CROWNS WEST STREAM RESTORATION PROJECT

ANNUAL MONITORING REPORT FOR 2009 (YEAR 3)

Contract Number D06003-2

Submitted to:

NCDENR - Ecosystem Enhancement Program
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1.0 EXECUTIVE SUMMARY

This Annual Report details the monitoring activities during the 2009 growing season (Monitoring Year 3) on the Crowns West Stream Restoration Site ("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 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 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. The Year 3 vegetation monitoring indicated an average survivability of 688 stems per acre. The data shows that the Site has met minimum interim success criteria of 320 trees per acre by the end of Year 3. The site is currently on track for meeting the final success criteria of 260 trees per acre by the end of Year 5.

During Year 3 monitoring, kudzu (*Pueraria spp.*) and privet (*Ligustrum L.)* were observed on the Site. The kudzu is located east of Haw Branch Road and is present in the NC Division of Highways (NCDOT) right-of-way and also occurs within the project easement. The privet is located along the southern easement boundary, west of Haw Branch Road or along the right side of the restored channel west, of Haw Branch Road. These vegetative problem areas were treated during Year 3 of monitoring and will also be treated in 2010.

The total length of stream channel restored on the Site was 3,835 LF. This entire length was inspected during Year 3 of the monitoring period (2009) to assess stream performance. The visual stability assessment noted that during Year 3 monitoring, several locations on M2 and the lower portion of M1 exhibited localized bank erosion, mostly in locations where sandy soils were present. These areas are small and do not call for repair at this time, but will be evaluated during Year 4 monitoring.

According to the cross-section survey, stream dimension remained stable during Year 3. The longitudinal profile for Year 3 showed that the in-stream structures and features are remaining stable. The entire stream length was inspected during Year 3 of the monitoring period to assess stream performance.

The on-site crest gauge documented the occurrence of at least three bankfull flow events during Year 3 of 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 3 of monitoring was approximately 1.03 feet (12.36 inches) above the bankfull stage.

The restoration plan for the Site did not include wetland areas. Therefore, no groundwater monitoring stations or rain gauges were installed on the Site.

In summary, the Site is on track to meet the hydrologic, vegetative, and stream success criteria specified in the Site's Restoration Plan.

2.0 PROJECT BACKGROUND

The project 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 3,904 LF of channel dimension, pattern and profile
- Improve floodplain function by matching floodplain elevation with bankfull stage
- Establish native stream bank and floodplain vegetation in the 10.8-acre permanent conservation easement
- Improve water quality in the Crowns West 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, Baker Engineering divided on-site streams into reaches. The reaches were numbered sequentially from west to east, with a "M" designation for "mainstem." M1 begins on the upstream portion of the project, and flows east, ending at Haw Branch Road. M2 begins at 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 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 which promote 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 provide living root mass to increase streambank stability and create 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 Site

Crowns West Restoration Site: 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, NC (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

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 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 Restoration Site: 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	Scheduled Dec-10	Scheduled Oct-10	N/A
Year 5 Monitoring	Scheduled Dec-11	Scheduled Oct-11	N/A

Table 3. Project Contacts

Crowns West Restoration Site: 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 Site: 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 area 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 stream banks 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 effuses)*, 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, 11 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 tags to ensure that the correct identification is made during future monitoring of the vegetation plots.

On a designated corner within each of the eleven vegetation plots, one herbaceous plot was also delineated. The herbaceous plots measure 1 meter x 1meter in size. These plots are photographed at the end of the growing season. The locations of the eleven 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 Site: 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

Table 5. Vegetation Species Planted Across the Restoration Site			
Crowns West Restoration Site: Project No. D06003-2			
Scientific Name	**Common Name**	**Percent Planted by Species**	**Total Number of Stems**
Fraxinus pennsylvanica	Green Ash	7.50%	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	7.50%	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

The species that were planted as part of the permanent ground cover seed mixture broadcast on the Site after construction were present during Year 3 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 3 monitoring period. Data from the Year 3 monitoring event of the 11 vegetation plots showed a range of 486 to 972 stems per acre. The data showed that the plots had an average of 688 stems per acre. Based on these results, all plots met the interim success criteria of 320 stems per acre at the end of monitoring Year 3.

Trees within each monitoring plot are flagged regularly to prevent planted trees from losing their identifying marks due to flag degradation. It is important for trees within the monitoring plots to remain marked to ensure they are all accounted for during the annual stem counts and calculation of tree survivability. Permanent aluminum tags are used on surviving stems to aid in relocation and identification during future counts. Flags are also used to mark trees because they do not interfere with the growth of the tree.

No significant volunteer woody species were observed in any of the vegetation plots. The plots will be assessed during Year 4 monitoring for significant volunteer species.

3.1.4 Vegetative Problem Areas

During monitoring Year 3, vegetation plot 1 encountered two different problems that may threaten future survivability of the plot and the surrounding area. These problems are weedy species occurring within the vegetation plot and saturated soils due to beaver dams. The strong presence of arrowleaf tearthumb (*Polygonum saggittatum*) and an unknown vine species in this area is affecting the survivability of the smaller planted stems. Two beaver dams in the area have caused the soils to become saturated for an extended period, which has caused planted stems, mostly sycamores, to begin to lean. The beaver dams will be removed during the winter of 2009/2010.

Other weedy species are mostly annuals and seem to pose very little threat to survivability on site.

During Year 3 monitoring, kudzu (*Pueraria spp.*) was observed on the Site. The kudzu is located south of Haw Branch Road and is present in the NCDOT right-of-way and also occurs within the project easement. This area of kudzu was treated during April 2009 and September 2009 by River Works, Inc.

Privet (*Ligustrum L.*) was also observed on the Site, during Year 3 monitoring. The privet is located along the southern easement boundary, west of Haw Branch Road or along the right side of the restored channel, west of Haw Branch Road. This area of privet was treated during April 2009 and September 2009 by River Works, Inc.

These areas have been treated previously with herbicides and are scheduled to be treated again in 2010. The areas will continue to be monitored and treated with herbicides to control the spread of invasives.

3.1.5 Vegetation Photographs

Photographs are used to visually document vegetation plot success. A total of 11 reference stations were established to document tree conditions at each vegetation plot across the Site. Additional photo stations were also established at each of the 11 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 on 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 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 will be completed in all five years of the 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 3 cross-section monitoring data for stream stability were collected during August 2009. 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 3. Data from each of these cross-sections were compared to data collected during the as-built condition survey, Years 1 and 2 of monitoring. The cross-sectional data are presented in Appendix B. The cross-sections show that there has been very little adjustment to stream dimension since construction.

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 through Year 3. The channels in cross-sections 3, 4, 7 and 8 have remained relatively stable since the as-built survey. The floodplains of cross-sections 7 and 8 remained stable through Year 3 monitoring. It is noted that Year 2 and Year 3 visual on-site observations of areas east of Haw Branch Road have documented the deposition of sediment on the floodplain. This is considered to be a natural system response and no areas of concern have been noted due to the deposition.

Cross-sections 2, 5, 6, and 9 are located across pools found at the apex of meander bends. Based on the cross-section data, the pools at cross-sections 2 and 6 have filled slightly since Year 1 monitoring but have remained stable through Year 3. Cross-sections 5 and 9 have remained deep and relatively stable since Year 1. The pool cross-sections are showing very slow development of point bar features on the inside bank of the meander bends.

The longitudinal profile for Year 3 was surveyed in August 2009 and was compared to data collected during the as-built condition survey, and Years 1 and 2 of monitoring. The results of the Year 3 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 Year 1 and Year 2 monitoring. The longitudinal profile shows that the riffles and in-stream structures throughout reach M1 are stable.

The Year 3 profile for M2 shows that the riffles at the beginning of the reach, (stations 33+95 to 45+05) have aggraded slightly since as-built conditions, but are showing a tendency to aggrade in drier years (i.e. Year 2) and scour back out in wetter year (i.e. Year 3). This is considered to be a normal pattern of stream bed dynamics within sandbed streams. The Year 2 profile for M2 shows that the pools have remained deep since Year 1. The maximum depth measured in the M2 pool areas is approximately 3 feet in depth. The longitudinal profiles of reaches M1 and M2 are presented in Appendix B. The longitudinal profile for the Site shows that the riffles and in-stream structures are stable on the downstream portion of the reach

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 on-site crest gauge documented the occurrence of at least three bankfull flow events during Year 3 of the post-construction monitoring period, as shown in Table 6. Inspection of conditions during site visits revealed visual evidence of out-of-bank flow, confirming the crest gauge readings. The largest on-site stream flow documented by the

crest gauge during Year 3 of monitoring was approximately 1.03 feet (12.36 inches) above the bankfull stage and was the result of overbank flooding of M2.

Table 6. Verification of Bankfull Events

Crowns West Restoration Site: EEP Contract No. D06003-2			
Date of Data Collection	**Estimated Date of Occurrence of Bankfull Event**	**Method of Data Collection**	**Measurement (feet)**
2/9/2009	Unknown	Crest Gage on M2	0.35
6/17/2009	5/30/2009	Crest Gage on M2	1.03
9/30/2009	8/15/2009	Crest Gage on M2	0.63

3.2.5 Stream Problem Areas

During Year 2 (2008) monitoring, the Site experienced several area 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 these repaired areas were functioning properly and will continue to be monitored closely during future site visits.

It is also noted that during Year 3 monitoring, several 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 and the presence of mostly sandy soils in the identified areas. These areas are small and are not considered to call for repair at this time. However, these areas are being closely observed during site visits.

Two beaver dams on the upstream portion of M1 have caused the soils to become saturated for an extended period, which has affected planted stems, mostly sycamores, to lean more than 45 degrees. The two dams are located between stations 10+00 and 13+00 and will be removed in the winter of 2009/2010.

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 stream bank is photographed at each permanent cross-section photo station. For each stream bank 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 will be used to document restoration success visually. Reference stations were photographed before construction and will be photographed for at least five years following construction. Reference photos will be taken once per year, from a height of approximately five to six feet. Permanent markers are 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 is dense along the edges of the restored stream, making the photography of some of the stream channel areas difficult.

3.2.7 Stream Stability Assessment

A summary of the results obtained from the visual inspection of in-stream structures performed during Year 3 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 3 monitoring, some bank areas as described in Section 3.2.5 have experienced some localized erosion problems. 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 Appendix B.

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 February 2009. This report summarizes the benthic samples collected in February 2009 for Year 2 of the post-construction monitoring phase. Year 3 data will be collected in February 2010.

The sampling methodology followed the Qual 4 method listed in NCDWQ's Standard Operating Procedures for Benthic Macroinvertebrates (2006). Field sampling was conducted by Michael Baker Engineering, Inc. 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 was 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 monitoring results is presented in Table 7 with complete laboratory results presented in Appendix B.

At Site 2, the undisturbed reference site, the Year 2 community structure and ecological habitat appears to be similar to that observed during the pre-construction and Year 1 monitoring periods. Site 2 results show stable total taxa richness. A steady increase in EPT taxa richness from January 2006 to February 2009 was observed during Year 2 monitoring. The Year 2 sampling results show improvements in both total and EPT biotic indices.

Site 1, which underwent complete restoration, exhibited improvements in total and EPT taxa richness during Year 2 monitoring. According to the lab results, Site 1 showed a decline in the total biotic index during Year 2 of monitoring, whereas, the EPT biotic index during Year 2 has improved since March 2006. It is anticipated that, as the project matures, populations will increase as more habitat in the form of snags, logs, and leaf packs become available.

Currently Site 1 has 25 percent Dominance in Common (DIC) compared to the reference site. This indicates that 25 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 25 percent from Year 2 monitoring, indicates that post-construction recolonization from refugia upstream or downstream is likely underway. It is anticipated that improvements in biotic indices and an increase in DIC will be seen in Year 3 as communities begin to re-colonize.

Table 7. Summary of Pre-Restoration vs. Post-Restoration Benthic Macroinvertebrate Sampling Data

Crowns West Restoration Site: EEP Contract No. D06003-2

	Site 1			Site 2		
	M1 Crowns West (Restoration)			Beaverdam Branch (Reference)		
	Pre	Post	Post	Pre	Post	Post
	3/3/2006	2/28/2008	2/9/2009	1/5/2006	2/28/2008	2/9/2009
Total Taxa Richness	24	14	20	28	35	34
EPT Taxa Richness	4	0	1	3	6	9
Total Biotic Index	6.75	3.99	7.50	7.78	6.73	6.59
EPT Biotic Index	5.78	NA	4.00	4.05	5.28	4.69
Dominance in Common (%)	41	18	25	N/A	N/A	N/A
EPT Abundance	-	0	2	-	29	35
Habitat Assessment Rating	42	88	65	89	106	91
Water Temperature (˚C)	Not Collected	10.5	8.6	Not Collected	7.9	8.9
DO Concentration (mg/l)	Not Collected	5.05	11.8	Not Collected	9	7.8
pH	Not Collected	6.63	6.98	Not Collected	7.24	7.52
Conductivity (µmhos/cm)	Not Collected	110	150	Not Collected	320	340

4.0 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Stream Monitoring - The total length of stream channel restored on the Site was 3,835 LF. This entire length was inspected during Year 3 of the monitoring period (2009) to assess stream performance. The visual stability assessment noted that during Year 3 monitoring, several banks on M2 and the lower portion of M1 exhibited small, localized erosion areas. These areas are small and do not call for repair at this time.

Based on the survey data, all riffles, pools, and other constructed features along the restored channel are stable and functioning as designed. The on-site crest gauge documented the occurrence of at least three bankfull flow events during Year 3 of the post-construction monitoring period. Inspection of site conditions during visits revealed visual evidence of out-of-bank flows.

Overall, the Site is on track to achieve the stream morphology success criteria specified in the Restoration Plan for the Site.

Macroinvertebrate lab results for the Site, exhibited improvements in total and EPT taxa richness. A decline was observed in the total biotic index during Year 2. However, an improvement in the EPT biotic index was observed during Year 2 of monitoring. 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 Site has 25 percent Dominance in Common (DIC) compared to the reference site, which indicates that 25 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. This indicates that post-construction recolonization from refugia upstream or downstream has begun.

Vegetation Monitoring - For the 11 monitoring plots, vegetation monitoring indicated a survivability range of 486 stems per acre to 972 stems per acre with an overall average of 688 stems per acre. The data show that the Site has met minimum success interim criteria of 320 trees per acre by the end of Year 3. Therefore, the Site is on track for meeting the final success criteria of 260 trees per acre by the end of Year 5.

During Year 3 monitoring, kudzu (*Pueraria spp.*) and privet (*Ligustrum L.)* were observed on the Site. These areas were treated in 2008 and are scheduled to be treated again during the 2009 growing season.

Overall, the site is on track to achieve the vegetative success criteria 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

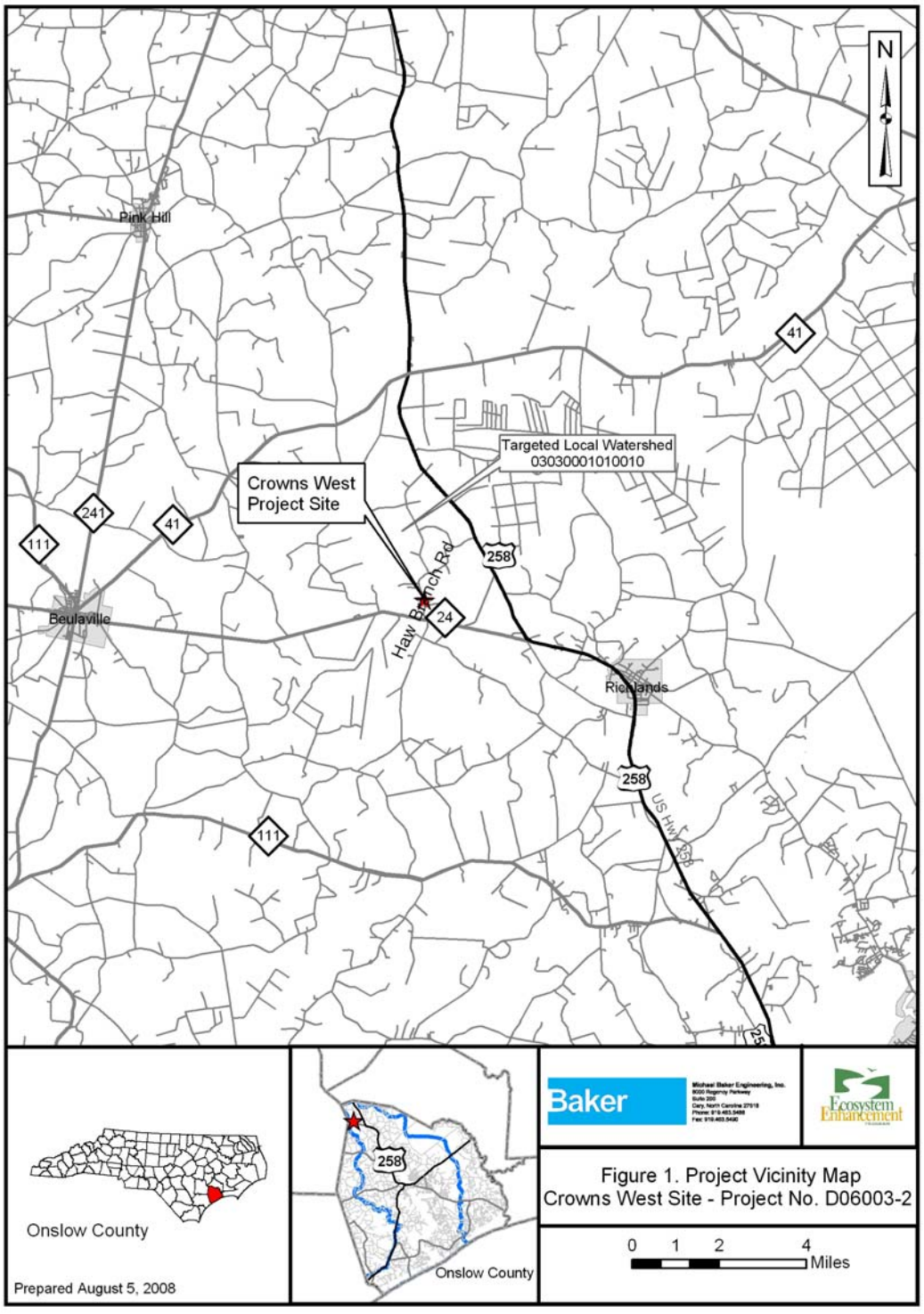


Figure 1. Location of Crowns West Stream Restoration Site.

PROJECT: D06003 – 2 CROWNS WEST

CROWNS WEST STREAM RESTORATION PROJECT
PROJECT # – D06003–2

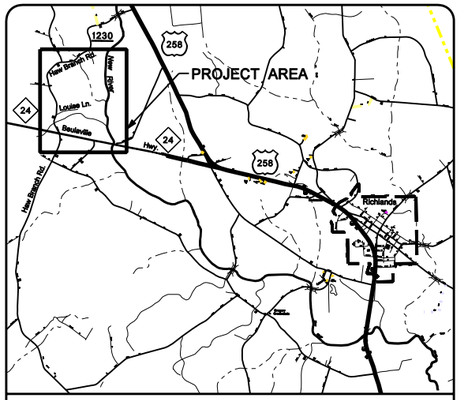
STATE	BUCK PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
NC	0290R	1	13

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

1	TITLE SHEET
1-A	STREAM CONVENTIONAL SYMBOLS GENERAL NOTES, STANDARD SPECIFICATIONS, AND VEGETATION SELECTION
1-B	CONVENTIONAL SYMBOLS
2 TO 2-C	TYPICAL POOL AND RIFFLE CROSS SECTIONS, STRUCTURE DETAILS
3 TO 8	AS-BUILT PLAN VIEWS

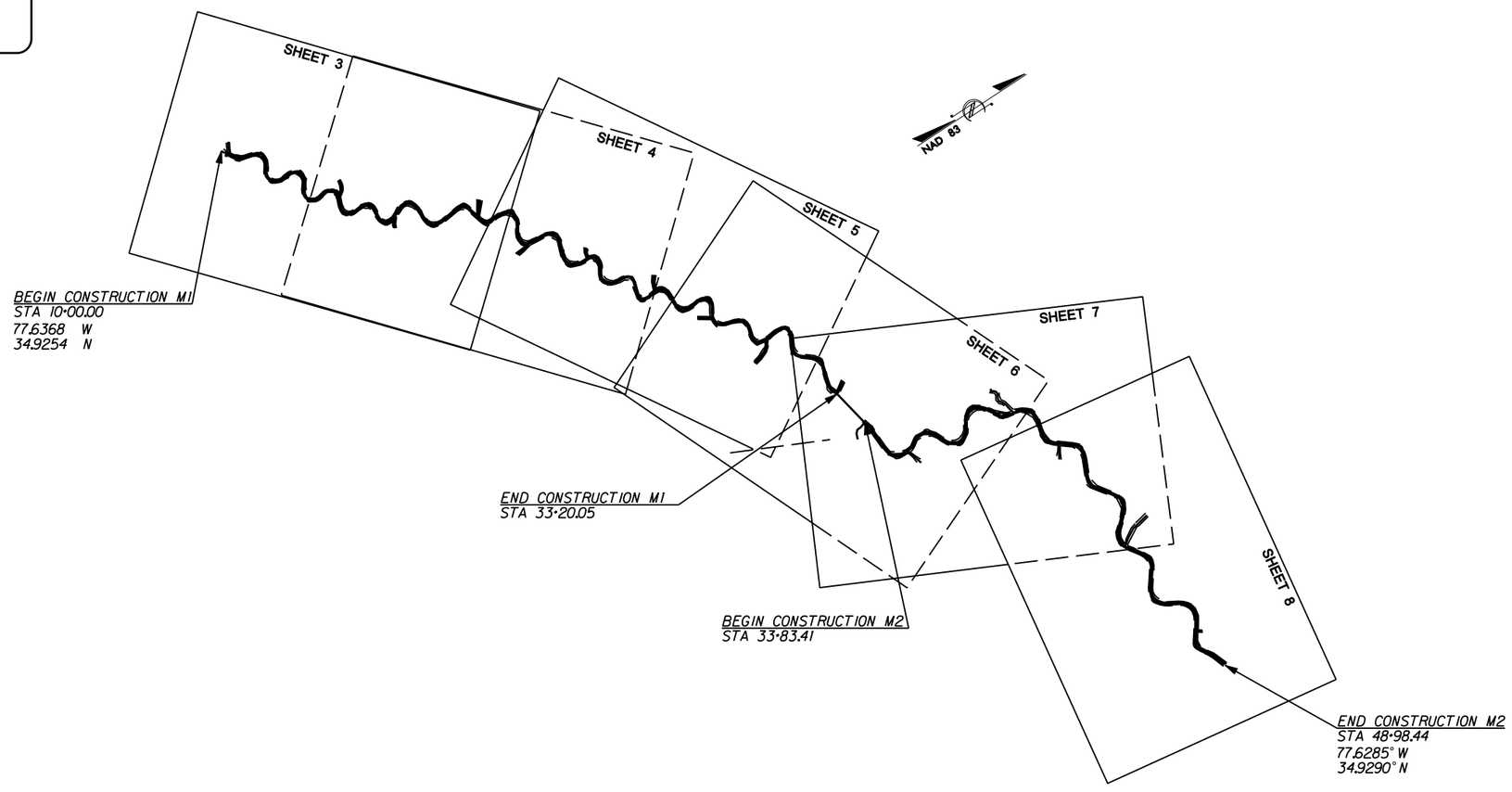


FIGURE 2A

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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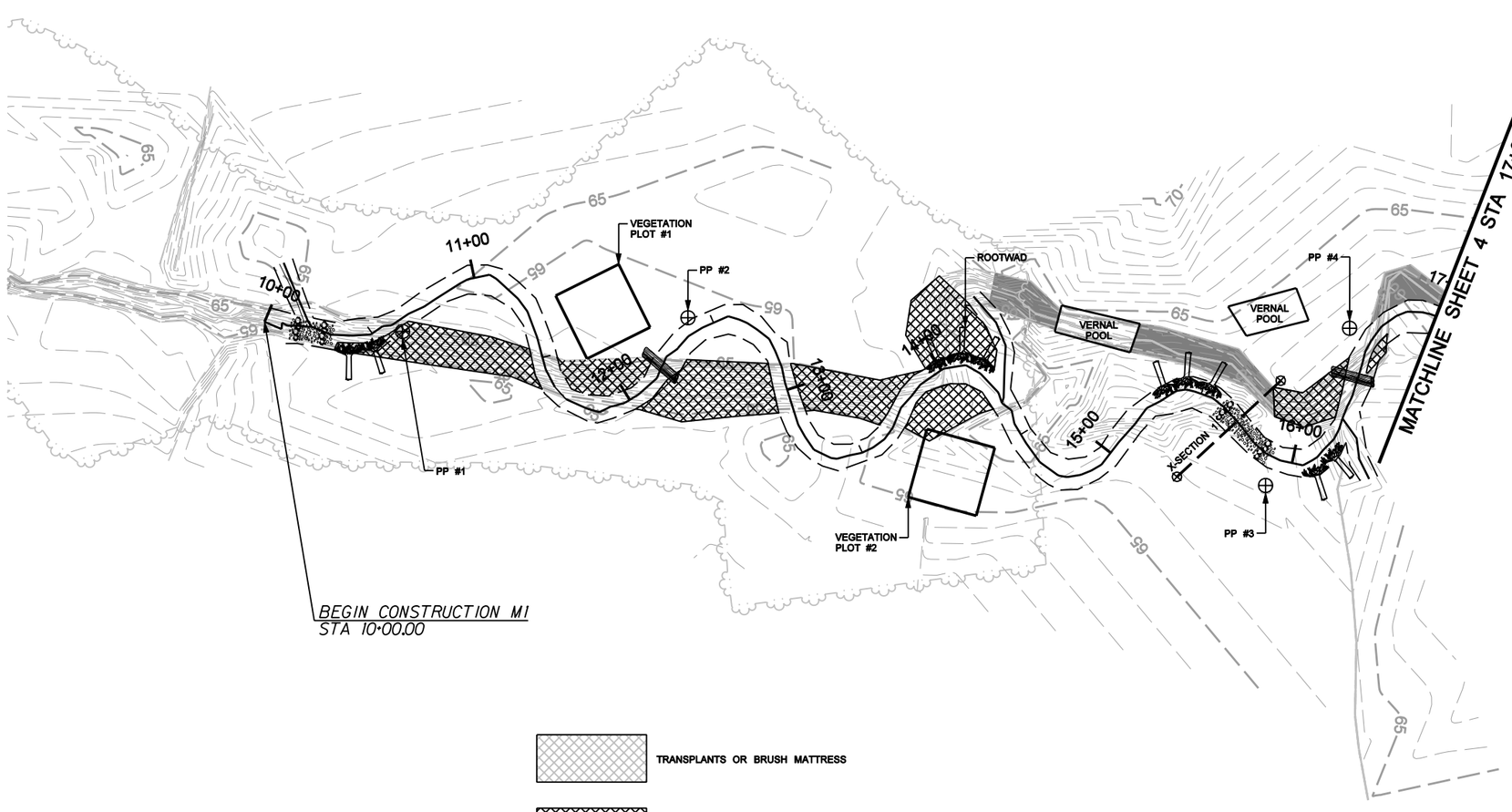
NAD 83



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.

FIGURE 2B

AS-BUILT
PLAN VIEW

30 15 0 30 60
SCALE (FT)

11/27/2007
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2/26/03

BUCK PROJECT REFERENCE NO.	SHEET NO.
0290R	4

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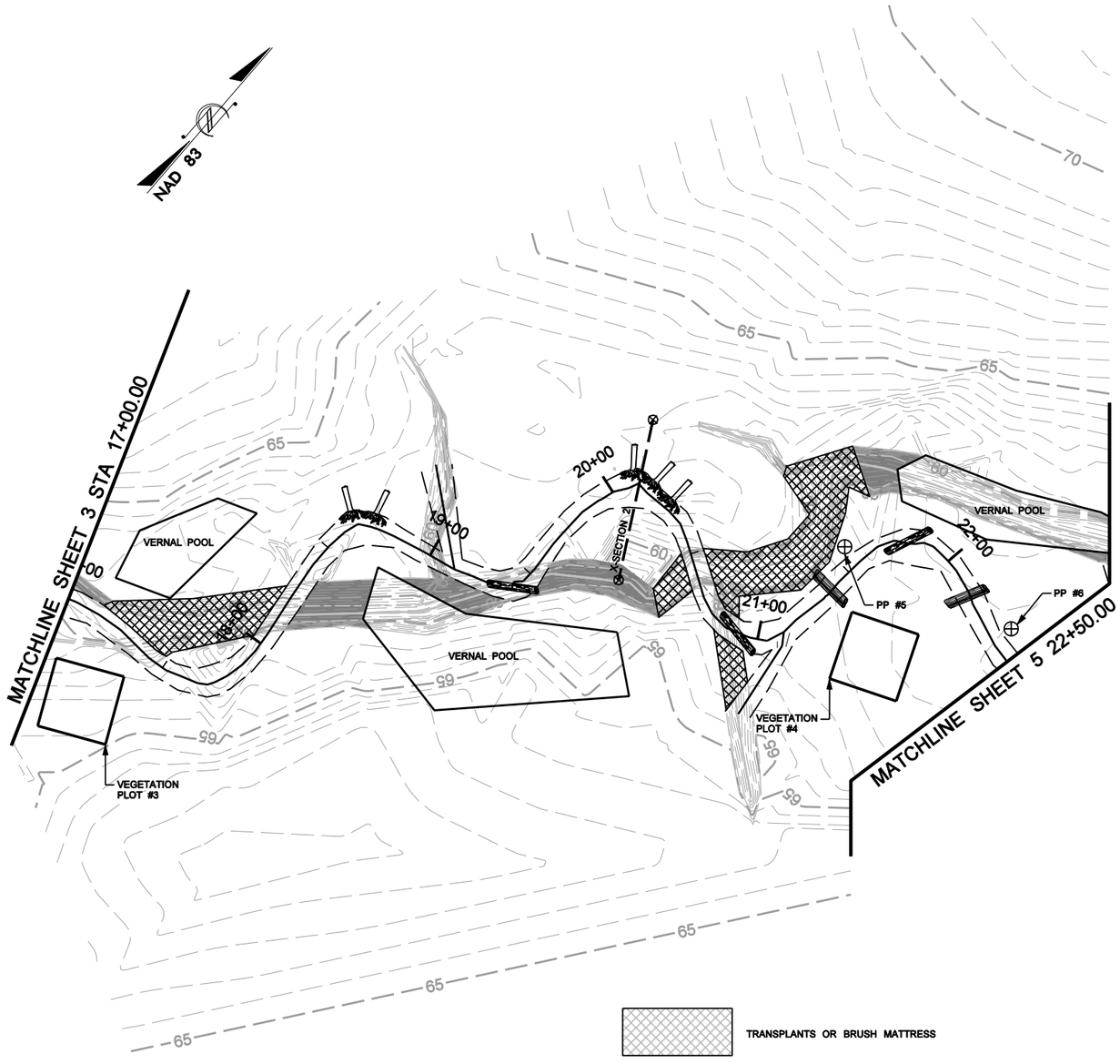

▨ TRANSPLANTS OR BRUSH MATTRESS

▦ 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

11/27/2007
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BUCK PROJECT REFERENCE NO.	SHEET NO.
0290R	5

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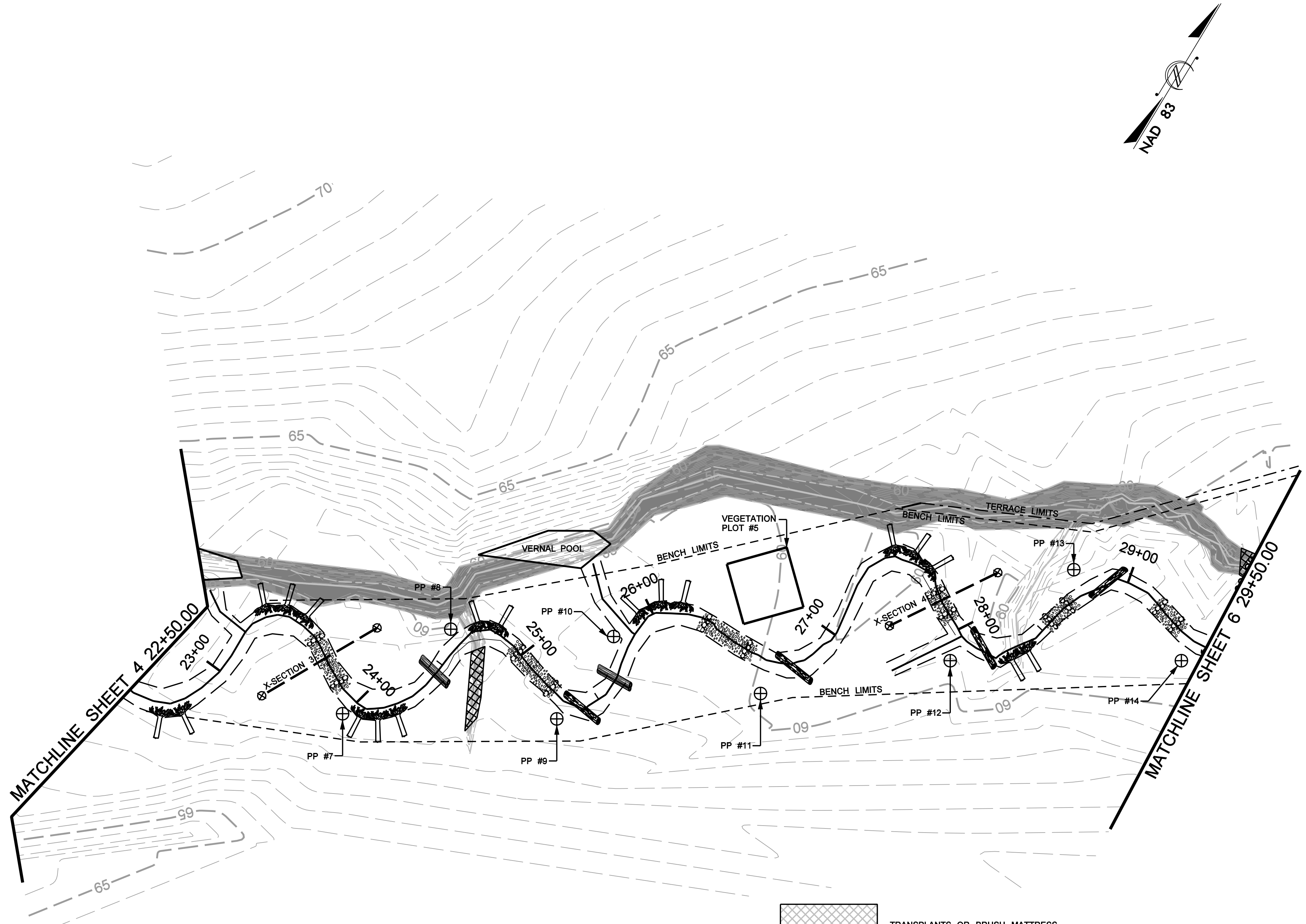

TRANSPLANTS OR BRUSH MATTRESS

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
11/27/2007 r:\0290R\design\as-built\0290R_Buck_ASB_06.dgn

BUCK PROJECT REFERENCE NO.	SHEET NO.
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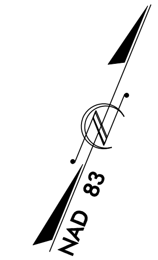

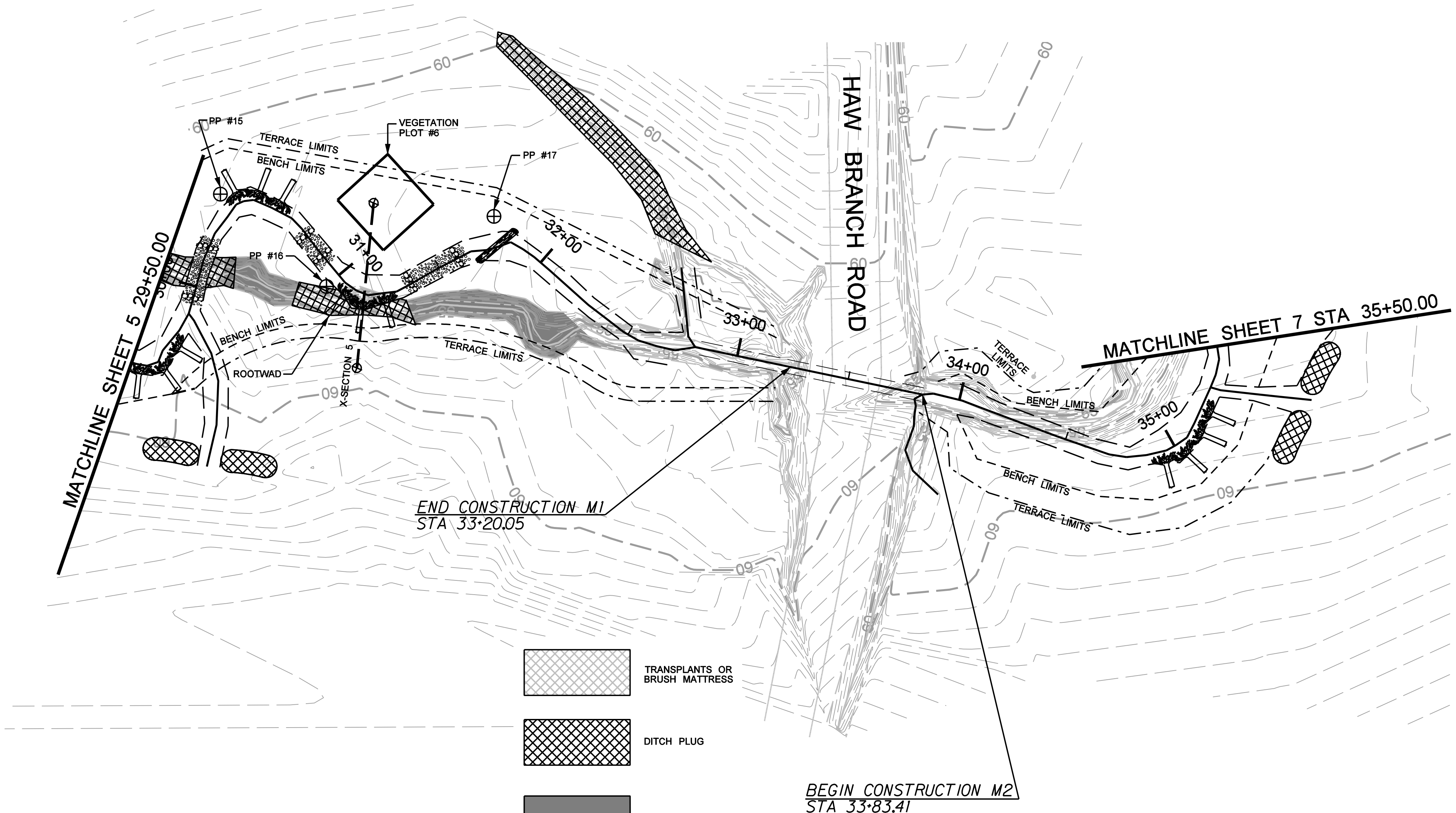

TRANSPLANTS OR BRUSH MATTRESS

DITCH PLUG

CHANNEL FILL

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

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

FIGURE 2E

AS-BUILT PLAN VIEW

30 15 0 30 60
SCALE (FT)

2/26/03

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0290R	7

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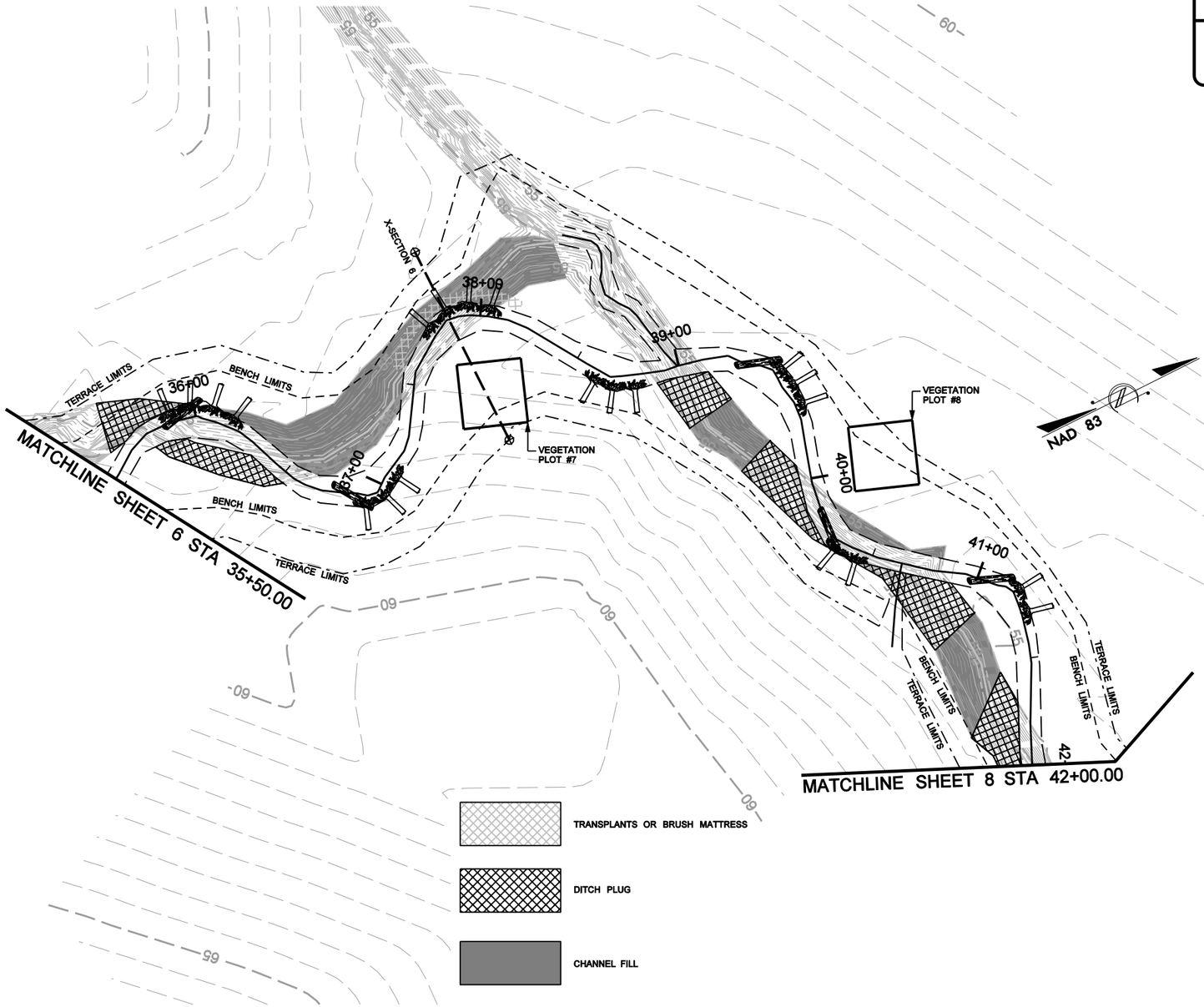

NOTE:
CONTOURS SHOWN ARE PRE-RESTORATION CONDITIONS.

AS-BUILT PLAN VIEW

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SCALE (FT)

FIGURE 2F

11/27/2007
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2/26/03

BUCK PROJECT REFERENCE NO.	SHEET NO.
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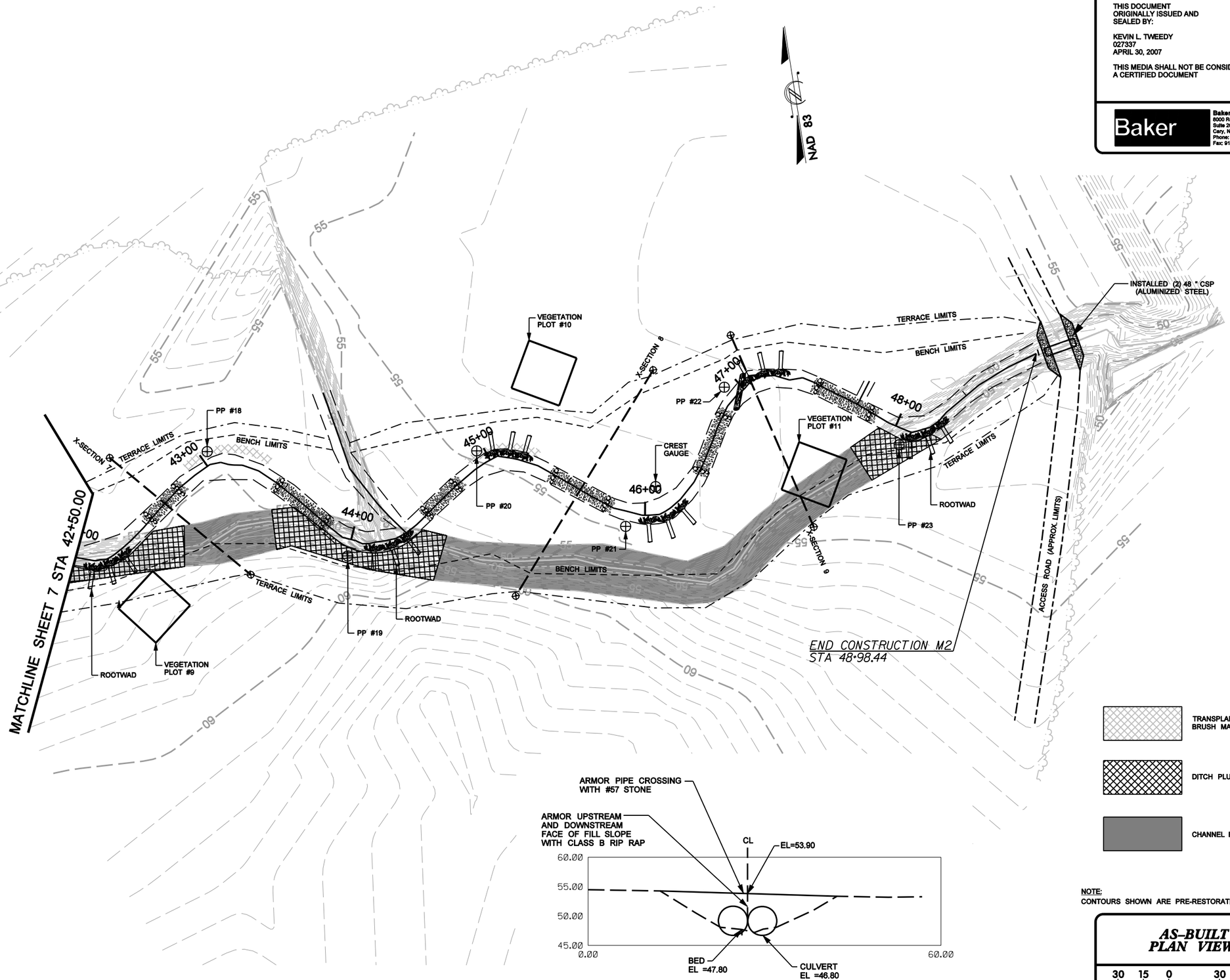


SECTION A-A'

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

APPENDIX A

VEGETATION RAW DATA

VEGETATION TABLES

Table A.1. Vegetation Metadata

Crowns West Restoration Site: Project No. D06003-2

Report Prepared By	Dwayne Huneycutt
Date Prepared	10/5/2009 13:41
database name	cvs-eep-entrytool-v2.2.7_2009.mdb
database location	L:\Monitoring\Veg Plot Info\CVS Data Tool\Crowns West\Year 3
computer name	CARYWDHUNEYCU2
file size	70713344
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 Site: Project No. D06003-2								
	Species	Common Name	Excellent	Good	Fair	Unlikely to Survive Year	Dead	
	Betula nigra	river birch	9	5			3	
	Celtis laevigata	sugarberry	1	2	1			
	Fraxinus pennsylvanica	green ash	7	5	7		1	
	Juglans nigra	black walnut			6		5	
	Nyssa biflora	swamp tupelo	4	16	8		2	
	Quercus lyrata	overcup oak	12	7	1			
	Quercus michauxii	swamp chestnut oak	6	3	3			
	Quercus nigra	water oak	1					
	Quercus phellos	willow oak	6	3	4			
	Taxodium distichum	bald cypress	4	12	5	1		
	Platanus occidentalis	American sycamore	24	12	12	1	2	
TOT:	**11**	**11**	**74**	**65**	**47**	**2**	**13**	

Table A.3. Vegetation Damage by Species

Crowns West Restoration Site: Project No. D06003-2							
	Species	CommonName	Count of Damage Categories	No Damage	Site too Wet	Vine Strangulation	
	Betula nigra	river birch	1	16		1	
	Celtis laevigata	sugarberry	0	4			
	Fraxinus pennsylvanica	green ash	0	20			
	Juglans nigra	black walnut	0	11			
	Nyssa biflora	swamp tupelo	1	29		1	
	Platanus occidentalis	American sycamore	3	48	2	1	
	Quercus lyrata	overcup oak	0	20			
	Quercus michauxii	swamp chestnut oak	0	12			
	Quercus nigra	water oak	0	1			
	Quercus phellos	willow oak	3	10		3	
	Taxodium distichum	bald cypress	0	22			
TOT:	**11**	**11**	**8**	**193**	**2**	**6**	

Table A.4. Vegetation Damage by Plot

Crowns West Restoration Site: Project No. D06003-2						
	Plot	Count of Damage Categories	No Damage	Site too Wet	Vine Strangulation	
	D060032-DH-0001-year:3	8	6	2	6	
	D060032-DH-0002-year:3	0	17			
	D060032-DH-0003-year:3	0	14			
	D060032-DH-0004-year:3	0	16			
	D060032-DH-0005-year:3	0	20			
	D060032-DH-0006-year:3	0	19			
	D060032-DH-0007-year:3	0	17			
	D060032-DH-0008-year:3	0	22			
	D060032-DH-0009-year:3	0	17			
	D060032-DH-0010-year:3	0	25			
	D060032-DH-0011-year:3	0	20			
TOT:	**11**	**8**	**193**	**2**	**6**	

Table A.5. Stem Count by Plot and Species

Crowns West Restoration Site: Project No. D06003-2																
	Species	Total Planted Stems	Number of Plots	Average Number of Stems	Plot D060032-DH-0001-Year:2	Plot D060032-DH-0002-Year:2	Plot D060032-DH-0003-Year:2	Plot D060032-DH-0004-Year:2	Plot D060032-DH-0005-Year:2	Plot D060032-DH-0006-Year:2	Plot D060032-DH-0007-Year:2	Plot D060032-DH-0008-Year:2	Plot D060032-DH-0009-Year:2	Plot D060032-DH-0010-Year:2	Plot D060032-DH-0011-Year:2	
	Betula nigra	17	8	2.12	3	1		1	5	1			4	1	1	
	Celtis laevigata	4	3	1.33				2				1	1			
	Fraxinus pennsylvanica	18	6	3			2	2			7	1		2	4	
	Juglans nigra	11	5	2.2						3	1	1	1		5	
	Nyssa biflora	30	9	3.33	1	4	2	3	4	1		4		4	7	
	Platanus occidentalis	50	11	4.55	6	8	7	3	1	6	1	6	5	6	1	
	Quercus lyrata	20	6	3.33	1	1				5	3		5	5		
	Quercus michauxii	12	7	1.71				3		2	2	1	1	2	1	
	Quercus nigra	1	1	1											1	
	Quercus phellos	12	5	2.4	3		2				1	2		4		
	Taxodium distichum	22	6	3.67		3	1		10	1	1	6				
TOT:	**11**	**197**	**11**		**14**	**17**	**14**	**14**	**20**	**19**	**16**	**22**	**17**	**24**	**20**	

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

Crowns West Restoration Site													
	Plots											**Year 3 Totals**	**Average Stems/acre**
Tree Species	1	2	3	4	5	6	7	8	9	10	11		
Betula nigra	2	1		1	4	1			4		1	14	
Celtis laevigata				2				1	1			4	
Fraxinus pennsylvanica			2	3			7	1		2	4	19	
Juglans nigra						1		1	1		3	6	
Nyssa biflora		4	2	3	3	1		4		4	7	28	N/A
Platanus occidentalis	6	8	7	2	1	6	1	6	4	6	1	48	
Quercus lyrata	1	1				5	3		5	5		20	
Quercus michauxii				3		2	2	1	1	2	1	12	
Quercus nigra											1	1	
Quercus phellos	3		2				1	2		5		13	
Taxodium distichum		3	1		10	1	1	6				22	
Stems/plot	12	17	14	14	18	17	15	22	16	24	18	187	
Stems/acre Year 3	486	688	567	567	729	688	607	891	648	972	729		688
Stems/acre Year 2	567	688	567	567	809	769	647	891	688	972	809	N/A	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

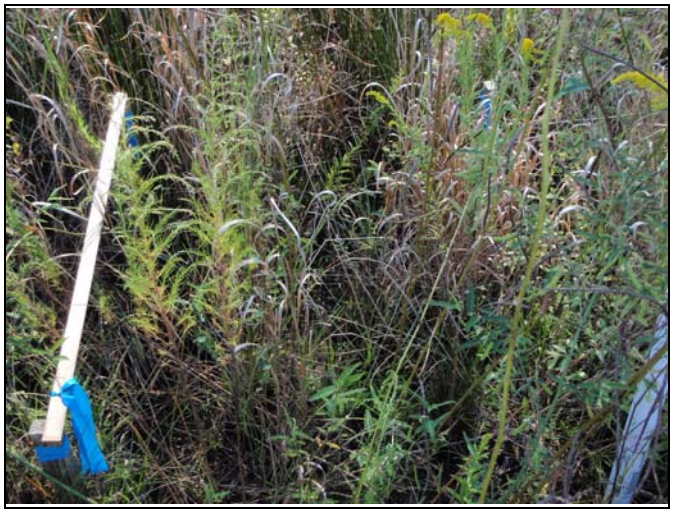
Vegetation Plot 4

Herbaceous Vegetation Plot 4

Vegetation Plot 5

Herbaceous Vegetation Plot 5

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

GEOMORPHIC RAW DATA

STREAM TABLES

Table B.1. Categorical Stream Feature Visual Stability Assessment

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

Table B.2. Baseline Stream Summary

Crowns West Restoration Site: 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 Site: 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)	11.52	9.79	12.79			12.38	10.43	10.09			10.32	10.38	14.61			8.77	8.76	9.62		
BF Mean Depth (ft)	0.73	0.61	0.46			1.89	1.57	1.61			0.71	0.61	0.50			0.72	0.58	0.66		
Width/Depth Ratio	15.78	16.05	27.97			6.54	6.64	6.27			14.48	16.99	29.05			12.18	15.10	14.51		
BF Cross-Sectional Area (ft²)	8.41	6.00	5.80			23.46	16.40	16.20			7.35	6.30	7.30			6.31	5.10	6.40		
BF Max Depth (ft)	1.25	0.97	0.91			3.05	2.75	2.77			1.27	1.10	1.15			1.19	0.92	0.66		
Width of Floodprone Area (ft)	60.22	-	-			69.87	-	-			64.56	-	-			58.25	-	-		
Entrenchment Ratio	5.2	6.1	4.7			5.6	6.7	6.9			6.3	5.3	4.4			6.6	6.6	6.00		
Bank Height Ratio	1.0	1.0	1.0			1.2	1.2	1.2			1.0	1.1	1.0			1.0	1.1	1.00		
Wetted Perimeter (ft)	12.98	11.01	13.71			16.16	13.57	13.31			11.74	11.6	15.61			10.21	9.92	10.94		
Hydraulic Radius (ft)	32.29	32.71	56.4			14.97	14.85	14.15			29.67	34.59	58.6			25.08	30.78	29.68		
Substrate																				
d50 (mm)																				
d84 (mm)																				

Parameter	Cross Section 5 Pool				
	MY1	MY2	MY3	MY4	MY5
Dimension					
BF Width (ft)	12.83	11.19	14.69		
BF Mean Depth (ft)	1.15	1.33	1.28		
Width/Depth Ratio	11.2	8.4	11.4		
BF Cross-Sectional Area (ft²)	14.70	14.9	18.9		
BF Max Depth (ft)	2.63	2.69	2.91		
Width of Floodprone Area (ft)	65.99	-	-		
Entrenchment Ratio	5.1	6.1	4.6		
Bank Height Ratio	1.0	1.1	1.0		
Wetted Perimeter (ft)	15.13	13.85	17.25		
Hydraulic Radius (ft)	23.53	18.17	24.14		
Substrate					
d50 (mm)					
d84 (mm)					

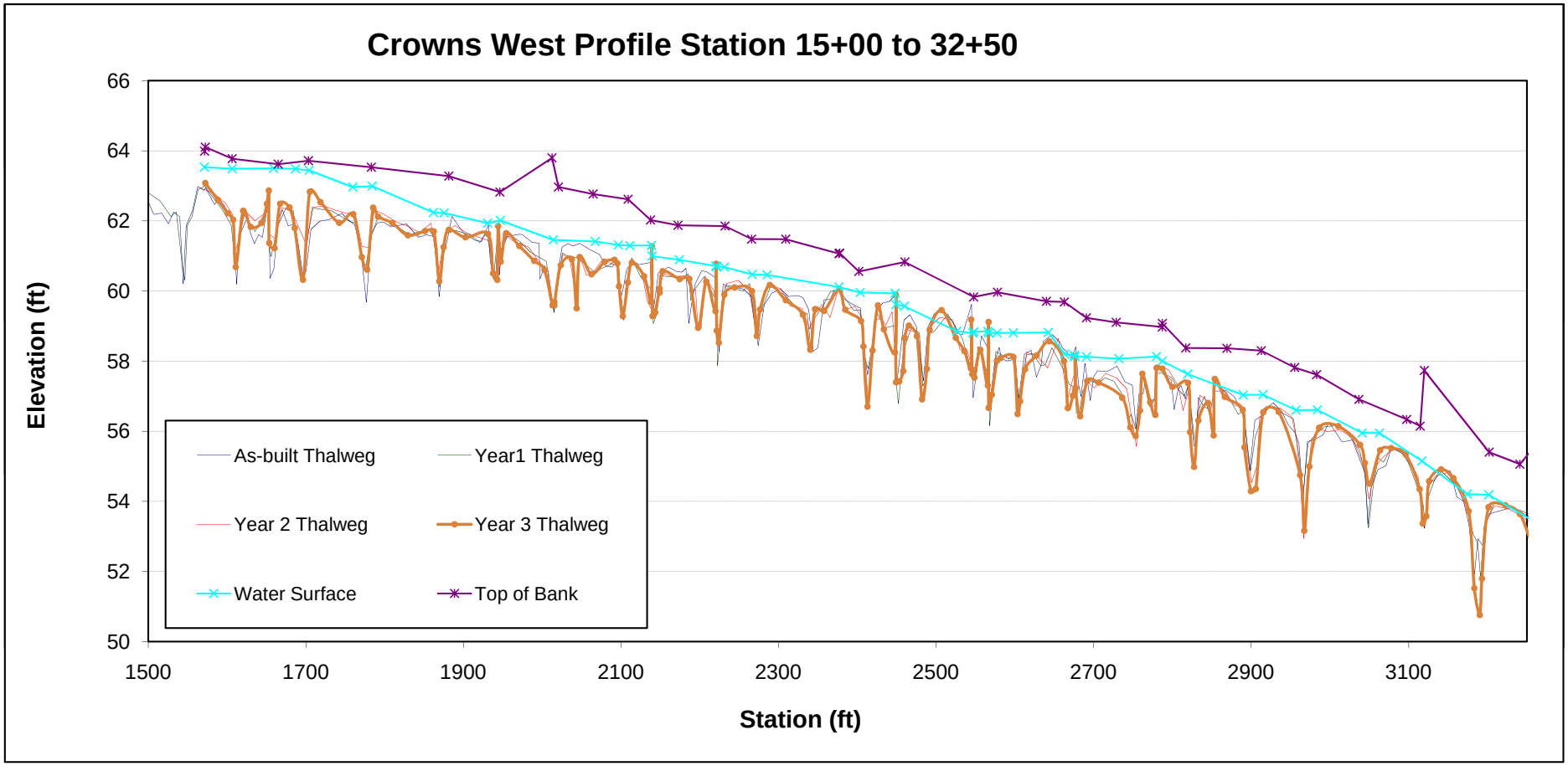
Parameter	MY-1 (2007)			MY-2 (2008)			MY-3 (2009)			MY-4 (2010)			MY-5 (2011)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern															
Channel Beltwidth (ft)															
Radius of Curvature (ft)															
Meander Wavelength (ft)															
Meander Width Ratio															
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						
Channel Length (ft)			3907.59			3907.59			3907.59						
Sinuosity			1.38			1.38			1.38						
Water Surface Slope (ft/ft)			0.0046			0.0046			0.0047						
BF Slope (ft/ft)															
Rosgen Classification			C			C			C						

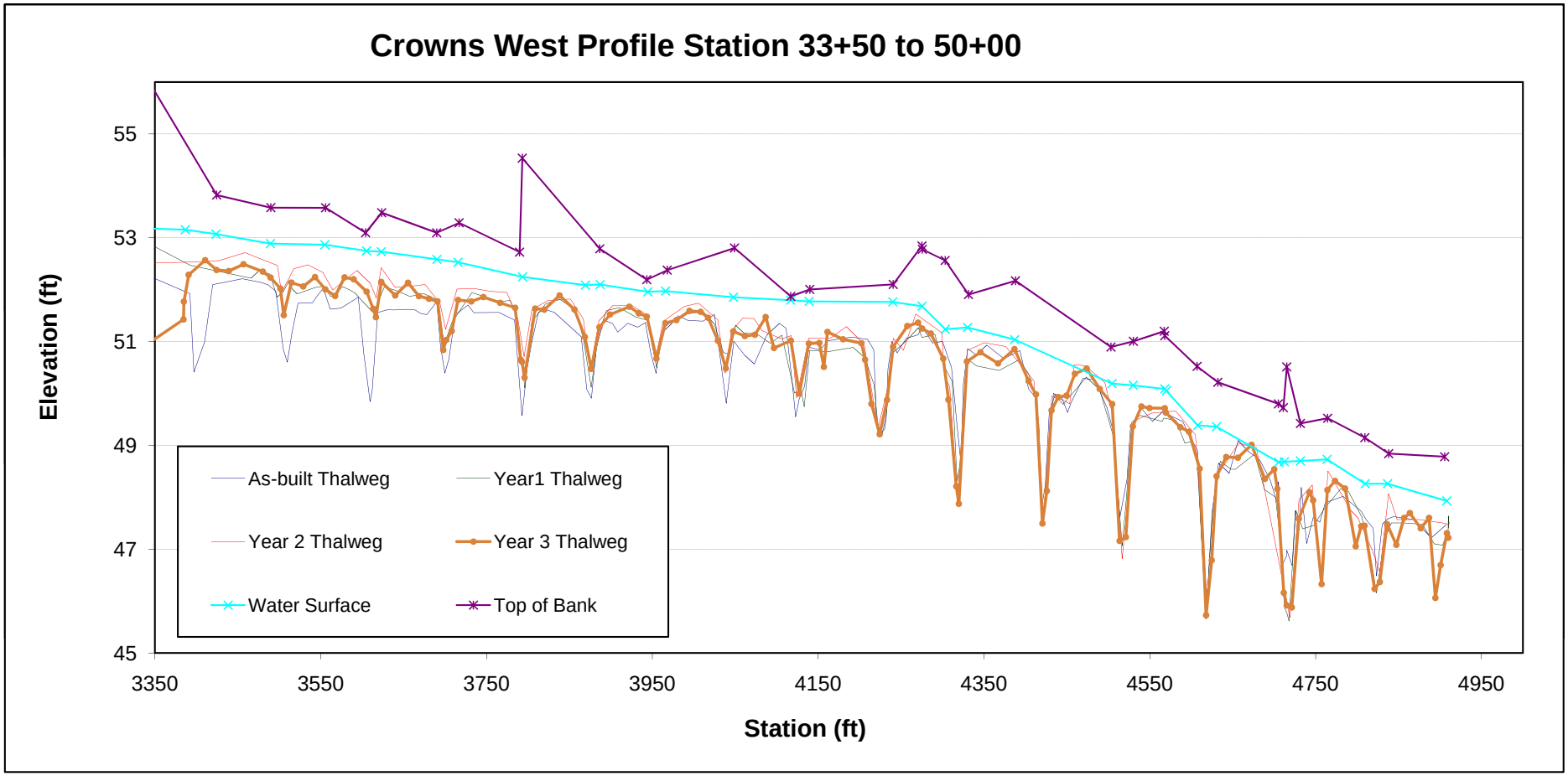
Reach: M2 (1515 feet)

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)	14.00	13.13	13.68			10.60	9.12	11.69			9.46	9.24	8.69			12.31	14.44	15.22		
BF Mean Depth (ft)	1.70	1.26	1.22			0.94	0.88	0.79			1.12	0.98	0.90			1.75	1.79	1.75		
Width/Depth Ratio	8.24	10.40	11.19			11.25	10.41	14.84			8.46	9.46	9.66			7.03	8.06	8.72		
BF Cross-Sectional Area (ft²)	23.77	16.60	16.70			9.98	8.00	9.20			10.57	9.00	7.80			21.55	25.90	26.60		
BF Max Depth (ft)	3.30	2.17	2.44			1.52	1.37	1.55			1.80	1.53	1.39			3.21	3.86	3.91		
Width of Floodprone Area (ft)	76.44	-	-			75.71	-	-			133.14	-	-			109.89	-	-		
Entrenchment Ratio	5.5	5.3	5.3			7.1	7.9	6.4			14.1	13.9	14.5			8.9	7.8	7.5		
Bank Height Ratio	1.0	1.1	1.1			1.0	1.1	1.0			1.0	1.1	1.0			1.0	1.1	1.1		
Wetted Perimeter (ft)	17.4	15.65	16.12			12.48	10.88	13.27			11.7	11.2	10.49			15.81	18.02	18.72		
Hydraulic Radius (ft)	18.18	22.06	23.6			23.44	21.7	30.47			18.04	19.9	20.22			15.81	17.91	19.19		
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						
Channel Length (ft)			3907.59			3907.59			3907.59						
Sinuosity			1.38			1.38			1.38						
Water Surface Slope (ft/ft)			0.0046			0.0046			0.0047						
BF Slope (ft/ft)															
Rosgen Classification			C			C			C						

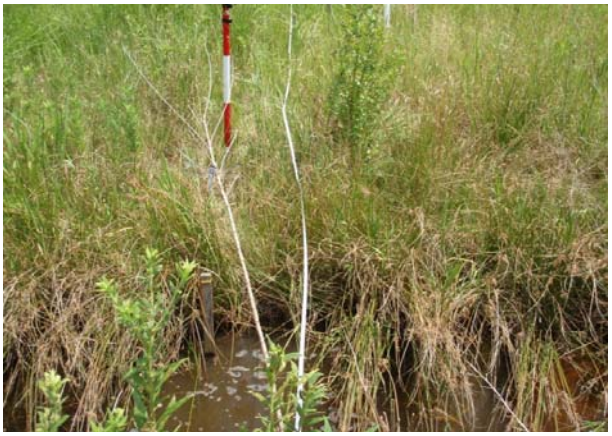
STREAM DATA
AND PHOTOS


Crowns West Profile Station 15+00 to 32+50
Elevation (ft)
66
64
62
60
58
56
54
52
50
1500
1700
1900
2100
2300
2500
2700
2900
3100
Station (ft)
As-built Thalweg
Year1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Water Surface
Top of Bank


Crowns West Profile Station 33+50 to 50+00
Elevation (ft)
55
53
51
49
47
45
3350
3550
3750
3950
4150
4350
4550
4750
4950
Station (ft)
As-built Thalweg
Year1 Thalweg
Year 2 Thalweg
Year 3 Thalweg
Water Surface
Top of Bank

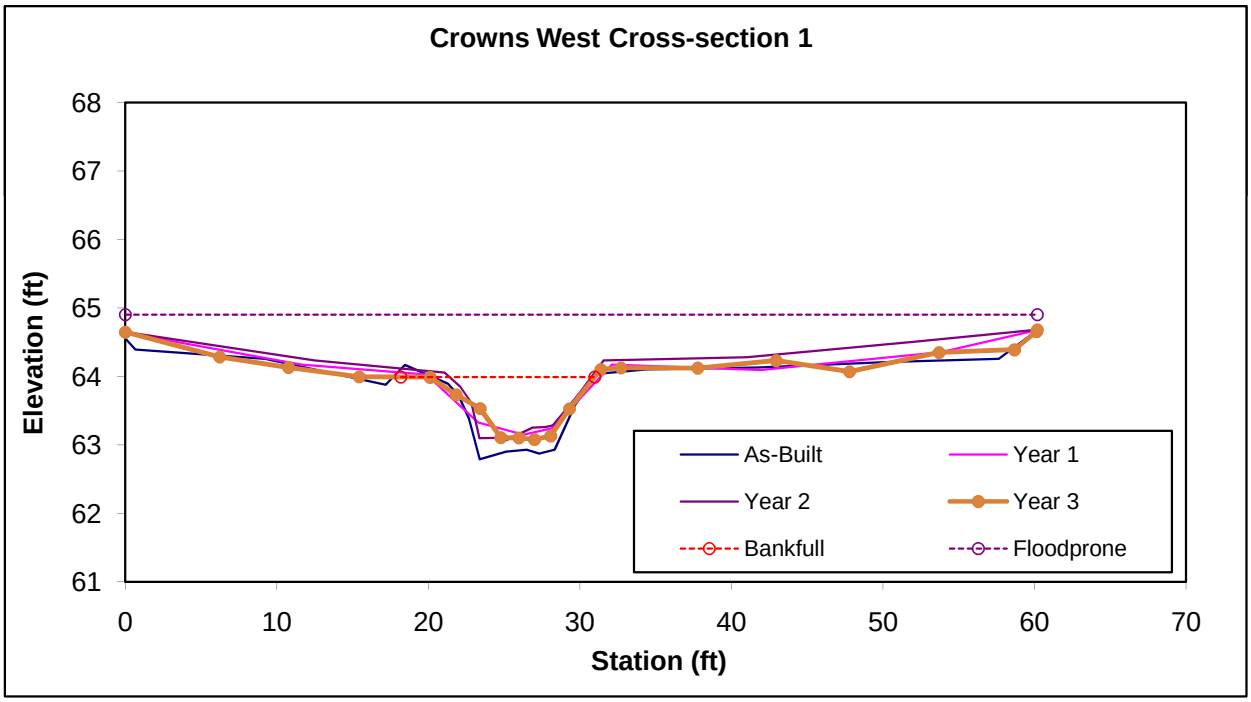
Permanent Cross-section 1
(Year 3 Data - Collected August 2009)

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	5.8	12.79	0.46	0.91	27.97	1	4.7	63.99	63.99



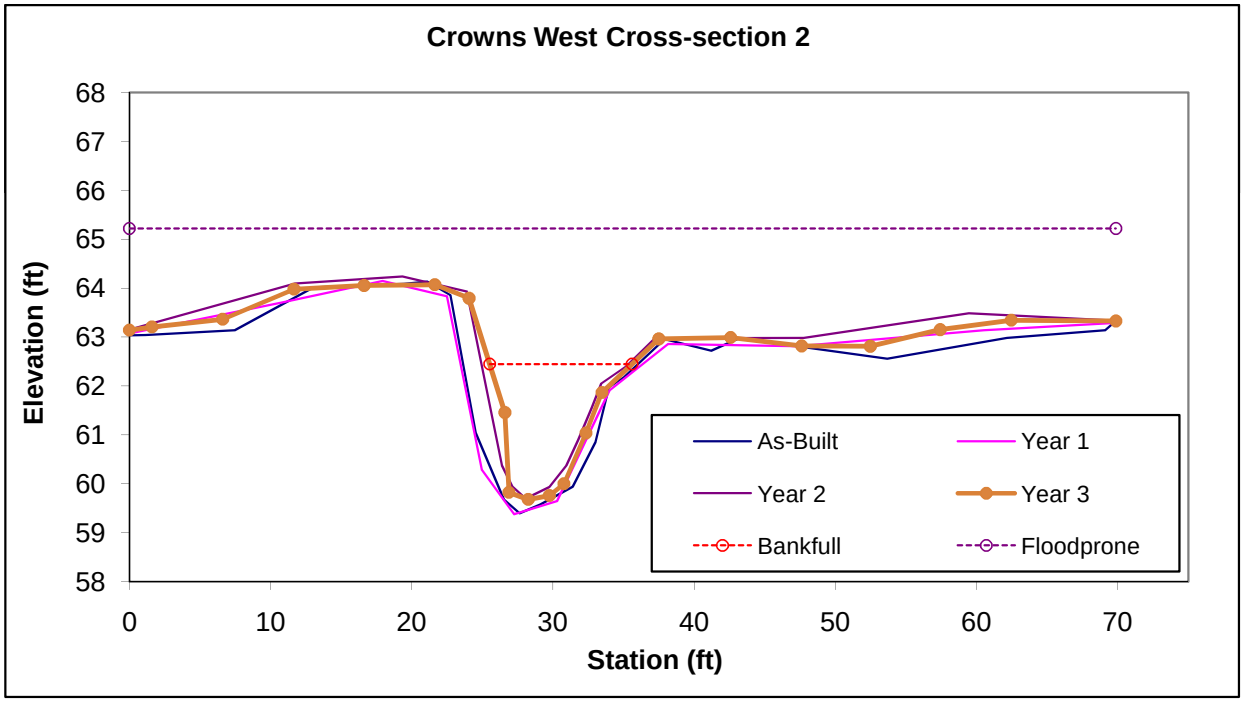
Permanent Cross-section 2

(Year 3 Data - Collected August 2009)

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		16.2	10.09	1.61	2.77	6.27	1.2	6.9	62.45	62.96



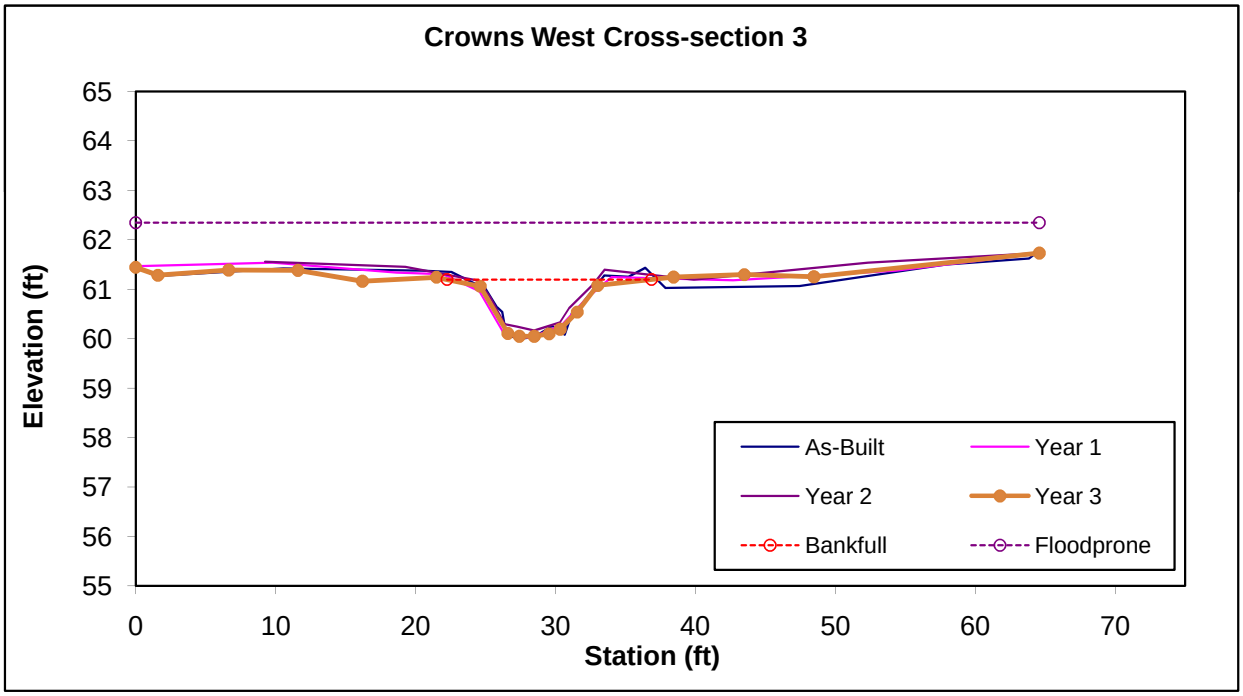
Permanent Cross-section 3

(Year 3 Data - Collected August 2009)

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	7.3	14.61	0.5	1.15	29.05	1	4.4	61.2	61.24



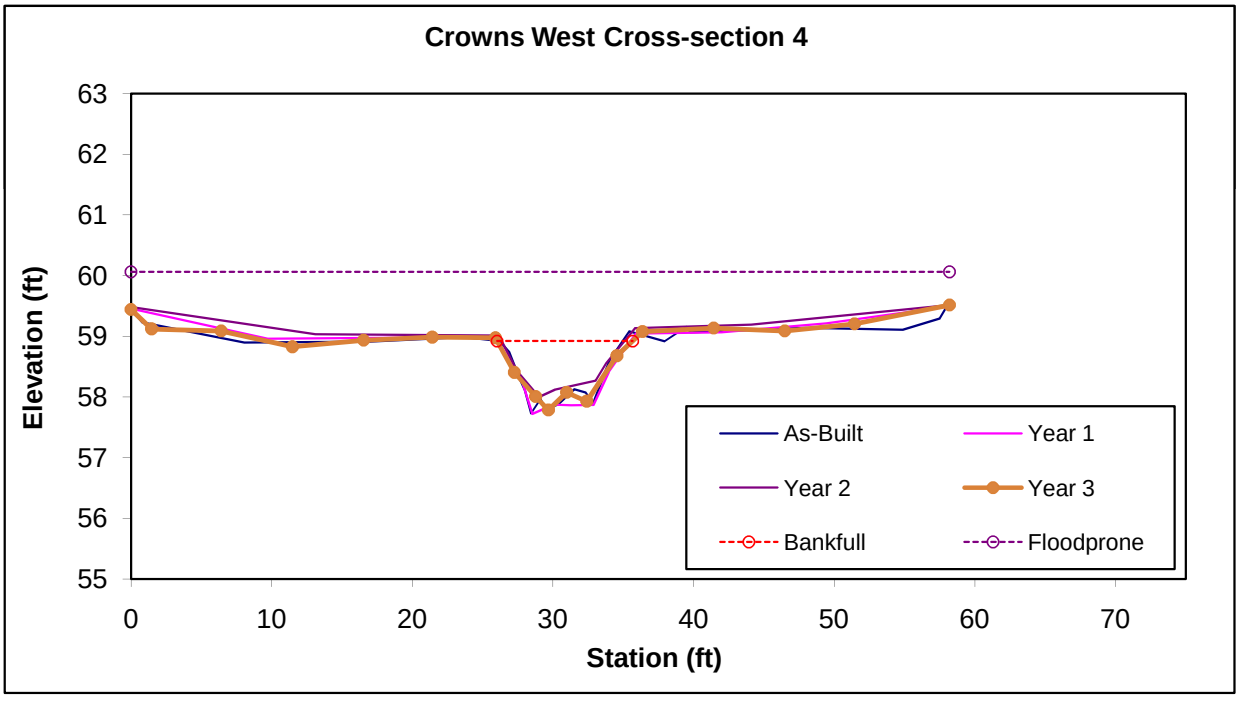
Permanent Cross-section 4

(Year 3 Data - Collected August 2009)

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	6.4	9.62	0.66	1.14	14.51	1	6	58.92	58.97



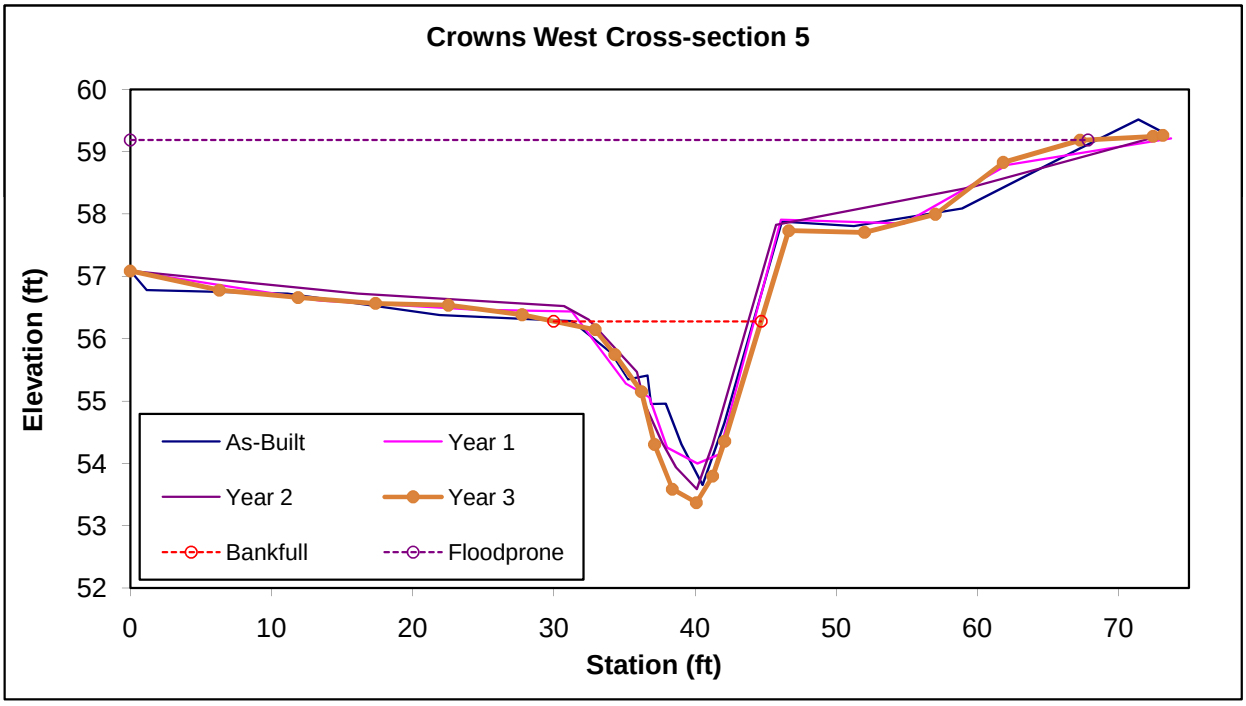
Permanent Cross-section 5

(Year 3 Data - Collected August 2009)

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		18.9	14.69	1.28	2.91	11.43	1	4.6	56.28	56.14

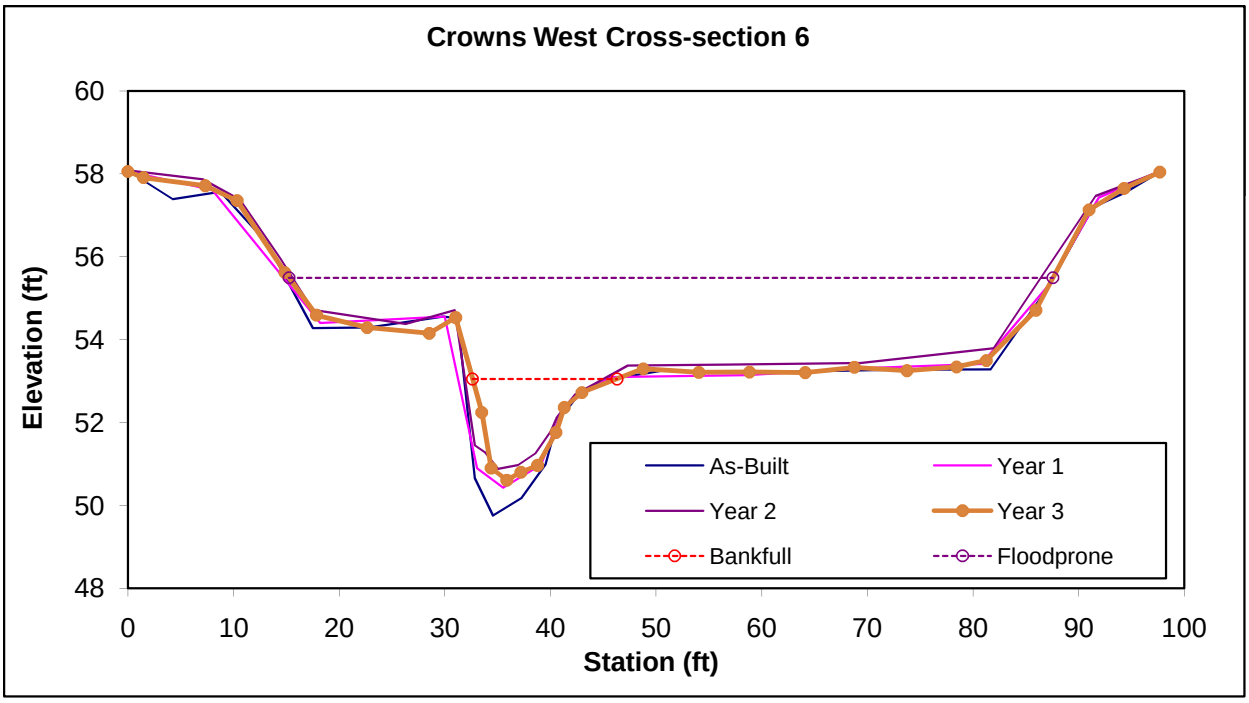


Permanent Cross-section 6
(Year 3 Data - Collected August 2009)

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		16.7	13.68	1.22	2.44	11.19	1.1	5.3	53.05	53.29



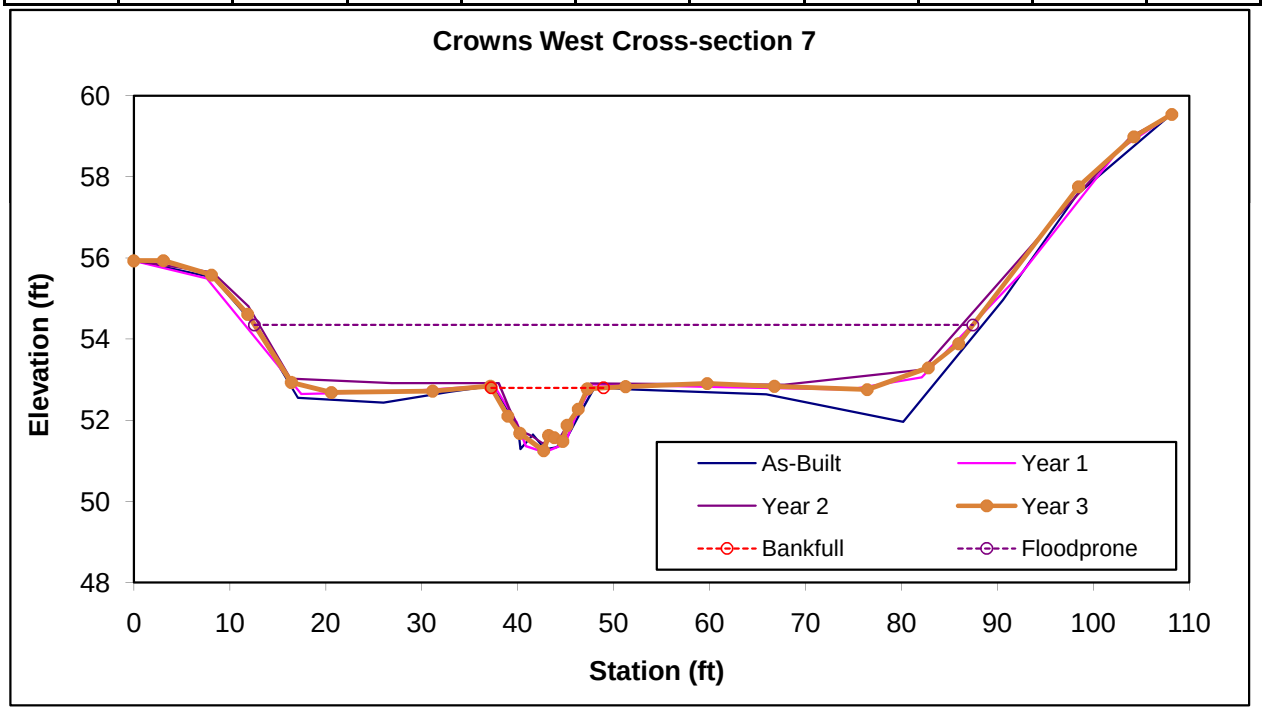
Permanent Cross-section 7

(Year 3 Data - Collected August 2009)

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	9.2	11.69	0.79	1.55	14.84	1	6.4	52.8	52.78



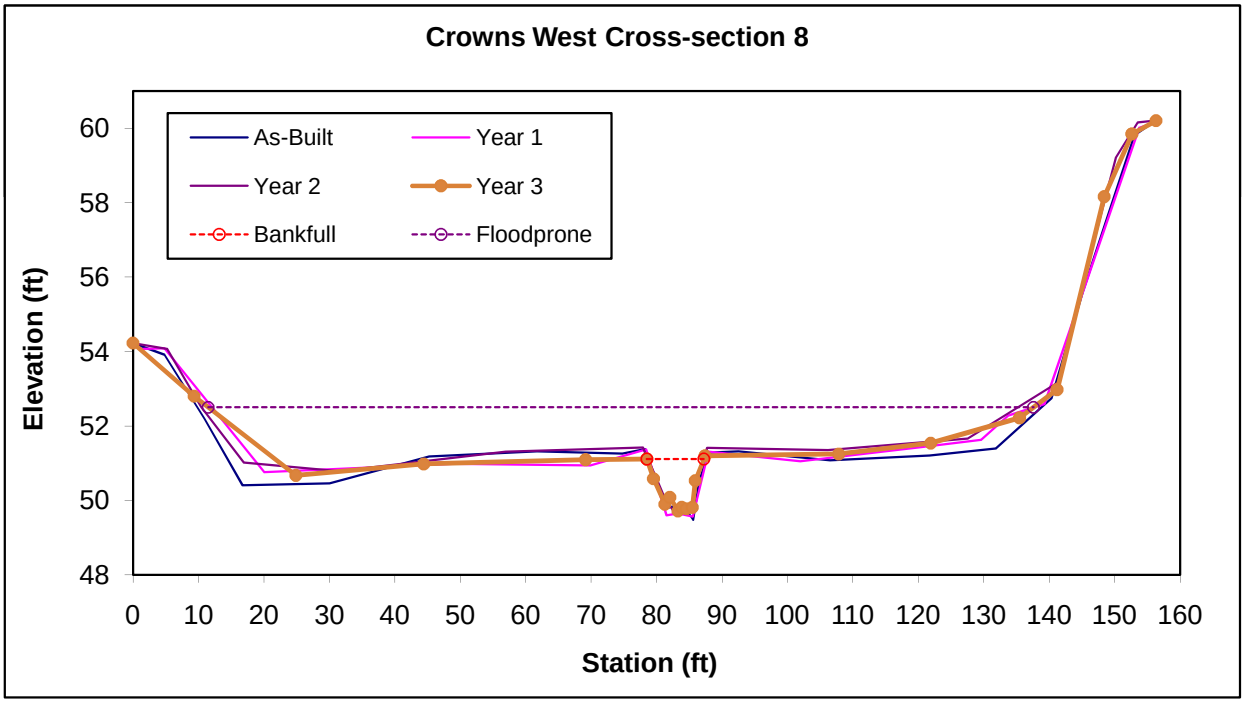
Permanent Cross-section 8

(Year 3 Data - Collected August 2009)

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	7.8	8.69	0.9	1.39	9.66	1	14.5	51.11	51.11



Permanent Cross-section 9

(Year 3 Data - Collected August 2009)

Photo Missing

Photo Missing

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	15.22	1.75	3.91	8.72	1.1	7.5	49.83	50.05

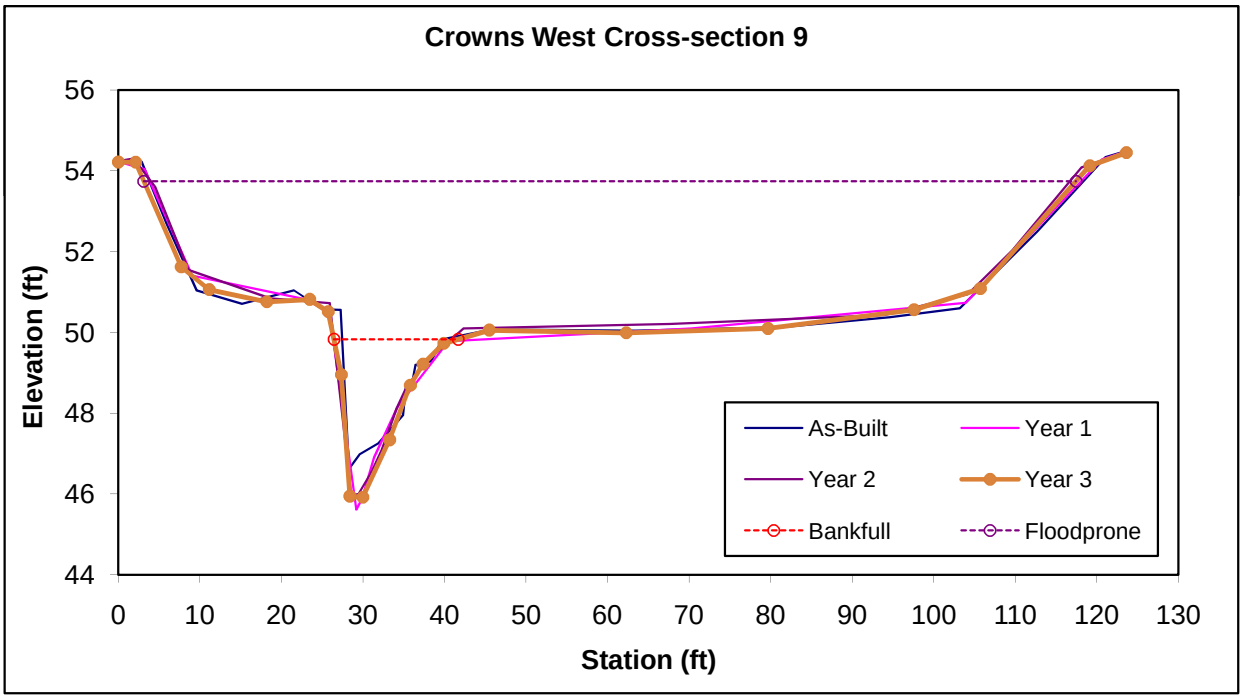


Photo Point 1 - Constructed Riffle 1

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 12

Photo Point 20 - Constructed Riffle 13

Photo Point 21 - Constructed Riffle 13

Photo Point 22 - Constructed Riffle 13

Photo Point 23 - Constructed Riffle 13

Crest Gauge after Bankfull – 0.63 feet

Beaver Dam above Photo Point 1

Beaver Dam below Photo Point 1

BENTHIC MACROINVERTEBRATES, BAKER ENGINEERING, CROWNS WEST PROJEC, ONSLOW, NC, 2/9/09.

SPECIES	T.V.	F.F.G.	STA. 1	STA. 2
MOLLUSCA				
Gastropoda				
Mesogastropoda				
Viviparidae				
Campeloma decisum	**6.5**	**SC**		3
Basommatophora				
Ancylidae		**SC**		
Ferrissia rivularis	***6**	**SC**	1	
Lymnaeidae		**SC**		
Pseudosuccinea columella	**7.7**	**SC**	5	
Physidae				
Physella sp.	**8.8**	**CG**		4
Planorbidae	***6**	**SC**		
Planorbella sp.	**6.8**			4
ANNELIDA				
Oligochaeta	***10**	**CG**		
Tubificida				
Tubificidae w.h.c.	**7.1**	**CG**		1
Hirudinea		**P**		
Rhynchobdellida				
Glossiphoniidae		**P**		
Placobdella papillifera	**9**	**P**		1
ARTHROPODA				
Crustacea				
Cladocera				
Daphnidae				
Ceriodaphnia sp.				1
Isopoda				
Asellidae		**SH**		
Caecidotea sp.	**9.1**	**CG**		3
Amphipoda		**CG**		
Crangonyctidae				
Crangonyx sp.	**7.9**	**CG**	7	
Gammaridae				
Gammarus sp.	**9.1**	**SH**		29
Decapoda				
Cambaridae	**7.5**			
Cambarus sp.	**7.6**	**CG**	5	6
Procambarus sp.	**7**	**SH**		1
Insecta				
Ephemeroptera				
Baetidae		**CG**		
Baetis intercalaris	**7**	**CG**		7
Pseudocloeon sp.	**4**	**CG**	2	5
Ephemerellidae		**SC**		
Attenella sp.	**1.6**	**CG**		2
Heptageniidae		**SC**		
Maccaffertium (Stenonema) sp.	***4**	**SC**		7
Stenacron interpunctatum	**6.9**	**SC**		2

SPECIES	T.V.	F.F.G.	STA. 1	STA. 2
Leptophlebiidae		**CG**		
Leptophlebia sp.	**6.2**	**CG**		1
Odonata				
Aeshnidae		**P**		
Boyeria vinosa	**5.9**	**P**		3
Calopterygidae		**P**		
Calopteryx dimidiata	**7.8**	**P**		10
Coenagrionidae		**P**		
Ischnura sp.	**9.5**		8	
Gomphidae		**P**		
Gomphus sp.	**5.8**	**P**		1
Libellulidae		**P**		
Libellula sp.	**9.6**	**P**	2	
Macromiinae				
Somatochlora sp.	**9.2**	**P**	1	
Trichoptera				
Hydropsychidae		**FC**		
Cheumatopsyche sp.	**6.2**	**FC**		2
Limnephilidae				
Pycnopsyche sp.	**2.5**	**SH**		7
Phryganeidae		**SH**		
Ptilostomis sp.	**6.4**	**SH**		2
Coleoptera				
Dryopidae				
Helichus sp.	**4.6**	**SC**		3
Dytiscidae		**P**		
Agabus sp.	**8.9**	**P**	1	
Neoporus sp.	**8.6**		10	3
Diptera				
Ceratopogonidae		**P**	1	
Chironomidae				
Ablabesmyia mallochi	**7.2**	**P**	1	
Clinotanypus sp.	***6**	**P**	1	
Conchapelopia sp.	**8.4**	**P**	6	5
Corynoneura sp.	**6**	**CG**		2
Cricotopus sp.	***7**	**CG**	5	3
Cricotopus bicinctus	**8.5**	**CG**	9	
Hydrobaenus pilipes	**9.5**	**SC**	1	
Polypedilum flavum (convictum)	**4.9**	**SH**		16
Rheotanytartsus exiguus gp.	**5.9**			5
Tanytarsus sp.	**6.8**	**FC**	1	2
Thienemanniella xena	**5.9**	**CG**		3
Xylotopus par	**6**	**SH**		2
Simuliidae		**FC**		
Simulium sp.	**6**	**FC**	10	5
Tipulidae		**SH**		
Pseudolimnophila sp.	**7.2**	**P**	1	
Tipula sp.	**7.3**	**SH**		1

BENTHIC MACROINVERTEBRATES, BAKER ENGINEERING, CROWNS WEST PROJEC, ONSLOW, NC, 2/9/09.

SPECIES	T.V.	F.F.G.	STA. 1	STA. 2
TOTAL NO. OF ORGANISMS			**78**	**152**
TOTAL NO. OF TAXA			**20**	**34**
EPT			**1**	**9**
NCBI assigned values			**5.15**	**4.15**

Crowns West (Site 1)

3/06 Revision 7

Habitat Assessment Field Data Sheet
Coastal Plain Streams

TOTAL SCORE 65

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 1 (Road Name Haw Br.) County Onslow

Date 2/9/09 **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 8.6 °C DO 11.75 mg/l Conductivity (corr.) 150 µS/cm pH 6.98

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 ✓ %Residential _____ %Active Pasture 50 % Active Crops
✓ %Fallow Fields _____ % Commercial _____ %Industrial _____ %Other - Describe: _____

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

Width: (meters) Stream 1-1.5m Channel (at top of bank) 1.5-2 **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) 1.0

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: clear, sunny 65° **Photos:** ☐ N ☐ Y ☐ Digital ☐ 35mm

Remarks: photo 1 upstream ; photo 2 downstream
TYPICAL STREAM CROSS SECTION DIAGRAM ON BACK

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 8

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 4

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 0

Remarks stone in riffle not exposed (veg is covering) Page Total 35

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 20

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.

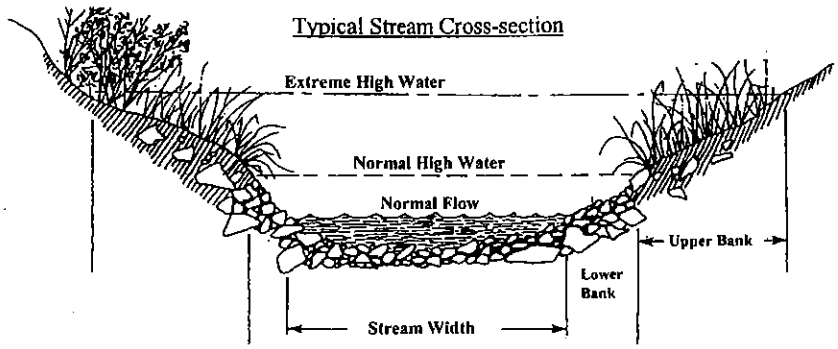
	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters	5	5
2. zone width 12-18 meters	(4)	(4)
3. zone width 6-12 meters	3	3
4. zone width < 6 meters	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters	4	4
b. zone width 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 30

TOTAL SCORE 65



This side is 45° bank angle.

Qual 4 completed 2-9-09

Beaverdam (Site 2)

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 Branch Location/road: Site 2 (RF) Road Name Davis Field) County Jones

Date 2/9/09 **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 8.9 °C DO 7.78 mg/l Conductivity (corr.) 348 µS/cm pH 7.52

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: 100 %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: clear, 52° **Photos:** ☐ N ☑ Y ☑ Digital ☐ 35mm

Remarks: (1) upstream (2) downstream
TYPICAL STREAM CROSS SECTION DIAGRAM ON BACK

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.

C Sticks C Snags/logs C Undercut banks or root mats ___ Macrophytes C 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	(8)
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.

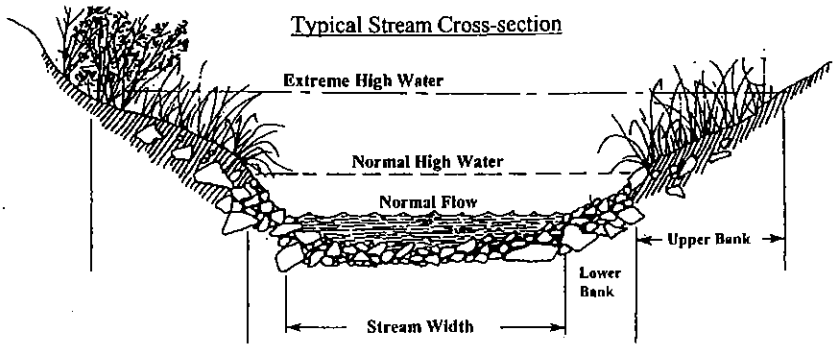
	Lft. Bank Score	Rt. Bank Score
A. Riparian zone **intact** (no breaks)		
1. zone width > 18 meters	(5)	(5)
2. zone width 12-18 meters	4	4
3. zone width 6-12 meters	3	3
4. zone width < 6 meters	2	2
B. Riparian zone **not intact** (breaks)		
1. breaks rare		
a. zone width > 18 meters	4	4
b. zone width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

38+53 **TOTAL SCORE** 91



This side is 45° bank angle.

photo 1 upstream
photo 2 downstream

Qual-4 completed 2-9-09

Site 1 – Crowns West macroinvertebrate sampling site, view is upstream (Year 2)

Site 1 – Crowns West macroinvertebrate sampling site, view is downstream (Year 2)

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

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