CROWNS WEST STREAM RESTORATION PROJECT

ANNUAL MONITORING REPORT FOR 2011 (YEAR 5)

Contract Number D06003-2

Submitted to:

NCDENR - Ecosystem Enhancement Program
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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

1.0 EXECUTIVE SUMMARY

This Annual Report details the monitoring activities during the 2011 growing season (Monitoring Year 5) on the Crowns West Stream Restoration Project ("Site"). As per the approved Restoration Plan for the Site, this Annual Monitoring Report presents data on stream geometry, stem count data from vegetation monitoring stations, and discusses any observed tendencies relating to stream stability and vegetation survival success.

Crowns West Branch had historically been channelized and riparian vegetation had been cleared in the lower half of the Site. The upstream area had a degraded, early successional buffer that included several invasive vegetation species. Prior to restoration, Crowns West Branch was incised along its length and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site. After construction, it was determined that 3,835 linear feet (LF) of stream were restored.

A total of 11 monitoring plots, 100 square meters (m^2) (10m x 10m) in size, were used to predict survivability of the woody vegetation planted on-site. Data from the Year 5 monitoring event for the 11 vegetation plots showed a range of 445 to 972 stems per acre, with an average survivability of 655 stems per acre.

According to the vegetative monitoring data, the Site has met the final success criteria of 260 stems per acre by the end of Year 5.

A small area of kudzu (*Pueraria spp.)* is located south of Haw Branch Road in the NCDOT right-of-way and also within the project easement. Kudzu within the project easement was treated in September 2008, April 2009 and September 2009 by River Works, Inc. During Year 4, this area was treated in September 2010. Due to the subsequent treatment events, the kudzu is now in a confined area and under control within the conservation easement. It is possible that this area of remaining kudzu may require treatment in the future following project closeout. The area is scheduled to be treated again prior to closeout.

The total length of stream channel restored on the Site was 3,835 LF. This entire length was inspected during Year 5 of the monitoring period to assess stream performance. The visual stability assessment during Year 4 monitoring, noted several locations on M2 and the lower portion of M1 that exhibited localized bank erosion, mostly in locations where sandy soils were present. During Year 5 of monitoring, these areas remained relatively unchanged and did not exhibit any other problems. To increase stream functionality and stability, these areas are scheduled to be hand repaired in the winter of 2011/2012.

According to the cross-section survey, stream dimension remained stable throughout the five-year monitoring period. The longitudinal profile following Year 5 showed that the in-stream structures and features have also remained stable throughout the five-year monitoring period.

The on-site crest gauge documented the occurrence of at least one bankfull flow event each year during the post-construction monitoring period. Inspection of conditions during site visits revealed visual evidence of out-of-bank flows. The largest on-site stream flow documented by the crest gauge during Year 5 of monitoring was approximately 3.72 feet (44.64 inches) above the bankfull stage.

The bankfull measurements collected through Year 5 document that the restored reaches have met the success criteria for bankfull events for the project.

The Site has met the stream morphological success criteria specified in the Restoration Plan.

Year 3 macroinvertebrate sampling for Site 1 showed substantial improvements in these samples. The Year 3 post-restoration data had shown that the Site has developed from a newly established coastal plain stream system with a weak benthic macroinvertebrate community into a system that exhibits diverse habitat. The Site is continuing to mature, and is able to support and cultivate biological diversity.

In summary, the Site has achieved the stream morphology and vegetative success criteria specified in the Restoration Plan for the Site.

2.0 PROJECT BACKGROUND

The Crowns West Restoration Project ("Site") involved the proposed restoration of 3,835 LF of stream. Table 1 summarizes the restoration areas on the Site. Selected site photographs are shown in Appendix A and B. A total of 10.8 acres of stream and riparian buffer are protected through a permanent conservation easement.

2.1 Project Objectives

The specific goals for the Crowns West Site Restoration Project were as follows:

- Restore 3,835 LF of channel dimension, pattern and profile
- Improve floodplain function by matching floodplain elevation with bankfull stage
- Establish native streambank and floodplain vegetation in the 10.8-acre permanent conservation easement
- Improve water quality in the Crowns West Branch and New River watersheds by reducing sediment and nutrient inputs
- Improve aquatic and riparian habitat by creating deeper pools and areas of re-aeration, planting a riparian buffer, and reducing bank erosion.

2.2 Project Structure, Restoration Type and Approach

For analysis and design purposes, Michael Baker Engineering, Inc. (Baker Engineering) divided on-site streams into reaches. The reaches were numbered sequentially from west to east, with an "M" designation for "mainstem." M1 begins on the upstream portion of the project, and flows east, ending on the western side of Haw Branch Road. M2 begins on the eastern side of Haw Branch Road and flows east, to the end of the wood line at the downstream end of the project. One unnamed tributary (UT1), flowing from Haw Branch Road to the confluence with Crowns West Branch, was originally proposed for restoration and was included in the 3,904 LF of stream restoration originally proposed for the Site. The landowner withdrew this short section of UT1 in exchange for additional property and stream length at the upstream section of M1 on Crowns West Branch. UT1 was to be tied into M2, as an alternative the tie-in point to M2 was stabilized. The total length of stream to be restored between M1 and M2 without the inclusion of UT1 was 3,835 LF of stream.

The restoration design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. The in-stream structures consisted of root wads, log vanes, log weirs, and constructed riffles. These structures have promoted a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, temporary and permanent seeding, bare-root planting, and transplants. Transplants provided living root mass to increase streambank stability and created holding areas for fish and aquatic biota. Native vegetation was planted across the Site. The entire restoration project is protected through a permanent conservation easement.

Table 1. Design Approach for the Crowns West Restoration Project

Crowns West Restoration Project: Project No. D06003-2				
Project Segment or Reach ID	**Mitigation Type ***	**Approach****	**Linear Footage**	**Stationing**
M1	R	P1, P2	2,320	10+46 - 24+37
M2	R	P1, P2	1,515	24+09 - 36+13
		Total linear feet of channel restored:	3,835	

*R = Restoration

**P1 = Priority I
P2 = Priority II

2.3 Location and Setting

The Site is located in Onslow County, North Carolina (Figure 1), approximately six miles northwest of the town of Richlands. The Site lies in the White Oak River Basin within North Carolina Division of Water Quality sub-basin 03-05-02 and NCEEP Targeted Local Watershed 03030001010010.

2.4 Project History and Background

Pre-restoration land use on the Site consisted primarily of row crop agriculture with adjacent woodlands. Crowns West Branch had been channelized and riparian vegetation had been cleared in the lower half of the Site. The upstream area had a degraded, early successional buffer that included several exotic vegetation species. Prior to restoration, Crowns West Branch was incised and lacked bedform diversity. As a result, channel degradation was widespread throughout the Site.

The chronology of the Crowns West Project is presented in Table 2. The contact information for all designers, contractors, and relevant suppliers is presented in Table 3. Relevant project background information is presented in Table 4.

2.5 Project Plan

Plans depicting the as-built conditions of the major project elements, locations of permanent monitoring cross-sections, and locations of permanent vegetation monitoring plots are presented in Figures 2A, 2B, 2C, 2D, 2E, 2F and 2G of this report.

Table 2. Project Activity and Reporting History

Crowns West Stream Restoration Project: Project No. D06003-2			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan Prepared	N/A	N/A	Jul-06
Restoration Plan Amended	N/A	N/A	N/A
Restoration Plan Approved	N/A	N/A	Aug-06
Final Design – (at least 90% complete)	N/A	N/A	Oct-06
Construction Begins	Nov-06	N/A	Nov-06
Temporary S&E mix applied to entire project area	N/A	N/A	Mar-07
Permanent seed mix applied to entire project area	Mar-07	N/A	Mar-07
Planting of live stakes	Mar-07	N/A	Mar-07
Planting of bare root trees	Mar-07	N/A	Mar-07
End of Construction	Mar-07	N/A	Mar-07
Survey of As-built conditions (Year 0 Monitoring-baseline)	Mar-07	Mar-07	Mar-07
Year 1 Monitoring	Dec-07	Oct-07	Dec-07
Year 2 Monitoring	Dec-08	Oct-08	Dec-08
Year 3 Monitoring	Dec-09	Oct-09	Dec-09
Year 4 Monitoring	Dec-10	Oct-10	Dec-10
Year 5 Monitoring	Dec-11	Nov-11	Dec-11

Table 3. Project Contacts

Crowns West Restoration Project: Project No. D06003-2	
Designer	
Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 Contact: Kevin Tweedy, Tel. 919-463-5488
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 Contact: Will Pedersen, Tel. 919-459-9001
Planting Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 Contact: Will Pedersen, Tel. 919-459-9001
Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 Contact: Will Pedersen, Tel. 919-459-9001
Seed Mix Sources	Mellow Marsh Farm, 919-742-1200
Nursery Stock Suppliers	International Paper, 1-888-888-7159
Monitoring Performers	
Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518
Stream Monitoring Point of Contact:	Dwayne Huneycutt, Tel. 919-463-5488
Vegetation Monitoring Point of Contact:	Dwayne Huneycutt, Tel. 919-463-5488

Table 4. Project Background

Crowns West Restoration Project: Project No. D06003-2	
Project County:	Onslow County, NC
Drainage Area:	
Reach: M1	0.65 mi²
Reach: M2	0.98 mi²
Estimated Drainage % Impervious Cover:	
M1	<5%
M2	<5%
Stream Order:	
M1	1
M2	2
Physiographic Region	Coastal Plain
Ecoregion	Carolina Flatwoods
Rosgen Classification of As-Built	C5c
Cowardin Classification	Riverine, Upper Perennial, Unconsolidated Bottom, Sand
Dominant Soil Types	
M1	Mk,CrB
M2	Mk,CrB, AuB
Reference site ID	Beaverdam Branch
USGS HUC for Project and Reference sites	03030001010010
NCDWQ Sub-basin for Project and Reference	03-05-02
NCDWQ classification for Project and Reference	C
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor?	N/A
% of project easement fenced	0%

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 Vegetation Assessment

3.1.1 Description of Vegetative Monitoring

As a final stage of construction, the stream margins and riparian areas of the Site were planted with bare root trees, live stakes, and a seed mixture of temporary and permanent ground cover herbaceous vegetation. The woody vegetation was planted randomly six to eight feet apart from the top of the streambanks to the outer edge of the project's re-vegetation limits. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. The tree species planted at the Site are shown in Table 5. The permanent seed mix of herbaceous species applied to the project's riparian area included soft rush (*Juncus effusus)*, redtop (*Agrostis alba),* Virginia wild rye (*Elymus virginicus),* switchgrass (*Panicum virgatum),* smartweed (*Polygonum pennsylvanicum),* tick seed (*Bidens frondosa),* lance leaf coreopsis (*Coreopsis lanceolata*), fox sedge (*Carex vulpinoidea*), hop sedge (C*arex lupulina*), and shallow sedge *(Carex lurida).* This seed mixture was broadcast on the Site at a rate of 15 pounds per acre. All planting was completed in March 2007.

At the time of planting, eleven vegetation plots – labeled 1 through 11 - were delineated on-site to monitor survival of the planted woody vegetation. Each vegetation plot is 0.025 acre in size, or 10 meters x 10 meters. All of the planted stems inside the plot were flagged to distinguish them from any colonizing individuals and to facilitate locating them in the future. The trees also were marked with aluminum metal hang tags to ensure that the correct identification was made during monitoring of the vegetation plots. Following Year 5 monitoring, the aluminum tags were relocated from the main stem of the planted trees, to an irrelevant limb or marking stakes as to not interfere with tree growth. This was done to ensure that if the need for future location of the planted stems is needed, then the trees can be easily identified by the aluminum tags.

On a designated corner within each of the eleven vegetation plots, one herbaceous plot was also delineated. The herbaceous plots measure 1 meter x 1 meter in size. The vegetation and herbaceous plots are photographed at the end of each growing season. The locations of the vegetation plots are presented in Figures 2A through 2G.

3.1.2 Vegetative Success Criteria

To characterize vegetation success criteria objectively, specific goals for woody vegetation density have been defined. Data from vegetation monitoring plots should display a surviving tree density of at least 320 trees per acre at the end of the third year of monitoring, and a surviving tree density of at least 260 five-year-old trees per acre at the end of the five-year monitoring period.

Table 5. Vegetation Species Planted Across the Restoration Site			
Crowns West Restoration Project: Project No. D06003-2			
Scientific Name	**Common Name**	**Percent Planted by Species**	**Total Number of Stems**
Bare Root Trees Species			
Betula nigra	River Birch	15%	1,110
Celtis laevigata	Sugarberry	5%	370
Fraxinus pennsylvanica	Green Ash	7.5%	555
Juglans nigra	Black Walnut	5%	370
Nyssa sylvatica var. biflora	Swamp Tupelo	10%	740
Platanus occidentalis	Sycamore	20%	1,480
Quercus lyrata	Overcup Oak	10%	740
Quercus michauxii	Swamp Chestnut Oak	10%	740
Quercus phellos	Willow Oak	7.5%	555
Taxodium distichum	Bald Cypress	10%	740
Native Herbaceous Species			
Elymus virginicus	Virginia wildrye	15%	NA
Panicum virgatum	Switchgrass	15%	NA
Carex vulpinoidea	Fox sedge	5%	NA
Polygonum pennsylvanicum	Smart Weed	5%	NA
Juncus effusus	Soft rush	10%	NA
Carex lupulina	Hop sedge	10%	NA
Agrostis alba	Redtop	10%	NA
Bidens frondosa	Tick seed	10%	NA
Coreopsis lanceolata	Lance leaf coreopsis	10%	NA
Carex lurida	Shallow sedge	10%	NA
Woody Vegetation for Live Stakes			
Salix sericia	Silky Willow	40%	1,040
Cornus amomum	Silky Dogwood	40%	1,040
Sambucus canadensis	Elderberry	20%	520

3.1.3 Vegetative Observations and Results

Most of the species that were planted as part of the permanent ground cover seed mixture broadcast on the Site after construction were present during Year 5 monitoring of the Site.

Tables A.1. through A.6. in Appendix A present vegetation metadata, vegetation vigor, vegetation damage and stem count data of the monitoring stations at the end of the Year 5 monitoring period. Data from the Year 5 monitoring event of the 11 vegetation plots showed a range of 445 to 972 stems per acre. The Year 5 monitoring data show that the Site displayed an average of 655 stems per acre. No significant volunteer woody species were observed in any of the vegetation plots during this period.

Based on these results, all plots have met the final success criteria of at least 260 stems per acre at the end of monitoring Year 5.

3.1.4 Vegetative Problem Areas

During monitoring Year 3, two vegetative problems were observed in Vegetation Plot 1 that threatened survivability of the plot. These problems were weedy species occurring within the vegetation plot and saturated soils due to nearby beaver dams. The strong presence of arrowleaf tearthumb (*Polygonum sagittatum*) and an unknown vine species in this area were affecting the survivability of the smaller planted stems. Another issue in this area was the presence of two nearby beaver dams that had caused the soils to become saturated for extended periods. This had caused planted stems, mostly sycamores, to become unstable. These trees were observed to be leaning following Year 3 monitoring at approximately 45 degrees.

The beaver dams observed in the Vegetation Plot 1 area were scheduled to be removed in the winter of 2009/2010. Dwayne Huneycutt of Baker Engineering met with Mark Batchlor, a representive with the United States Department of Agriculture (USDA), on the Site in February 2010. Mr. Huneycutt and Mr. Batchlor noted during this site visit, that the beaver dams observed in the fall of 2009 were not active and were breached and/or destroyed. According to Mr. Batchlor, it was likely that the beaver had moved off-site. No beaver dams or visible beaver activity were noted in September 2010 or September 2011.

Following Year 5 monitoring, this upstream portion of the Site was fairly dry and no beaver activity was observed in the area. The soils in the vicinity of vegetation plot 1 are no longer saturated since the beaver activity has ceased, and the planted stems were observed to be thriving and no additional stems were found to be leaning.

Other weedy species observed following Year 5 monitoring were mostly annuals and seem to pose very little threat to vegetation survivability at the Site.

A small area of kudzu (*Pueraria spp.*) was located south of Haw Branch Road in the NCDOT right-of-way and also within the project easement at the end of Year 5 monitoring. The kudzu within the project easement was treated in September 2008, April 2009 and September 2009 by River Works, Inc. During Year 4, this area was treated in September 2010. Due to the subsequent treatment events, the kudzu is now under control within the conservation easement. However, some areas still persist within the conservation easement. It is noted that an area of untreated kudzu north of and outside of

to the site's conservation easement is still present and active. This area of kudzu provides an additional source of possible regeneration that may affect the presence of kudzu on the Site. It is noted that some spot treatment may be needed periodically after project closeout. Complete elimination of the kudzu may be difficult due this adjacent population. The kudzu within the project area is scheduled to be treated prior to closeout.

Some minimal areas of privet (*Ligustrum l.*) were observed on the Site during Year 5 monitoring. The privet is located along the southern easement boundary, west of Haw Branch Road, along the upstream, right bank of the restored channel, west of Haw Branch Road. This area of privet was not treated in 2010. However, the area was previously treated in September 2008, April 2009 and September 2009 by River Works, Inc. The herbicides applied to the infested areas in previous years, appear to have significantly eliminated the majority of the privet shrubs with the conservation easement. The area is also scheduled to be treated again prior to closeout.

3.1.5 Vegetation Photographs

Photographs are used to visually document vegetation plot success. A total of eleven reference stations were established following construction to document tree conditions at each vegetation plot across the Site. Additional photo stations were also established at each of the eleven vegetation plots for herbaceous vegetation monitoring. Reference photos of both tree conditions and herbaceous conditions are taken at least once per year. Photos of the tree plots showing the on-site vegetation are included in Appendix A of this report. Photos of the herbaceous plots are also included in Appendix A.

3.2 Stream Assessment

3.2.1 Morphometric Success Criteria

To document the stated success criteria, the following monitoring program was instituted following construction completion of the Site:

Cross-sections: Two permanent cross-sections were installed per 1,000 LF of stream restoration work, with one of the locations being a riffle cross-section and one location being a pool cross-section. A total of nine permanent cross-sections were established across the Site. Each cross-section was marked on both banks with permanent pins in concrete to establish the exact transect used. The permanent cross-section pins are surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg.

The approved Restoration Plan requires the following criteria be met to achieve stream restoration success: There should be little change in as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections will be classified using the Rosgen Stream Classification System, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

Longitudinal Profiles: A complete longitudinal profile was surveyed following construction completion to record as-built conditions. The profile was conducted for the entire length of the restored channels (M1 and M2). Measurements included thalweg, water surface, bankfull and top of low bank. Each of these measurements was taken at the head of each feature (e.g., riffle, pool, and glide). In addition, maximum pool depth was recorded. All surveys were tied to a single, permanent benchmark.

As directed by EEP guidelines, longitudinal profiles were completed each year for the five-year monitoring period. The longitudinal profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep, with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed for channels of the design stream type.

3.2.2 Morphometric Results

Year 5 cross-section monitoring data for stream stability were collected during November 2011. The nine permanent cross-sections along the restored channels (five located across riffles and four located across pools) were re-surveyed to document stream dimension at the end of monitoring Year 5. Data from each of these cross-sections were compared to data collected during the as-built condition survey, Years 1, 2, 3 and 4 of monitoring. The cross-sectional data are presented in Appendix B and in Table B.3.

Cross-sections 1, 3, 4, 7 and 8 are located across riffles found between meander bends. Cross-section 1 has aggraded slightly since the as-built survey but has remained relatively stable throughout the five-year monitoring period. Stream dimension in cross-sections 3, 4, 7 and 8 have remained relatively stable since as-built conditions. The floodplains of cross-sections 7 and 8 on the downstream portion of the Site have remained stable through Year 5 monitoring. It was noted during Years 2 and 3 that visual on-site observations of areas on reach M2 documented deposition of sediment on the floodplain. This is considered to be a natural system response and no significant areas of concern have been noted due to this deposition.

Cross-sections 2, 5, 6, and 9 are located across pools found at the apex of meander bends. Based on the cross-sectional data, the pool at cross-section 6 has filled slightly since Year 1 monitoring, but has remained relatively stable through Years 2, 3, 4 and 5. It was noted during Year 4, that cross-sections 2, 5 and 9 have remained at or below the as-built thalweg elevations in the maximum pool depths. All pools are remaining deep and are stable.

Overall, the Year 5 cross-sections show that there have been some minor adjustments to stream dimension since construction. However, the channel is currently stable and functioning as designed.

The longitudinal profiles of reaches M1 and M2 are presented in Appendix B and Table B.3. The longitudinal profile for Year 5 was surveyed in November 2011 and was compared to data collected during the as-built condition survey, and Years 1, 2, 3 and 4 of monitoring. The results of the Year 5 longitudinal profile show that the pools and riffles in M1 have maintained elevations and pool depths, similar to those documented

during the as-built survey, and Years 1, 2, 3 and 4 of monitoring. The longitudinal profile shows that the riffles and in-stream structures throughout reach M1 are stable.

The Year 5 profile for M2 shows that the riffles and pools at the beginning of the reach, (stations 33+95 to 42+50) have aggraded slightly since as-built conditions. This section of M2 is showing a tendency to aggrade in drier years (Year 2 and 4) and scour in wetter years (Year 3 and 5). This is considered to be a normal pattern of stream bed dynamics within sandbed streams.

The Year 5 profile for areas downstream of station 42+50 show that the pools have remained deep since Year 1. The longitudinal profile for M2 shows that the riffles and in-stream structures are stable on the downstream portion of the reach.

Overall, the Year 5 longitudinal profile shows that there have been some minor adjustments to the stream profile since construction and as-built conditions. These adjustments within the channel are noted to be progressing towards a more stable condition. However, the channel is stable and functioning as designed.

3.2.3 Hydrologic Criteria

One crest gauge was installed on the Site to document bankfull events. The gauge is checked regularly and records the highest out-of-bank flow between site visits. The gauge is located on the downstream portion of reach M2, which is presented in Figure 2G.

The approved Restoration Plan requires that two bankfull flow events must be documented within the five-year monitoring period. The two bankfull events must occur in separate years, otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

3.2.4 Hydrologic Monitoring Results

The crest gauge on the Site has documented at least one bankfull event per year during Year 5 of the post-construction monitoring period, as shown in Table 6 and Table 7. Inspection of conditions during site visits revealed visual evidence of out-of-bank flow, confirming the crest gauge readings. The highest on-site stream flow documented by the crest gauge during Year 5 of monitoring was approximately 0.67 feet above the bankfull stage and was the result of overbank flooding of M2. Photographs documenting bankfull evidence observed during Year 5 are presented in Appendix B.

Table 6. Verification of Bankfull Events

Crowns West Restoration Project: EEP Contract No. D06003-2			
Date of Data Collection	**Estimated Date of Occurrence of Bankfull Event**	**Method of Data Collection**	**Measurement (feet)**
3/9/2011	Winter of 2011	Crest Gage on M2	0.67
6/16/2011	5/14/2011	Crest Gage on M2	0.31

The crest gauge readings were continued for all five years of the monitoring period in order to observe yearly flood event depths that occurred on the Site. The data in Table 7 present a summary of the highest bankfull events documented during each monitoring year on the Site. The two highest bankfull measurements in the five-year period recorded by the crest gauge were 3.72 feet and 1.91 feet. These two measurements occurred in 2010 and 2008, respectively.

The Site has met the established success criteria of two bankfull events documented in separate years as stated in the site's Restoration Plan.

Table 7. Summary of Highest Bankfull Events

Crowns West Restoration Project: EEP Contract No. D06003-2			
Date of Data Collection	**Estimated Date of Occurrence of Bankfull Event**	**Method of Data Collection**	**Measurement (feet)**
7/6/2007	Unknown	Crest Gage on M2	0.40
3/24/2008	Winter of 2008	Crest Gage on M2	1.91
6/17/2009	5/30/2009	Crest Gage on M2	1.03
12/1/2010	9/29/2010	Crest Gage on M2	3.72
3/9/2011	Winter of 2011	Crest Gage on M2	0.67

3.2.5 Stream Problem Areas

During Year 2 (2008) monitoring, the Site experienced several areas of localized bank erosion. These problems were repaired in November 2008. The stream problem areas were located on reaches M1 and M2. All problems areas were located in pools where erosion occurred around root wads that were installed in sandy soils.

During Year 3 (2009) monitoring, several additional bank areas on M2 and the lower portion of M1 exhibited small localized, areas of bank erosion, attributed to the number of high flow events during the year, the presence of mostly sandy soils in the identified areas and the lack of well established planted vegetation. These areas were small and were not considered to warrant repair at the time.

Also in Year 3, two beaver dams on the upstream portion of M1 had caused the soils to become saturated for an extended period. This saturation affected some of the planted stems, mostly sycamores, to lean more than 45 degrees. Some of the sycamores in vegetation plot 1 were affected by the saturation. However, at the end of Year 5 monitoring, the leaning trees were alive and some have re-sprouted into upright, vertical stems.

Following Years 4 and 5 monitoring, no beaver dams were present on the Site. All trees within vegetation plot 1 that were impacted by the soft soils are currently still alive and are included in the stems totals presented in Table A.1 through A.6. A detailed explanation of the beaver dams and affected areas are discussed in section 3.1.4 of this report.

During Year 5 all areas repaired during Years 2 and 3 were functioning properly with no further degradation noted.

Following the Year 5 visual stability assessment some problems areas noted are scheduled to be repaired before closeout. A total of three areas are to be repaired on the Site and are located at pools. One pool is located on the upstream portion of the Site and two pools are located on the downstream portion of the Site. The purpose of this work is to increase stream functionality and stability. These areas are scheduled to be hand repaired in the winter of 2011/2012.

3.2.6 Stream Photographs

Photographs are used to visually document restoration success. A total of 23 reference stations were established to document conditions at the constructed grade control structures across the Site, and additional photo stations were established at each of the 9 permanent cross-sections. The GPS coordinates of each grade control structure photo station have been noted as additional reference to ensure the same photo location is used throughout the monitoring period. Reference photos are taken at least once per year.

Each streambank is photographed at each permanent cross-section photo station. For each streambank photo, the photo view line follows a survey tape placed across the channel, perpendicular to flow (representing the cross-section line). The photograph is framed so that the survey tape is centered in the photo (appears as a vertical line at the center of the photograph), keeping the channel water surface line horizontal and near the lower edge of the frame.

Photographs are used to document restoration success visually. Reference stations were photographed before construction and are photographed for at least five years following construction. Reference photos are taken once per year, from a camera height of approximately five to six feet. Permanent markers were established to ensure that the same locations (and view directions) on the Site are photographed during each monitoring event. Photos for each of the nine permanent cross-sections are included in Appendix B. A photo log of the restored channel is also presented in Appendix B of this report. Herbaceous vegetation has continued to become more dense along the edges of the restored stream, making the photography of some of the stream channel areas difficult throughout the monitoring period.

3.2.7 Stream Stability Assessment

A summary of the results obtained from the visual inspection of in-stream structures performed during Year 5 of post-construction monitoring is presented in Table B.1. The percentages noted are a general, overall field evaluation of the how the features were performing at the time of the photo point survey. According to the visual stability assessment, during Year 5 monitoring, some bank areas as described in Section 3.2.5 experienced localized minor erosion. Excluding these bank areas, all other stream features are performing as designed.

3.2.8 Quantitative Measures Summary Tables

The quantitative pre-construction, reference reach, and design data used to determine restoration approach, as well as the as-built baseline data used during the project's post construction monitoring period are summarized in Table B.2.

3.2.9 Benthic Macroinvertebrate Sampling

Benthic macroinvertebrate monitoring was conducted in accordance with the Crowns West Restoration Plan. Because of seasonal fluctuations in populations, macroinvertebrate sampling must be consistently conducted in the same season as the initial species evaluations. Benthic sampling for the Site as well as the reference site was conducted during March 2010. This report summarizes the benthic samples collected in March 2010 for Year 3 of the post-construction monitoring phase, the final data collection event for benthic macroinvertebrates for the site.

The sampling methodology followed the Qual 4 method listed in NCDWQ's Standard Operating Procedures for Benthic Macroinvertebrates (2006). Field sampling was conducted by Baker Engineering. Laboratory identification of collected species was conducted by Wendell Pennington, of Pennington and Associates, Inc.

Benthic macroinvertebrate samples were collected at one location on the Site (Site 1) and one location at the Beaverdam Branch reference site in Jones County (Site 2). Site 1 is located within the restoration area of M1 on the Site.

Benthic macroinvertebrates were collected to assess quantity and quality of life in the streams. In particular, specimens belonging to the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), (EPT species) are useful as an index of water quality. These groups are generally the least tolerant to water pollution and therefore are very useful indicators of water quality. Sampling for these three orders is referred to as EPT sampling.

Habitat assessments using NCDWQ's protocols were also conducted at each site. Physical and chemical measurements including water temperature, dissolved oxygen concentration (mg/L), pH, and specific conductivity were recorded at each site. The habitat assessment field data sheets, lab results and photos are presented in Appendix B.

3.2.10 Benthic Macroinvertebrate Sampling Results and Discussion

A comparison between the pre- and post-construction benthic monitoring results is presented in Table 7 with complete laboratory results presented in Appendix B.

At Site 2, the undisturbed reference site, the Year 3 community structure and ecological habitat appears to be similar to that observed during the pre-construction, Year 1 and Year 2 monitoring periods. Site 2 data show a stable total taxa richness and a stable EPT taxa richness. EPT taxa richness at Site 2 has remained relatively stable since Year 1 monitoring. The Year 3 sampling results displayed relatively stable total and EPT biotic indices.

Site 1, which underwent complete restoration, exhibited improvements in total and EPT taxa richness during Year 3 monitoring as compared with Year 1 monitoring. Also, Site 1 showed an improvement in the total biotic index following Year 3 of monitoring. The EPT biotic index following Year 3 has increased from no observed communities to an index 6.36 since March 2006. It is anticipated that, as the project matures, EPT populations will increase as more habitat in the form of snags, logs, and leaf packs become available.

The Year 3 data for the Site displayed 37.5 percent Dominance in Common (DIC) compared to the reference site. This indicates that 37.5 percent of the dominant communities at the reference site are dominant at Site 1. In pre-construction conditions, Site 1 had a DIC of 41 percent. The DIC result of 37.5 percent at Site 1following Year 3 monitoring, indicates that post-construction recolonization from refugia upstream or downstream, is likely returning to pre-restoration levels. It is anticipated that improvements in biotic indices and an increase in DIC will be seen in as communities begin to re-colonize and the project matures.

Overall, the Year 3 data for Site 1 has displayed substantial improvements in all criteria of the macro invertebrate samples. The Year 3 post-restoration data has shown that the Site has developed from a newly established coastal plain stream system with a weak benthic macroinvertebrate community into a system that exhibits diverse habitats, is continually maturing, and is able to support and cultivate biological diversity.

Table 8. Summary of Pre-Restoration vs. Post-Restoration Benthic Macroinvertebrate Sampling Data								
Crowns West Restoration Project: EEP Contract No. D06003-2								
	Site 1				**Site 2**			
	M1 Crowns West (Restoration)				**Beaverdam Branch (Reference)**			
	Pre	**Post**	**Post**	**Post**	**Pre**	**Post**	**Post**	**Post**
	3/3/2006	**2/28/2008**	**2/9/2009**	**3/10/2010**	**1/5/2006**	**2/28/2008**	**2/9/2009**	**3/10/2010**
Total Taxa Richness	24	14	20	19	28	35	34	31
EPT Taxa Richness	4	0	1	4	3	6	9	6
Total Biotic Index	6.75	3.99	7.50	6.80	7.78	6.73	6.59	6.40
EPT Biotic Index	5.78	None	4.00	6.36	4.05	5.28	4.69	6.19
Dominance in Common (%)	41	18	25	37.5	N/A	N/A	N/A	N/A
EPT Abundance	-	0	2	17	-	29	35	28
Habitat Assessment Rating	42	88	65	67	89	106	91	91
Water Temperature (˚C)	Not Collected	10.5	8.6	9.4	Not Collected	7.9	8.9	14.3
DO Concentration (mg/l)	Not Collected	5.05	11.8	10.91	Not Collected	9	7.8	9.3
pH	Not Collected	6.63	6.98	5.96	Not Collected	7.24	7.52	6.6
Conductivity (µmhos/cm)	Not Collected	110	150	90	Not Collected	320	340	240

4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Vegetation Monitoring - For the 11 monitoring plots, vegetation monitoring indicated a survivability range of 445 stems per acre to 972 stems per acre with an overall average of 655 stems per acre. The data show that the Site has met the final success criteria of at least 260 stems per acre by the end of Year 5.

A small area of kudzu (*Pueraria spp.)* is located south of Haw Branch Road in the NCDOT right-of-way and also within the project easement. Kudzu within the project easement was treated in September 2008, April 2009 and September 2009 by River Works, Inc. During Year 4, this area was treated in September 2010. Due to the subsequent treatment events, the kudzu is now in a confined area and under control within the conservation easement. It is possible that the areas of remaining kudzu may need to be treated in the future following project closeout. The area is scheduled to be treated prior to closeout.

According to the vegetative monitoring data, the Site has met the final success criteria of 260 stems per acre by the end of Year 5.

Stream Monitoring - The total length of stream channel restored on the Site was 3,835 LF. This entire length was inspected during Year 5 of the monitoring period to assess stream performance. Visual stability assessments during Years 2 and 3 noted several small, localized bank erosion areas. Those observed during Year 2 were repaired and those observed during Year 3 did not require repairs. The visual stability assessment noted during Year 4 monitoring that several locations on M2 and the lower portion of M1 exhibited localized bank erosion. Most of these areas were in locations where sandy soils are present. During Year 5 of monitoring, these areas did not exhibit any further problems and appear to be stable.

Following the Year 5 visual stability assessment some problems areas noted are scheduled to be repaired before closeout. A total of three areas are to be repaired on the Site and are located at pools. One pool is located on the upstream portion of the Site and two pools are located on the downstream portion of the Site. The purpose of this work is to increase stream functionality and stability. These areas are scheduled to be hand repaired in the winter of 2011/2012.

Based on the survey data, all riffles, pools, and other constructed features along the restored channel are stable and functioning as designed. During the five-year monitoring period, both stream reaches on the Site have shown that bedform diversity is being maintained. The pools have undergone some adjustment since as-built conditions, but have maintained flat water surface slopes. The riffles have also undergone some adjustment since as-built conditions but have remained steeper and shallower than the pools.

According to the Year 5 cross-section survey data, stream dimension has remained stable throughout the five-year monitoring period. The longitudinal profile data for Year 5 shows that the in-stream structures and features have also remained stable during the five-year monitoring period.

The on-site crest gauge documented the occurrence of at least one bankfull flow event each year of the five-year post-construction monitoring period. The highest on-site stream flow documented by the crest gauge during the five-year monitoring period was approximately 3.72 feet (44.64 inches) above the bankfull stage and was the result of overbank flooding of M2. Inspection of site conditions during visits revealed visual evidence of out-of-bank flows. The

highest on-site crest gauge recordings during each year of monitoring are as follows: Year 1 (0.40 feet), Year 2 (1.91 feet), Year 3 (1.03 feet), Year 4 (3.72 feet) and Year 5 (0.67 feet).

Year 3 macroinvertebrate sampling results for the Site, exhibited improvements in total and EPT taxa richness. The total biotic index improved since Year 2 while a decline in the EPT biotic index was observed during Year 3. It is anticipated that, as the project matures, benthic macroinvertebrate populations will increase as more habitat in the form of snags, logs, and leaf packs become available. The DIC result of 37.5 percent at Site 1 following Year 3 monitoring, indicates that post-construction re-colonization from refugia upstream or downstream, is likely returning to pre-restoration levels. It is projected that continued improvements in biotic indices and an increase in DIC will be seen in the future as communities continue to re-establish on the Site.

It is concluded that the Site has achieved the stream morphology success criteria specified in the Restoration Plan for the Site.

Project Closeout - Yearly monitoring data was presented in each annual monitoring report throughout the five-year monitoring period. According to the data presented in each yearly monitoring report, the Site has achieved the vegetative success criteria and the stream morphological success criteria as specified in the Restoration Plan for the Site.

5.0 WILDLIFE OBSERVATIONS

Observations of deer and raccoon tracks are common on the Site. During certain times of the year, frogs, snakes, lizards and crawfish and have been observed.

6.0 REFERENCES

Rosgen, D. L. 1994. *A Classification of Natural Rivers*. Catena 22: 169-199.

Schafale, M. P., and A. S. Weakley. 1990. *Classification of the Natural Communities of North Carolina, Third Approximation*. North Carolina Natural Heritage Program, Division of Parks and Recreation. NCDENR. Raleigh, NC.

USDA, NC Agricultural Experiment Station, *Soil Survey of Onslow County, North Carolina*, 1992.

NCDWQ, Standard Operating Procedures for Benthic Macroinvertebrates. (2006).

FIGURES

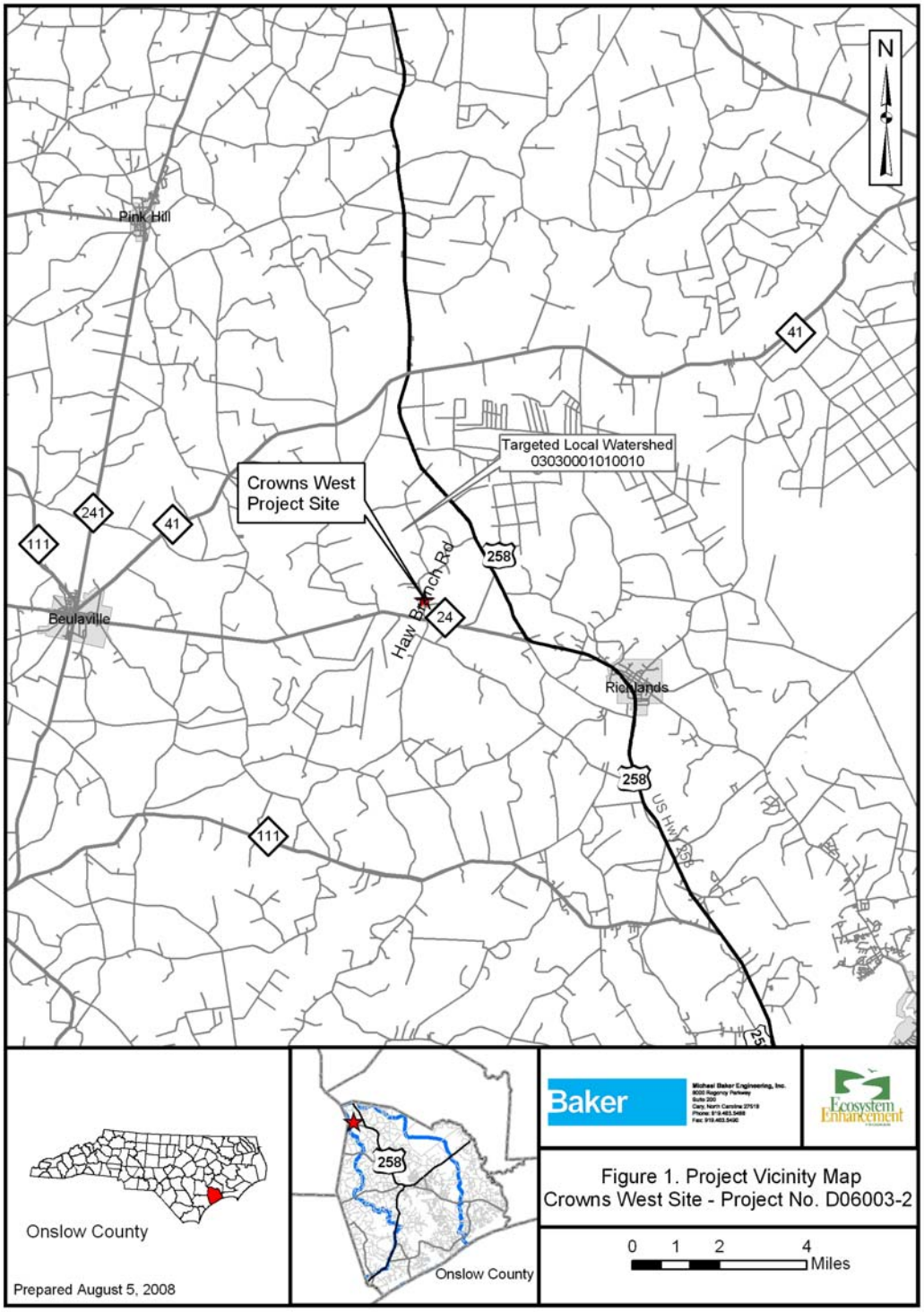


Figure 1. Location of Crowns West Stream Restoration Project.

PROJECT: D06003 – 2 CROWNS WEST

CROWNS WEST STREAM RESTORATION PROJECT
PROJECT # – D06003–2

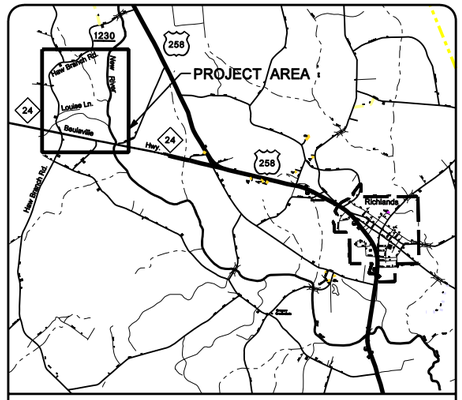
STATE	BUCK PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
NC	0290R	1	13

NO.	DATE	CHECKED BY	APPROVED BY
1	04/09/07	JOSHUA WHITE	KEVIN TWEEDY
2	04/30/07	JOSHUA WHITE	KEVIN TWEEDY

ONSLOW COUNTY

LOCATION: OFF HAW BRANCH ROAD SR 1230
NORTHWEST OF RICHLANDS

TYPE OF WORK: AS–BUILT FOR STREAM RESTORATION



VICINITY MAP

INDEX OF SHEETS

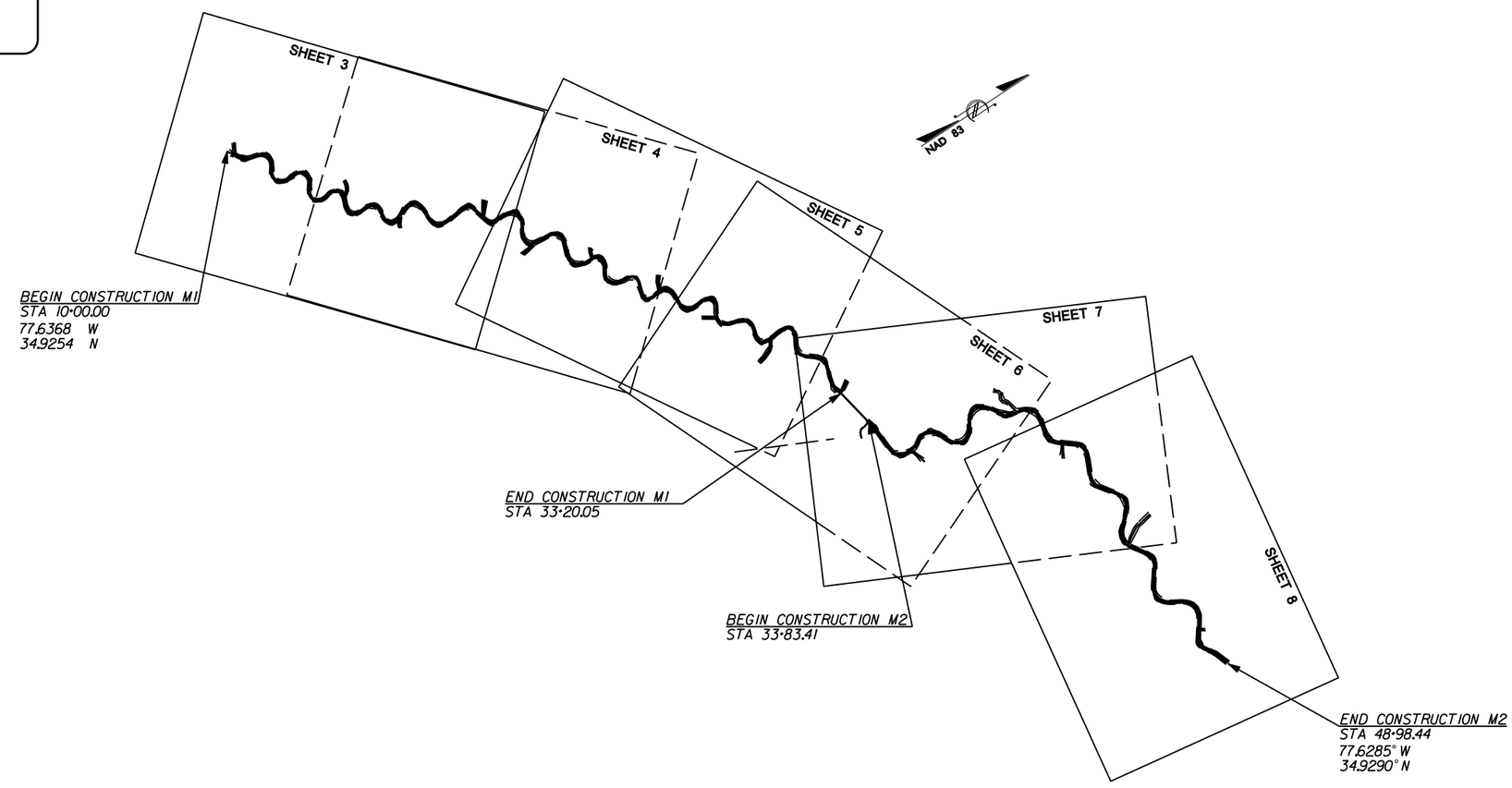


FIGURE 2A

GRAPHIC SCALES

30 15 0 30 60
PLANS

30 15 0 30 60
PROFILE (HORIZONTAL)

5 0 5 10
PROFILE (VERTICAL)

DESIGN DATA

EXISTING STREAM LENGTH = 3334 FT
AS–BUILT STREAM LENGTH = 3835 FT

PROJECT REACH	EXISTING	AS–BUILT
M1	1819 FT	2320 FT
M2	1515 FT	1515 FT

PREPARED FOR THE OFFICE OF:
NCDENR – ECOSYSTEM ENHANCEMENT PROGRAM
2728 CAPITAL BLVD, SUITE 1H 103
RALEIGH, NC 27604

Ecosystem Enhancement Program

CONTACT: GUY PEARCE
EEP FULL DELIVERY COORDINATOR

PREPARED IN THE OFFICE OF:

Baker
Baker Engineering
8000 Regency Parkway
Suite 200
Cary, NORTH CAROLINA 27518
Phone: 919.463.5488
Fax: 919.463.5490

MARCH 2007
COMPLETION DATE:

KEVIN TWEEDY, PE
PROJECT ENGINEER

JOSHUA WHITE
PROJECT DESIGNER

PROJECT ENGINEER

THIS DOCUMENT ORIGINALLY ISSUED AND SEALED BY:

KEVIN L. TWEEDY
027337
APRIL 30, 2007

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P.E.
SIGNATURE:

2/26/03

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0290R	3

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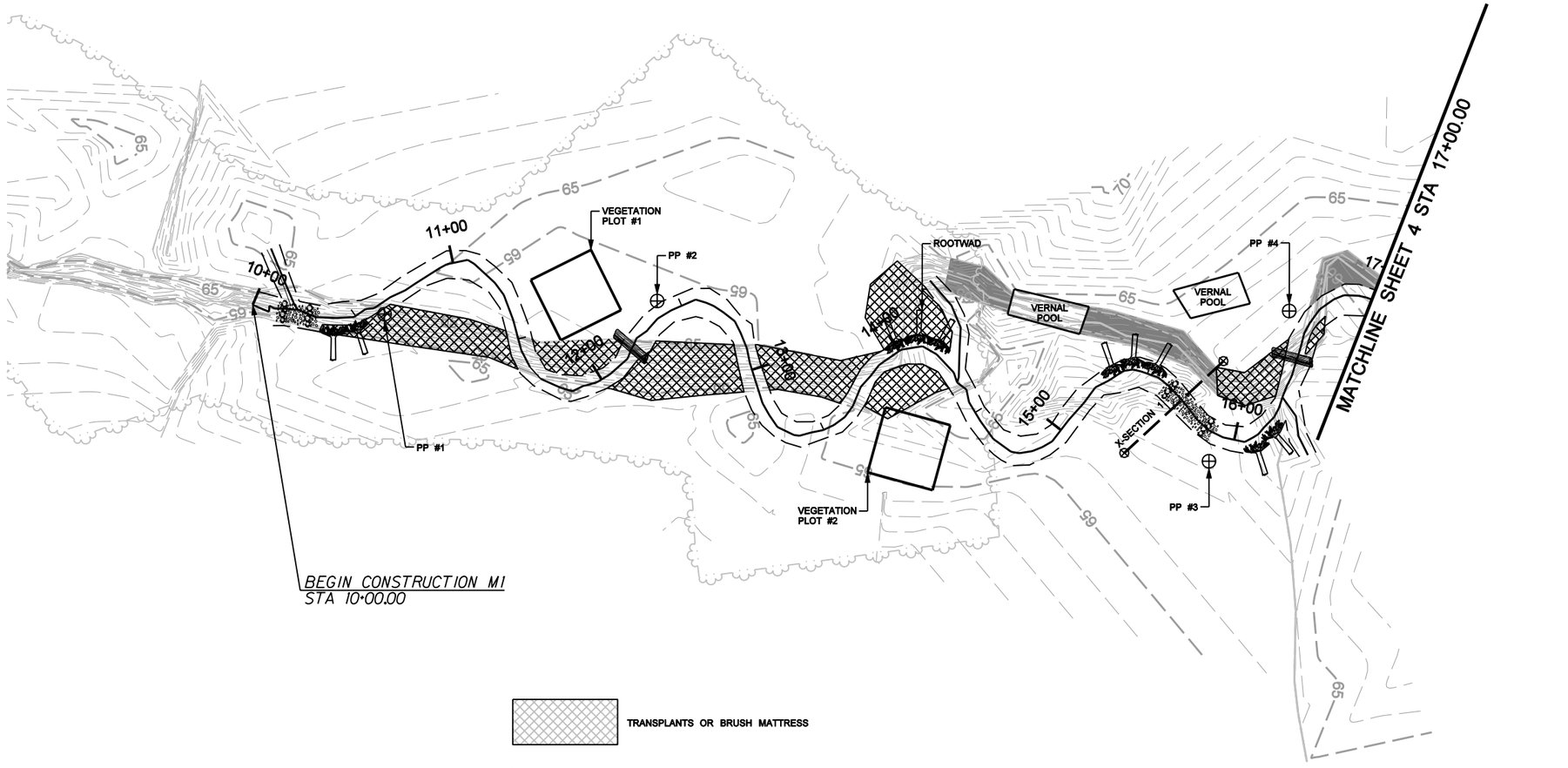

TRANSPLANTS OR BRUSH MATTRESS

DITCH PLUG

CHANNEL FILL

FIGURE 2B

NOTE:
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT PLAN VIEW

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SCALE (FT)

11/27/2007
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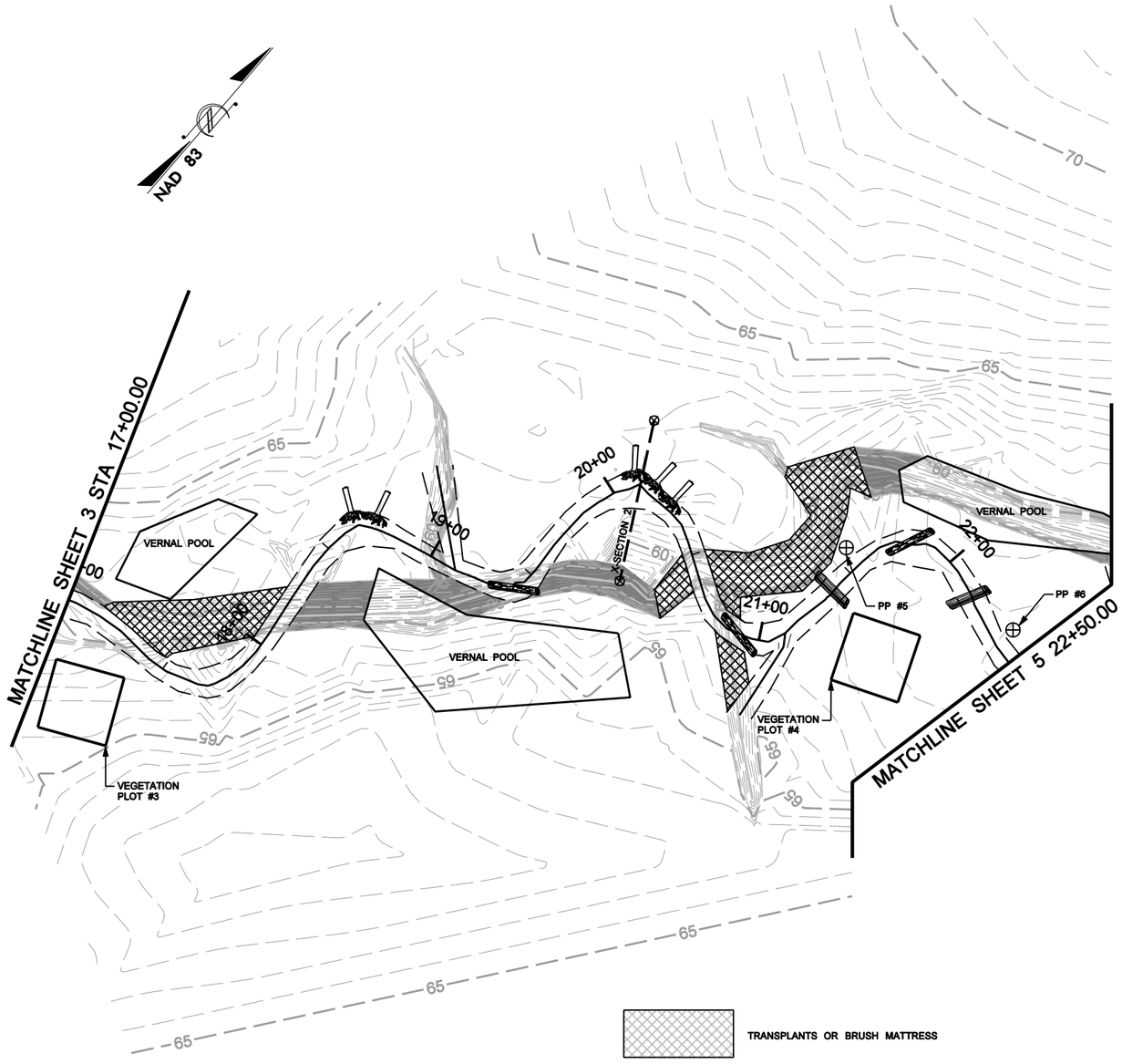

TRANSPLANTS OR BRUSH MATTRESS

DITCH PLUG

CHANNEL FILL

NOTE:
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT PLAN VIEW

30 15 0 30 60
SCALE (FT)

FIGURE 2C

2/26/03

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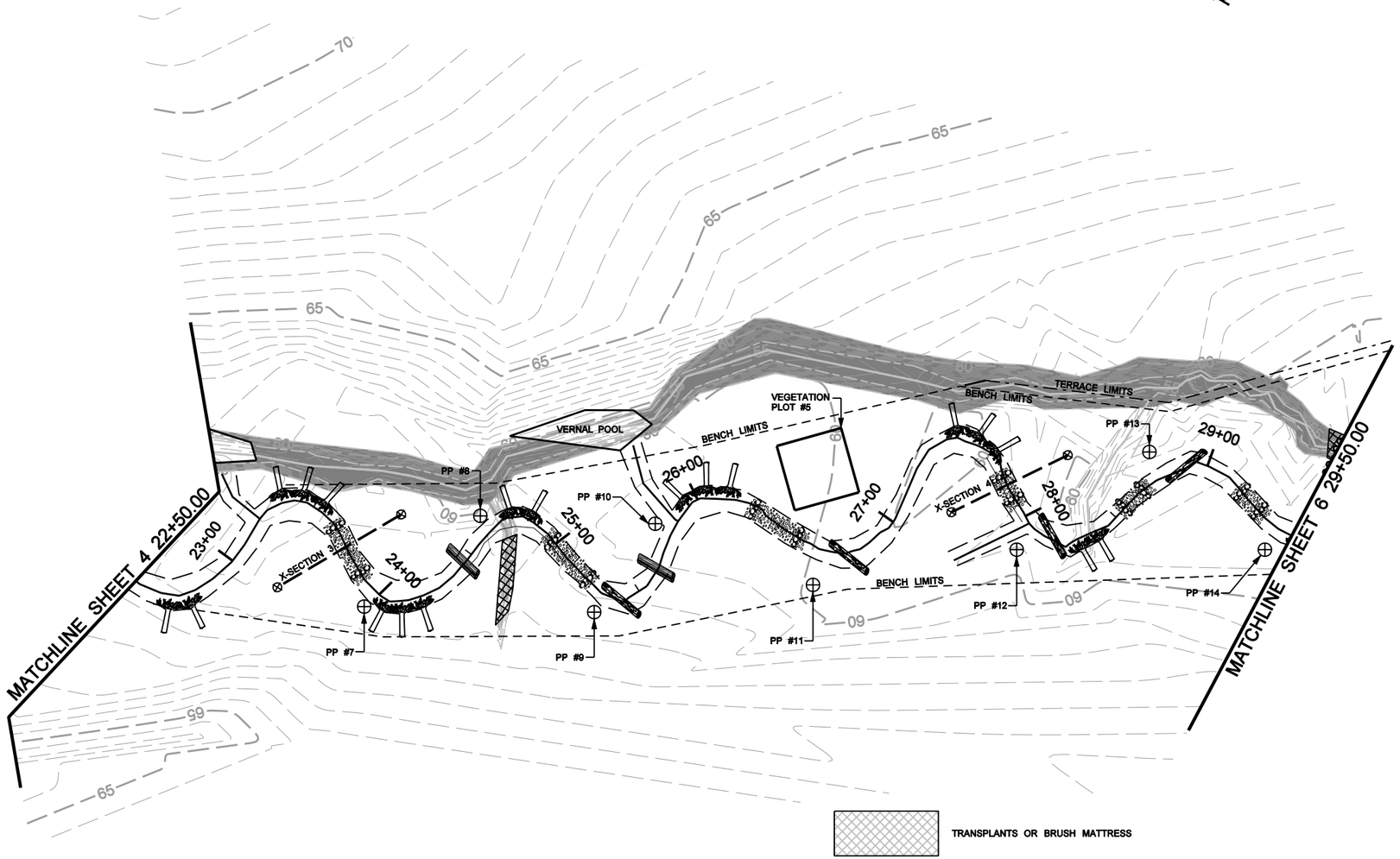

TRANSPLANTS OR BRUSH MATTRESS

DITCH PLUG

CHANNEL FILL

NOTE;
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE;
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT PLAN VIEW

30 15 0 30 60
SCALE (FT)

FIGURE 2D

2/26/03

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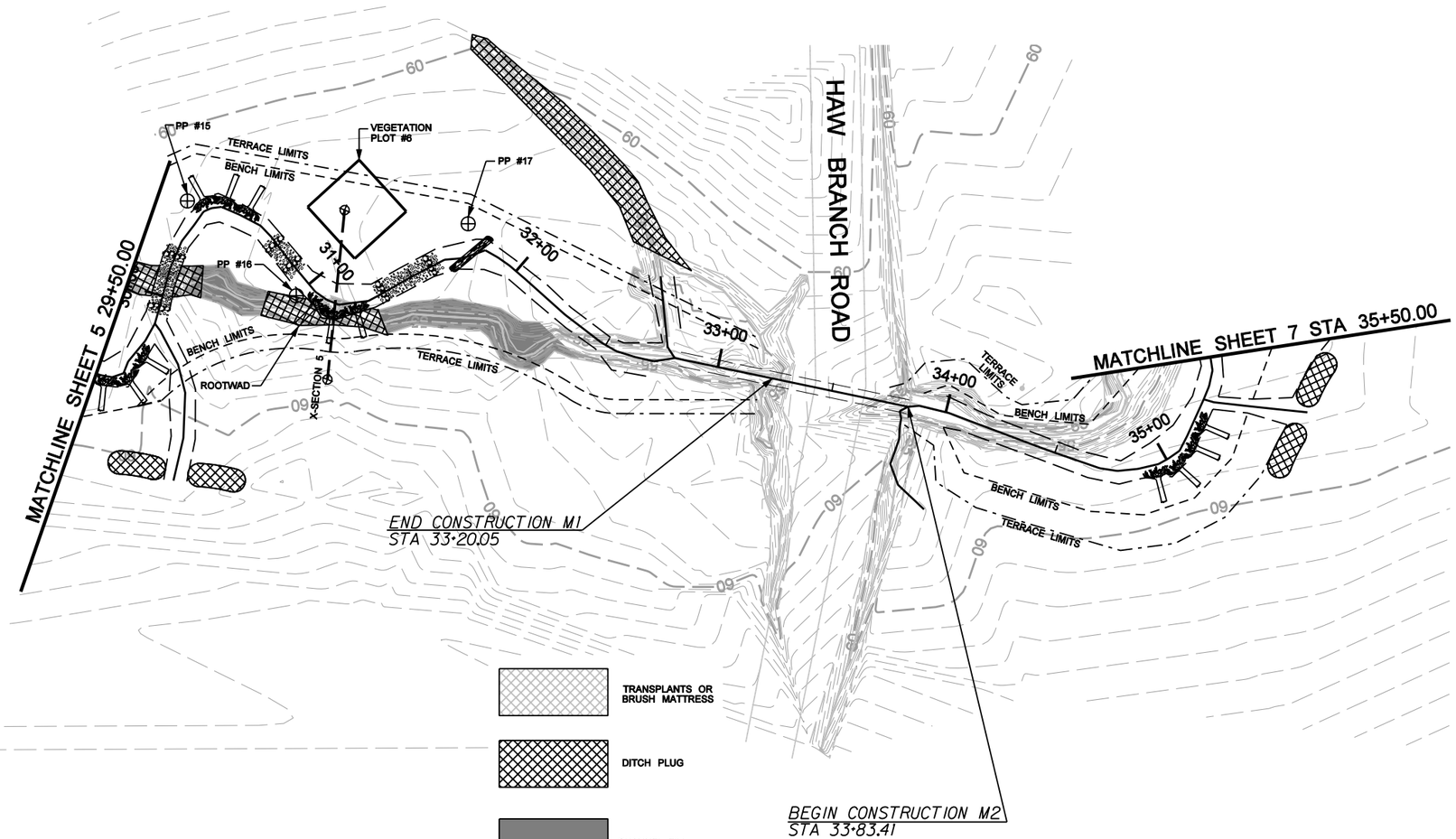

TRANSPLANTS OR BRUSH MATTRESS

DITCH PLUG

CHANNEL FILL

NOTE:
PRESERVED TREES WHERE POSSIBLE BETWEEN STATIONS 10+00 TO 33+66.

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT PLAN VIEW

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SCALE (FT)

FIGURE 2E

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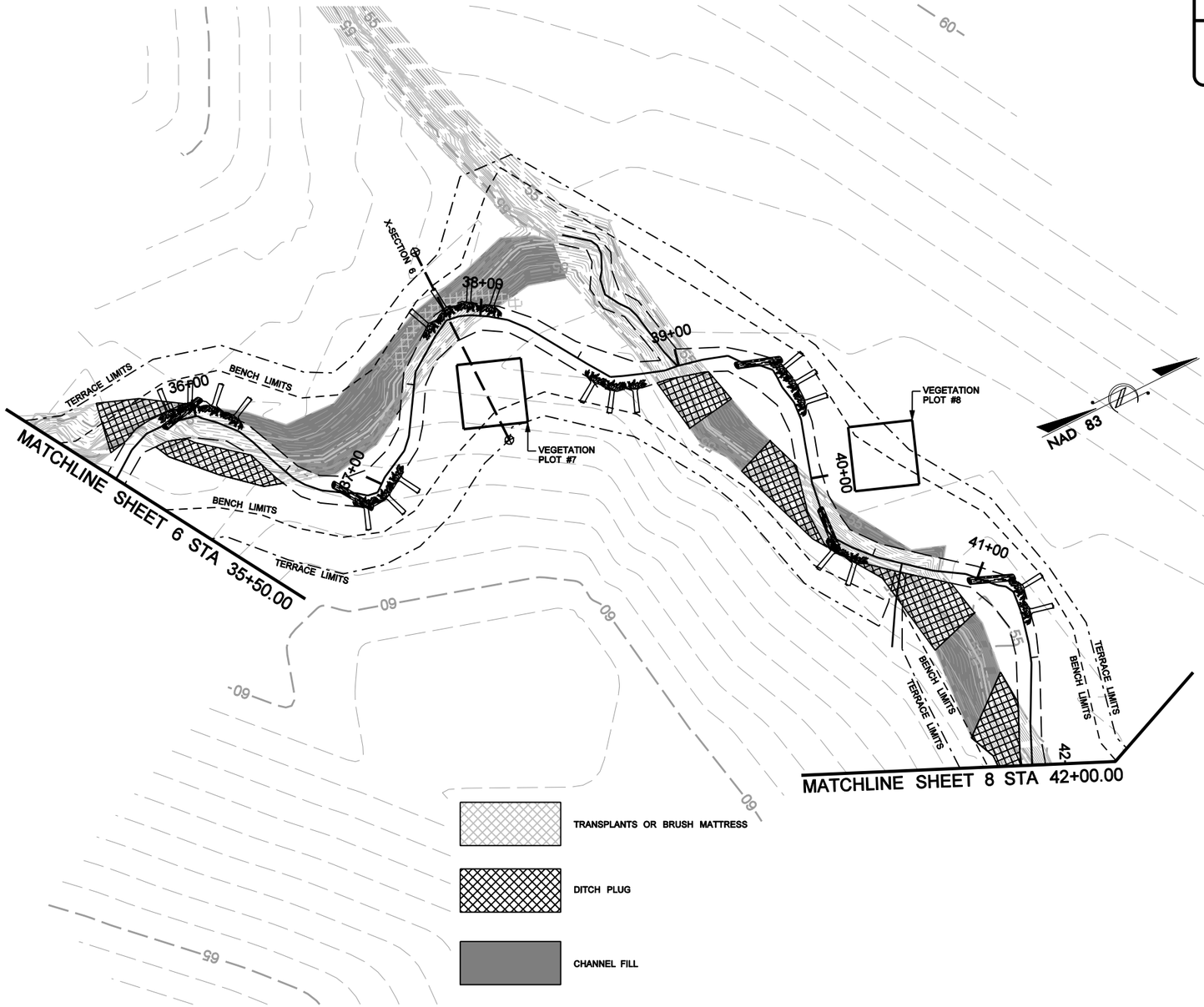

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT
PLAN VIEW

30 15 0 30 60
SCALE (FT)

FIGURE 2F

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2/26/03

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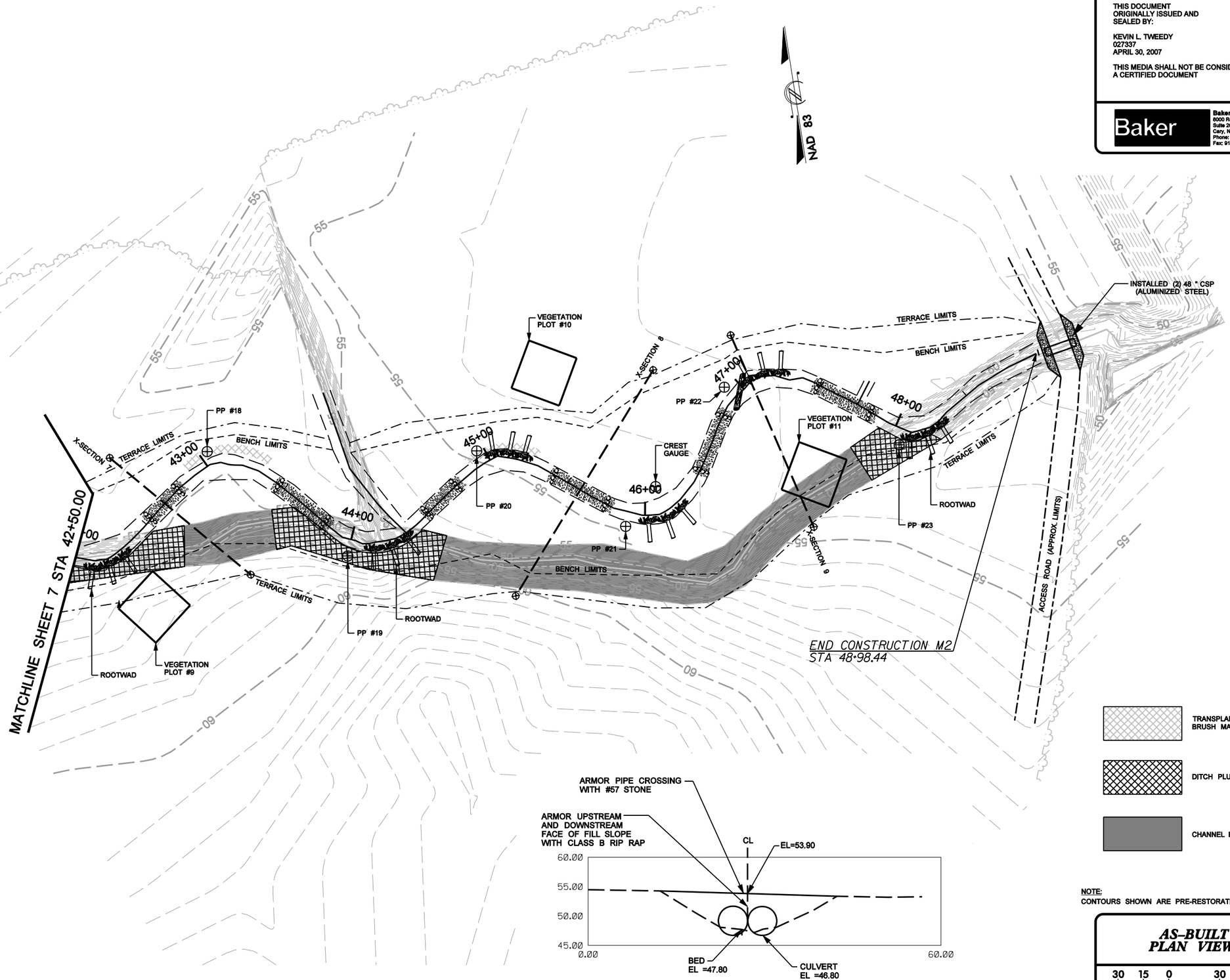

SECTION A-A'

TRANSPLANTS OR BRUSH MATTRESS

DITCH PLUG

CHANNEL FILL

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT PLAN VIEW

30 15 0 30 60
SCALE (FT)

FIGURE 2G

11/27/2007
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APPENDIX A

VEGETATION RAW DATA

VEGETATION TABLES

Table A.1. Vegetation Metadata

Crowns West Restoration Project: Project No. D06003-2

Report Prepared By	Dwayne Huneycutt
Date Prepared	10/11/2011 14:16
database name	Baker-2010-A-Crowns West.mdb
database location	L:\Monitoring\Veg Plot Info\CVS Data Tool\2010
computer name	CARYWDHUNEYCU2
file size	38010880
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	D060032
project Name	Crowns West
Description	Stream Restoration Project
River Basin	White Oak
length(ft)	3835
stream-to-edge width (ft)	50
area (sq m)	35624.71
Required Plots (calculated)	10
Sampled Plots	0

Table A.2. Vegetation Vigor by Species

Crowns West Restoration Project: Project No. D06003-2

	Species	Common Name	Excellent	Good	Fair	Unlikely to Survive Year	Dead	Missing
	Betula nigra	river birch	11	1	1			
	Celtis laevigata	sugarberry			4			
	Fraxinus pennsylvanica	green ash	9	6	3		1	
	Juglans nigra	black walnut			1			
	Nyssa biflora	swamp tupelo	2	11	16			
	Quercus lyrata	overcup oak	14	3	1		2	
	Quercus michauxii	swamp chestnut oak	6	6				
	Quercus nigra	water oak	1					
	Quercus phellos	willow oak	9	1	2			
	Taxodium distichum	bald cypress	10	8	3		1	
	Platanus occidentalis	American sycamore	24	18	7			
TOT:	**11**	**11**	**86**	**54**	**38**	**0**	**4**	**0**

Table A.3. Vegetation Damage by Species

Crowns West Restoration Project: Project No. D06003-2

	Species	Common Name	Count of Damage Categories	No Damage	Beaver	Unknown
	Betula nigra	river birch	1	12		1
	Celtis laevigata	sugarberry	0	4		
	Fraxinus pennsylvanica	green ash	1	18		1
	Juglans nigra	black walnut	0	1		
	Nyssa biflora	swamp tupelo	2	27		2
	Platanus occidentalis	American sycamore	3	46	1	2
	Quercus lyrata	overcup oak	1	19	1	
	Quercus michauxii	swamp chestnut oak	0	12		
	Quercus nigra	water oak	0	1		
	Quercus phellos	willow oak	0	12		
	Taxodium distichum	bald cypress	3	19		3
TOT:	**11**	**11**	**11**	**171**	**2**	**9**

Table A.4. Vegetation Damage by Plot

Crowns West Restoration Project: Project No. D06003-2						
	Plot	Count of Damage Categories	No Damage	Beaver	Unknown	
	D060032-DH-0001-year:5	2	10	2		
	D060032-DH-0002-year:5	0	17			
	D060032-DH-0003-year:5	0	14			
	D060032-DH-0004-year:5	0	15			
	D060032-DH-0005-year:5	5	13		5	
	D060032-DH-0006-year:5	1	15		1	
	D060032-DH-0007-year:5	1	13		1	
	D060032-DH-0008-year:5	2	20		2	
	D060032-DH-0009-year:5	0	15			
	D060032-DH-0010-year:5	0	24			
	D060032-DH-0011-year:5	0	15			
TOT:	**11**	**11**	**171**	**2**	**9**	

Table A.5. Stem Count by Plot and Species

Crowns West Restoration Project: Project No. D06003-2																	
	Species	Common Name	Total Planted Stems	# Plots	Average # Stems	Plot D060032-DH-0001-year:4	Plot D060032-DH-0002-year:4	Plot D060032-DH-0003-year:4	Plot D060032-DH-0004-year:4	Plot D060032-DH-0005-year:4	Plot D060032-DH-0006-year:4	Plot D060032-DH-0007-year:4	Plot D060032-DH-0008-year:4	Plot D060032-DH-0009-year:4	Plot D060032-DH-0010-year:4	Plot D060032-DH-0011-year:4	
	Betula nigra	river birch	13	7	1.86	2	1		1	4	1			3		1	
	Celtis laevigata	sugarberry	4	3	1.33				2				1	1			
	Fraxinus pennsylvanica	green ash	18	6	3			2	2			7	1		2	4	
	Juglans nigra	black walnut	1	1	1								1				
	Nyssa biflora	swamp tupelo	29	9	3.22	1	4	2	3	3	1		4		4	7	
	Platanus occidentalis	American sycamore	49	11	4.45	5	8	7	3	1	6	1	6	5	6	1	
	Quercus lyrata	overcup oak	18	5	3.6		1				5	3		4	5		
	Quercus michauxii	swamp chestnut oak	12	7	1.71				3		2	2	1	1	2	1	
	Quercus nigra	water oak	1	1	1											1	
	Quercus phellos	willow oak	12	4	3	3		2					2		5		
	Taxodium distichum	bald cypress	21	6	3.5		3	1		9	1	1	6				
TOT:	**11**	**11**	**178**	**11**		**11**	**17**	**14**	**14**	**17**	**16**	**14**	**22**	**14**	**24**	**15**	

Table A.6. Stem Count for Each Species Arranged by Plot

Crowns West Restoration Project: Project No. D06003-2													
	Plots											Year 5 Totals	Average Stems/acre
Tree Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**		
Betula nigra	2	1		1	4	1			3		1	13	
Celtis laevigata				2				1	1			4	
Fraxinus pennsylvanica			2	2			7	1		2	4	18	
Juglans nigra								1				1	
Nyssa biflora	1	4	2	3	3	1		4		4	7	29	
Platanus occidentalis	5	8	7	3	1	6	1	6	5	6	1	49	N/A
Quercus lyrata		1				5	3		4	5		18	
Quercus michauxii				3		2	2	1	1	2	1	12	
Quercus nigra											1	1	
Quercus phellos	3		2					2		5		12	
Taxodium distichum		3	1		9	1	1	6				21	
Stems/plot Year 5	11	17	14	14	17	16	14	22	14	24	15	178	
Stems/acre Year 5	**445**	**688**	**567**	**567**	**688**	**648**	**567**	**891**	**567**	**972**	**607**		655
Stems/acre Year 4	486	688	567	567	729	648	567	891	526	972	607		659
Stems/acre Year 3	486	688	567	567	729	688	607	891	648	972	607	N/A	677
Stems/acre Year 2	567	688	567	567	809	769	647	891	688	972	809		725
Stems/acre Initial	729	729	607	648	972	760	640	1053	850	1093	931		819

VEGETATION PHOTOS

Vegetation Plot 1

Herbaceous Vegetation Plot 1

Vegetation Plot 2

Herbaceous Vegetation Plot 2

Vegetation Plot 3

Herbaceous Vegetation Plot 3

Vegetation Plot 4

Herbaceous Vegetation Plot 4

Vegetation Plot 5

Herbaceous Vegetation Plot 6

Vegetation Plot 6

Herbaceous Vegetation Plot 6

Vegetation Plot 7

Herbaceous Vegetation Plot 7

Vegetation Plot 8

Herbaceous Vegetation Plot 8

Vegetation Plot 9

Herbaceous Vegetation Plot 9

Vegetation Plot 10

Herbaceous Vegetation Plot 10

Vegetation Plot 11

Herbaceous Vegetation Plot 11

APPENDIX B

STREAM RAW DATA

STREAM TABLES

Table B.1. Categorical Stream Feature Visual Stability Assessment

Crowns Wet Restoration Project: Project No. D06003-2						
	Performance Percentage					
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	100%	100%	95%	95%	95%	95%
B. Pools	100%	100%	90%	90%	90%	90%
C. Thalweg	100%	100%	100%	100%	100%	100%
D. Meanders	100%	100%	100%	100%	100%	100%
E. Bed General	100%	100%	100%	100%	100%	100%
F. Bank Condition	100%	100%	95%	95%	95%	95%
G. Wads	100%	100%	75%	90%	90%	90%

Table B.2. Baseline Stream Summary

Crowns West Restoration Project: Project No. D06003-2

Crowns West - Reach M1

Parameter	USGS Gauge		Regional Curve Interval			Pre-Existing Condition			Reference Reach(es) Data			Design			As-built		
Dimension - Riffle	-----	-----	LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
BF Width (ft)	-----	-----	-----	-----	-----	5.6	5.9	6.2	-----	-----	-----	9	9.0	9.0	8.8	10.1	11.3
Floodprone Width (ft)	-----	-----	-----	-----	-----	8.0	10.5	13.0	-----	-----	-----	70.0	90.0	110.0	58.2	61	64.6
BF Mean Depth (ft)	-----	-----	-----	-----	-----	1.4	1.6	1.7	-----	-----	-----	0.9	0.9	0.9	0.72	0.73	0.74
BF Max Depth (ft)	-----	-----	-----	-----	-----	1.70	2.0	2.20	1.5	1.6	1.7	1.1	1.2	1.2	1.2	1.2	1.3
BF Cross-sectional Area (ft²)	-----	-----	-----	-----	-----	8.4	9.0	9.5	24	24.0	24	8.0	8.0	8.0	6.3	8.4	7.4
Width/Depth Ratio	-----	-----	-----	-----	-----	3.4	3.9	4.3	11.0	14.0	17.0	-----	10.0	-----	12.2	13.9	15.3
Entrenchment Ratio	-----	-----	-----	-----	-----	1.3	1.8	2.2	10.0	10.5	11.0	7.0	9.0	11.0	5.3	6.1	6.6
Bank Height Ratio	-----	-----	-----	-----	-----	2.7	2.8	2.9	1.0	1.2	1.3	1.0	1.1	1.2	1.0	1.0	1.0
BF Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	-----	1.5	1.5	1.5	2.2	-----	2.2	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	45	58.5	72	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	18	27	36	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	6.5	8	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	2.5	-----	3.4	23	34	45	-----	-----	-----
Substrate and Transport Parameters																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	.2/.29/.36/.68/.94			.3/.4/.5/.9/1.2			-----			-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	1,938	-----	-----	-----	-----	-----	2,372	-----	-----	2,275	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	0.7	-----	3	-----	3	-----	0.7	-----	-----	0.7	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	G5/E5	-----	-----	C5c	-----	-----	E5	-----	-----	E5	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	-----	-----	37	37	37	-----	17.3	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.27	-----	-----	1.66	-----	-----	1.4	-----	-----	1.4	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.004	-----	-----	0.0004	-----	-----	0.0030	-----	-----	0.004	-----

Crowns West - Reach M2																	
Parameter	**USGS Gauge**		**Regional Curve Interval**			**Pre-Existing Condition**			**Reference Reach(es) Data**			**Design**			**As-built**		
Dimension - Riffle	-----	-----	LL	UL	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
BF Width (ft)	-----	-----	-----	-----	-----	5.8	-----	12.0	-----	-----	-----	-----	10	-----	8.77	10.13	11.52
Floodprone Width (ft)	-----	-----	-----	-----	-----	17.0	-----	37.0	-----	-----	-----	60.0	70.0	80.0	58.2	78.4	133.1
BF Mean Depth (ft)	-----	-----	-----	-----	-----	1.4	-----	1.8	-----	-----	-----	1.0	1.0	1.0	0.71	0.84	1.12
BF Max Depth (ft)	-----	-----	-----	-----	-----	2.5	-----	3.0	1.5	-----	1.7	1.2	1.3	1.3	1.19	1.41	1.80
BF Cross-sectional Area (ft²)	-----	-----	-----	-----	-----	9.7	-----	16.8	24	24	24	10.0	10	10.0	6.3	8.5	10.6
Width/Depth Ratio	-----	-----	-----	-----	-----	3.4	-----	8.6	11.0	-----	17.0	-----	10.0	-----	8.5	12.4	15.8
Entrenchment Ratio	-----	-----	-----	-----	-----	1.5	-----	6.4	10.0	-----	11.0	6.0	7.0	8.0	5.2	7.9	14.1
Bank Height Ratio	-----	-----	-----	-----	-----	1.9	-----	2.3	1.0	-----	1.3	1.0	1.1	1.2	1.0	1.0	1.0
BF Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	-----	1.5	-----	1.5	1.6	-----	1.6	-----	-----	-----
Pattern																	
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	50	65	80	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	20	30	40	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	6.5	8	-----	-----	-----
Profile																	
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	2.5	-----	3.4	25	38	50	-----	-----	-----
Substrate and Transport Parameters																	
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	.2/.29/.36/.68/.94			.3/.4/.5/.9/1.2			-----			-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters																	
Channel length (ft)	-----	-----	-----	-----	-----	-----	1396	-----	-----	-----	-----	-----	1528	-----	-----	1560	-----
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	1	-----	3	-----	3	-----	1	-----	-----	1	-----
Rosgen Classification	-----	-----	-----	-----	-----	-----	G5/E5	-----	-----	C5c	-----	-----	E5	-----	-----	E5	-----
BF Discharge (cfs)	-----	-----	-----	-----	-----	-----	-----	-----	37	37	37	-----	16.2	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	-----	1.27	-----	-----	1.66	-----	-----	1.4	-----	-----	1.38	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	0.004	-----	-----	0.0004	-----	-----	0.003	-----	-----	0.004	-----

Table B.3. Morphology and Hydraulic Monitoring Summary

Crowns West Restoration Project: Project No. D06003-2																				
Reach: M1 (2320 feet)																				
Parameter	Cross-section 1 Riffle					Cross-section 2 Pool					Cross-section 3 Riffle					Cross-section 4 Riffle				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	19.20	9.79	12.79	9.83	9.29	12.88	10.43	10.09	10.44	9.83	11.39	10.38	14.61	10.80	8.61	9.72	8.76	9.62	9.08	8.87
BF Mean Depth (ft)	0.44	0.61	0.46	0.60	0.56	1.81	1.57	1.61	1.98	1.93	0.68	0.61	0.50	0.62	0.66	0.80	0.58	0.66	0.67	0.63
Width/Depth Ratio	44.11	16.05	27.97	16.32	16.64	7.11	6.64	6.27	5.26	5.09	16.83	16.99	29.05	17.43	13.13	12.20	15.10	14.51	13.62	14.02
BF Cross-sectional Area (ft^2)	8.40	6.00	5.80	5.90	5.20	23.30	16.40	16.20	20.70	19.00	7.70	6.30	7.30	6.70	5.70	7.70	5.10	6.40	6.10	5.60
BF Max Depth (ft)	1.00	0.97	0.91	1.04	0.56	3.07	2.75	2.77	3.00	2.64	1.21	1.10	1.15	1.24	0.66	1.26	0.92	0.66	1.07	1.04
Width of Floodprone Area (ft)	60.21	60.18	60.18	60.16	60.18	69.89	69.89	69.87	64.62	60.06	64.57	65.50	64.56	64.64	64.62	58.30	58.18	58.20	58.26	58.20
Entrenchment Ratio	3.1	6.1	4.7	6.1	6.5	5.4	6.7	6.9	6.2	6.1	5.7	5.3	4.4	6.0	7.5	6.0	6.6	6.0	6.4	6.6
Bank Height Ratio	0.9	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.1	1.3	1.0	1.1	1.0	1.1	1.0	1.0	1.1	1.0	1.1	1.2
Wetted Perimeter (ft)	20.08	11.01	13.71	11.03	10.41	16.5	13.57	13.31	14.4	13.69	12.75	11.6	15.61	12.04	9.93	11.32	9.92	10.94	10.42	10.13
Hydraulic Radius (ft)	88.66	32.71	56.4	33.24	33.84	16.03	14.85	14.15	12.5	12.11	34.34	34.59	58.6	35.48	26.92	25.2	30.78	29.68	27.91	28.67
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	Cross-section 5 Pool				
	MY1	MY2	MY3	MY4	MY5
Dimension					
BF Width (ft)	12.92	11.19	14.69	11.61	9.54
BF Mean Depth (ft)	1.37	1.33	1.28	1.55	1.64
Width/Depth Ratio	9.4	8.4	11.4	7.5	5.8
BF Cross-sectional Area (ft^2)	17.7	14.9	18.9	18.0	15.6
BF Max Depth (ft)	2.40	2.69	2.91	3.11	2.71
Width of Floodprone Area (ft)	62.48	68.39	67.83	70.67	62.35
Entrenchment Ratio	4.8	6.1	4.6	5.6	6.4
Bank Height Ratio	1.0	1.1	1.0	1.0	1.0
Wetted Perimeter (ft)	15.66	13.85	17.25	14.71	12.82
Hydraulic Radius (ft)	20.21	18.17	24.14	16.51	13.26
Substrate					
d50 (mm)					
d84 (mm)					

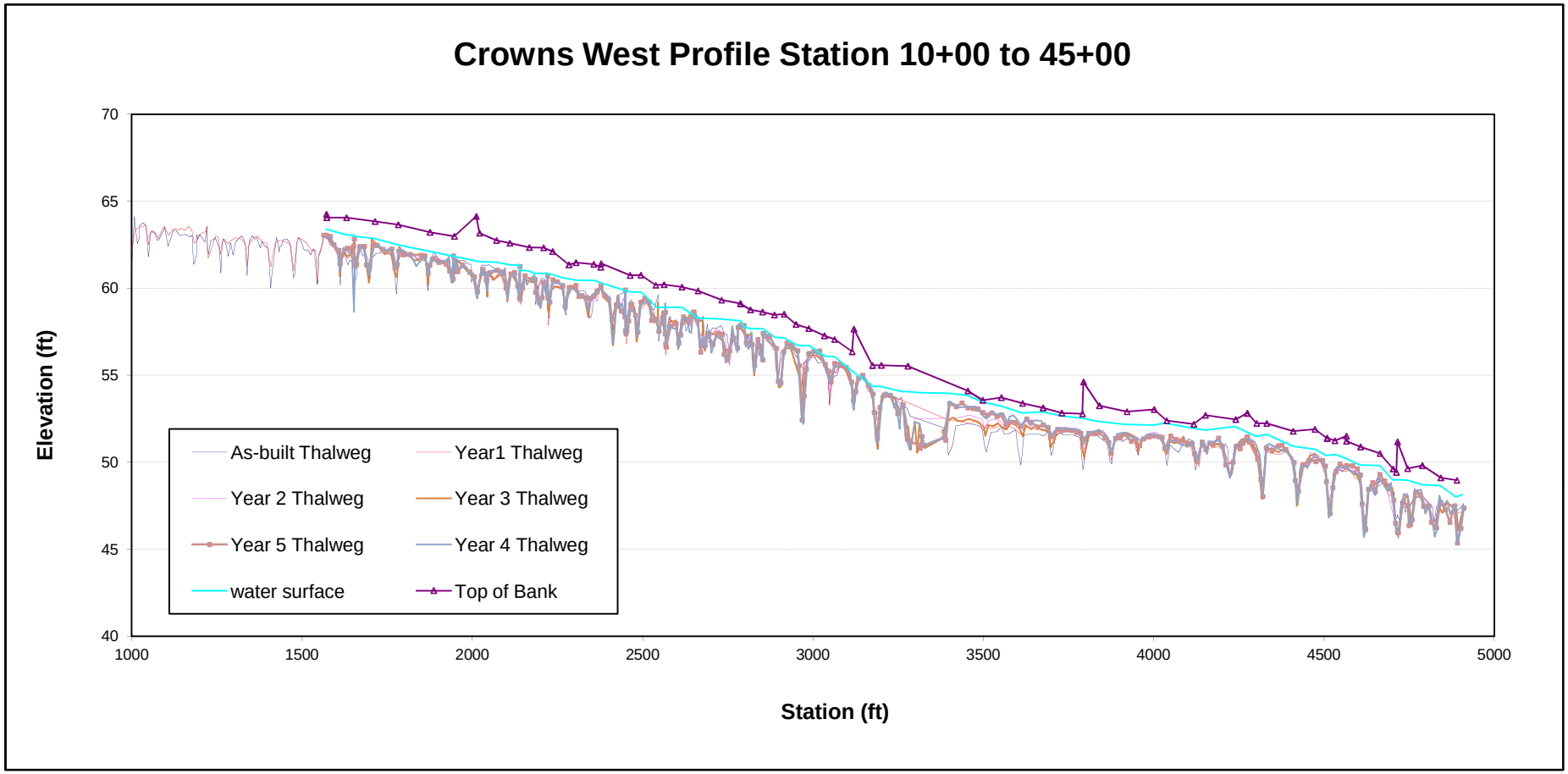
Parameter	MY-1 (2007)			MY-2 (2008)			MY-3 (2009)			MY-4 (2010)			MY-5 (2011)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			2833.1			2833.1			2833.1			2833.1			2833.1
Channel Length (ft)			3907.59			3907.59			3907.59			3907.59			3907.59
Sinuosity			1.38			1.38			1.38			1.38			1.38
Water Surface Slope (ft/ft)			0.0041			0.0041			0.0041			0.0041			0.0046
BF Slope (ft/ft)			0.0057			0.0057			0.0057			0.0057			0.0063
Rosgen Classification			C			C			C			C			C

Reach: M2 (1515 feet)

Parameter	Cross-section 6 Pool					Cross-section 7 Riffle					Cross-section 8 Riffle					Cross-section 9 Pool				
	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5	MY1	MY2	MY3	MY4	MY5
Dimension																				
BF Width (ft)	14.17	13.13	13.68	13.42	12.89	10.01	9.12	11.69	11.01	10.28	9.38	9.24	8.69	8.93	8.16	14.08	14.44	15.22	13.62	15.13
BF Mean Depth (ft)	1.45	1.26	1.22	1.21	1.03	1.02	0.88	0.79	0.76	0.76	1.21	0.98	0.90	0.81	0.83	1.78	1.79	1.75	1.68	1.76
Width/Depth Ratio	9.75	10.40	11.19	11.05	12.46	9.86	10.41	14.84	14.58	13.52	7.74	9.46	9.66	11.00	9.87	7.90	8.06	8.72	8.04	8.60
BF Cross-sectional Area (ft^2)	20.60	16.60	16.70	16.30	13.30	10.20	8.00	9.20	8.30	7.80	11.40	9.00	7.80	7.30	6.80	25.11	25.90	26.60	23.00	26.60
BF Max Depth (ft)	2.63	2.17	2.44	2.00	1.72	1.62	1.37	1.55	1.47	0.76	1.74	1.53	1.39	1.33	1.41	4.17	3.86	3.91	4.06	4.11
Width of Floodprone Area (ft)	87.97	85.74	87.56	85.50	85.31	87.73	85.64	87.44	86.07	87.16	140.14	138.05	137.59	129.41	135.51	118.98	116.46	117.45	118.62	117.87
Entrenchment Ratio	5.2	5.3	5.3	5.1	5.2	7.6	7.9	6.4	6.7	7.2	13.9	13.9	14.5	13.2	15.3	8.2	7.8	7.5	8.5	7.6
Bank Height Ratio	1.0	1.1	1.1	1.1	1.2	1.0	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.1	1.1	1.1	1.1
Wetted Perimeter (ft)	17.07	15.65	16.12	15.84	14.95	12.05	10.88	13.27	12.53	11.80	11.8	11.2	10.49	10.55	9.82	17.64	18.02	18.72	16.98	18.65
Hydraulic Radius (ft)	20.95	22.06	23.6	23.31	25.95	20.74	21.7	30.47	29.92	27.80	16.69	19.9	20.22	22.81	20.57	17.58	17.91	19.19	17.76	18.96
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	MY-1 (2007)			MY-2 (2008)			MY-3 (2009)			MY-4 (2010)			MY-5 (2011)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
Profile															
Riffle length (ft)															
Riffle Slope (ft/ft)															
Pool Length (ft)															
Pool Spacing (ft)															
Additional Reach Parameters															
Valley Length (ft)			2833.1			2833.1			2833.1			2833.1			2833.1
Channel Length (ft)			3907.59			3907.59			3907.59			3907.59			3907.59
Sinuosity			1.38			1.38			1.38			1.38			1.38
Water Surface Slope (ft/ft)			0.0041			0.0041			0.0041			0.0041			0.0046
BF Slope (ft/ft)			0.0057			0.0057			0.0057			0.0057			0.0063
Rosgen Classification			C			C			C			C			C

STREAM DATA
AND PHOTOS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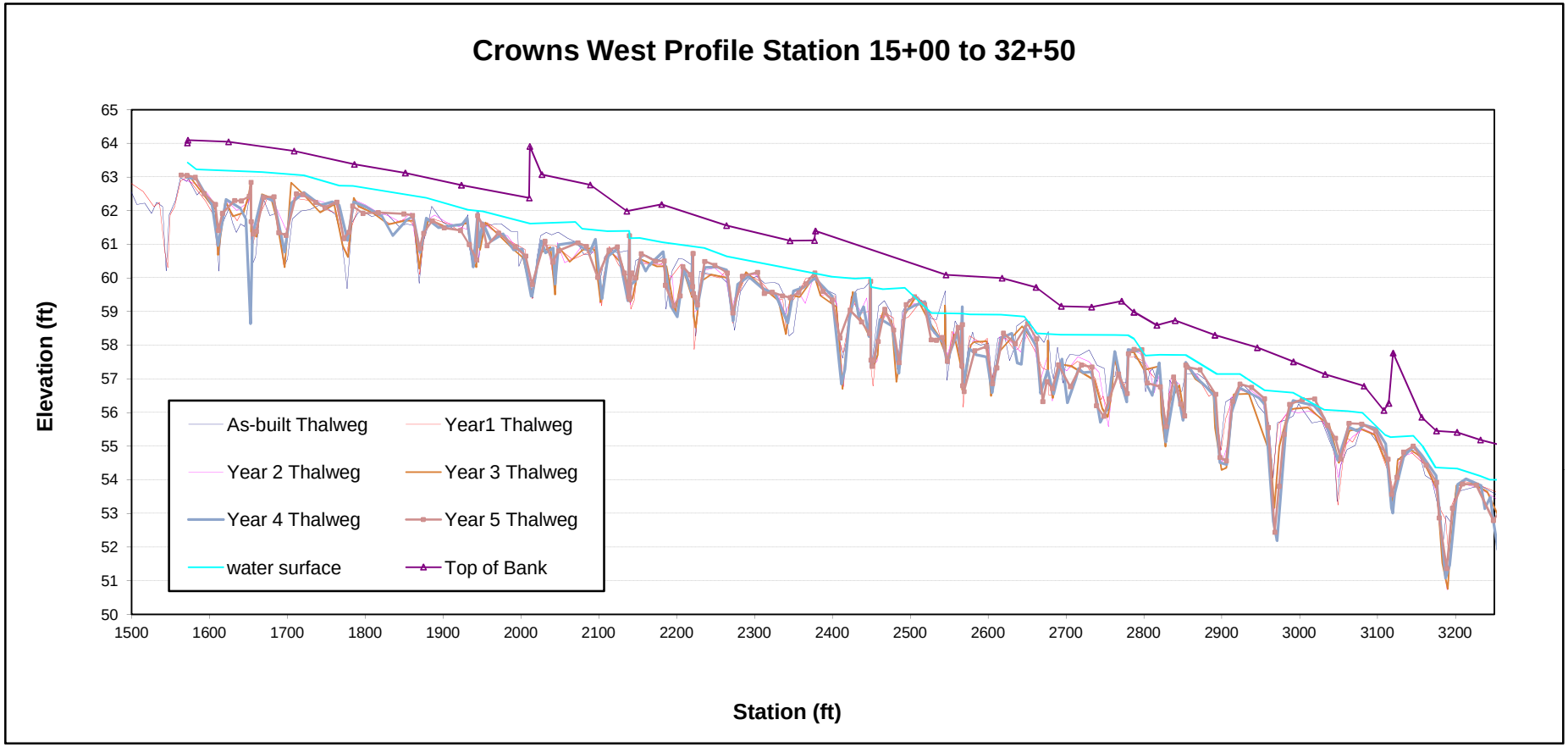
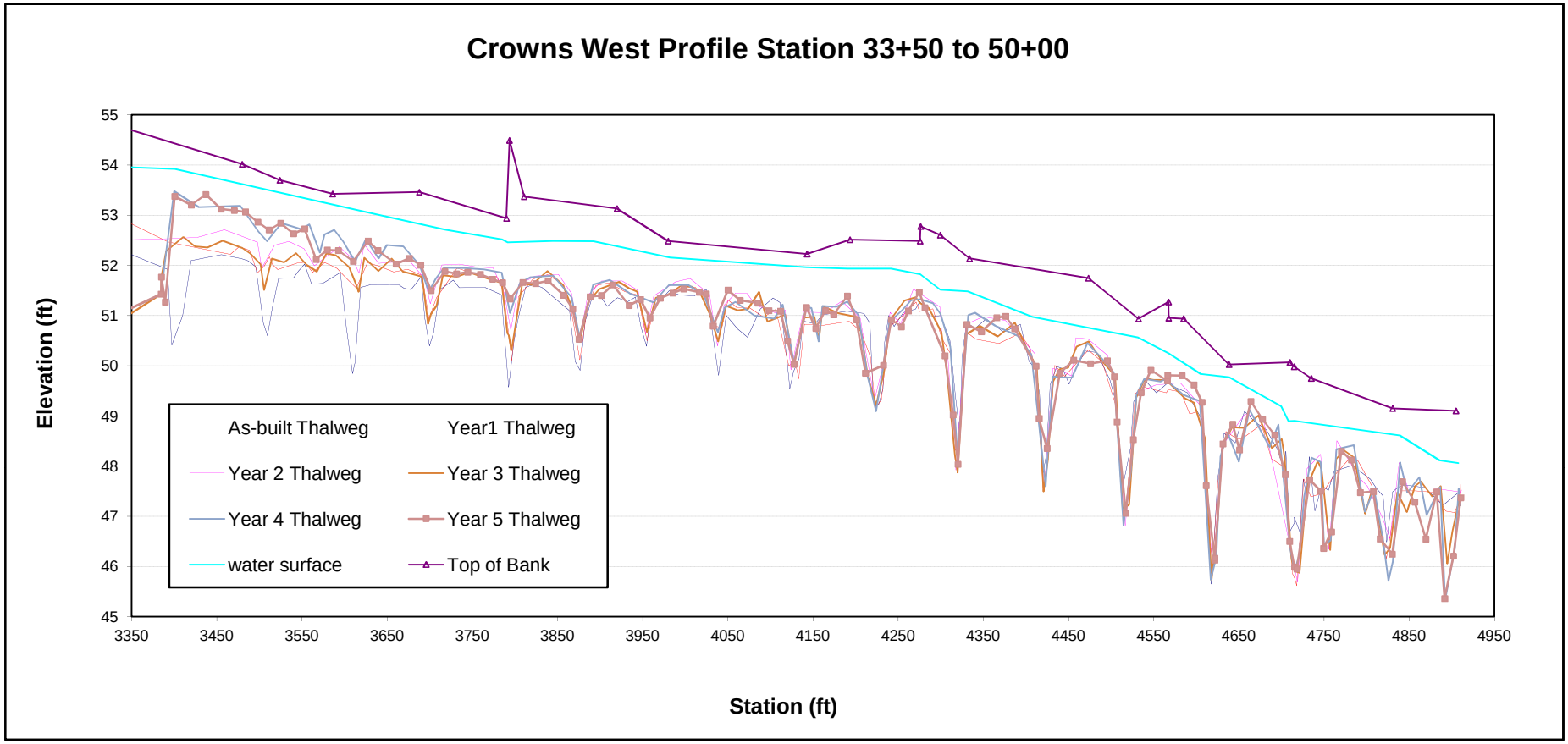
Elevation (ft)
70
65
60
55
50
45
40
1000
1500
2000
2500
3000
3500
4000
4500
5000
Station (ft)
As-built Thalweg
Year1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Year 5 Thalweg
Year 4 Thalweg
water surface
Top of Bank


Crowns West Profile Station 15+00 to 32+50
Elevation (ft)
65
64
63
62
61
60
59
58
57
56
55
54
53
52
51
50
1500
1600
1700
1800
1900
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
3100
3200
Station (ft)
As-built Thalweg
Year1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Year 4 Thalweg
Year 5 Thalweg
water surface
Top of Bank


Crowns West Profile Station 33+50 to 50+00
Elevation (ft)
55
54
53
52
51
50
49
48
47
46
45
3350
3450
3550
3650
3750
3850
3950
4050
4150
4250
4350
4450
4550
4650
4750
4850
4950
Station (ft)
As-built Thalweg
Year1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Year 4 Thalweg
Year 5 Thalweg
water surface
Top of Bank

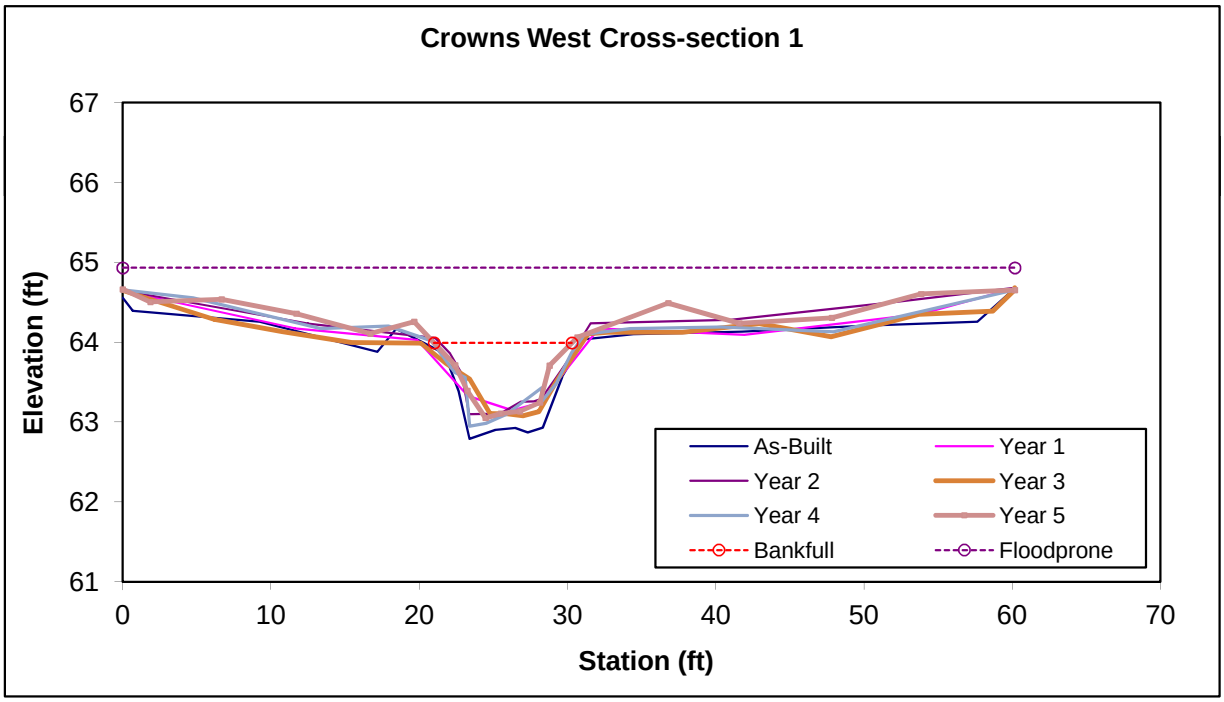
Permanent Cross-section 1

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	5.2	9.29	0.56	0.94	16.64	1.1	6.5	63.99	64.06



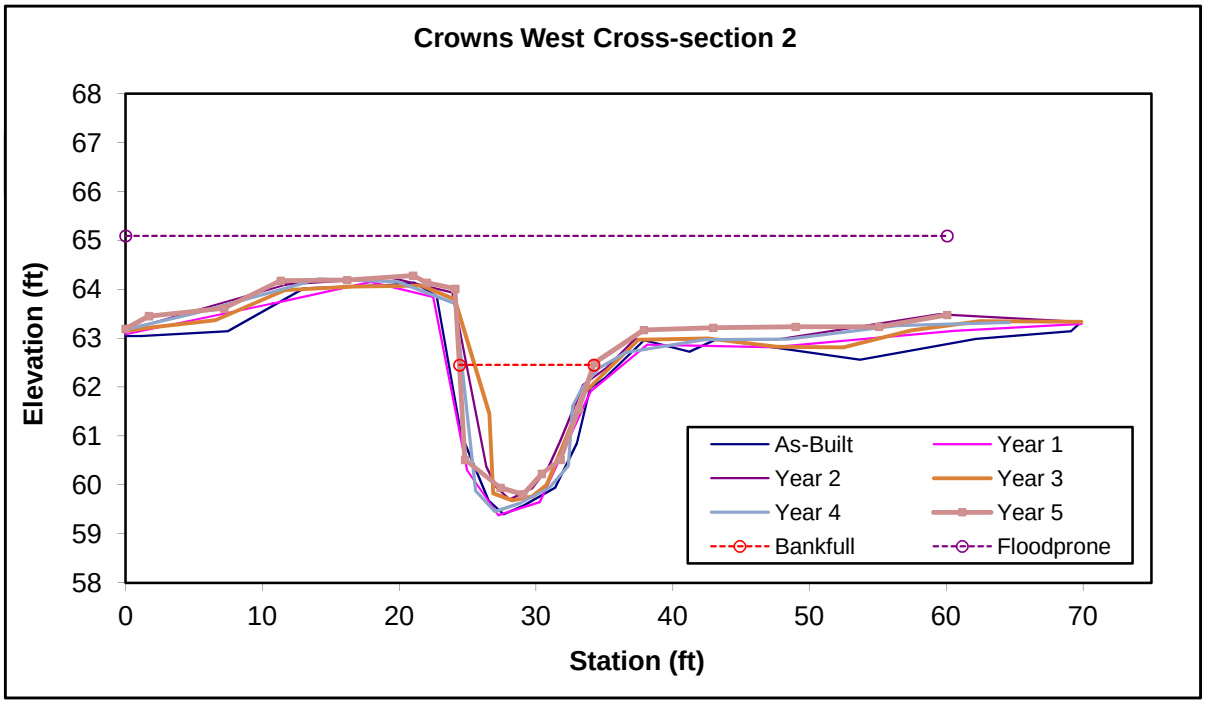
Permanent Cross-section 2

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		19	9.83	1.93	2.64	5.09	1.3	6.1	62.45	63.17



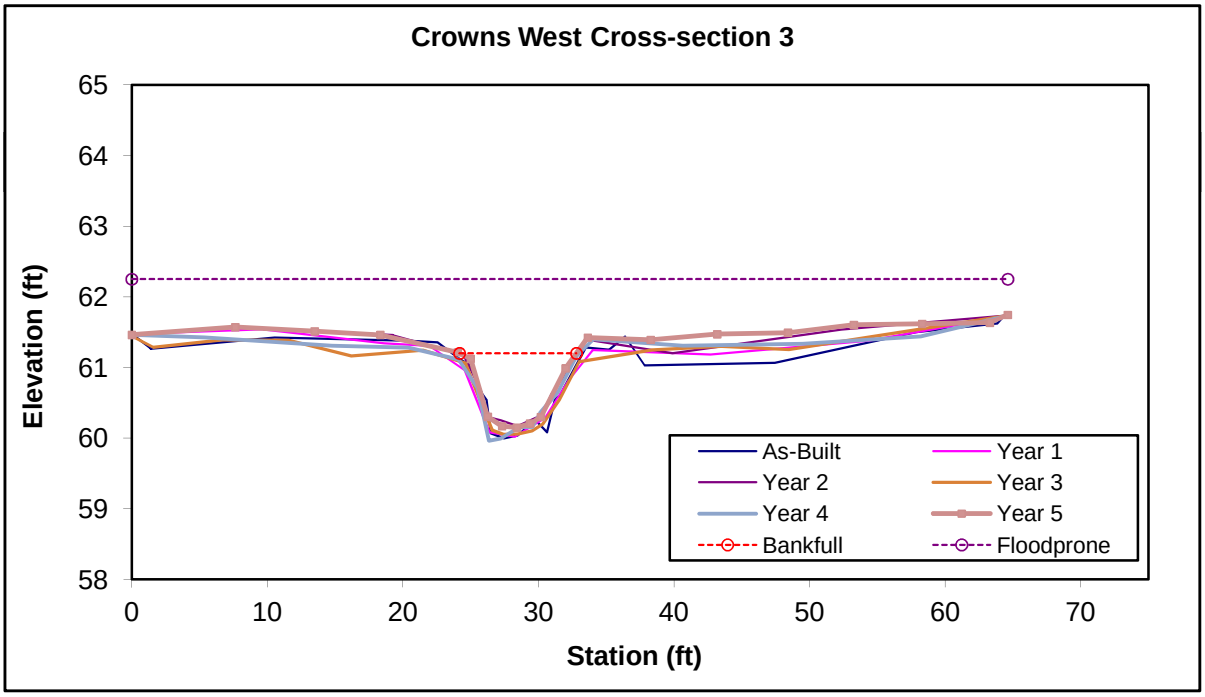
Permanent Cross-section 3

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

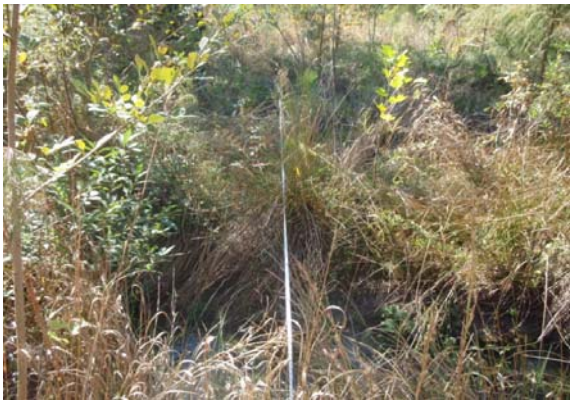
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	5.7	8.61	0.66	1.05	13.13	1	7.5	61.2	61.21



Permanent Cross-section 4

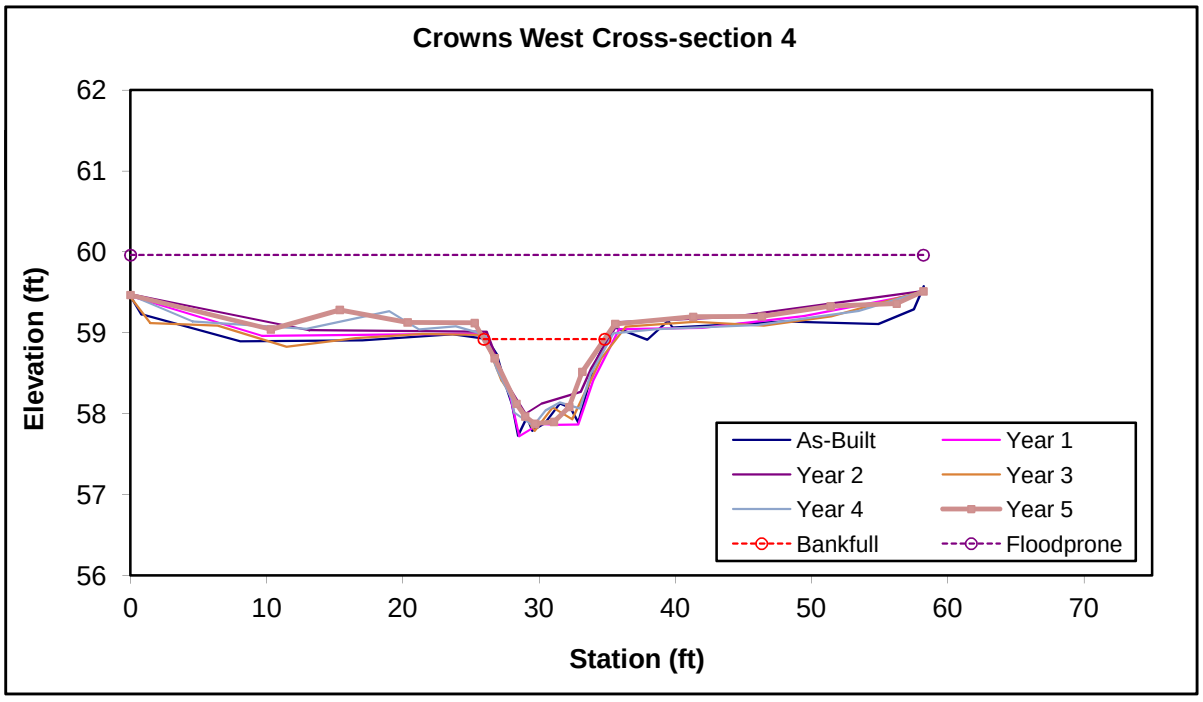
(Year 5 Data - Collected November 2011)

Looking at the Left Bank



Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	5.6	8.87	0.63	1.04	14.02	1.2	6.6	58.92	59.11



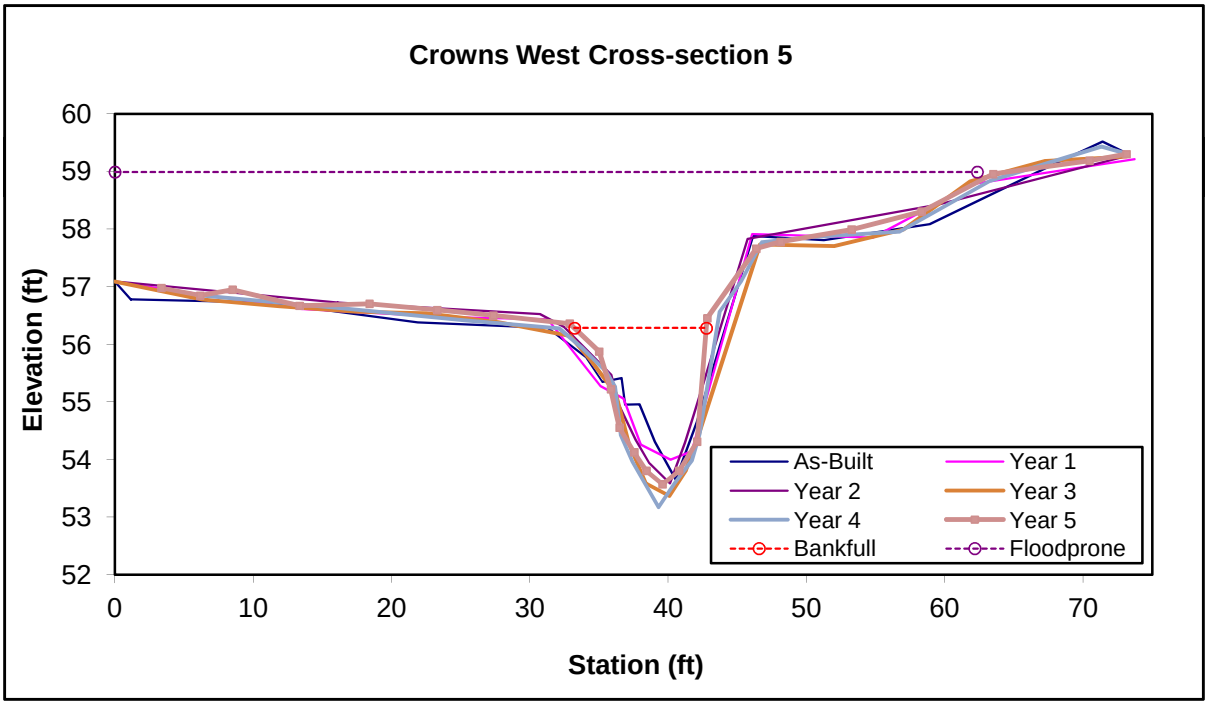
Permanent Cross-section 5

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		15.6	9.54	1.64	2.71	5.81	1	6.4	56.28	56.36



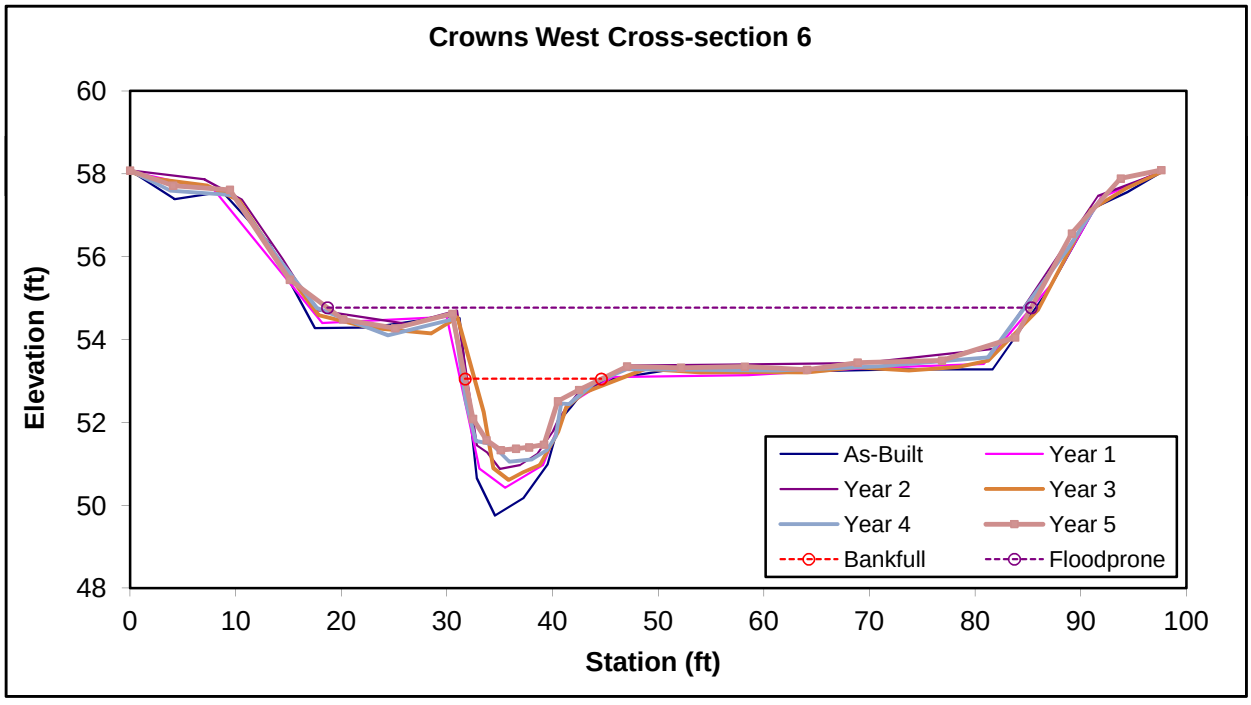
Permanent Cross-section 6

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		13.3	12.89	1.03	1.72	12.46	1.2	5.2	53.05	53.35



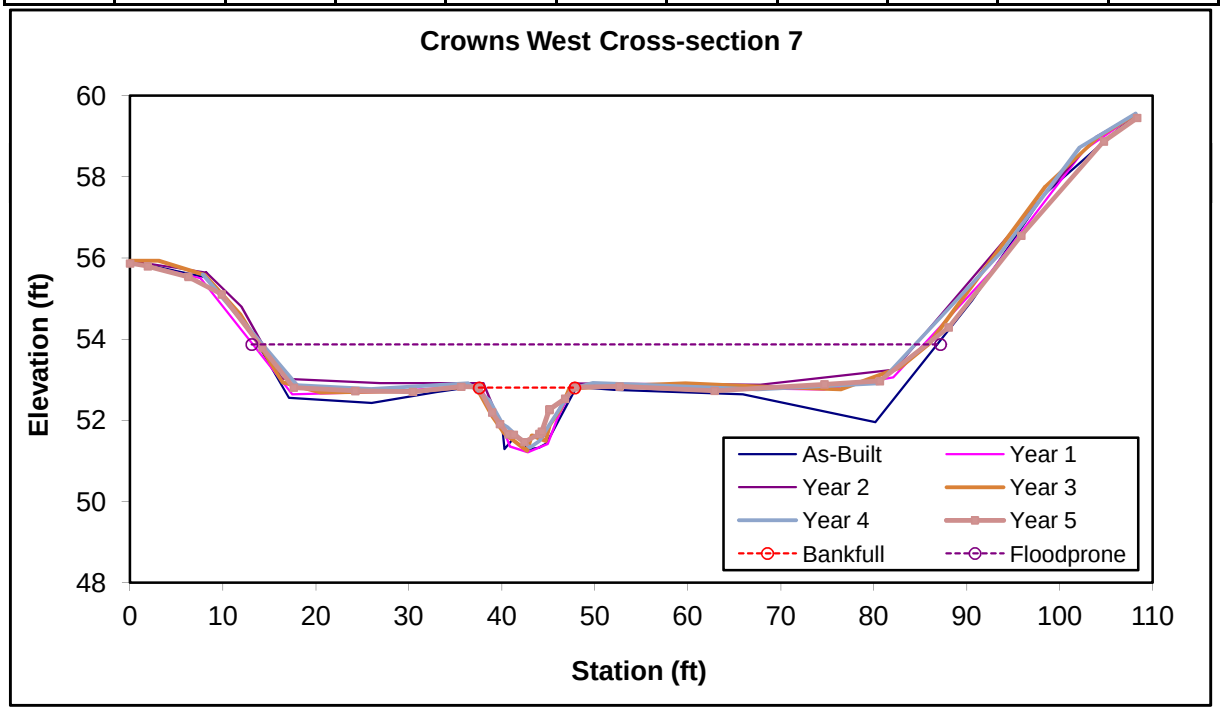
Permanent Cross-section 7

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	7.8	10.28	0.76	1.34	13.52	1	7.2	52.8	52.81



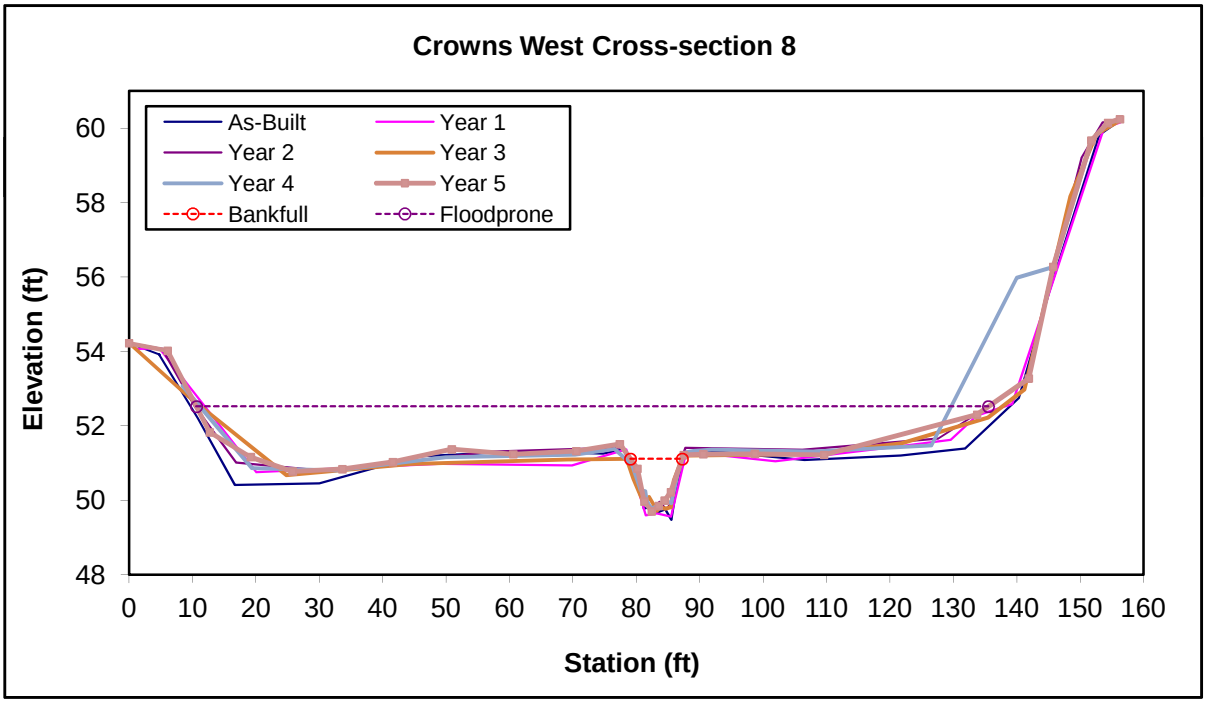
Permanent Cross-section 8

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	6.8	8.16	0.83	1.41	9.87	1.1	15.3	51.11	51.22



Permanent Cross-section 9

(Year 5 Data - Collected November 2011)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		26.6	15.13	1.76	4.11	8.6	1.1	7.6	49.83	50.16

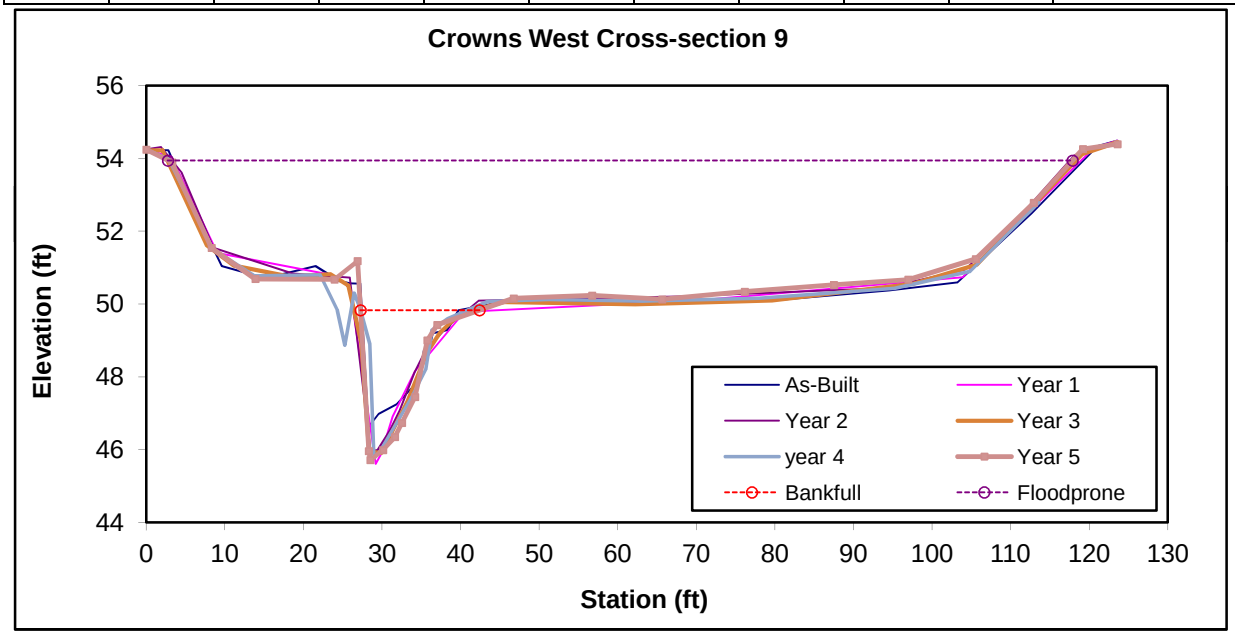


Photo Point 1 - Constructed Riffle 1

Photo Point 2 - Log Weir 1

Photo Point 3 - Constructed Riffle 2

Photo Point 4 - Log Weir 2

Photo Point 5 - Log Weir 3

Photo Point 6 - Log Weir 4

Photo Point 7 - Constructed Riffle 3

Photo Point 8 - Log Weir 5

Photo Point 9 - Constructed Riffle 4

Photo Point 10 - Log Weir 6

Photo Point 11 - Constructed Riffle 5

Photo Point 12 - Constructed Riffle 6

Photo Point 13 - Constructed Riffle 7

Photo Point 14 - Constructed Riffle 8

Photo Point 15 - Constructed Riffle 9

Photo Point 16 - Constructed Riffle 10

Photo Point 17 - Constructed Riffle 11

Photo Point 18 - Constructed Riffle 12

Photo Point 19 - Constructed Riffle 13

Photo Point 20 - Constructed Riffle 14

Photo Point 21 - Constructed Riffle 15

Photo Point 22 - Constructed Riffle 16

Photo Point 23 - Constructed Riffle 17

Crest Gauge after Bankfull – 0.31 feet. Bankfull event occurred on or about May 14, 2011

Site 1
Crowns West

Year 3

3/06 Revision 7

Habitat Assessment Field Data Sheet
Coastal Plain Streams

TOTAL SCORE 67

Biological Assessment Unit, DWQ
Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream Crowns West Location/road: Site (Road Name Haw Branch Rd) County Onslow

Date 3-10-10 **CC#** _____ Basin Neuse Subbasin 03-05-02

Observer(s) DH, RD Type of Study: ☐ Fish ☑ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude _____ Longitude _____ Ecoregion: ☑ CA ☐ SWP ☐ Sandhills ☐ CB

Water Quality: Temperature 9.4 °C DO 10.91 mg/l Conductivity (corr.) 90 µS/cm pH 5.96

Physical Characterization: Visible land use refers to immediate area that you can see from sampling location. Check off what you observe driving thru the watershed in watershed land use.

Visible Land Use: 50 %Forest 10 %Residential ✓ %Active Pasture 30 % Active Crops
_____%Fallow Fields ✓ % Commercial _____%Industrial 10 %Other - Describe: Restoration Site

Watershed land use ☐ Forest ☑ Agriculture ☐ Urban ☐ Animal operations upstream

Width: (meters) Stream 1-1.5m Channel (at top of bank)_____ **Stream Depth**: (m) Avg_____Max ____
☐ **Width variable** ☐ **Braided channel** ☐ **Large river >25m wide**
Bank Height (from deepest part of channel to top of bank): (m)_____

Flow conditions : ☐High ☑ Normal ☐Low
Channel Flow Status
Useful especially under abnormal or low flow conditions.
A. Water reaches base of both banks, minimal channel substrate exposed ..... ☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed..... ☑
C. Water fills 25-75% of available channel, many logs/snags exposed..... ☐
D. Root mats out of water..... ☐
E. Very little water in channel, mostly present as standing pools..... ☐

Turbidity: ☑ Clear ☐ Slightly Turbid ☐ Turbid ☐ Tannic ☐ Milky ☐ Colored (from dyes) ☐ Green tinge
Good potential for Wetlands Restoration Project?? ☐ YES ☐ NO
Details N/A

☐ Channelized ditch
☐ Deeply incised-steep, straight banks ☐ Both banks undercut at bend ☐ Channel filled in with sediment
☐ Recent overbank deposits ☐ Bar development ☐ Sewage smell
☐ Excessive periphyton growth ☐ Heavy filamentous algae growth

Manmade Stabilization: ☐N ☑Y: ☐ Rip-rap, cement, gabions (stone) ☑ Sediment/grade-control structure ☐ Berm/levee
Weather Conditions:_____ **Photos:** ☐N ☐Y ☐Digital ☐35mm

Remarks:_____
TYPICAL STREAM CROSS SECTION DIAGRAM ON BACK

Photos: upstream + downstream

I. Channel Modification

	Score
A. Natural channel-minimal dredging	(15)
B. Some channelization near bridge, or historic (>20 year old), and/or bends beginning to reappear..	10
C. Extensive channelization, straight as far as can see, channelized ditch	5
D. Banks shored with hard structure, >80% of reach disrupted, instream habitat gone	0

Remarks _____ Subtotal 15

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >50% of the reach is snags, and 1 type is present, circle the score of 16. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

✓ **Sticks** L **Snags/logs** L **Undercut banks or root mats** ___ **Macrophytes** ✓ **Leafpacks**

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>50% Score	30-50% Score	10-30% Score	<10% Score
4 or 5 types present	20	15	(10)	5
3 types present	18	13	8	4
2 types present	17	12	7	3
1 type present	16	11	6	2

No substrate for benthos colonization and no fish cover.....0

☐ No woody vegetation in riparian zone Remarks _____ Subtotal 10

III. Bottom Substrate (silt, clay, sand, detritus, gravel) look at entire reach for substrate scoring.

	Score
A. Substrate types mixed	
1. gravel dominant	15
2. sand dominant	(13)
3. detritus dominant	7
4. silt/clay/muck dominant	4
B. Substrate homogeneous	
1. nearly all gravel	12
2. nearly all sand	7
3. nearly all detritus	4
4. nearly all silt/clay/muck	1

Remarks _____ Subtotal 13

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow.

	Score
A. Pools present	
1. Pools Frequent (>30% of 100m length surveyed)	
a. variety of pool sizes	(10)
b. pools about the same size (indicates pools filling in)	8
2. Pools Infrequent (<30% of the 100m length surveyed)	
a. variety of pool sizes	6
b. pools about the same size	4
B. Pools absent	
1. Deep water/run habitat present	(19)
2. Deep water/run habitat absent	0

Subtotal 10

Remarks _____ Page Total 48

V. Bank Stability and Vegetation

	Score	Score
A. Banks stable or no banks, just flood plain		
1. little or no evidence of erosion or bank failure, little potential for erosion	10	10
B. Erosion areas present		
1. diverse trees, shrubs, grass; plants healthy with good root systems.....	9	(9)
2. few trees or small trees and shrubs; vegetation appears generally healthy.....	7	7
3. sparse vegetation; plant types and conditions suggest poorer soil binding.....	4	4
4. mostly grasses, few if any trees and shrubs, high erosion and failure potential at high flow	2	2
5. little or no bank vegetation, mass erosion and bank failure evident.....0	0	

Total 9

Remarks_____

VI. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** canopy with some breaks for light penetration	10
B. Stream with **full canopy** - breaks for light penetration absent.....	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal.....	7
D. Stream with **minimal** canopy - full sun in all but a few areas.....	(2)
E. **No canopy** and no shading.....	0

Subtotal 2

Remarks_____

VII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters.....	5	5
2. zone width 12-18 meters.....	(4)	(4)
3. zone width 6-12 meters.....	3	3
4. zone width < 6 meters.....	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters.....	4	4
b. zone width 12-18 meters.....	3	3
c. zone width 6-12 meters.....	2	2
d. zone width < 6 meters.....	1	1
2. breaks common		
a. zone width > 18 meters.....	3	3
b. zone width 12-18 meters.....	2	2
c. zone width 6-12 meters.....	1	1
d. zone width < 6 meters.....	0	0

Total 8

Remarks_____

Page Total 19

TOTAL SCORE 67

Site 2
Beaverdam Br.

Year 3

3/06 Revision 7

Habitat Assessment Field Data Sheet
Coastal Plain Streams

TOTAL SCORE 91

Biological Assessment Unit, DWQ
Directions for use: The observer is to survey a **minimum of 100 meters with 200 meters preferred** of stream, preferably in an **upstream** direction starting above the bridge pool and the road right-of-way. The segment which is assessed should represent average stream conditions. To perform a proper habitat evaluation the observer needs to get into the stream. To complete the form, select the description which best fits the observed habitats and then circle the score. If the observed habitat falls in between two descriptions, select an intermediate score. A final habitat score is determined by adding the results from the different metrics.

Stream Beaverdam Br. Location/road: Site 2 (Road Name Davis Field) County Jones

Date 3-18-10 **CC#** _____ Basin Neuse Subbasin 03-04-11

Observer(s) DH, RD Type of Study: ☐ Fish ☑ Benthos ☐ Basinwide ☐ Special Study (Describe) _____

Latitude _____ Longitude _____ Ecoregion: ☑ CA ☐ SWP ☐ Sandhills ☐ CB

Water Quality: Temperature 14.3 °C DO 9.30 mg/l Conductivity (corr.) 240 µS/cm pH 6.60

Physical Characterization: Visible land use refers to immediate area that you can see from sampling location. Check off what you observe driving thru the watershed in watershed land use.

Visible Land Use: 60 %Forest ✓ %Residential ✓ %Active Pasture ✓ % Active Crops
_____%Fallow Fields _____% Commercial _____%Industrial _____%Other - Describe: _____

Watershed land use ☐ Forest ☑ Agriculture ☐ Urban ☐ Animal operations upstream

Width: (meters) Stream 2m Channel (at top of bank) 2m **Stream Depth**: (m) Avg _____ Max ____
☐ **Width variable** ☐ **Braided channel** ☐ **Large river >25m wide**
Bank Height (from deepest part of channel to top of bank): (m) 1m

Flow conditions : ☐High ☐Normal ☐Low
Channel Flow Status
Useful especially under abnormal or low flow conditions.

A. Water reaches base of both banks, minimal channel substrate exposed	☐
B. Water fills >75% of available channel, or <25% of channel substrate is exposed	☑
C. Water fills 25-75% of available channel, many logs/snags exposed	☐
D. Root mats out of water	☐
E. Very little water in channel, mostly present as standing pools	☐

Turbidity: ☐Clear ☐ Slightly Turbid ☐Turbid ☐Tannic ☐Milky ☐Colored (from dyes) ☐Green tinge
Good potential for Wetlands Restoration Project?? ☐ **YES** ☐ **NO**
Details N/A

☐Channelized ditch
☐Deeply incised-steep, straight banks ☐Both banks undercut at bend ☐Channel filled in with sediment
☐Recent overbank deposits ☐Bar development ☐Sewage smell
☐Excessive periphyton growth ☐Heavy filamentous algae growth

Manmade Stabilization: ☐N ☐Y: ☐Rip-rap, cement, gabions ☐ Sediment/grade-control structure ☐Berm/levee
Weather Conditions: _____ **Photos:** ☐N ☐Y ☐Digital ☐35mm

Remarks: _____
TYPICAL STREAM CROSS SECTION DIAGRAM ON BACK

Photos:

fish (minnows)

I. Channel Modification

	Score
A. Natural channel-minimal dredging.....	15
B. Some channelization near bridge, or historic (>20 year old), and/or bends beginning to reappear..	10
C. Extensive channelization, straight as far as can see, channelized ditch.....	5
D. Banks shored with hard structure, >80% of reach disrupted, instream habitat gone.....	0

Remarks_____ Subtotal 15

II. Instream Habitat: Consider the percentage of the reach that is favorable for benthos colonization or fish cover. If >50% of the reach is snags, and 1 type is present, circle the score of 16. Definition: leafpacks consist of older leaves that are packed together and have begun to decay (not piles of leaves in pool areas). Mark as Rare, Common, or Abundant.

____**Sticks** ____**Snags/logs** ____**Undercut banks or root mats** ____**Macrophytes** ____**Leafpacks**

AMOUNT OF REACH FAVORABLE FOR COLONIZATION OR COVER

	>50% Score	30-50% Score	10-30% Score	<10% Score
4 or 5 types present.....	20	15	10	5
3 types present.....	18	13	8	4
2 types present.....	17	12	7	3
1 type present.....	16	11	6	2
No substrate for benthos colonization and no fish cover.....				0

☐ No woody vegetation in riparian zone Remarks_____ Subtotal 15

III. Bottom Substrate (silt, clay, sand, detritus, gravel) look at entire reach for substrate scoring.

	Score
A. Substrate types mixed	
1. gravel dominant.....	15
2. sand dominant.....	13
3. detritus dominant.....	7
4. silt/clay/muck dominant.....	4
B. Substrate homogeneous	
1. nearly all gravel.....	12
2. nearly all sand	10
3. nearly all detritus.....	4
4. nearly all silt/clay/muck.....	1

Remarks_____ Subtotal 13

IV. Pool Variety Pools are areas of deeper than average maximum depths with little or no surface turbulence. Water velocities associated with pools are always slow.

	Score
A. Pools present	
1. Pools Frequent (>30% of 100m length surveyed)	
a. variety of pool sizes.....	10
b. pools about the same size (indicates pools filling in).....	8
2. Pools Infrequent (<30% of the 100m length surveyed)	
a. variety of pool sizes.....	6
b. pools about the same size.....	4
B. Pools absent	
1. Deep water/run habitat present.....	4
2. Deep water/run habitat absent.....	0

Subtotal 10

Remarks_____ Page Total 53

V. Bank Stability and Vegetation

	Score	Score
A. Banks stable or no banks, just flood plain		
1. little or no evidence of erosion or bank failure, little potential for erosion	10	10
B. Erosion areas present		
1. diverse trees, shrubs, grass; plants healthy with good root systems	(9)	(9)
2. few trees or small trees and shrubs; vegetation appears generally healthy	7	7
3. sparse vegetation; plant types and conditions suggest poorer soil binding	4	4
4. mostly grasses, few if any trees and shrubs, high erosion and failure potential at high flow	2	2
5. little or no bank vegetation, mass erosion and bank failure evident 0	0	

Total 18

Remarks

VI. Light Penetration (Canopy is defined as tree or vegetative cover directly above the stream's surface. Canopy would block out sunlight when the sun is directly overhead).

	Score
A. Stream with **good** canopy with some breaks for light penetration	(10)
B. Stream with **full canopy** - breaks for light penetration absent	8
C. Stream with **partial** canopy - sunlight and shading are essentially equal	7
D. Stream with **minimal** canopy - full sun in all but a few areas	2
E. **No canopy** and no shading	0

Subtotal 10

Remarks

VII. Riparian Vegetative Zone Width

Definition: A break in the riparian zone is any area which allows sediment to enter the stream. Breaks refer to the near-stream portion of the riparian zone (banks); places where pollutants can directly enter the stream.

	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters	(5)	(5)
2. zone width 12-18 meters	4	4
3. zone width 6-12 meters	3	3
4. zone width < 6 meters	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters	4	4
b. zone width 12-18 meters	3	3
c. zone width 6-12 meters	2	2
d. zone width < 6 meters	1	1
2. breaks common		
a. zone width > 18 meters	3	3
b. zone width 12-18 meters	2	2
c. zone width 6-12 meters	1	1
d. zone width < 6 meters	0	0

Total 10

Remarks

Page Total 38

TOTAL SCORE 91

Site 1 – Crowns West macroinvertebrate sampling site, view is upstream (Year 3)

Site 1 – Crowns West macroinvertebrate sampling site, view is downstream (Year 3)

Site 2 – Beaverdam Branch macroinvertebrate sampling site, view is upstream (Year 3)

Site 2 – Beaverdam Branch macroinvertebrate sampling site, view is downstream (Year 3)