043	0.0108
Pool Length (ft)								-		-		18	40	23	40
Pool Max Depth (ft)		3.19	5.25	2.24	3.31			1.2	1.6	4.8	6.7	1.2		5.9	
Pool Spacing (ft)^		46	127	29	42			24	43	129	226	12	59	130	267
Pool Volume (ft^3)															
Pattern															
Channel Beltwidth (ft)	n/a	119		-		refer to table 5a		27	62	113	258	27	62	113	258
Radius of Curvature (ft)		103	313	-				16	23	65	97	16	23	65	97
Rc:Bankfull Width (ft/ft)		3.6	10.9	-				2.0	3.0	2.0	3.0	2.0	3.0	2.0	3.0
Meander Wave Length (ft)		179	315	-				62	94	258	388	62	94	258	388
Meander Width Ratio		4.1		-				3.5	8.0	3.5	8.0	3.5	8.0	3.5	8.0
Substrate, Bed and Transport Parameters															
Ri%/Ru%/P%/G%/S%	n/a					refer to table 5a									
SC%/Sa%/G%/C%/B%/Be%															
d16/d35/d50/d84/d95/d100		0.2/0.5/1.0/22.0/30.2/>2048		<0.062/<0.062/<0.062/3.55/13.3/>2048								<0.062/<0.062/0.4/44.2/64.0/128.0		<0.062/<0.062/20.73/61.79/110.07/180.0	
Reach Shear Stress (Competency) lb/ft^2		0.41		0.96				N/A[3]		N/A[3]		0.34		0.38	0.53
Max part size (mm) mobilized at bankfull															
Stream Power (Capacity) W/m^2															
Additional Reach Parameters															
Drainage Area (SM)	n/a	4.95	5.07	0.1		refer to table 5a		0.1		5.07		0.1		5.07	
Watershed Impervious Cover Estimate (%)		17		17				17		17		17		17	
Rosgen Classification		C5		G5				C5		C5		C5		C4	
Bankfull Velocity (fps)		5.0		4.4				2.7		4.3		2.7		4.2	4.6
Bankfull Discharge (cfs)		370		14				14		370		14		370	
Q-NFF regression		422		-											
Q-USGS extrapolation		-		-											
Q-Mannings		237		-											
Valley Length (ft)		982		184				-		-					
Channel Thalweg Length (ft)		1080		184				240		1158*		233		1171*	
Sinuosity (ft)		1.1		1.0				1.3		1.3		1.2		1.3	
Water Surface Slope (ft/ft)		-		-				-		-		N/A[1]		N/A[1]	
Bankfull Slope (ft/ft)		0.0033		0.0183				0.0123		0.0044		0.0126		0.0038	

(-): Data was not provided
N/A: Not Applicable

[1]Design parameters were expanded during the final design phase.

[2]Restoration approach was adjusted from a priority 1 to a priority 2 during the final design phase.

[3]The critical shear stress analysis was not perfomed on the sand bed channels.

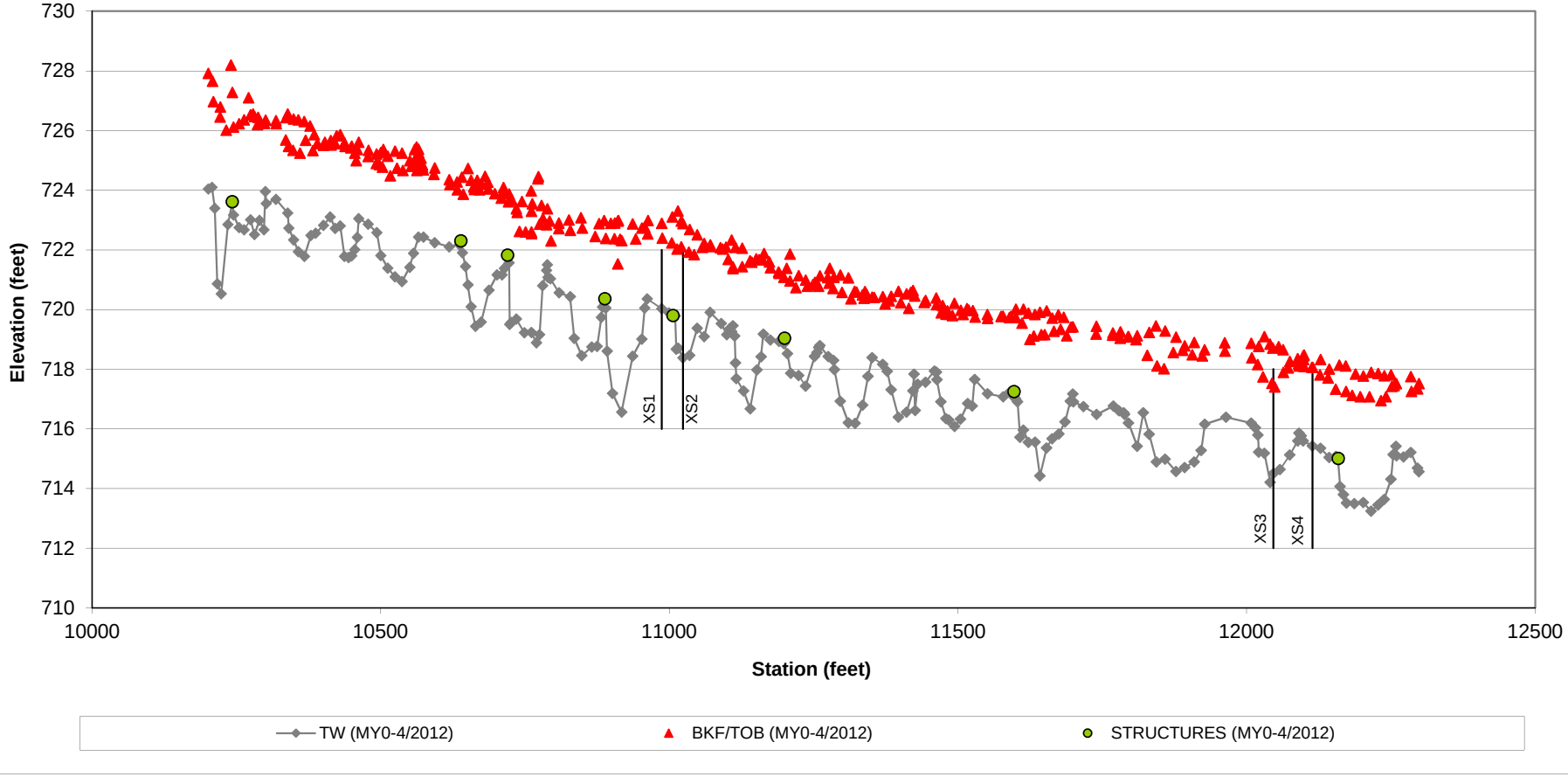
*LF provided included portions of the stream that will be monitoring and have been reconstructed, but for which mitigation credit will not be claimed. Please refer to Table 1 in Appendix 1 for the credit summary lengths.

^Pool to pool spacing calculations were measured using the most downstream pool in the meander for the as-built compared to the design pool to pool spacing, which included pools and plunge pools in the min and max values.

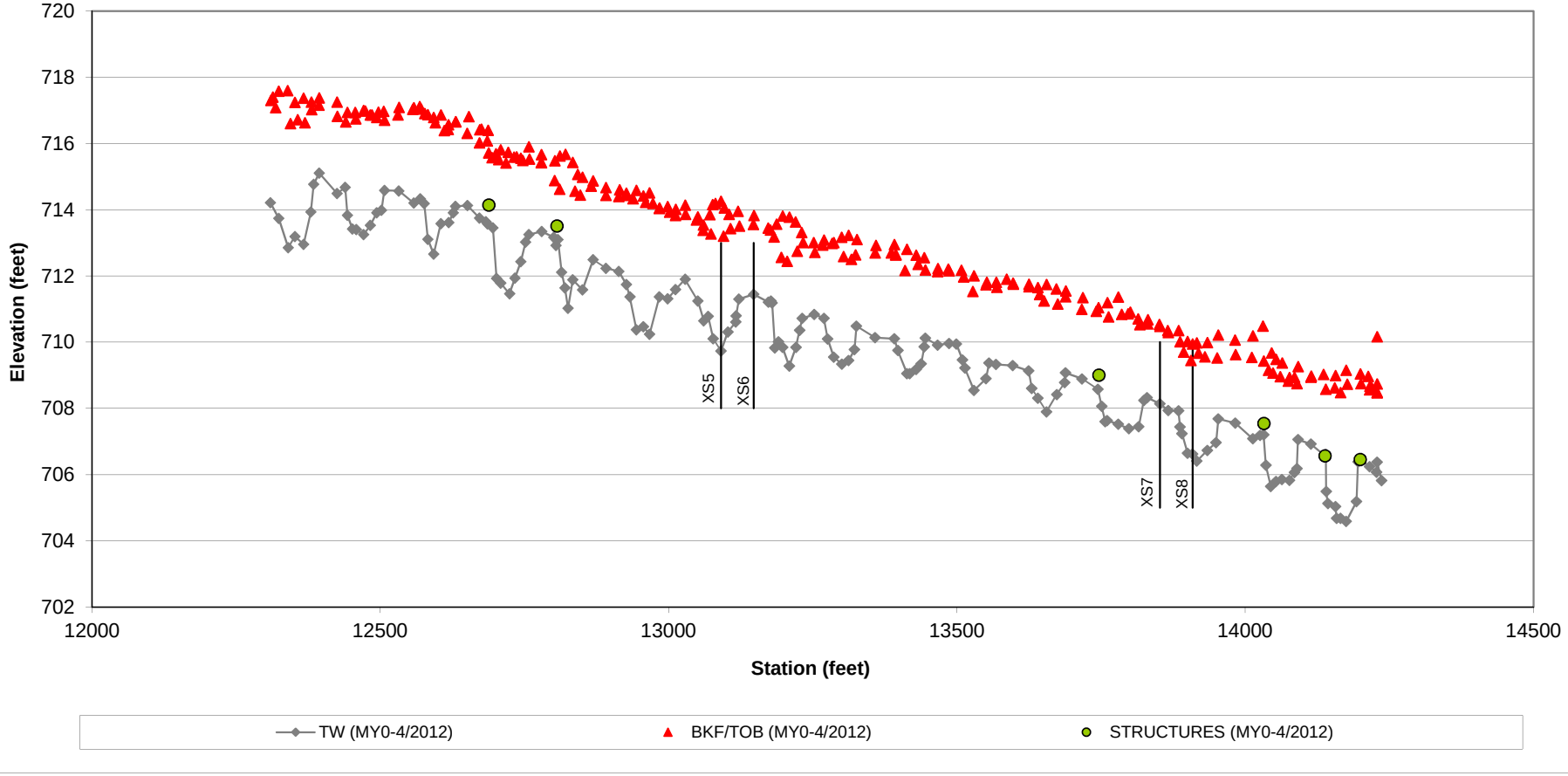
Appendix 2. Morphological Summary Data and Plots
Table 6. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reaches 1 and 2, Little Troublesome Creek, UT1
Monitoring Year 0

	Irvin Creek Reach 1																							
	Cross-Section 1 (Riffle)						Cross-Section 2 (Pool)						Cross-Section 3 (Pool)						Cross-Section 4 (Riffle)					
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
based on fixed bankfull elevation																								
Bankfull Width (ft)	18.6						19.9						31.1						19.7					
Floodprone Width (ft)	200+						N/A						N/A						200+					
Bankfull Mean Depth (ft)	1.6						1.9						1.9						1.7					
Bankfull Max Depth (ft)	2.4						3.7						4.2						2.6					
Bankfull Cross-Sectional Area (ft^2)	29.3						36.8						57.6						33.7					
Bankfull Width/Depth Ratio	11.8						10.7						16.8						11.5					
Bankfull Entrenchment Ratio	2.2+						N/A						N/A						2.2+					
Bankfull Bank Height Ratio	1.0						1.0						1.0						1.0					
	Irvin Creek Reach 2																							
	Cross-Section 5 (Pool)						Cross-Section 6 (Riffle)						Cross-Section 7 (Riffle)						Cross-Section 8 (Pool)					
based on fixed bankfull elevation	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Bankfull Width (ft)	35.3						18.1						20.9						29.2					
Floodprone Width (ft)	N/A						200+						200+						N/A					
Bankfull Mean Depth (ft)	1.4						1.6						1.6						1.7					
Bankfull Max Depth (ft)	4.0						2.4						2.4						3.6					
Bankfull Cross-Sectional Area (ft^2)	47.9						29.0						32.7						50.1					
Bankfull Width/Depth Ratio	26.0						11.3						13.3						17.0					
Bankfull Entrenchment Ratio	N/A						2.2+						2.2+						N/A					
Bankfull Bank Height Ratio	1.0						1.0						1.0						1.0					
	UT1												Little Troublesome Creek											
	Cross-Section 9 (Riffle)						Cross-Section 10 (Pool)						Cross-Section 11 (Riffle)						Cross-Section 12 (Pool)					
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
based on fixed bankfull elevation																								
Bankfull Width (ft)	10.9						9.3						32.6						41.0					
Floodprone Width (ft)	36.7						N/A						200+						N/A					
Bankfull Mean Depth (ft)	0.5						0.7						2.7						3.1					
Bankfull Max Depth (ft)	1.0						1.2						4.1						5.9					
Bankfull Cross-Sectional Area (ft^2)	5.1						6.4						87.1						125.3					
Bankfull Width/Depth Ratio	23.0						13.5						12.2						13.4					
Bankfull Entrenchment Ratio	2.2+						N/A						2.2+						N/A					
Bankfull Bank Height Ratio	1.0						1.0						1.0						1.0					
	Little Troublesome Creek																							
	Cross-Section 13 (Riffle)																							
Dimension and Substrate	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**																		
based on fixed bankfull elevation																								
Bankfull Width (ft)	48.8																							
Floodprone Width (ft)	200+																							
Bankfull Mean Depth (ft)	1.6																							
Bankfull Max Depth (ft)	4.2																							
Bankfull Cross-Sectional Area (ft^2)	79.6																							
Bankfull Width/Depth Ratio	30.0																							
Bankfull Entrenchment Ratio	2.2+																							
Bankfull Bank Height Ratio	1.0																							

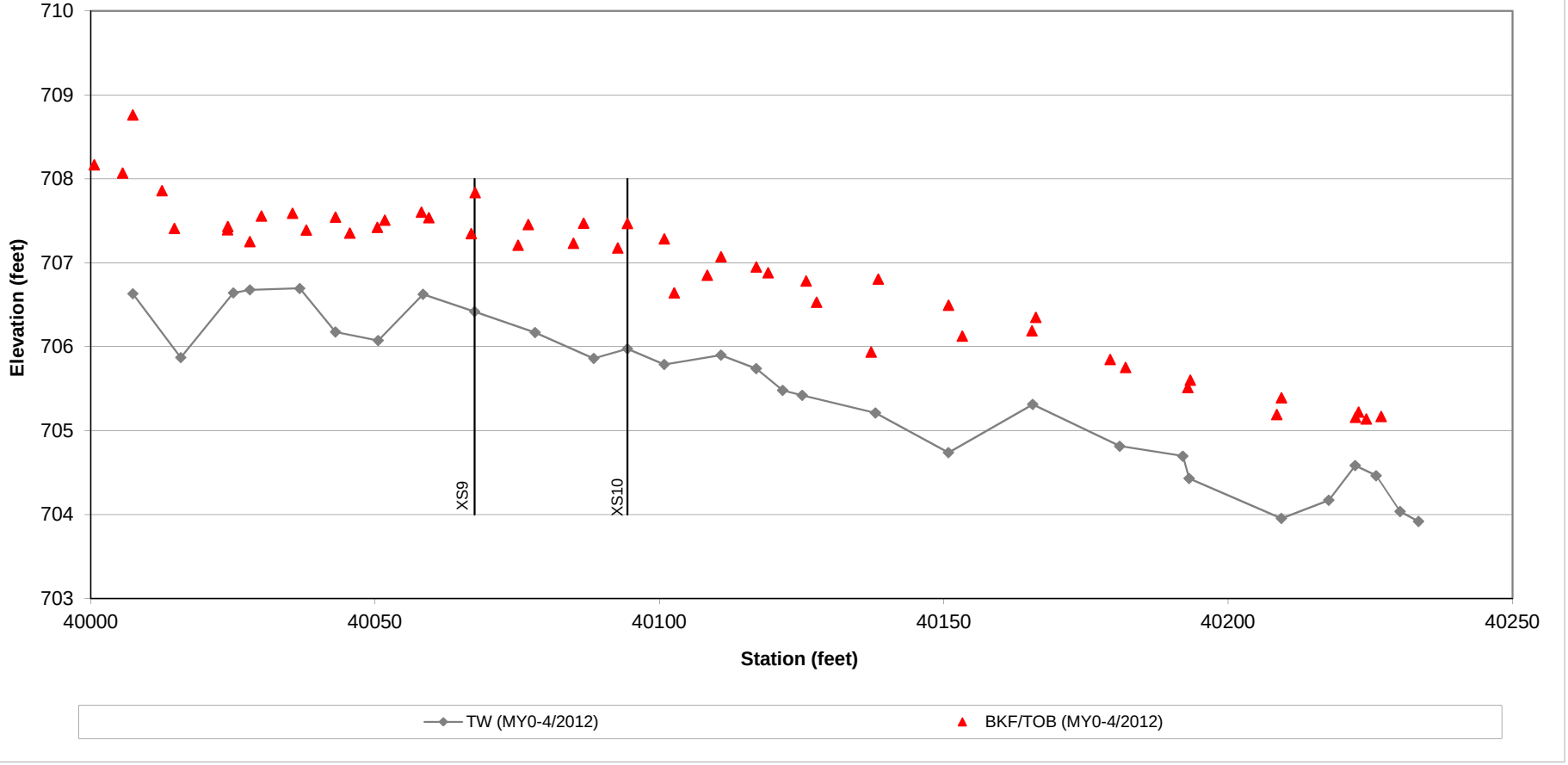
Appendix 2. Morphological Summary Data and Plots
Figure 3a. Longitudinal Profile Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1
Monitoring Year 0



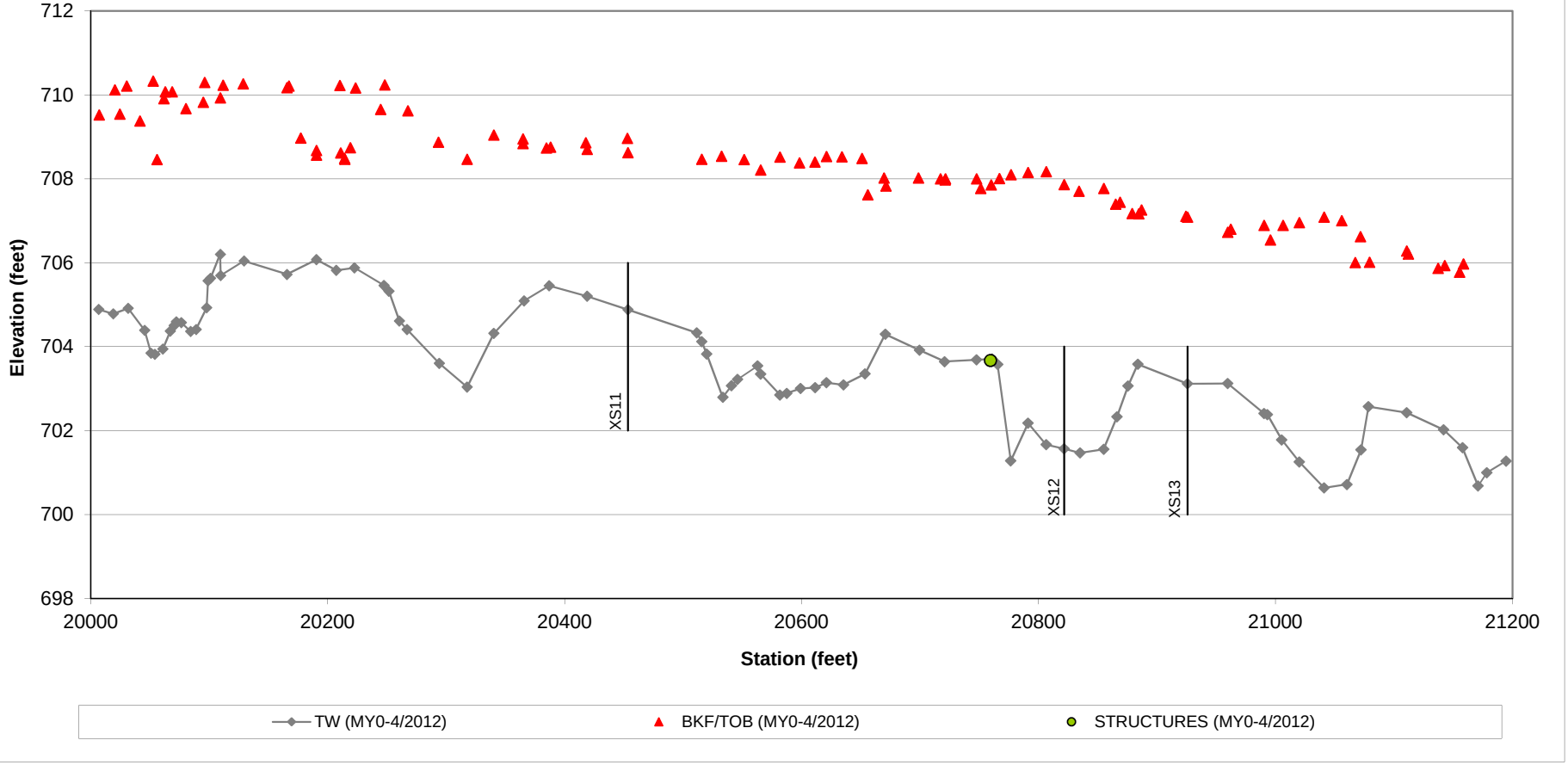
Appendix 2. Morphological Summary Data and Plots
Figure 3b. Longitudinal Profile Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2
Monitoring Year 0



Appendix 2. Morphological Summary Data and Plots
Figure 3c. Longitudinal Profile Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
UT1
Monitoring Year 0



Appendix 2. Morphological Summary Data and Plots
Figure 3d. Longitudinal Profile Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek
Monitoring Year 0



Appendix 2. Morphological Summary Data and Plots
Figure 4a. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Cross-Section 1 (Riffle)
Monitoring Year 0

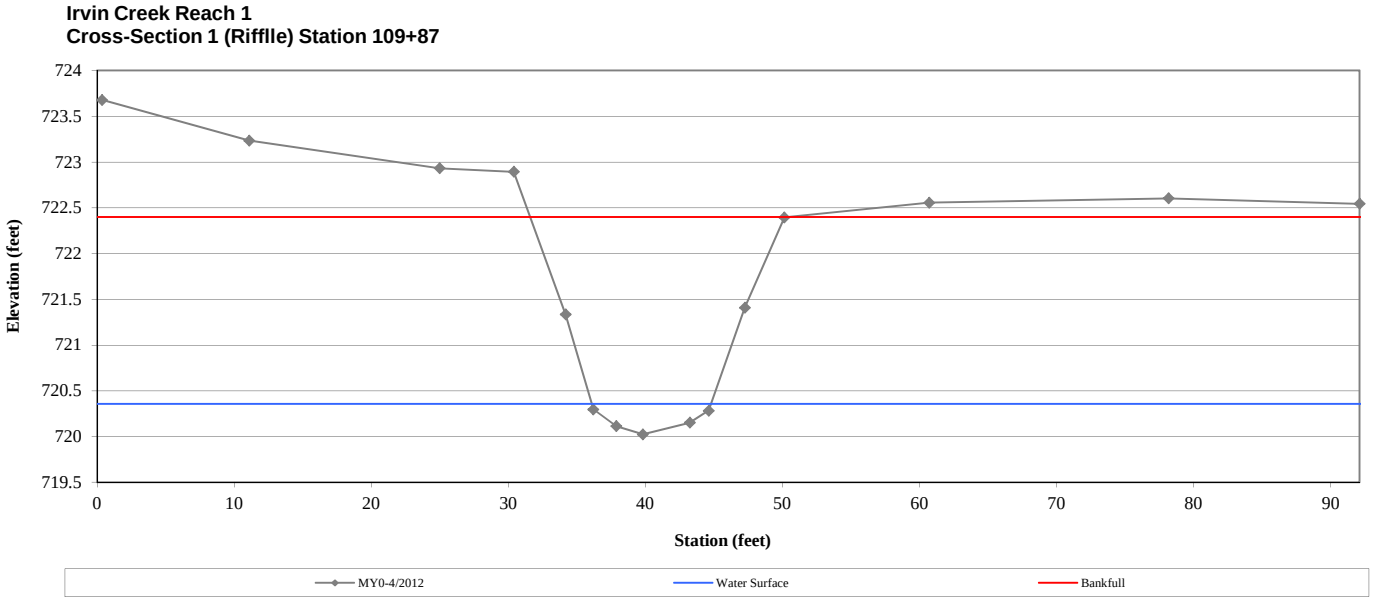
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	1
Drainage Area	0.8 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	722.4
Bankfull Cross-Sectional Area (ft2)	29.3
Bankfull Width (ft)	18.6
Flood Prone Area Elevation (ft)	724.8
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.4
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	11.8
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 1: View Upstream (6/27/2012)

Cross-Section 1: View Downstream (6/27/2012)

Station	Elevation	Station	Elevation
0.37	723.68		
11.10	723.23		
25.00	722.93		
30.41	722.89		
34.19	721.33		
36.21	720.30		
37.89	720.11		
39.83	720.02		
43.25	720.15		
44.63	720.28		
47.26	721.41		
50.15	722.40		
60.72	722.56		
78.19	722.60		
92.11	722.54		



Appendix 2. Morphological Summary Data and Plots
Figure 4b. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Cross-Section 2 (Pool)
Monitoring Year 0

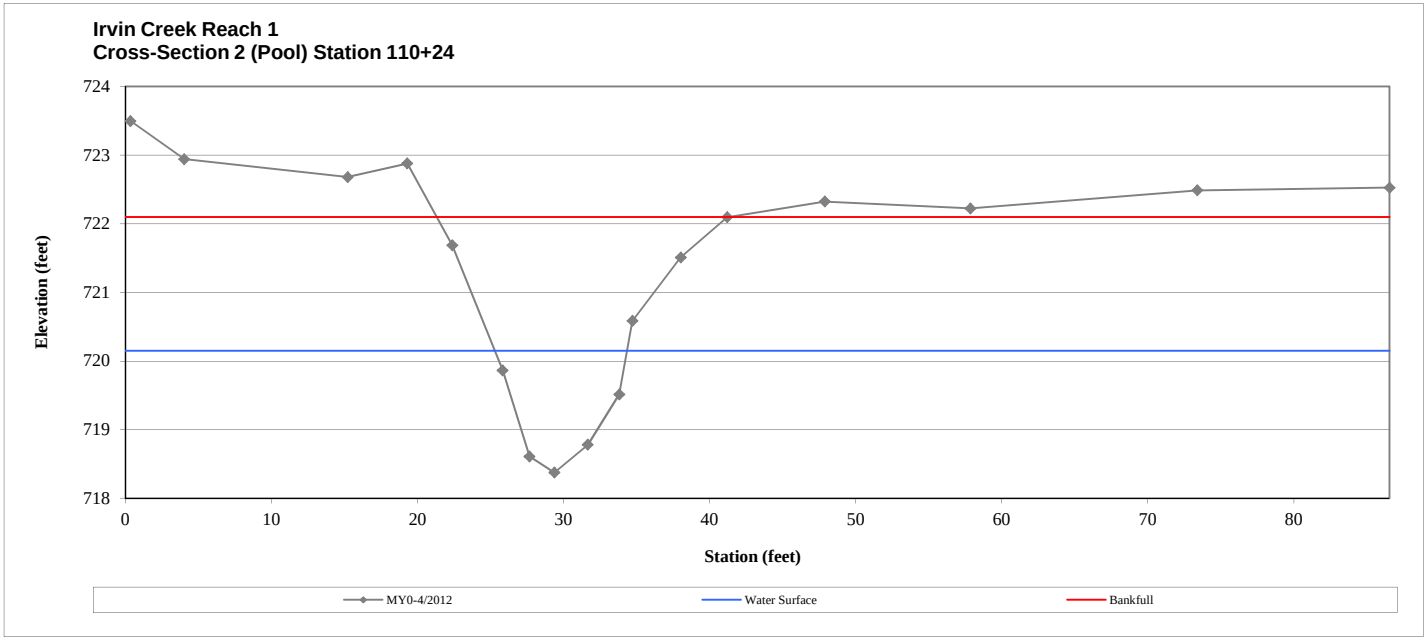
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	2
Drainage Area	0.8 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	722.1
Bankfull Cross-Sectional Area (ft2)	36.8
Bankfull Width (ft)	19.9
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	3.7
Mean Depth at Bankfull (ft)	1.9
W/D Ratio	10.7
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 2: View Upstream (4/25/2012)

Cross-Section 2: View Downstream (4/25/2012)

Station	Elevation	Station	Elevation
0.34	723.50		
4.03	722.94		
15.21	722.68		
19.30	722.88		
22.38	721.69		
25.83	719.86		
27.67	718.61		
29.37	718.37		
31.66	718.78		
33.81	719.52		
34.71	720.58		
38.02	721.51		
41.20	722.10		
47.88	722.32		
57.86	722.22		
73.39	722.49		
86.55	722.53		



Appendix 2. Morphological Summary Data and Plots
Figure 4c. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Cross-Section 3 (Pool)
Monitoring Year 0

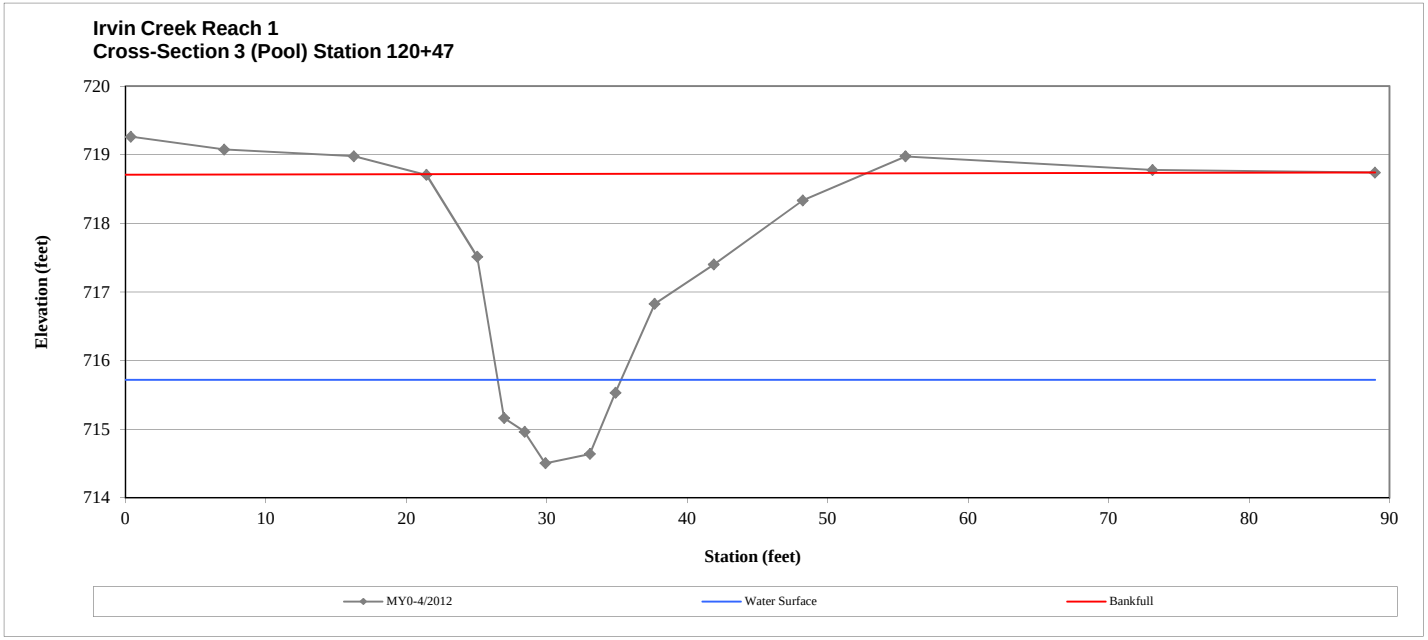
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	3
Drainage Area	0.8 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	718.7
Bankfull Cross-Sectional Area (ft2)	57.6
Bankfull Width (ft)	31.1
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	4.2
Mean Depth at Bankfull (ft)	1.9
W/D Ratio	16.8
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 3: View Upstream (4/25/2012)

Cross-Section 3: View Downstream (4/25/2012)

Station	Elevation	Station	Elevation
0.38	719.26		
7.03	719.08		
16.26	718.98		
21.44	718.71		
25.05	717.51		
26.96	715.16		
28.42	714.96		
29.90	714.51		
33.07	714.64		
34.89	715.53		
37.68	716.83		
41.90	717.40		
48.23	718.33		
55.54	718.98		
73.12	718.78		
88.97	718.74		



Appendix 2. Morphological Summary Data and Plots
Figure 4d. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Cross-Section 4 (Riffle)
Monitoring Year 0

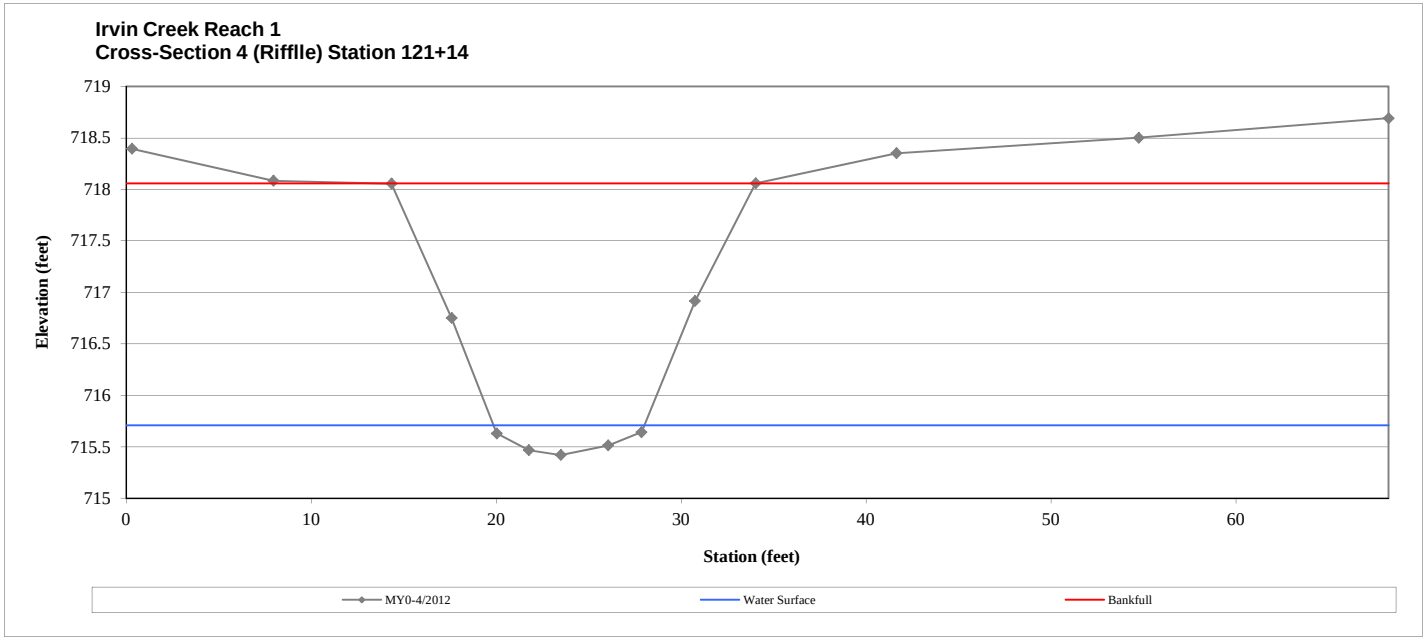
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	4
Drainage Area	0.8 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	718.1
Bankfull Cross-Sectional Area (ft2)	33.7
Bankfull Width (ft)	19.7
Flood Prone Area Elevation (ft)	720.7
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.6
Mean Depth at Bankfull (ft)	1.7
W/D Ratio	11.5
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 4: View Upstream (4/25/2012)

Cross-Section 4: View Downstream (4/25/2012)

Station	Elevation	Station	Elevation
0.32	718.40		
7.97	718.08		
14.35	718.06		
17.60	716.75		
20.04	715.63		
21.78	715.47		
23.50	715.42		
26.07	715.51		
27.87	715.64		
30.76	716.92		
34.03	718.06		
41.65	718.35		
54.74	718.50		
68.25	718.69		



Appendix 2. Morphological Summary Data and Plots
Figure 4e. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Cross-Section 5 (Pool)
Monitoring Year 0

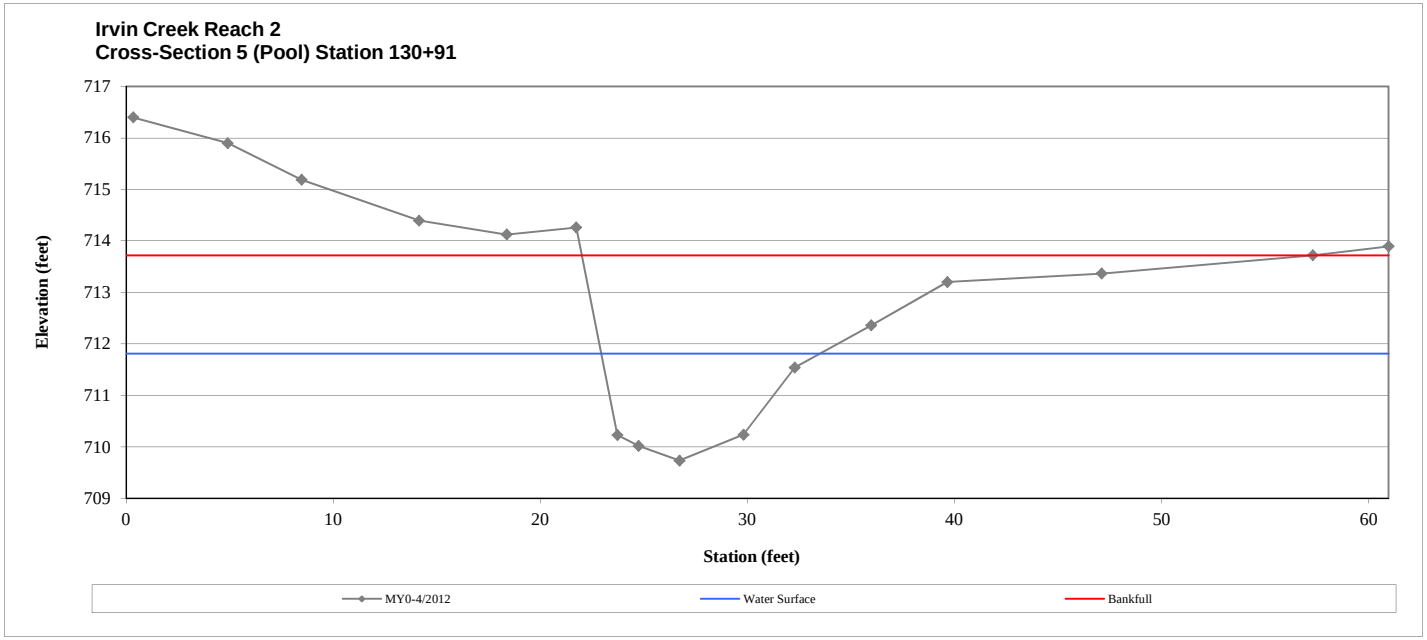
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	5
Drainage Area	0.9 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	713.7
Bankfull Cross-Sectional Area (ft2)	47.9
Bankfull Width (ft)	35.3
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	4.0
Mean Depth at Bankfull (ft)	1.4
W/D Ratio	26.0
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 5: View Upstream (5/18/2012)

Cross-Section 5: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.34	716.40		
4.91	715.90		
8.48	715.19		
14.15	714.40		
18.38	714.12		
21.74	714.26		
23.72	710.23		
24.74	710.02		
26.72	709.73		
29.81	710.24		
32.29	711.54		
35.98	712.36		
39.66	713.20		
47.11	713.37		
57.30	713.72		
60.96	713.89		



Appendix 2. Morphological Summary Data and Plots
Figure 4f. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Cross-Section 6 (Riffle)
Monitoring Year 0

River Basin	Cape Fear
Watershed HUC	3030002
XS ID	6
Drainage Area	0.9 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

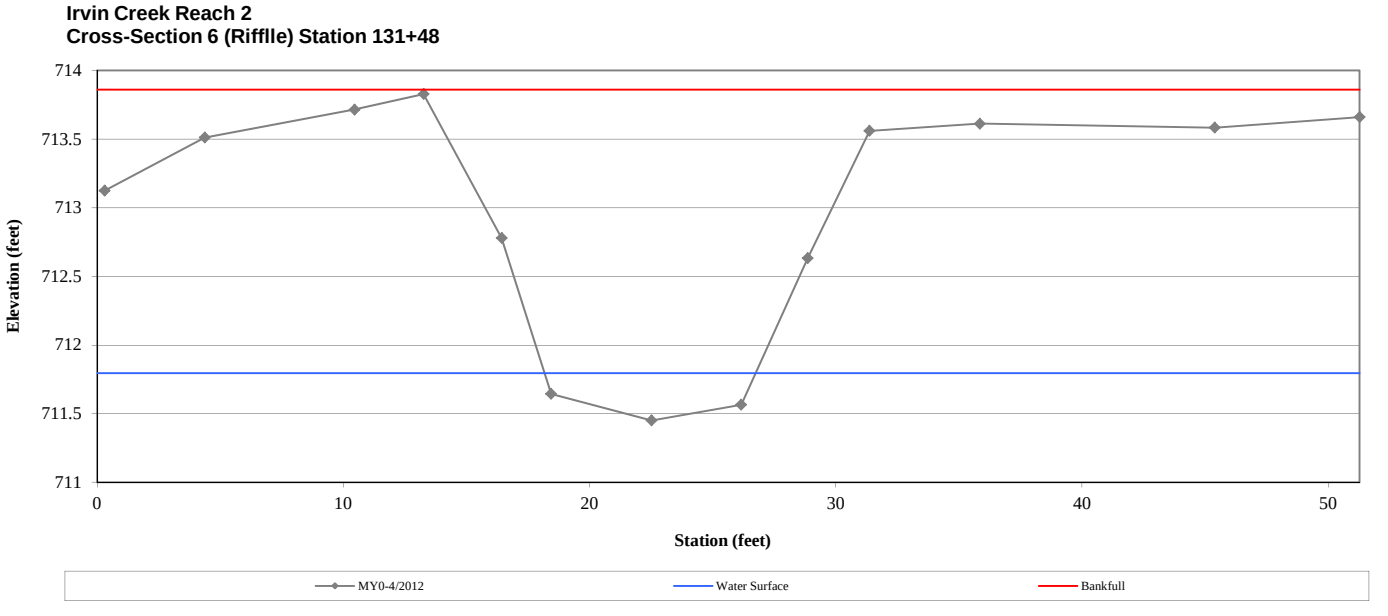
Summary Data*	
Bankfull Elevation (ft)	713.9
Bankfull Cross-Sectional Area (ft2)	29.0
Bankfull Width (ft)	18.1
Flood Prone Area Elevation (ft)	716.2
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.4
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	11.3
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

*Summary cross-section calculations exclude floodplain area (STA 0 to 13.26 and 31.37 to 51.27)

Cross-Section 6: View Upstream (5/18/2012)

Cross-Section 6: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.30	713.12		
4.37	713.51		
10.45	713.72		
13.26	713.83		
16.43	712.78		
18.44	711.64		
22.52	711.45		
26.16	711.57		
28.86	712.63		
31.37	713.56		
35.85	713.61		
45.39	713.58		
51.27	713.66		



Appendix 2. Morphological Summary Data and Plots
Figure 4g. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Cross-Section 7 (Riffle)
Monitoring Year 0

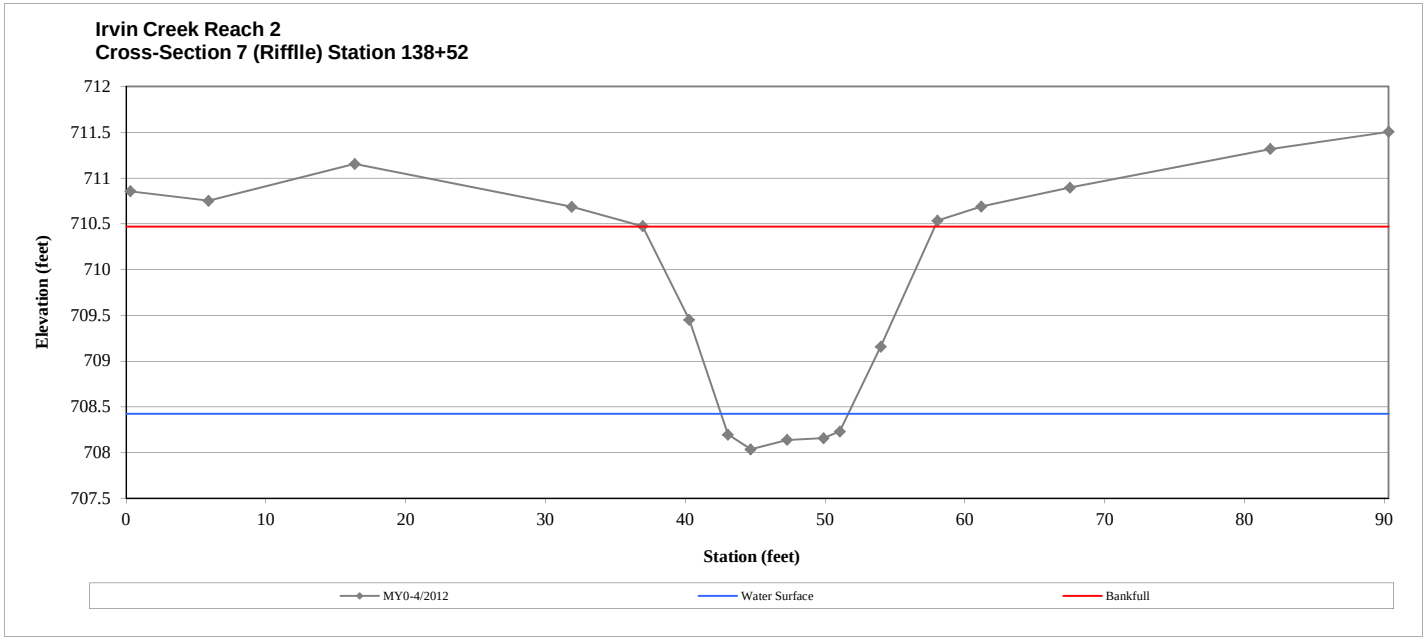
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	7
Drainage Area	0.9 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	710.5
Bankfull Cross-Sectional Area (ft2)	32.7
Bankfull Width (ft)	20.9
Flood Prone Area Elevation (ft)	712.9
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	2.4
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	13.3
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 7: View Upstream (5/18/2012)

Cross-Section 7: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.31	710.85		
5.90	710.75		
16.35	711.15		
31.88	710.68		
36.95	710.47		
40.29	709.45		
43.05	708.20		
44.68	708.03		
47.28	708.14		
49.89	708.16		
51.05	708.23		
53.99	709.16		
58.05	710.54		
61.19	710.69		
67.51	710.90		
81.85	711.32		
90.31	711.51		



Appendix 2. Morphological Summary Data and Plots
Figure 4h. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Cross-Section 8 (Pool)
Monitoring Year 0

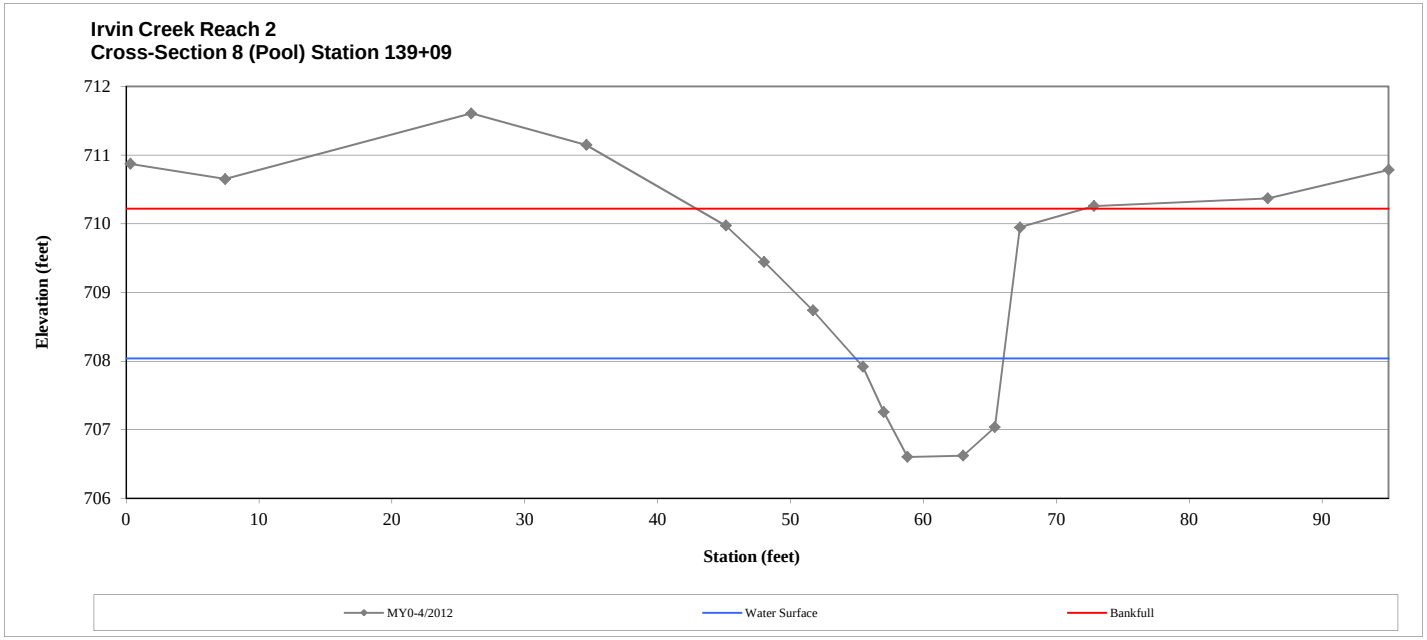
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	8
Drainage Area	0.9 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	710.2
Bankfull Cross-Sectional Area (ft2)	50.1
Bankfull Width (ft)	29.2
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	3.6
Mean Depth at Bankfull (ft)	1.7
W/D Ratio	17.0
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 8: View Upstream (5/18/2012)

Cross-Section 8: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.32	710.87		
7.46	710.65		
25.98	711.61		
34.64	711.15		
45.13	709.97		
48.01	709.45		
51.68	708.74		
55.44	707.92		
57.02	707.26		
58.80	706.60		
62.99	706.62		
65.37	707.04		
67.27	709.95		
72.83	710.26		
85.92	710.37		
95.00	710.79		



Appendix 2. Morphological Summary Data and Plots
Figure 4i. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
UT1, Cross-Section 9 (Riffle)
Monitoring Year 0

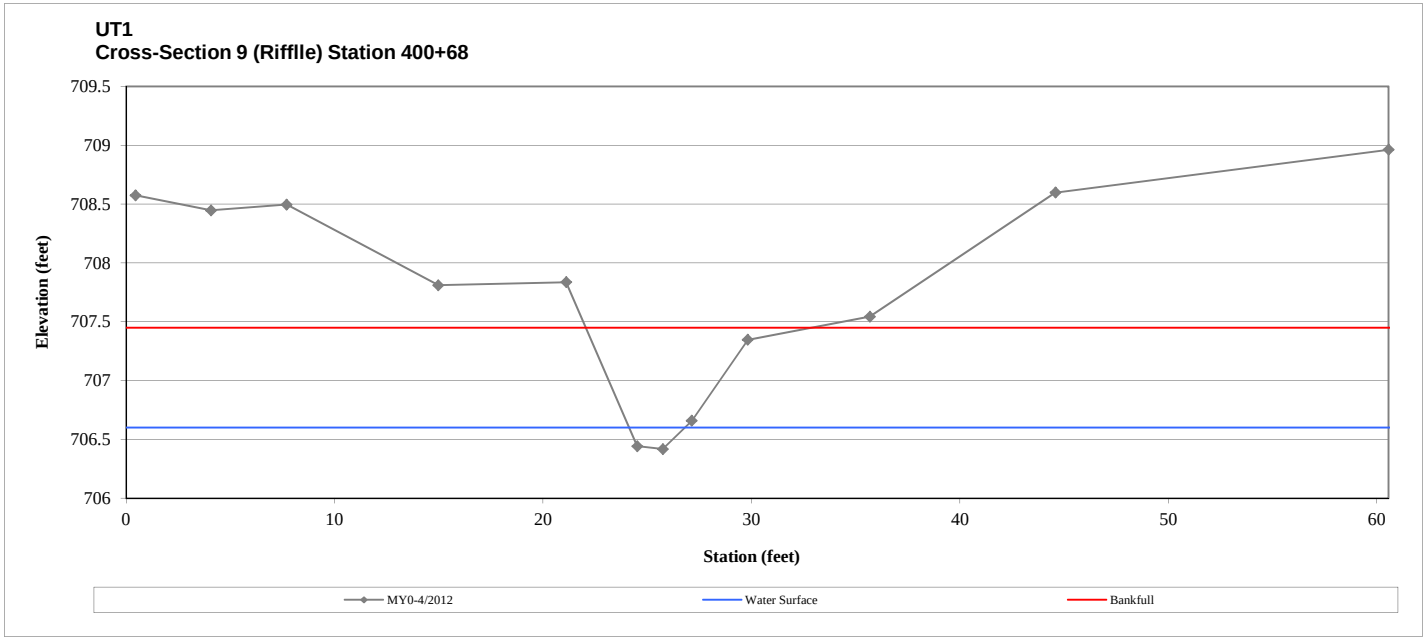
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	9
Drainage Area	0.1 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	707.5
Bankfull Cross-Sectional Area (ft2)	5.1
Bankfull Width (ft)	10.9
Flood Prone Area Elevation (ft)	708.5
Flood Prone Width (ft)	36.7
Max Depth at Bankfull (ft)	1.0
Mean Depth at Bankfull (ft)	0.5
W/D Ratio	23.0
Entrenchment Ratio	3.6
Bank Height Ratio	1.0
Stream Type	C

Cross-Section 9: View Upstream (5/18/2012)

Cross-Section 9: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.45	708.58		
4.07	708.45		
7.70	708.50		
14.98	707.81		
21.11	707.84		
24.52	706.44		
25.75	706.42		
27.14	706.66		
29.82	707.35		
35.69	707.54		
44.58	708.60		
60.56	708.96		



Appendix 2. Morphological Summary Data and Plots
Figure 4j. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
UT1, Cross-Section 10 (Pool)
Monitoring Year 0

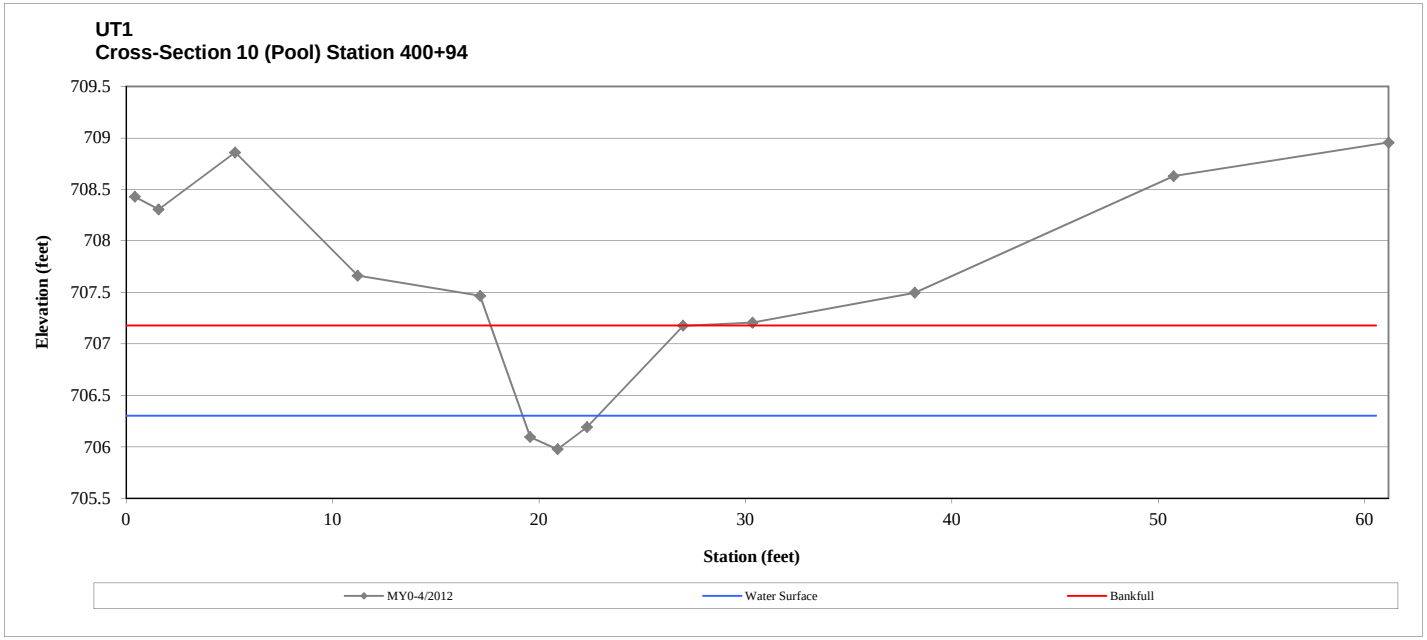
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	10
Drainage Area	0.1 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	707.2
Bankfull Cross-Sectional Area (ft2)	6.4
Bankfull Width (ft)	9.3
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	1.2
Mean Depth at Bankfull (ft)	0.7
W/D Ratio	13.5
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 10: View Upstream (5/18/2012)

Cross-Section 10: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.42	708.43		
1.58	708.31		
5.28	708.86		
11.22	707.66		
17.15	707.47		
19.58	706.09		
20.90	705.98		
22.33	706.19		
26.99	707.18		
30.34	707.21		
38.20	707.50		
50.75	708.63		
61.16	708.96		



Appendix 2. Morphological Summary Data and Plots
Figure 4k. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek, Cross-Section 11 (Riffle)
Monitoring Year 0

River Basin	Cape Fear
Watershed HUC	3030002
XS ID	11
Drainage Area	5.1 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

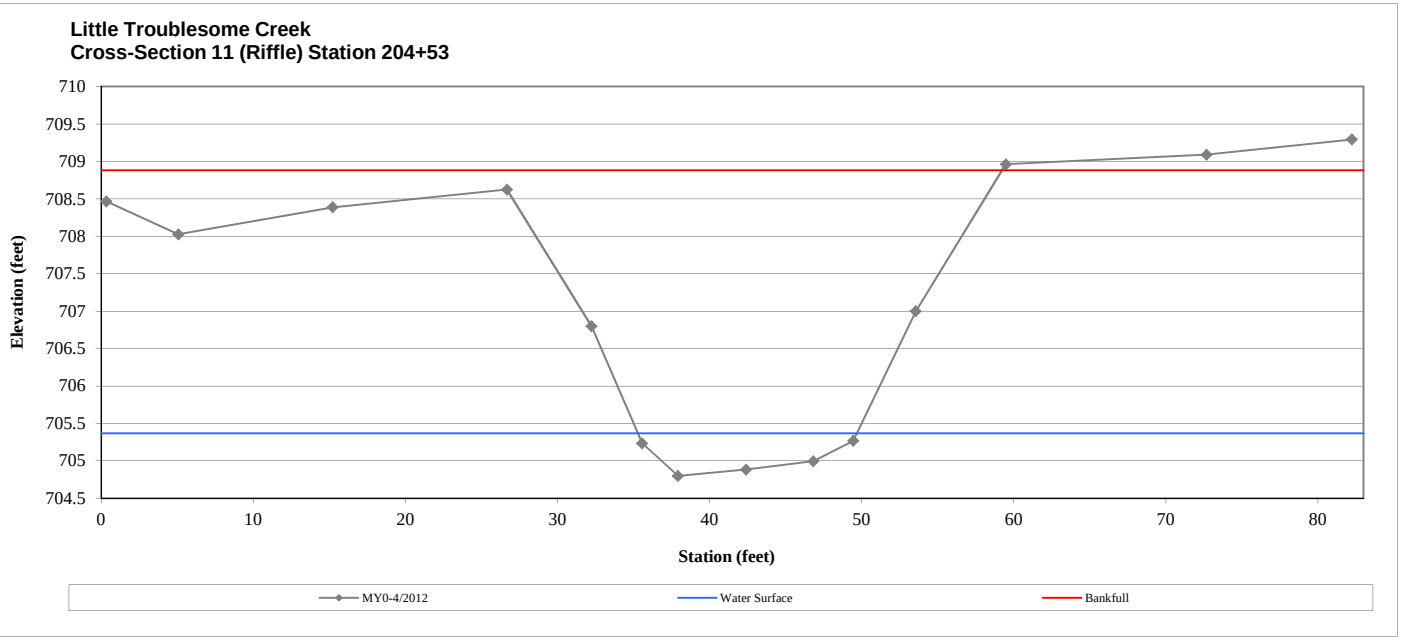
Summary Data	
Bankfull Elevation (ft)	708.9
Bankfull Cross-Sectional Area (ft2)	87.1
Bankfull Width (ft)	32.6
Flood Prone Area Elevation (ft)	713.0
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	4.1
Mean Depth at Bankfull (ft)	2.7
W/D Ratio	12.2
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

*Summary cross-section calculations exclude floodplain area (STA 0 to 26.68)

Cross-Section 11: View Upstream (5/18/2012)

Cross-Section 11: View Downstream (5/18/2012)

Station	Elevation	Station	Elevation
0.34	708.47		
5.08	708.03		
15.23	708.39		
26.68	708.62		
32.25	706.80		
35.57	705.24		
37.93	704.80		
42.41	704.88		
46.83	704.99		
49.45	705.27		
53.56	707.00		
59.48	708.96		
72.67	709.09		
82.23	709.29		



Appendix 2. Morphological Summary Data and Plots
Figure 4l. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek, Cross-Section 12 (Pool)
Monitoring Year 0

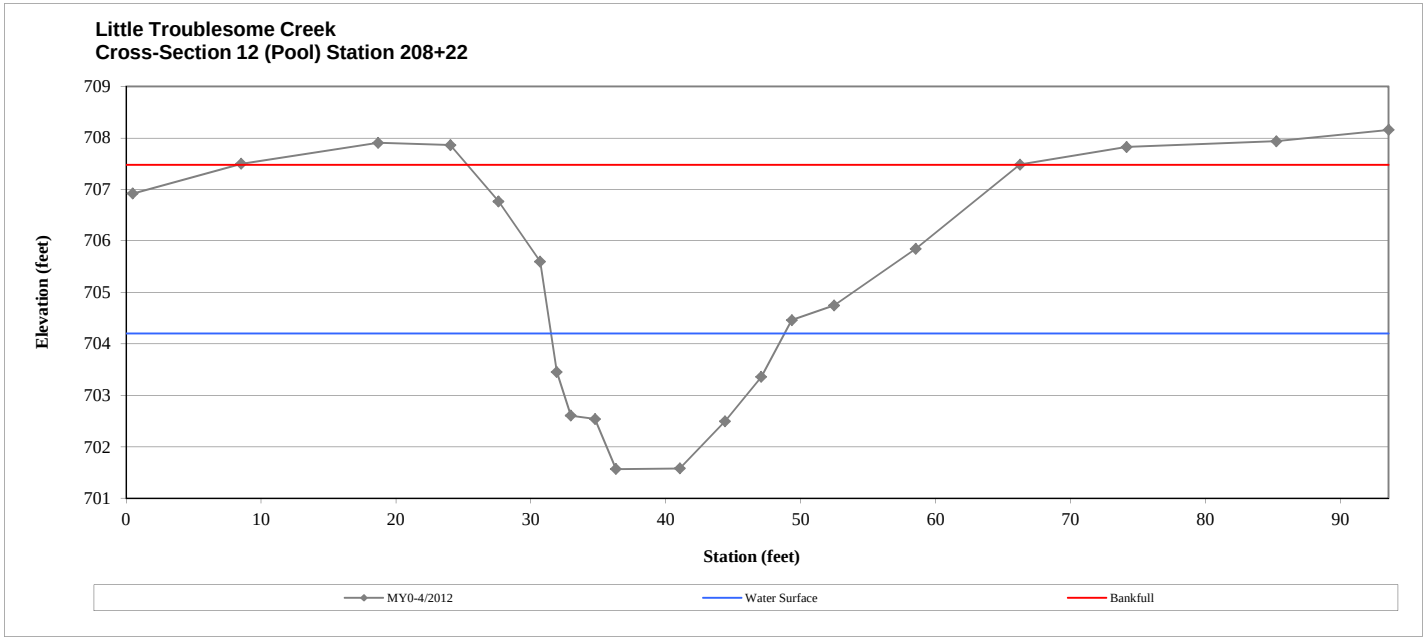
River Basin	Cape Fear
Watershed HUC	3030002
XS ID	12
Drainage Area	5.1sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

Summary Data	
Bankfull Elevation (ft)	707.5
Bankfull Cross-Sectional Area (ft2)	125.3
Bankfull Width (ft)	41.0
Flood Prone Area Elevation (ft)	N/A
Flood Prone Width (ft)	N/A
Max Depth at Bankfull (ft)	5.9
Mean Depth at Bankfull (ft)	3.1
W/D Ratio	13.4
Entrenchment Ratio	N/A
Bank Height Ratio	1.0
Stream Type	N/A

Cross-Section 12: View Upstream (4/25/2012)

Cross-Section 12: View Downstream (4/25/2012)

Station	Elevation	Station	Elevation
0.49	706.92		
8.53	707.50		
18.68	707.91		
24.03	707.86		
27.60	706.77		
30.68	705.60		
31.92	703.45		
32.96	702.61		
34.75	702.54		
36.30	701.57		
41.03	701.58		
44.39	702.50		
47.07	703.36		
49.34	704.46		
52.48	704.75		
58.52	705.85		
66.24	707.48		
74.16	707.83		
85.24	707.94		
93.56	708.16		



Appendix 2. Morphological Summary Data and Plots
Figure 4m. Cross-Section Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek, Cross-Section 13 (Riffle)
Monitoring Year 0

River Basin	Cape Fear
Watershed HUC	3030002
XS ID	13
Drainage Area	5.1 sq.mi
Date	4/2012
Field Crew	Turner Land Surveying

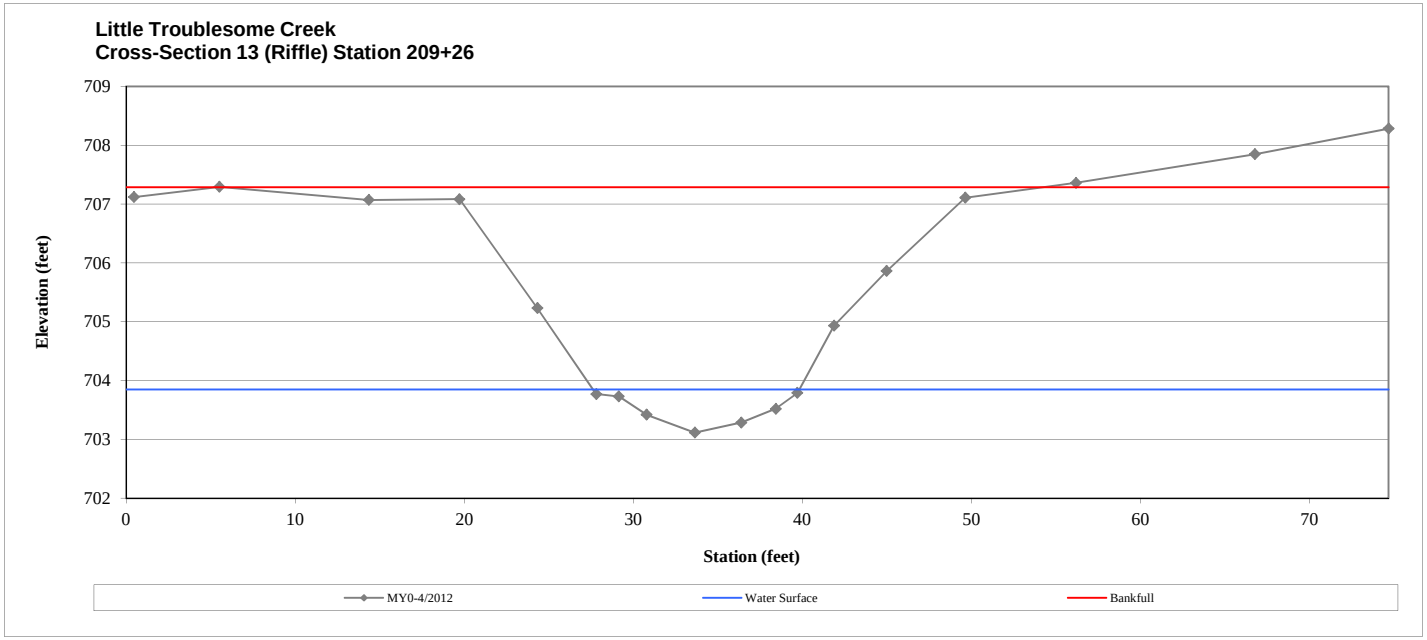
Summary Data	
Bankfull Elevation (ft)	707.3
Bankfull Cross-Sectional Area (ft2)	79.6
Bankfull Width (ft)	48.8
Flood Prone Area Elevation (ft)	711.5
Flood Prone Width (ft)	200+
Max Depth at Bankfull (ft)	4.2
Mean Depth at Bankfull (ft)	1.6
W/D Ratio	30.0
Entrenchment Ratio	2.2+
Bank Height Ratio	1.0
Stream Type	C

*Summary cross-section calculations exclude floodplain area (STA 0 to 5.52)

Cross-Section 13: View Upstream (4/25/2012)

Cross-Section 13: View Downstream (4/25/2012)

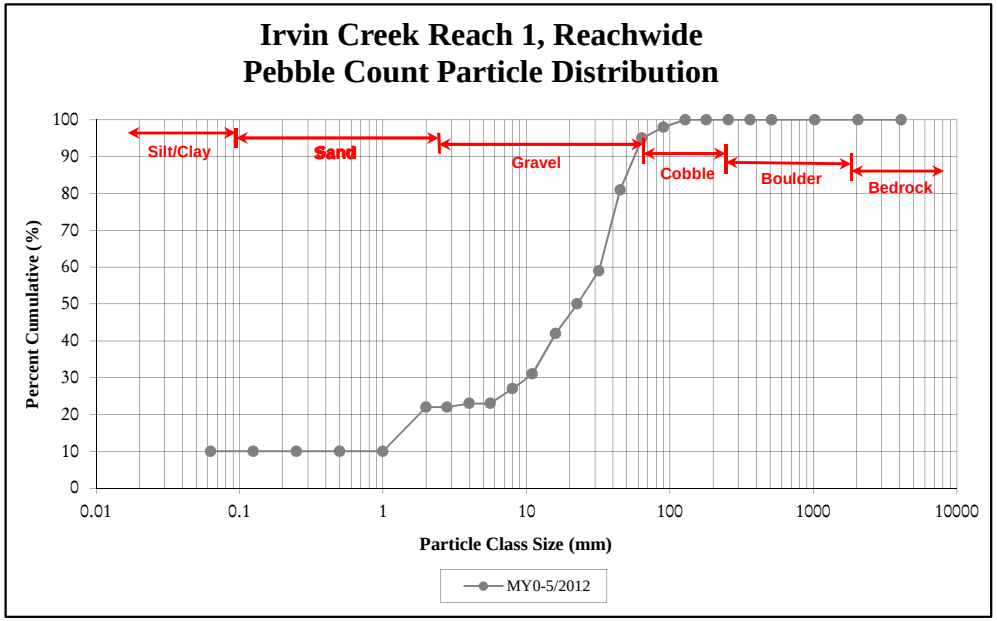
Station	Elevation	Station	Elevation
0.46	707.12		
5.52	707.29		
14.36	707.07		
19.72	707.08		
24.33	705.23		
27.81	703.77		
29.14	703.73		
30.78	703.42		
33.64	703.12		
36.39	703.29		
38.43	703.52		
39.71	703.79		
41.87	704.93		
44.99	705.86		
49.63	707.11		
56.19	707.36		
66.77	707.85		
74.67	708.29		

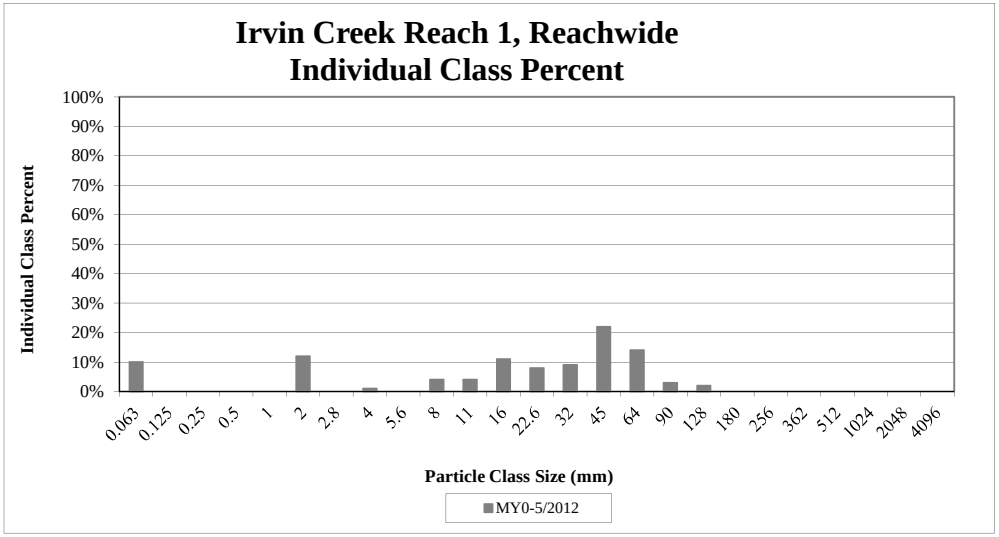


Appendix 2. Morphological Summary Data and Plots
Figure 5a. Reachwide and Cross-Section Pebble Count Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			Irvin Creek Reach 1 Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062		10	10	10	10
SAND	Very fine	0.062	0.125					10
	Fine	0.125	0.250					10
	Medium	0.250	0.500					10
	Coarse	0.5	1.0					10
	Very Coarse	1.0	2.0	3	9	12	12	22
GRAVEL	Very Fine	2.0	2.8					22
	Very Fine	2.8	4.0	1		1	1	23
	Fine	4.0	5.7					23
	Fine	5.7	8.0		4	4	4	27
	Medium	8.0	11.3		4	4	4	31
	Medium	11.3	16.0	3	8	11	11	42
	Coarse	16.0	22.6	6	2	8	8	50
	Coarse	22.6	32	7	2	9	9	59
	Very Coarse	32	45	21	1	22	22	81
	Very Coarse	45	64	14		14	14	95
COBBLE	Small	64	90	3		3	3	98
	Small	90	128	2		2	2	100
	Large	128	180					100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	> 2048					100
			Total	60	40	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	22.6
D_{84} =	48.5
D_{95} =	64.0
D_{100} =	128.0

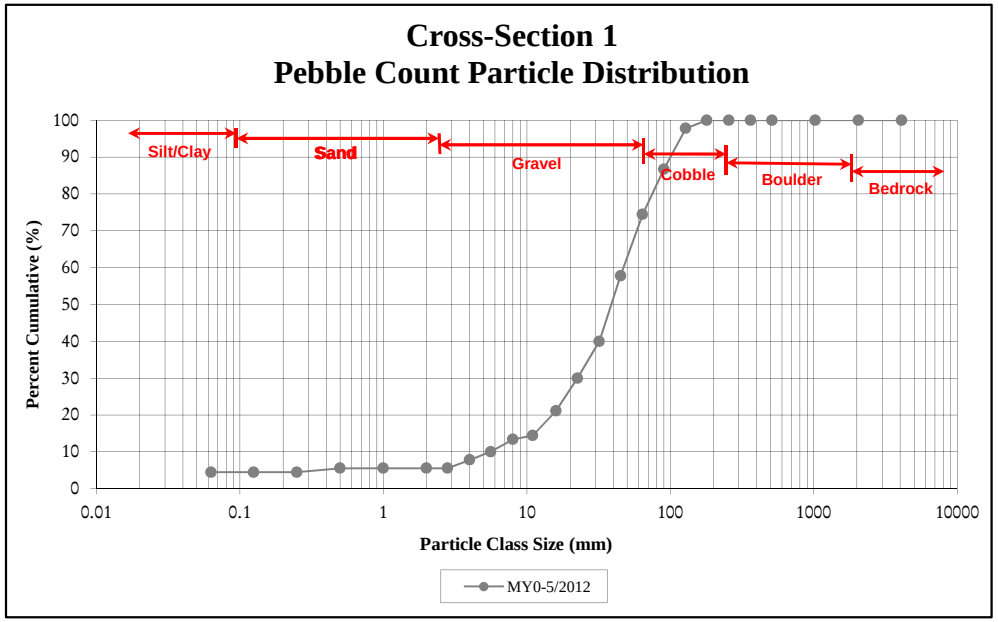


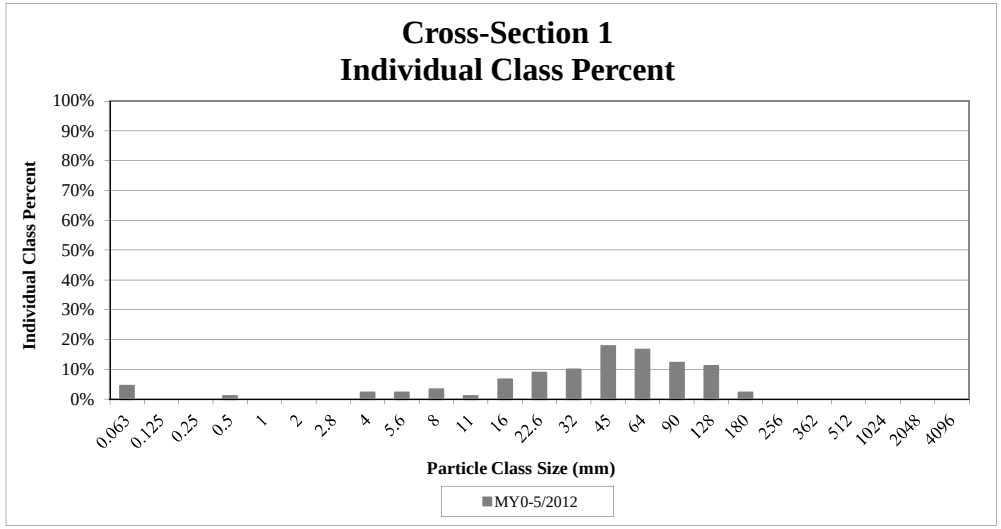


Appendix 2. Morphological Summary Data and Plots
Figure 5b. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Cross-Section 1 (Riffle)
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 1 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	4	4	4
SAND	Very fine	0.062	0.125			4
	Fine	0.125	0.250			4
	Medium	0.250	0.500	1	1	6
	Coarse	0.5	1.0			6
	Very Coarse	1.0	2.0			6
GRAVEL	Very Fine	2.0	2.8			6
	Very Fine	2.8	4.0	2	2	8
	Fine	4.0	5.7	2	2	10
	Fine	5.7	8.0	3	3	13
	Medium	8.0	11.3	1	1	14
	Medium	11.3	16.0	6	7	21
	Coarse	16.0	22.6	8	9	30
	Coarse	22.6	32	9	10	40
	Very Coarse	32	45	16	18	58
	Very Coarse	45	64	15	17	74
COBBLE	Small	64	90	11	12	87
	Small	90	128	10	11	98
	Large	128	180	2	2	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	> 2048			100
			Total	90	100	100

Cross-Section 1 Channel materials (mm)	
D_{16} =	12.0
D_{35} =	26.9
D_{50} =	38.8
D_{84} =	83.5
D_{95} =	117.2
D_{100} =	180.0

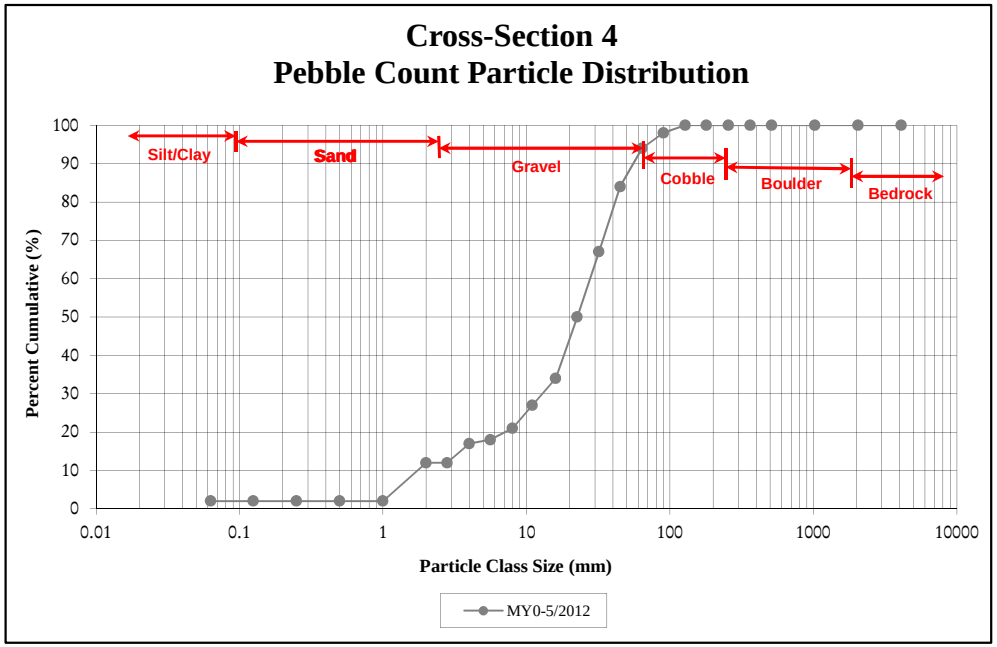


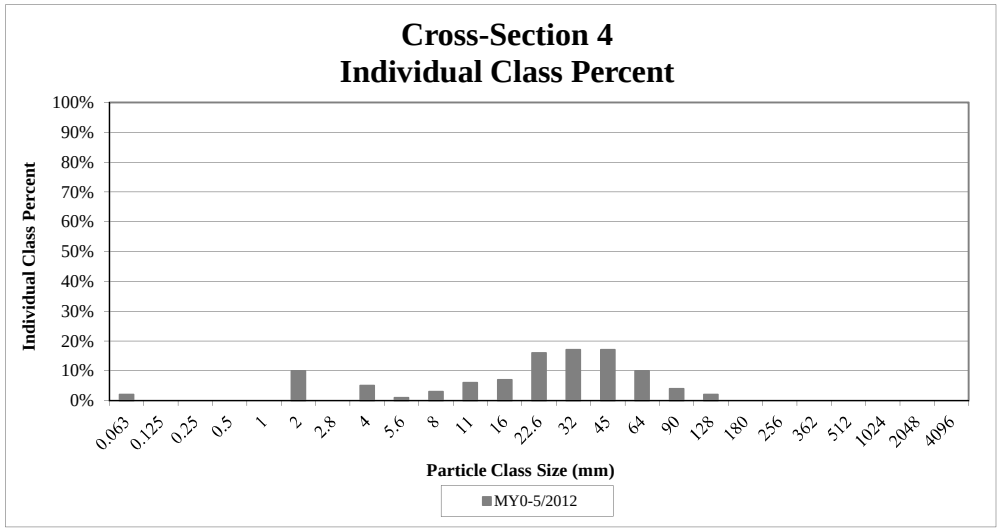


Appendix 2. Morphological Summary Data and Plots
Figure 5c. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 1, Cross-Section 4 (Riffle)
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 4 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	2	2	2
SAND	Very fine	0.062	0.125			2
	Fine	0.125	0.250			2
	Medium	0.250	0.500			2
	Coarse	0.5	1.0			2
	Very Coarse	1.0	2.0	10	10	12
GRAVEL	Very Fine	2.0	2.8			12
	Very Fine	2.8	4.0	5	5	17
	Fine	4.0	5.7	1	1	18
	Fine	5.7	8.0	3	3	21
	Medium	8.0	11.3	6	6	27
	Medium	11.3	16.0	7	7	34
	Coarse	16.0	22.6	16	16	50
	Coarse	22.6	32	17	17	67
	Very Coarse	32	45	17	17	84
	Very Coarse	45	64	10	10	94
COBBLE	Small	64	90	4	4	98
	Small	90	128	2	2	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 4 Channel materials (mm)	
D_{16} =	3.7
D_{35} =	16.3
D_{50} =	22.6
D_{84} =	45.0
D_{95} =	69.7
D_{100} =	128.0

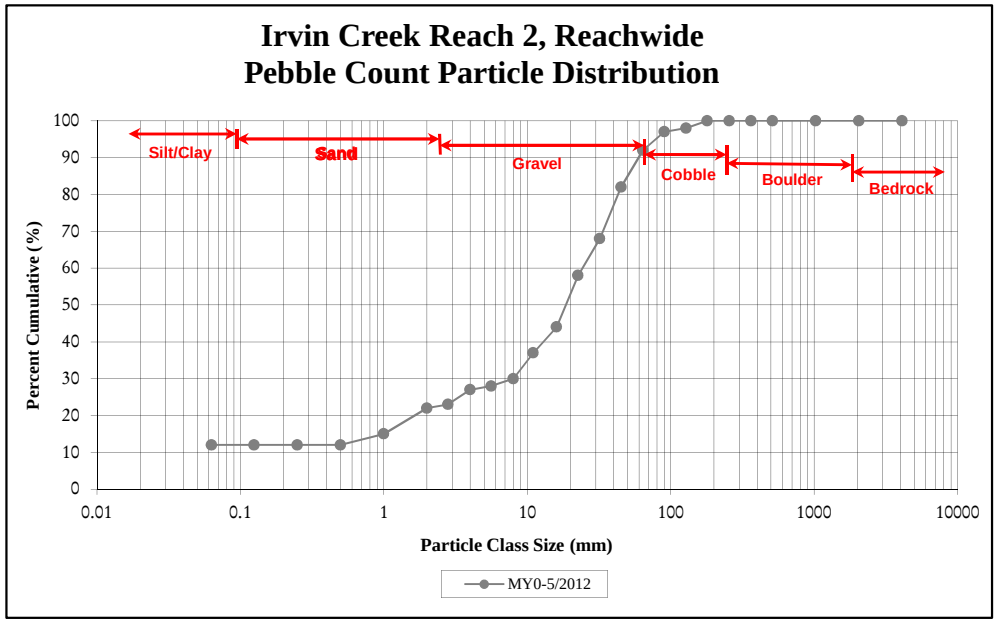


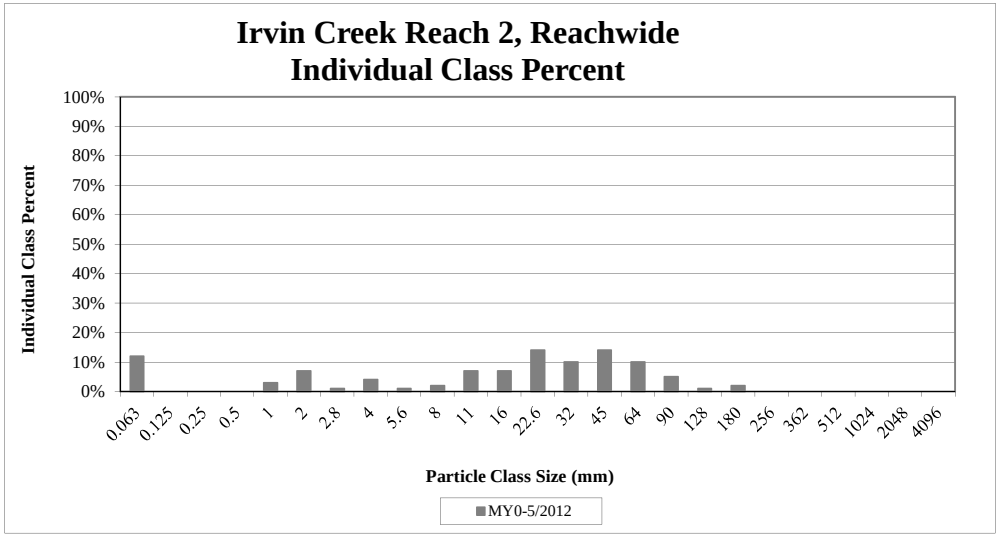


Appendix 2. Morphological Summary Data and Plots
Figure 5d. Reachwide and Cross-Section Pebble Count Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			Irvin Creek Reach 2 Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	1	11	12	12	12
SAND	Very fine	0.062	0.125					12
	Fine	0.125	0.250					12
	Medium	0.250	0.500					12
	Coarse	0.5	1.0		3	3	3	15
	Very Coarse	1.0	2.0	3	4	7	7	22
GRAVEL	Very Fine	2.0	2.8		1	1	1	23
	Very Fine	2.8	4.0	1	3	4	4	27
	Fine	4.0	5.7		1	1	1	28
	Fine	5.7	8.0		2	2	2	30
	Medium	8.0	11.3	2	5	7	7	37
	Medium	11.3	16.0	3	4	7	7	44
	Coarse	16.0	22.6	10	4	14	14	58
	Coarse	22.6	32	9	1	10	10	68
	Very Coarse	32	45	14		14	14	82
	Very Coarse	45	64	9	1	10	10	92
COBBLE	Small	64	90	5		5	5	97
	Small	90	128	1		1	1	98
	Large	128	180	2		2	2	100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	60	40	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	18.6
D_{84} =	48.3
D_{95} =	78.5
D_{100} =	180.0

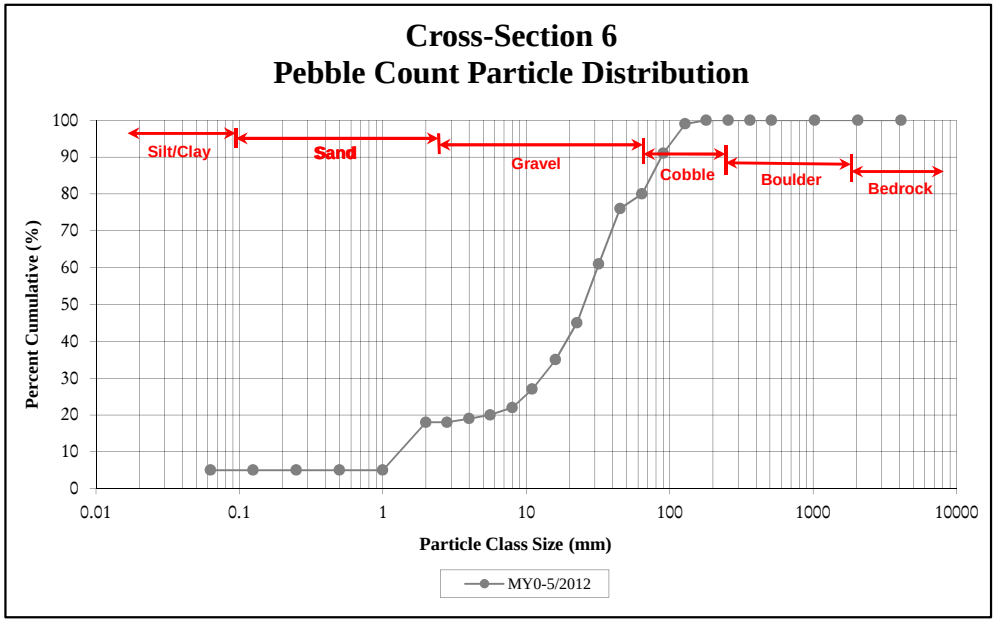


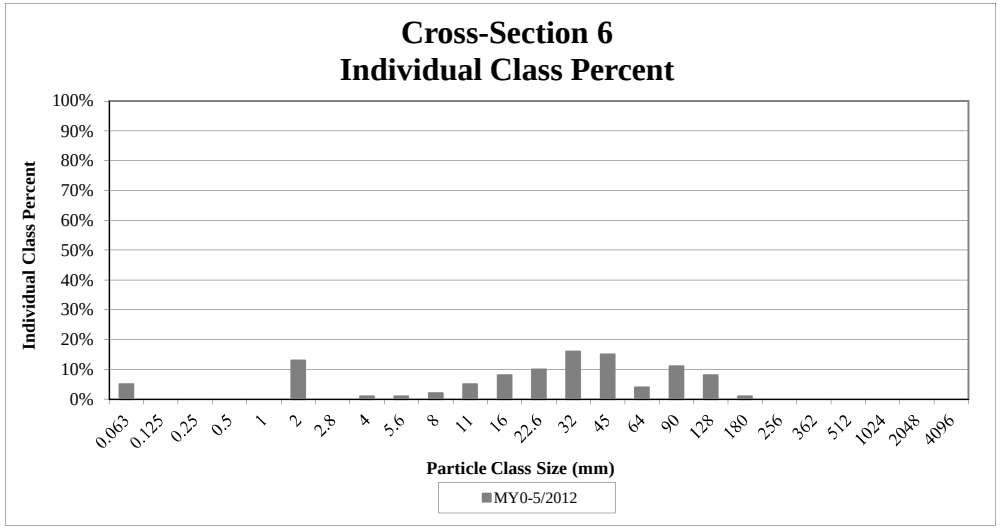


Appendix 2. Morphological Summary Data and Plots
Figure 5e. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Cross-Section 6 (Riffle)
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 6 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	5	5	5
SAND	Very fine	0.062	0.125			5
	Fine	0.125	0.250			5
	Medium	0.250	0.500			5
	Coarse	0.5	1.0			5
	Very Coarse	1.0	2.0	13	13	18
GRAVEL	Very Fine	2.0	2.8			18
	Very Fine	2.8	4.0	1	1	19
	Fine	4.0	5.7	1	1	20
	Fine	5.7	8.0	2	2	22
	Medium	8.0	11.3	5	5	27
	Medium	11.3	16.0	8	8	35
	Coarse	16.0	22.6	10	10	45
	Coarse	22.6	32	16	16	61
	Very Coarse	32	45	15	15	76
	Very Coarse	45	64	11	11	87
COBBLE	Small	64	90	8	8	95
	Small	90	128	5	5	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	> 2048			100
			Total	100	100	100

Cross-Section 6 Channel materials (mm)	
D_{16} =	1.8
D_{35} =	16.0
D_{50} =	25.2
D_{84} =	58.1
D_{95} =	90.0
D_{100} =	128.0

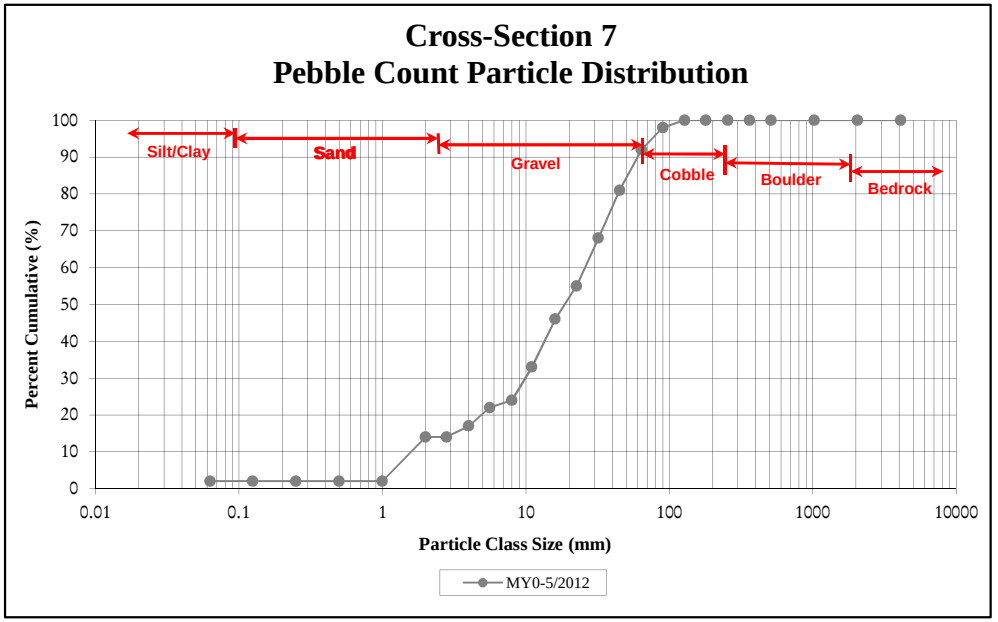


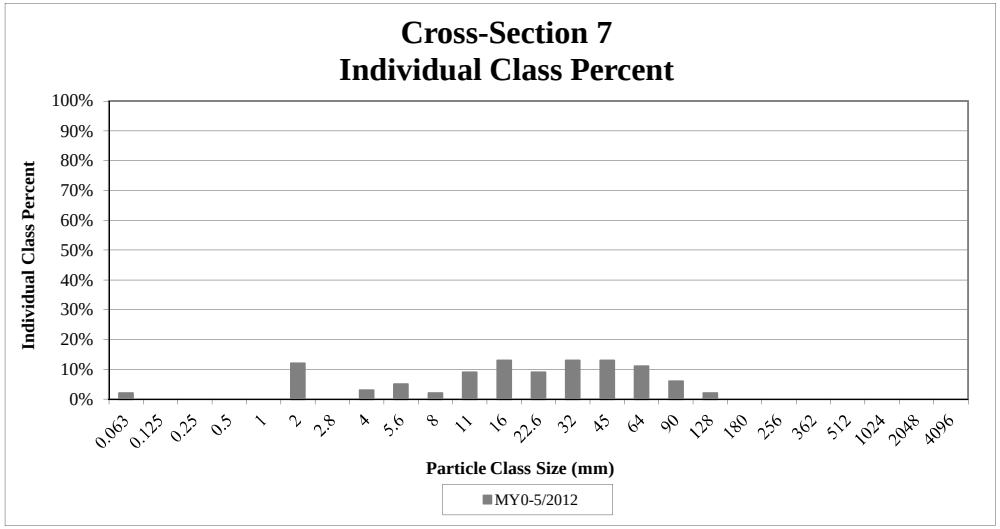


Appendix 2. Morphological Summary Data and Plots
Figure 5f. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Irvin Creek Reach 2, Cross-Section 7 (Riffle)
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 7 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	2	2	2
SAND	Very fine	0.062	0.125			2
	Fine	0.125	0.250			2
	Medium	0.250	0.500			2
	Coarse	0.5	1.0			2
	Very Coarse	1.0	2.0	12	12	14
GRAVEL	Very Fine	2.0	2.8			14
	Very Fine	2.8	4.0	3	3	17
	Fine	4.0	5.7	5	5	22
	Fine	5.7	8.0	2	2	24
	Medium	8.0	11.3	9	9	33
	Medium	11.3	16.0	13	13	46
	Coarse	16.0	22.6	9	9	55
	Coarse	22.6	32	13	13	68
	Very Coarse	32	45	13	13	81
	Very Coarse	45	64	11	11	92
COBBLE	Small	64	90	6	6	98
	Small	90	128	2	2	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	> 2048			100
			Total	100	100	100

Cross-Section 7 Channel materials (mm)	
D_{16} =	3.6
D_{35} =	11.7
D_{50} =	18.7
D_{84} =	49.5
D_{95} =	75.9
D_{100} =	128.0

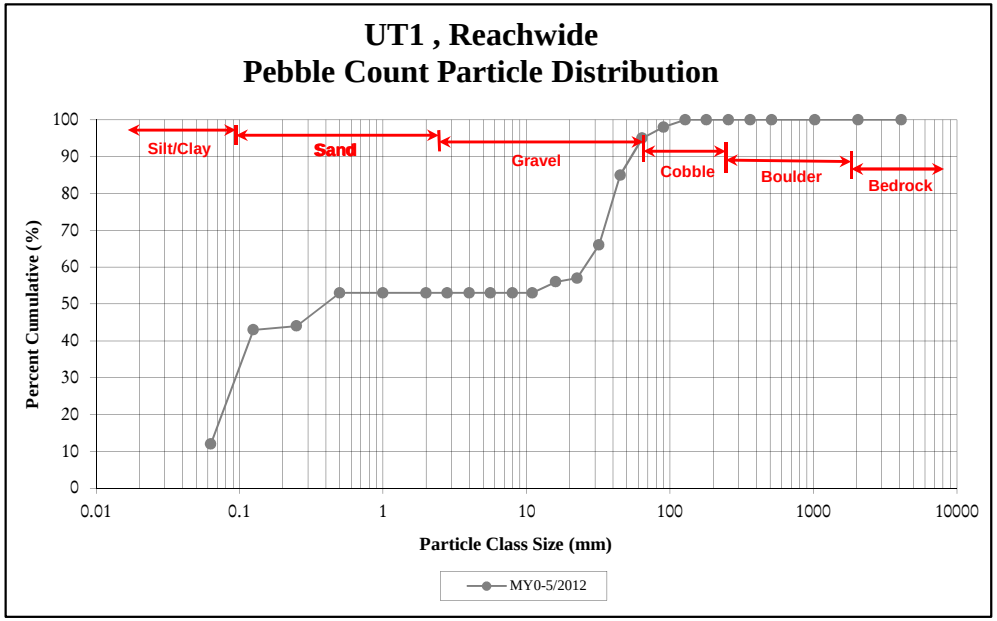


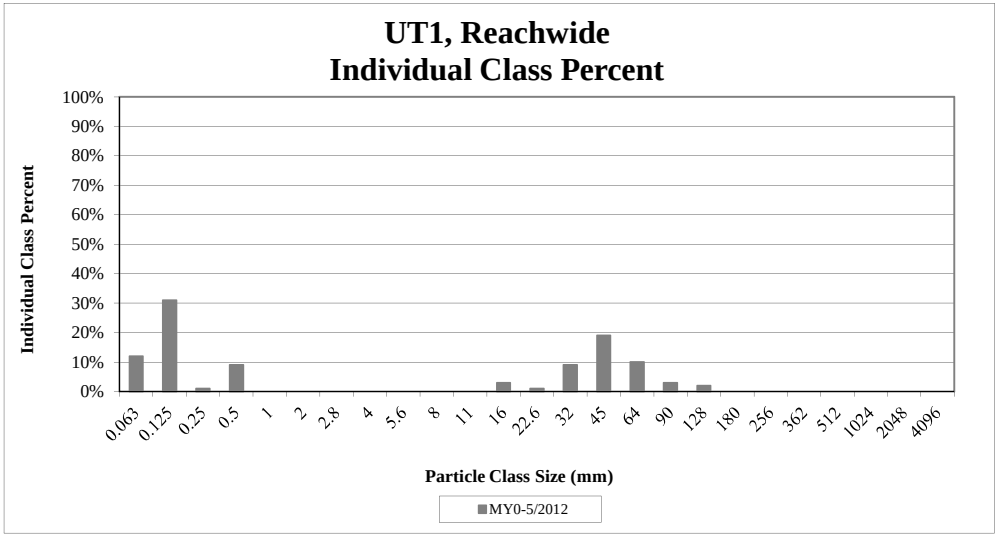


Appendix 2. Morphological Summary Data and Plots
Figure 5g. Reachwide and Cross-Section Pebble Count Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
UT1, Reachwide
Monitoring Year 0 of 5

Particle Class		Diameter (mm)		Particle Count			UT1 Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062		12	12	12	12
SAND	Very fine	0.062	0.125	11	20	31	31	43
	Fine	0.125	0.250		1	1	1	44
	Medium	0.250	0.500	2	7	9	9	53
	Coarse	0.5	1.0					53
	Very Coarse	1.0	2.0					53
GRAVEL	Very Fine	2.0	2.8					53
	Very Fine	2.8	4.0					53
	Fine	4.0	5.7					53
	Fine	5.7	8.0					53
	Medium	8.0	11.3					53
	Medium	11.3	16.0	3		3	3	56
	Coarse	16.0	22.6	1		1	1	57
	Coarse	22.6	32	9		9	9	66
	Very Coarse	32	45	19		19	19	85
	Very Coarse	45	64	10		10	10	95
COBBLE	Small	64	90	3		3	3	98
	Small	90	128	2		2	2	100
	Large	128	180					100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	> 2048					100
			Total	60	40	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	0.4
D_{84} =	44.2
D_{95} =	64.0
D_{100} =	128.0

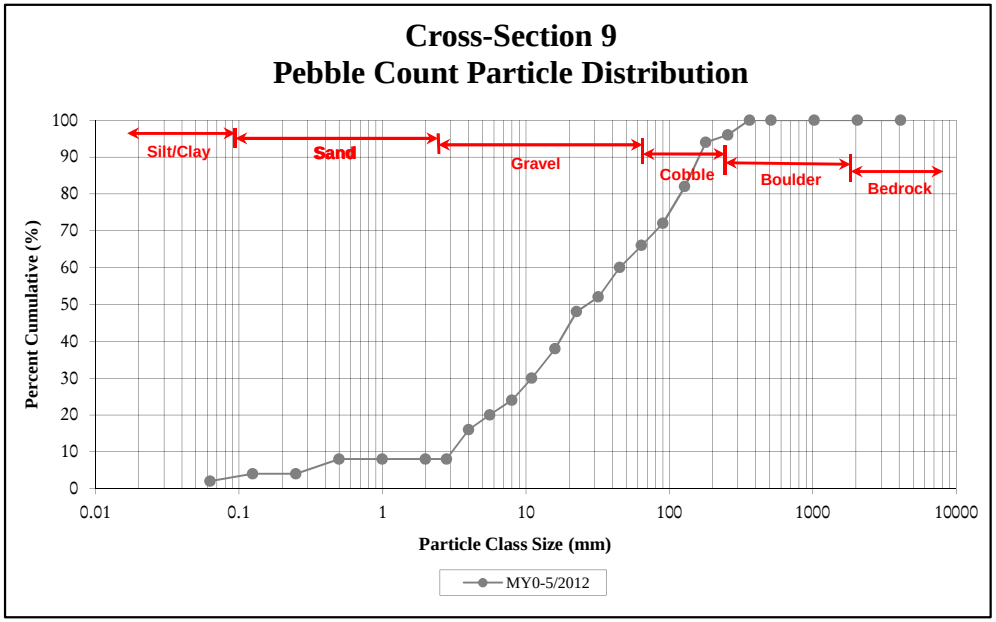


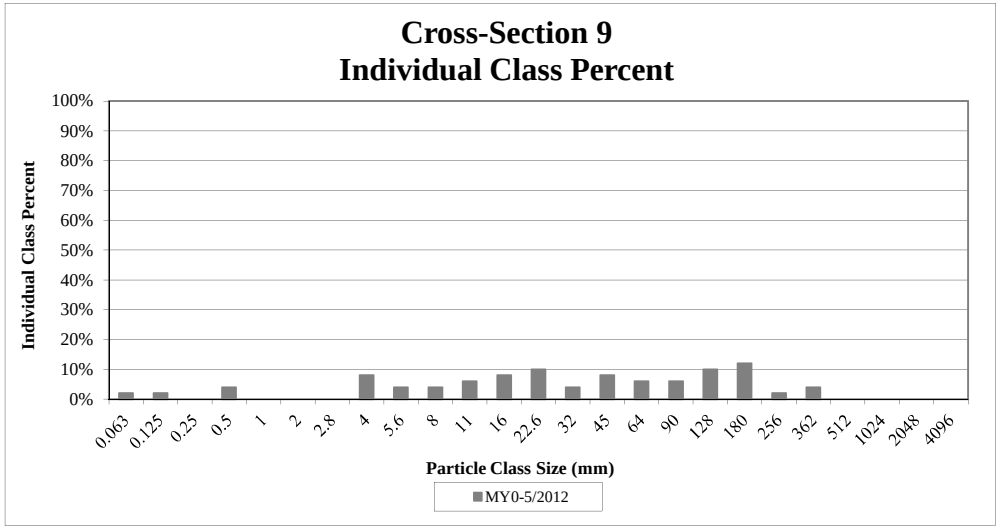


Appendix 2. Morphological Summary Data and Plots
Figure 5h. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
UT1, Cross-Section 9 (Riffle)
Monitoring Year 0 of 5

Particle Class		Diameter (mm)		Particle Count	Cross-Section 9 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	9	9	9
SAND	Very fine	0.062	0.125	5	5	14
	Fine	0.125	0.250			14
	Medium	0.250	0.500			14
	Coarse	0.5	1.0			14
	Very Coarse	1.0	2.0			14
GRAVEL	Very Fine	2.0	2.8			14
	Very Fine	2.8	4.0			14
	Fine	4.0	5.7			14
	Fine	5.7	8.0	2	2	16
	Medium	8.0	11.3	2	2	18
	Medium	11.3	16.0	3	3	21
	Coarse	16.0	22.6	17	17	38
	Coarse	22.6	32	22	22	60
	Very Coarse	32	45	21	21	81
	Very Coarse	45	64	12	12	93
COBBLE	Small	64	90	4	4	97
	Small	90	128	3	3	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	> 2048			100
			Total	100	100	100

Cross-Section 9 Channel materials (mm)	
D_{16} =	8.0
D_{35} =	21.3
D_{50} =	27.3
D_{84} =	49.1
D_{95} =	75.9
D_{100} =	128.0

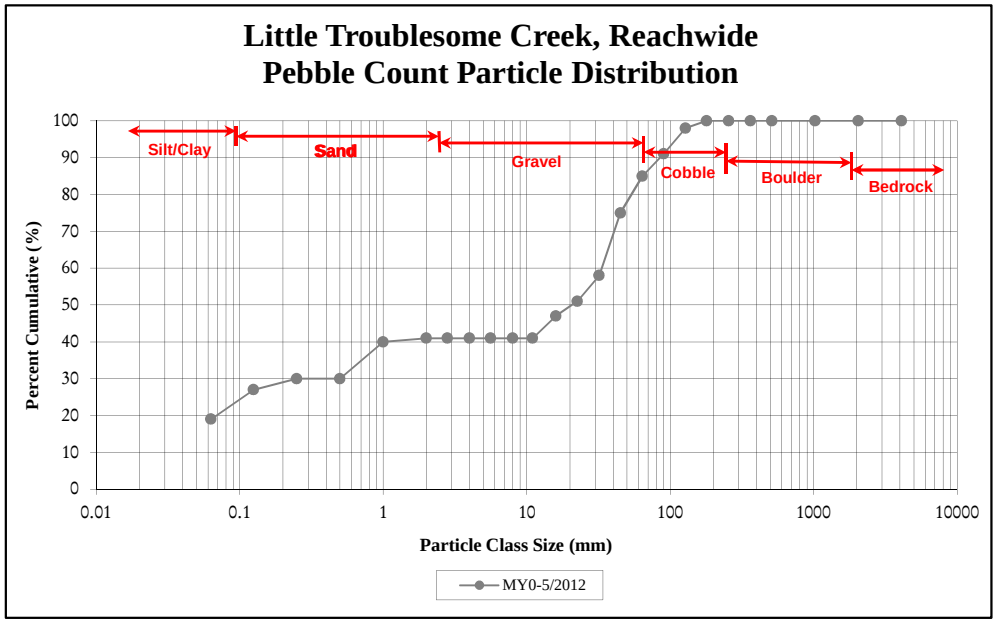


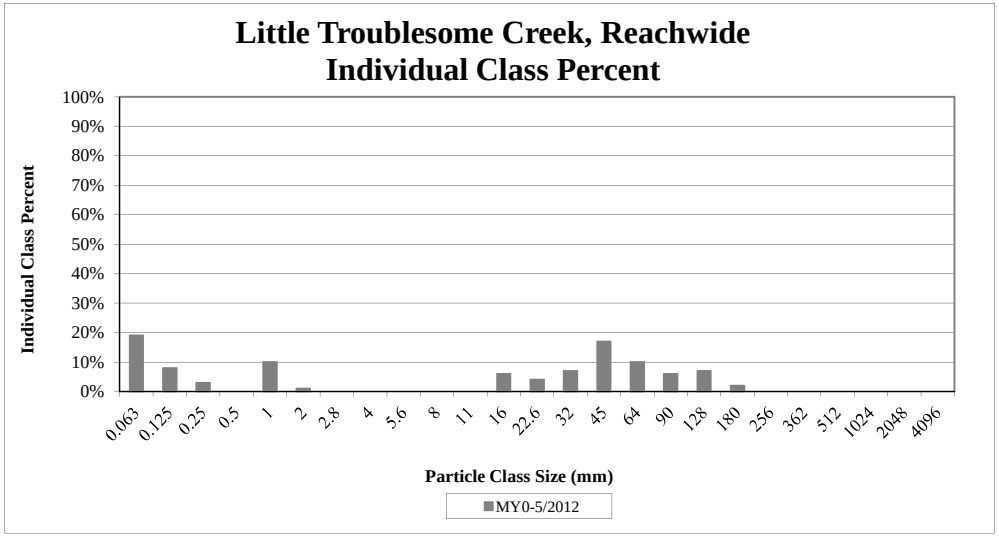


Appendix 2. Morphological Summary Data and Plots
Figure 5i. Reachwide and Cross-Section Pebble Count Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek, Reachwide
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count			Little Troublesome Creek Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	1	18	19	19	19
SAND	Very fine	0.062	0.125	2	6	8	8	27
	Fine	0.125	0.250		3	3	3	30
	Medium	0.250	0.500					30
	Coarse	0.5	1.0	3	7	10	10	40
	Very Coarse	1.0	2.0		1	1	1	41
GRAVEL	Very Fine	2.0	2.8					41
	Very Fine	2.8	4.0					41
	Fine	4.0	5.7					41
	Fine	5.7	8.0					41
	Medium	8.0	11.3					41
	Medium	11.3	16.0	3	3	6	6	47
	Coarse	16.0	22.6	2	2	4	4	51
	Coarse	22.6	32	7		7	7	58
	Very Coarse	32	45	17		17	17	75
	Very Coarse	45	64	10		10	10	85
COBBLE	Small	64	90	6		6	6	91
	Small	90	128	7		7	7	98
	Large	128	180	2		2	2	100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	60	40	100	100	100

Reachwide	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	20.7
D_{84} =	61.8
D_{95} =	110.1
D_{100} =	180.0

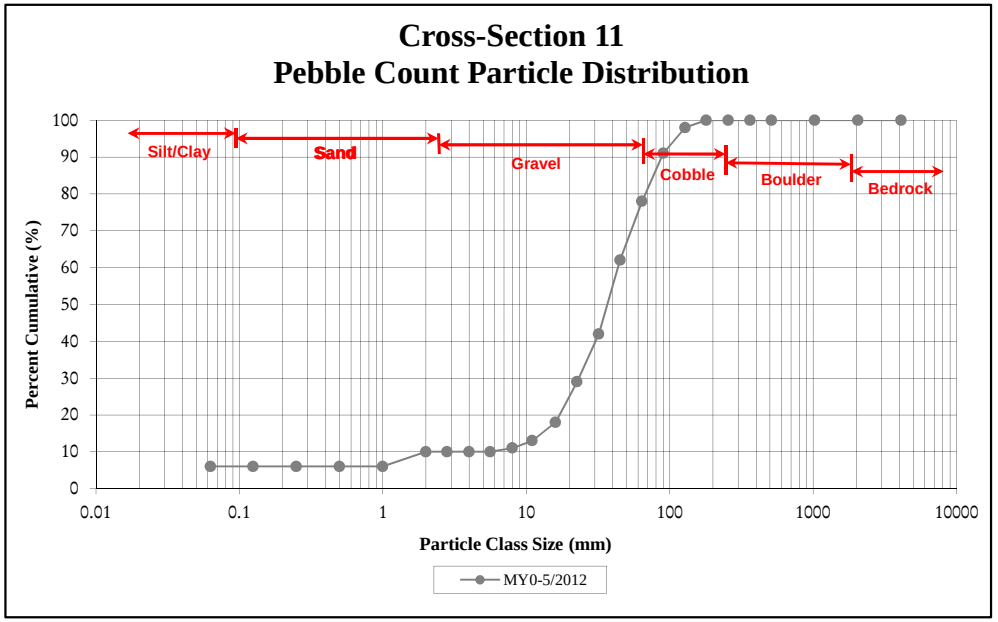


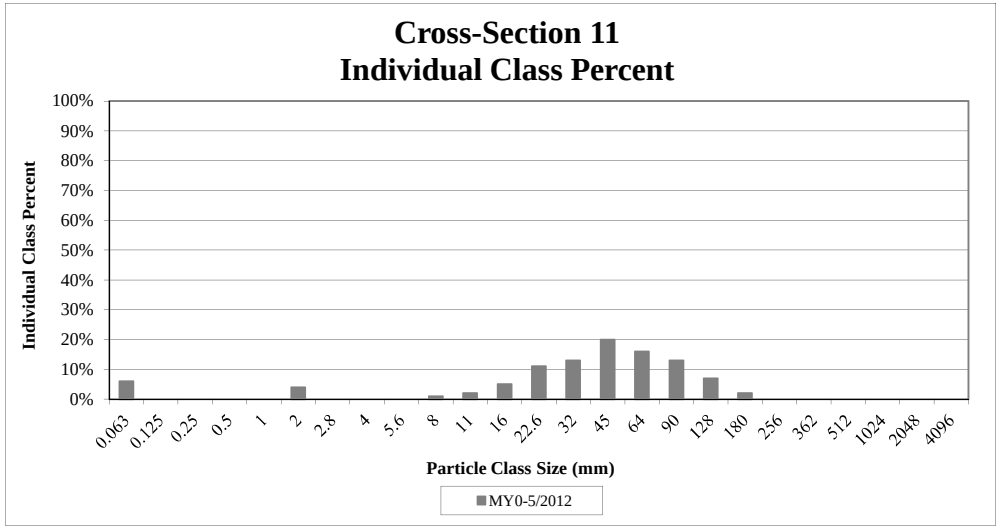


Appendix 2. Morphological Summary Data and Plots
Figure 5j. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek , Cross-Section 11 (Riffle)
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 11 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	6	6	6
SAND	Very fine	0.062	0.125			6
	Fine	0.125	0.250			6
	Medium	0.250	0.500			6
	Coarse	0.5	1.0			6
	Very Coarse	1.0	2.0	4	4	10
GRAVEL	Very Fine	2.0	2.8			10
	Very Fine	2.8	4.0			10
	Fine	4.0	5.7			10
	Fine	5.7	8.0	1	1	11
	Medium	8.0	11.3	2	2	13
	Medium	11.3	16.0	5	5	18
	Coarse	16.0	22.6	11	11	29
	Coarse	22.6	32	13	13	42
	Very Coarse	32	45	20	20	62
	Very Coarse	45	64	16	16	78
COBBLE	Small	64	90	13	13	91
	Small	90	128	7	7	98
	Large	128	180	2	2	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	> 2048			100
			Total	100	100	100

Cross-Section 11 Channel materials (mm)	
D_{16} =	13.8
D_{35} =	26.5
D_{50} =	36.7
D_{84} =	74.9
D_{95} =	110.1
D_{100} =	180.0

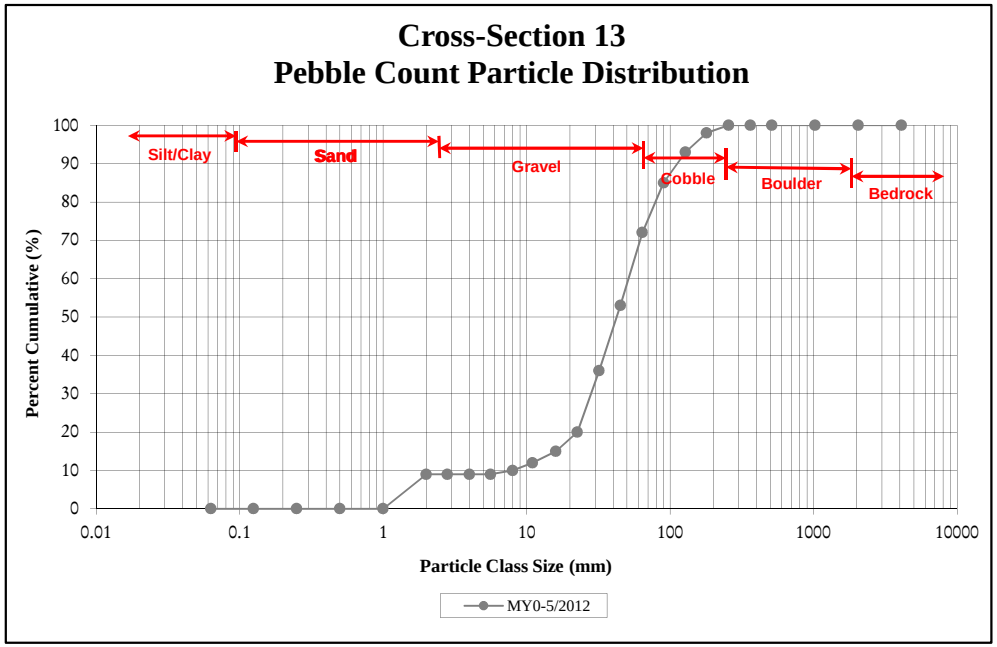


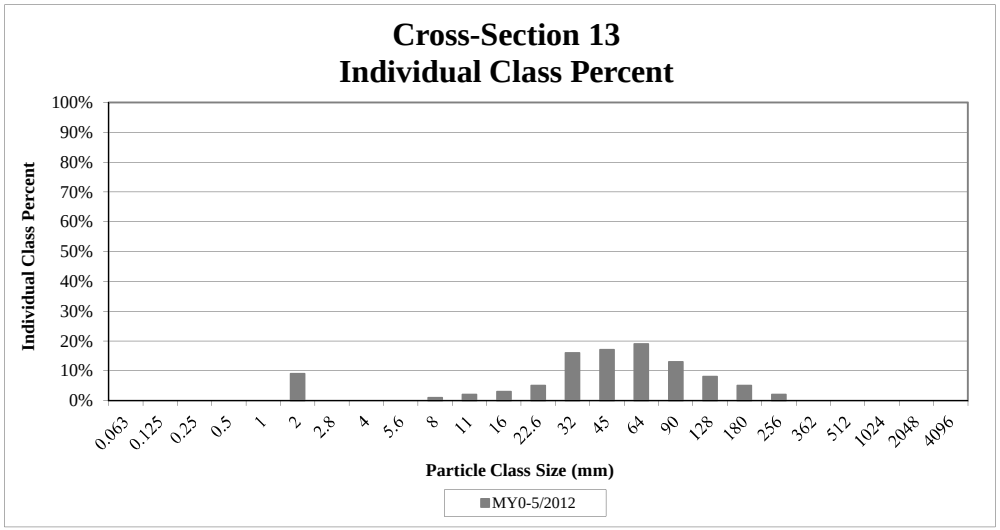


Appendix 2. Morphological Summary Data and Plots
Figure 5k. Reachwide and Cross-Section Substrate Plots
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Little Troublesome Creek , Cross-Section 13 (Riffle)
Monitoring Year 0

Particle Class		Diameter (mm)		Particle Count	Cross-Section 13 Summary	
		min	max	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062			0
SAND	Very fine	0.062	0.125			0
	Fine	0.125	0.250			0
	Medium	0.250	0.500			0
	Coarse	0.5	1.0			0
	Very Coarse	1.0	2.0	9	9	9
GRAVEL	Very Fine	2.0	2.8			9
	Very Fine	2.8	4.0			9
	Fine	4.0	5.7			9
	Fine	5.7	8.0	1	1	10
	Medium	8.0	11.3	2	2	12
	Medium	11.3	16.0	3	3	15
	Coarse	16.0	22.6	5	5	20
	Coarse	22.6	32	16	16	36
	Very Coarse	32	45	17	17	53
	Very Coarse	45	64	19	19	72
COBBLE	Small	64	90	13	13	85
	Small	90	128	8	8	93
	Large	128	180	5	5	98
	Large	180	256	2	2	100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	100	100	100

Cross-Section 13 Channel materials (mm)	
D_{16} =	17.1
D_{35} =	31.3
D_{50} =	42.4
D_{84} =	87.7
D_{95} =	146.7
D_{100} =	256.0





Stream Site Photographs

	
Photo Point 1 – looking upstream (04/25/2012)	Photo Point 1 – looking downstream (04/25/2012)
	
Photo Point 2 – looking upstream (04/25/2012)	Photo Point 2 – looking downstream (04/25/2012)
	
Photo Point 3 – looking upstream (04/25/2012)	Photo Point 3 – looking downstream (04/25/2012)

	
Photo Point 4 – looking upstream (04/25/2012)	Photo Point 4 – looking downstream (04/25/2012)
	
Photo Point 5 – looking upstream (05/17/2012)	Photo Point 5 – looking downstream (05/17/2012)
	
Photo Point 6 – looking upstream (04/25/2012)	Photo Point 6 – looking downstream (04/25/2012)

Photo Point 7 – looking upstream (04/25/2012)

Photo Point 7 – looking downstream (04/25/2012)

Photo Point 8 – looking upstream (04/25/2012)

Photo Point 8 – looking downstream (04/25/2012)

Photo Point 9 – looking upstream (04/25/2012)

Photo Point 9 – looking downstream (04/25/2012)

Photo Point 10 – looking upstream (04/25/2012)

Photo Point 10 – looking downstream (04/25/2012)

Photo Point 11 – looking upstream (04/25/2012)

Photo Point 11 – looking downstream (04/25/2012)

Photo Point 12 – looking upstream (05/17/2012)

Photo Point 12 – looking downstream (05/17/2012)

	
Photo Point 13 – looking upstream (05/17/2012)	Photo Point 13 – looking downstream (05/17/2012)
	
Photo Point 14 – looking upstream (05/17/2012)	Photo Point 14 – looking downstream (05/17/2012)
	
Photo Point 15 – looking upstream (05/17/2012)	Photo Point 15 – looking downstream (05/17/2012)

Photo Point 16 – looking upstream (05/17/2012)

Photo Point 16 – looking downstream (05/17/2012)

Photo Point 17 – looking upstream (04/25/2012)

Photo Point 17 – looking downstream (04/25/2012)

Photo Point 18 – looking upstream (05/17/2012)

Photo Point 18 – looking downstream (05/17/2012)

Photo Point 19 – looking upstream (04/25/2012)

Photo Point 19 – looking upstream (04/25/2012)

Photo Point 20 – looking upstream - Irvin (04/25/2012)

Photo Point 20 – looking upstream – LTC (04/25/2012)

Photo Point 20 – looking downstream - LTC (04/25/2012)

Photo Point 21 – looking upstream (05/17/2012)

Photo Point 21 – looking downstream (05/17/2012)

Photo Point 22 – looking upstream (05/17/2012)

Photo Point 22 – looking downstream (05/17/2012)

Photo Point 23 – looking upstream (05/17/2012)

Photo Point 23 – looking downstream (05/17/2012)

	
Photo Point 24 – looking upstream (04/25/2012)	Photo Point 24 – looking downstream (04/25/2012)
	
Photo Point 25 – looking upstream (04/25/2012)	Photo Point 25 – looking downstream (04/25/2012)

APPENDIX 3. Vegetation Plot Data

Appendix 3. Vegetation Plot Data
Table 7a. Planted and Total Stem Counts (Species by Plot with Annual Means)
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Wetland Site
Monitoring Year 0

			Current Data (MY0-4&5/2012)																						Annual Means	
			Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6		Plot 7		Plot 8		Plot 9		Plot 10		Plot 11		Current Mean	
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
Alnus serrulata	hazel alder	Tree/Shrub	6	6	2	2	1	1	7	7	3	3	2	2	1	1	5	5	2	2	3	3	3	3	**3**	**3**
Betula nigra	river birch	Tree	1	1	2	2	4	4	4	4	1	1	4	4	3	3	4	4	8	8	3	3	5	5	**4**	**4**
Cornus amomum	silky dogwood	Shrub			5	5			3	3			7	7			2	2	3	3	2	2			**3**	**3**
Fraxinus pennsylvanica	green ash	Tree			3	3	6	6	3	3	8	8	2	2	8	8			3	3	2	2	5	5	**4**	**4**
Nyssa sylvatica	blackgum	Tree					1	1	1	1	2	2					2	2			1	1			**2**	**2**
Platanus occidentalis	american sycamore	Tree	7	7	2	2	5	5			4	4	1	1	3	3	6	6			6	6	6	6	**4**	**4**
Quercus michauxii	swamp chestnut oak	Tree	3	3	1	1			2	2	2	2					1	1							**2**	**2**
Quercus phellos	willow oak	Tree			2	2															1	1			**2**	**2**
Unknown							3	3							1	1			2	2					**2**	**2**
Plot Area (acres)			**0.0247**																							
Species Count			**4**	**4**	**7**	**7**	**6**	**6**	**6**	**6**	**6**	**6**	**5**	**5**	**5**	**5**	**6**	**6**	**5**	**5**	**7**	**7**	**4**	**4**	**6**	**6**
Stem Count			**17**	**17**	**17**	**17**	**20**	**20**	**20**	**20**	**20**	**20**	**16**	**16**	**16**	**16**	**20**	**20**	**18**	**18**	**18**	**18**	**19**	**19**	**17**	**17**
Stems per Acre			**688**	**688**	**688**	**688**	**810**	**810**	**810**	**810**	**810**	**810**	**648**	**648**	**648**	**648**	**810**	**810**	**729**	**729**	**729**	**729**	**769**	**769**	**701**	**701**

Type=Shrub or Tree
P = Planted
T = Total

Appendix 3. Vegetation Plot Data
Table 7b. Planted and Total Stem Counts (Species by Plot with Annual Means)
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Wetland Site
Monitoring Year 0

			Current Data (MY0-4&5/2012)																						Annual Means	
			Plot 12		Plot 13		Plot 14		Plot 15		Plot 16		Plot 17		Plot 18		Plot 19		Plot 20		Plot 21		Plot 22		Current Mean	
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
Alnus serrulata	hazel alder	Tree/Shrub	4	4	3	3	5	5	3	3	3	3					3	3			3	3	3	3	**3**	**3**
Betula nigra	river birch	Tree	5	5	4	4	3	3	3	3	5	5	5	5	1	1	3	3	6	6			1	1	**4**	**4**
Cornus amomum	silky dogwood	Shrub	2	2	1	1	1	1	1	1	5	5			2	2	3	3					1	1	**3**	**3**
Fraxinus pennsylvanica	green ash	Tree	1	1	6	6	3	3	2	2	1	1	4	4	4	4	1	1	5	5	2	2	2	2	**4**	**4**
Nyssa sylvatica	blackgum	Tree	1	1	1	1											2	2			4	4	2	2	**2**	**2**
Platanus occidentalis	american sycamore	Tree			1	1	6	6	5	5	2	2	2	2	6	6	2	2	5	5	4	4	9	9	**4**	**4**
Quercus michauxii	swamp chestnut oak	Tree			2	2			1	1			3	3			2	2			1	1			**2**	**2**
Quercus phellos	willow oak	Tree							1	1			2	2	2	2					2	2	1	1	**2**	**2**
Unknown																	1	1							**2**	**2**
Plot Area (acres)			**0.0247**																							
Species Count			**5**	**5**	**7**	**7**	**5**	**5**	**7**	**7**	**5**	**5**	**5**	**5**	**5**	**5**	**8**	**8**	**3**	**3**	**6**	**6**	**7**	**7**	**6**	**6**
Stem Count			**13**	**13**	**18**	**18**	**18**	**18**	**16**	**16**	**16**	**16**	**16**	**16**	**15**	**15**	**17**	**17**	**16**	**16**	**16**	**16**	**19**	**19**	**17**	**17**
Stems per Acre			**526**	**526**	**729**	**729**	**729**	**729**	**648**	**648**	**648**	**648**	**648**	**648**	**607**	**607**	**688**	**688**	**648**	**648**	**648**	**648**	**769**	**769**	**701**	**701**

Type=Shrub or Tree
P = Planted
T = Total

Appendix 3. Vegetation Plot Data
Table 7c. Planted and Total Stem Counts (Species by Plot with Annual Means)
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Stream Site
Monitoring Year 0

			Current Data (MY0-4&5/2012)																								Annual Means	
			Plot 23		Plot 24		Plot 25		Plot 26		Plot 27		Plot 28		Plot 29		Plot 30		Plot 31		Plot 32		Plot 33		Plot 34		Plot 35		Current Mean	
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
Betula nigra	river birch	Tree	2	2	1	1	2	2	2	2					1	1	2	2	8	8	5	5	10	10	1	1	2	2	**3**	**3**
Carpinus caroliniana	american hornbeam	Tree/Shrub	4	4	10	10	3	3	2	2	3	3	4	4	3	3	9	9	2	2	2	2	4	4	8	8	2	2	**4**	**4**
Cornus amomum	silky dogwood	Shrub			3	3																			2	2	3	3	**3**	**3**
Fraxinus pennsylvanica	green ash	Tree	5	5	5	5	13	13	6	6	7	7	6	6	6	6	2	2	7	7	3	3	1	1	4	4	2	2	**5**	**5**
Liriodendron tulipifera	tuliptree	Tree	8	8	2	2					1	1	3	3	2	2	7	7	5	5	3	3	1	1	4	4	1	1	**3**	**3**
Platanus occidentalis	american sycamore	Tree	5	5	3	3	2	2	5	5	14	14	11	11	10	10	2	2	2	2	10	10	1	1			3	3	**6**	**6**
Quercus phellos	willow oak	Tree			4	4																	6	6	7	7	5	5	**6**	**6**
Quercus rubra	northern red oak	Tree			2	2											1	1	2	2	1	1					5	5	**2**	**2**
Unknown					1	1																							**1**	**1**
Plot Area (acres)			**0.0247**																											
Species Count			**5**	**5**	**9**	**9**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**8**	**8**	**6**	**6**
Stem Count			**24**	**24**	**31**	**31**	**20**	**20**	**15**	**15**	**25**	**25**	**24**	**24**	**22**	**22**	**23**	**23**	**26**	**26**	**24**	**24**	**23**	**23**	**26**	**26**	**23**	**23**	**24**	**24**
Stems per Acre			**972**	**972**	**1255**	**1255**	**810**	**810**	**607**	**607**	**1012**	**1012**	**972**	**972**	**891**	**891**	**931**	**931**	**1053**	**1053**	**972**	**972**	**931**	**931**	**1053**	**1053**	**931**	**931**	**953**	**953**

Type=Shrub or Tree
P = Planted
T = Total

Appendix 3. Vegetation Plot Data
Table 8a. CVS Vegetation Tables - Metadata
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Wetland Site
Monitoring Year 0

Report Prepared By	Ben Clements
Date Prepared	*5/15/2011 9:30*
database name	*LTC-Wetland_MY0-cvs-eep-entrytool-v2.2.7.mdb*
database location	*Q:\ActiveProjects\005-02124 Little Troublesome Creek FDP\Monitoring\Baseline Monitoring\Vegetation Assessment*
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	*This worksheet, which is a summary of the project and the project data.*
Plots	*List of plots surveyed.*
Vigor	*Frequency distribution of vigor classes.*
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.*
Stem Count by Plot and Spp	*Unknown*
PROJECT SUMMARY----------	
Project Code	94640
project Name	Little Troublesome Creek-Cotton Rd Site
Description	Wetland Mitigation Site
length (ft)	n/a
stream-to-edge width (ft)	n/a
area (sq m)	72843.42
Required Plots (calculated)	16
Sampled Plots	22

Appendix 3. Vegetation Plot Data
Table 8b. CVS Vegetation Tables - Metadata
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Stream Site
Monitoring Year 0

Report Prepared By	Ben Clements
Date Prepared	*5/22/2012 14:10*
database name	*LTC-Stream_MY0-cvs-eep-entrytool-v2.2.7.mdb*
database location	*Q:\ActiveProjects\005-02124 Little Troublesome Creek FDP\Monitoring\Baseline Monitoring\Vegetation Assessment*
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	*This worksheet, which is a summary of the project and the project data.*
Plots	*List of plots surveyed.*
Vigor	*Frequency distribution of vigor classes.*
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.*
Stem Count by Plot and Spp	*Unknown*
PROJECT SUMMARY----------	
Project Code	94640
project Name	Little Troublesome Mitigation Site
Description	Stream Mitigation Site
length (ft)	n/a
stream-to-edge width (ft)	n/a
area (sq m)	50990.39
Required Plots (calculated)	13
Sampled Plots	13

Appendix 3. Vegetation Plot Data

Table 9a. CVS Vegetation Tables - Vigor by Species

Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)

Wetland Site

Monitoring Year 0

	Species	CommonName	4	3	2	1	0	Missing
	Alnus serrulata	hazel alder	62					
	Betula nigra	river birch	75					
	Cornus amomum	silky dogwood	38					
	Fraxinus pennsylvanica	green ash	71					
	Nyssa sylvatica	blackgum	17					
	Quercus michauxii	swamp chestnut oak	18					
	Quercus phellos	willow oak	11					
	Platanus occidentalis	american sycamore	82					
	Unknown		7					
TOT:			**381**					

vigor	Count	Percent
0	0	0
1	0	0
2	0	0
3	0	0
4	381	100
TOT	**381**	**100**

Notes: Vigor Scores

4: Excellent

3: Good

2: Fair

1: Unlikely to survive year

2: Dead

Appendix 3. Vegetation Plot Data

Table 9b. CVS Vegetation Tables - Vigor by Species

Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)

Stream Site

Monitoring Year 0

	Species	CommonName	4	3	2	1	0	Missing
	Betula nigra	river birch	36					
	Cornus amomum	silky dogwood	8					
	Fraxinus pennsylvanica	green ash	67					
	Quercus phellos	willow oak	22					
	Carpinus caroliniana	american hornbeam	56					
	Quercus rubra	northern red oak	11					
	Liriodendron tulipifera	tuliptree	37					
	Platanus occidentalis	american sycamore	68					
	Unknown		1					
TOT:			**306**					

vigor	Count	Percent
0	0	0
1	0	0
2	0	0
3	0	0
4	306	100
TOT	**306**	**100**

Notes: Vigor Scores

4: Excellent

3: Good

2: Fair

1: Unlikely to survive year

2: Dead

Appendix 3. Vegetation Plot Data

Table 10a. CVS Vegetation Tables - Damage by Species

Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)

Wetland Site

Monitoring Year 0

Species	Common Name	No Damage
Alnus serrulata	hazel alder	62
Betula nigra	river birch	75
Cornus amomum	silky dogwood	38
Fraxinus pennsylvanica	green ash	71
Nyssa sylvatica	blackgum	17
Platanus occidentalis	american sycamore	82
Quercus michauxii	swamp chestnut oak	18
Quercus phellos	willow oak	11
Unknown		7
TOT:		**381**

Damage	Count	Percent Of Stems
No Damage	381	100
TOT:	**381**	**100**

Appendix 3. Vegetation Plot Data

Table 10b. CVS Vegetation Tables - Damage by Species

Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)

Stream Site

Monitoring Year 0

Species	Common Name	No Damage
Betula nigra	river birch	36
Carpinus caroliniana	American hornbeam	56
Cornus amomum	silky dogwood	8
Fraxinus pennsylvanica	green ash	67
Liriodendron tulipifera	tuliptree	37
Platanus occidentalis	American sycamore	68
Quercus phellos	willow oak	22
Quercus rubra	northern red oak	11
Unknown		1
TOT:		**306**

Damage	Count	Percent Of Stems
No Damage	306	100
TOT:	**306**	**100**

Appendix 3. Vegetation Plot Data
Table 11a. CVS Vegetation Tables - Stem Count by Plot and Species
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Wetland Site
Monitoring Year 0

	Species	CommonName	Total Stems	# plots	avg# stems	94640-WEI-0001	94640-WEI-0002	94640-WEI-0003	94640-WEI-0004	94640-WEI-0005	94640-WEI-0006	94640-WEI-0007	94640-WEI-0008	94640-WEI-0009	94640-WEI-0010	94640-WEI-0011	94640-WEI-0012	94640-WEI-0013	94640-WEI-0014	94640-WEI-0015	94640-WEI-0016	94640-WEI-0017	94640-WEI-0018	94640-WEI-0019	94640-WEI-0020	94640-WEI-0021	94640-WEI-0022
	Alnus serrulata	hazel alder	62	19	3	6	2	1	7	3	2	1	5	2	3	3	4	3	5	3	3			3		3	3
	Betula nigra	river birch	75	21	4	1	2	4	4	1	4	3	4	8	3	5	5	4	3	3	5	5	1	3	6		1
	Cornus amomum	silky dogwood	38	14	3		5		3		7		2	3	2		2	1	1	1	5		2	3			1
	Fraxinus pennsylvanica	green ash	71	20	4		3	6	3	8	2	8		3	2	5	1	6	3	2	1	4	4	1	5	2	2
	Nyssa sylvatica	blackgum	17	10	2			1	1	2			2		1		1	1						2		4	2
	Platanus occidentalis	american sycamore	82	19	4	7	2	5		4	1	3	6		6	6		1	6	5	2	2	6	2	5	4	9
	Quercus michauxii	swamp chestnut oak	18	10	2	3	1		2	2			1					2		1		3		2		1	
	Quercus phellos	willow oak	11	7	2		2								1					1		2	2			2	1
	Unknown		7	4	2			3				1		2										1			
TOT:			**381**	**9**	**17**	**17**	**17**	**20**	**20**	**20**	**16**	**16**	**20**	**18**	**18**	**19**	**13**	**18**	**18**	**16**	**16**	**16**	**15**	**17**	**16**	**16**	**19**

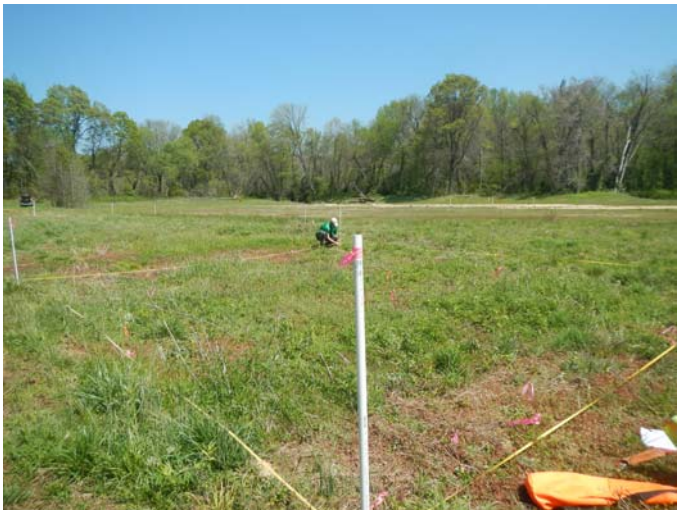
Appendix 3. Vegetation Plot Data
Table 11b. CVS Vegetation Tables - Stem Count by Plot and Species
Little Troublesome Creek Mitigation Site (NCEEP Project No. 94640)
Stream Site
Monitoring Year 0

	Species	CommonName	Total Stems	# plots	avg# stems	plot 94640-WEI-0023	plot 94640-WEI-0024	plot 94640-WEI-0025	plot 94640-WEI-0026	plot 94640-WEI-0027	plot 94640-WEI-0028	plot 94640-WEI-0029	plot 94640-WEI-0030	plot 94640-WEI-0031	plot 94640-WEI-0032	plot 94640-WEI-0033	plot 94640-WEI-0034	plot 94640-WEI-0035
	Betula nigra	river birch	36	11	3	2	1	2	2			1	2	8	5	10	1	2
	Carpinus caroliniana	american hornbeam	56	13	4	4	10	3	2	3	4	3	9	2	2	4	8	2
	Cornus amomum	silky dogwood	8	3	3		3										2	3
	Fraxinus pennsylvanica	green ash	67	13	5	5	5	13	6	7	6	6	2	7	3	1	4	2
	Liriodendron tulipifera	tuliptree	37	11	3	8	2			1	3	2	7	5	3	1	4	1
	Platanus occidentalis	american sycamore	68	12	6	5	3	2	5	14	11	10	2	2	10	1		3
	Quercus phellos	willow oak	22	4	6		4									6	7	5
	Quercus rubra	northern red oak	11	5	2		2						1	2	1			5
	Unknown		1	1	1		1											
TOT:			**306**	**9**	**24**	**24**	**31**	**20**	**15**	**25**	**24**	**22**	**23**	**26**	**24**	**23**	**26**	**23**

Wetland Site Vegetation Photographs

Vegetation Plot 1 (04/25/2012)

Vegetation Plot 2 (04/25/2012)



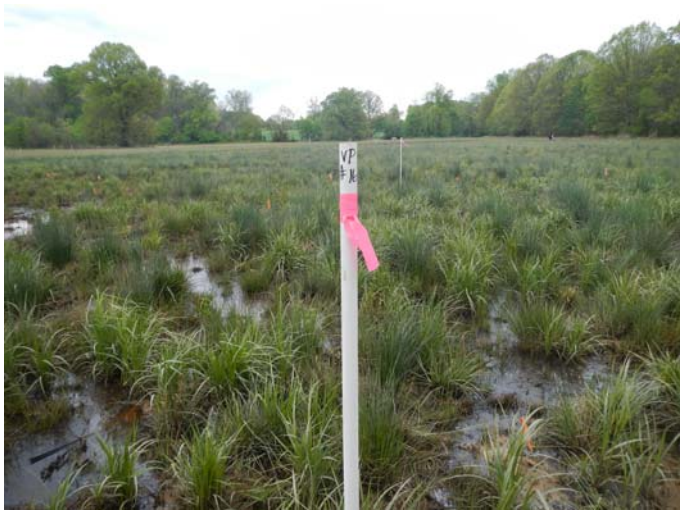
Vegetation Plot 3 (04/25/2012)

Vegetation Plot 4 (04/25/2012)

Vegetation Plot 5 (04/25/2012)

Vegetation Plot 6 (04/25/2012)

	
Vegetation Plot 7 (04/25/2012)	Vegetation Plot 8 (04/25/2012)
	
Vegetation Plot 9 (04/25/2012)	Vegetation Plot 10 (04/25/2012)
	
Vegetation Plot 11 (04/25/2012)	Vegetation Plot 12 (04/25/2012)

	
Vegetation Plot 13 (04/25/2012)	Vegetation Plot 14 (04/25/2012)
	
Vegetation Plot 15 (04/25/2012)	Vegetation Plot 16 (04/25/2012)
	
Vegetation Plot 17 (04/25/2012)	Vegetation Plot 18 (04/25/2012)

	
Vegetation Plot 19 (04/25/2012)	Vegetation Plot 20 (04/25/2012)
	
Vegetation Plot 21 (04/25/2012)	Vegetation Plot 22 (04/25/2012)

Stream Site Vegetation Photographs

	
Vegetation Plot 23 (05/21/2012)	Vegetation Plot 24 (05/21/2012)
	
Vegetation Plot 25 (05/21/2012)	Vegetation Plot 26 (05/21/2012)
	
Vegetation Plot 27 (05/21/2012)	Vegetation Plot 28 (05/21/2012)

Vegetation Plot 29 (05/17/2012)

Vegetation Plot 30 (05/17/2012)

Vegetation Plot 31 (05/17/2012)

Vegetation Plot 32 (05/17/2012)

Vegetation Plot 33 (05/17/2012)

Vegetation Plot 34 (05/17/2012)

Vegetation Plot 35 (05/17/2012)

APPENDIX 4. As-Built Plan Sheets

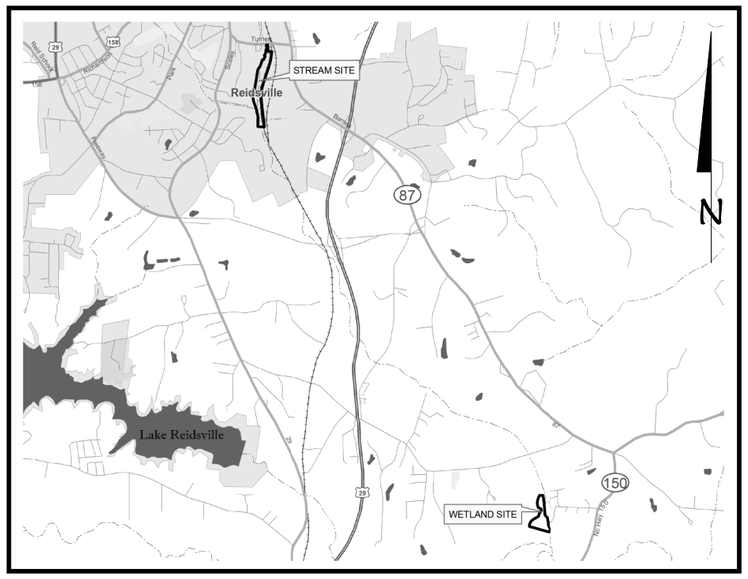
Little Troublesome Creek Mitigation Site

Rockingham County, NC

Cape Fear River Basin Cataloging Unit 03030002

for

North Carolina Ecosystem Enhancement Program



Vicinity Map
Not to Scale

Ecosystem Enhancement PROGRAM

BEFORE YOU DIG!
CALL 1-800-632-4949
N.C. ONE-CALL CENTER
IT'S THE LAW!

BASELINE DRAWING
ISSUED SEPTEMBER 5, 2012

REACH ORGINS

Reach	Latitude	Longitude
Irvin Creek Reach 1	N 36° 20' 18.11"	W 79° 39' 25.27"
Irvin Creek Reach 2	N 36° 20' 02.80"	W 79° 39' 29.31"
Little Troublesome Creek	N 36° 19' 48.21"	W 79° 39' 31.19"
UT1	N 36° 19' 44.62"	W 79° 39' 28.32"

Sheet Index

Cover Sheet	0.1
Legend	0.2
Stream Baseline Overview	1.0
Stream Baseline Plans	1.1-1.11
Wetland Baseline Overview	2.0
Wetland Baseline Plans	2.1-2.2
Stream Baseline Planting	3.0
Wetland Baseline Planting	4.0

Project Directory

Engineering:
Wildlands Engineering, Inc
License No. F-0831
5605 Chapel Hill Road
Suite 122
Raleigh, NC 27607
Jeff Keaton, PE
919-851-9986

Owner:
Ecosystem Enhancement Program
NC Department of Environment and Natural Resources
1652 Mail Service Center
Raleigh, NC 27699-1652
Guy Pearce
919-715-1157

Surveying (Stream):
Turner Land Surveying, PLLC
License No. P-0702
3201 Glenridge Drive
Raleigh, NC 27604
Elisabeth G. Turner, PLS
919-875-1378

Contractor:
Fluvial Solutions, Inc
PO Box 28749
Raleigh, NC 27611
919-605-6134

Surveying (Wetland):
CE Robertson and Associates, PC
License No. P-2928
PO Box 584
Eden, NC 27289
Gene Robertson, PLS
336-627-0498

DENR Contract No. 003267
EEP Project No. 94640

WILDLANDS ENGINEERING

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Ecological Restoration Services
5605 Chapel Hill Road, Suite 122
Raleigh, NC 27607
Tel: 919.851.9986
Fax: 919.851.9987
Firm License No. F-0831

Final Baseline Drawing

Little Troublesome Creek Mitigation Site
Rockingham County, NC
Cover Sheet

Date:	August 31, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

COVER SHEET

Sheet
0.1

LEGEND

- Existing Property Line
- Existing Utility Easement
- Existing Sanitary Sewer Line
- Existing Gas Line
- Existing Power Pole
- Existing Power Line Tower
- Existing Railroad Tracks
- Existing Paved Road
- Existing Building
- Bedrock

- Conservation Easement
- Proposed Channel Centerline
- Proposed Bankfull
- Preconstruction Major Contour
- Preconstruction Minor Contour

- Proposed Root Wads
- Proposed Log Vane
- Proposed Constructed Riffle
- Proposed Rock Cross Vane
- Proposed Drainage Berm
- Proposed Brush Toe Protection
- Proposed Ephemeral Pool

- As-Built Channel Centerline
- As-Built Bankfull
- As-Built Major Contour (715)
- As-Built Minor Contour
- Permanent Cross Section (XS)
- Monitoring Gage
- PP #6 — Photo Point
- VP # — Vegetation Plot
- As-Built Constructed Riffle
- As-Built Log Vane
- As-Built Rock Cross Vane
- As-Built J-Hook
- As-Built Ephemeral Pool

- Zone 1 - Stream Bank Planting Zone
- Zone 2 - Floodplain and Wetland Planting Zone
- Zone 3 - Easements (Seed Only)
- Zone 4 - Wetland Trees Only

- Wetland Restoration
- Wetland Enhancement
- Wetland Creation
- Berm Cuts

Final Baseline Drawing

WILDLANDS ENGINEERING, INC.
Ecological Restoration Services
Phone
Fax

Little Troublesome Creek Mitigation Site
Rockingham County, NC

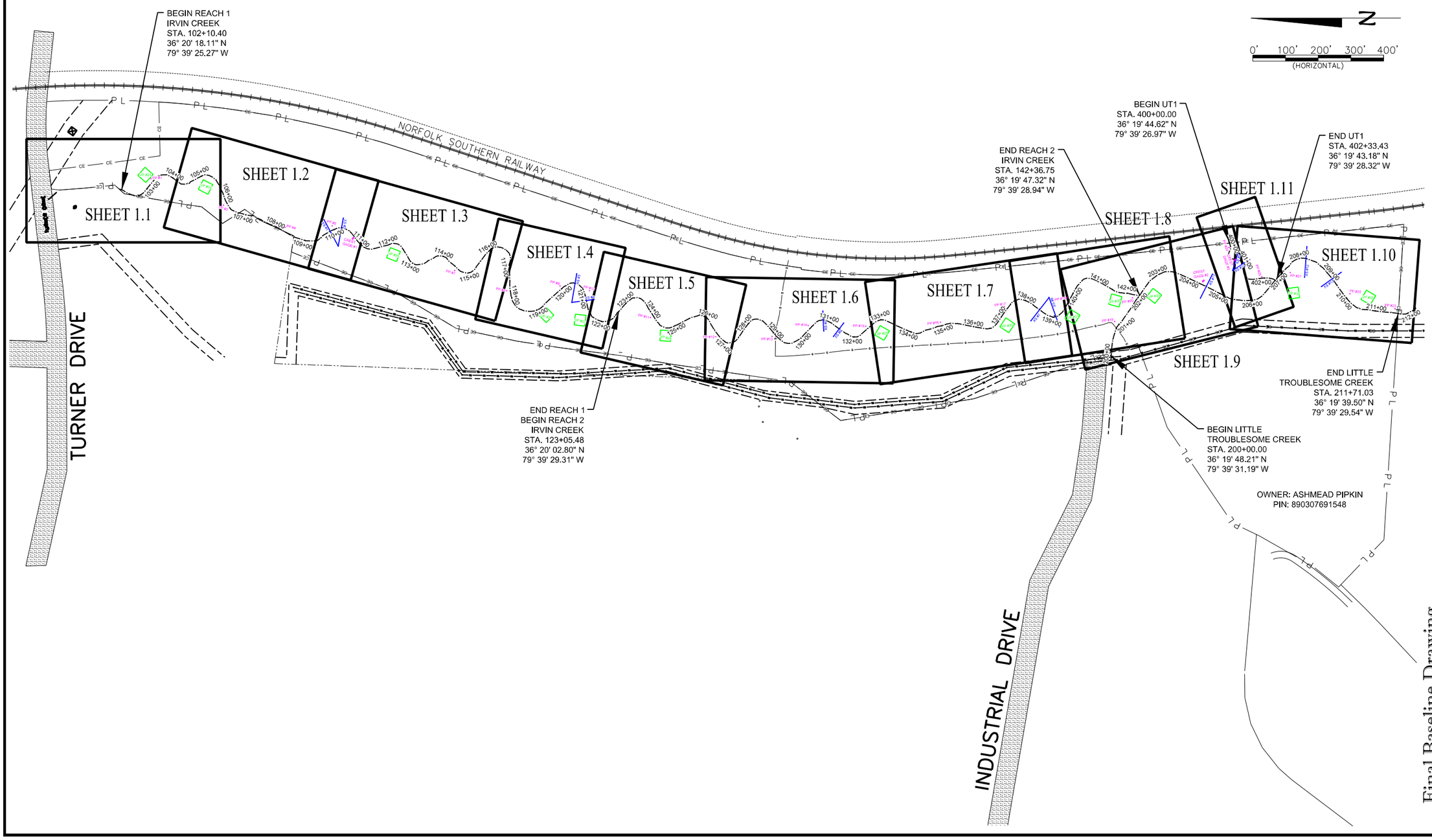
Legend

Date: September 9, 2013
Job Number:
Project Engineer: DBK
Drawn By: DSA
Checked By: DBK

Revisions

LEGEND

Sheet
0.2



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Little Troublesome Creek Mitigation Site
Rockingham County, NC
Stream Baseline Overview

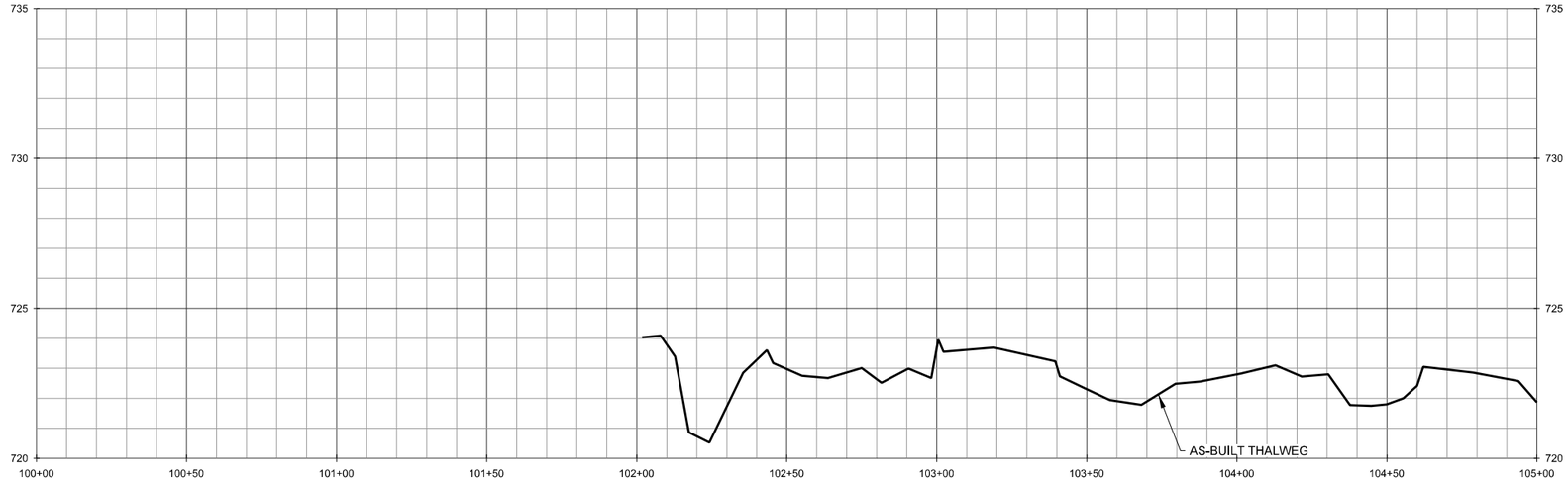
Final Baseline Drawing

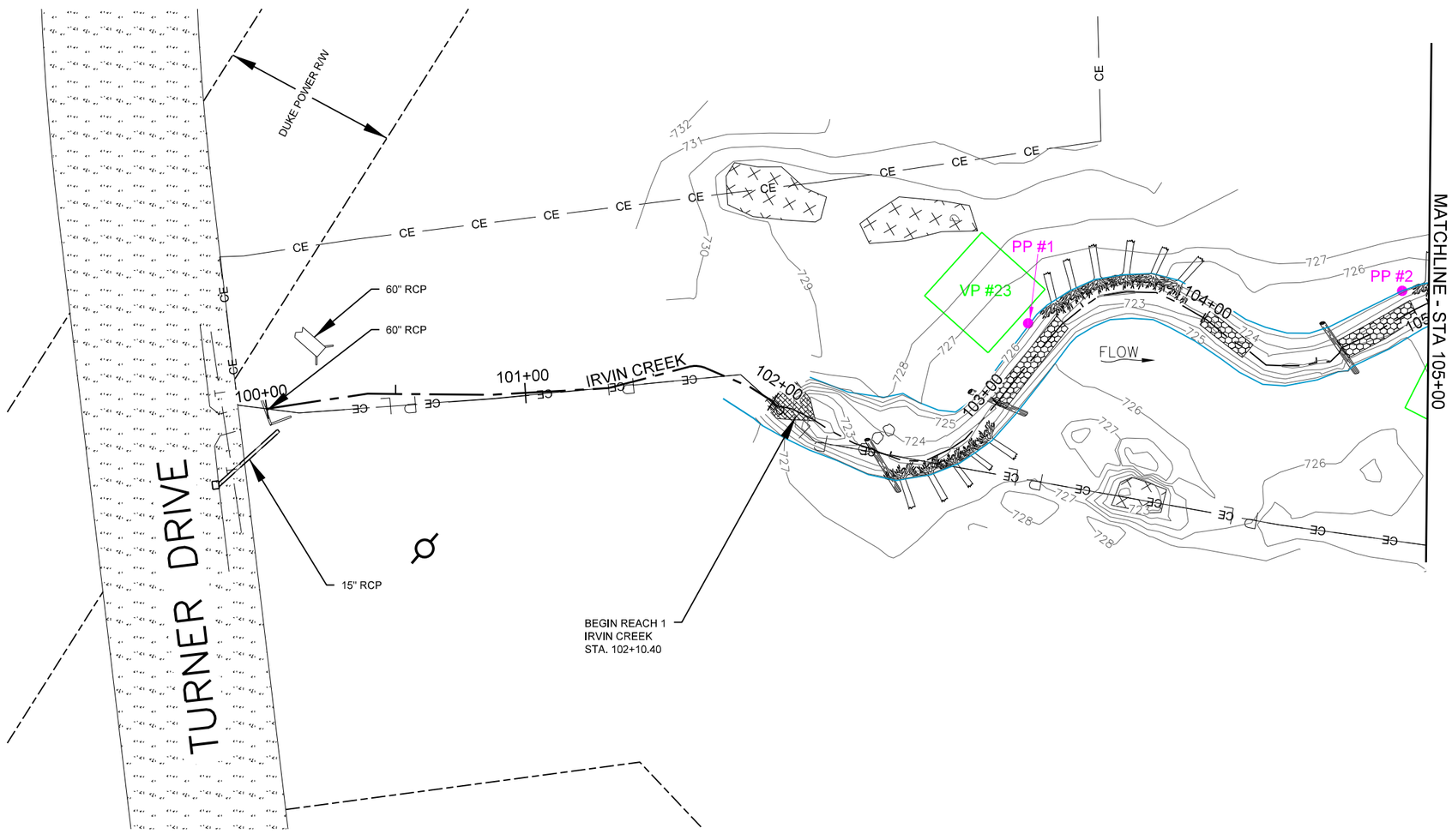
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

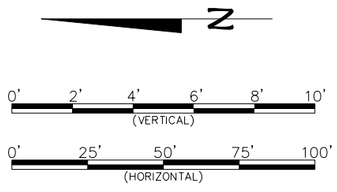
Revisions

STREAM BASELINE OVERVIEW

Sheet
1.0







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Firm License No. F-0831

Little Troublesome Creek Mitigation Site
Rockingham County, NC
Stream Baseline Plans
Irvin Creek Reach 1 Plan and Profile

Final Baseline Drawing

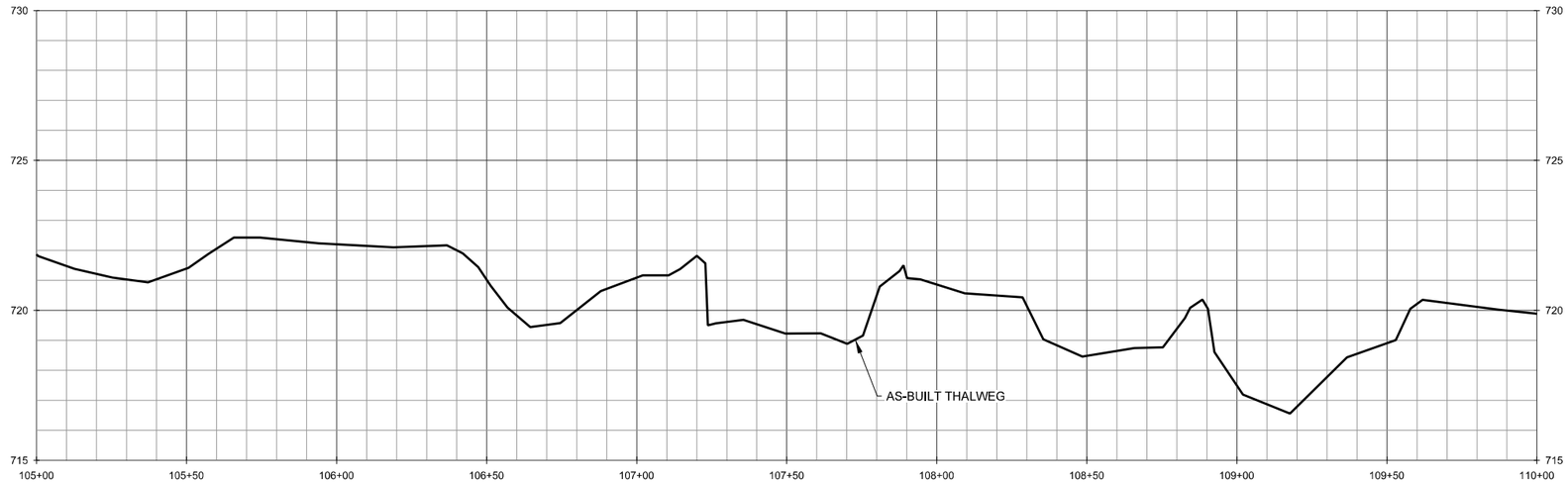
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

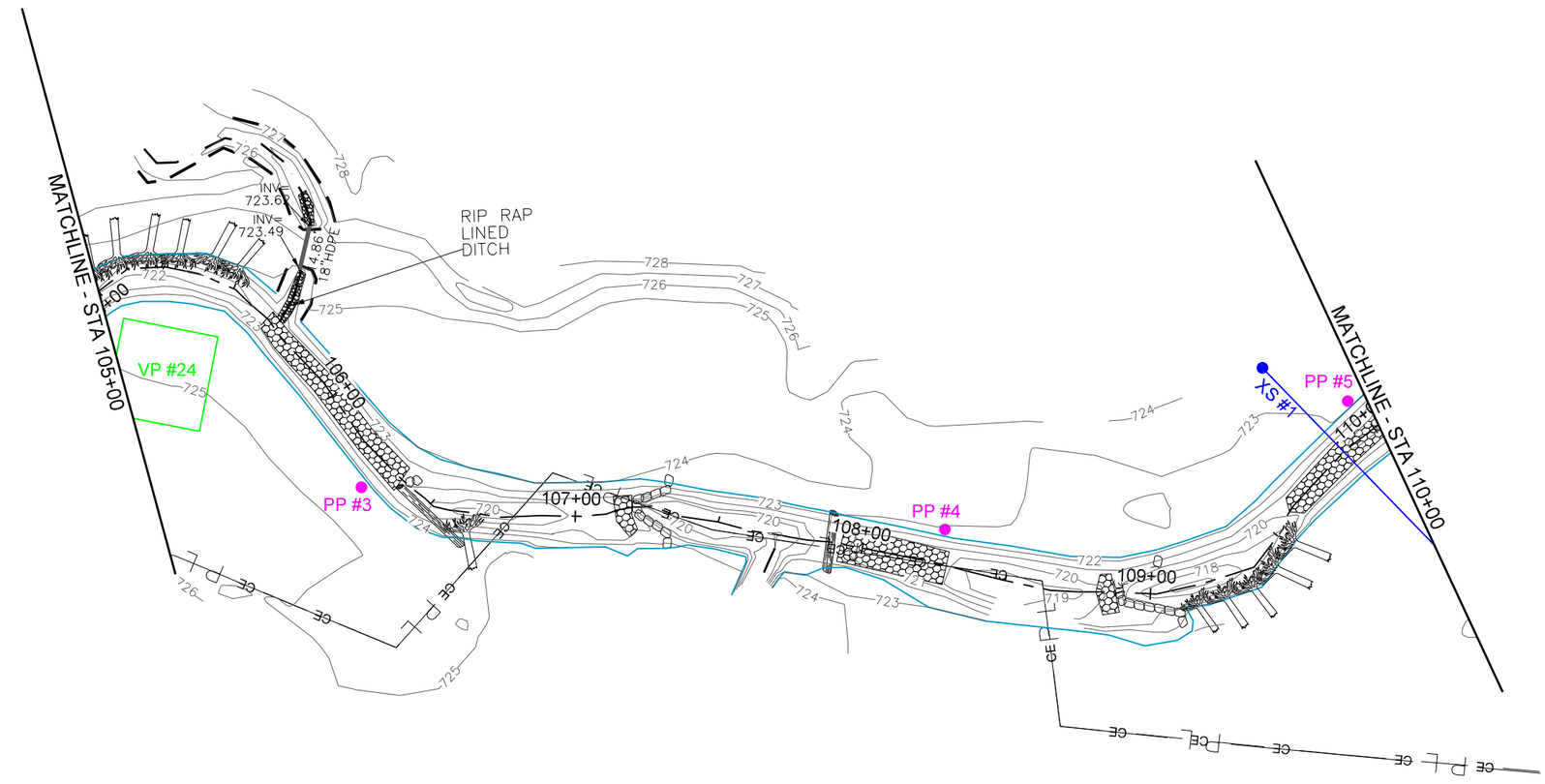
Revisions

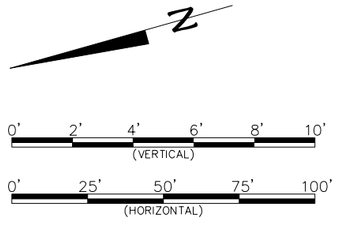
STREAM BASELINE PLANS

Sheet

1.1







Final Baseline Drawing

WILDLANDS ENGINEERING

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Ecological Restoration Services
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Raleigh, NC 27607
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Fax: 919.851.9987
Firm License No. F-0831

Little Troublesome Creek Mitigation Site
Rockingham County, NC

Stream Baseline Plans

Irvin Creek Reach 1 Plan and Profile

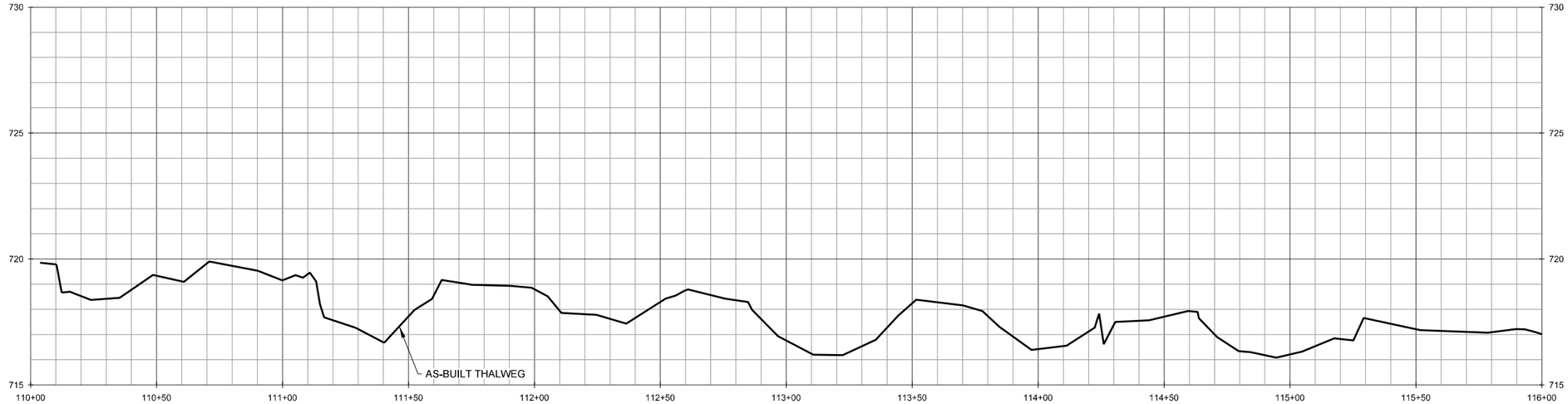
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

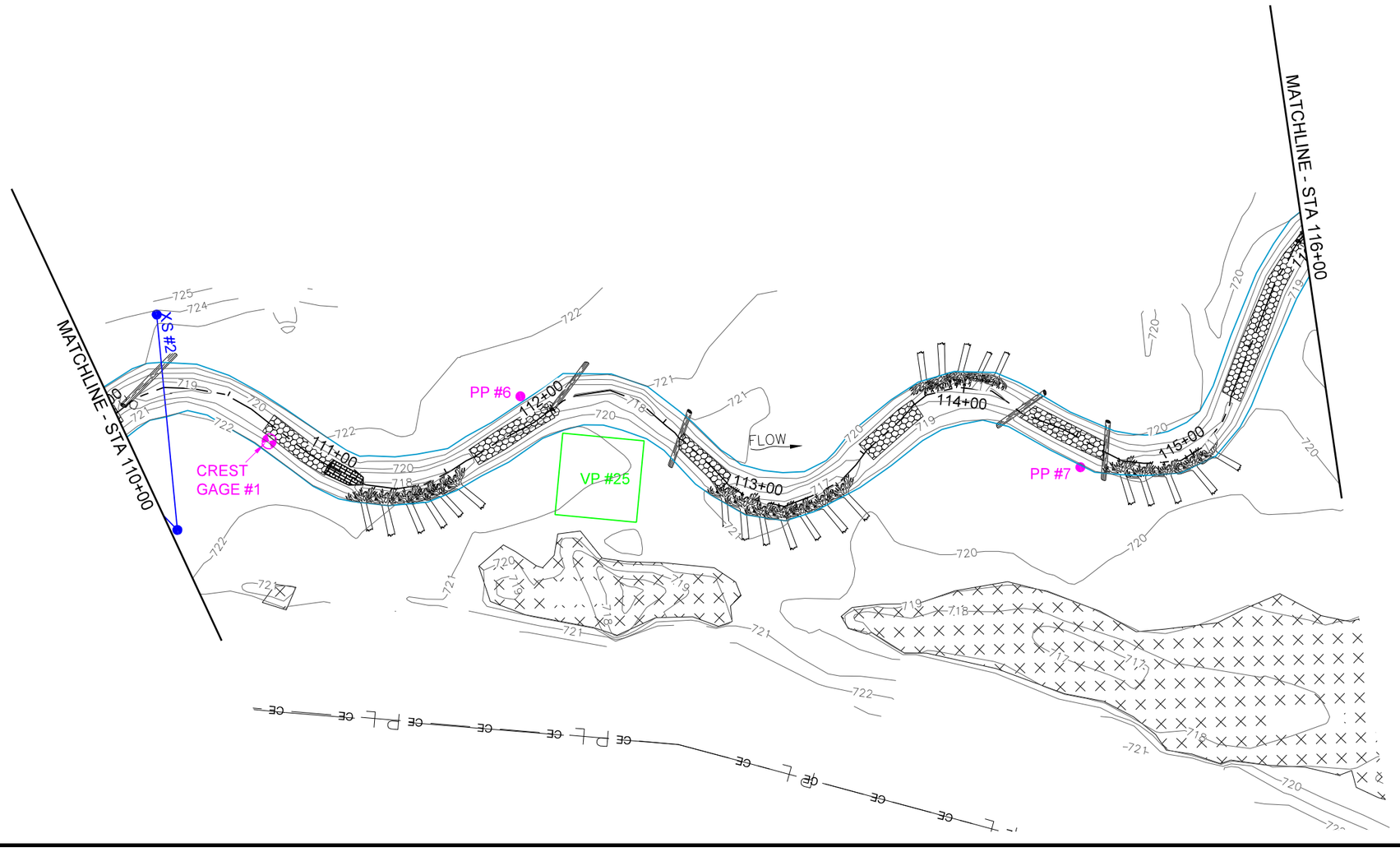
Revisions

STREAM BASELINE PLANS

Sheet

1.2





Final Baseline Drawing

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Little Troublesome Creek Mitigation Site
Rockingham County, NC

Stream Baseline Plans
Irvin Creek Reach 1 Plan and Profile

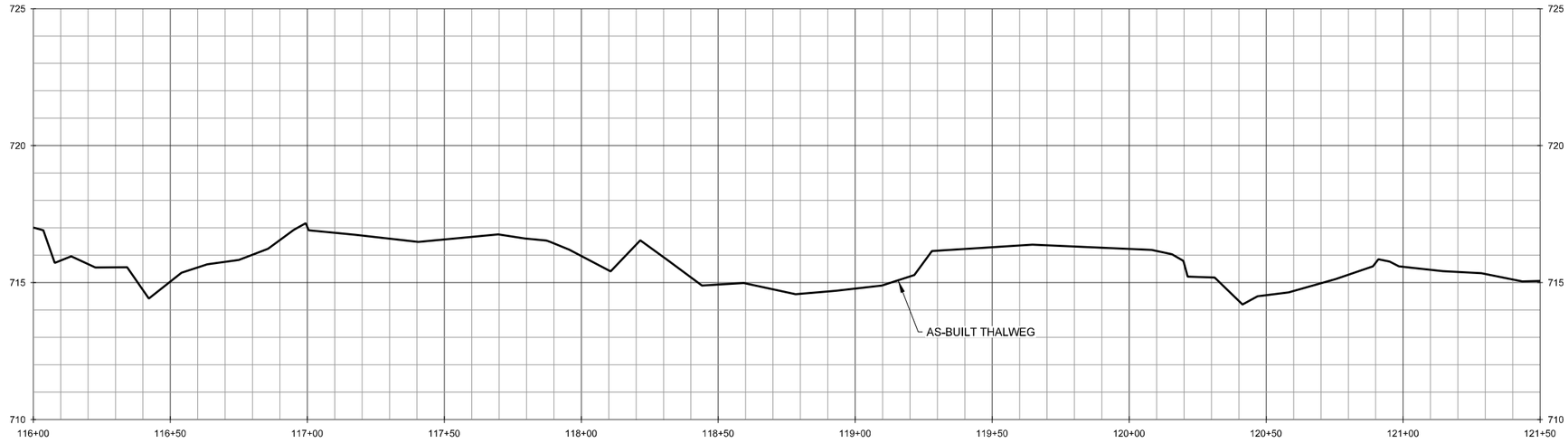
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

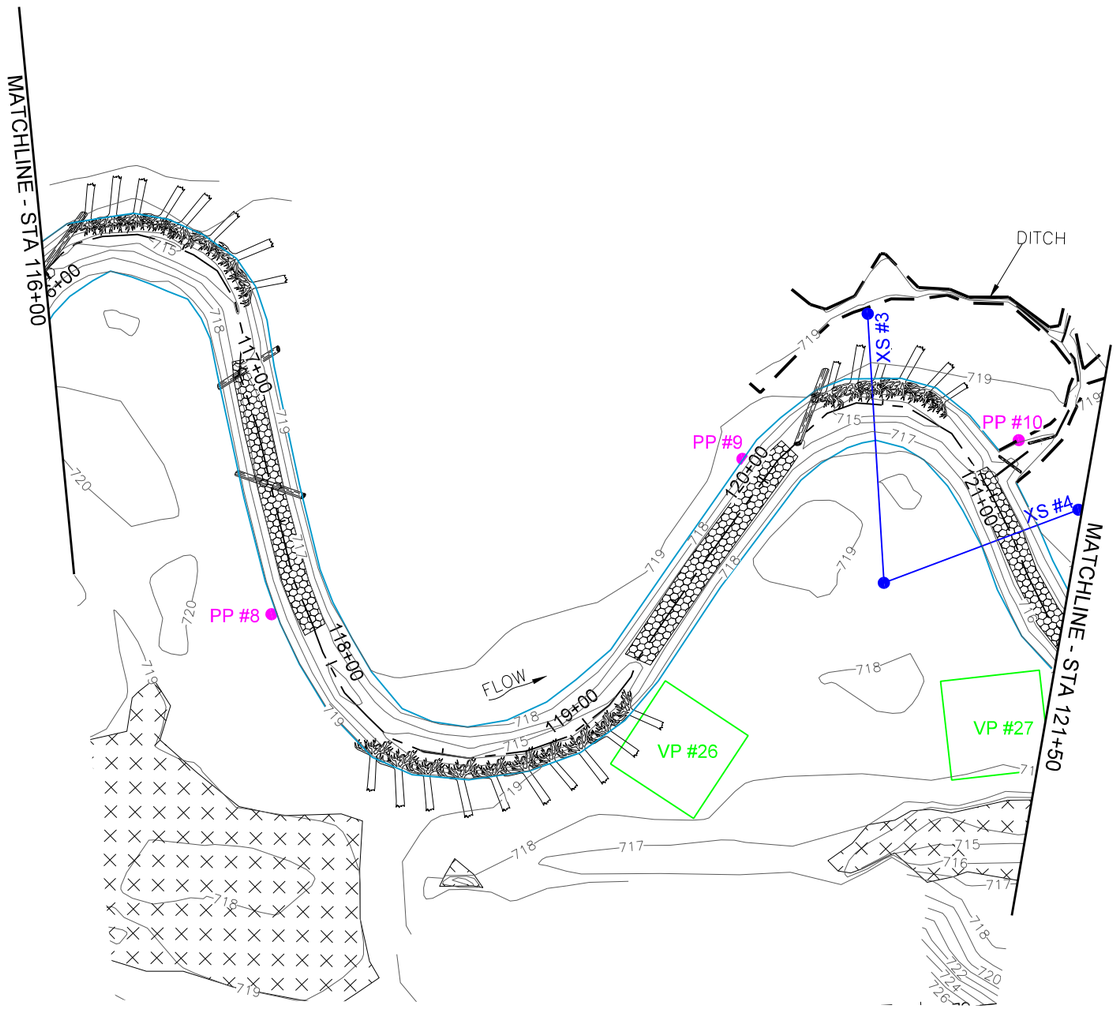
Revisions

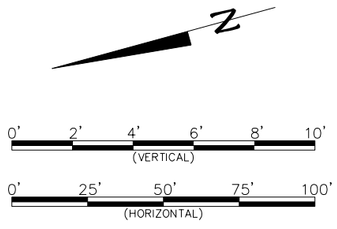
STREAM BASELINE PLANS

Sheet

1.3







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Irvin Creek Reach 1 Plan and Profile

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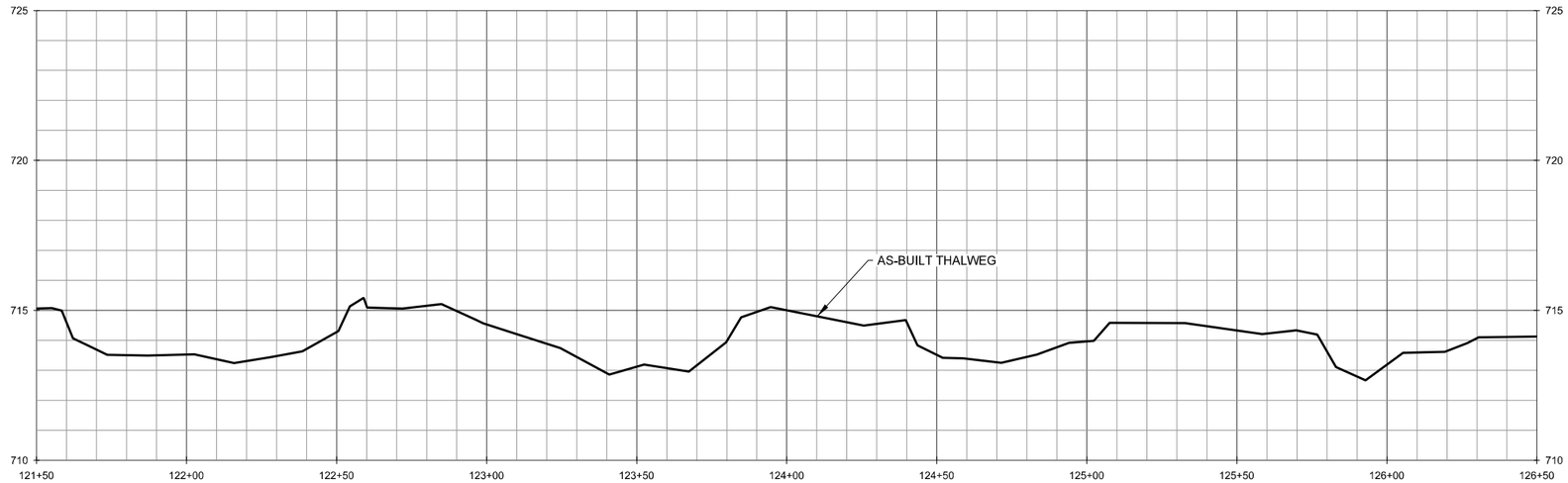
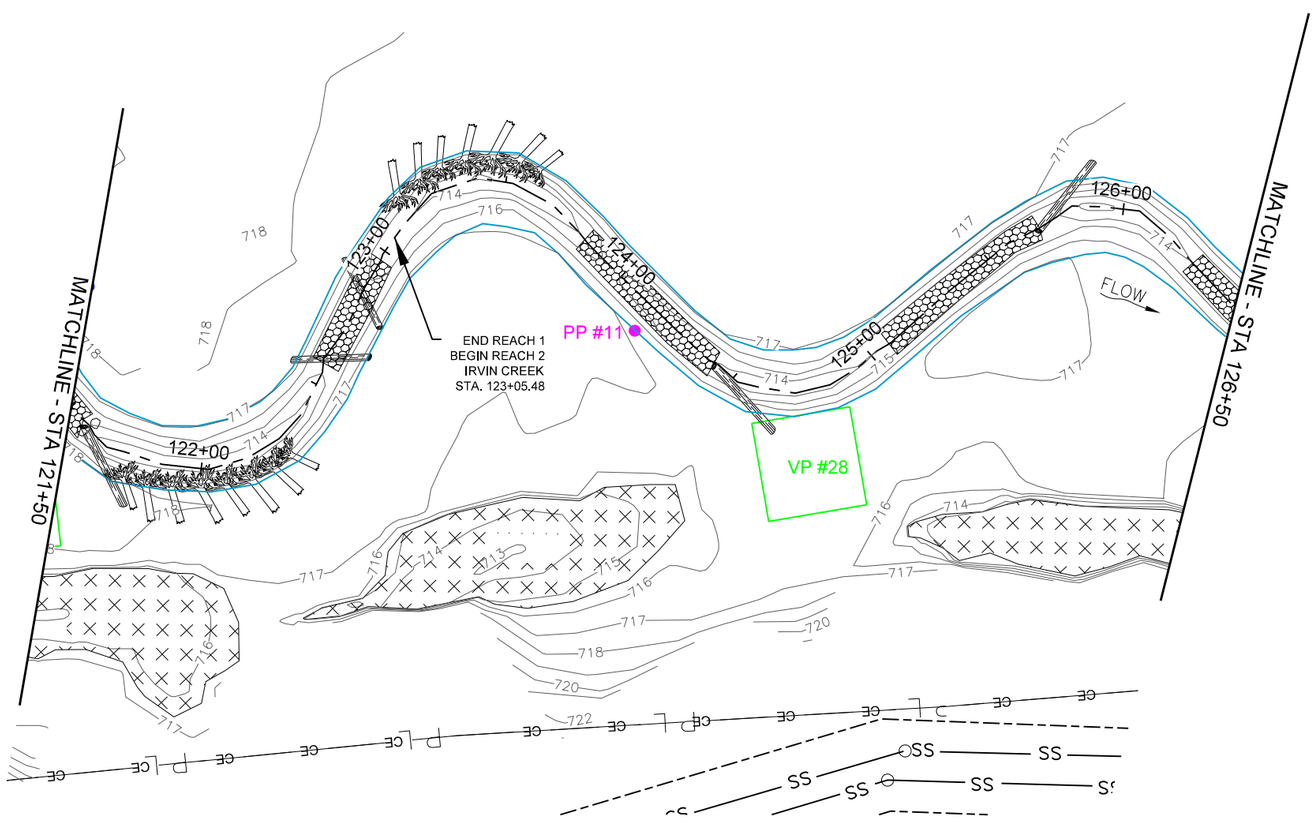
Revisions

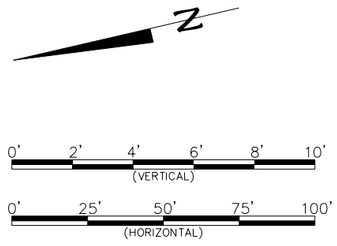
STREAM BASELINE PLANS

Sheet

1.4







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Final Baseline Drawing

Little Troublesome Creek Mitigation Site
Rockingham County, NC

Stream Baseline Plans

Irvin Creek Reach 1 & 2 Plan and Profile

Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
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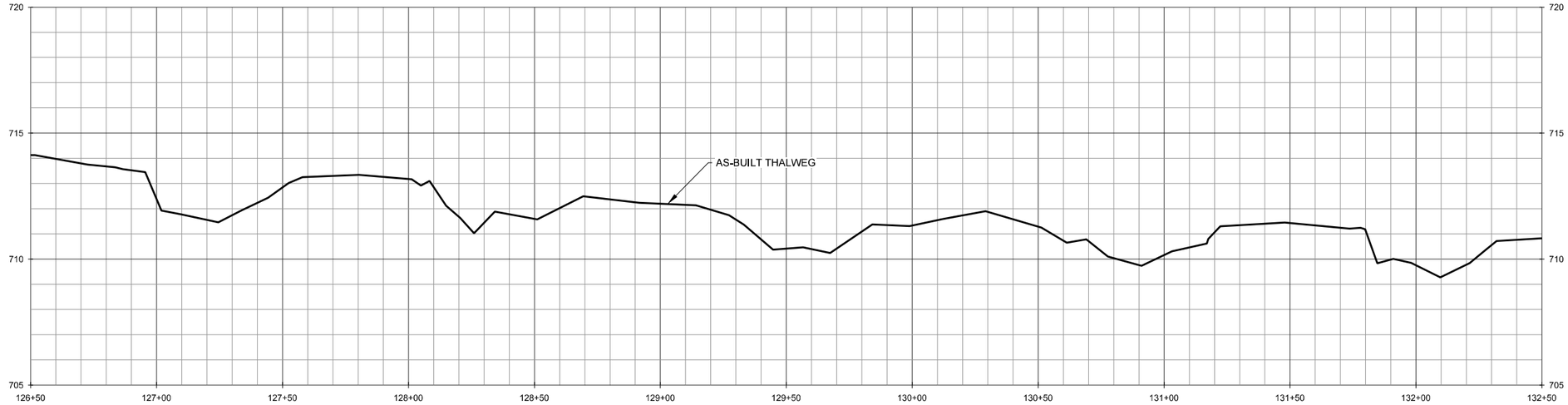
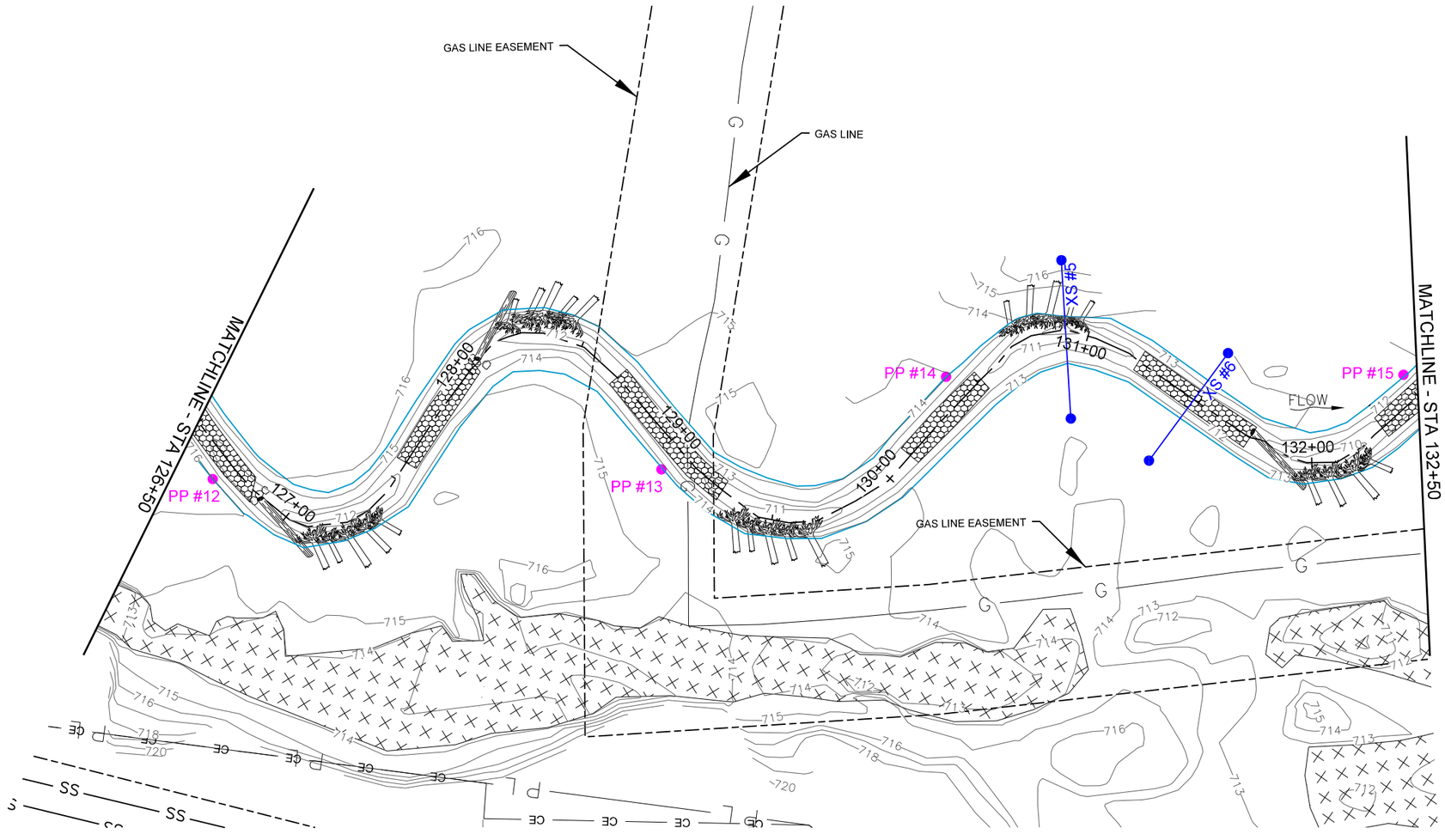
Revisions

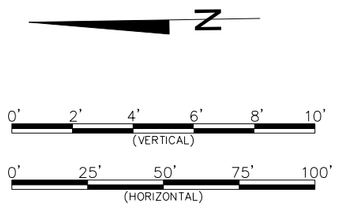
STREAM BASELINE PLANS

Sheet

1.5







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Rockingham County, NC

Stream Baseline Plans
Irvin Creek Reach 2 Plan and Profile

Date:	September 5, 2012
Job Number:	005-12700
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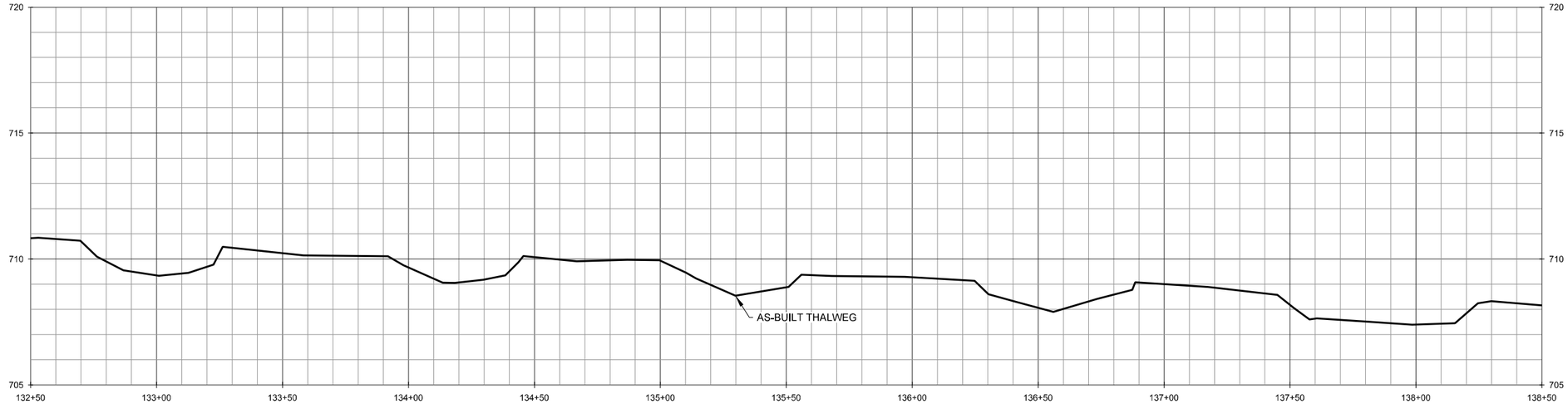
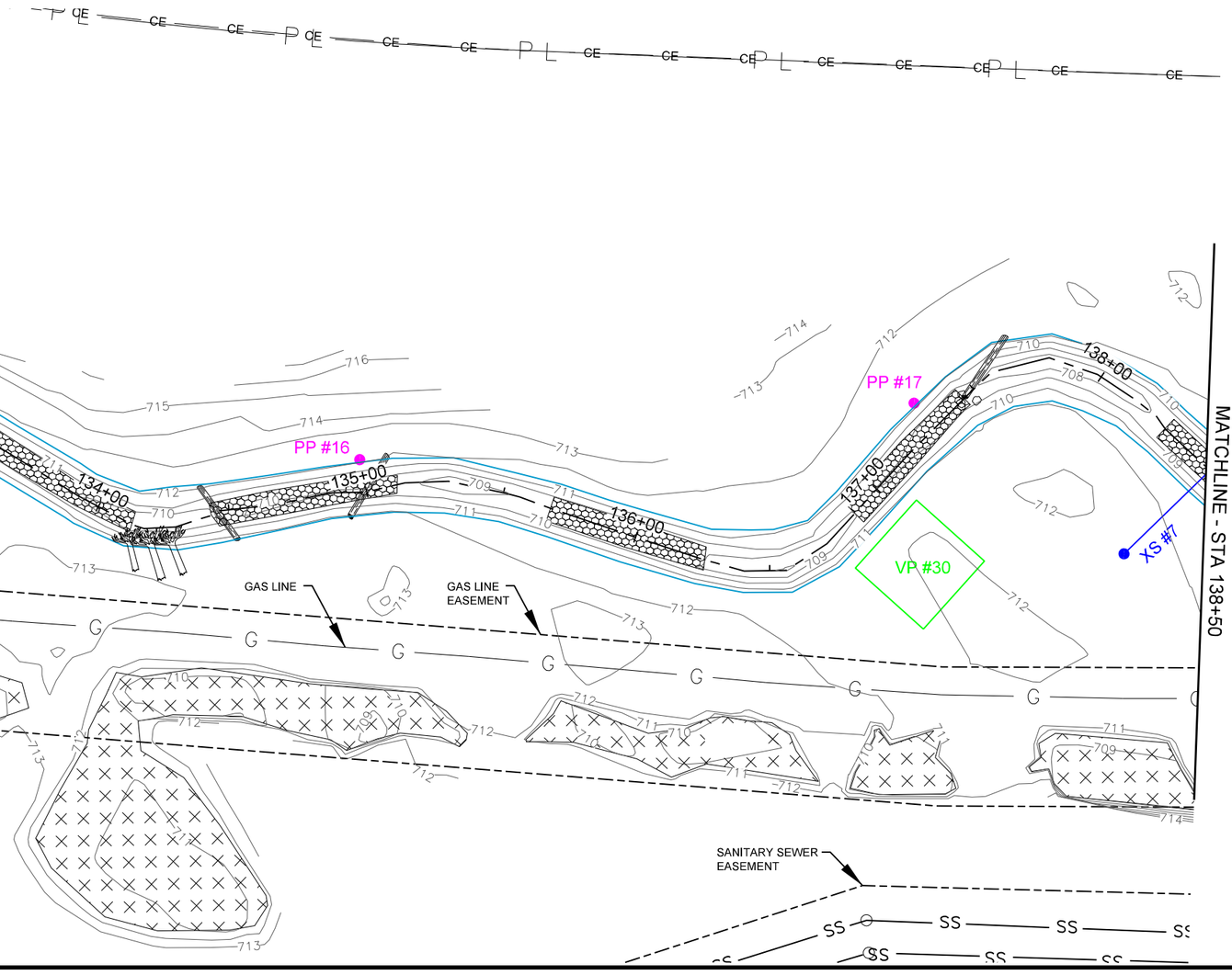
Revisions

STREAM BASELINE PLANS

Sheet

1.6





Final Baseline Drawing

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Little Troublesome Creek Mitigation Site
Rockingham County, NC

Stream Baseline Plans
Irvin Creek Reach 2 Plan and Profile

Date:	September 5, 2012
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Drawn By:	JTL
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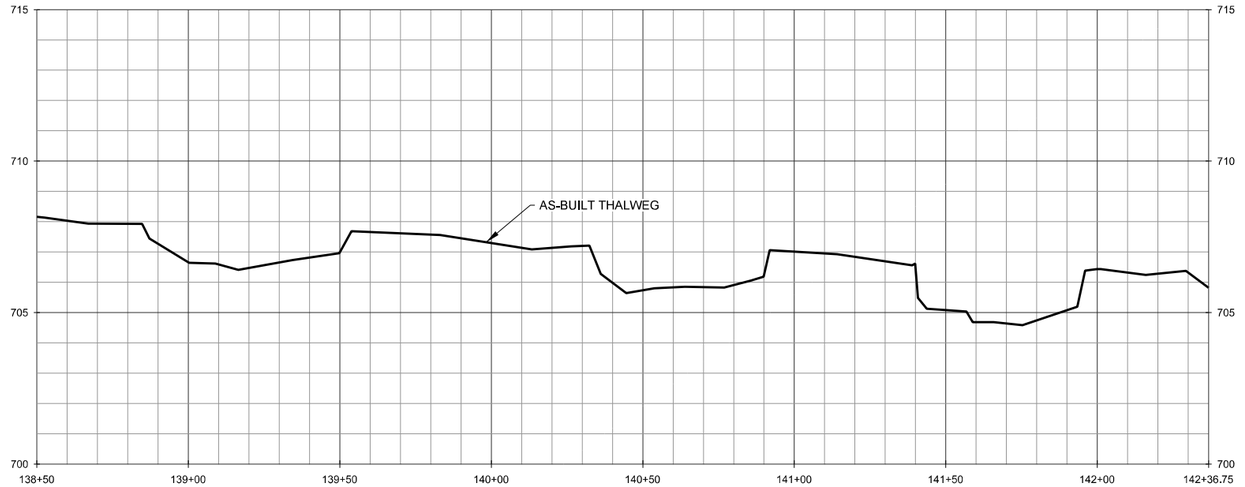
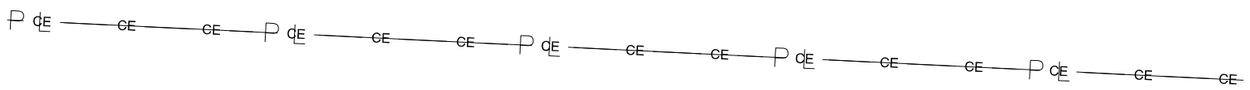
Revisions

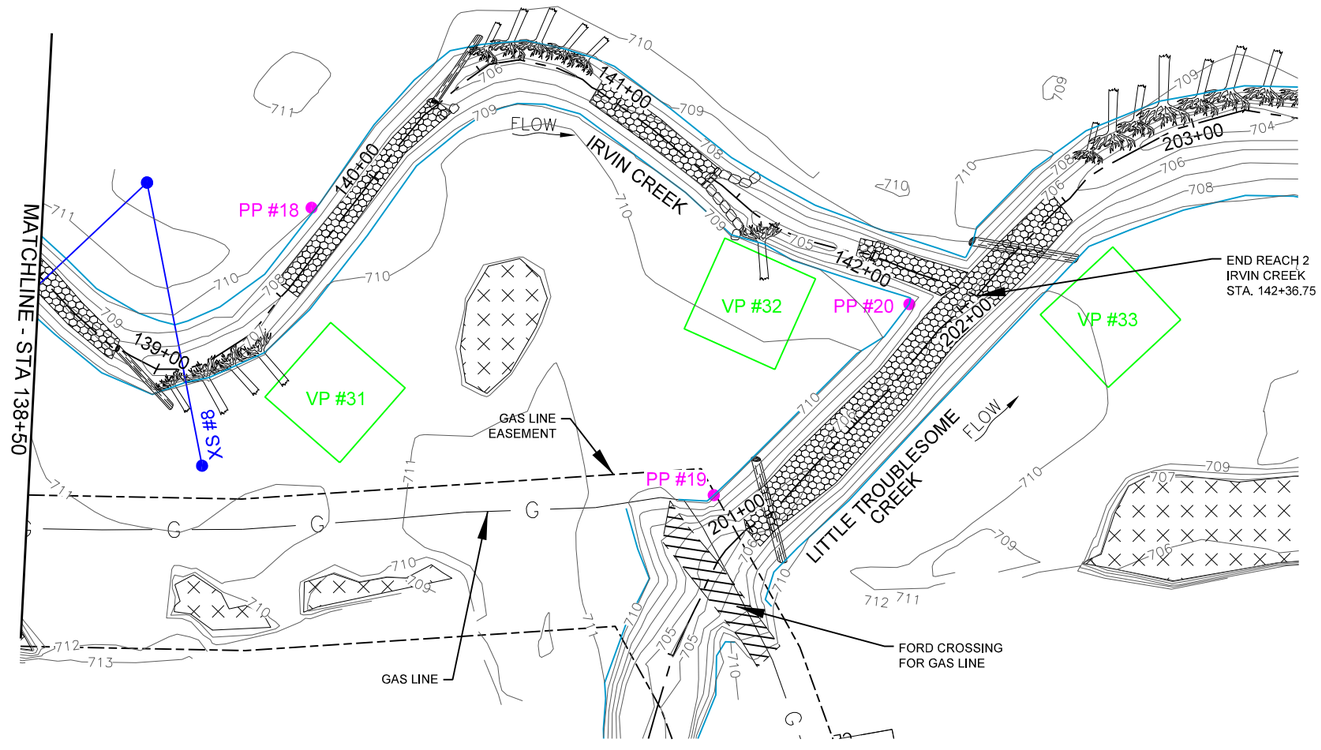
STREAM BASELINE PLANS

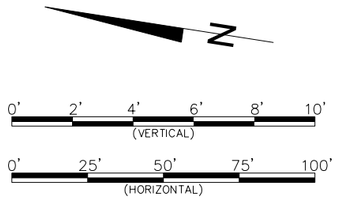
Sheet

1.7









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Little Troublesome Creek Mitigation Site
Rockingham County, NC
Stream Baseline Plans
Irvin Creek Reach 2 Plan and Profile

Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

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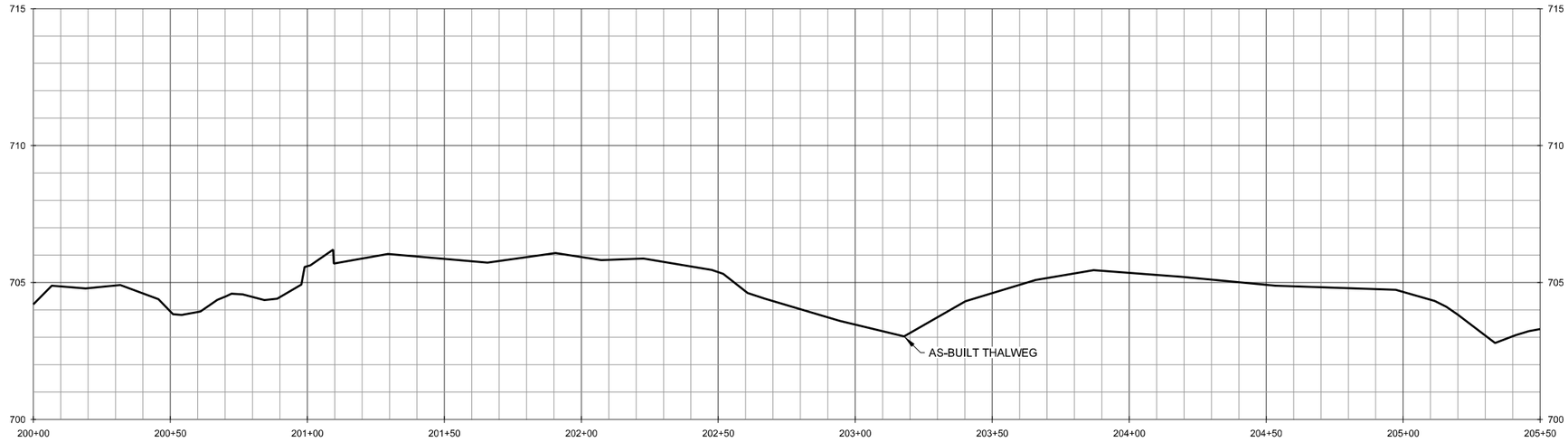
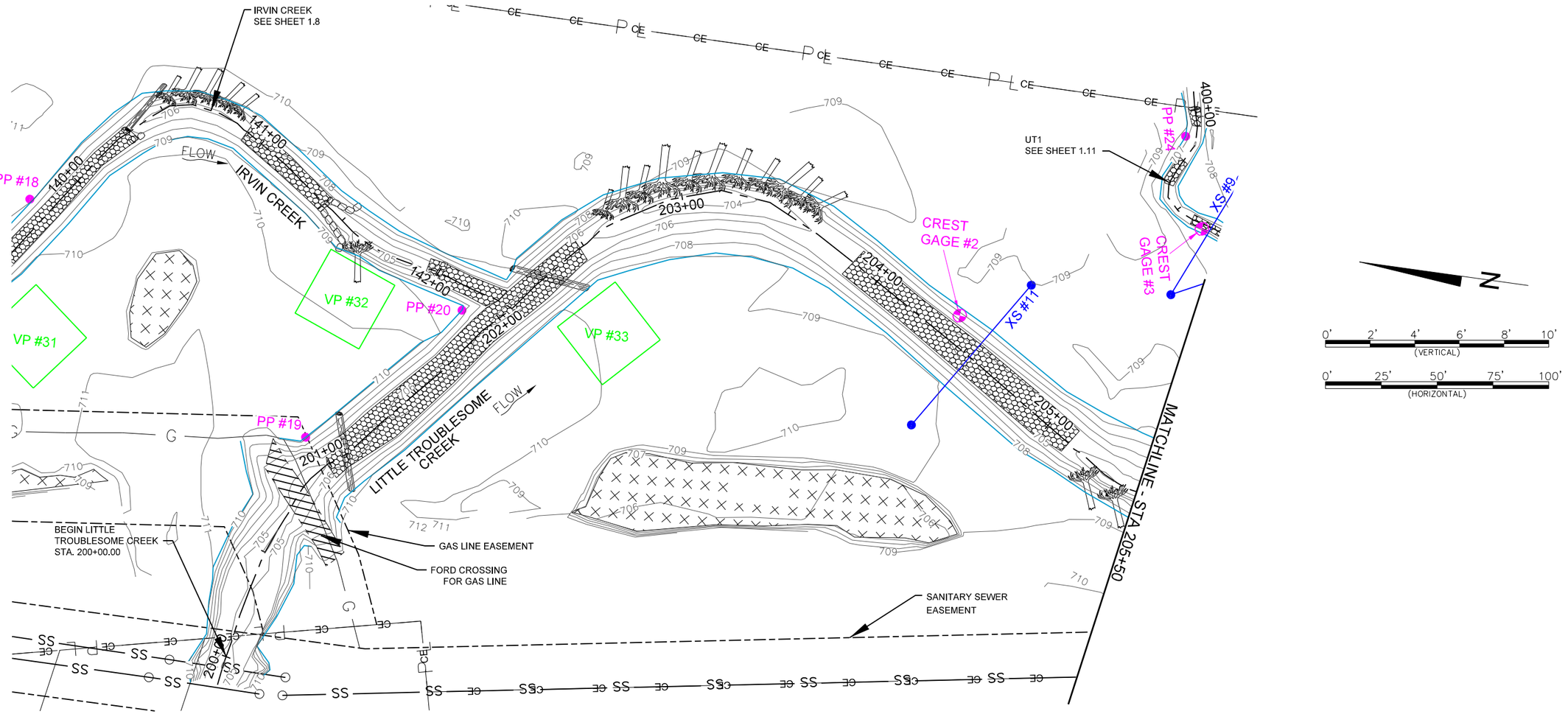
1.8





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Final Baseline Drawing

Little Troublesome Creek Mitigation Site
Rockingham County, NC

Stream Baseline Plans

Little Troublesome Creek Plan and Profile

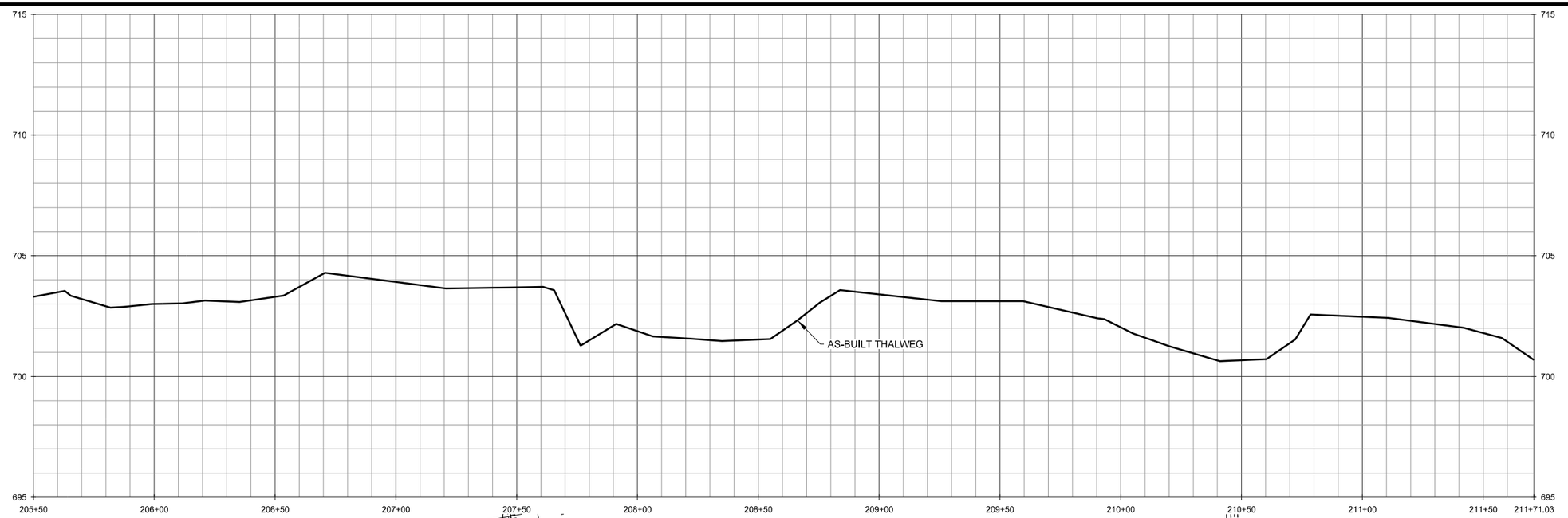
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

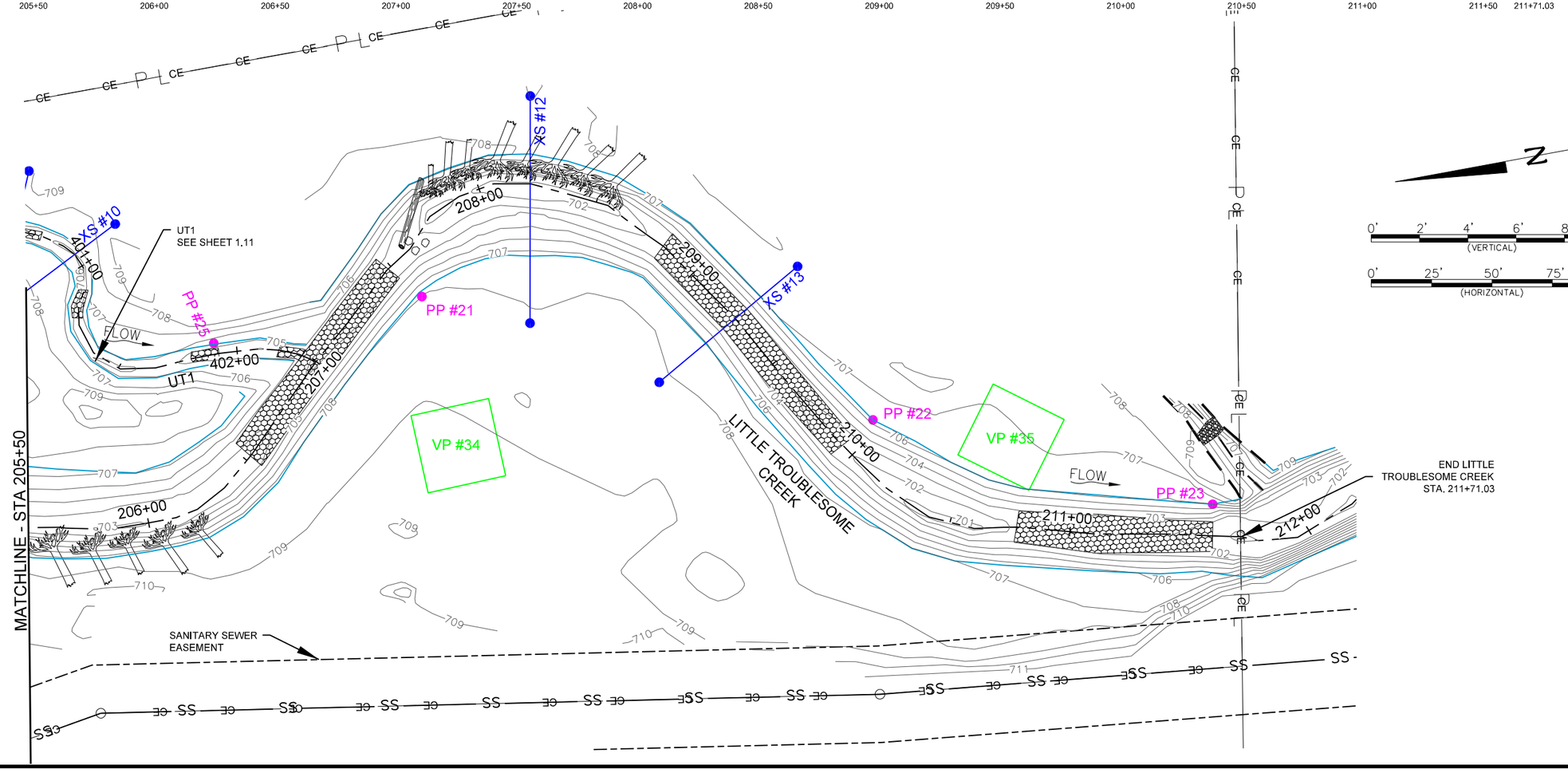
Revisions

STREAM BASELINE PLANS

Sheet

1.9





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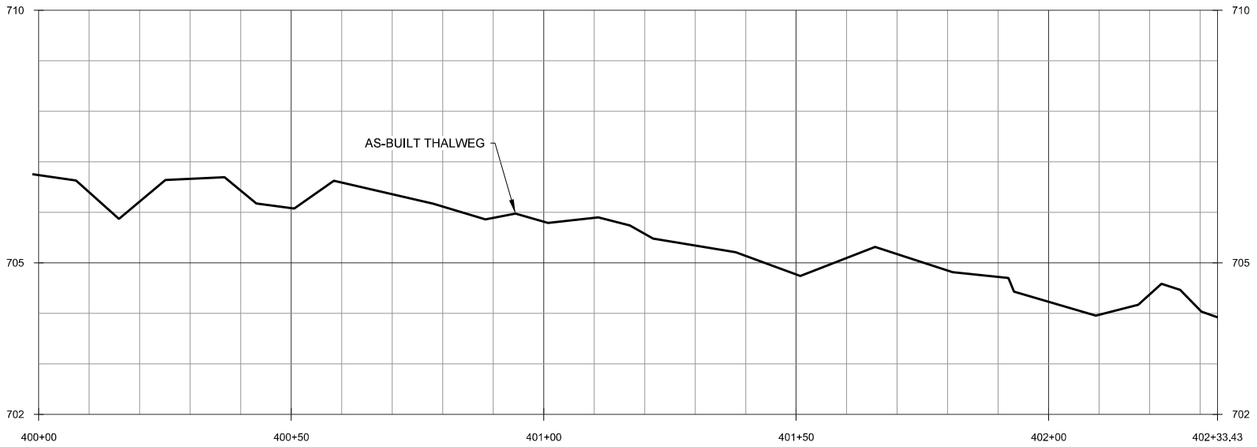
Little Troublesome Creek Mitigation Site
Rockingham County, NC
Stream Baseline Plans
Little Troublesome Creek Plan and Profile

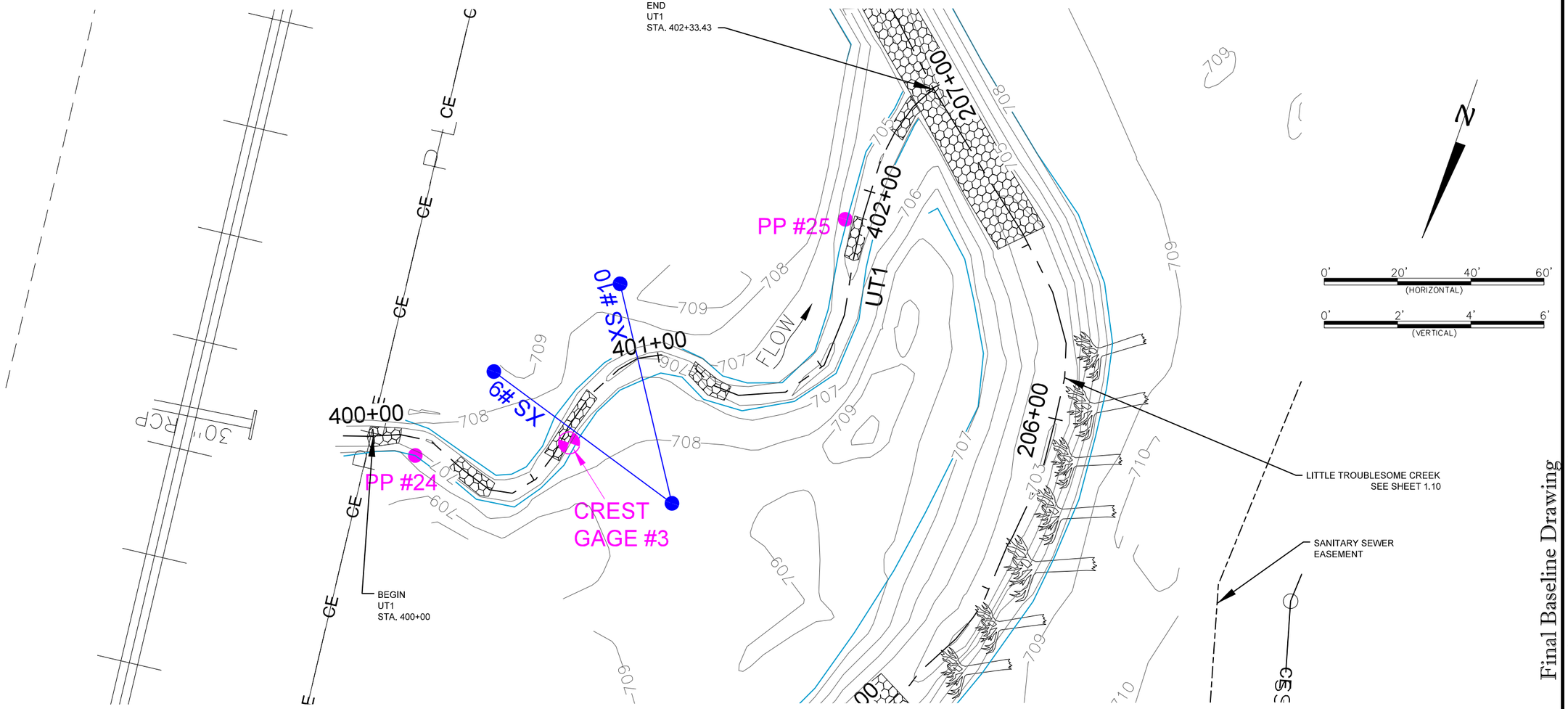
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

Sheet
1.10





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Final Baseline Drawing

Little Troublesome Creek Mitigation Site
Rockingham County, NC

Stream Baseline Plans
UT1 Plan and Profile

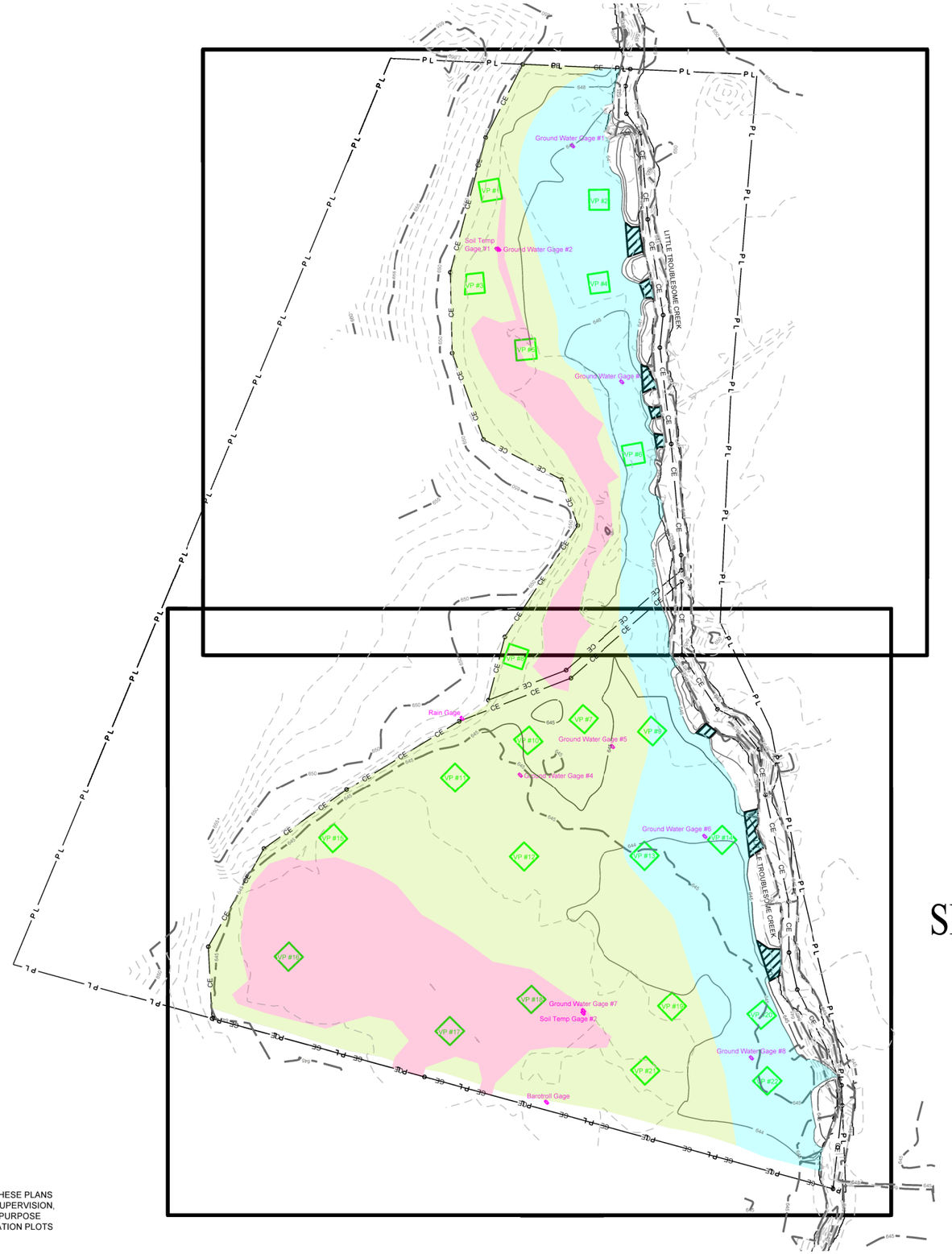
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM BASELINE PLANS

Sheet

1.11



SHEET 2.2

SHEET 2.1

I, C.E. ROBERTSON, CERTIFY THAT THE INFORMATION SHOWN ON THESE PLANS WAS DERIVED FROM AN ACTUAL FIELD SURVEY MADE UNDER MY SUPERVISION, THAT THE RATIO OF PRECISION AS CALCULATED IS 1:10,000+. THE PURPOSE OF THIS SURVEY IS FOR TOPOGRAPHIC INFORMATION AND VEGETATION PLOTS ONLY, NO BOUNDARY DETERMINATIONS WERE MADE AT THIS TIME.

N

0' 100' 200' 300'
(HORIZONTAL)

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Final Baseline Drawing

Little Troublesome Creek Mitigation Site
Rockingham County, NC
Wetland Baseline Overview

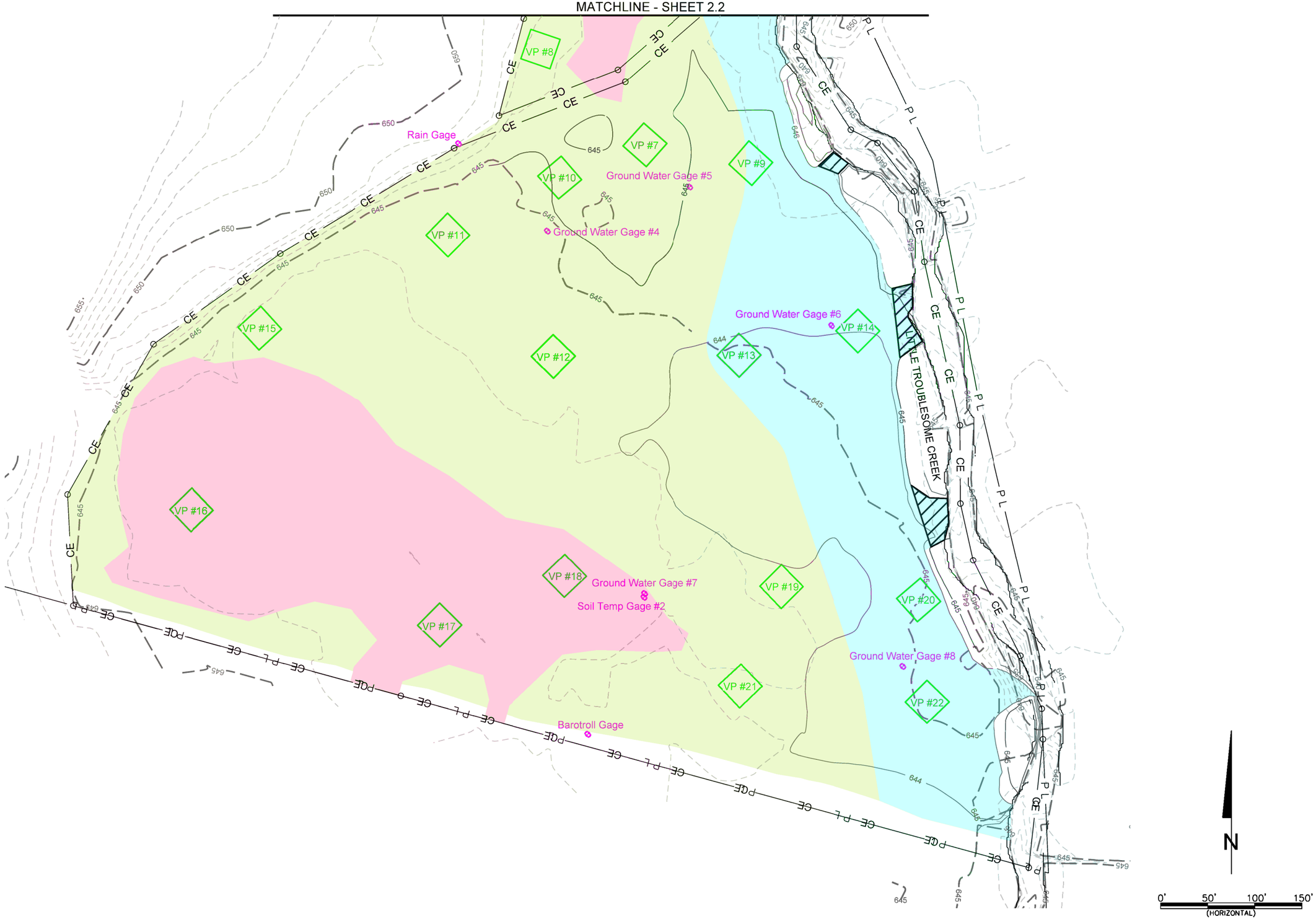
Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

WETLAND BASELINE OVERVIEW

Sheet
2.0

MATCHLINE - SHEET 2.2



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Little Troublesome Creek Mitigation Site
Rockingham County, NC
Wetland Baseline Plans

Final Baseline Drawing

Date:	September 5, 2012
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Project Engineer:	JNK
Drawn By:	JTL
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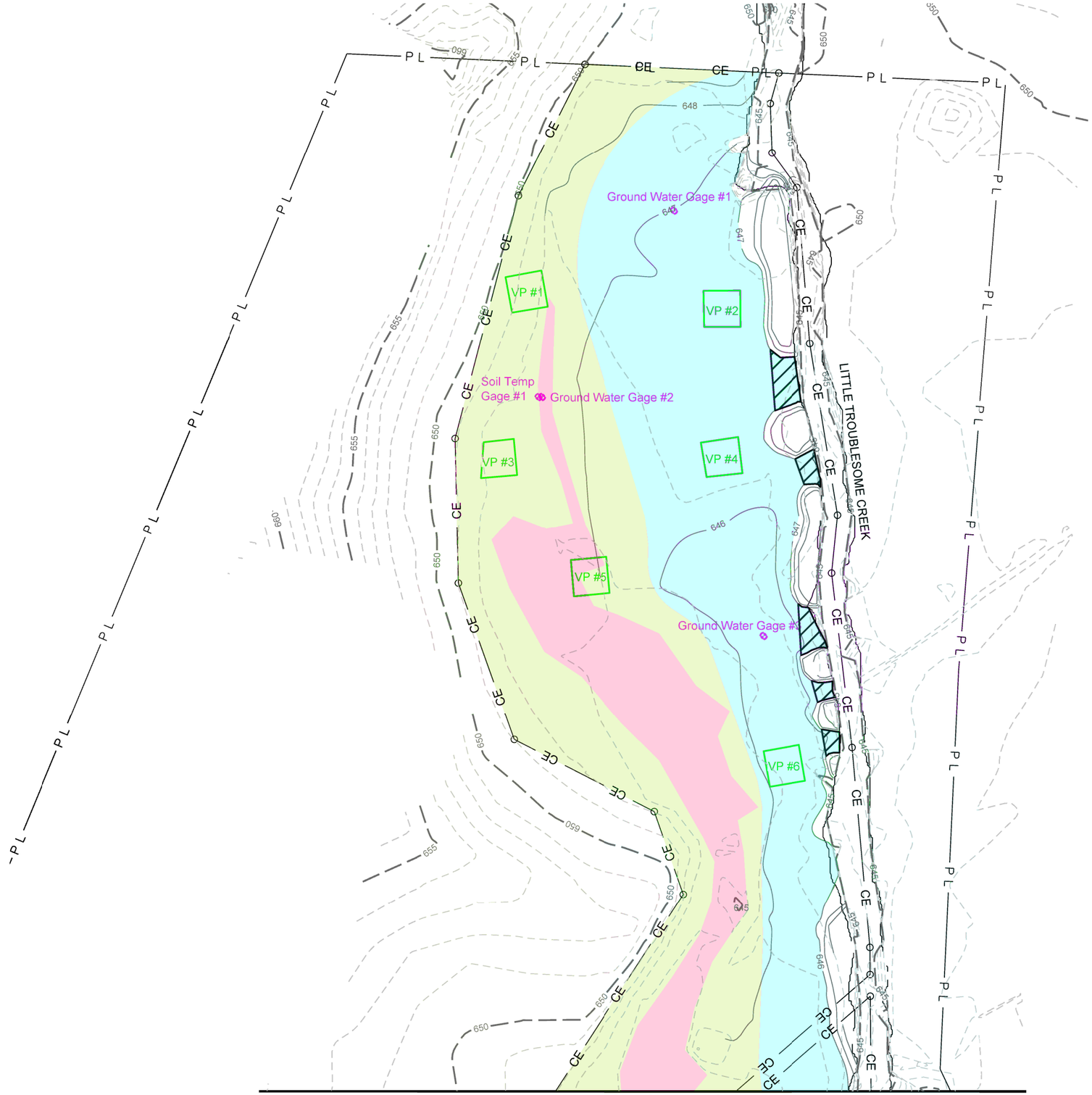
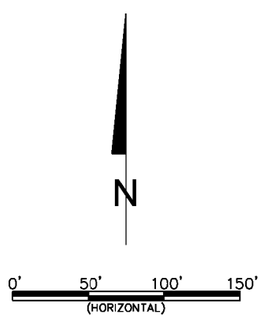
Revisions

WETLAND BASELINE PLANS

Sheet

2.1





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Little Troublesome Creek Mitigation Site
Rockingham County, NC
Wetland Baseline Plans

Final Baseline Drawing

Date:	September 5, 2012
Job Number:	003-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

WETLAND BASELINE PLANS

Sheet

2.2

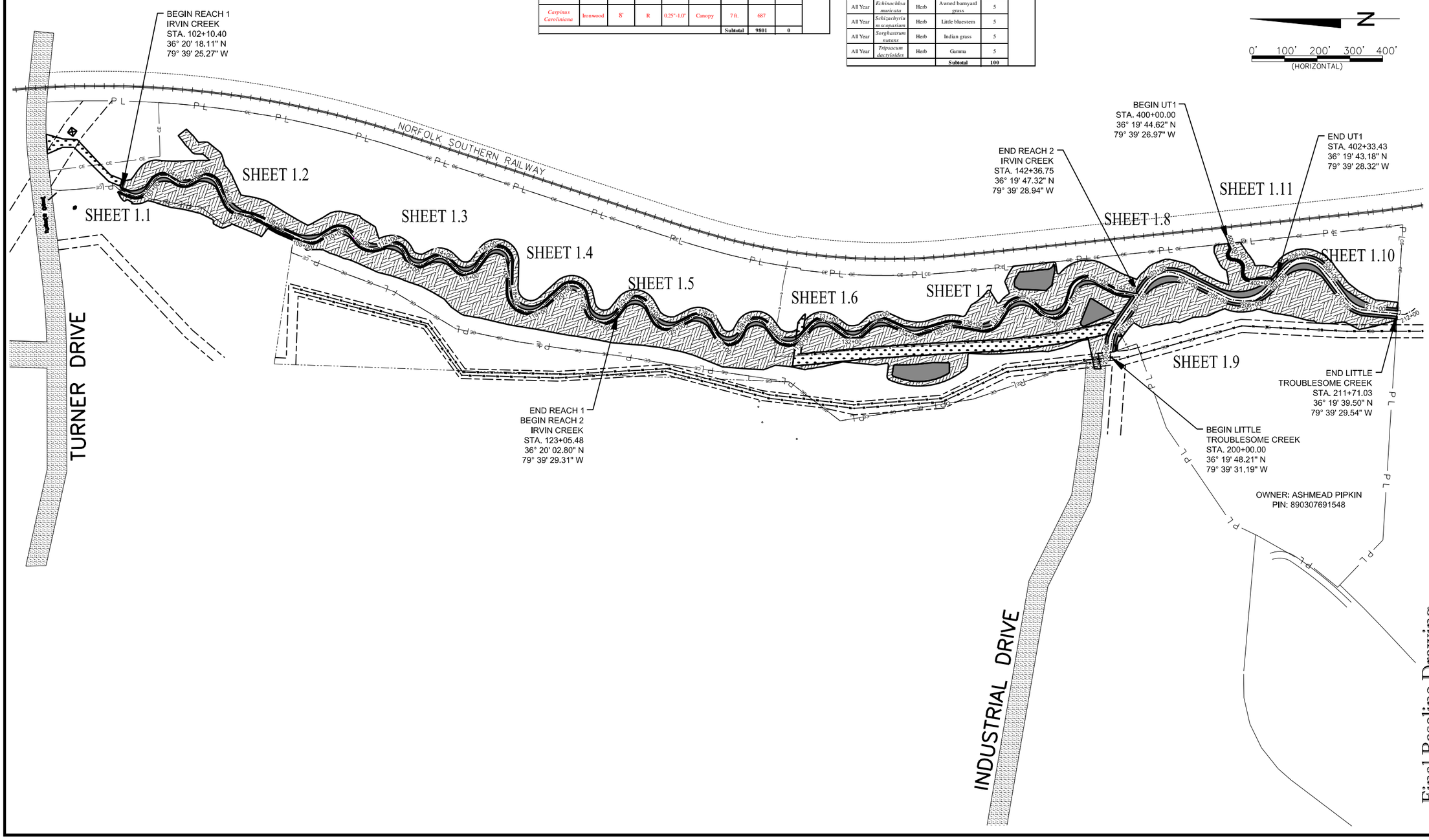
Planting Summary Table								
Streambank Planting							Acres	1.9
Species	Common Name	Max Spacing	Unit Type	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs
Salix sericea	Silky Willow	8'	L	0.5"-1.0"	Shrub	2-8 ft	993	
Salix nigra	Black Willow	8'	L	0.5"-1.0"	Shrub	2-8 ft	662	
Cornus amomum	Silky Dogwood	8'	L	0.5"-1.0"	Shrub	2-8 ft	1655	
Juncus effusus	Soft Rush	3'	P	1.0"-2.0"	Herb	3 ft	3581	
						Subtotal	1815	0

Planting Summary Table								
Floodplain Planting							Acres	12.6
Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs
~~*Juglans nigra*~~	~~Black Walnut~~	~~8'~~	~~R~~	~~0.25"-1.0"~~	~~Canopy~~	~~6 ft.~~	~~2823~~	
Liriodendron tulipifera	Tulip Poplar	8'	R	0.25"-1.0"	Canopy	6 ft.	1400	
Quercus phellos	Willow Oak	8'	R	0.25"-1.0"	Canopy	6 ft.	400	
Plantus occidentalis	Sycamore	8'	R	0.25"-1.0"	Canopy	7 ft.	1400	
Fraxinus pennsylvanica	Green Ash	8'	R	0.25"-1.0"	Canopy	7ft.	1374	
Betula nigra	River Birch	8'	R	0.25"-1.0"	Canopy	7ft.	1374	
Quercus rubra	Southern Red Oak	8'	R	0.25"-1.0"	Canopy	9 ft.	343	
Carpinus Caroliniana	Ironwood	8'	R	0.25"-1.0"	Canopy	7 ft.	687	
						Subtotal	9801	0

Permanent Seeding					
Recommended application rate 20 -25 lbs. per acre				Acres	14.5
Approved Date	Species Name	Stratum	Common Name	Percent	
All Year	*Elymus virginicus*	Herb	Virginia wild rye	15	
All Year	*Panicum virgatum*	Herb	Switchgrass	15	
All Year	*Agrostis stolonifera*	Herb	Creeping bentgrass	10	
All Year	*Rudbeckia hirta NC ecotype*	Herb	Black-eyed susan	10	
All Year	*Coreopsis lanceolata*	Herb	Coreopsis	10	
All Year	*Panicum clandestinum*	Herb	Deer tongue	10	
All Year	*Andropogon gerardii*	Herb	Big bluestem	5	
All Year	*Juncus effusus*	Herb	Soft rush	5	
All Year	*Echinochloa muricata*	Herb	Awned barnyard grass	5	
All Year	*Schizachyrium scoparium*	Herb	Little bluestem	5	
All Year	*Sorghastrum nutans*	Herb	Indian grass	5	
All Year	*Tripsacum dactyloides*	Herb	Gamma	5	
			Subtotal	100	

Temporary Seeding					
				Acres	33.8
Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
Aug 15 - May 1	*Secale cereale*	Herb	Rye Grain	140	
May 1 - Aug 15	*Setaria italica*	Herb	German Millet	50	

Planting Summary Table					
Easements Planting				Acres	1.1
Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
All Year	*Panicum virgatum*	Herb	Switchgrass	5	
			Subtotal	5	



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Little Troublesome Creek Mitigation Site
Rockingham County, NC
Stream Planting

Final Baseline Drawing

Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

STREAM PLANTING

Sheet

3.0

Planting Summary Table

Floodplain Planting								Acres	12.6
Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs	
~~*Juglans nigra*~~	~~Black Walnut~~	~~8'~~	~~R~~	~~0.25"-1.0"~~	~~Canopy~~	~~6 ft.~~	~~2823~~		
Liriodendron tulipifera	Tulip Poplar	8'	R	0.25"-1.0"	Canopy	6 ft.	1400		
Quercus phellos	Willow Oak	8'	R	0.25"-1.0"	Canopy	6 ft.	400		
Plantus occidentalis	Sycamore	8'	R	0.25"-1.0"	Canopy	7 ft.	1400		
Fraxinus pennsylvanica	Green Ash	8'	R	0.25"-1.0"	Canopy	7ft.	1374		
Betula nigra	River Birch	8'	R	0.25"-1.0"	Canopy	7ft.	1374		
Quercus rubra	Southern Red Oak	8'	R	0.25"-1.0"	Canopy	9 ft.	343		
Carpinus Caroliniana	Ironwood	8'	R	0.25"-1.0"	Canopy	7 ft.	687		
						Subtotal	9801	0	

Planting Summary Table

Easements Planting				Acres	1.1
Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
All Year	*Panicum virgatum*	Herb	Switchgrass	5	
			Subtotal	5	

Permanent Seeding

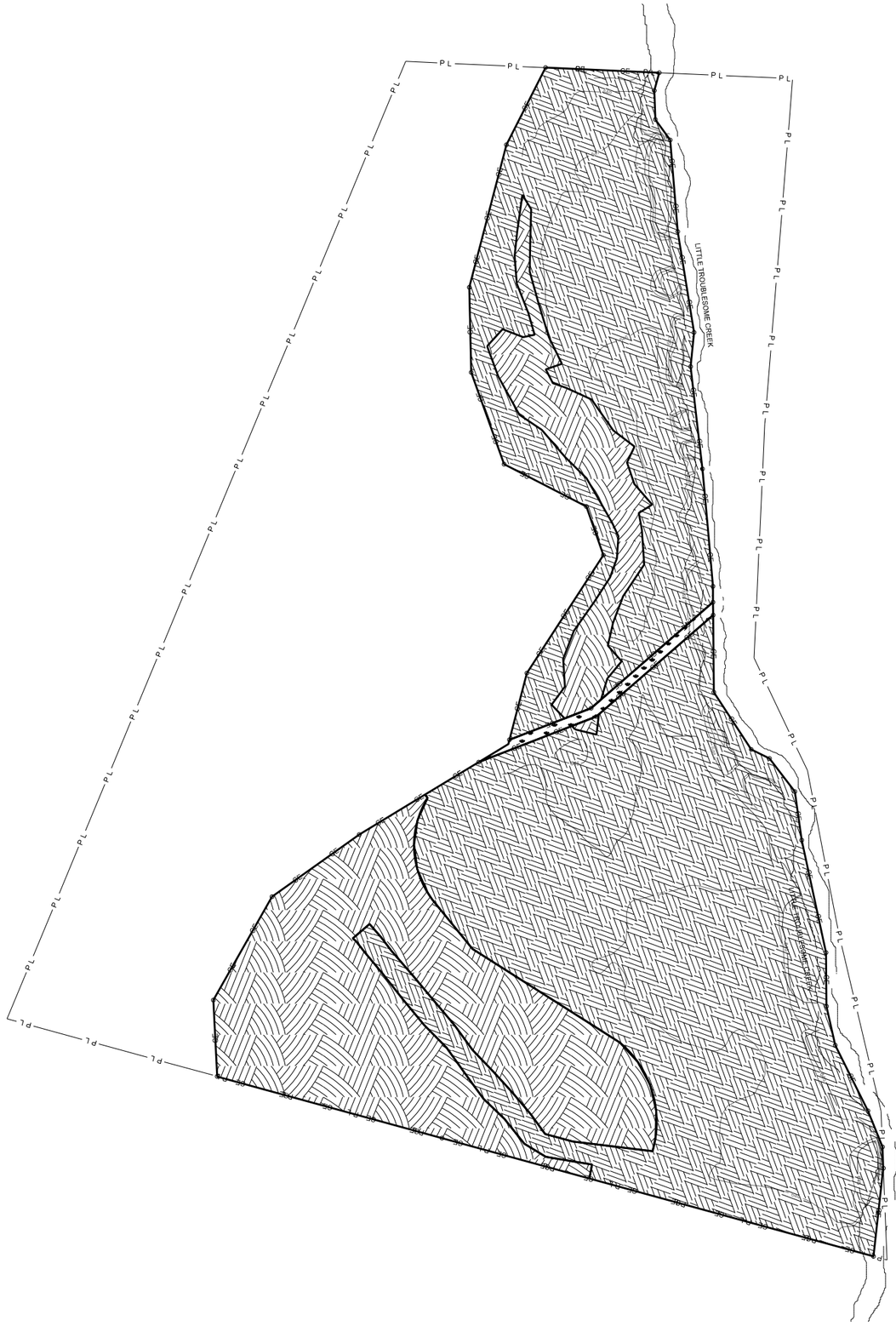
Recommended application rate 20 -25 lbs. per acre				Acres	14.5
Approved Date	Species Name	Stratum	Common Name	Percent	
All Year	*Elymus virginicus*	Herb	Virginia wild rye	15	
All Year	*Panicum virgatum*	Herb	Switchgrass	15	
All Year	*Agrostis stoloniifera*	Herb	Creeping bentgrass	10	
All Year	*Rudbeckia hirta NC ecotype*	Herb	Black-eyed susan	10	
All Year	*Coreopsis lanceolata*	Herb	Coreopsis	10	
All Year	*Panicum clandestinum*	Herb	Deer tongue	10	
All Year	*Andropogon gerardii*	Herb	Big bluestem	5	
All Year	*Juncus effusus*	Herb	Soft rush	5	
All Year	*Echinochloa muricata*	Herb	Awned barnyard grass	5	
All Year	*Schizachyrium scoparium*	Herb	Little bluestem	5	
All Year	*Sorghastrum nutans*	Herb	Indian grass	5	
All Year	*Tripsacum dactyloides*	Herb	Gamma	5	
			Subtotal	100	

Temporary Seeding

				Acres	33.8
Approved Date	Species Name	Stratum	Common Name	Density (lbs/acre)	
Aug 15 - May 1	*Secale cereale*	Herb	Rye Grain	140	
May 1 - Aug 15	*Setaria italica*	Herb	German Millet	50	

Planting Summary Table

Wetland Planting								Acres	19.1
Species	Common Name	Max Spacing	Unit Type*	Min. Caliper Size	Stratum	Indiv. Spacing	# of Stems	Total lbs	
Alnus serrulata	Tag Alder	8'	R	0.25"-1.0"	Canopy	6-8 ft.	1299		
Cornus ammomum	Silky Dogwood	8'	R	0.25"-1.0"	Canopy	6-8 ft.	1299		
Quercus phellos	Willow Oak	8'	R	0.25"-1.0"	Canopy	6-8 ft.	649		
Plantus occidentalis	Sycamore	8'	R	0.25"-1.0"	Canopy	6-8 ft.	2598		
Betula nigra	River Birch	8'	R	0.25"-1.0"	Canopy	6-8 ft.	2598		
Nyssa sylvatica	Black Gum	8'	R	0.25"-1.0"	Canopy	6-8 ft.	1299		
Quercus michauxii	Swamp Chestnut Oak	8'	R	0.25"-1.0"	Canopy	6-8 ft.	649		
Fraxinus pennsylvanica	Green Ash	8'	R	0.25"-1.0"	Canopy	6-8 ft.	2598		
						Subtotal	19058	0	



WILDLANDS ENGINEERING

WILDLANDS ENGINEERING, INC.
Ecological Restoration Services
5605 Chapel Hill Road, Suite 122
Raleigh, NC 27607
Tel: 919.851.9986
Fax: 919.851.9987
Firm License No. F-0831

Little Troublesome Creek Mitigation Site
Rockingham County, NC
Wetland Planting

Final Baseline Drawing

Date:	September 5, 2012
Job Number:	005-12700
Project Engineer:	JNK
Drawn By:	JTL
Checked By:	JWH

Revisions

WETLAND PLANTING

Sheet
4.0

APPENDIX 5. Recorded Gas Line Easement

GRANT OF EASEMENT
TRANSMISSION

Return Recorded Document to:
Sandy Ogint
Administrator Property Records
Piedmont Natural Gas Company, Inc.
4720 Piedmont Row Dr.
Charlotte, NC 28210

STATE OF NORTH CAROLINA
COUNTY OF ROCKINGHAM
TAX ID # 8903-19-69-2224

LINE NUMBER _____
PARCEL NUMBER ROCK-1

THIS GRANT OF EASEMENT made this 18th day of June, 2012, from WILDLANDS LITTLE TROUBLESOME CREEK HOLDINGS, LLC (hereinafter designated as GRANTOR), to PIEDMONT NATURAL GAS COMPANY, INC., (hereinafter designated as GRANTEE).

WITNESSETH

That GRANTOR, for and in consideration of the sum of $10.00, and other valuable considerations, the receipt of which is hereby acknowledged, hereby bargains, sells, and conveys unto GRANTEE, its successors and assigns, a right of way and easement rights for the purpose of laying, constructing, maintaining, operating, repairing, altering, replacing, removing, and protecting one or more pipelines for the transportation of natural gas under, upon, over, through, and across the land of GRANTOR (or in which GRANTOR has interest) situated in Reidsville Township, Rockingham County, North Carolina, as described in deed(s) recorded in Book 1409, page 1478 , Rockingham County Registry.

This GRANT OF EASEMENT shall supersede an agreement between W. B. Pipkin and wife, Ruth Pringle Pipkin and Pennsylvania & and Southern Gas Company now doing business as Piedmont Natural Gas Company, Inc. recorded November 29, 1963, in Book 608, Page 340, Rockingham County Registry.

The right of way herein granted is 50 feet wide and encompasses 1.62 acres, more or less, as shown on the attached survey dated January 4, 2012 by McKim and Creed and entitled "Easement to be Acquired From Wildlands Little Troublesome Creek Holdings, LLC".

GRANTEE shall have all rights necessary or convenient for the full use and enjoyment of the rights herein granted, including without limitation: (1) free and full right of access to and from said right of way over and across the aforesaid land; (2) to keep said right of way cleared of trees, buildings, and other obstructions; and (3) to construct, install, operate, utilize, rebuild, remove, protect and maintain pipes, valves, markers, cathodic protection equipment, anode beds and other appurtenant devises in conjunction with said gas facilities.

GRANTOR reserves the right to use the land over which said right of way and easement rights are hereby granted for all purposes not inconsistent with said easement rights, the North Carolina Utilities Commission, GRANTEE'S current encroachment specifications, and any federal, state, or local law, rule, or regulation, provided that GRANTOR and GRANTEE agree that: (1) notwithstanding anything to the contrary herein, GRANTOR shall give written notification to GRANTEE and GRANTOR shall obtain written approval from GRANTEE prior to any activity as defined in items (2)–(7) of this paragraph; (2) the depth of said gas facilities below the surface of the ground shall not be reduced by grading or any other work and any slopes allowed within said right of way shall be no greater than a four to one (4:1) ratio; (3) if streets, roads, equipment crossings, fences or utility lines are constructed across said right of way, they shall cross as nearly as possible at right angles to gas line(s) and in no event shall they be constructed laterally along and over the easement; (4) fences shall have minimum twelve (12) foot wide gate(s) (5) Removable pavers shall be installed along the entire length and width of the pipeline easement in paved parking areas; (6) improvements shall not adversely affect, in GRANTEE'S sole discretion, the access to, safety, construction, reconstruction, operation, or maintenance of GRANTEE'S facilities and GRANTEE shall not be liable for damages to said future improvements installed within said right of way; (7) landscaping on the right of way shall be limited to lawn grasses and shrubs which have a maximum mature height of four (4) feet, (8) buildings, storage sheds, mobile homes, wells, septic tanks, and/or related drain fields, absorption pits, detention ponds, irrigation systems (except crossing), sprinkler heads, swimming pools, ponds, lakes, erosion control sediment traps, underground vaults, burial grounds, explosives or flammable materials, fires of any type, fire hydrants, catch basins, air strips, electrical transformers or enclosures, utility poles, dumpsters, trash, uprooted stumps, boulders, rubble, building materials, junk or inoperable vehicles, satellite signal receiver systems, or other obstructions are prohibited within said right of way; (9) GRANTOR shall not: (a) interfere with GRANTEE'S access or maintenance to its facilities, or (b) endanger the safety of GRANTOR, GRANTEE, or the general public; (10) GRANTEE reserves the right to construct future pipelines within said right of way and GRANTOR shall not interfere with or object to the construction of said future pipelines; and (11) all facilities installed by GRANTEE shall be and remain the property of GRANTEE and may be removed by it at any time and from time to time.

GRANTEE agrees that it shall be responsible for actual damages to improvements that existed prior to this EASEMENT and annual crops of GRANTOR both inside and outside said right of way on the above-referenced land caused by the construction, installation, operation, utilization, inspection, rebuilding, removal, and maintenance of said facilities, and in going to and from said right of way, and shall be responsible for the breakage caused to any bridge and any extraordinary damage to any road due to heavy hauling to and from said right of way, if claim is made within sixty (60) days after such damages are sustained.

To have and to hold said right of way and easement rights unto GRANTEE, its affiliates, successors, and assigns, perpetually and continuously. GRANTOR expressly give(s) GRANTEE, its successors and assigns, the right to assign, license, lease, or otherwise transfer, in whole or part, this GRANT OF EASEMENT or any rights given herein, to any person or entity, including but not limited to, any affiliated parent or subsidiary entity of GRANTEE, for the uses and purposes expressly stated herein.

GRANTOR hereby bind(s) GRANTOR and GRANTOR'S heirs, representatives, and assigns to warrant and forever defend all and singular said premises unto GRANTEE, its successors and assigns, against the claims of all persons whomsoever.

IN WITNESS WHEREOF, this GRANT OF EASEMENT has been signed and sealed by GRANTOR, as of the date first above written.

GRANTOR:

Wildlands Little Troublesome Creek Holdings, LLC

By: Shawn D. Wilkerson Sign

Shawn D. Wilkerson Print

Title: Member / Manager / President (Circle One)

STATE OF NORTH CAROLINA

COUNTY OF

I, Charlotte P. Kinney, a Notary Public of Mecklenburg County, North Carolina, do hereby certify that Shawn D. Wilkerson, Member / Manager / President (Circle One) of Wildlands Little Troublesome Creek Holdings LLC, GRANTOR, personally appeared before me this day and acknowledged the due execution of the foregoing GRANT OF EASEMENT on behalf of the limited liability company.

Witness my hand and seal this 18th day of June, 2012.

CHARLOTTE P. KINNEY
NOTARY PUBLIC
Mecklenburg County, North Carolina

Notary Seal

Charlotte P Kinney Sign

Notary Public

Charlotte P. Kinney Print

My Commission Expires: Jan. 31, 2016

AREA OF:	SQ. FT.	ACRE
PROPOSED EASEMENT	70,855	1.63

PROJECT LOCALIZED FROM POINT #3
#5 REBAR
GRID COORDINATES
N: 940696.42
E: 1806267.23
CF: 0.99994857

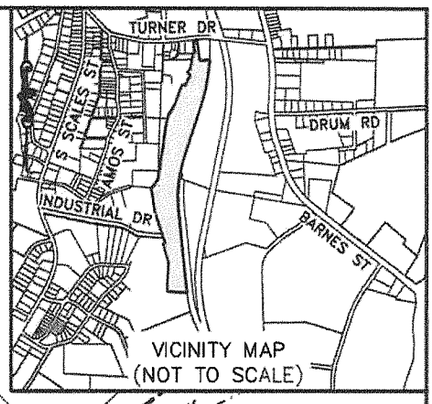
THE STATE PLANE COORDINATES (SPC) FOR THIS PROJECT WERE PRODUCED WITH VRS GPS OBSERVATIONS AND PROCESSED WITH VRS SOFTWARE ON DEC. 7, 2011.

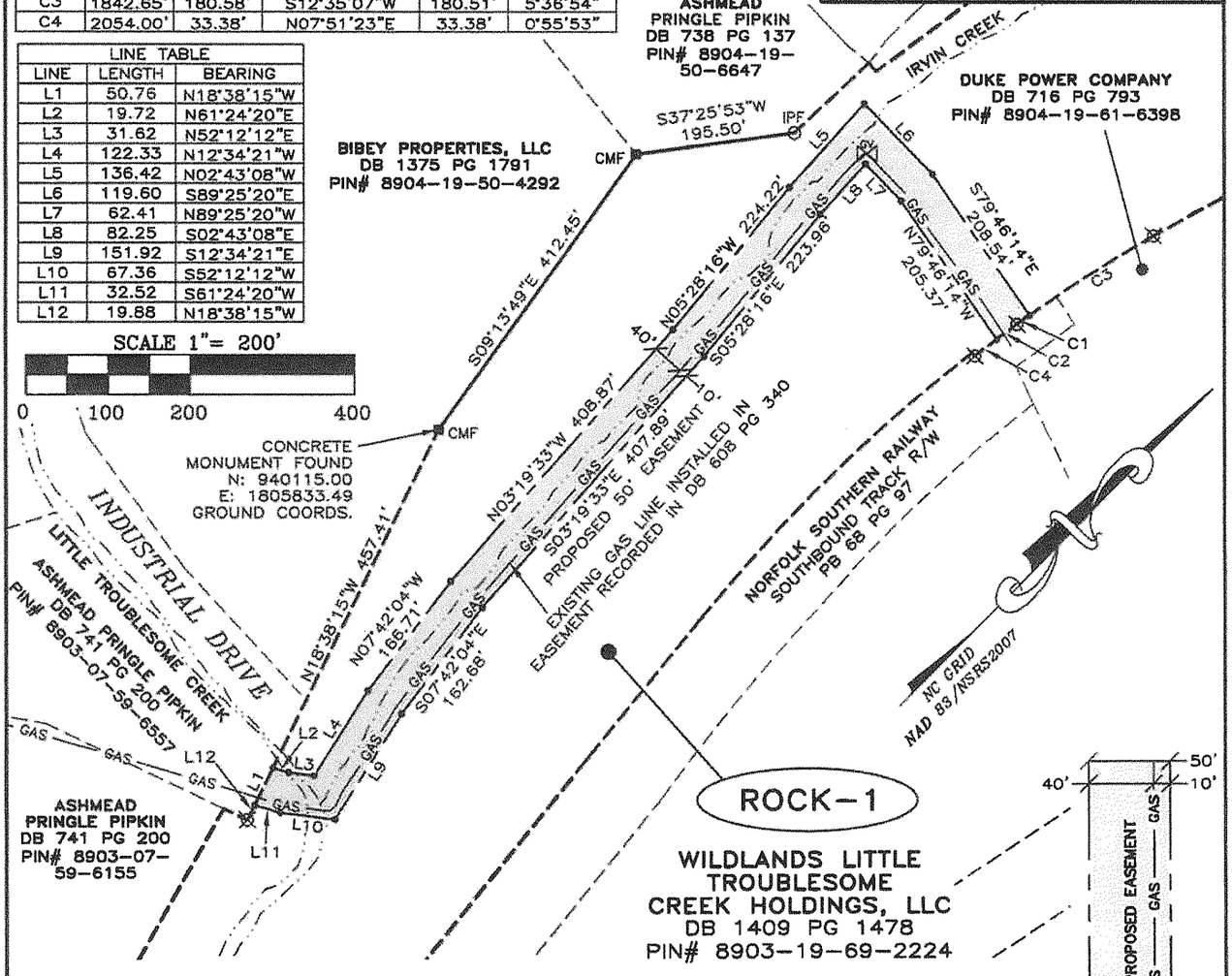
THE NETWORK POSITIONAL ACCURACY OF THE VRS DERIVED POSITIONAL INFORMATION IS 0.046 AND SURVEY CLASS MEETS OR EXCEEDS CLASS B.

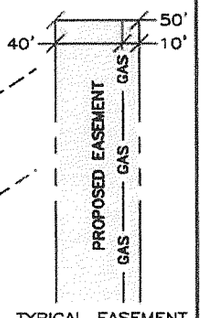
HORIZONTAL POSITIONS ARE REFERENCED TO NAD 83/NSRS (2007)
VERTICAL POSITIONS ARE REFERENCED TO NAVD88 USING (GEOID09)
COMBINED FACTOR: 0.99994857; GEOID MODEL: GEOID09; UNITS: US SURVEY FEET

CURVE TABLE					
CURVE	RADIUS	LENGTH	CHORD BEARING	CHORD	DELTA
C1	1842.65'	19.00'	S09°28'57"W	19.00'	0°35'27"
C2	2054.00'	31.02'	S08°45'16"W	31.01'	0°51'55"
C3	1842.65'	180.58'	S12°35'07"W	180.51'	5°36'54"
C4	2054.00'	33.38'	N07°51'23"E	33.38'	0°55'53"

LINE TABLE		
LINE	LENGTH	BEARING
L1	50.76	N18°38'15"W
L2	19.72	N61°24'20"E
L3	31.62	N52°12'12"E
L4	122.33	N12°34'21"W
L5	136.42	N02°43'08"W
L6	119.60	S89°25'20"E
L7	62.41	N89°25'20"W
L8	82.25	S02°43'08"E
L9	151.92	S12°34'21"E
L10	67.36	S52°12'12"W
L11	32.52	S61°24'20"W
L12	19.88	N18°38'15"W







TYPICAL EASEMENT LAYOUT (NTS)

I, JAMES L. STRICKLAND, PLS L-4247, CERTIFY THAT THIS PLAT WAS DRAWN UNDER MY SUPERVISION FROM AN ACTUAL SURVEY MADE UNDER MY SUPERVISION (DEED DESCRIPTION RECORDED IN BOOK 1409 PAGE 1478); THAT THE BOUNDARY LINES NOT SURVEYED ARE INDICATED WITH DASHED LINES AS DRAWN FROM INFORMATION IN BOOK 1409 PAGE 1478 OR OTHER REFERENCE SOURCE; THAT THE RATIO OF PRECISION IS 1:10,000; THAT THIS PLAT MEETS THE REQUIREMENTS OF THE STANDARDS OF PRACTICE FOR LAND SURVEYING IN NORTH CAROLINA (21 NCAC 56.1600);

THAT THIS PLAT WAS PREPARED FOR THE PURPOSE OF EASEMENT ACQUISITION ONLY, AND IS NOT INTENDED TO BE A BOUNDARY SURVEY OF THE PROPERTY SHOWN HEREON. IT IS THE INTENT OF THIS PLAT THAT THE EASEMENT SHALL CROSS THE ENTIRE PARCEL;

THAT THE CONTROL AND TIES TO THIS SURVEY WERE PERFORMED USING GPS METHODS;

THAT THIS SURVEY IS OF ANOTHER CATEGORY, SUCH AS THE RECOMBINATION OF EXISITNG PARCELS, A COURT-ORDERED SURVEY, OR OTHER EXCEPTION TO THE DEFINITION OF SUBDIVISION;

WITNESS MY ORIGINAL SIGNATURE, LICENSE NUMBER,

AND SEAL THIS 12TH DAY OF JANUARY, AD 2012.

NORTH CAROLINA PROFESSIONAL SEAL L-4247 LAND SURVEYOR JAMES L. STRICKLAND

James L. Strickland 1-12-12

JAMES L. STRICKLAND
PROFESSIONAL LAND SURVEYOR L-4247

LEGEND

- CMF ■ CONC. MON. FOUND
- IPF ○ IRON PIPE FOUND
- ⊠ COMPUTED POINT
- • EASEMENT POINT
- GV ⋈ GAS VALVE
- PROPERTY BOUNDARY AS SURVEYED
- PROPERTY BOUNDARY BY DEED
- ADJOINER PROPERTY
- PROPOSED EASEMENT
- GAS — GAS — EXISTING GAS LINE
- EXISTING CREEK (DIGITIZED FROM PB 68 PG 97)

NOTES:

- FOR SOURCE OF TITLE REFER TO DEEDS AND PLATS REFERENCED HEREON.
- ALL DISTANCES ARE HORIZONTAL GROUND DISTANCES IN US SURVEY FEET UNLESS OTHERWISE NOTED.
- AREA BY COORDINATE COMPUTATION.
- PROPERTY SUBJECT TO ANY VALID & ENFORCEABLE EASEMENTS, RESTRICTIONS & RIGHTS OF WAY OF RECORD.

EASEMENT SURVEY PREPARED FOR
PIEDMONT NATURAL GAS COMPANY
LITTLE TROUBLESOME CREEK

EASEMENT TO BE ACQUIRED FROM OWNER:
WILDLANDS LITTLE TROUBLESOME CREEK HOLDINGS, LLC
INDUSTRIAL DRIVE

ROCK-1

REIDSVILLE TOWNSHIP
ROCKINGHAM COUNTY, NORTH CAROLINA

McKIM & CREED
ENGINEERS, PLANNERS, SURVEYORS
8020 TOWER POINT DRIVE
CHARLOTTE, NORTH CAROLINA 28227
PHONE (704) 841-2588
FAX (704) 841-2567
F-1222

01/04/2012