

**Beaverdam Mitigation Project  
Harnett County, North Carolina**

**Cape Fear River Basin No. 03030004  
DENR-EEP Contract No. D06029-B**

**Year 4 Monitoring Report**



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## **1.0 SUMMARY**

This Annual Report details the monitoring activities during the 2011 growing season on the Beaverdam Swamp Mitigation Site. Construction of the site, including planting of trees, was completed in February 2008. The 2011 data represents results from the fourth year of hydrology and vegetation monitoring for both wetlands and streams.

The design for the Beaverdam Swamp Site involved stream restoration, riverine wetland restoration, and wetland enhancement. After construction, it was determined that the project generated 10,114 linear feet of stream restoration, 292 linear feet of stream enhancement, 9.90 acres of wetland restoration, and 2.04 acres of wetland enhancement. The As-Built survey is included as **Appendix A**.

This Annual Report presents the data from eight automated hydrology monitoring stations, 14 vegetation monitoring plots, three crest gauges, one tipping bucket rain gauge, one funnel rain gauge, 20 cross sections, 3,455 linear feet of profile survey, and photographic reference locations. Data were also collected from three reference automated hydrology monitoring stations.

In 2011, data collected from the groundwater monitoring gauges on the Beaverdam Mitigation Site indicate that one of the five hydrology monitoring stations in the restoration area, station BDAW1, recorded hydroperiods of at least 10 percent of the growing season. BDAW5 and BDAW7 recorded hydroperiods of 8 percent of the growing season. The remaining two gauges (BDAW2 and BDAW6) experienced hydroperiods of less than or equal to 5 percent. BDRAW1 was the only reference gauge to experience a hydroperiod above 10 percent of the growing season. Reference gauges BDRAW2 and BDRAW3 had hydroperiods of 8 percent of the growing season. The groundwater elevation at BDRAW2 may be affected by its relatively close location to the channel. Gauges BDAW3, BDAW4, and BDAW8 are located in potential additional wetland restoration areas and recorded hydroperiods below the hydrology success criterion for the site. The groundwater elevations appear to follow rainfall trends over the last three seasons.

Weather station data from the Dunn Weather Station were used in conjunction with the rain gauges located on the site to document precipitation amounts. The Dunn weather station data for 2011 was below normal limits throughout most of the growing season. On-site rainfall amounts indicate a dry start to the growing season. During the months of April and May, the rainfall was within the normal limits but below the annual average for May. Rainfall trends during 2009 through 2011 are mostly below normal monthly rainfall amounts.

This Annual Monitoring Report documents vegetation survival on 14 vegetation-monitoring plots. The vegetation monitoring documented surviving planted stem density between 240 and 720 stems per acre. All plots had previously met and exceeded the minimum criteria of 320 stems per acres after three years. Remedial action to control competition is recommended for the area around Plot 5. No additional remedial actions are recommended. Herbaceous vegetation is now estimated at over 90 percent cover across the site. Volunteer woody species are present but do not pose a threat to the target natural community except as noted around Plot 5.

During the 2011 monitoring season, all three crest gauges recorded bankfull events at the site. The restored stream channel is stable and is providing the intended habitat and hydrologic functions. All monitored cross sections and longitudinal profile for 2011 show little adjustment in stream dimension.

## **2.0 INTRODUCTION**

### **2.1 PROJECT DESCRIPTION**

The Beaverdam Swamp Stream and Wetland Mitigation project is in Harnett County, North Carolina, approximately 3 miles southwest of Erwin (**Figure 1**). The property is on an old floodplain terrace to either side of Bunnlevel Erwin Road (SR 1779). Access is directly from Bunnlevel Erwin Road through pasture and agricultural fields. Construction at the site was completed in February 2008. Groundwater, surface water, and rain gauges were functional beginning in February 2008. This report details the results of the 2011 monitoring season, and represents Year 4 of monitoring for the site.

The mitigation site consists of three stream systems and associated riparian wetlands along the floodplain. The three distinct unnamed tributaries (UT) are identified as UT1, UT2, and UT3. The USGS Erwin, NC topographic quadrangle (**Figure 2**) shows UT 1 and UT 2 drain into Beaverdam Swamp and UT3 discharges directly into the Cape Fear River. UT1 has a drainage area of 602 acres (0.94 mi<sup>2</sup>), UT2 has a drainage area of 147 acres (0.23 mi<sup>2</sup>), and UT3 has a drainage area of 262 acres (0.41 mi<sup>2</sup>). Surrounding land use consists of existing forest, open pasture, and agricultural fields. On-site topography, soils, and existing wetland areas demonstrate that the site historically supported riverine wetlands. A conservation easement protects the restoration and preservation areas (**Figure 3**).

The pre-restoration altered conditions of the stream and the riparian buffer reduced water quality and impaired habitat. Livestock access resulted in the direct input of nutrients and biochemical oxygen demand (BOD) into the stream and wetlands. Hoof-shear created bank instability resulting in heavy sedimentation. Water quality was also diminished due to raised turbidity from bank erosion and elevated water temperatures caused by the lack of tree shading. Habitat was reduced by the diminished water quality and loss of physical habitat such as bed features, woody debris, and a well developed vegetative community. Migrating head-cuts had incised the channels and drained wetlands. There are two wetland restoration areas (WR) associated with UT3 and three wetland enhancement areas (WE) associated with UT1.

### **2.2 PROJECT PURPOSE**

The objective of this project is to provide 10,200 stream mitigation units (SMU) and 9 wetland mitigation units (WMU) to the North Carolina Ecosystem Enhancement Program (EEP) through the full delivery process in the Cape Fear River Basin 03030004110020 hydrologic unit, and to improve riparian and aquatic habitats and water quality through ecological restoration practices. Stream mitigation was provided through restoration and enhancement on three stream systems that are tributaries to Beaverdam Swamp. Riverine wetland mitigation was provided through enhancement and restoration. The site was identified and developed by Environmental Banc and Exchange, LLC (EBX) through the EEP full delivery mitigation process.

Monitoring of the Beaverdam Swamp Mitigation Site is required to demonstrate successful mitigation based on criteria in the Restoration Plan and through a comparison to reference site conditions. The success criteria components adhere to EEP and USACE guidelines. Hydrology, vegetation, and stream monitoring are conducted on an annual basis. This Annual Monitoring Report details the results of the monitoring efforts for 2011 (Year 4) at the Beaverdam Swamp Mitigation Site.

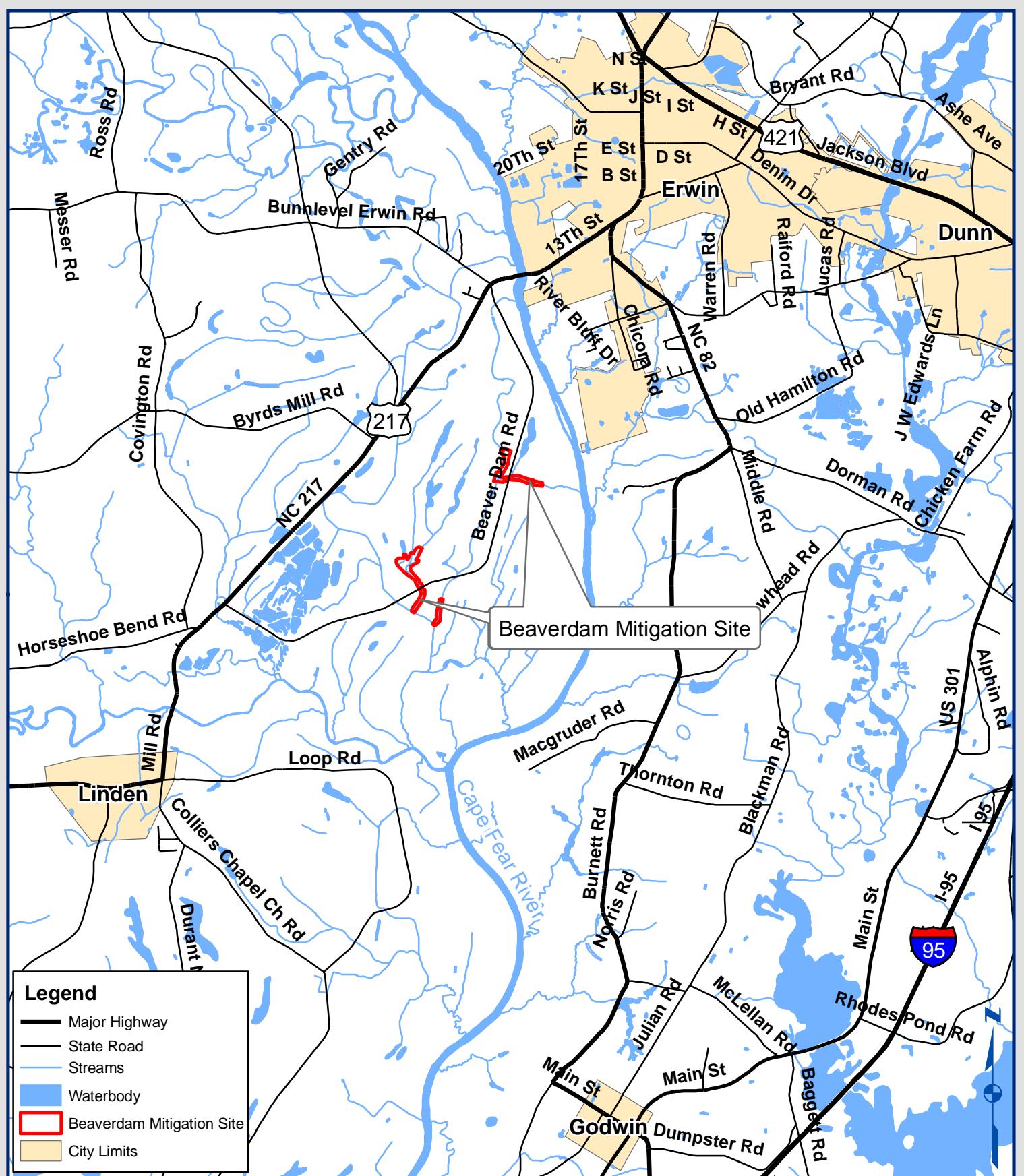
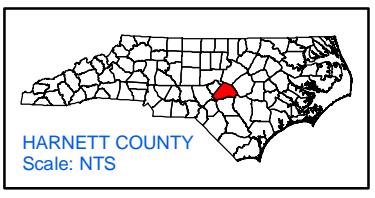
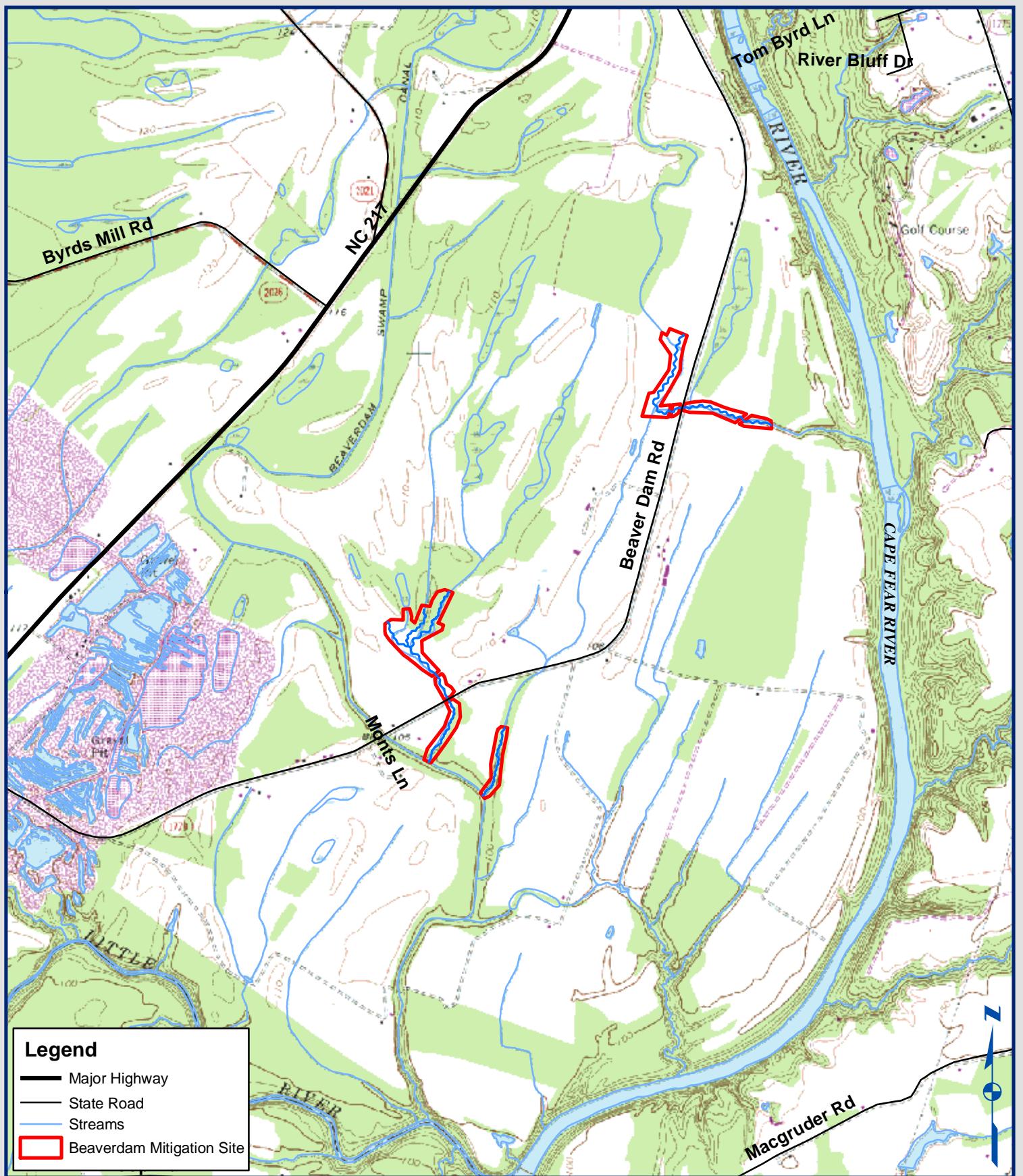


Figure 1.  
Beaverdam Creek Mitigation Site  
Project Vicinity Map

0 0.5 1 2 Miles



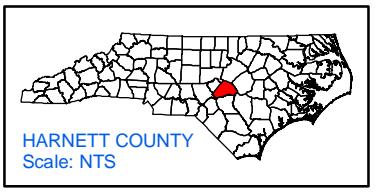


**Figure 2.**  
**Beaverdam Creek Mitigation Site**  
**USGS Map**



SOURCE: USGS,  
Erwin, NC Quadrangle, 1973

0 1,000 2,000 4,000  
Feet



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The Beaverdam Swamp Mitigation Report (May 2008) documented 10,114 linear feet of stream restoration, 292 linear feet of stream enhancement Level II, 9.90 acres of wetland restoration, and 2.04 acres of wetland enhancement, resulting in 10,231 SMUs and 10.9 WMUs for the project (**Table 1**). The raised streambed elevation will provide the hydrology for restoring the wetlands. The wetland and stream restoration will provide multiple ecological and water quality benefits within the Cape Fear River Basin. Benefits include nutrient removal, sediment and BOD reduction, water storage, improved groundwater recharge, improved in-stream and riparian habitat, and restored wetland habitat.

**Table 1. Project Mitigation Structure and Objectives**

Reach Name	As-Built Length (feet)	Wetland (acres)	WMU	SMU	Restoration Approach
UT1-A/B/C	3,403			3,403	Restoration
UT1-D	829			829	Restoration
UT1-E (Valley)	556			556	Restoration
UT1-F	583			583	Restoration
UT2	1,264			1,264	Restoration
UT3-A/B	3,479			3,479	Restoration
UT3-C	292			117	Enhancement
WR-A		3.70	3.70		Restoration
WR-B		6.20	6.20		Restoration
WE-A		0.80	0.40		Enhancement
WE-B		0.70	0.35		Enhancement
WE-C		0.14	0.07		Enhancement
WE-D		0.40	0.20		Enhancement
<b>Total</b>	<b>10,406</b>	<b>11.94</b>	<b>10.92</b>	<b>10,231</b>	

### **2.3 PROJECT HISTORY & SCHEDULE**

The project was constructed in the fall and winter of 2007/2008, and the five year monitoring is expected to be completed in the fall of 2012 (**Table 2**). **Table 3** lists the project contacts.

**Table 2. Project Activity and Reporting History**

Month	Activity
February 2008	Construction Completed
February 2008	Planting Completed
February 2008	Post Construction Monitoring Gauges Installed
May 2008	As-Built Report Submitted
November 2008	1st Annual Monitoring Report
November 2009	2nd Annual Monitoring Report
October 2010	3rd Annual Monitoring Report
November 2011	4th Annual Monitoring Report
November 2012	5th Annual Monitoring Report (Scheduled)

**Table 3. Project Contacts**

Contact	Firm Information
<b>Project Manager</b> Norton Webster	Environmental Banc & Exchange , LLC (919) 608-9688
<b>Designer</b> Todd St. John, PE	Kimley-Horn and Associates (919) 653-2950
<b>Monitoring Contractor</b> Daniel Ingram	WK Dickson and Co., Inc (919) 782-0495

## 3.0 HYDROLOGY

### 3.1 HYDROLOGIC SUCCESS CRITERIA

As stated in the Restoration Plan, the hydrology success criterion for the site is to restore wetland hydrology at the site so that water table will remain within 12 inches of the soil surface continuously for at least 10 percent of the growing season (approximately 24 days). The growing season is from March 16 to November 11. Based on daily minimum temperatures greater than 28 degrees Fahrenheit occurring in 5 of 10 years, the growing season for Harnett County is 240 days long. Gauge data will be compared to gauge data from a reference wetland in growing seasons with less than normal rainfall. In periods of low rainfall, if a restoration gauge hydroperiod exceeds the reference gauge hydroperiods, and both exceed five percent of the growing season, then the gauge will be deemed successful. The results of hydrology monitoring across the wetland restoration site are presented in this annual monitoring report.

Additional potential wetland enhancement acreage was identified outside of the proposed wetland restoration and enhancement acreage shown in the Restoration Plan. These are in the forested section of UT1A, UT1C, and UT2. These areas have appropriate bottomland hardwood species; however, because of the channelization of the streams, these areas lacked hydrology prior to restoration. Three monitoring gauges have been established in these locations to verify if wetland hydrology is restored in this acreage.

### 3.2 DESCRIPTION OF HYDROLOGY MONITORING EFFORTS

Eight automated HOBO groundwater gauges, one tipping bucket rain gauge, and one funnel rain gauge were installed prior to the beginning of the first growing season (**Figure 3**). Three additional automated groundwater gauges were installed in a reference wetland. Groundwater gauges are installed to a minimum depth of 40 inches below the ground surface. The monitoring protocol for the site specifies that automated monitoring stations will be downloaded and checked for malfunctions on a monthly basis. During monthly site visits, manual groundwater gauges are read, crest gauge readings are taken, and cumulative rainfall totals are collected from the on-site rain gauges. During the 2011 growing season, all eight automated loggers performed well with no periods of missing data.

#### *Automated Gauges*

HOBO automatic groundwater gauges record water table elevations four times daily at 06:00, 12:00, 18:00, and 24:00. These automatic gauges employ pressure sensors that record water elevation above the bottom of the sensor (with atmospheric pressure compensation). The calibration water table depth is recorded at monthly downloads. To determine wetland hydroperiods, the automatically recorded data are compared to the calibration data to determine a standard correction factor between the calibration gauge and the automatic gauge for each

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location. The standard correction factor is applied to correct daily readings. The corrected daily readings are used to determine wetland hydroperiods.

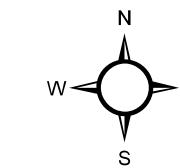
*Data Interpretation*

Wetland hydroperiods are calculated for four daily water table depth elevations. A hydroperiod is calculated if the water table is equal to or less than 12 inches below ground surface for at least 24 hours. If a gauge falls below -12 inches for four consecutive readings (24 hours) then the hydroperiod ends at the last reading within 12 inches of the ground surface. If a gauge falls below -12 inches for only three readings then maintains a reading above -12 inches for a minimum of



0 100 200 400  
Feet  
1 inch = 200 feet

Figure 3a  
Beaverdam  
2011 Monitoring Site Map

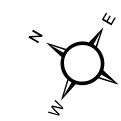


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WATERSHED SCIENCES



0 100 200 400  
Feet  
1 inch = 200 feet

Figure 3b  
Beaverdam  
2011 Monitoring Site Map



24 hours, the hydroperiod is calculated continuously. This methodology accounts for minor technical malfunctions experienced by the automatic gauges.

### 3.3 RESULTS OF HYDROLOGY MONITORING

The following hydroperiod statistics were calculated for each monitoring station during the growing season: 1) period of most consecutive days and percent of growing season that the water table was within twelve inches of the surface; 2) cumulative number of days and percent of growing season that the water table was within twelve inches of the soil surface; and 3) number of times that the water table rose to within twelve inches of the soil surface (**Table 4**). Raw hydrograph data collected from the monitoring gauges are provided in **Appendix C**.

**Table 4. Hydrologic Monitoring Results**

2011 Max Hydroperiod (Growing Season 16-Mar through 11-Nov, 240 days)					
Gauge	Consecutive		Cumulative		Occurrences
	Days	Percent of growing Season	Days	Percent of growing Season	
<b>Restoration/Enhancement Area</b>					
AW1	34	14	42	18	3
AW2	9	4	18	8	6
AW5	19	8	40	17	4
AW6	13	5	23	10	6
AW7	18	8	32	13	6
<b>Gauges Outside Restoration/Enhancement Area</b>					
AW3*	1	0	2	1	2
AW4*	0	0	0	0	0
AW8*	10	4	14	6	4
<b>Reference Gauges</b>					
REFAW1	48	20	48	20	1
REFAW2	19	8	36	15	6
REFAW3	20	8	40	17	5

\* Gauge is not located in restoration area

The site was designed to re-integrate the streams with the drained wetlands, restoring stream and wetland habitat features, and re-establishing a native, forested hardwood wetland ecosystem. Hydrology in the riparian areas is driven primarily by high groundwater and overbank flooding. One monitoring gauge (AW1) had a hydroperiod greater than 10 percent of the growing season in Year 4. Gauges AW5 and AW7 both had hydroperiods of eight percent. Gauge AW2 recorded a hydroperiod less than 5 percent. This gauge is located relatively close to the channel and groundwater may be influenced by its proximity to the channel. Rainfall immediately prior to and during the early growing season was below normal limits. This resulted in diminished wetland hydroperiods. Two of three reference gauges also recorded hydroperiods less than the success criterion. **Table 5** lists the minimum depth at which the under performing gauges achieved a 10 percent hydroperiod.

**Table 5. Hydroperiod Depths for Unsuccessful Gauges**

Gauge	10 Percent Hydroperiod Depth
AW2	-26.22
AW5	-19.48
AW6	-21.68
AW7	-22.39
AW3*	-17.84
AW4*	-32.73
AW8*	-29.40
RAW2	-16.18
RAW3	-13.83

\*Gauge is not located in restoration area

Gauge data indicate the groundwater elevations have experienced a slow decline since 2009 monitoring year (**Table 6**). This trend follows the rainfall recorded at nearby Dunn where rainfall patterns are trending below the normal limits most months as discussed on climate data in Section 3.3.3. Reference gauges also follow a similar decline in groundwater elevation.

**Table 6. Summary of Annual Hydrology Monitoring Data 2008-2011**

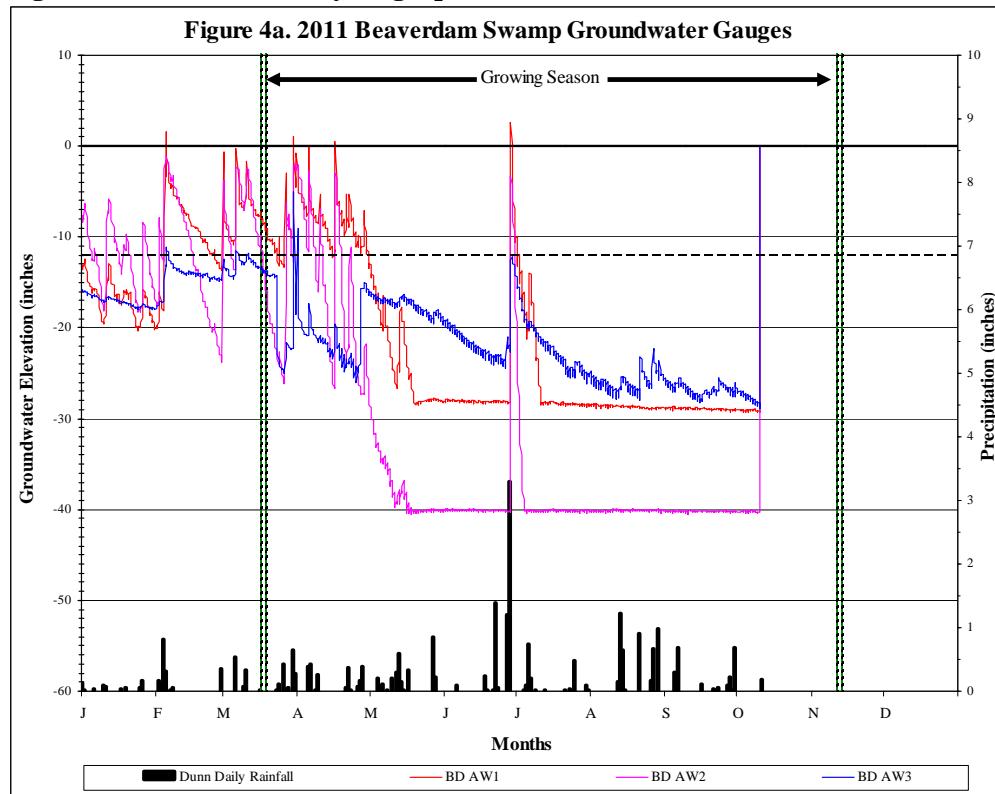
Gauge	Max Consecutive Hydroperiod (percent of growing season)				
	2008	2009	2010	2011	2012
<b>Restoration/Enhancement Area</b>					
AW1	23.4	31	20	14	--
AW2	3.6	10	8	4	--
AW5	6.9	21	13	8	--
AW6	4.1	10	4	5	--
AW7	6.9	16	13	8	--
<b>Gauges Outside Restoration/Enhancement Area</b>					
AW3	12	100	48	0	--
AW4	1.5	3	0	0	--
AW8	6.3	24	20	4	--
<b>Reference Gauges</b>					
RAW1	29.8	32	24	20	--
RAW2	6.1	14	10	8	--
RAW3	6.4	21	13	8	--

Gauges located outside of the proposed restoration areas (Gauges AW3, AW4 and AW8) did not meet success criteria during the monitoring 2011 Monitoring Year. The restoration gauges and the reference gauges show a similar trend across the years of the monitoring period. The gauges outside of the restoration/enhancement area appear to have greater exaggerations in the trend. The exaggeration is likely due to the existing mature hardwood canopy removing the groundwater more efficiently during the period with less rainfall.

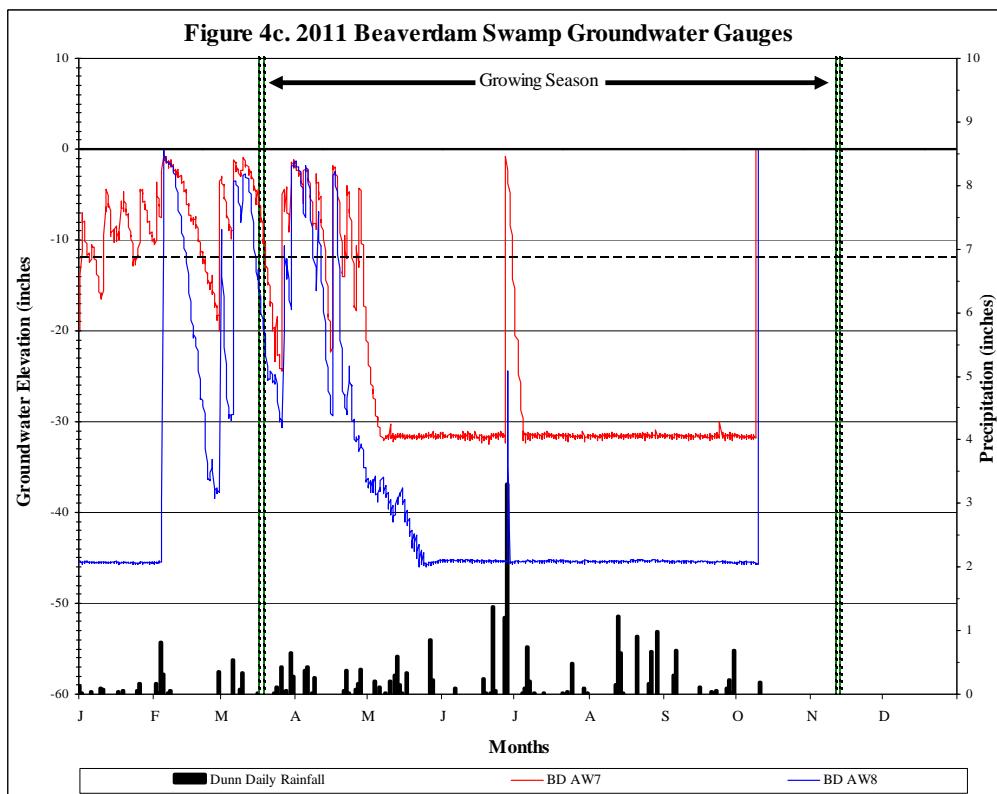
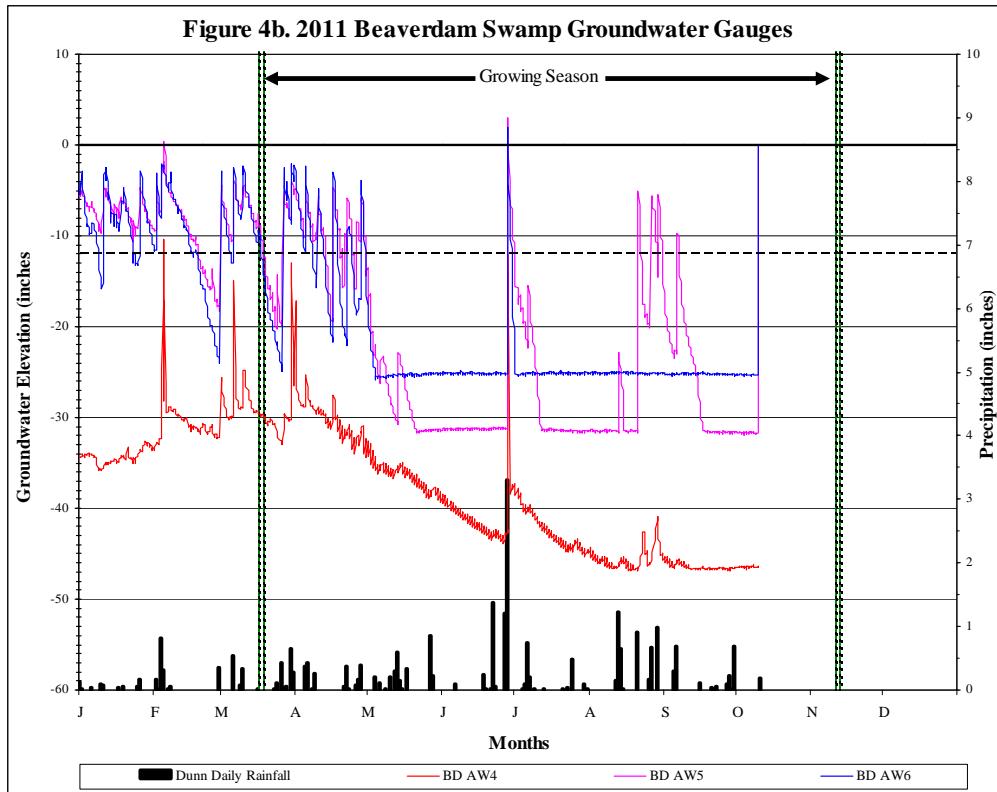
### 3.3.1 Site Data

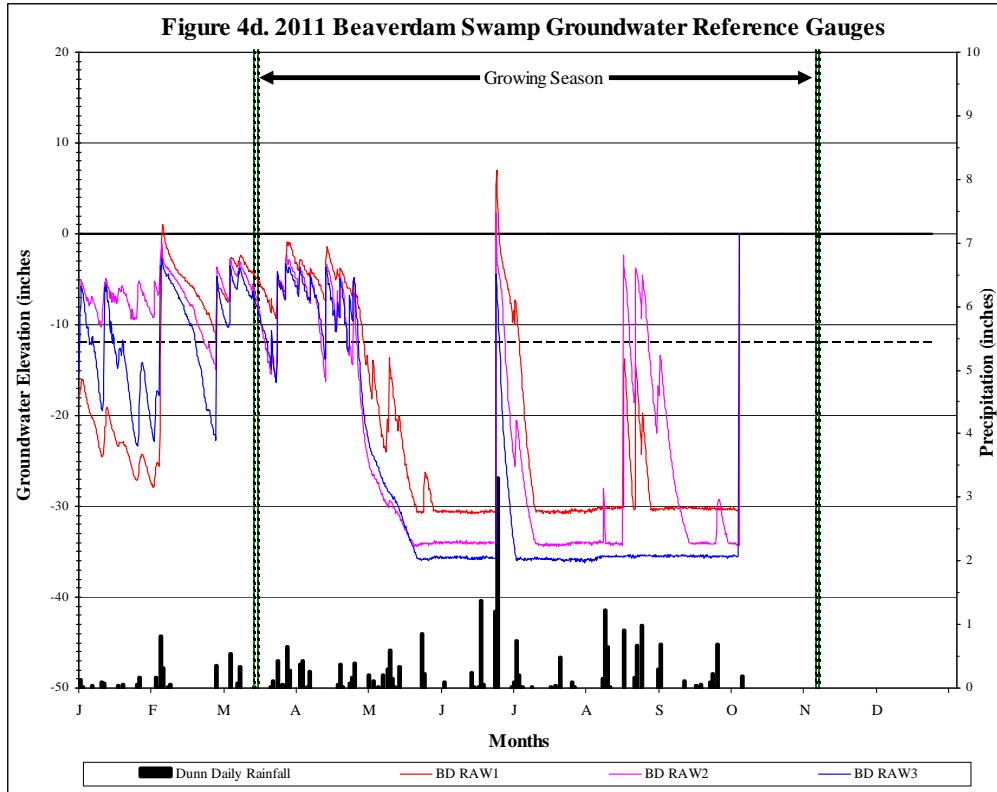
Depth of groundwater for each of the monitoring gauges is shown in a graph with precipitation (**Figure 4**). This hydrograph demonstrates the reaction at each monitoring location of the groundwater level to specific rainfall events. Raw hydrograph data collected from the monitoring gauges is provided in **Appendix C**.

**Figure 4. Groundwater Hydrographs**



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### 3.3.2 Reference Data

The approved Mitigation Plan provides that if the rainfall data for any given year during the monitoring period is not normal, the reference wetland data can be assessed to determine if there is a positive correlation between the performance of the restoration site and the natural hydrology of the reference site. The three reference gauges had hydroperiods ranging from 8 to 20 percent of the growing season. Two reference gauges failed to meet the restoration hydroperiod criterion. All gauges indicate a downward trend in groundwater elevation in 2010 and 2011 (**Table 6**).

### 3.3.3 Climate Data

Monthly rainfall for 2011 was compared to historical precipitation for Harnett County (**Table 7** and **Figure 5**). Observed precipitation data were collected from an automated weather station in Dunn (Harnett County). The Dunn weather station data for 2011 was below normal limits for January, February, March, and June, and within normal limits for April, May, and August. No data was available for July. The manual on-site rain gauge recorded normal rainfall amounts during the months of April and May, and below normal rainfall in March. The automatic on-site rain gauge recorded below normal rainfall in January, February, and March; no data was collected after March due to malfunction.

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**Table 7. Comparison of Normal Rainfall to 2011 Observed Rainfall**

Month	Average	Normal Limits		Dunn Precipitation	On-Site Manual RG	On-Site Automatic RG
		30 Percent	70 Percent			
January	4.12	3.00	5.18	0.66	---	0.59
February	3.59	2.36	4.27	1.73	---	1.42
March	4.71	3.42	5.78	2.54	2.05	1.93
April	3.25	1.99	4.34	2.13	4.17	*
May	3.82	2.37	4.75	2.99	2.45	0.03
June	4.50	2.56	5.22	6.31	---	*
July	5.64	3.42	6.89	1.70	---	*
August	4.86	3.17	6.02	4.74	---	*
September	4.50	2.24	5.56	2.19	---	*
October	3.16	1.89	4.26	2.53	10.47	*
November	3.08	2.07	4.01	2.42		
December	3.57	2.18	4.35	0.80		
Total	48.80	42.45	51.56	30.74	19.14	3.97

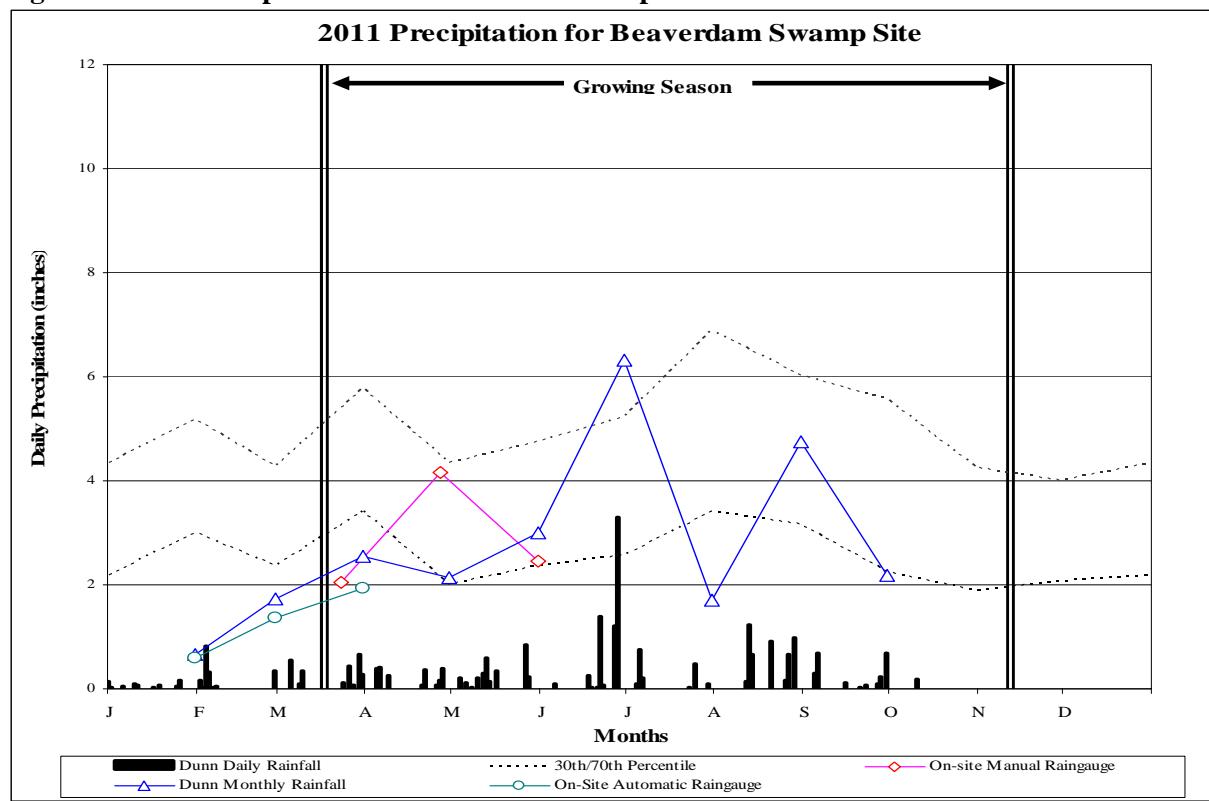
\*On-Site Automatic Rain Gauge malfunctioned between 24 March and 25 May, 27 May and 10 October

Longer-term rainfall patterns show the rainfall has been below normal limits most of the last three years, most importantly prior to the growing season (**Table 8**).

**Table 8. Observed Rainfall Summary**

Month	Average	Normal Limits		Dunn Precipitation			
		30 Percent	70 Percent	2008	2009	2010	2011
January	4.12	3.00	5.18	1.65	1.48	3.02	0.66
February	3.59	2.36	4.27	3.29	1.83	2.56	1.73
March	4.71	3.42	5.78	3.69	3.84	1.96	2.54
April	3.25	1.99	4.34	8.88	0.56	0.63	2.13
May	3.82	2.37	4.75	2.86	2.17	2.75	2.99
June	4.50	2.56	5.22	2.69	0.43	1.28	6.31
July	5.64	3.42	6.89	4.31	2.50	2.71	1.70
August	4.86	3.17	6.02	4.72	2.65	1.38	4.74
September	4.50	2.24	5.56	5.01	1.84	0.36	2.19
October	3.16	1.89	4.26	1.43	1.83	0.55	2.53
November	3.08	2.07	4.01	2.18	0.90	0.82	2.42
December	3.57	2.18	4.35	2.04	3.95	1.25	0.80
Average	---	42.45	51.56	---	---	---	---
Total	48.80	---	---	42.75	23.98	19.27	30.74
Below 30 percentile							
Below monthly average							

**Figure 5. 2011 Precipitation for Beaverdam Swamp Site**



### 3.4 HYDROLOGIC CONCLUSIONS

Data collected from the groundwater monitoring gauges on the Beaverdam Mitigation Site in 2011 indicate that one of the five restoration area hydrology monitoring stations recorded hydroperiods of at least 10 percent of the growing season and meet the hydrologic success criterion for 2011. BDAW5 and BDAW7 recorded hydroperiods of 8 percent of the growing season. Two gauges (BDAW2 and BDAW6) experienced hydroperiods of less than or equal to 5 percent, but achieved a 10 percent hydroperiod at a depth of no greater than 32.73 inches below the soil surface. BDRAW1 was the only reference gauge to experience a hydroperiod above 10 percent of the growing season. The remaining two reference gauges (BDRAW2 and BDRAW3) had hydroperiods of 8 percent of the growing season. The groundwater elevation at BDRAW2 may be affected by its relatively close location to the channel. Gauges BDAW3, BDAW4, and BDAW8 are located in areas of potential additional wetland restoration. These gauges failed to demonstrate wetland hydrology during 2011.

Dunn weather station rainfall data indicates that the 2011 growing season rainfall amounts were below normal for most of the growing season, except for May, June, August, October, and November when rainfall levels were within the normal range or slightly above. Rainfall trends for 2009 through 2011 are below normal or below average amount for most months.

## 4.0 VEGETATION

### 4.1 VEGETATION SUCCESS CRITERIA

Successful establishment of vegetation in wetland restoration and riparian areas will be the survival of 260-planted stems following Year 5 monitoring. The site must also meet the interim success criterion of the survival of at least 320 planted stems per acre at the end of the Year 3 monitoring period. Up to 20 percent of the species composition may be comprised of volunteers. Remedial action may be required should volunteers present a problem or exceed 20 percent composition.

A digital image photo log will be used to subjectively evaluate the restoration site over time. A series of images over the five-year monitoring period should demonstrate maturation of planted vegetation and volunteer hydrophytic species.

### 4.2 DESCRIPTION OF SPECIES AND VEGETATION MONITORING

Fourteen vegetation sampling plots were established within the planted restoration areas to monitor the success of planted vegetation. The vegetation plots are 0.05 acres in size. The vegetation plots are distributed across the site, but the precise location and orientation of the plots was random (see locations on as-built drawings in **Appendix A**). The plots cover approximately two percent of the planted area. Twelve tree species were planted on the site (**Table 9**).

**Table 9. Planted Tree Species**

Common Name	Scientific Name	FAC Status
River Birch	<i>Betula nigra</i>	FACW
Pignut Hickory	<i>Carya glabra</i>	FACU
Green Ash	<i>Fraxinus pennsylvanica</i>	FACW
Black Walnut	<i>Juglans nigra</i>	FACU
Tulip Poplar	<i>Liquidambar styraciflua</i>	FAC+
Swamp Tupelo	<i>Nyssa biflora</i>	OBL
Overcup Oak	<i>Quercus lyrata</i>	OBL
Swamp Chestnut Oak	<i>Quercus michauxii</i>	FACW-
Coastal Willow Oak	<i>Quercus phellos</i>	FACW-
Northern Red Oak	<i>Quercus rubra</i>	FACU
Bald Cypress	<i>Taxodium distichum</i>	OBL
Slippery Elm	<i>Ulmus rubra</i>	FAC

Planted stems inside each plot were flagged with orange or pink flagging to help in locating them in the future. Each stem is tagged with a sequentially numbered aluminum tag.

### 4.3 RESULTS OF VEGETATION MONITORING

Stem counts for each of the 14 vegetation-monitoring plots were recorded by species (**Table 10**). Most of the planted stems appeared healthy and have recent growth. During Year 1 (2008), a number of the plots were located in areas where livestock accidentally accessed the restoration area and damaged many stems. The access points have since been secured. The damage increased mortality in a number of the plots. Because of mortality during the first year, areas of the site were supplemented with additional trees.

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The planted stems in the monitoring range in height from 1 foot to greater than 10 feet with few over 10 feet. The average height appears to be around 5 feet. Most planted trees show reasonably good growth. Plot survival ranged from 240 to 720 stems per acre with an average of 464 stems per acre (**Table 11**). Some of the numbered tags have been lost or damaged over the last four years. This may be due to tags being swept over small stems during early flooding shortly after planting or small animal theft.

**Table 10. Results of 2011 Vegetation Monitoring by Plot**

Species	VP 1	VP 2	VP 3	VP 4	VP 5	VP 6	VP 7	VP 8	VP 9	VP 10	VP 11	VP 12	VP 13	VP 14
Black gum	3	11	3	2	1	4		2	1	13	4	6		
Black walnut														
Cypress	5	3	3	4					2	11	1	1		
Green ash	15	6	3	3	3	4	5	2			1	7		
Hickory			1		1			1	2		2	4		
Northern red oak							5						9	15
Overcup oak	3	5	5	6	4		8	4	2	7	4			3
Paw Paw									1					
River birch		3	2	9	3	8		2	5	1	3			
Slippery elm							2				1		13	11
Swamp chestnut oak								2	3			3		6
Tulip poplar		1		2				2			1			
Unknown								1			1	2		
Willow oak			2			5	4	2				1	2	1

**Table 11. Summary of Vegetation Monitoring Results – Year 4**

Plot Number	Stems Planted	2011 Stems	Stems per Acre					
			As-Built	2008 Year 1	2009 Year 2	2010 Year 3	2011 Year 4	2012 Year 5
1	35	26	620	360	540	480	520	
2	40	29	640	420	580	500	580	
3	37	19	600	340	420	380	380	
4	41	26	640	340	520	540	520	
5	41	12	620	260	500	380	240	
6	35	21	660	360	380	360	420	
7	43	24	620	360	600	480	480	
8	33	18	660	560	540	480	360	
9	26	16	400	340	340	340	320	
10	32	32	460	420	600	600	640	
11	38	18	760	480	440	400	360	
12	35	24	700	640	640	560	480	
13	34	27	680	500	540	500	480	
14	33	36	660	480	480	620	720	

2011 Average Stems per Acre: 464

2011 Range of Stems per Acre: 240-720

A few plots have planted trees that exhibit smaller height. This may be due to competition from Eastern baccharis (*Baccharis halimifolia*) (VP 5), past herbicide treatment (VP 8 and VP 9), or

locally dry conditions (VP 3, VP 8, VP 11, VP 13, and VP 14). Plot 5 has fallen below the 5-year success criteria of 260 stems per acre, likely due to competition. It is recommended that remedial action to control competition from eastern baccharis be initiated in the area surrounding this plot to release planted stems. A plan view drawing of the vegetation plots is provided in **Figures 6a** and **6b**. The drawing includes the appropriate information pertaining to vegetation monitoring of the project. The herbaceous vegetation coverage at the site averages over 90 percent with most plots over 95 percent. Due to the existing forest cover around Plots 7, Plot 8, and Plot 9, these plots exhibit the least dense herbaceous coverage with a few small areas having limited herbaceous cover. Coverage of eastern baccharis is high surrounding Plot 5 and has limited herbaceous coverage. A number of plots have become dominated by one or two species. Figure 6 also shows the locations of the following features:

- Vegetation monitoring plots
- Locations of any vegetation problem areas
- Symbology to represent vegetative problem types (if appropriate)

In most plots, the herbaceous vegetation shows vigorous growth and diversity. The herbaceous cover is typically dense across most of the site and a few weeds typical of pasture and disturbed land are still present. The most common herbaceous species across the site (occurrence in at least 50 percent of the plots) are common rush (*Juncus effusus*), tall fescue (*Schedonorus phoenix*), sawtooth blackberry (*Rubus argutus*), and Canada goldenrod (*Solidago canadensis*). Other species found across the site are beaked panic grass (*Panicum anceps*), deertongue (*Dichanthelium clandestinum*), dog fennel (*Eupatorium capillifolium*), and swamp sunflower (*Helianthus angustifolius*). Overall diversity appears to be unchanged from the previous monitoring period, but weedy species have decreased in dominance. The herbaceous coverage across the mitigation site is variable in composition, as would be expected in a natural riparian system.

Woody volunteer species are also monitored throughout the five-year monitoring period (**Table 12**). These volunteer species are not always obvious due to germination after construction and planting. Vigor and survival due to the earlier drought as well as proximity to seed sources have affected the volunteer species. In some areas, dense herbaceous cover also obscures smaller volunteer individuals. Twenty different species were observed within the monitoring plots as volunteers. Plot 5 has a dense coverage of the woody shrub Eastern baccharis. Diversity in the remaining plots is still good. Remedial action to control areas where woody volunteers dominate is recommended. No other remedial action is recommended at this time.

**Table 12. Volunteer Tree Species**

Common Name	Scientific Name	Indicator Status
Red Maple	<i>Acer rubrum</i>	FAC
Eastern Baccharis	<i>Baccharis halimifolia</i>	FAC
River Birch	<i>Betula nigra</i>	FACW
American Hornbeam	<i>Carpinus caroliniana</i>	FAC
Common Buttonbush	<i>Cephalanthus occidentalis</i>	OBL
Persimmon	<i>Diospyros virginiana</i>	FAC
Green Ash	<i>Fraxinus pennsylvanica</i>	FACW
Chinese Privet	<i>Ligustrum sinense</i>	FAC
Sweetgum	<i>Liquidambar styraciflua</i>	FAC+
Tuliptree	<i>Liriodendron tulipifera</i>	FAC
Blackgum	<i>Nyssa sylvatica</i>	FAC
Loblolly Pine	<i>Pinus taeda</i>	FAC
American Sycamore	<i>Platanus occidentalis</i>	FACW-
Southern Red Oak	<i>Quercus falcata</i>	FACU-
Willow Oak	<i>Quercus phellos</i>	FACW-
Northern Red Oak	<i>Quercus rubra</i>	FACU
Winged Sumac	<i>Rhus copallina</i>	NI
Black Willow	<i>Salix nigra</i>	OBL
American Black Elderberry	<i>Sambucus nigra</i>	FACW-
Winged Elm	<i>Ulmus alata</i>	FACU+

#### **4.4 VEGETATION OBSERVATIONS & CONCLUSIONS**

In general, the live stems were healthy and most exhibited new growth. In the past, a number of incidents where cattle entered the planted easement area were recorded. This has been corrected and the site appears to have recovered with healthy vegetative growth across the site. Because of low survival in the initial planting, areas with low survival were replanted during the winter/spring of 2009. The replanted trees appear healthy with new growth. Some plots are experiencing slower growth than was anticipated due to competition from eastern baccharis and dry conditions. All plots have met the interim success criteria of 320 stems per acres after three years, as documented by this report. One plot has experienced mortality due to competition and has fallen below the 5-year success criteria of 260 stems per acres. For the 2011 monitoring year, the average number of stems per acre on site is 464 and plots range from 240 to 720 stems per acre. Remedial action to control competition is recommended for the area around Plot 5. No additional remedial actions are recommended.

Herbaceous vegetation is healthy and locally dense. The plots in the enhancement areas exhibit less herbaceous density due to the forest canopy. Both hydrophytic and non-hydrophytic herbaceous vegetation is found across the site. The most common herbaceous species across the site (occurrence in at least 50 percent of the plots) are common rush, tall fescue, sawtooth blackberry, and Canada goldenrod.

### **5.0 STREAM MONITORING**

#### **5.1 STREAM SUCCESS CRITERIA**

As stated in the approved Mitigation Plan, the stream restoration success criteria for the site includes the following:

- *Bankfull Events*: Two bankfull flow events must be documented within the five-year monitoring period.
- *Cross-Sections*: There should be little change in as-built cross sections. Cross sections shall be classified using the Rosgen stream classification method and all monitored cross-sections should fall within the quantitative parameters defined for "E" or "C" type channels.
- *Longitudinal Profiles*: The longitudinal profiles should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. Bedforms observed should be consistent with those observed in "E" and "C" type channels.
- *Photo Reference Stations*: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures.
- *Benthic Macroinvertebrates*: Sampling of benthic macroinvertebrates within the restored stream channel shall be conducted for the first three years of post-restoration monitoring.

## **5.2 STREAM MORPHOLOGY MONITORING PLAN**

The stream monitoring program will be implemented to document system development and progress toward achieving the success criteria. The monitoring program will be undertaken for 5 years or until the final success criteria are achieved, whichever is longer.

### **5.2.1 Cross Sections**

Two permanent cross sections will be installed per 1,000 linear feet of stream restoration work, with one located at a riffle and one located at a pool. Each cross section will be marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross sections to facilitate easy comparison of year-to-year data. The annual cross-section survey will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross sections will be classified using the Rosgen stream classification system.

### **5.2.2 Longitudinal Profile**

A longitudinal profile will be measured annually throughout the five-year monitoring period. The profile will be measured along a representative length of restored channel. Measurements will include thalweg, water surface, bankfull, and top of low bank. Each of these measurements will be taken at the head of each feature, for example, shallow, pool, and the max pool depth. The survey will be tied to a permanent benchmark.

### **5.2.3 Hydrology**

The occurrence of bankfull events within the monitoring period will be documented by the use of a crest gauge and photographs. The two crest gauges will record the highest watermark between site visits, and the gauge will be checked monthly to document high flows. Digital images will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

### **5.2.4 Photo Reference Stations**

Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures.

## 5.3 STREAM MORPHOLOGY MONITORING RESULTS

### 5.3.1 Cross Sections

The cross sections were surveyed during the monitoring set-up, Year 1, Year 2, Year 3, and in August 2011 for Year 4. The baseline data has been compared with the Year 1-3 monitoring data in **Appendix B**. Compared to the documented baseline data, the Year 4 channel cross sections showed that overall stream dimensions remained stable throughout the growing season. Very little change is noticed through Year 4 Monitoring on most cross sections. Cross Sections 6, 7 and 13 show a slight amount of aggradation but present no threat to channel stability.

### 5.3.2 Longitudinal Profile

A longitudinal profile survey was conducted along six separate reaches of the restoration project, totaling approximately 3,455 linear feet. Survey was conducted in reach UT1-B Upper from STA 112+72 to STA 119+20, in reach UT1-C from STA 107+00 to STA 112+72, in reach UT1-D from STA 154+00 to STA 158+30, in reach UT1-F from STA 182+80 to STA 185+80, in UT3-A from STA 239+00 to STA 335+00, and in reach UT3-B from STA 307+00 to STA 315+20. The longitudinal profile information documents the elevations and locations of known streambed features and in-stream grade control structures according to the As-Built survey plans, as shown in **Appendix A**. The profile and cross sections show that there has been very little adjustment to stream dimension since construction. **Table 13** summarizes stream areas requiring observation.

**Figure 6** shows the locations of the stream areas that require observation.

**Table 13. Stream Observation Areas**

SOA	Feature	STA	Description
SOA1	Left/Right Banks	UT1-A 153+00 - 153+30	Sparse vegetation on left and right banks, Re-seed with a permanent seed, will continue to monitor
SOA2	Right Bank Fencing	UT1-B 118+90	Easement fencing is loose at stream crossing allowing potential cattle access, Repair and reinforcement is recommended.
SOA3	Left/Right Banks	UT3 304+30 - 304+50	Sparse vegetation on left and right banks, Re-seed with a permanent seed, will continue to monitor
SOA4	Left Bank	UT3 329+50 - 329+80	Sparse vegetation on left bank, Re-seed with a permanent seed, will continue to monitor
SOA5	Right Bank	UT3 335+10 - 335+40	Localized erosion on right bank, Re-seed with a permanent seed, will continue to monitor

### 5.3.3 Hydrology

During 2011, three crest gauges were monitored to determine if there were any out-of-bank events in the Beaverdam stream channel (**Table 14**). All three crest gauges recorded bankfull events between February and October. CG1 (UT1-A) had two bankfull events in the months of April and October. CG2 (UT2) recorded only one event in April, however, CG3 (UT3-A) had three bankfull events in 2011. The largest stream flow documented for Year 4 by the onsite crest gauges was a flow that occurred during April by CG2 at a height of 1.10 feet. CG3 also had a 1.10 feet bankfull event recording during the February site visit. Due to drought conditions in early 2011 most restored reaches lacked flow for a portion of the monitoring period.



0 100 200 400  
Feet  
1 inch = 200 feet

**WK DICKSON**  
WATERSHED SCIENCES



Figure 6b  
Beaverdam Mitigation Project  
2011 Stream Current Conditions Map



0 100 200 300 400  
Feet  
1 inch = 200 feet

**WK** DICKSON  
WATERSHED SCIENCES

**Table 14. Crest Gauge Data**

Month Recorded	CG1	CG2	CG3
January	---	---	---
February	---	---	1.10
March	---	---	---
April	0.50	1.10	0.60
May	---	---	---
June	---	---	---
July	---	---	---
August	---	---	---
September	---	---	---
October	0.30	---	0.75
November	---	---	---
December	---	---	---

## 5.5 STREAM CONCLUSIONS

In-stream structures installed within the channel include cross vanes, log vanes, rock vanes, log weirs, and step-pools. Visual observations of structures throughout the 2011 growing season indicated that most structures are functioning as designed. Two rock-A-vanes on UT2 are experiencing slight piping around the header rocks. These structures are stable however; they are not functioning properly due to the header rocks being set too high. On UT1-B at station 118+90 the easement fencing on the right bank of the crossing is loose permitting cattle access into the easement. Repair and reinforcement to the fencing is recommended. Sparse vegetation along both left and right banks of UT1-A from station 153+00 to 153+30 is present. Also on UT3 there are two areas of sparse vegetation from station 304+30 to 304+50 on the left and right banks, and 329+50 to 329+80 on the left bank. From station 335+10 to 335+40 minor localized erosion along the right bank is present. It is recommended that these areas be reseeded with a permanent seed. No major areas of bank erosion or stability issues were observed. The banks and structures will be monitored to ensure that they remain stable. **Table 15** summarizes the morphologic parameters; a more detailed morphologic parameters table is provided in **Appendix E**.

**Table 15. Summary of Morphologic Monitoring Parameter**

Parameter		Bankfull Xsec Area, Abkf (sq ft)	Avg. Bankfull Width, Wbkf (ft)	Bankfull W/D Ratio	Bankfull Mean Depth, Dbkf (ft)	Bankfull Max Depth, Dmax (ft)
Reach UT1-A	<b>As-Built</b>	9.6	7.6	6.1	1.3	1.9
	<b>Year 1</b>	7.5	7.4	7.3	1	1.7
	<b>Year 2</b>	8	10.2	13.1	0.8	1.8
	<b>Year 3</b>	8.5	9.1	9.8	0.9	1.9
	<b>Year 4</b>	8.2	8.4	8.6	1	1.7
Reach UT1-B Upper	<b>As-Built</b>	5.8	9.9	16.9	0.6	1.1
	<b>Year 1</b>	4.6	9	17.5	0.5	0.9
	<b>Year 2</b>	4.4	9.1	18.8	0.5	0.9
	<b>Year 3</b>	4.5	11.2	28.1	0.4	0.9
	<b>Year 4</b>	5	9.3	17.6	0.5	1
<b>Reach UT1-C</b>	<b>As-Built</b>	18.4	16.4	14.6	1.1	2.5

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Parameter		Bankfull Xsec Area, Abkf (sq ft)	Avg. Bankfull Width, Wbkf (ft)	Bankfull W/D Ratio	Bankfull Mean Depth, Dbkf (ft)	Bankfull Max Depth, Dmax (ft)
	<b>Year 1</b>	16.5	15.1	13.7	1.1	2.1
	<b>Year 2</b>	9.5	10.1	12.5	0.9	1.6
	<b>Year 3</b>	15.1	16.9	18.8	0.8	2.3
	<b>Year 4</b>	15.5	16.8	18.3	0.9	2
<b>Reach UT1-D</b>	<b>As-Built</b>	6.8	9.8	14	0.7	1.3
	<b>Year 1</b>	9	11.8	15.4	0.8	1.5
	<b>Year 2</b>	8.7	11.5	15.1	0.8	1.5
	<b>Year 3</b>	8.3	12.4	18.4	0.7	1.4
	<b>Year 4</b>	8.1	12.2	18.5	0.7	1.3
<b>Reach UT1-F</b>	<b>As-Built</b>	5.4	9	15.1	0.6	1.2
	<b>Year 1</b>	4.8	9.2	17.4	0.5	1
	<b>Year 2</b>	5.2	9.9	18.7	0.5	1
	<b>Year 3</b>	4.8	8.9	16.5	0.5	1
	<b>Year 4</b>	4.5	9.6	20.4	0.5	1
<b>Reach UT2</b>	<b>As-Built</b>	9.5	10.5	11.6	0.9	1.7
	<b>Year 1</b>	9.1	10.4	11.9	0.9	1.6
	<b>Year 2</b>	8.9	10.4	12.1	0.9	1.6
	<b>Year 3</b>	9.2	10.7	12.4	0.9	1.7
	<b>Year 4</b>	8.4	10.5	13.1	0.8	1.5
<b>Reach UT3-A</b>	<b>As-Built</b>	181.1	50.1	13.9	3.6	6.8
	<b>Year 1</b>	176	47.3	12.8	3.8	6.9
	<b>Year 2</b>	4.7	8.2	14.3	0.6	1.3
	<b>Year 3</b>	5.1	9.4	17.2	0.5	1.3
	<b>Year 4</b>	4	8.4	18.65	0.5	1
<b>Reach UT3-B Upper</b>	<b>As-Built</b>	14.9	24.1	39.8	0.6	1.4
	<b>Year 1</b>	13.9	23.6	40.7	0.6	1.3
	<b>Year 2</b>	3.4	7.8	18.7	0.4	0.8
	<b>Year 3</b>	15	24.2	39	0.6	1.3
	<b>Year 4</b>	11.5	18.7	30.55	0.55	1.1

Note: The data presented here are averages of the cross section data for each stream reach. Variations in the data are due to channel adjustment and changes in bankfull elevation.

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

- One of the five hydrology monitoring stations within the restoration/enhancement area recorded hydroperiods of at least 10 percent of the growing season and met the hydrologic success criterion for 2011. BDRAW1 was the only reference gauge to experience a hydroperiod above 10 percent of the growing season. BDAW5 and BDAW7 recorded hydroperiods of 8 percent of growing season. Only BDRAW2 was below 5 percent. The groundwater elevation at BDRAW2 may be affected by its

*Beaverdam Mitigation Site  
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relatively close location to the channel. Reference gauges 2 and 3 (BDRAW2 and BDRAW3) had hydroperiods of 8 percent of the growing season.

- Gauges BDAW 3, BDAW4, and BDAW8 are located in potential wetland restoration areas and had hydroperiods less than the success criterion.
- Dunn weather station rainfall data indicates that the 2011 growing season rainfall amounts were below normal for most of the growing season, except for May, June and August when rainfall levels were within the normal range or slightly above.
- Dunn weather station rainfall data indicates that 2010 and 2011 annual rainfall patterns are below normal limits.
- Vegetation monitoring efforts have documented the average number of stems per acre on site to be 464 for the 2011 monitoring year, with the range of stem density being 240 to 720 stems per acre.
- All plots met the interim success criteria of 320 stems per acres after three years. Plot 5 has experienced mortality due to competition and has fallen below the 5-year success criteria of 260 stems per acres. Remedial action to control competition is recommended for the area around Plot 5. No additional remedial actions are recommended.
- Data collected during monitoring Year 4 and observations of conditions at the site indicate that the project continues to be successful. The stream morphology is generally stable. Two rock cross-vane structures were stable, but not functioning as designed. The structures will not affect the site's ability to achieve the stream success criteria. It is recommended that the easement fence on UT1-B be fixed to keep cattle out of the easement. One area along UT1-A from station 153+00 to 153+30 on both the left and right banks and three areas on UT3 from 304+30 to 304+50 left and right banks, 329+50 to 329+80 left bank, and 335+10 to 335+40 right bank need to be reseeded with a permanent seed. It was concluded that the site continues to be on track to achieve the stream success criteria specified in the Restoration Plan.
- Vegetation, hydrologic, and stream monitoring will continue through 2012.

## **APPENDIX A**

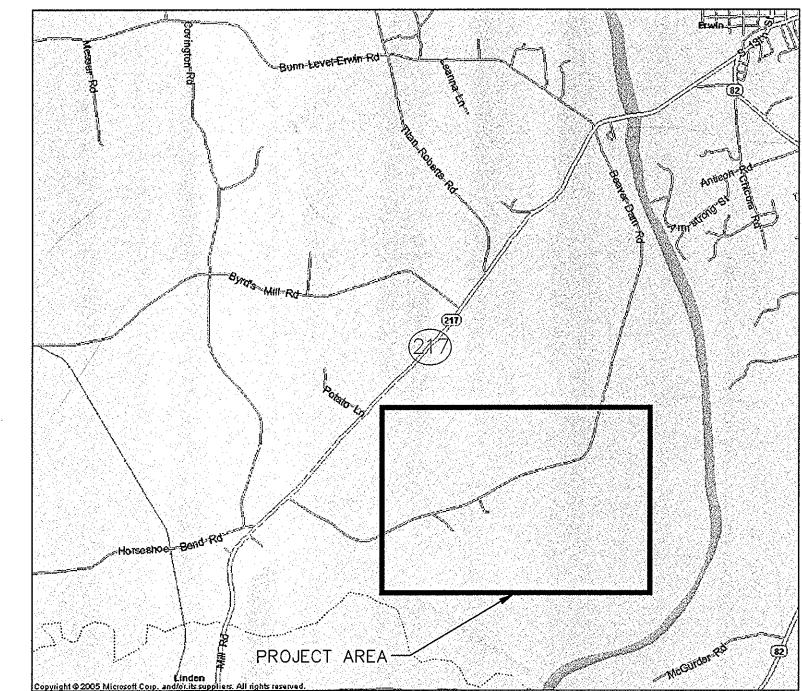
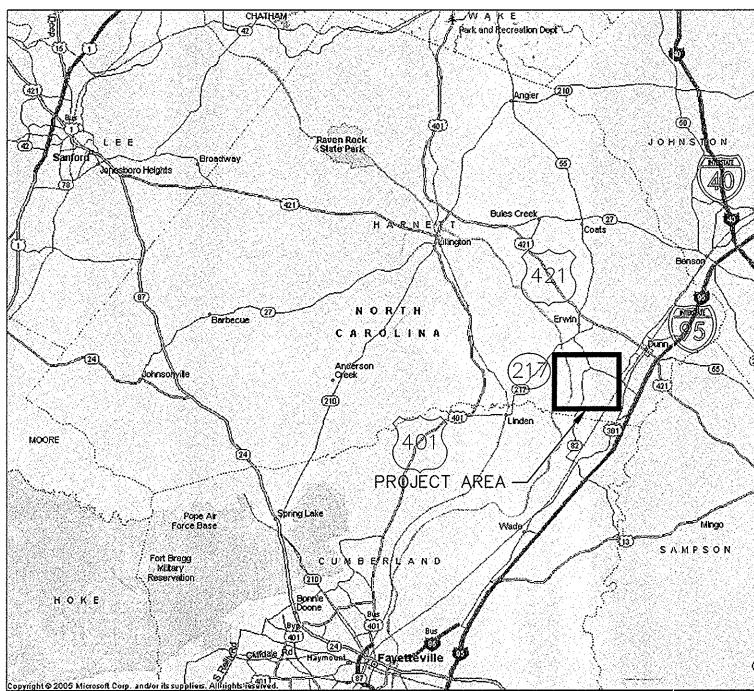
### **As-Built Survey**



# RECORD SET FOR BEAVERDAM SWAMP STREAM AND WETLAND RESTORATION PROJECT EBX NEUSE I, LLC



HARNETT COUNTY, NORTH CAROLINA  
STATE PROJECT NO.: D06029-B



## INDEX OF SHEETS

SHEET NO.	DESCRIPTION
1	TITLE SHEET
2-3	LEGENDS AND SYMBOLS
4-19	GRADING PLAN AND PROFILE
20-23	TYPICAL CROSS SECTIONS
24-39	PLANTING PLAN

*The record drawings represent the construction plans with adjustments made to represent constructed conditions.*

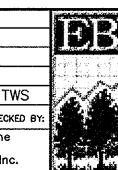


906 N. QUEEN ST., SUITE A  
KINSTON, NC 28501  
TEL: 252-522-2500 FAX: 252-522-4747  
EMAIL: MATRIX@EARTHLINK.NET

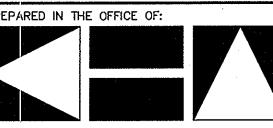
NC-EEP CONTACT: GUY PEARCE (919) 715-1656  
KIMLEY-HORN AND ASSOCIATES CONTACT: TODD ST. JOHN, P.E. (919) 653-2950  
ENVIRONMENTAL BANC & EXCHANGE CONTACT: NORTON WEBSTER (919) 829-9909  
DISTURBED AREA: 33.4 ACRES

1	REVISED PER EROSION CONTROL REVIEW	08/23/07	JIK	TWS
REV.:	DATE:	DRAWN BY:	CHECKED BY:	

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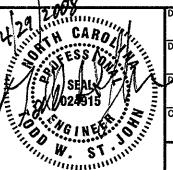
PREPARED IN THE OFFICE OF:



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CLIENT: STATE OF NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM	TITLE: TITLE SHEET
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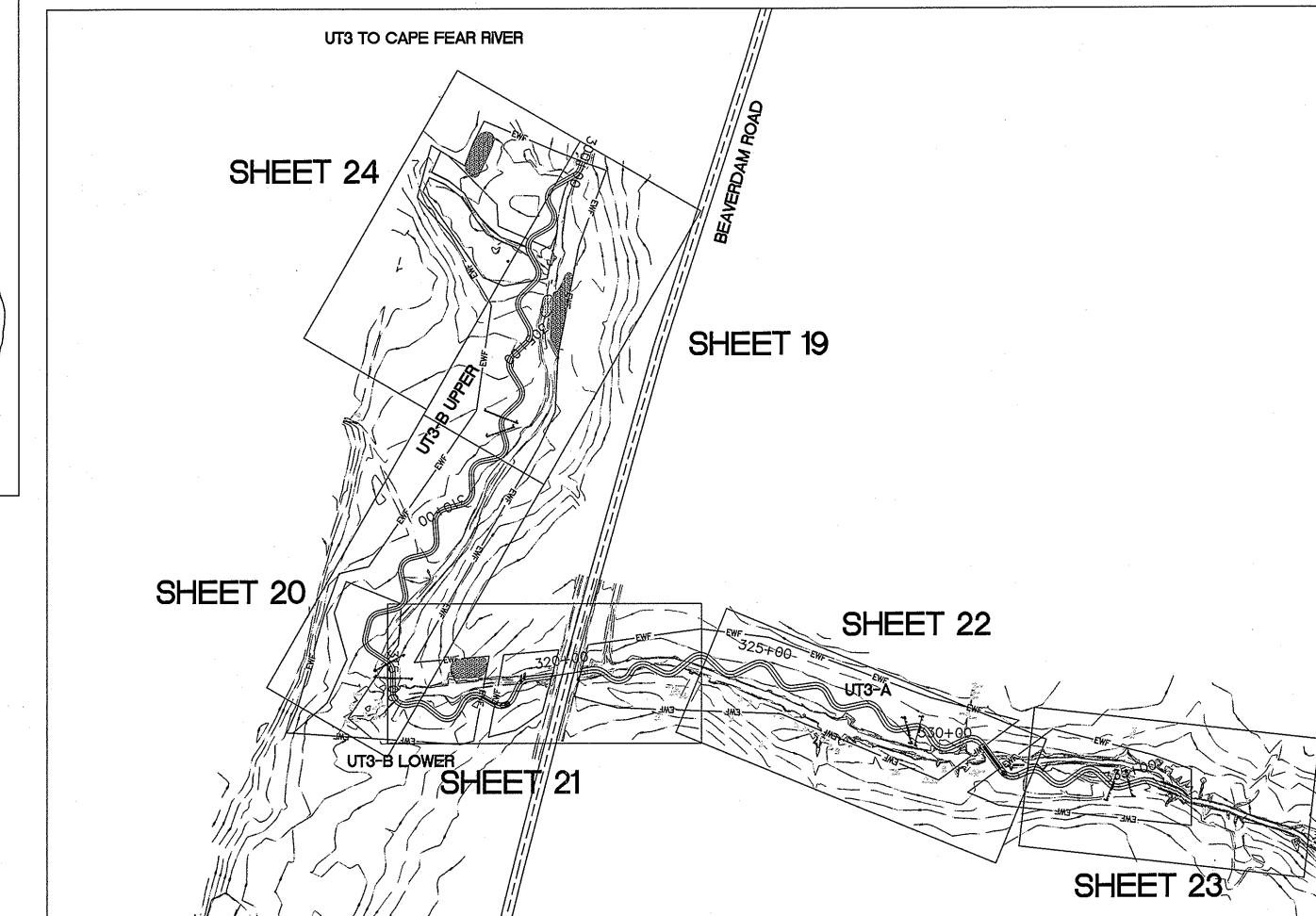
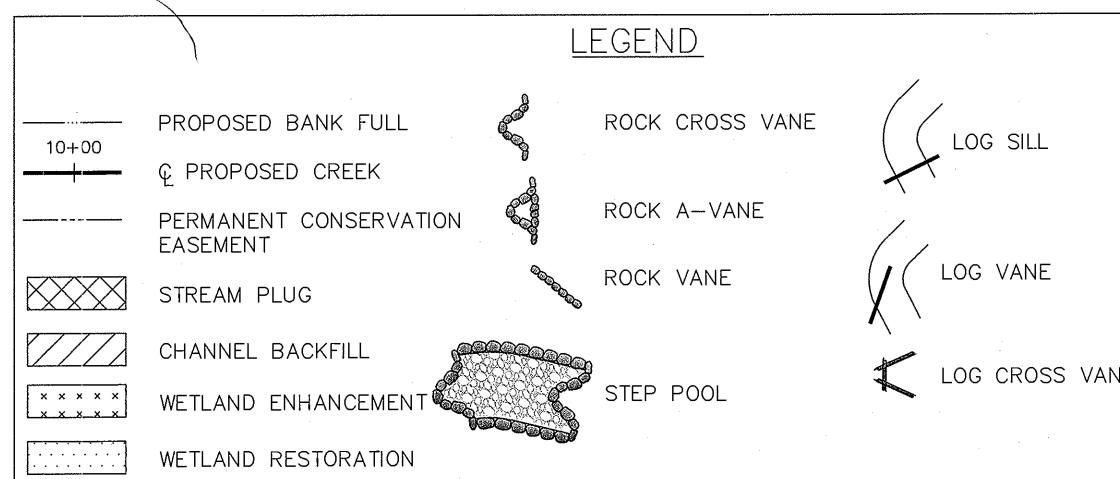
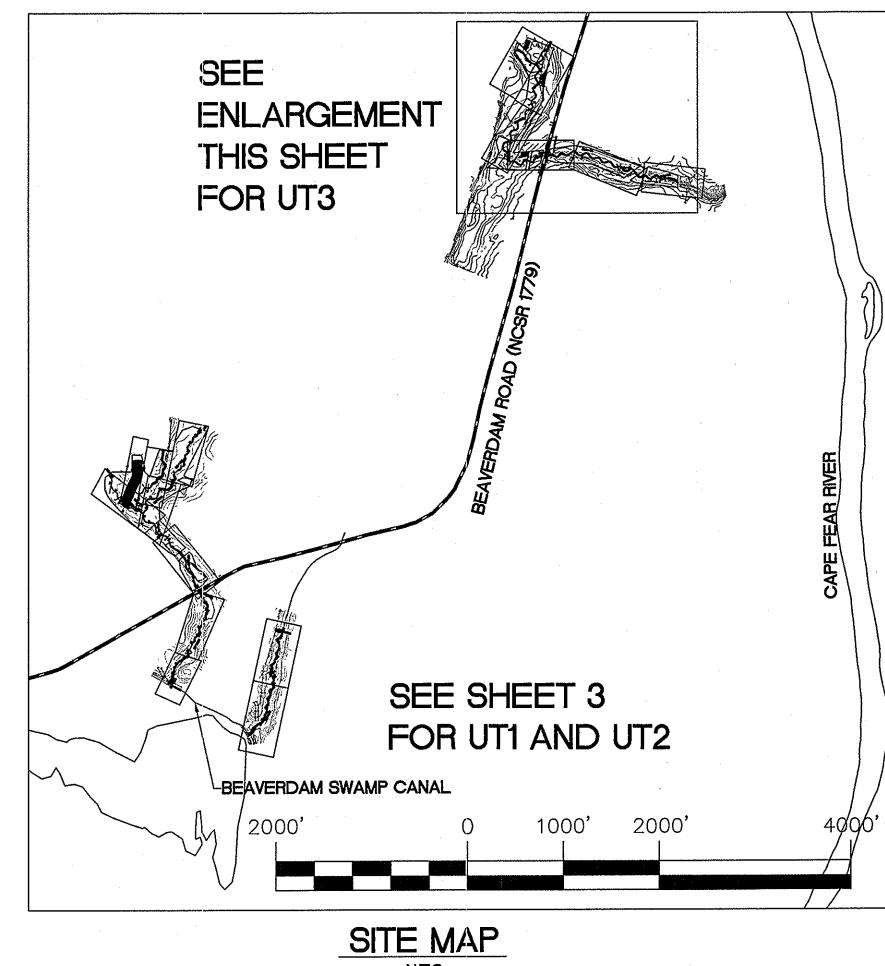
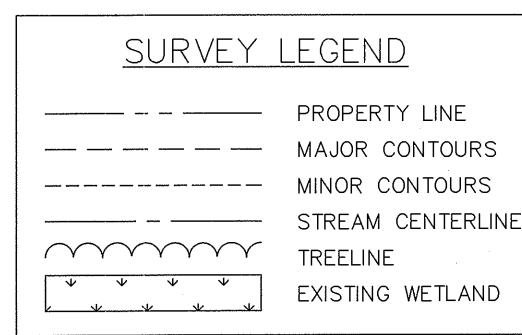


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DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT:  
**BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC**

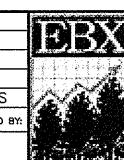
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JOB NUMBER: 012620010 SHEET NUMBER: 1

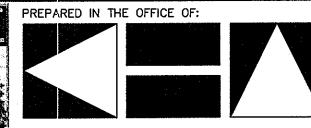


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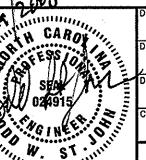


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ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: LEGENDS AND SYMBOLS

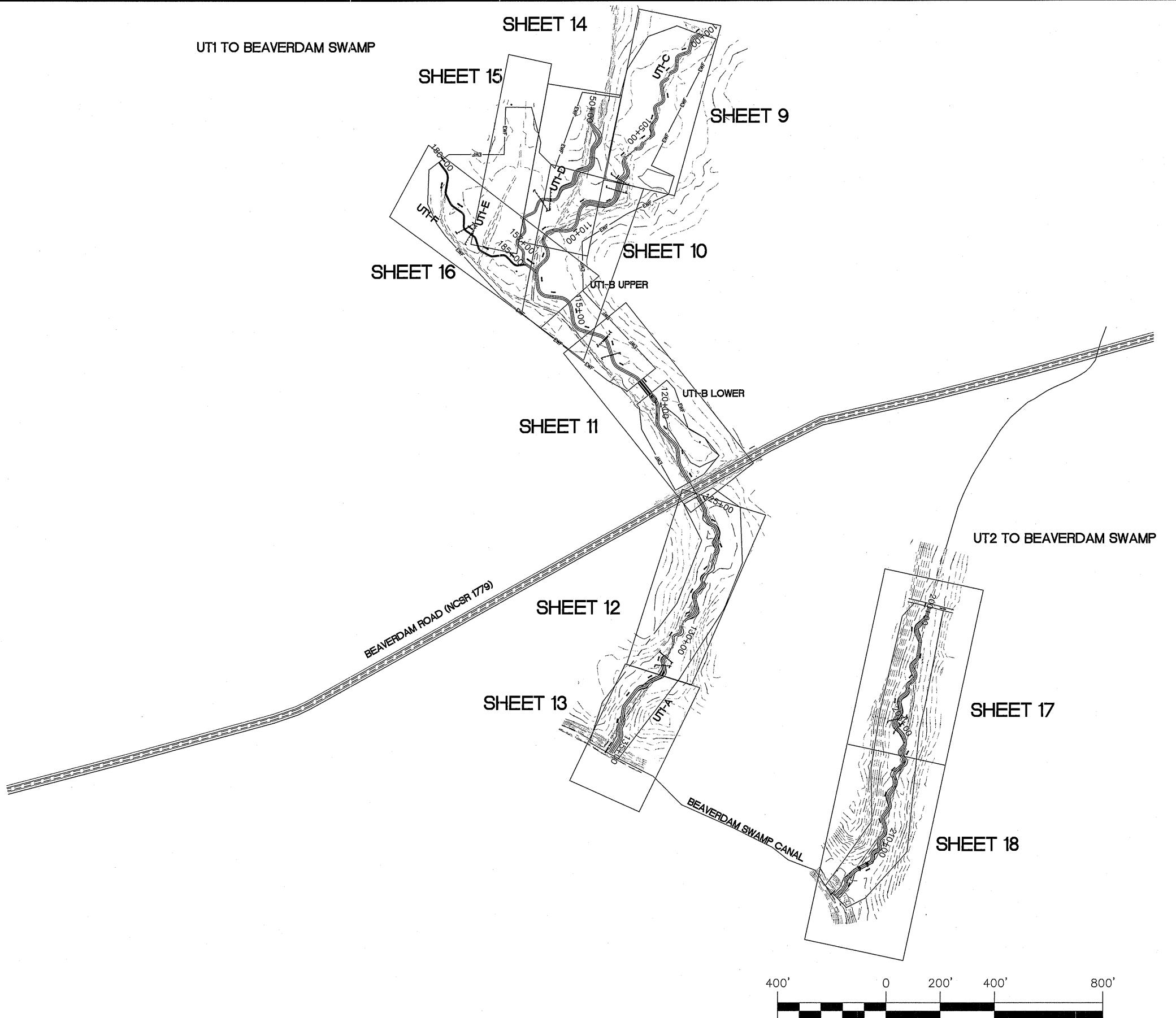


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STREAM AND WETLAND RESTORATION  
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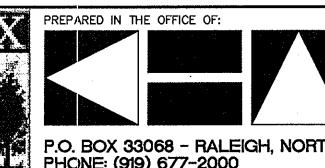
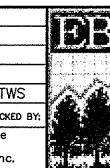
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TITLE: LEGENDS AND SYMBOLS

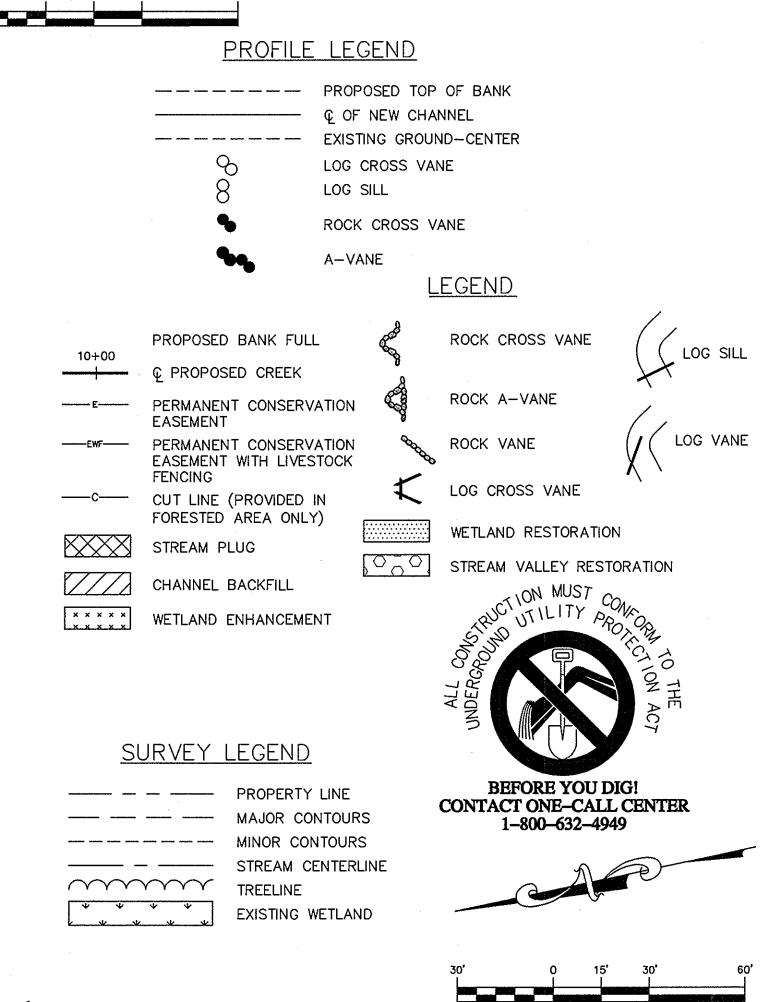
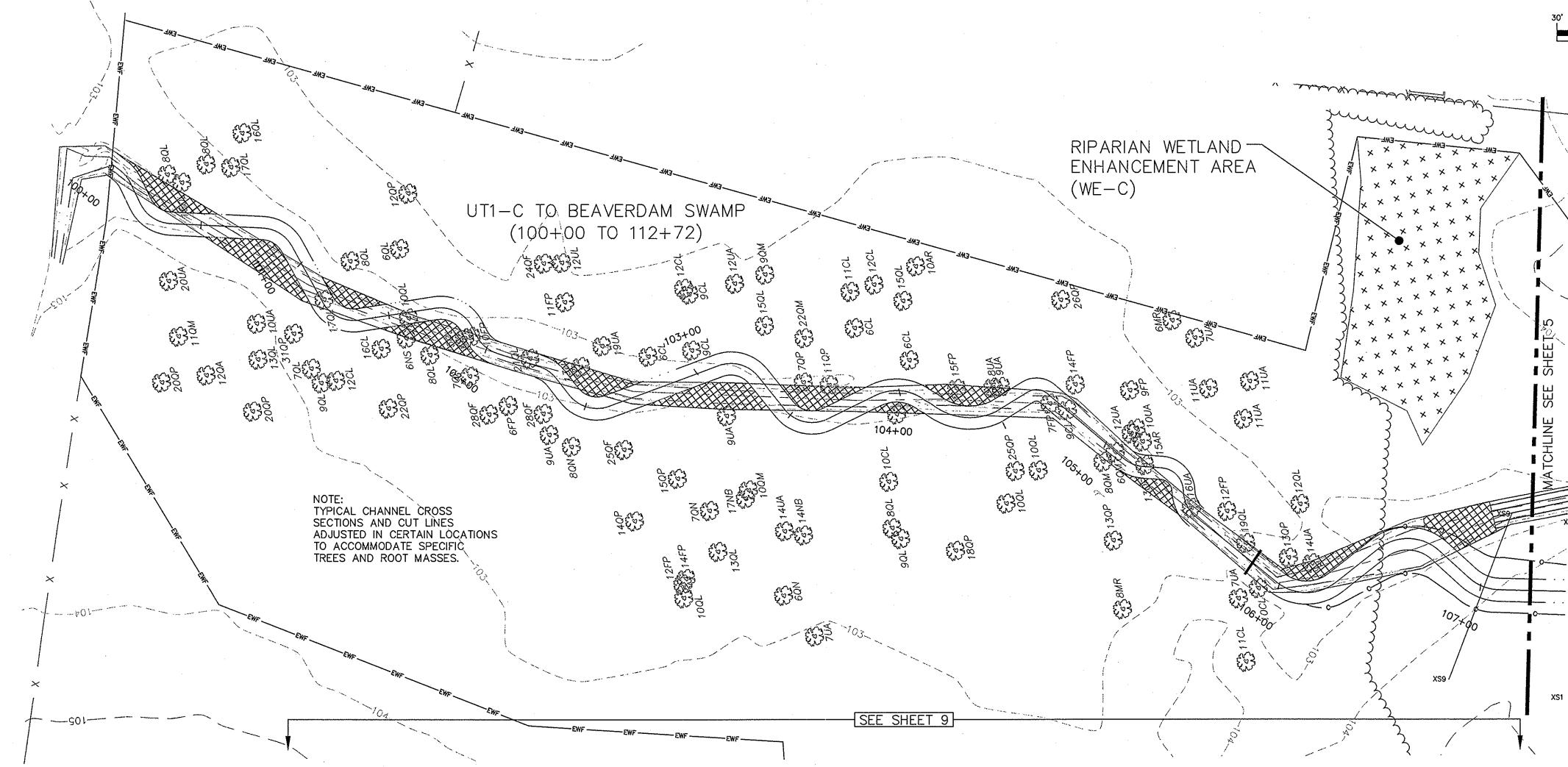
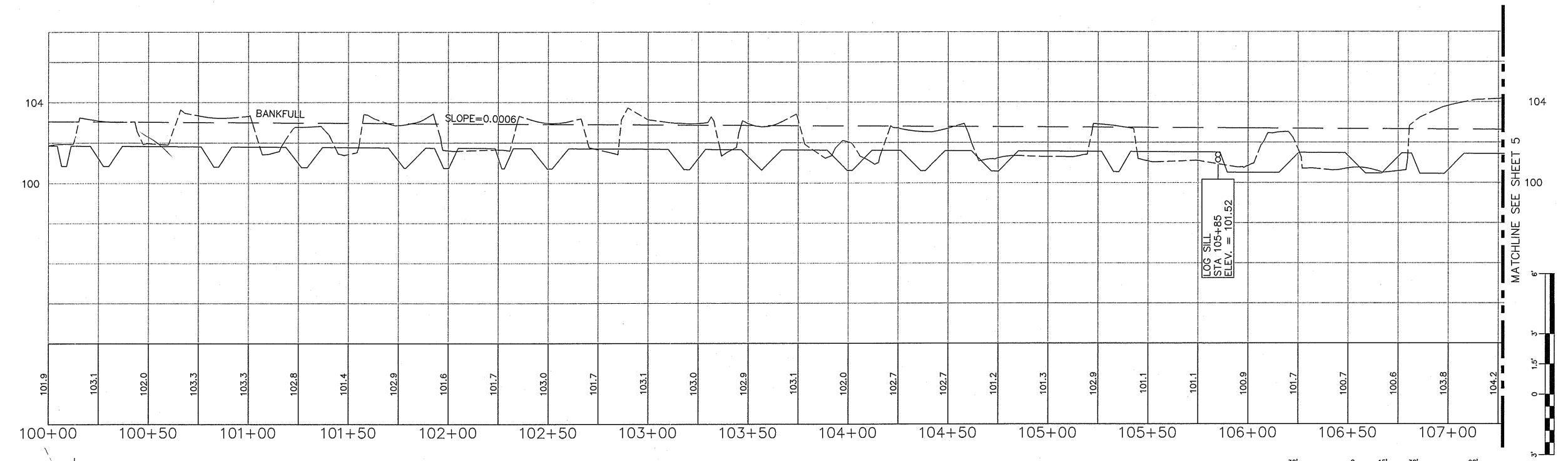


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DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

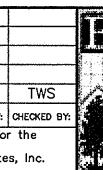
PROJECT: BEAVERDAM SWAMP  
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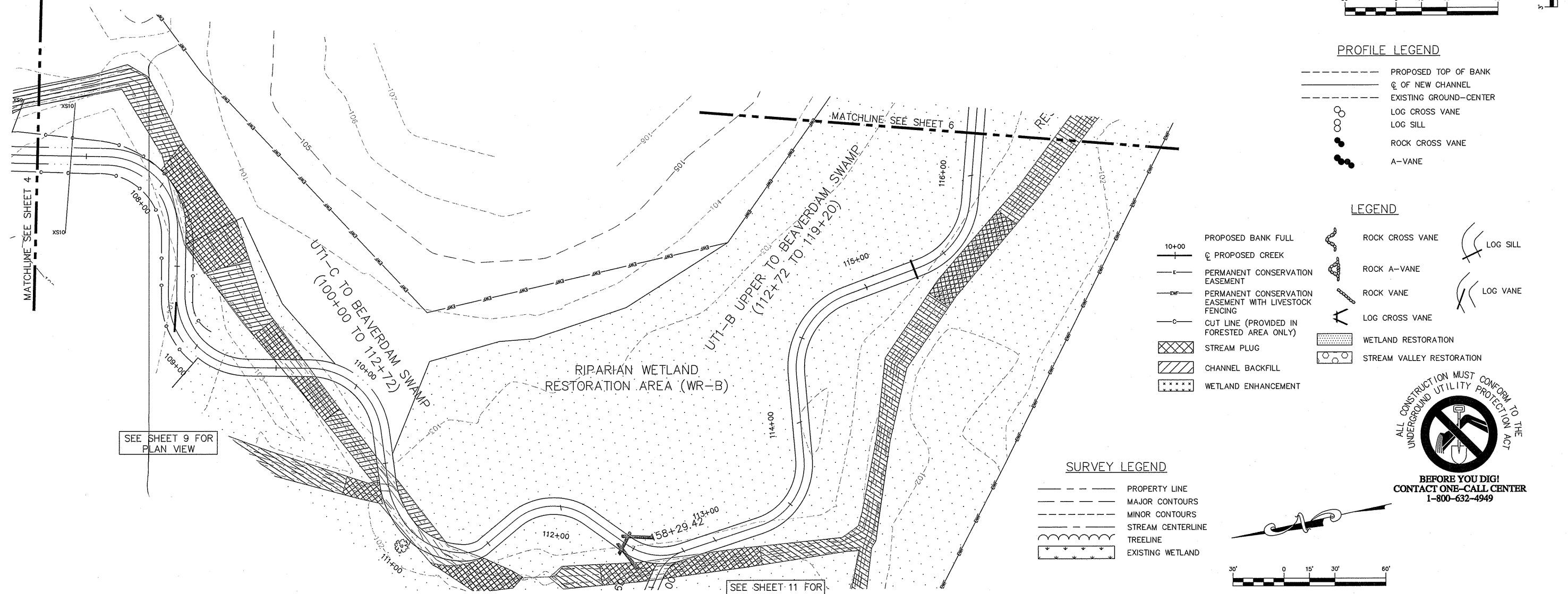
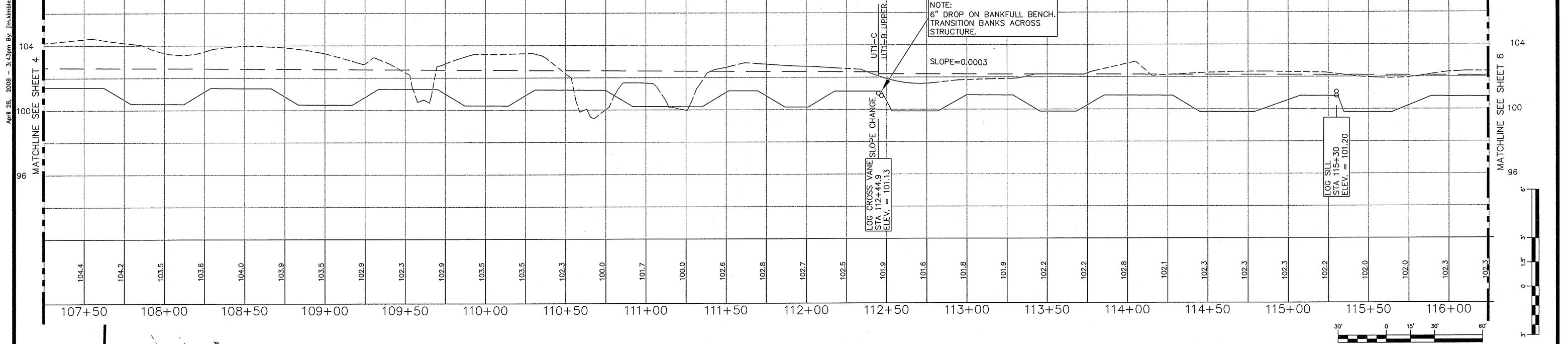


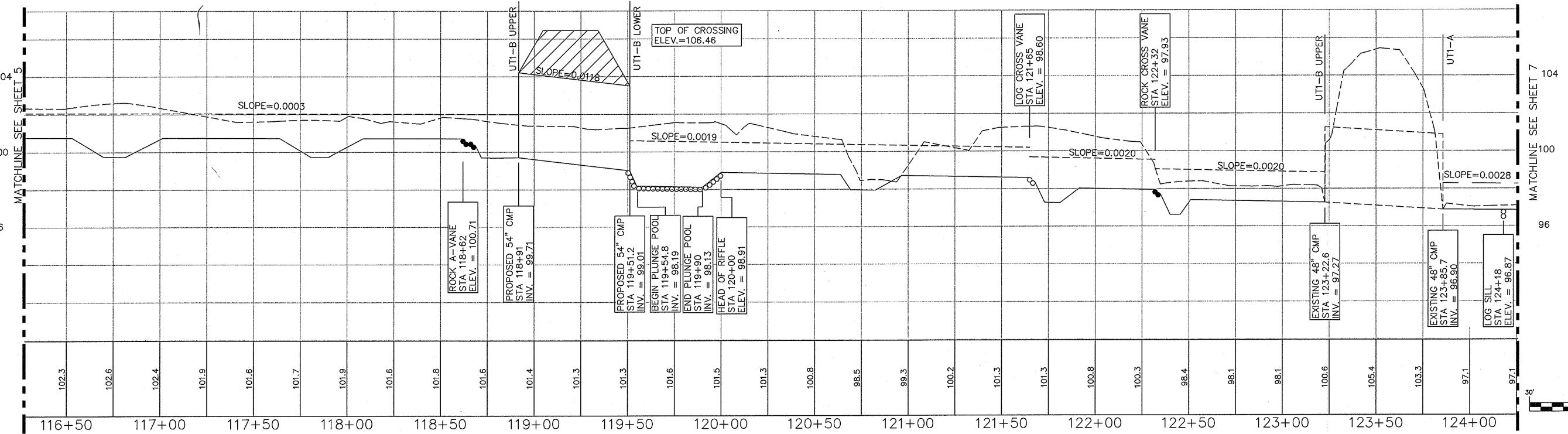
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DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
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EBX NEUSE I, LLC

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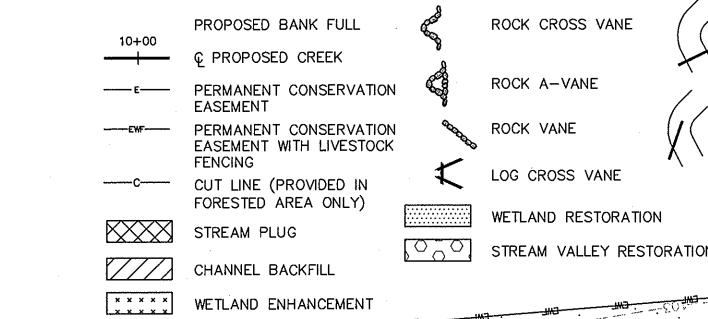
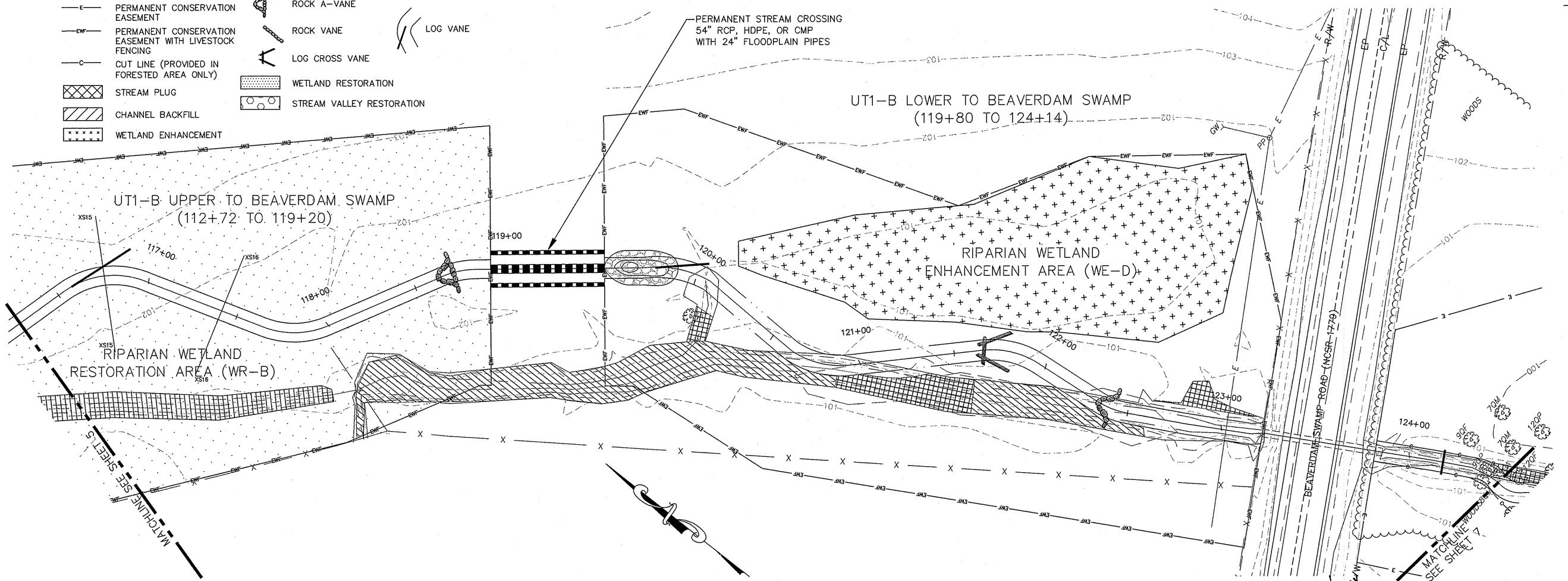
JOB NUMBER: 012620010 SHEET NUMBER: 4





PROFILE LEGEND

- PROPOSED TOP OF BANK
- OF NEW CHANNEL
- EXISTING GROUND-CENTER
- LOG CROSS VANE
- LOG SILL
- ROCK CROSS VANE
- A-VANE

UT1-B UPPER TO BEAVERDAM SWAMP  
(112+72 TO 119+20)

SURVEY LEGEND

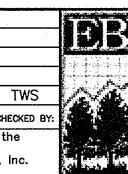
- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND



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30' 0 15' 30' 60'

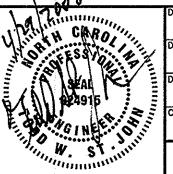
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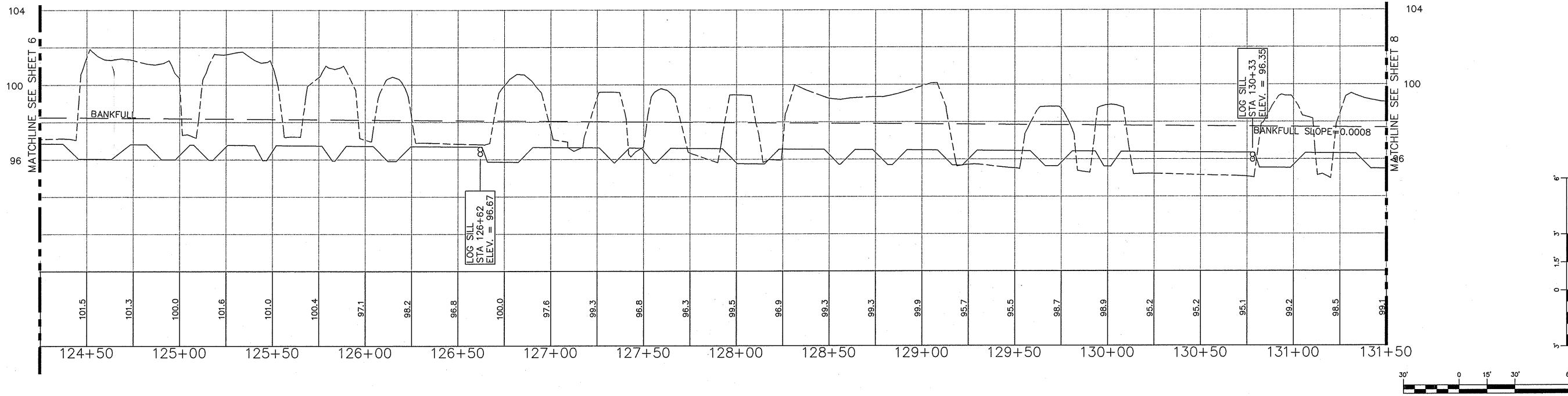
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STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC  
The record drawings represent the construction plans with  
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JOB NUMBER: 012620010 SHEET NUMBER: 6



## PROFILE LEGEND

- - - PROPOSED TOP OF BANK
- - - Q. OF NEW CHANNEL
- - - EXISTING GROUND-CENTER
- - - LOG CROSS VANE
- - - LOG SILL
- - - ROCK CROSS VANE
- - - A-VANE

## LEGEND

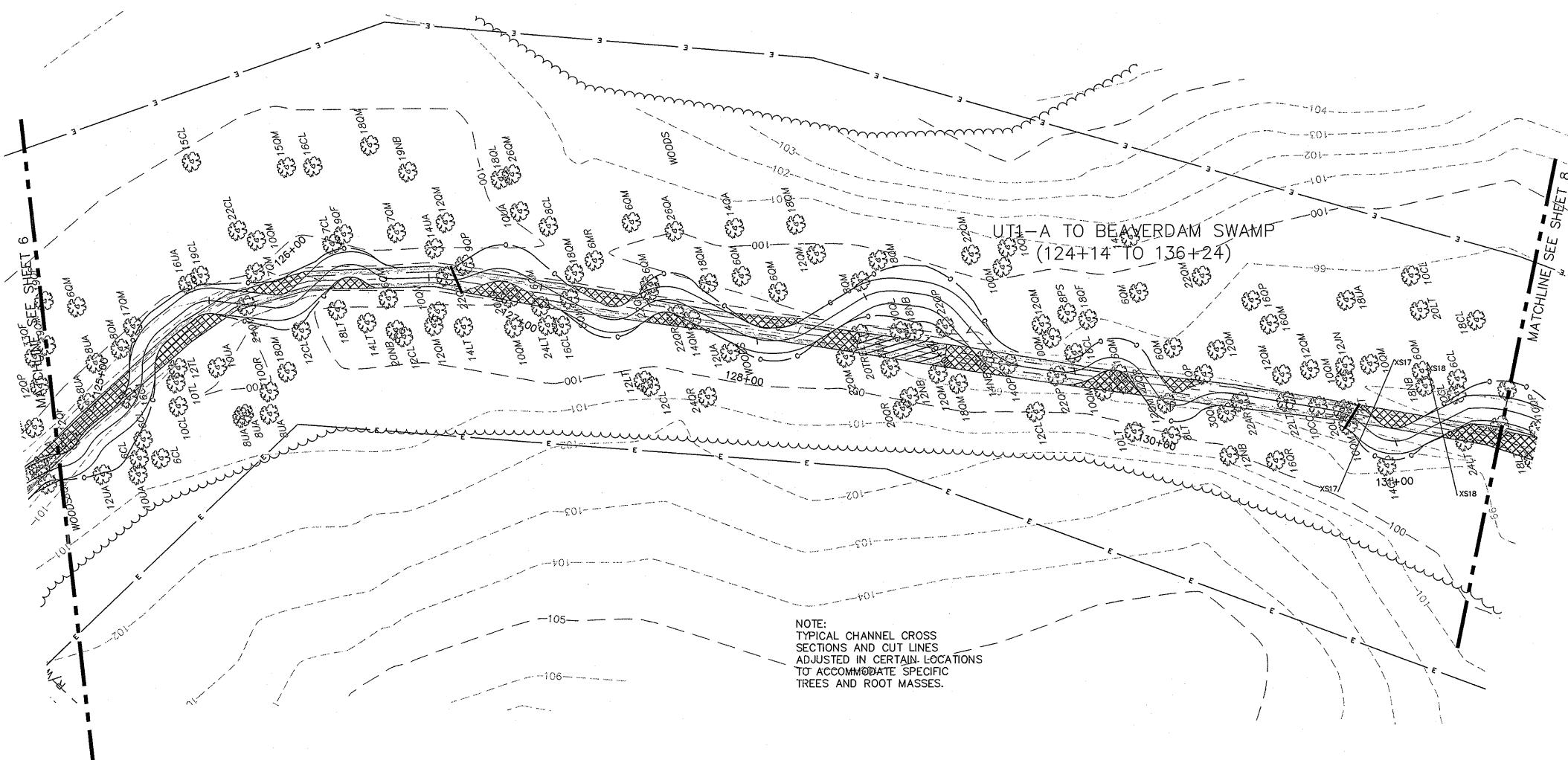
- - - PROPOSED BANK FULL
- - - C PROPOSED CREEK
- - - E PERMANENT CONSERVATION EASEMENT
- - - EWF PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
- - - C CUT LINE (PROVIDED IN FORESTED AREA ONLY)
- - - X STREAM PLUG
- - - H CHANNEL BACKFILL
- - - XXX WETLAND ENHANCEMENT
- ○ ○ LOG SILL
- ○ ○ LOG VANE
- ○ ○ LOG CROSS VANE
- ○ ○ ROCK VANE
- ○ ○ ROCK CROSS VANE
- ○ ○ A-VANE

## SURVEY LEGEND

- - - PROPERTY LINE
- - - MAJOR CONTOURS
- - - MINOR CONTOURS
- - - STREAM CENTERLINE
- - - TREELINE
- - - X X X EXISTING WETLAND

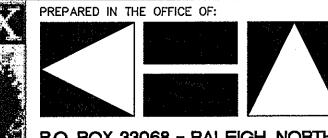


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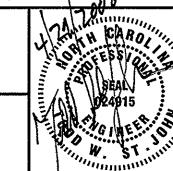
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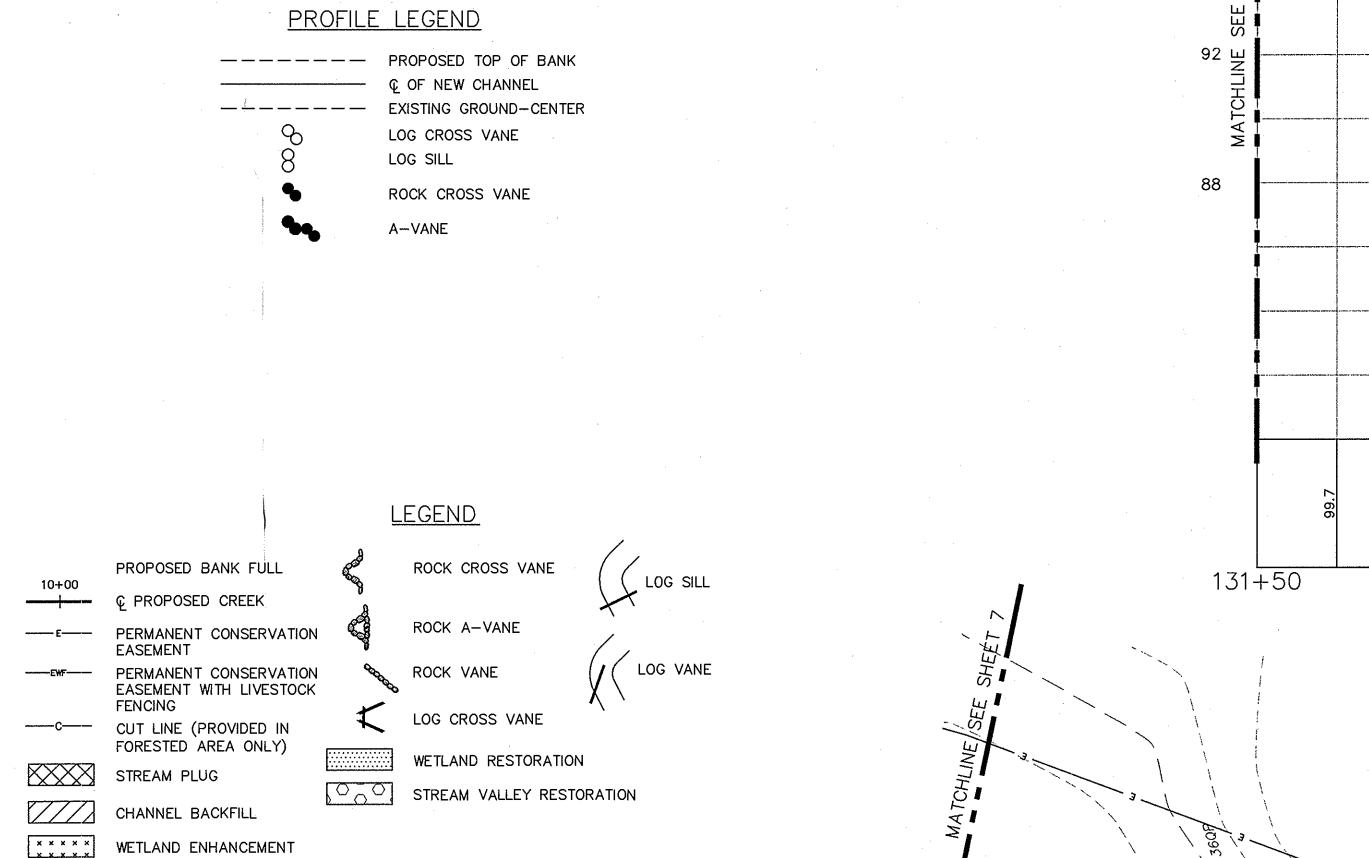


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DRAWN BY: JIK  
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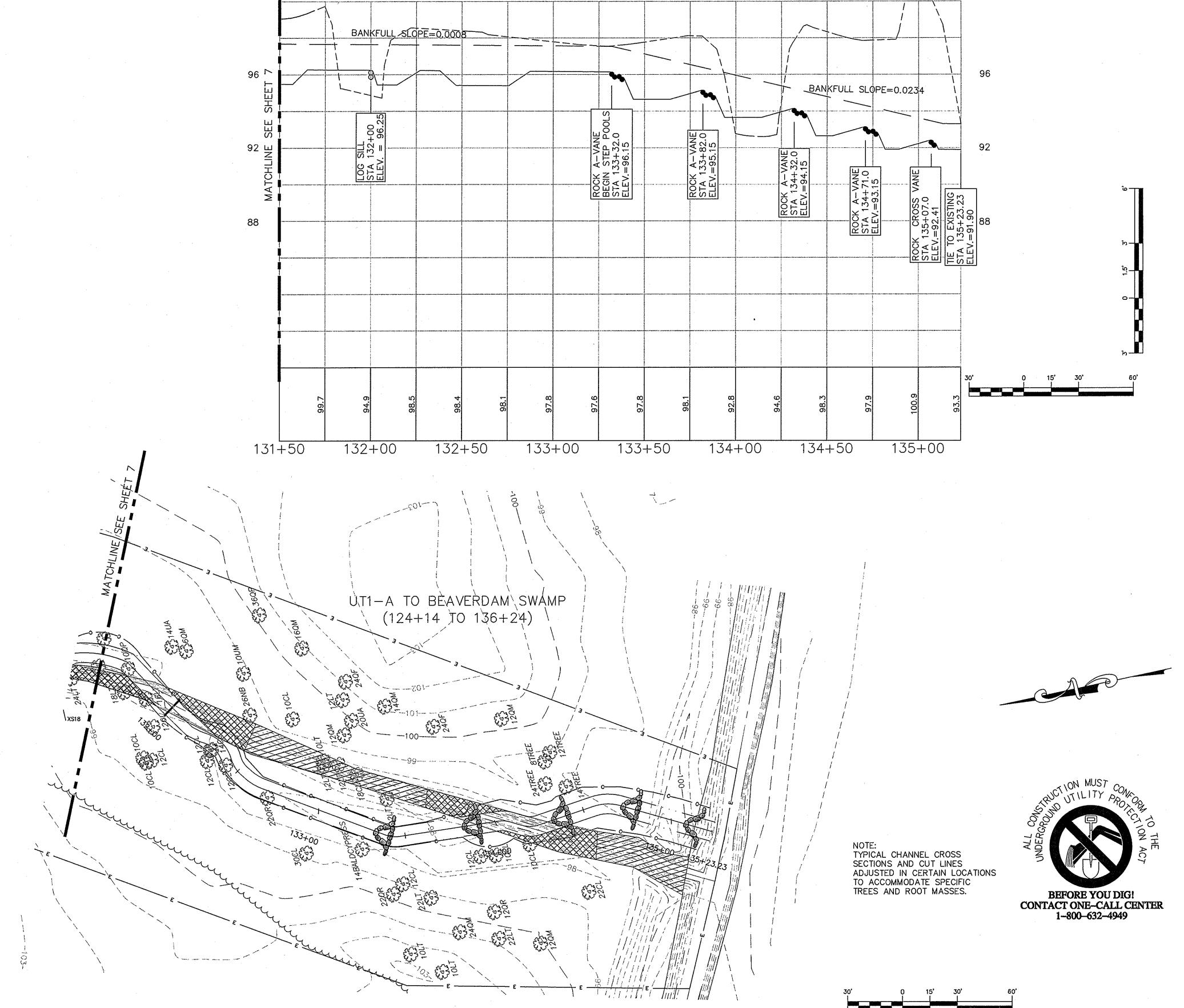
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JOB NUMBER: 012620010 SHEET NUMBER: 7

**SURVEY LEGEND**

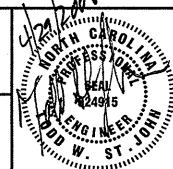
- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND



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TITLE:

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PROFILEDATE: 02/25/08  
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DESIGNED BY: RTL  
CHECKED BY: TSJ

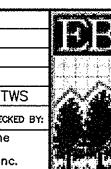
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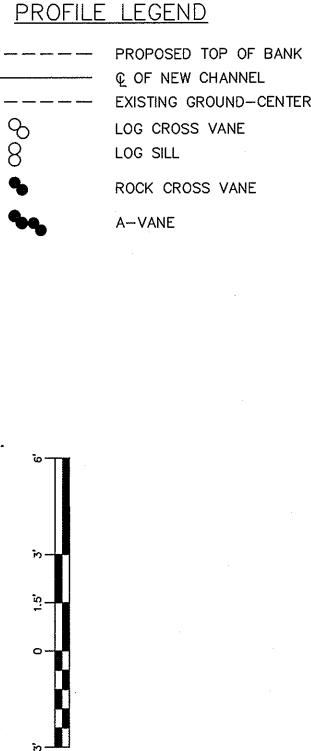
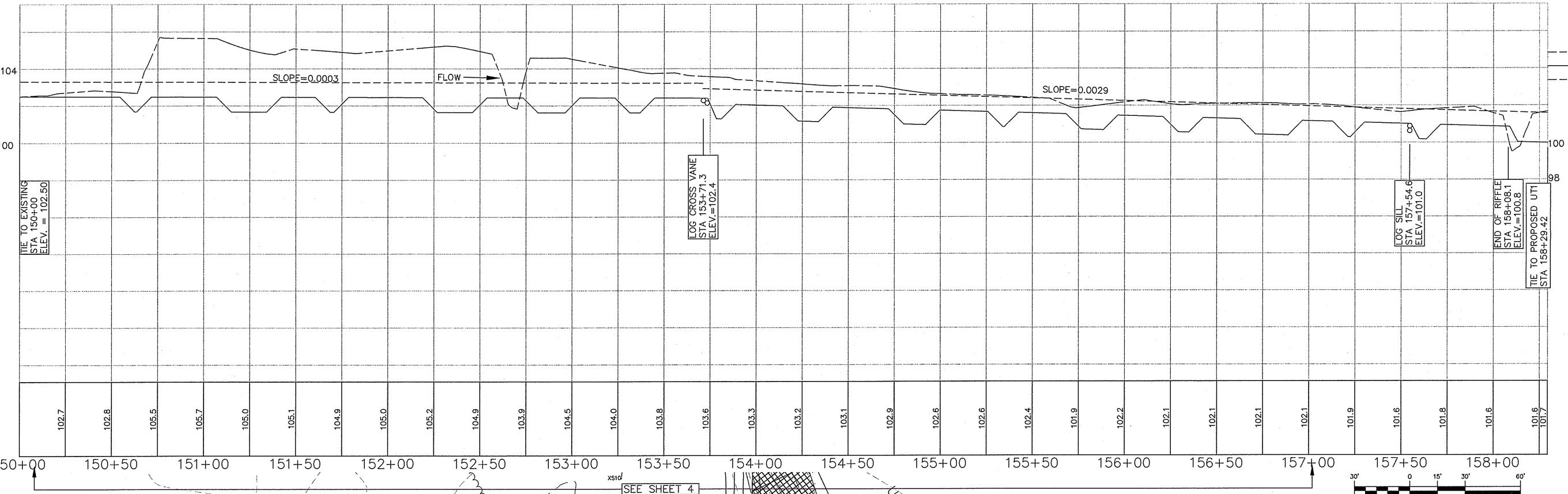


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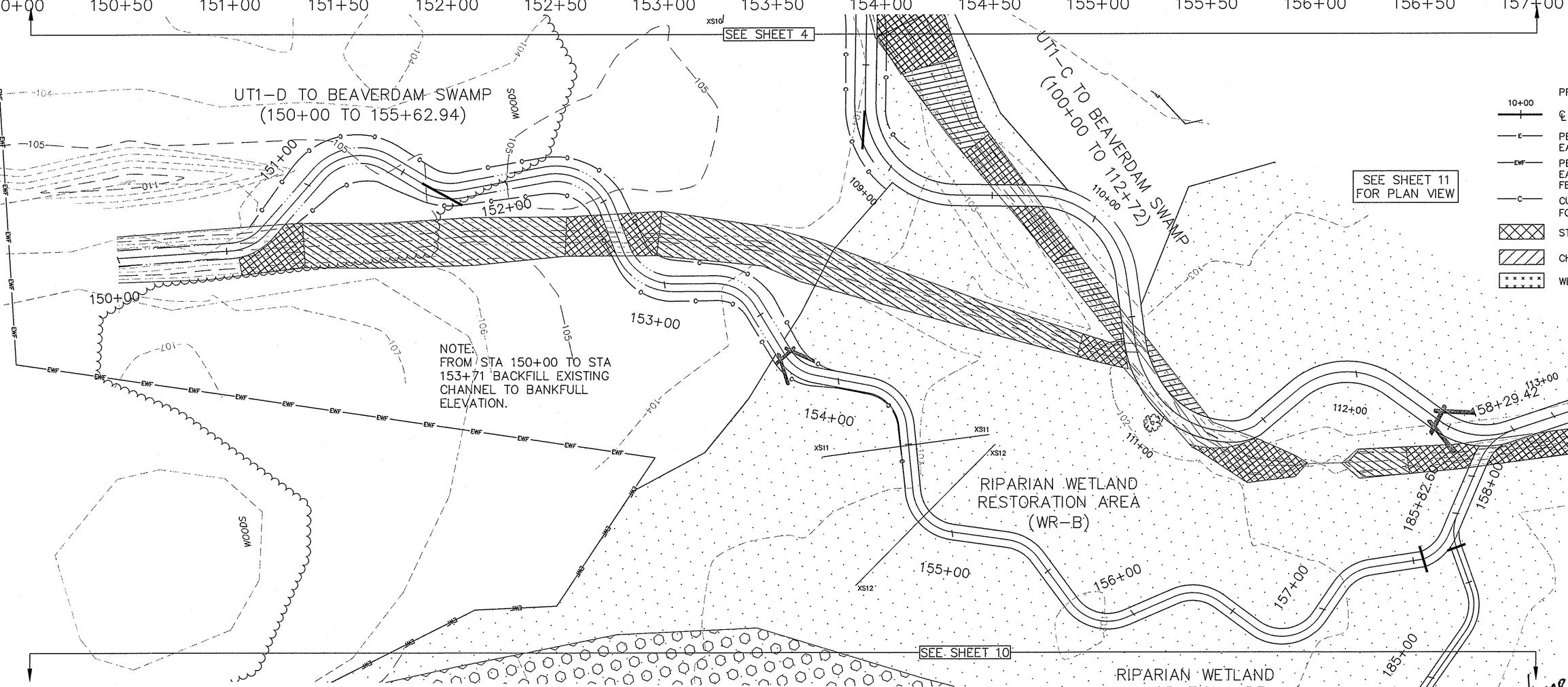
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## LEGEND

- PROPOSED BANK FULL
- Q PROPOSED CREEK
- E PERMANENT CONSERVATION EASEMENT
- EWF PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
- C CUT LINE (PROVIDED IN FORESTED AREA ONLY)
- STREAM PLUG
- CHANNEL BACKFILL
- WETLAND RESTORATION
- STREAM VALLEY RESTORATION
- WETLAND ENHANCEMENT



## SURVEY LEGEND

- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND

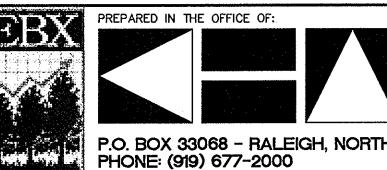


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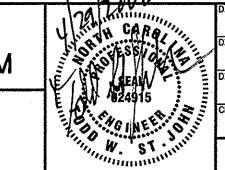
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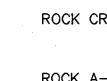
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**LEGEND**

10+00	PROPOSED BANK FULL
C	PROPOSED CREEK
E	PERMANENT CONSERVATION EASEMENT
EWF	PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
C	CUT LINE (PROVIDED IN FORESTED AREA ONLY)
XXXXX	STREAM PLUG
/	CHANNEL BACKFILL
*****	WETLAND ENHANCEMENT

**ROCK CROSS VANE**

ROCK A-VANE



LOG CROSS VANE



WETLAND RESTORATION



STREAM VALLEY RESTORATION

**LOG SILL**

LOG VANE



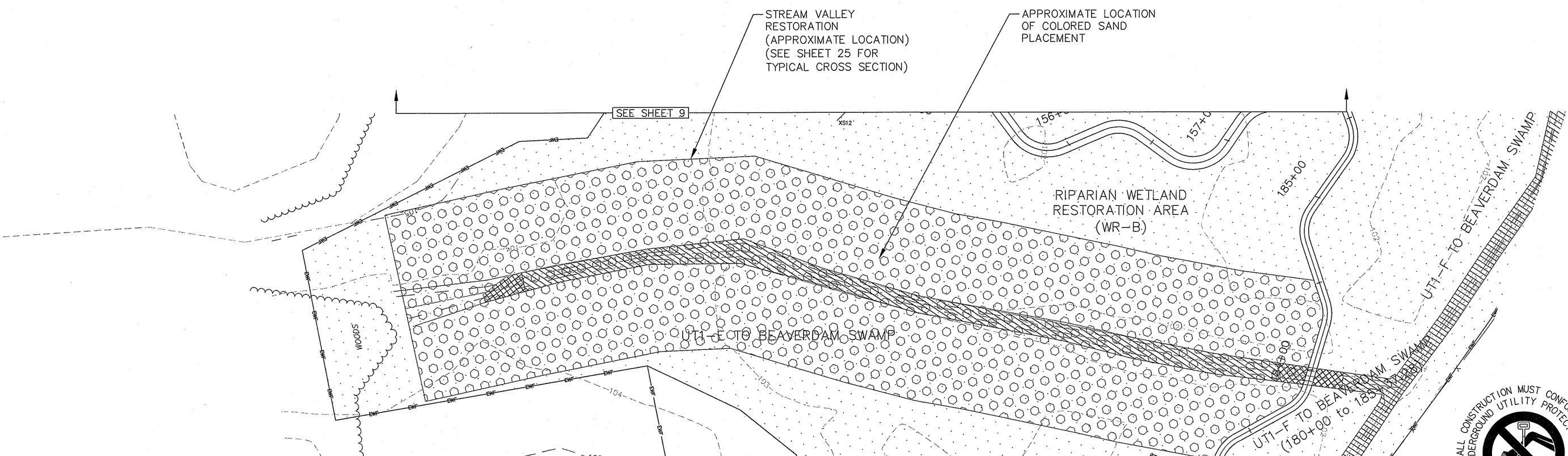
LOG VANE

**SURVEY LEGEND**

— — — —	PROPERTY LINE
— — — —	MAJOR CONTOURS
— — — —	MINOR CONTOURS
— — — —	STREAM CENTERLINE
— — — —	TREELINE
— — — —	EXISTING WETLAND

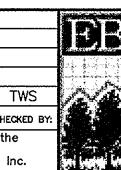
**PROFILE LEGEND**

— — — —	PROPOSED TOP OF BANK
C	OF NEW CHANNEL
— — — —	EXISTING GROUND-CENTER
— — — —	LOG CROSS VANE
— — — —	LOG SILL
— — — —	ROCK CROSS VANE
— — — —	A-VANE



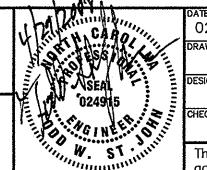
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CHECKED BY: TSJ

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PROFILE LEGEND

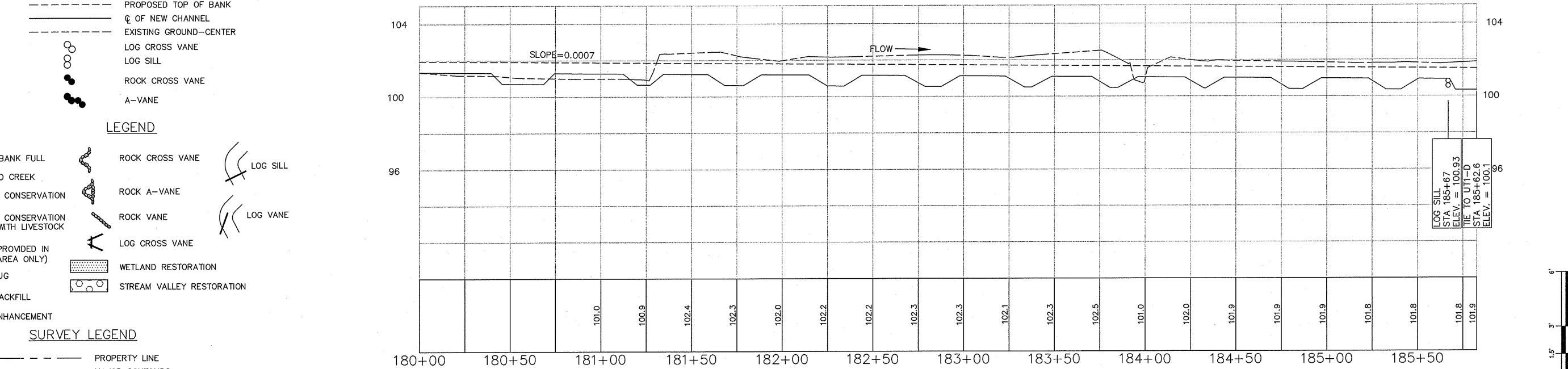
- PROPOSED TOP OF BANK
- OF NEW CHANNEL
- EXISTING GROUND-CENTER
- LOG CROSS VANE
- LOG SILL
- ROCK CROSS VANE
- A-VANE

LEGEND

- PROPOSED BANK FULL
- OF PROPOSED CREEK
- PERMANENT CONSERVATION EASEMENT
- PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
- CUT LINE ( PROVIDED IN FORESTED AREA ONLY)
- STREAM PLUG
- CHANNEL BACKFILL
- WETLAND ENHANCEMENT
- ROCK CROSS VANE
- ROCK A-VANE
- ROCK VANE
- LOG CROSS VANE
- WETLAND RESTORATION
- STREAM VALLEY RESTORATION

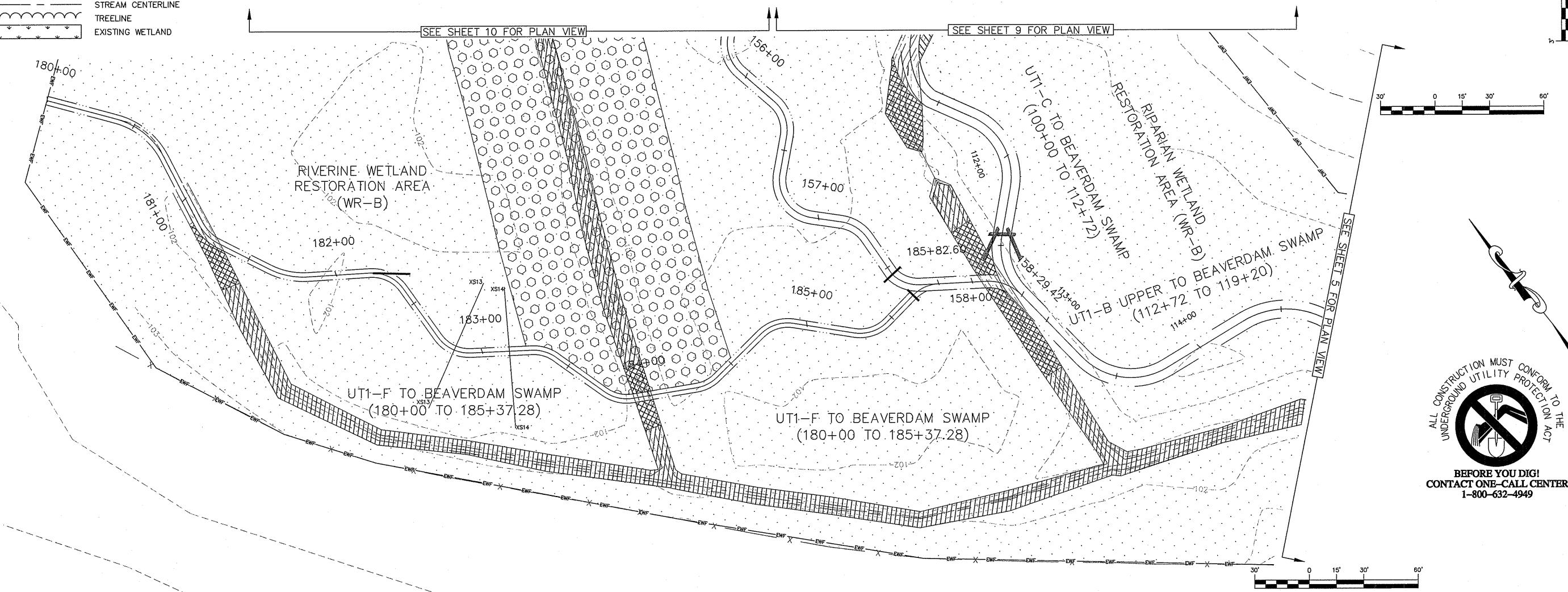
SURVEY LEGEND

- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND

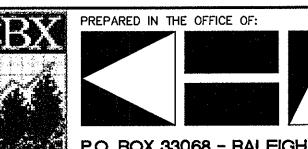
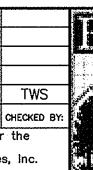


SEE SHEET 10 FOR PLAN VIEW

SEE SHEET 9 FOR PLAN VIEW



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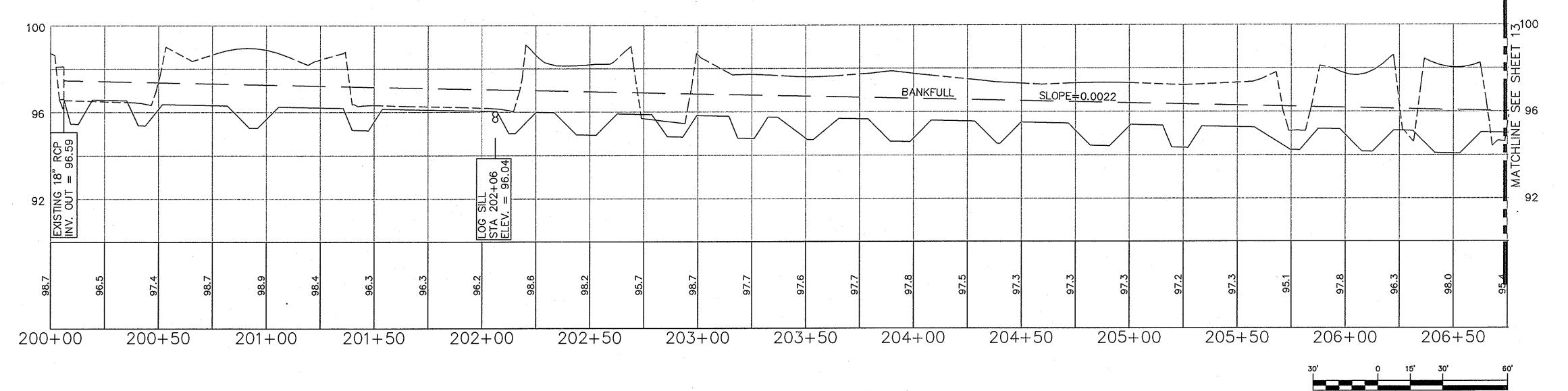


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DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
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EBX NEUSE I, LLC

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JOB NUMBER: 012620010 SHEET NUMBER: 11



PROFILE LEGEND

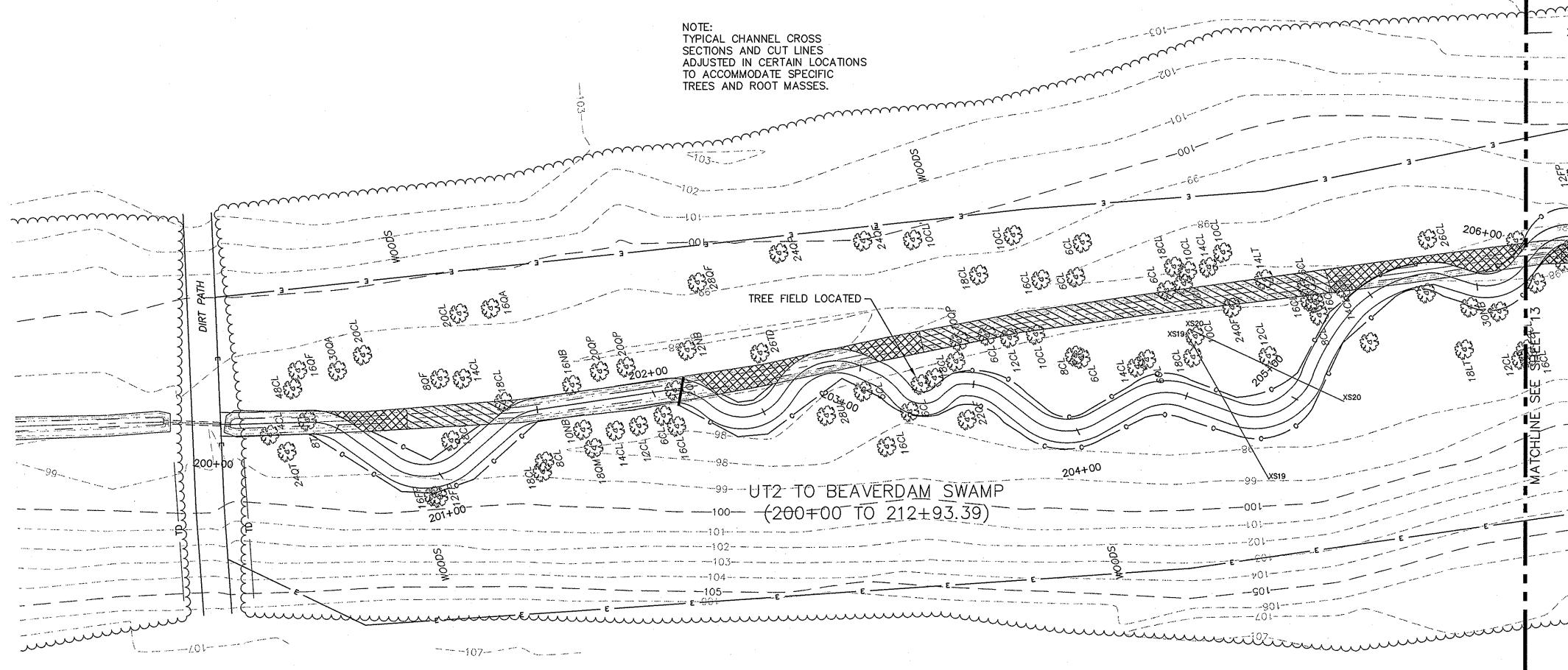
- PROPOSED TOP OF BANK
- PROPOSED CREEK
- EXISTING GROUND-CENTER
- LOG CROSS VANE
- LOG SILL
- ROCK CROSS VANE
- A-VANE

LEGEND

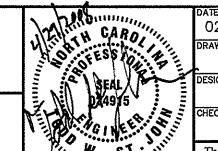
- PROPOSED BANK FULL
- PROPOSED CREEK
- PERMANENT CONSERVATION EASEMENT
- PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
- CUT LINE (PROVIDED IN FORESTED AREA ONLY)
- STREAM PLUG
- CHANNEL BACKFILL
- WETLAND RESTORATION
- LOG SILL
- ROCK VANE
- LOG CROSS VANE
- WETLAND ENHANCEMENT

SURVEY LEGEND

- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND



CLIENT: STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: GRADING PLAN AND PROFILE



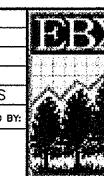
DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 12

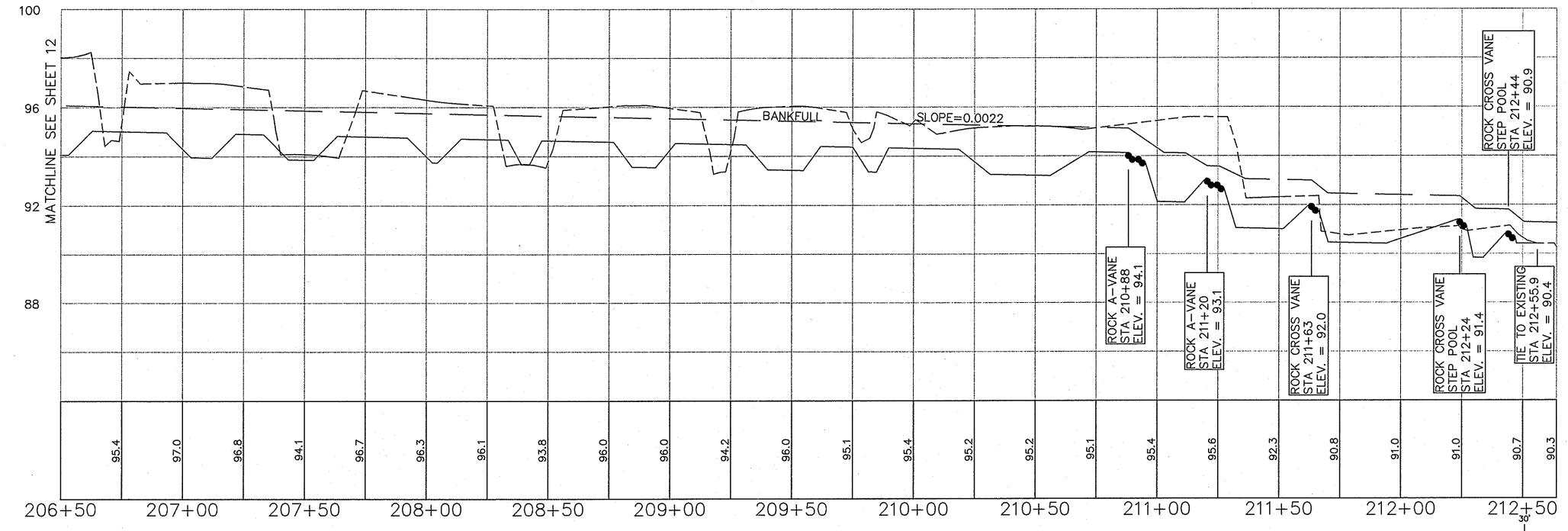
1	REVISED PER EROSION CONTROL REVIEW	08/23/07	JIK	TWS
REV. NO.:	REVISION:	DATE:	DRAWN BY:	CHECKED BY:



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P.O. BOX 33068 - RALEIGH, NORTH CAROLINA 27636-3068  
PHONE: (919) 677-2000 FAX: (919) 677-2050

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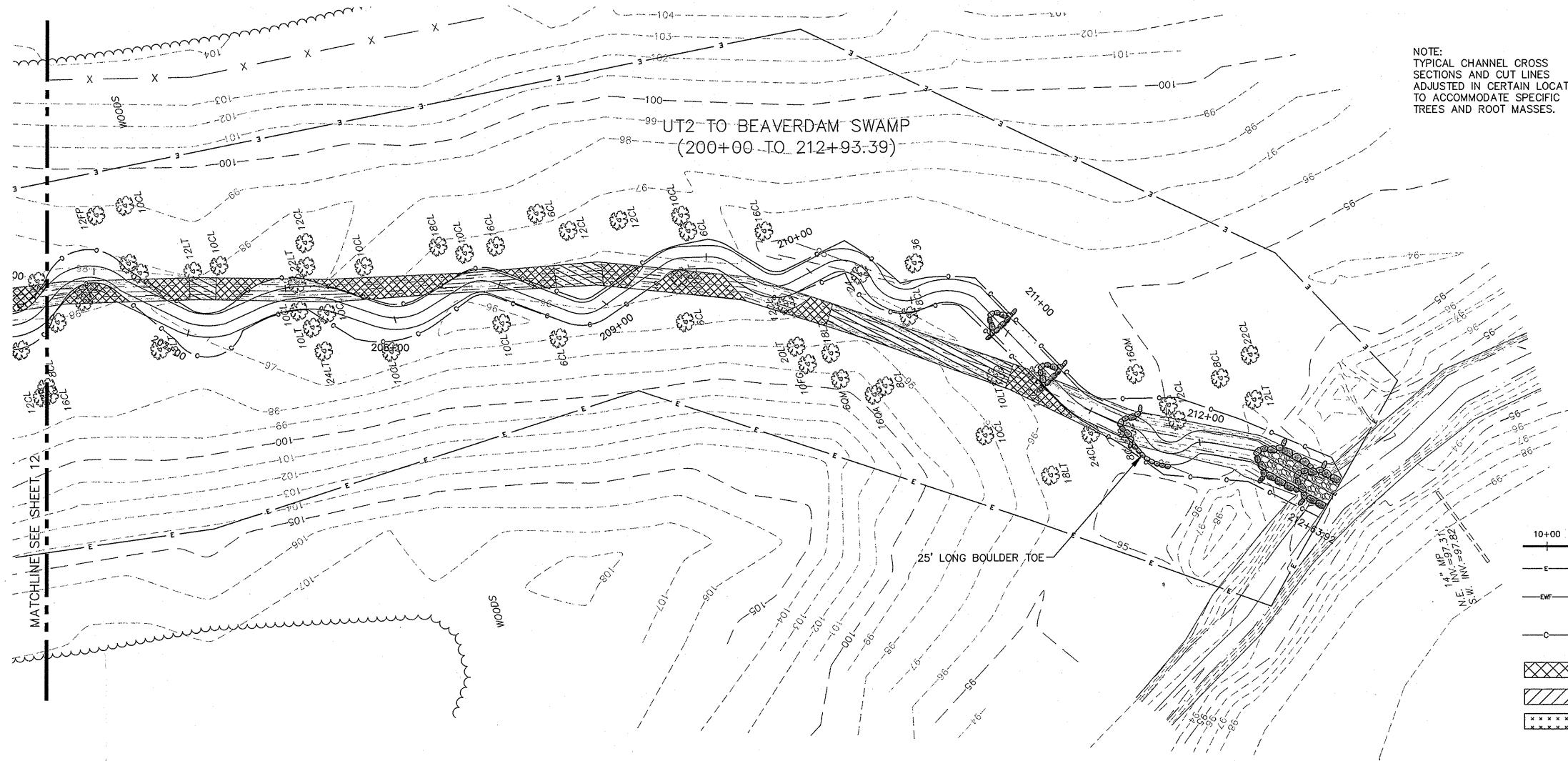


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#### PROFILE LEGEND

- PROPOSED TOP OF BANK
- - - C OF NEW CHANNEL
- - - EXISTING GROUND-CENTER
- - - LOG CROSS VANE
- - - LOG SILL
- - - ROCK CROSS VANE
- - - A-VANE

NOTE:  
TYPICAL CHANNEL CROSS  
SECTIONS AND CUT LINES  
ADJUSTED IN CERTAIN LOCATIONS  
TO ACCOMMODATE SPECIFIC  
TREES AND ROOT MASSES.



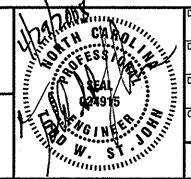
#### SURVEY LEGEND

- - - PROPERTY LINE
- - - MAJOR CONTOURS
- - - MINOR CONTOURS
- - - STREAM CENTERLINE
- - - TREELINE
- - - EXISTING WETLAND

#### LEGEND

- 10+00 PROPOSED BANK FULL
- C PROPOSED CREEK
- E PERMANENT CONSERVATION EASEMENT
- EWF PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
- C CUT LINE (PROVIDED IN FORESTED AREA ONLY)
- SP Stream PLUG
- CB CHANNEL BACKFILL
- WE Wetland ENHANCEMENT
- RC Rock CROSS VANE
- LS Log SILL
- RA Rock A-VANE
- RV Rock VANE
- LC Log CROSS VANE
- WR Wetland RESTORATION
- SVR Stream VALLEY RESTORATION

CLIENT: STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: GRADING PLAN AND  
PROFILE

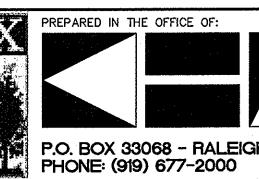
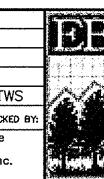


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

The record drawings represent the construction plans with  
adjustments made to represent constructed conditions.

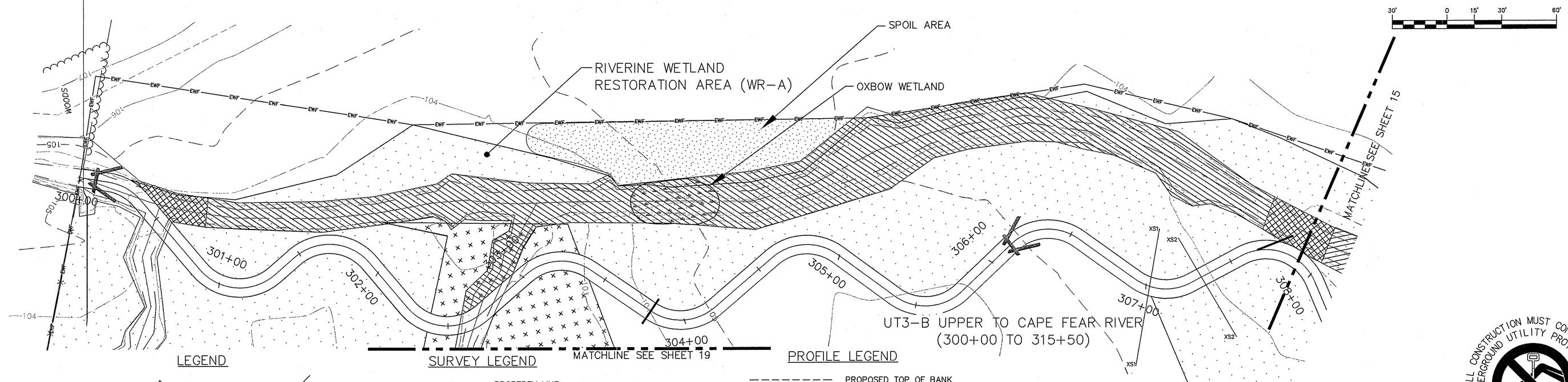
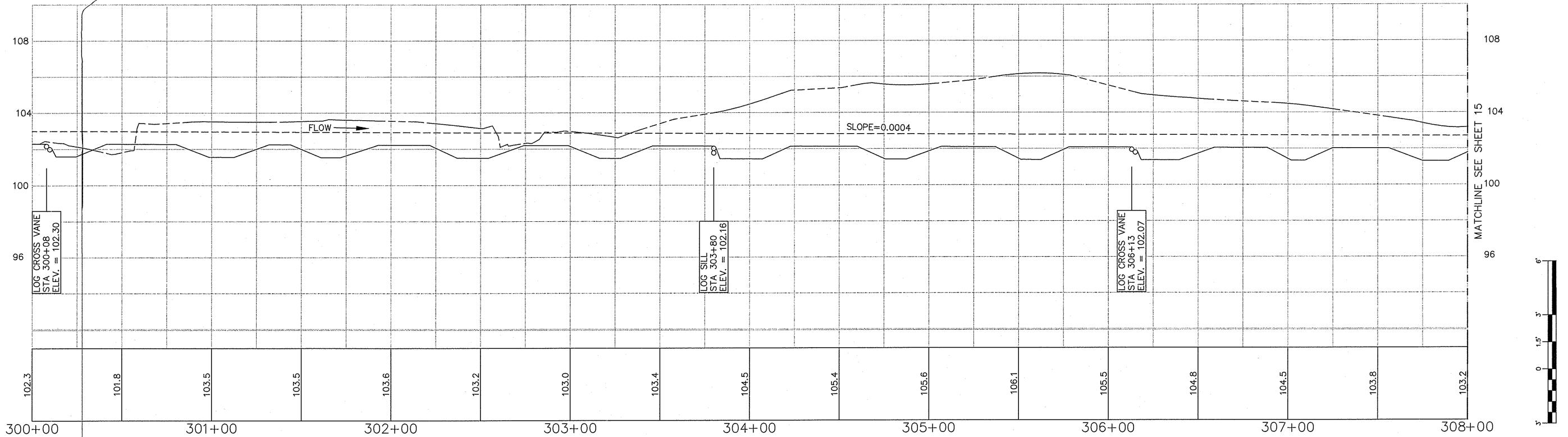
JOB NUMBER: 012620010 SHEET NUMBER: 13



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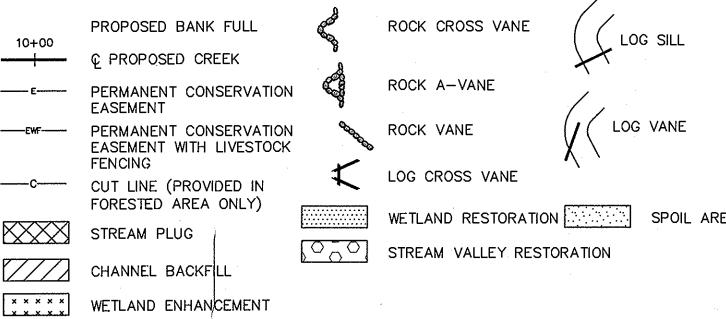
1 REVISED PER EROSION CONTROL REVIEW  
REV. NO.: REVISION: 08/23/07 DATE: DRAWN BY: CHECKED BY:  
1

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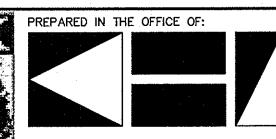
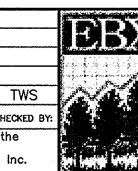


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TITLE: GRADING PLAN AND  
PROFILE

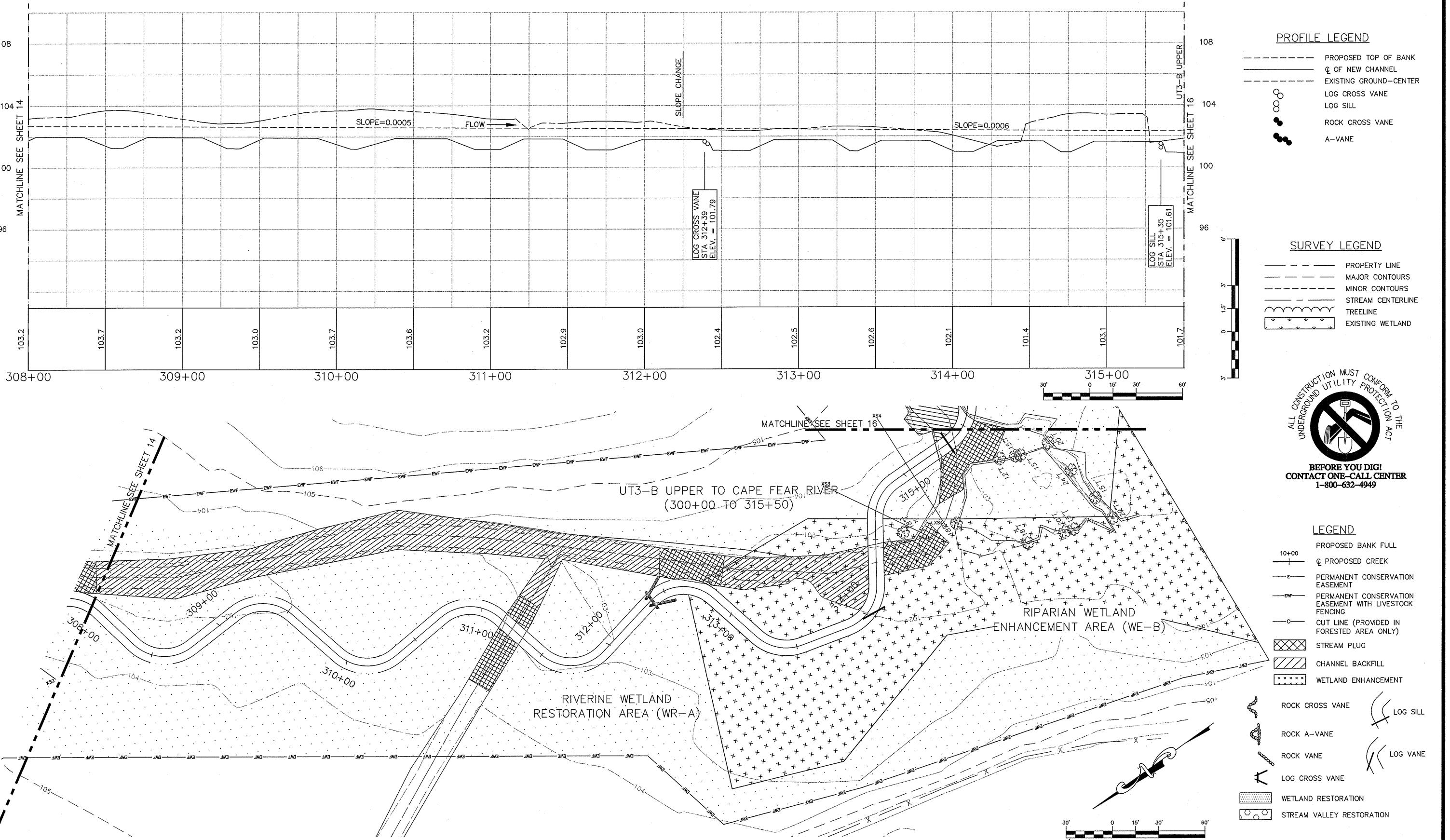


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

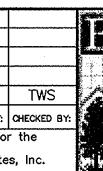
PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

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adjustments made to represent constructed conditions.

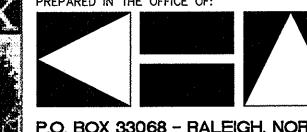
JOB NUMBER: 012620010 SHEET NUMBER:  
14



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REV. No.:	REASON:	DATE:	DRAWN BY:	CHECKED BY:



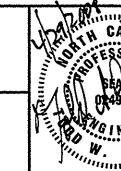
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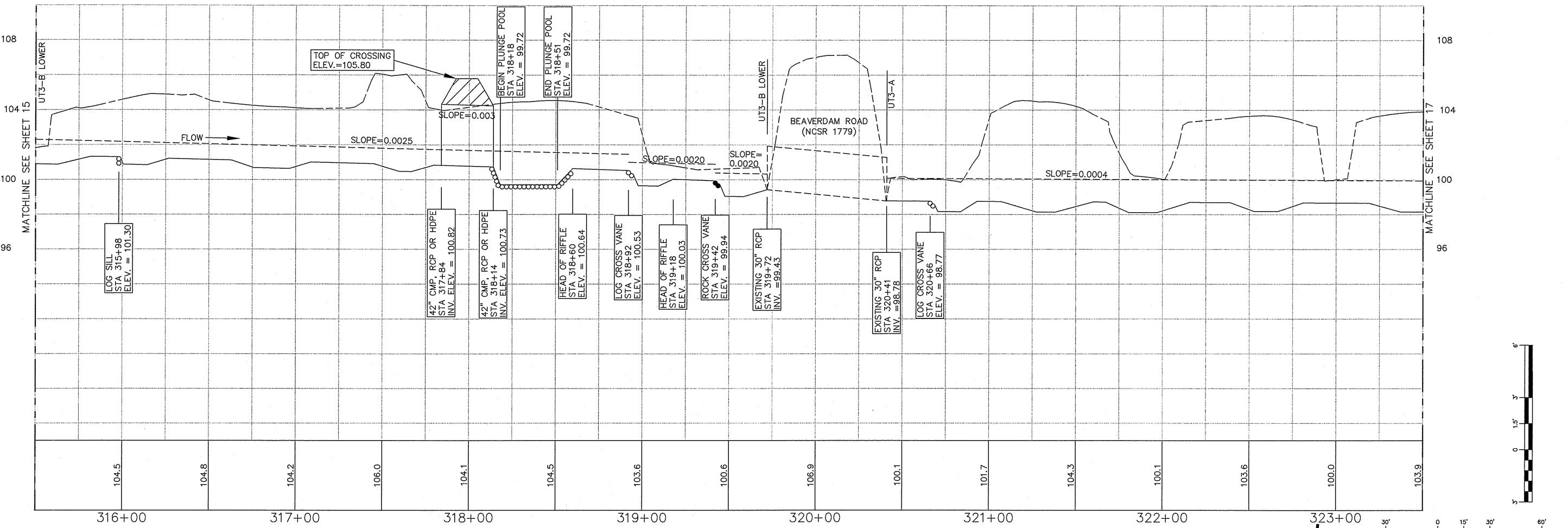
CLIENT: STATE OF NORTH CAROLINA  
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TITLE: GRADING PLAN AND PROFILE

DATE: 02/25/08	PROJECT: BEAVERDAM SWAMP
DRAWN BY: JIK	STREAM AND WETLAND RESTORATION
DESIGNED BY: RTL	EBX NEUSE I, LLC
CHECKED BY: TSJ	



The record drawings represent the construction plans with adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 15

LEGEND

- PROPOSED BANK FULL
- PROPOSED CREEK
- PERMANENT CONSERVATION EASEMENT
- PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING
- CUT LINE (PROVIDED IN FORESTED AREA ONLY)
- STREAM PLUG
- CHANNEL BACKFILL
- WETLAND ENHANCEMENT
- ROCK CROSS VANE
- LOG SILL
- ROCK A-VANE
- LOG VANE
- LOG CROSS VANE
- WETLAND RESTORATION
- STREAM VALLEY RESTORATION
- SPOIL AREA

SPOIL AREA

LOG SILL

ROCK A-VANE

LOG VANE

LOG CROSS VANE

WETLAND RESTORATION

STREAM VALLEY RESTORATION

SPOIL AREA

SPOIL AREA

LOG SILL

ROCK A-VANE

LOG VANE

LOG CROSS VANE

WETLAND RESTORATION

STREAM VALLEY RESTORATION

SPOIL AREA

SPOIL AREA

LOG SILL

ROCK A-VANE

LOG VANE

LOG CROSS VANE

WETLAND RESTORATION

STREAM VALLEY RESTORATION

SPOIL AREA

PROFILE LEGEND

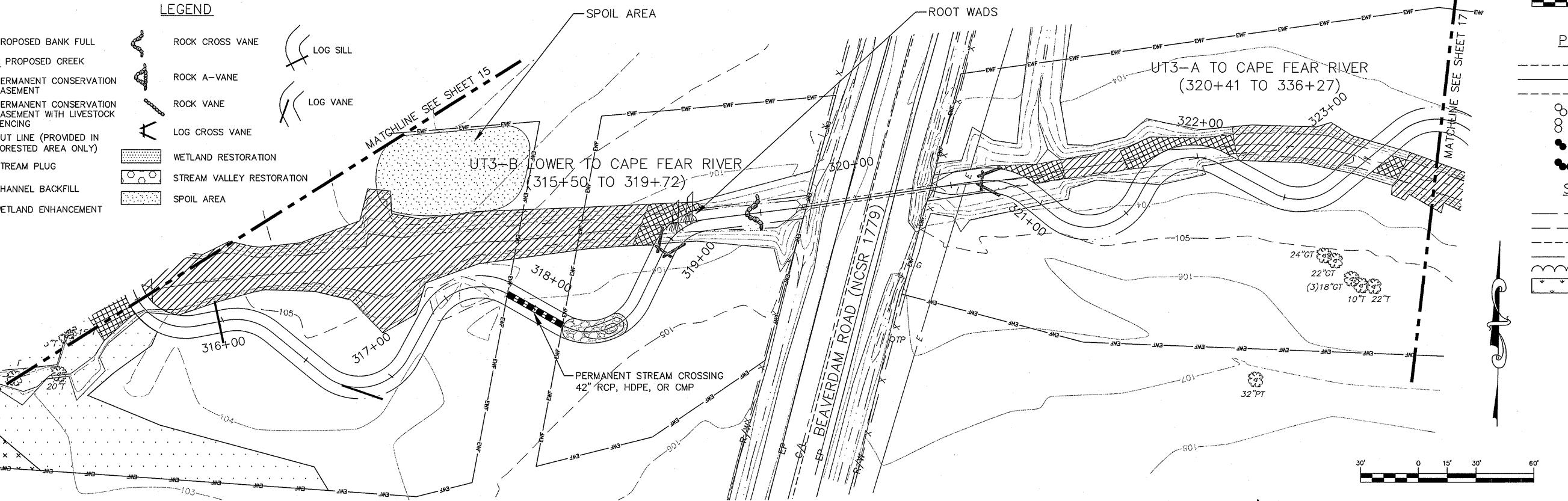
- PROPOSED TOP OF BANK
- OF NEW CHANNEL
- EXISTING GROUND-CENTER
- LOG CROSS VANE
- LOG SILL
- ROCK CROSS VANE
- A-VANE

SURVEY LEGEND

- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND

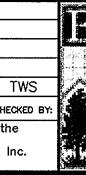


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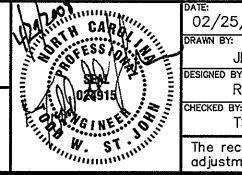
1	REVISED PER EROSION CONTROL REVIEW	08/23/07	JIK	TWS
REV. No.:	REVISION:	DATE:	DRAWN BY:	CHECKED BY:

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TITLE: **GRADING PLAN AND  
PROFILE**

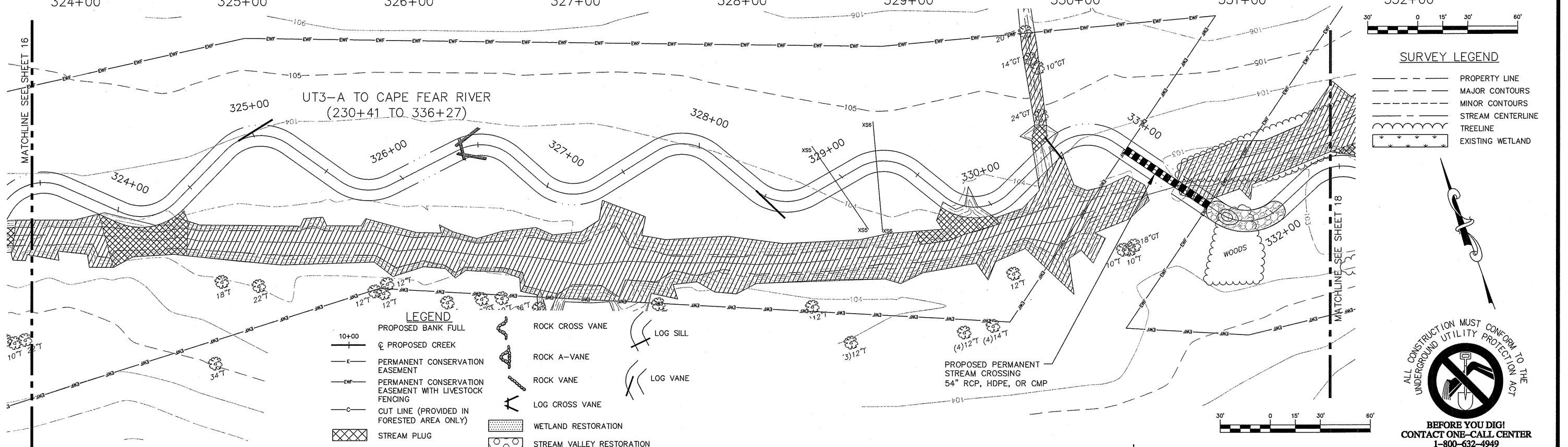
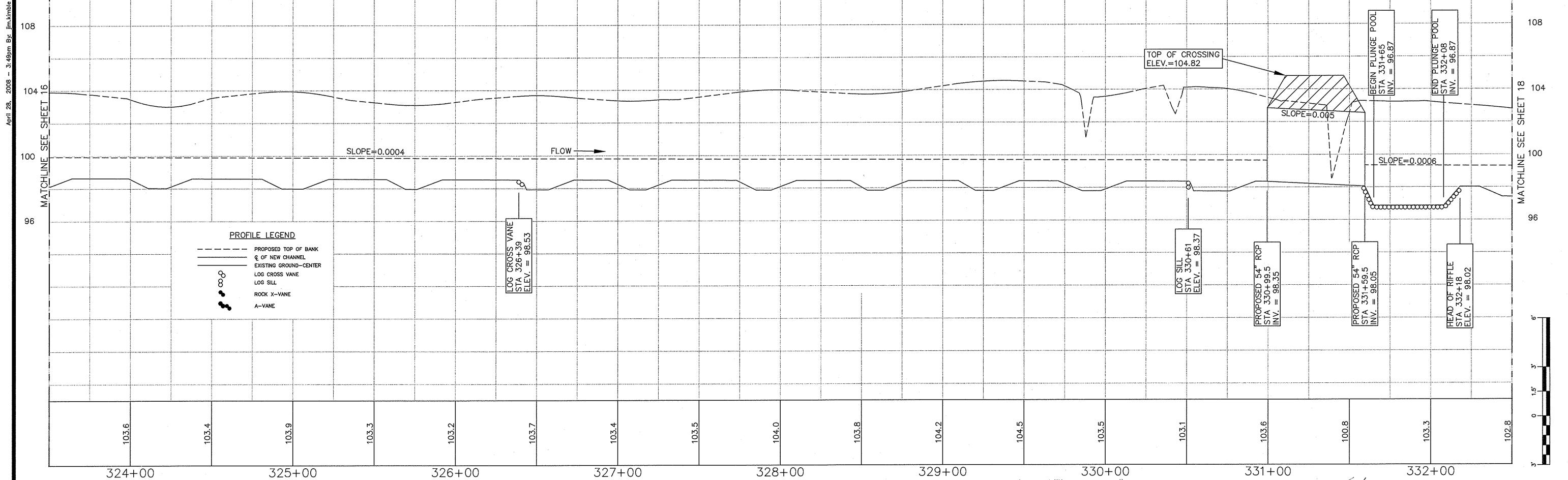


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: **BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC**

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 16



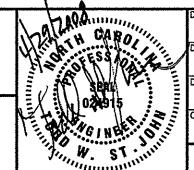
REV. NO.: 1	REvised per Erosion Control Review	DATE: 08/23/07	DRAWN BY: JIK	checked by: TWS
REV. NO.: 1	REVISION:	DATE:	DRAWN BY:	checked by:



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TITLE: GRADING PLAN AND PROFILE

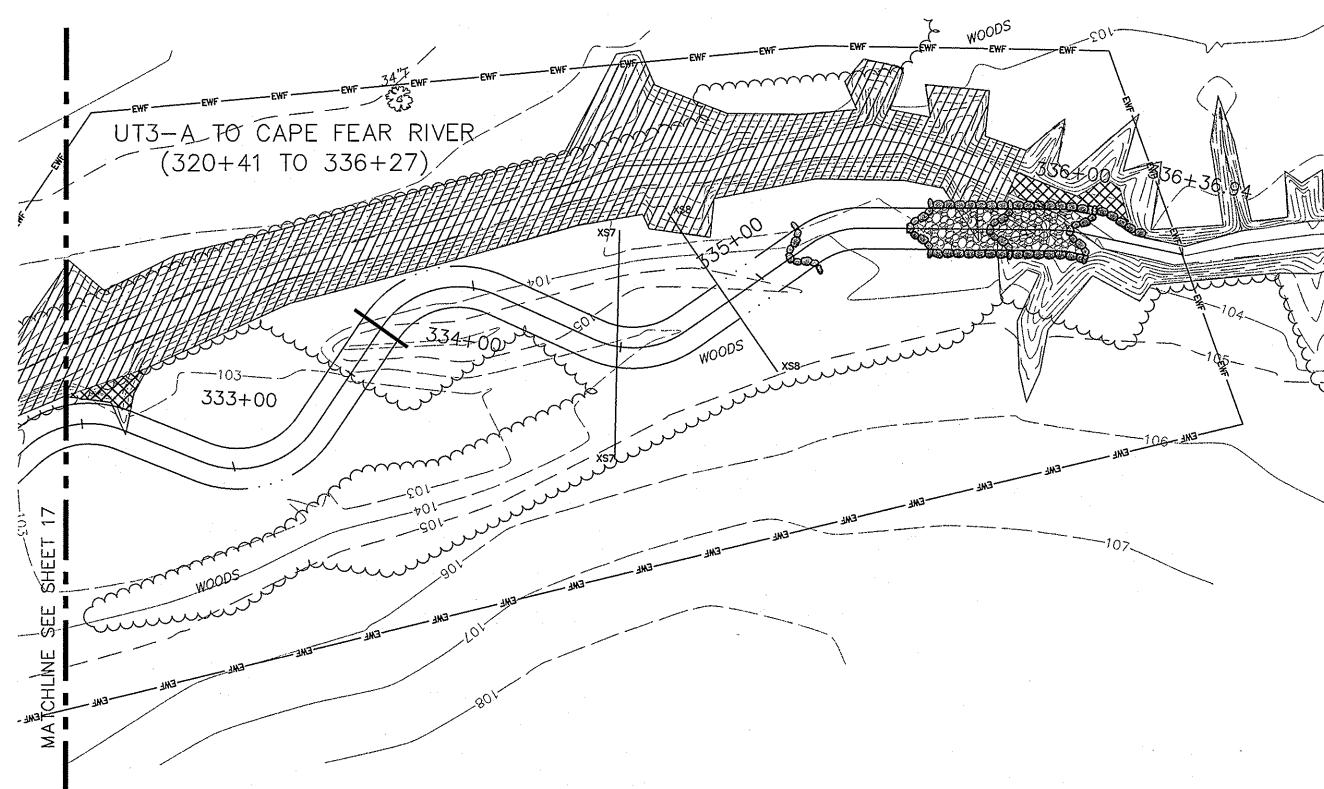
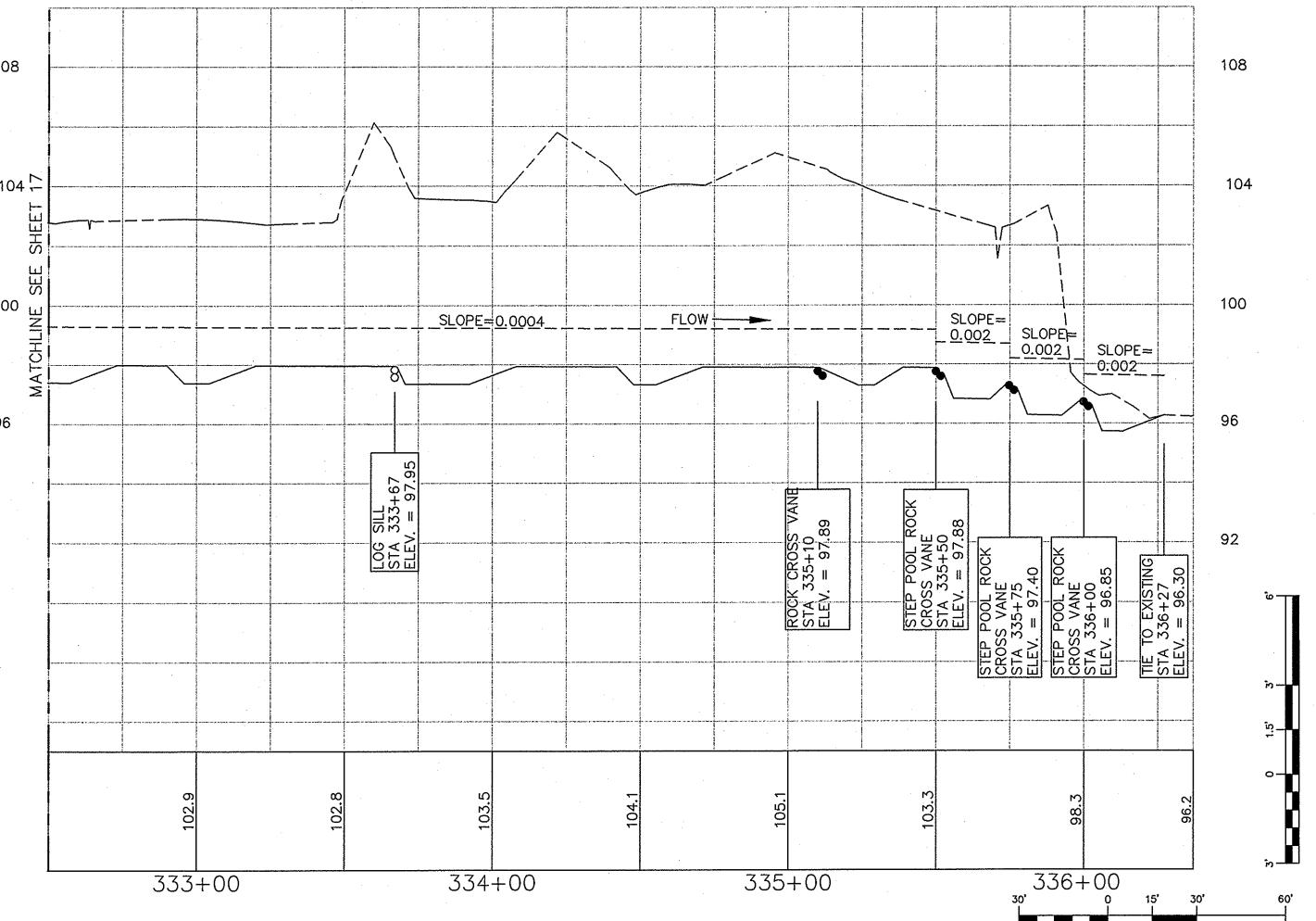


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 17



## PROFILE LEGEND

PROPOSED TOP OF BANK  
 & OF NEW CHANNEL  
 EXISTING GROUND-CENTER  
 LOG CROSS VANE  
 LOG SILL  
 ROCK CROSS VANE  
 A-VANE

LEGEND

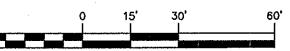
10+00	PROPOSED BANK FULL		ROCK CROSS VANE		LOG SILL
	PROPOSED CREEK		ROCK A-VANE		LOG VANE
	PERMANENT CONSERVATION EASEMENT		ROCK VANE		LOG VANE
	PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING		LOG CROSS VANE		LOG VANE
	CUT LINE (PROVIDED IN FORESTED AREA ONLY)		WETLAND RESTORATION		STREAM VALLEY RESTORATION
	STREAM PLUG		WETLAND RESTORATION		STREAM VALLEY RESTORATION
	CHANNEL BACKFILL		WETLAND RESTORATION		STREAM VALLEY RESTORATION
	WETLAND ENHANCEMENT		WETLAND RESTORATION		STREAM VALLEY RESTORATION

### SURVEY LEGEND

— PROPERTY LINE  
 - - - MAJOR CONTOURS  
 - - - MINOR CONTOURS  
 ~~~~~ STREAM CENTERLINE  
 ~~~~~ TREELINE  
 \* \* \* EXISTING WETLAND



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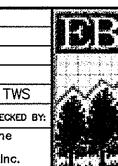
A circular registration stamp for a professional engineer from North Carolina. The outer ring contains the text "NORTH CAROLINA" at the top and "PROFESSIONAL ENGINEER" at the bottom. The center of the stamp contains the name "EDWARD W. ST. JOHN" and the number "024916". There is also some handwritten text and a signature over the stamp.

DATE: 02/25/08 PROJECT: BEAVERDAM SWAMP  
DRAWN BY: JIK STREAM AND WETLAND REST  
DESIGNED BY: RTL CHECKED BY: EBX NEUSE I, LLC

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|             |               |
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| JOB NUMBER: | SHEET NUMBER: |
| 012620010   | 18            |

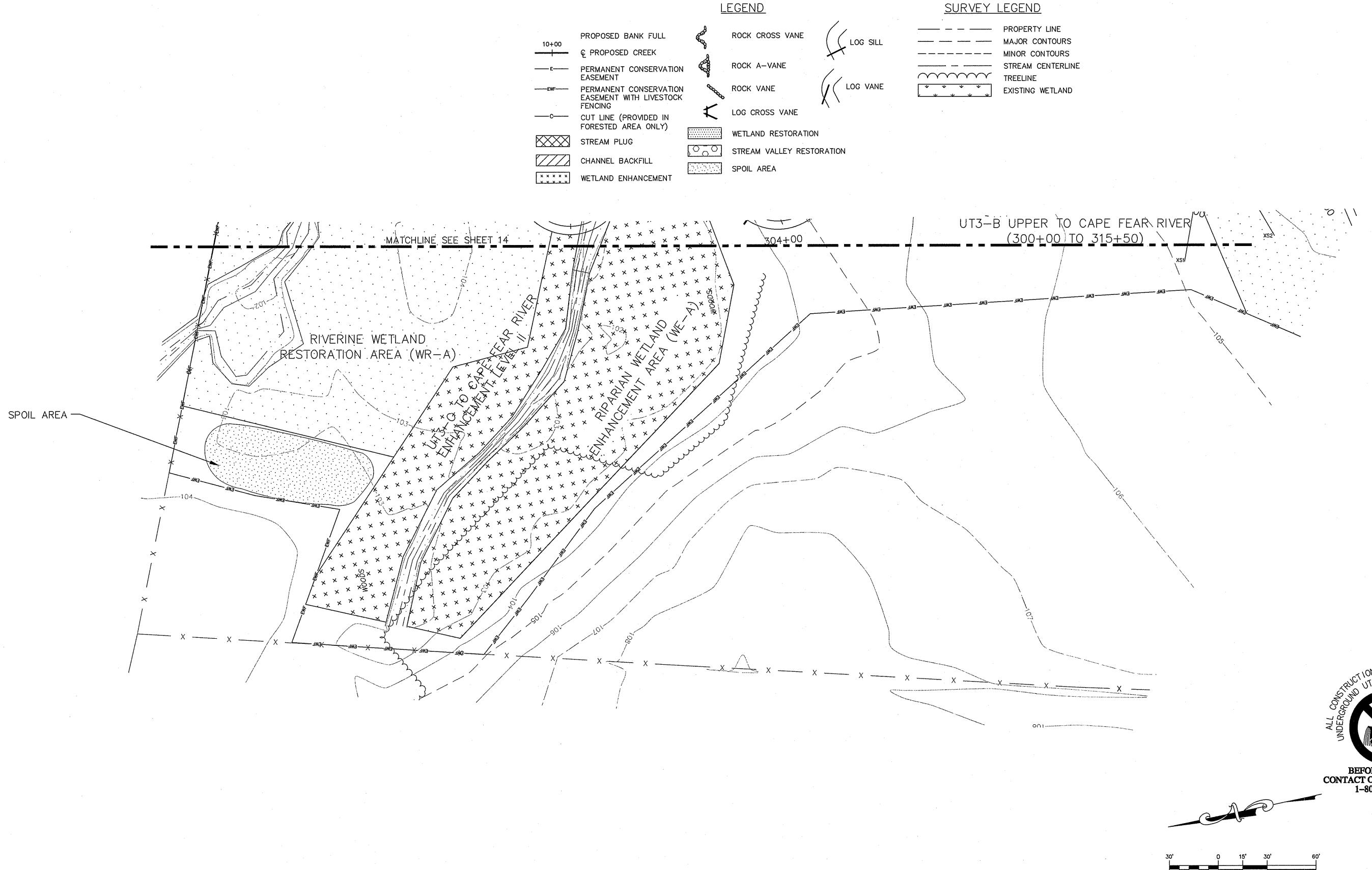
1 REVISED PER EROSION CONTROL REVIEW



The logo consists of a black rectangle containing a white triangle pointing upwards and to the right, positioned to the left of the company name.

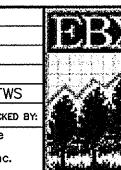
|            |  |
|------------|--|
|            | <b>CLIENT:</b><br><b>STATE OF NORTH CAROLINA</b><br><b>ECOSYSTEM ENHANCEMENT PROGRAM</b> |
| <b>IC.</b> | <b>TITLE:</b><br><b>GRADING PLAN AND</b><br><b>PROFILE</b>                               |

**MC. TITLE: GRADING PLAN AND PROFILE**



T:\pn\012620010 Beaverdam Swamp Restoration\0010\_LDD\dwg\RECORD SET 04-10-08\05-PLANS.dwg

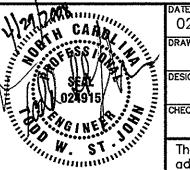
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P.O. BOX 33068  
PHONE: (919) 677-1111

The logo for Kimley-Horn and Associates, Inc. It features a stylized graphic on the left composed of two black rectangles and a white triangle. To the right of the graphic, the company name is written in a large, bold, sans-serif font.

|         |  |
|---------|--|
| CLIENT: | STATE OF NORTH CAROLINA<br>ECOSYSTEM ENHANCEMENT PROGRAM |
| TITLE:  | GRADING PLAN AND<br>PROFILE                              |



|          |               |
|----------|---------------|
| 2/25/08  | PROJECT:      |
| EN BY:   |               |
| JIK      | <b>STREAM</b> |
| GNED BY: |               |
| RTL      |               |
| EKED BY: |               |
| TSJ      |               |

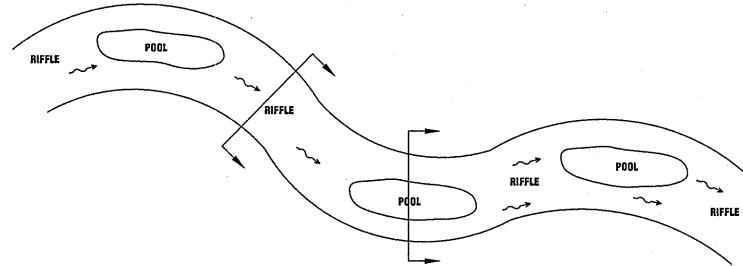
The record drawings represent the instruments made to represent

**BEAVERDAM SWAMP  
AND WETLAND RESTORATION  
EBX NEUSE I, LLC**

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

|             |               |
|-------------|---------------|
| JOB NUMBER: | SHEET NUMBER: |
| 012620010   | 19            |





### TYPICAL PLAN VIEW SCHEMATIC

NTS

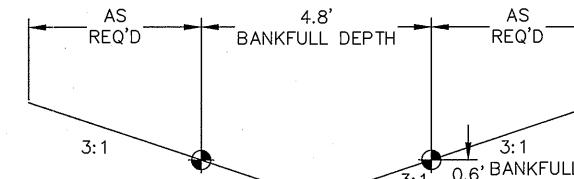
## NOTES:

TYPICAL SECTIONS ARE PROVIDED TO GIVE THE GENERAL DIMENSIONS OF THE CHANNEL. FINAL GRADING WILL GIVE THE CHANNEL A MORE "NATURAL" APPEARANCE AND ALLOW A SMOOTH TRANSITION FROM EXISTING CHANNEL TO NEW CHANNEL.

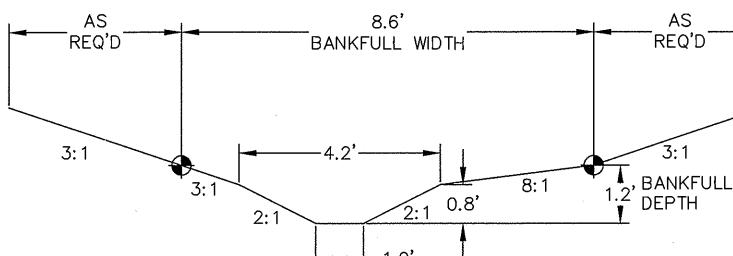
ALL POOLS SHALL BE OVERDUG 1' TO ACCOUNT FOR SEDIMENTATION.

## LEGEND:

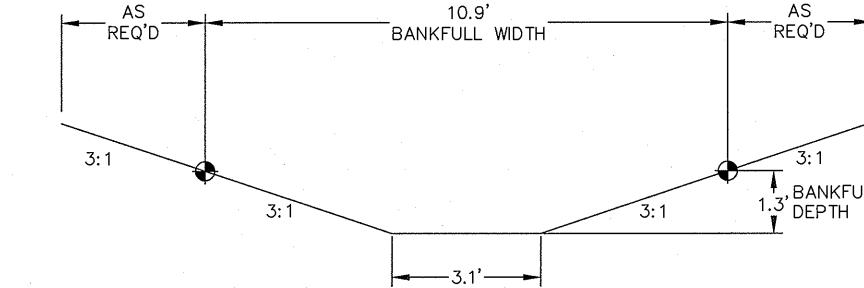
● BANKFULL ELEVATION TO ACT AS VERTICAL CONTROL POINT. POINT SHOULD BE VERIFIED BY DESIGNER BEFORE EARTHWORK BEGINS.



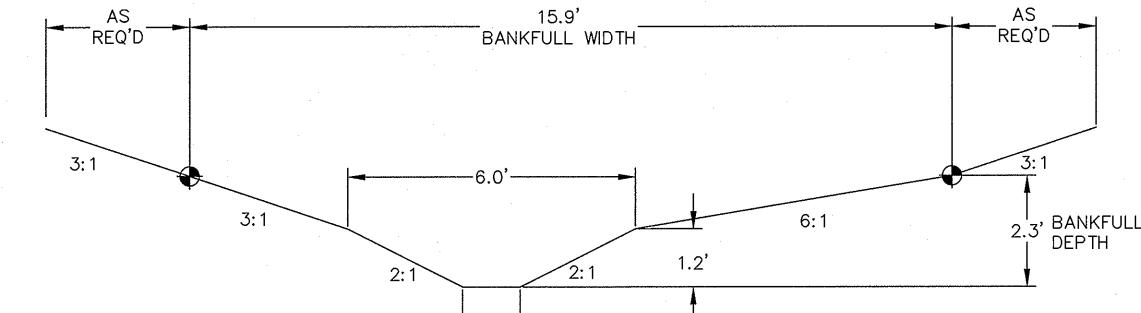
**UT1-F RIFFLE**  
STA 180+00 TO 186+31



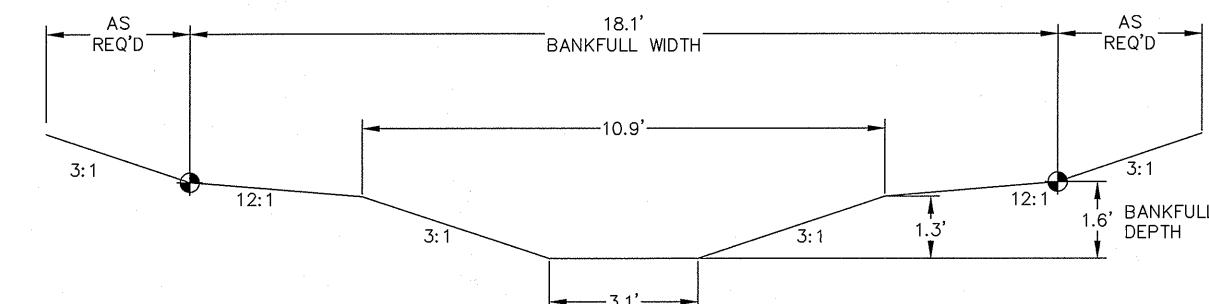
**UT1-F POOL**  
STA 180+00 TO 186+31



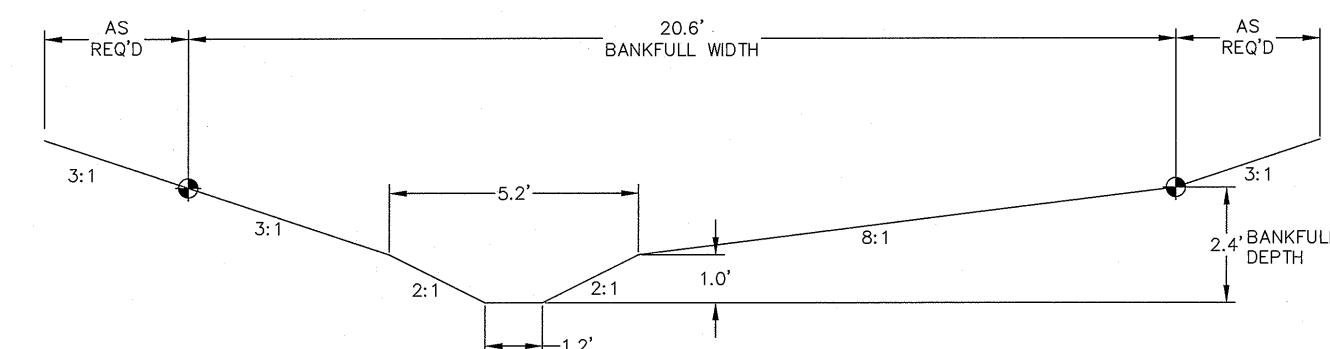
**UT1-B UPPER RIFFLE**  
STA 112+63 TO 118+91



**UT1-B UPPER POOL**  
STA 112+63 TO 118+91



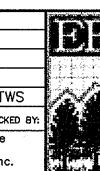
**UT1-B LOWER RIFFLE**  
STA 119+01 TO 123+22



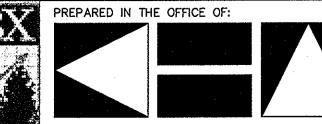
**UT1-B LOWER POOL**  
STA 119+01 TO 123+22

|           |                                    |          |           |             |
|-----------|------------------------------------|----------|-----------|-------------|
| 1         | REVISED PER EROSION CONTROL REVIEW | 08/23/07 | JIK       | TWS         |
| REV. NO.: | REVISION:                          | DATE:    | DRAWN BY: | CHECKED BY: |

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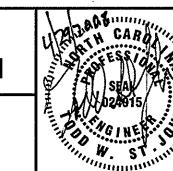
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**Kimley-Horn  
and Associates, Inc.**

P.O. BOX 33068 - RALEIGH, NORTH CAROLINA 27636-3068  
PHONE: (919) 677-2000 FAX: (919) 677-2050

CLIENT: **STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM**  
TITLE: **TYPICAL CROSS SECTIONS**



DATE: 02/25/08

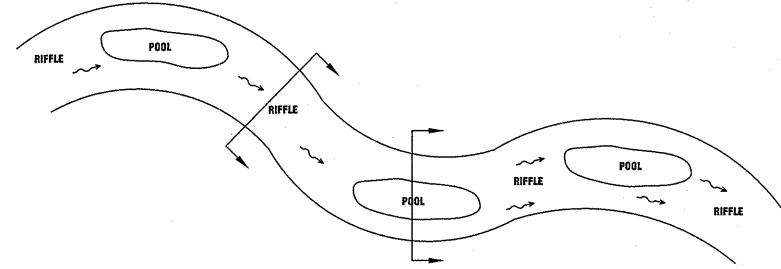
DRAWN BY: JIK

DESIGNED BY: RTL

CHECKED BY: TSJ

PROJECT: **BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC**  
The record drawings represent the construction plans with adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 21



### TYPICAL PLAN VIEW SCHEMATIC

NTS

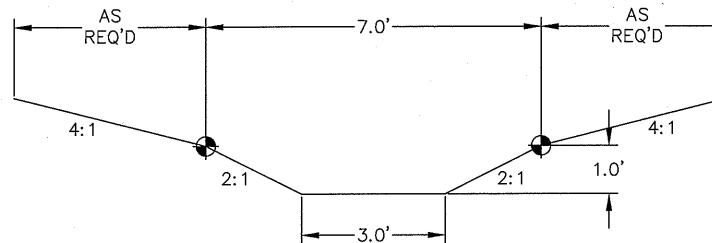
## NOTES:

TYPICAL SECTIONS ARE PROVIDED TO GIVE THE GENERAL DIMENSIONS OF THE CHANNEL. FINAL GRADING WILL GIVE THE CHANNEL A MORE "NATURAL" APPEARANCE AND ALLOW A SMOOTH TRANSITION FROM EXISTING CHANNEL TO NEW CHANNEL.

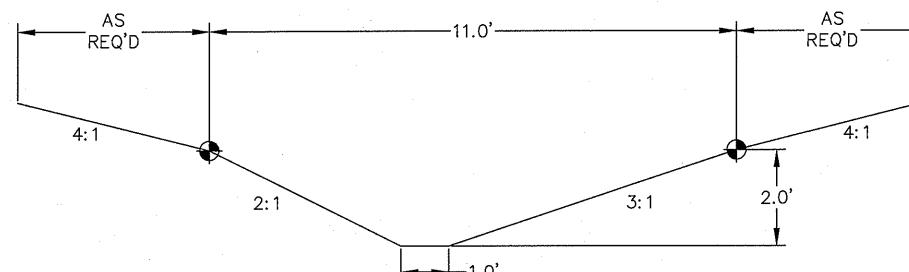
ALL POOLS SHALL BE OVERDUG 1' TO ACCOUNT FOR SEDIMENTATION.

## LEGEND:

● BANKFULL ELEVATION TO ACT AS VERTICAL CONTROL POINT. POINT SHOULD BE VERIFIED BY DESIGNER BEFORE EARTHWORK BEGINS.

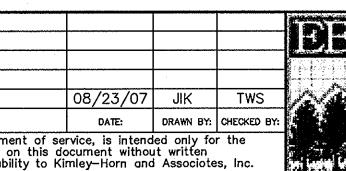


**UT2 RIFFLE**  
STA 200+00 TO 212+63.92



**UT2 POOL**  
STA 200+00 TO 212+62.94

|           |                                    |          |           |             |
|-----------|------------------------------------|----------|-----------|-------------|
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ROUTED BY:

APPROVED BY:

TSJ

DATE:

02/25/08

DRAWN BY:

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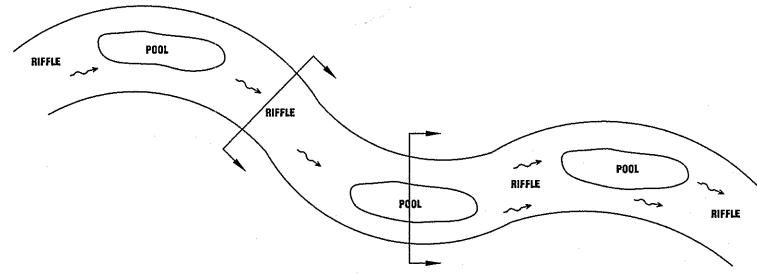
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DESIGNED BY:

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TYPICAL PLAN VIEW SCHEMATIC

NTS

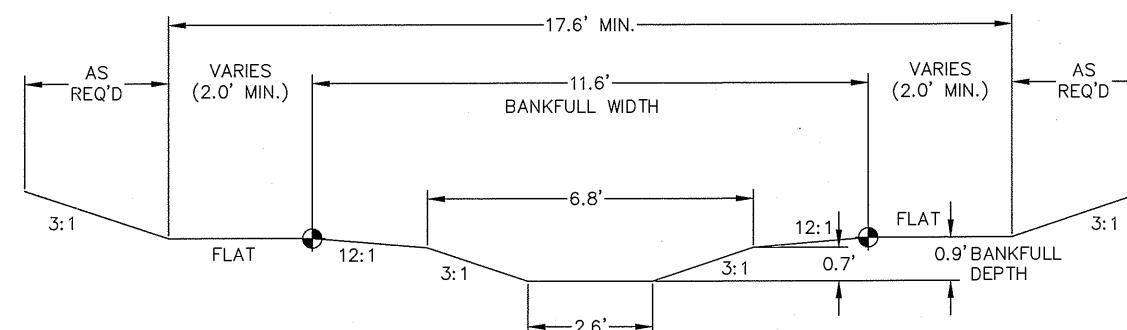
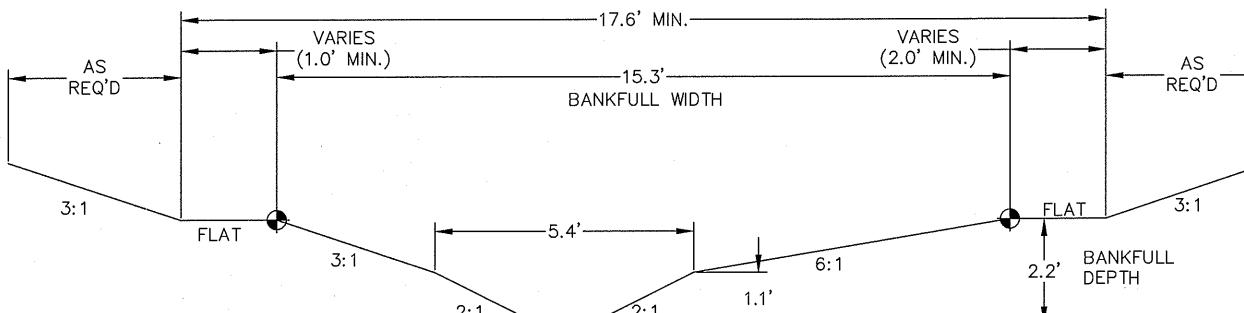
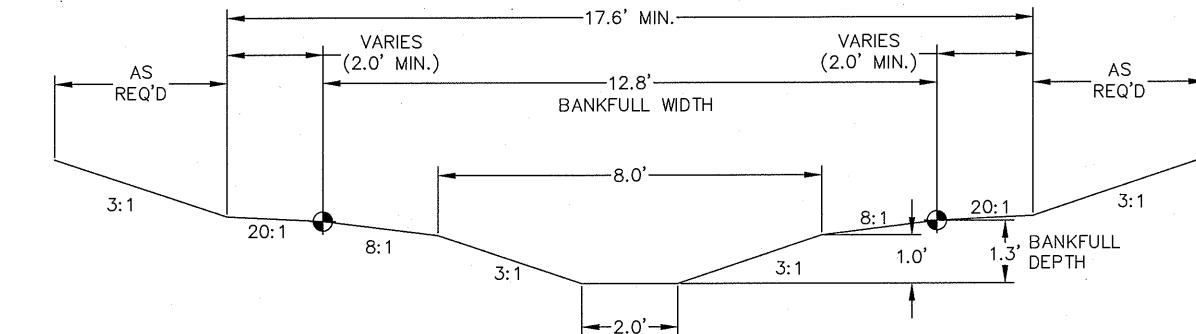
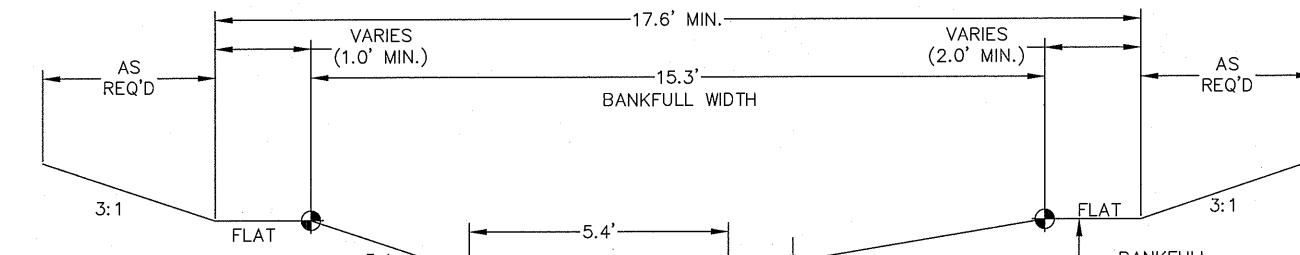
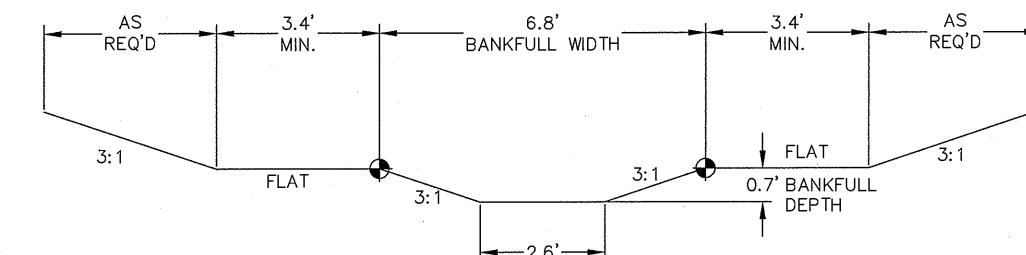
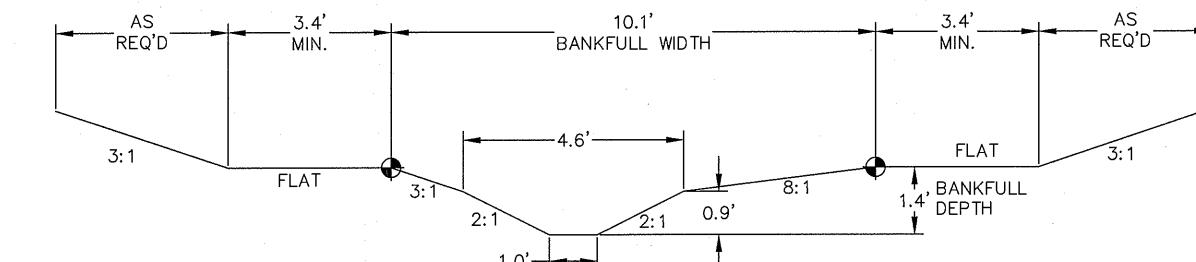
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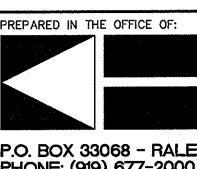
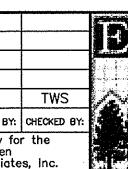
ALL POOLS SHALL BE OVERDUG 1' TO ACCOUNT FOR SEDIMENTATION.

## LEGEND:

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UT3-B LOWER RIFFLE  
STA 315+50 TO 319+72UT3-B LOWER POOL  
STA 315+50 TO 319+72UT3-A RIFFLE  
STA 320+41 TO 336+27UT3-A POOL  
STA 320+41 TO 336+27UT3-B UPPER RIFFLE  
STA 300+00 TO 315+50UT3-B UPPER POOL  
STA 300+00 TO 315+50

|           |                                    |          |           |             |
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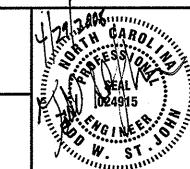


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ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: TYPICAL CROSS SECTIONS

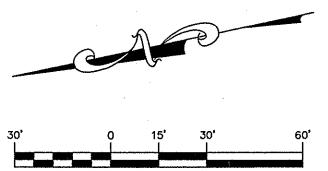
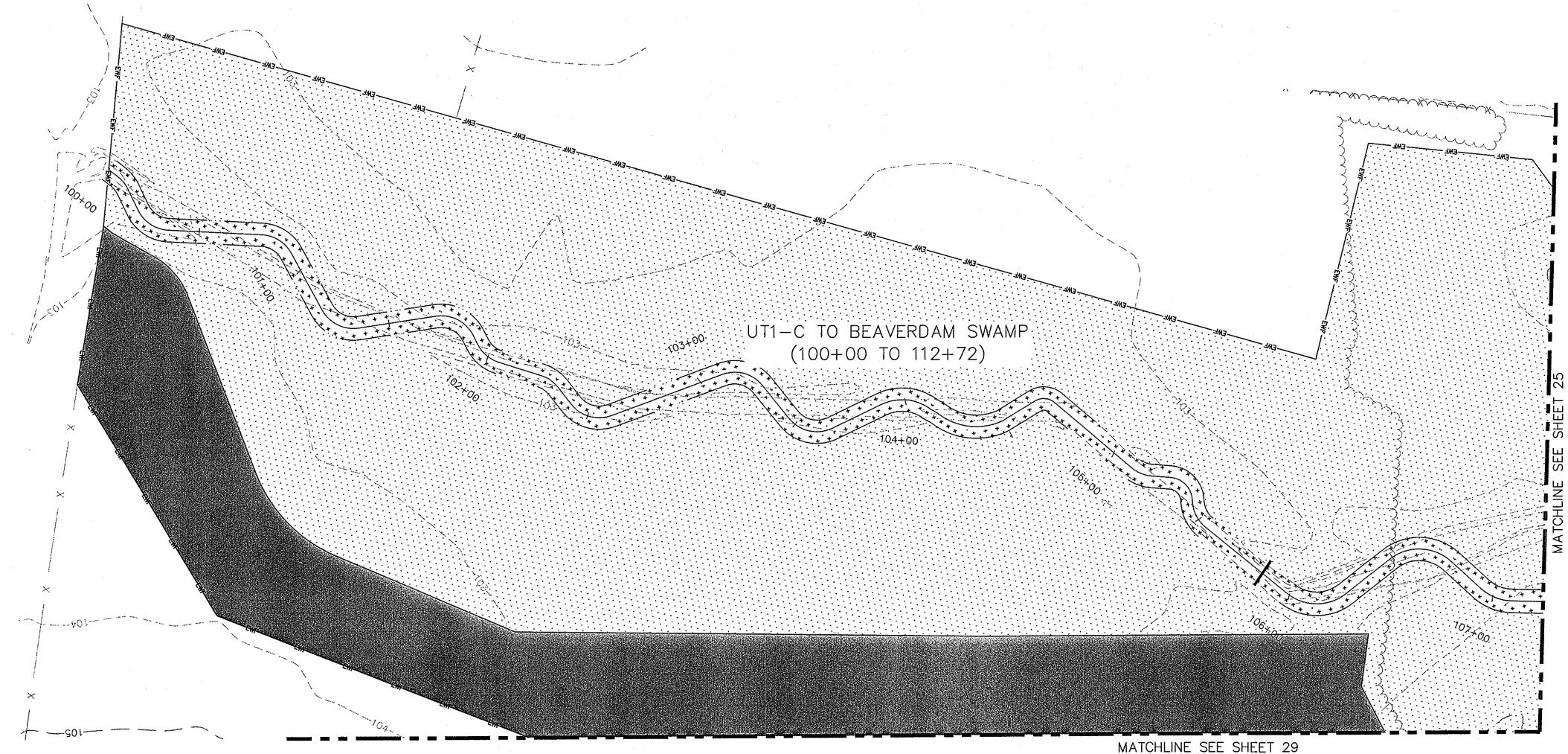


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 23

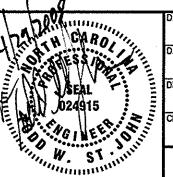


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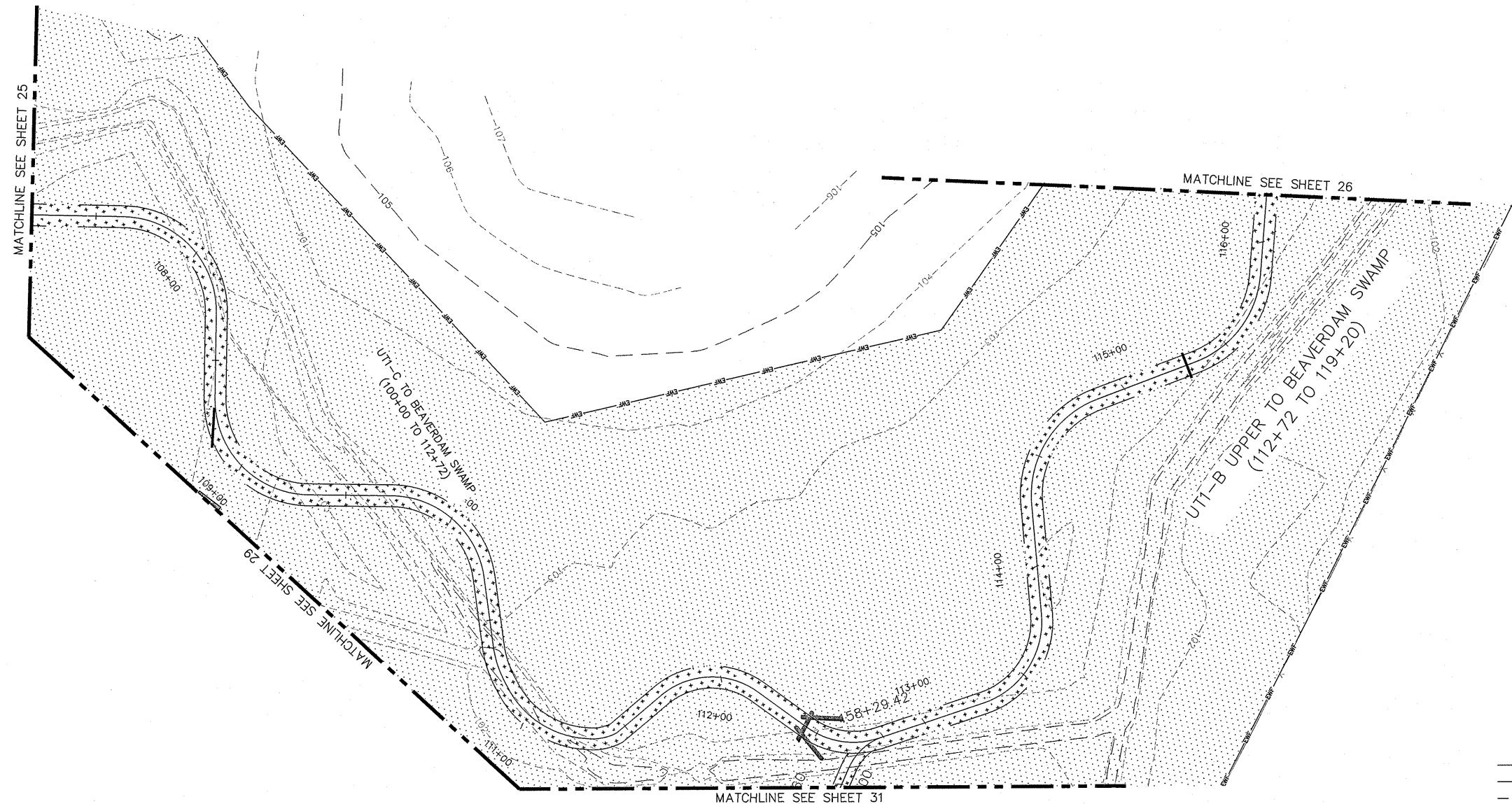
CLIENT: **STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM**  
TITLE: **PLANTING PLAN**



DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: **BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC**

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

PLANTING LEGEND

|        |  |              |
|--------|--|--------------|
| ZONE 1 |  | STREAM BANKS |
| ZONE 2 |  | RIPARIAN     |
| ZONE 3 |  | UPLAND       |
| ZONE 4 |  | TO REMAIN    |

LEGEND

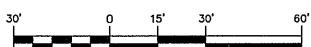
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|  | PROPOSED BANK FULL                                     |
|  | PROPOSED CREEK   |
|  | PERMANENT CONSERVATION EASEMENT                        |
|  | PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING |
|  | ROCK CROSS VANE  |
|  | ROCK A-VANE  |
|  | ROCK VANE  |
|  | LOG CROSS VANE   |
|  | LOG SILL   |
|  | LOG VANE   |

SURVEY LEGEND

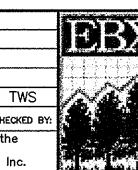
|  |                   |
|--|-------------------|
|  | PROPERTY LINE     |
|  | MAJOR CONTOURS    |
|  | MINOR CONTOURS    |
|  | STREAM CENTERLINE |
|  | TREELINE          |
|  | EXISTING WETLAND  |



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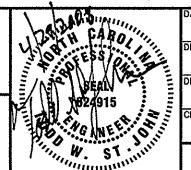


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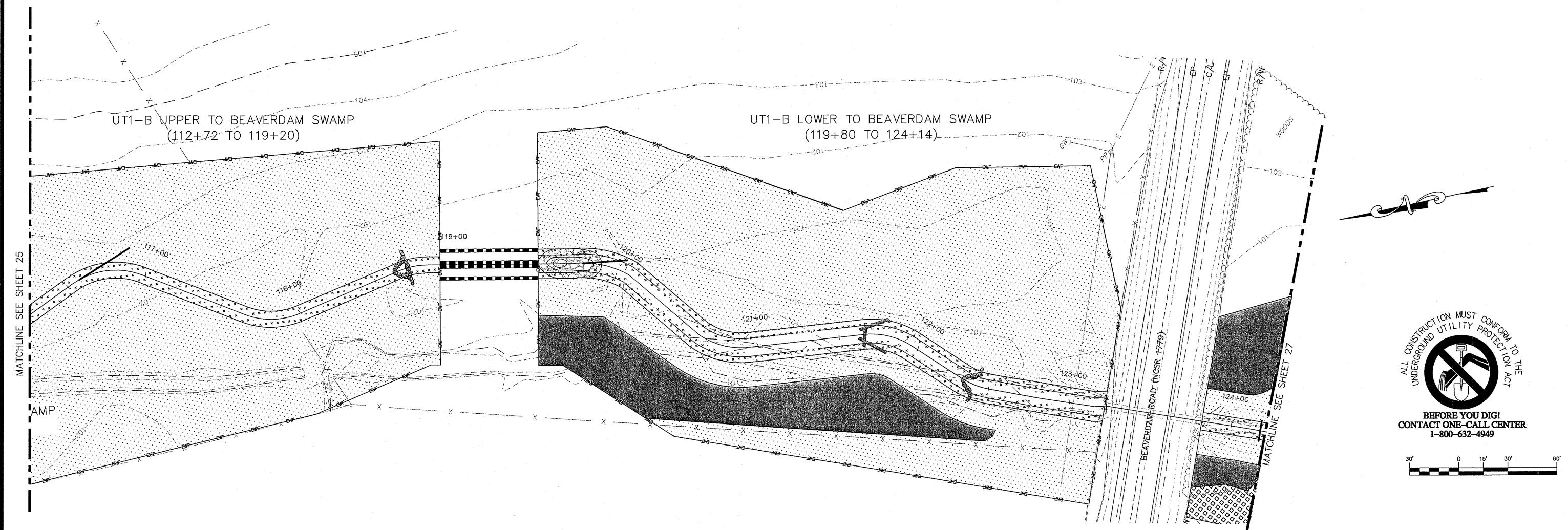
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CLIENT: **STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM**  
TITLE: **PLANTING PLAN**



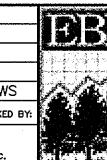
DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: **BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC**  
The record drawings represent the construction plans with  
adjustments made to represent constructed conditions.  
JOB NUMBER: 012620010 SHEET NUMBER: 25



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CLIENT: STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM

TITLE: PLANTING PLAN



DATE: 02/25/08

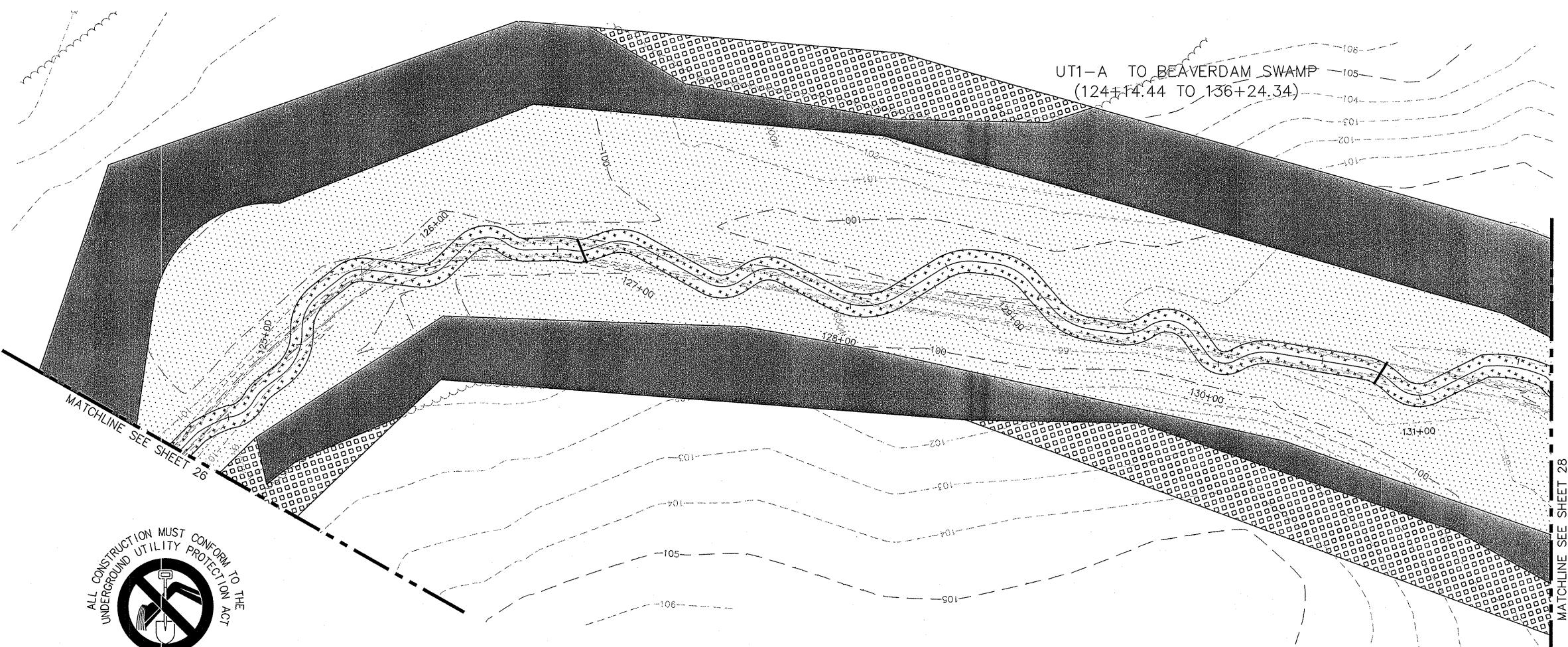
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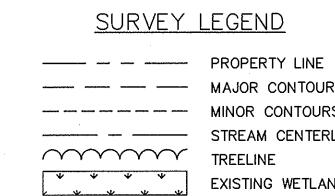
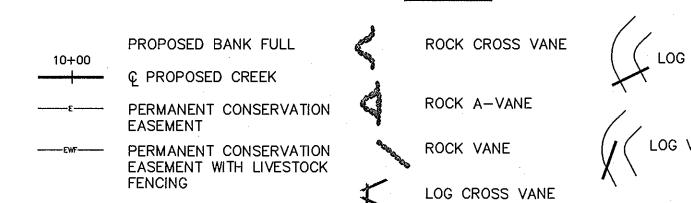
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLCThe record drawings represent the construction plans with  
adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 26



30' 0' 15' 30' 60'



PLANTING LEGEND

|        |              |
|--------|--------------|
| ZONE 1 | STREAM BANKS |
| ZONE 2 | RIPARIAN     |
| ZONE 3 | UPLAND       |
| ZONE 4 | TO REMAIN    |

NOTE:  
UT1-A BELOW BEAVERDAM ROAD TO RECEIVE  
INVASIVE REMOVAL TREATMENT AND SUPPLEMENTAL  
PLANTING ONLY WITHIN THE FORESTED AREA.  
FORESTED AREA SHALL NOT BE RIPLED.

|           |                                    |          |           |             |
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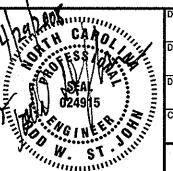
CLIENT: STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM

TITLE: PLANTING PLAN

PLANNED BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
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PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC



The record drawings represent the construction plans with  
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JOB NUMBER: 012620010 SHEET NUMBER: 27

PLANTING LEGEND

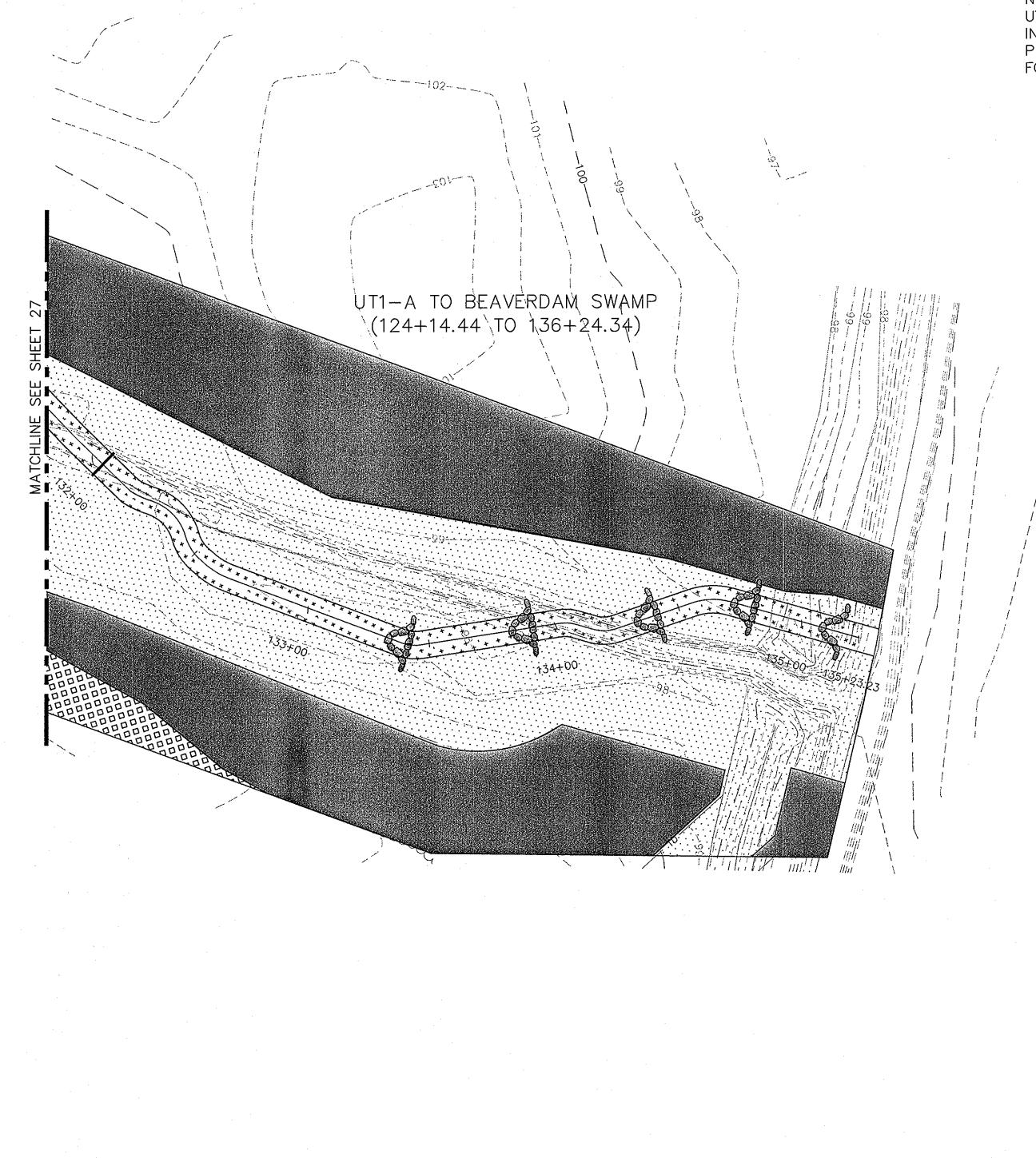
- ZONE 1 STREAM BANKS
- ZONE 2 RIPARIAN
- ZONE 3 UPLAND
- ZONE 4 TO REMAIN

LEGEND

- |  |  |
|--|--|
|  | PROPOSED BANK FULL                                     |
|  | PROPOSED CREEK   |
|  | PERMANENT CONSERVATION EASEMENT                        |
|  | PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING |
|  | ROCK CROSS VANE  |
|  | ROCK A-VANE  |
|  | ROCK VANE  |
|  | LOG CROSS VANE   |
|  | LOG SILL   |

SURVEY LEGEND

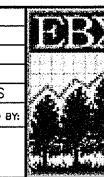
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- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND



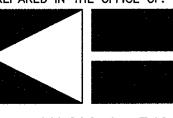
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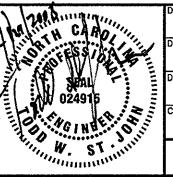


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ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: PLANTING PLAN

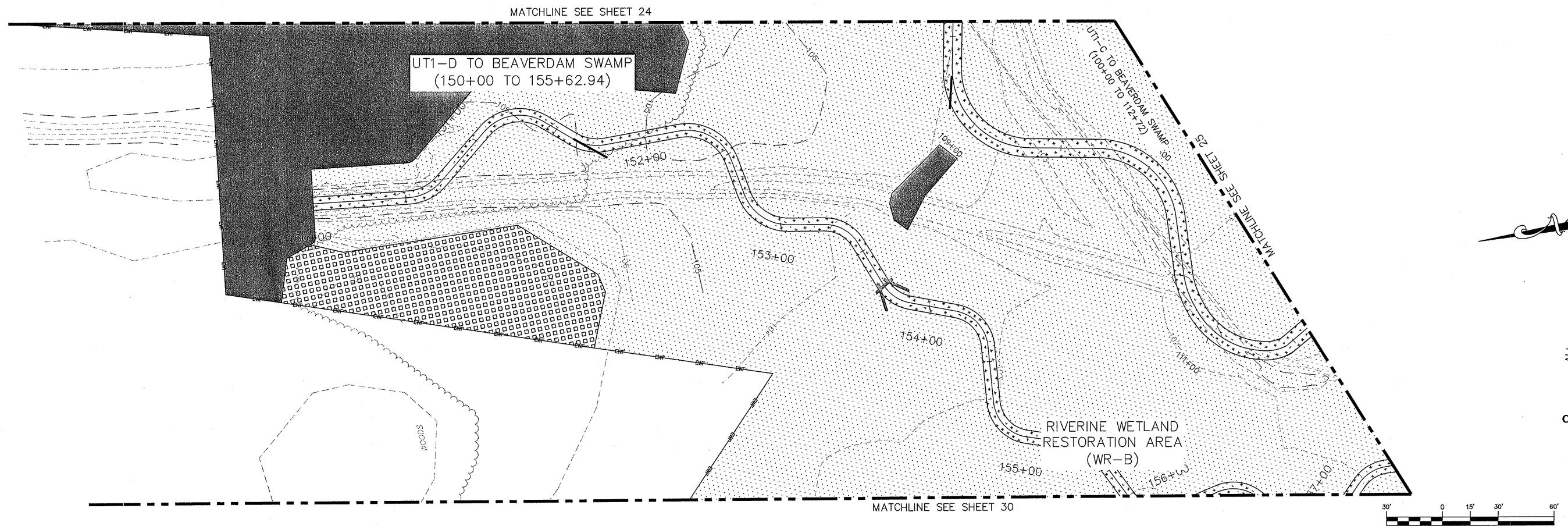


PROJECT: BEAVERDAM SWAMP

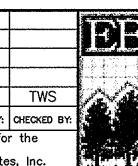
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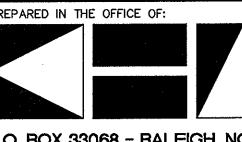
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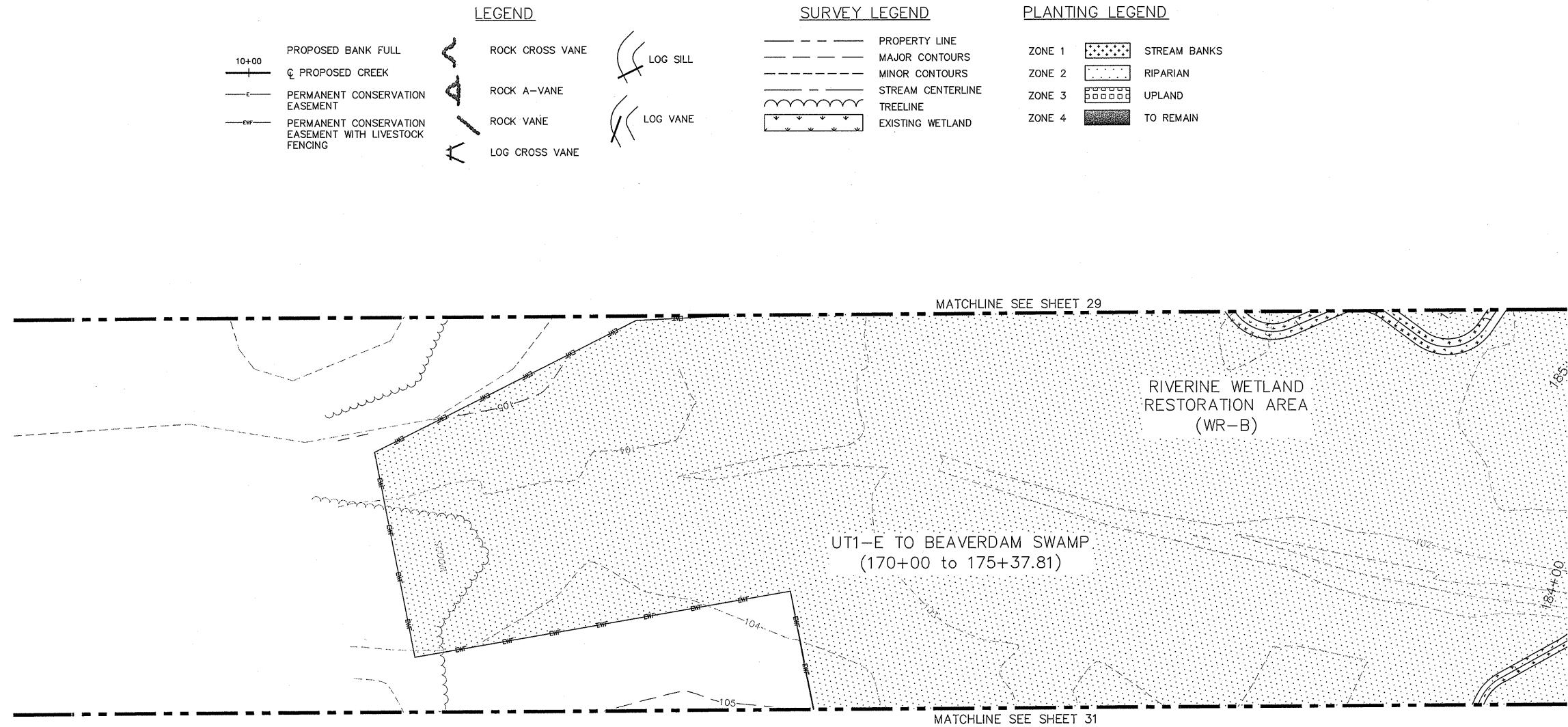


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| REVISION:<br>JIK  | DESIGNED BY:<br>RTL     | DRAWN BY:<br>JIK        | EBX NEUSE I, LLC   |
| DATE:<br>02/25/08   | MAIL NO:<br>024915      | PHONE:<br>0212-555-1111 | ST. JOHN   |
| REVISION:<br>TSJ  | DESIGNED BY:<br>RTL     | CHECKED BY:<br>TSJ      | PROFESSIONAL<br>ENGINEER<br>REGISTRATION<br>BOARD<br>NORTH<br>CAROLINA |

The record drawings represent the construction plans with  
adjustments made to represent constructed conditions.

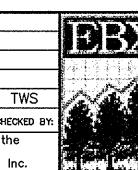
JOB NUMBER:  
012620010  
SHEET NUMBER:  
29



30' 0' 15' 30' 60'

|           |                                    |          |           |             |
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| 1         | REVISED PER EROSION CONTROL REVIEW | 08/23/07 | JIK       | TWS         |
| REV. No.: | REVISION:                          | DATE:    | DRAWN BY: | CHECKED BY: |

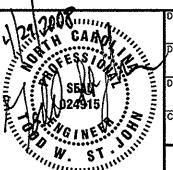
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ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: PLANTING PLAN

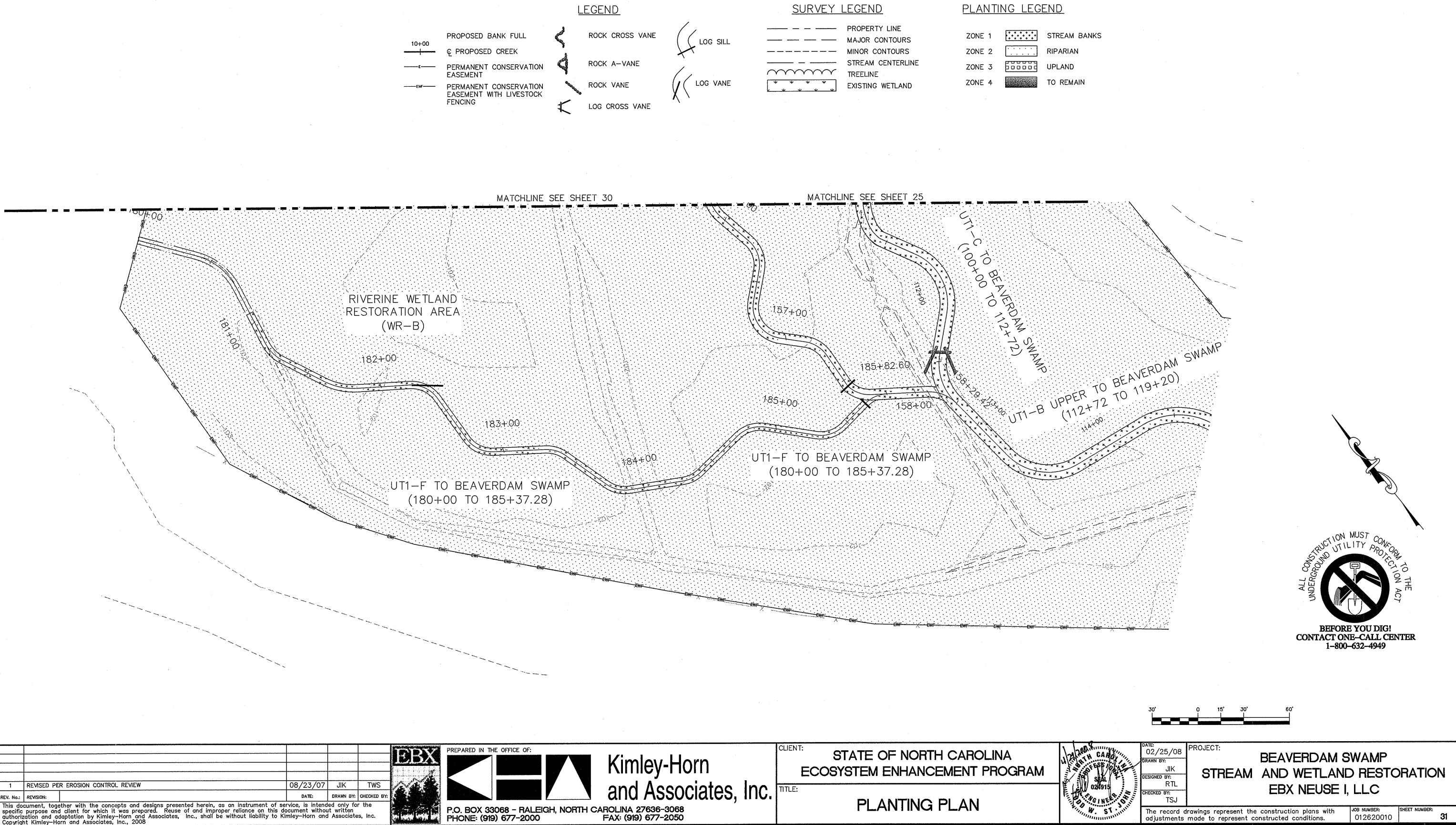


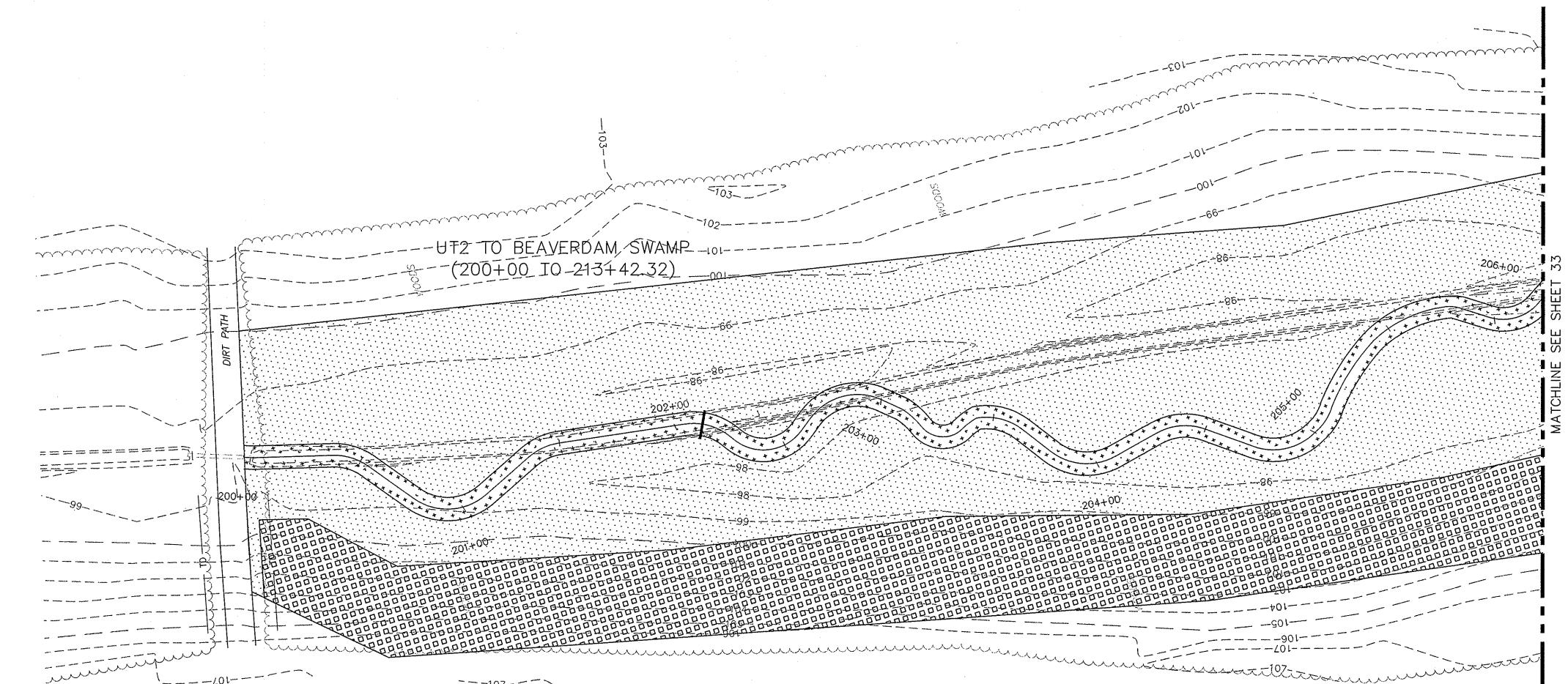
DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

The record drawings represent the construction plans with adjustments made to represent constructed conditions.

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| JOB NUMBER: 012620010 | sheet number: 30 |
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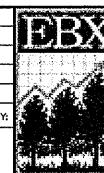


**NOTE:**  
FORESTED AREA TO RECEIVE INVASIVE REMOVAL  
TREATMENT AND SUPPLEMENTAL PLANTING ONLY.  
FORESTED AREA SHALL NOT BE RIPPED.

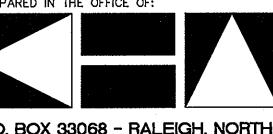


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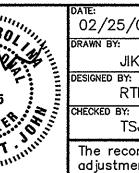
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|   |   |
|---|---|
| CLIENT:<br>STATE OF NORTH CAROLINA<br>ECOSYSTEM ENHANCEMENT PROGRAM | PROJECT:<br>BEAVERDAM SWAMP<br>STREAM AND WETLAND RESTORATION<br>EBX NEUSE I, LLC |
| TITLE:<br>PLANTING PLAN   |   |

PLANTING PLAN

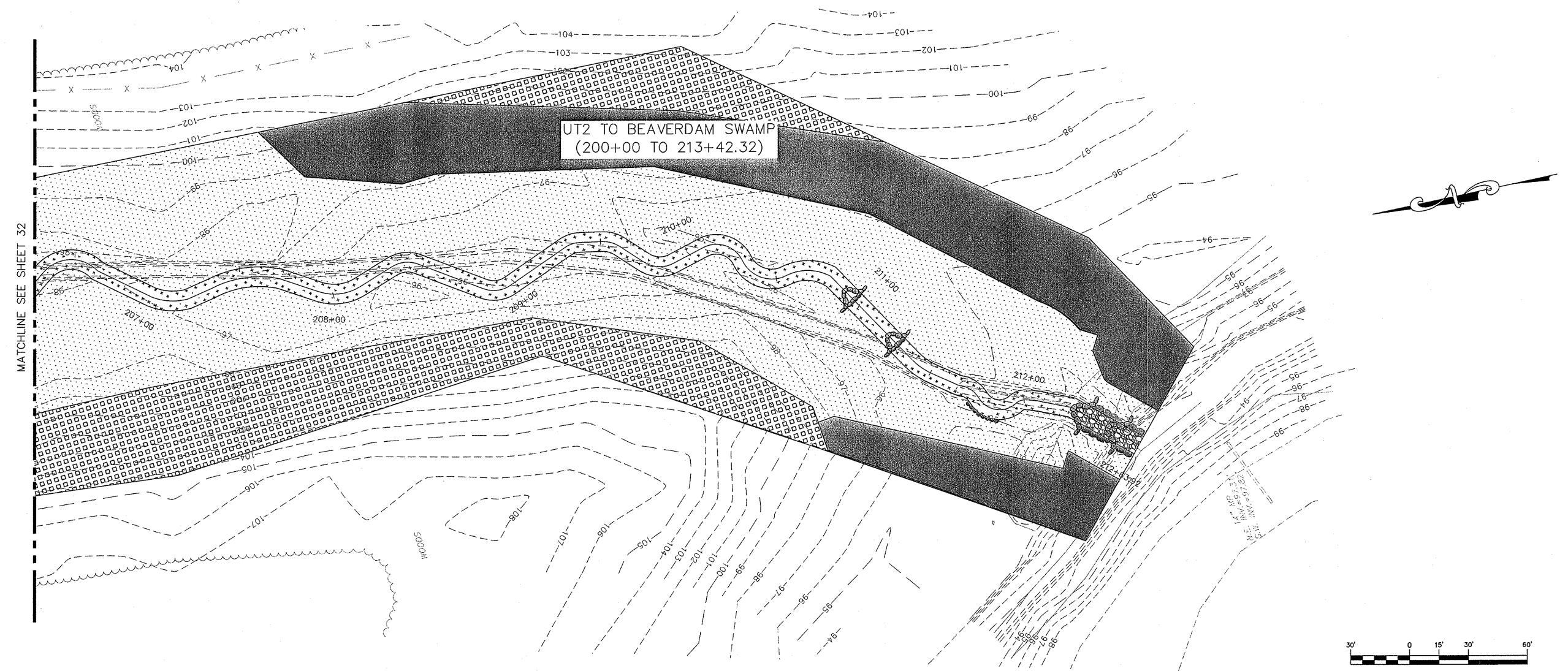


DATE:  
02/25/08  
DRAWN BY:  
JIK  
DESIGNED BY:  
RTL  
CHECKED BY:  
TSJ

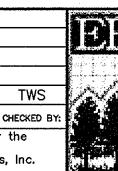
The record drawings represent the construction plans with  
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JOB NUMBER:  
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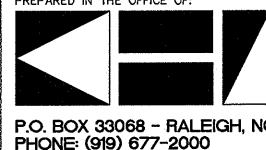
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32



1 REVISED PER EROSION CONTROL REVIEW  
REV. No.: 08/23/07 JIK TWS  
REVISION: DATE: DRAWN BY: CHECKED BY:

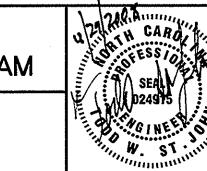


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CLIENT: STATE OF NORTH CAROLINA  
ECOSYSTEM ENHANCEMENT PROGRAM  
TITLE: PLANTING PLAN



DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

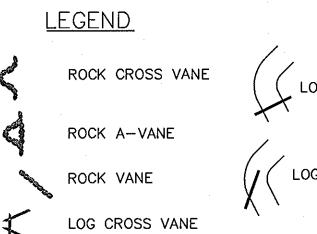
PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC  
The record drawings represent the construction plans with  
adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 33



**LEGEND**

- 10+00 PROPOSED BANK FULL
- PROPOSED CREEK
- PERMANENT CONSERVATION EASEMENT
- PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING

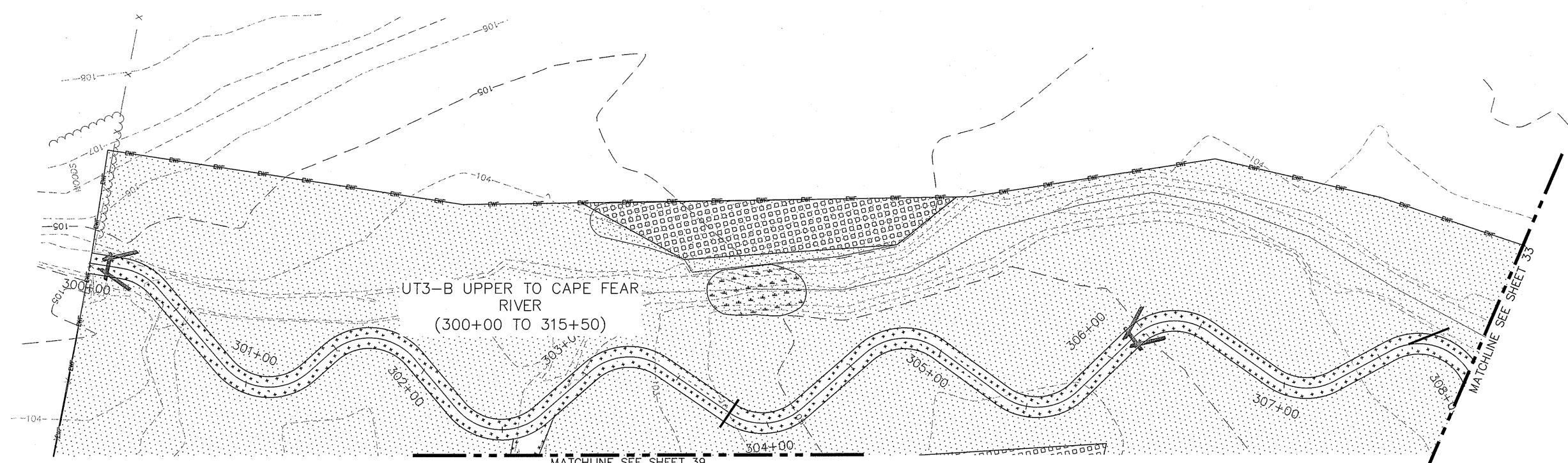


**SURVEY LEGEND**

- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND

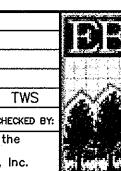
**PLANTING LEGEND**

|        |              |
|--------|--------------|
| ZONE 1 | STREAM BANKS |
| ZONE 2 | RIPARIAN     |
| ZONE 3 | UPLAND       |
| ZONE 4 | TO REMAIN    |

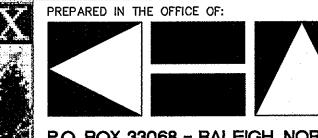


30' 0' 15' 30' 60'

|           |                                    |          |           |             |
|-----------|------------------------------------|----------|-----------|-------------|
| 1         | REVISED PER EROSION CONTROL REVIEW | 08/23/07 | JIK       | TWS         |
| REV. NO.: | REVISION:                          | DATE:    | DRAWN BY: | CHECKED BY: |

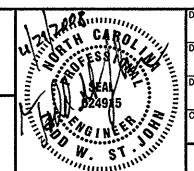


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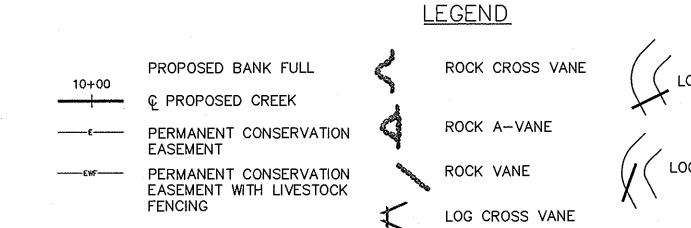
CLIENT: STATE OF NORTH CAROLINA  
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TITLE: PLANTING PLAN



DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC  
The record drawings represent the construction plans with  
adjustments made to represent constructed conditions.  
JOB NUMBER: 012620010 SHEET NUMBER: 34

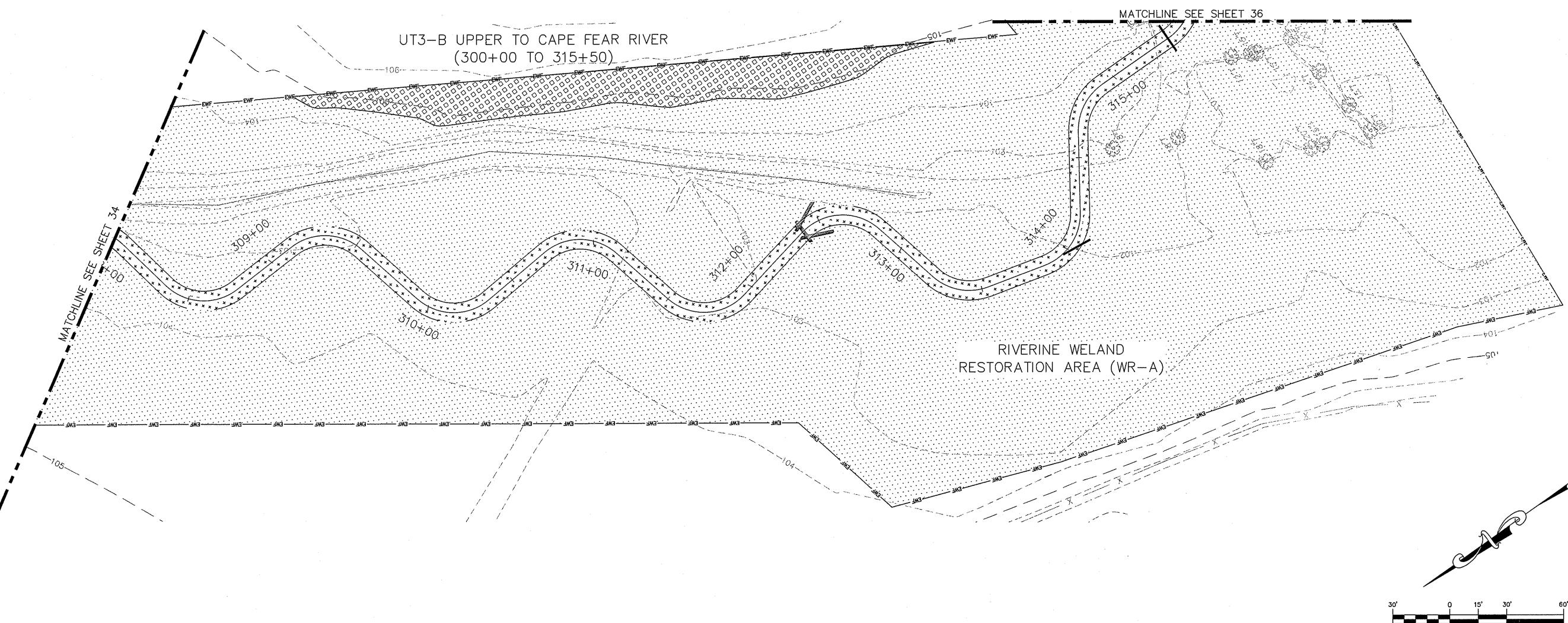
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SURVEY LEGEND

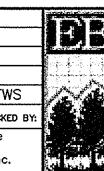
- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND

PLANTING LEGEND

- |        |              |
|--------|--------------|
| ZONE 1 | STREAM BANKS |
| ZONE 2 | RIPARIAN     |
| ZONE 3 | UPLAND       |
| ZONE 4 | TO REMAIN    |



|           |                                    |          |           |             |
|-----------|------------------------------------|----------|-----------|-------------|
| 1         | REVISED PER EROSION CONTROL REVIEW | 08/23/07 | JIK       | TWS         |
| REV. No.: | REVISION:                          | DATE:    | DRAWN BY: | CHECKED BY: |



PREPARED IN THE OFFICE OF:

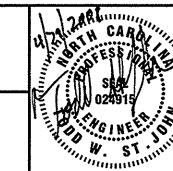


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TITLE: PLANTING PLAN



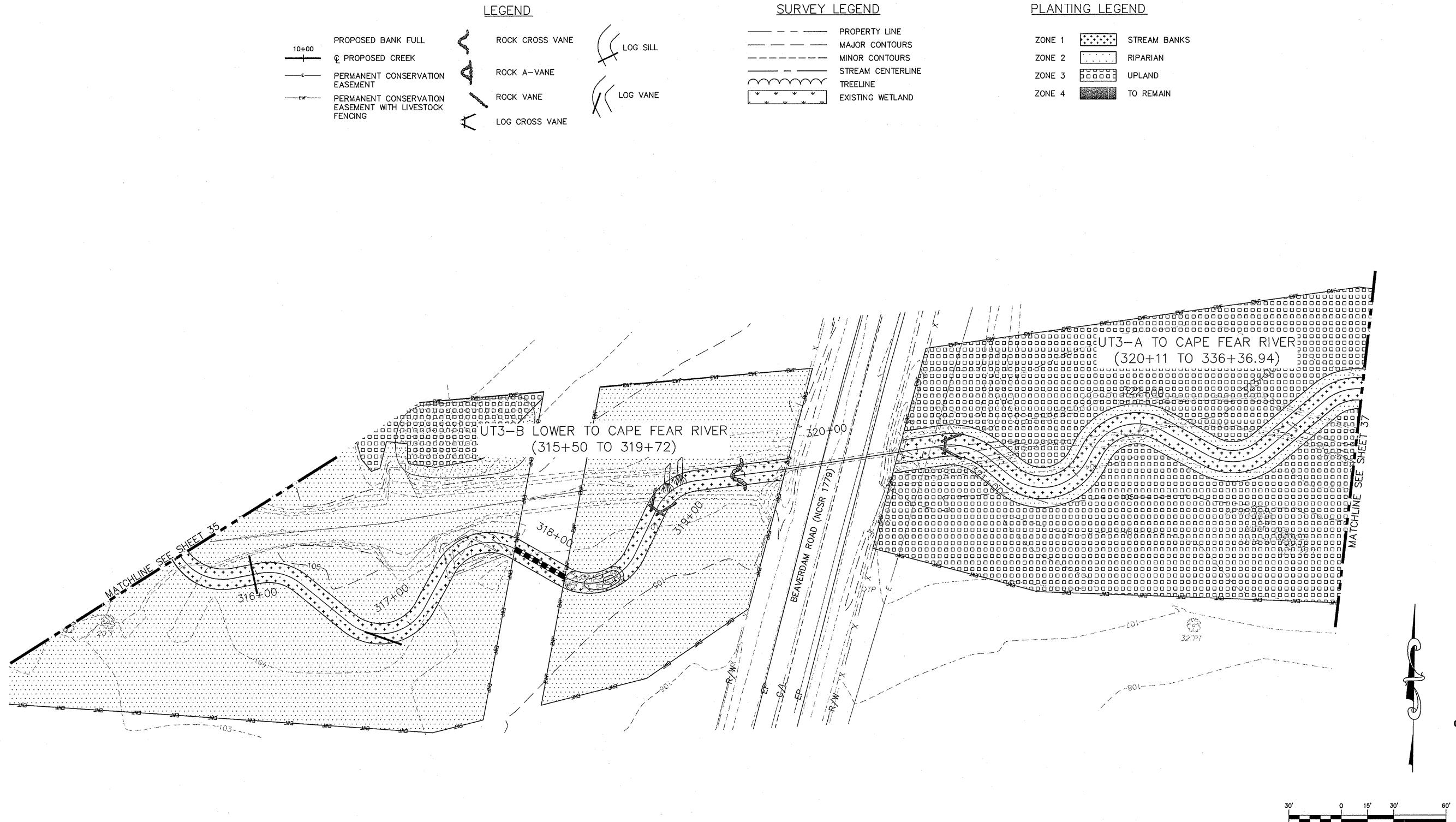
DATE: 02/25/08

DRAWN BY:  
JIKDESIGNED BY:  
RTLCHECKED BY:  
TSJ

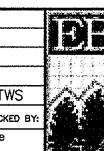
PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

The record drawings represent the construction plans with  
adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 35



|          |                                    |          |           |             |
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CHECKED BY: TSJ

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JOB NUMBER: 012620010 SHEET NUMBER: 36

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**LEGEND**

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- PROPOSED CREEK
- PERMANENT CONSERVATION EASEMENT
- PERMANENT CONSERVATION EASEMENT WITH LIVESTOCK FENCING

**LEGEND**

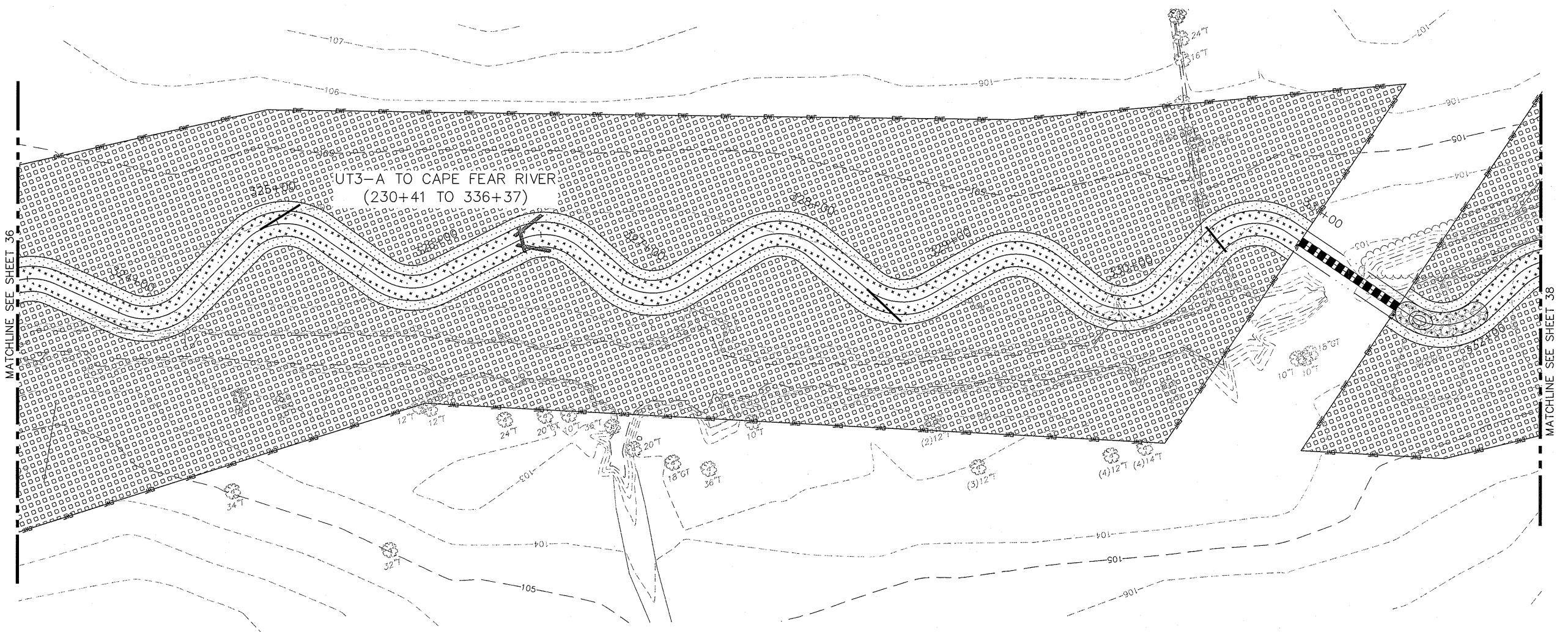
- ROCK CROSS VANE
- LOG SILL
- ROCK A-VANE
- ROCK VANE
- LOG VANE
- LOG CROSS VANE

**SURVEY LEGEND**

- PROPERTY LINE
- MAJOR CONTOURS
- MINOR CONTOURS
- STREAM CENTERLINE
- TREELINE
- EXISTING WETLAND

**PLANTING LEGEND**

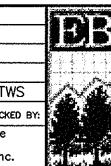
|        |              |
|--------|--------------|
| ZONE 1 | STREAM BANKS |
| ZONE 2 | RIPARIAN     |
| ZONE 3 | UPLAND       |
| ZONE 4 | TO REMAIN    |



30' 0' 15' 30' 60'

|           |                                    |          |           |             |
|-----------|------------------------------------|----------|-----------|-------------|
| 1         | REVISED PER EROSION CONTROL REVIEW | 08/23/07 | JIK       | TWS         |
| REV. No.: | REVISION:                          | DATE:    | DRAWN BY: | CHECKED BY: |

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TITLE: PLANTING PLAN

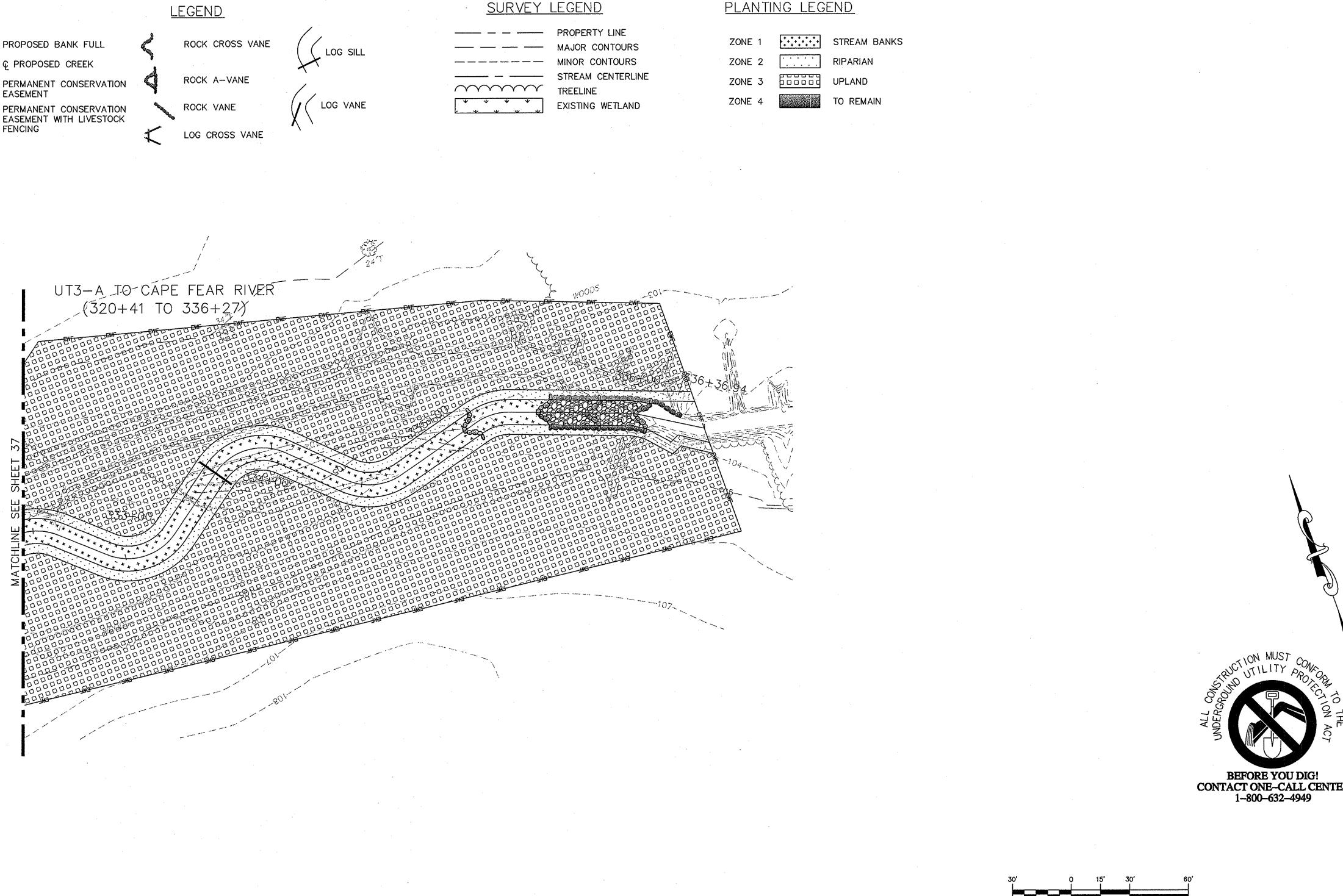


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

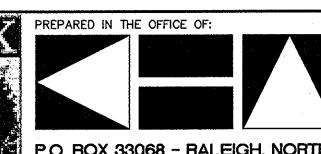
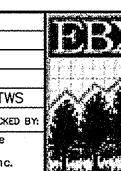
PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

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X08 NUMBER: 012620010 SHEET NUMBER: 37



|          |                                    |          |           |             |
|----------|------------------------------------|----------|-----------|-------------|
| 1        | REVISED PER EROSION CONTROL REVIEW | 08/23/07 | JIK       | TWS         |
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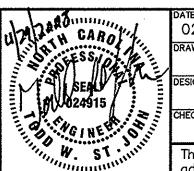


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TITLE: PLANTING PLAN

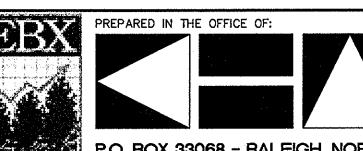
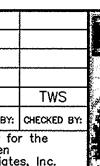


DATE: 02/25/08  
DRAWN BY: JIK  
DESIGNED BY: RTL  
CHECKED BY: TSJ

PROJECT: BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC

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adjustments made to represent constructed conditions.

JOB NUMBER: 012620010 SHEET NUMBER: 38



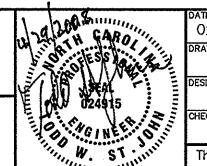
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| REV. No.: 1 | REvised PER EROSION CONTROL REVIEW | DATE: 08/23/07 | DRAWN BY: JIK | CHECKED BY: TWS |
| REVISON:    |                                    | DATE:          | DRAWN BY:     | CHECKED BY:     |

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ECOSYSTEM ENHANCEMENT PROGRAM**  
 TITLE: **PLANTING PLAN**

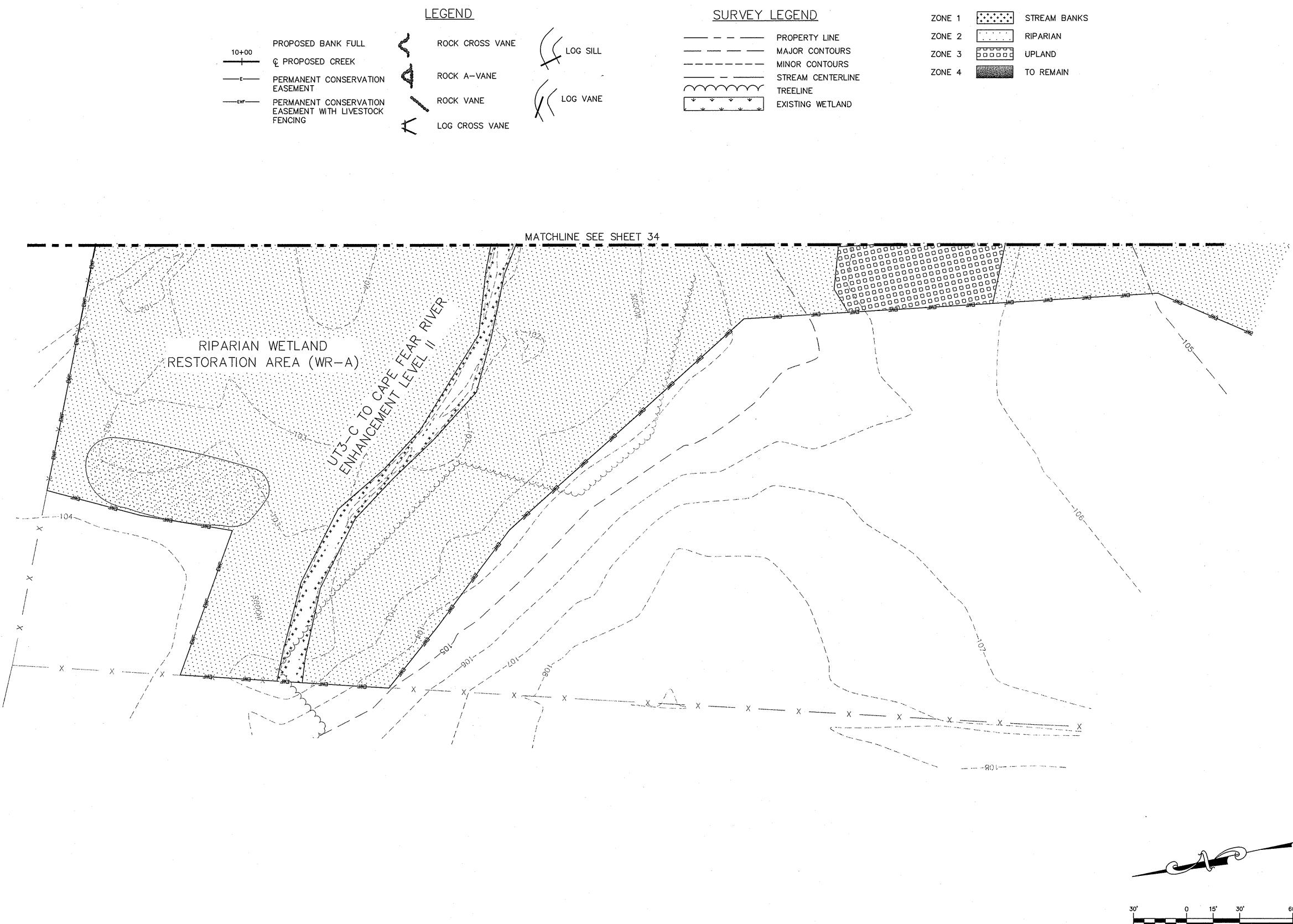


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 DRAWN BY: JIK  
 DESIGNED BY: RTL  
 CHECKED BY: TSJ

PROJECT: **BEAVERDAM SWAMP  
STREAM AND WETLAND RESTORATION  
EBX NEUSE I, LLC**

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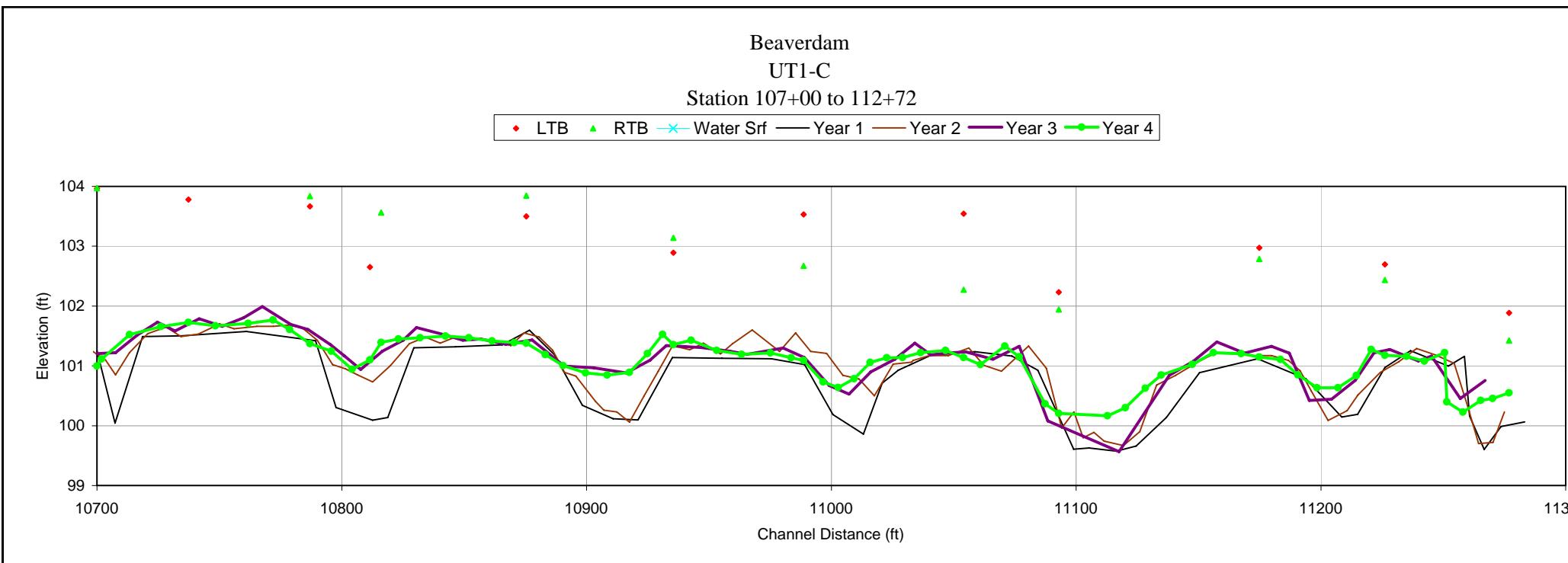
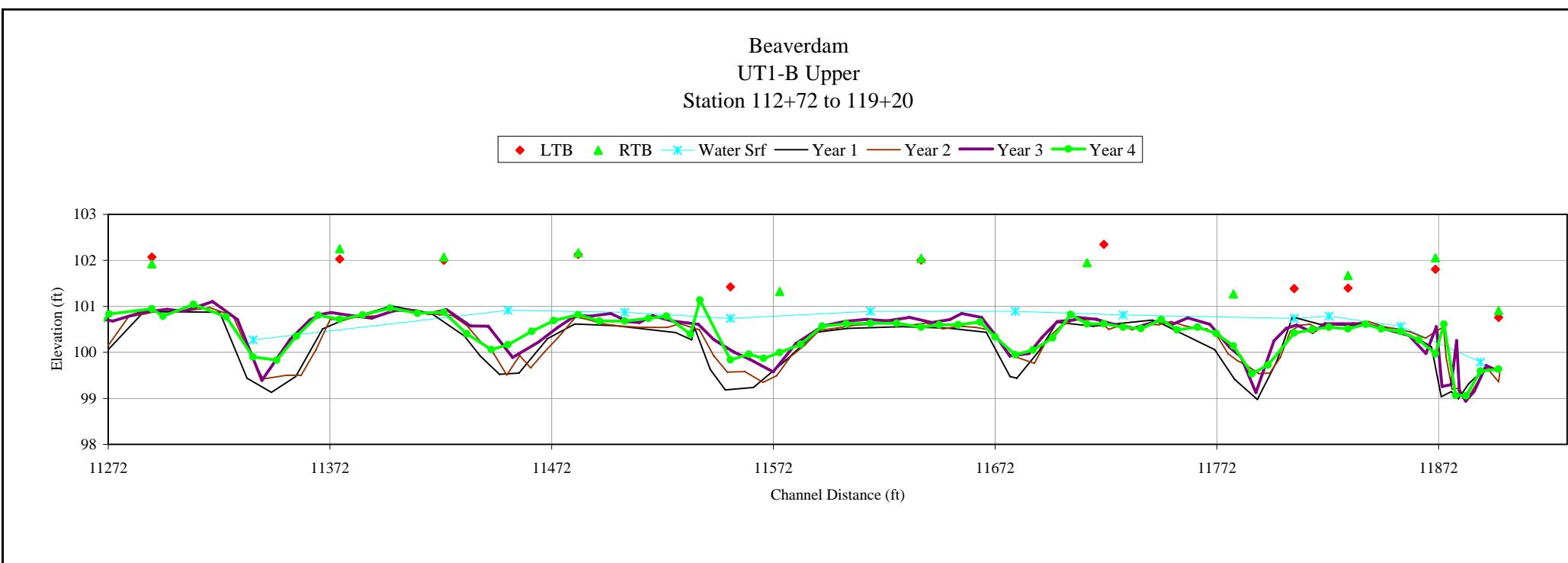
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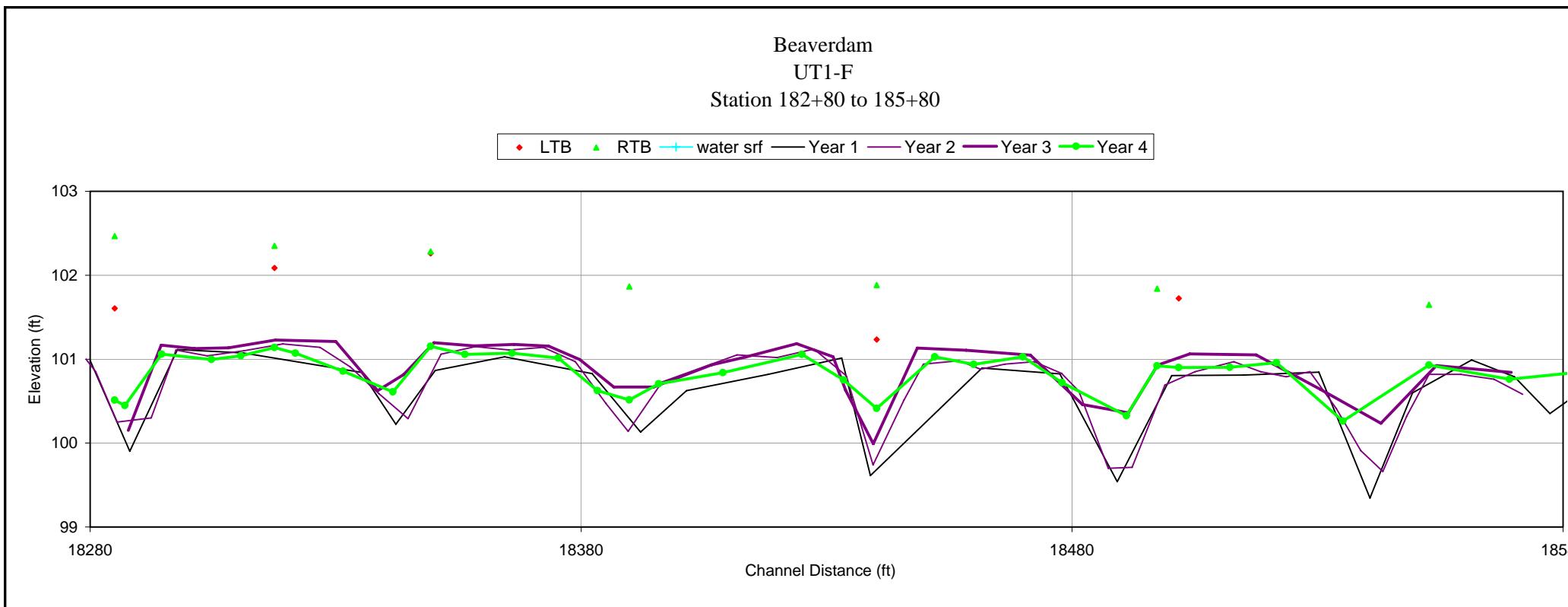
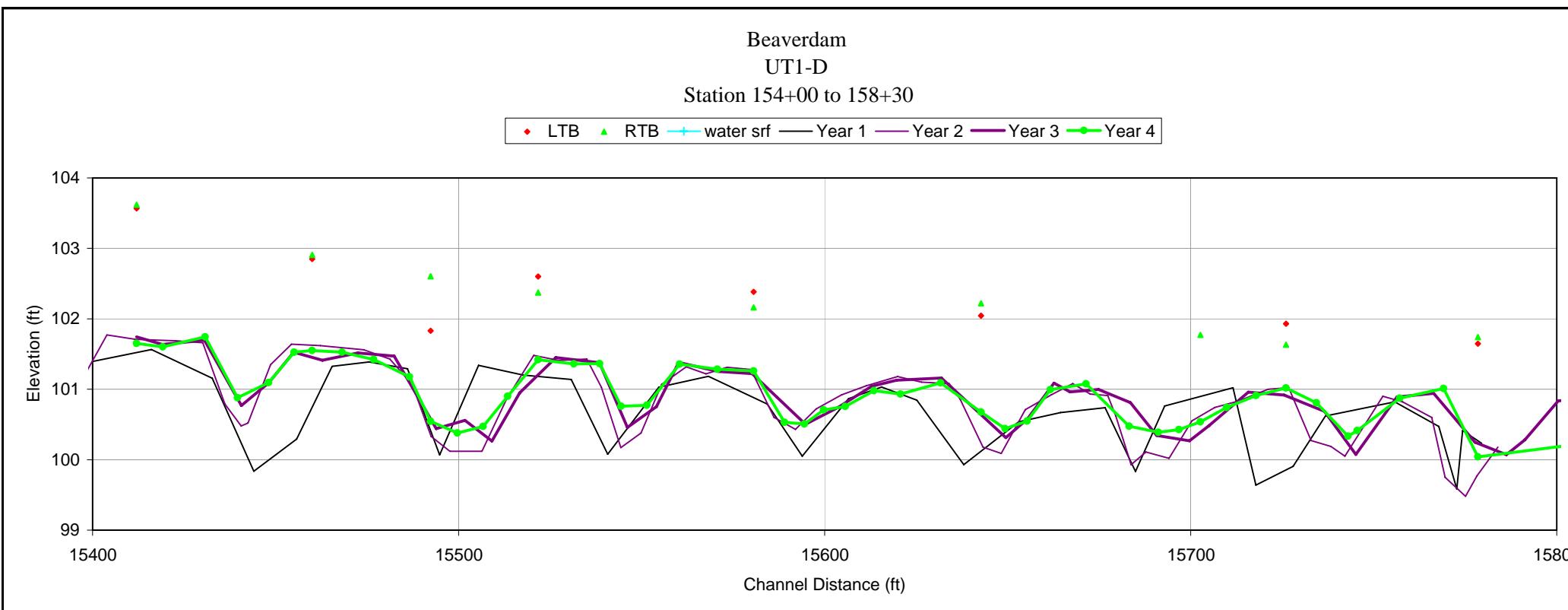


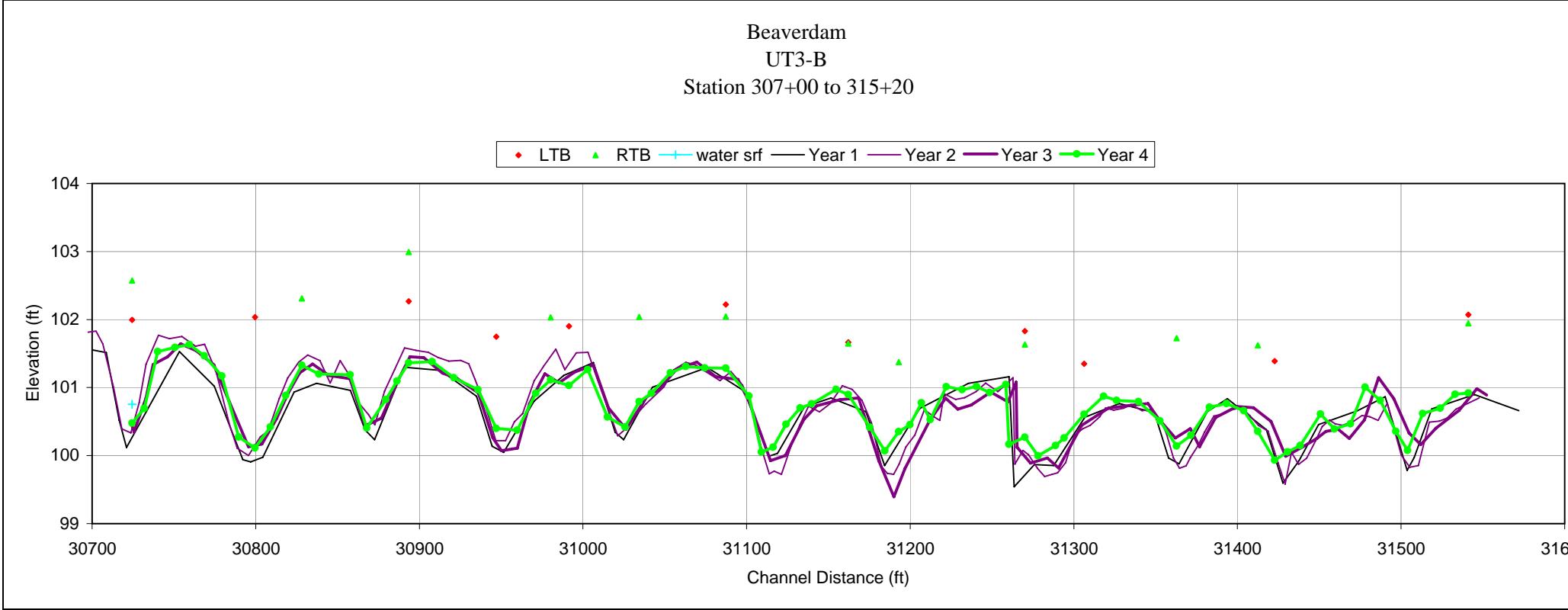
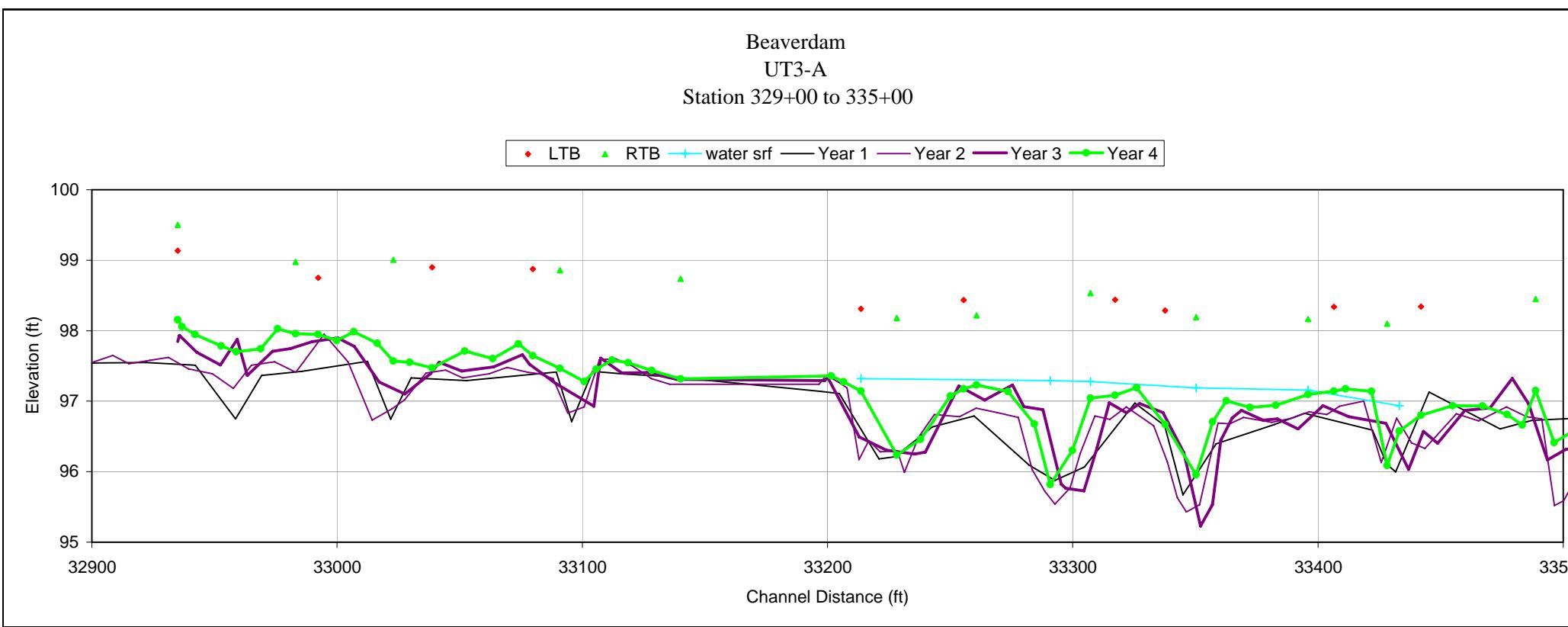
## **APPENDIX B**

### **2011 Profile and Cross Section Data**









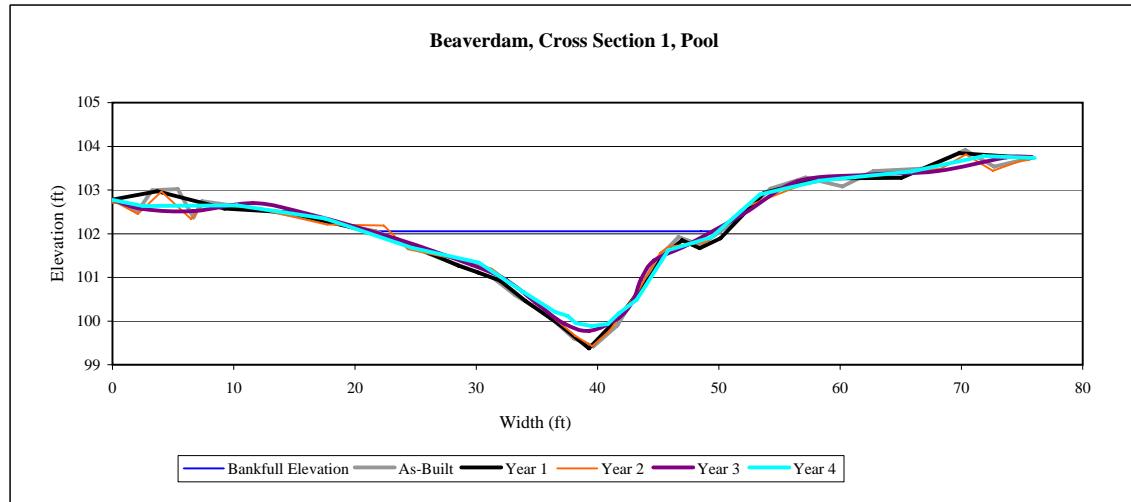
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



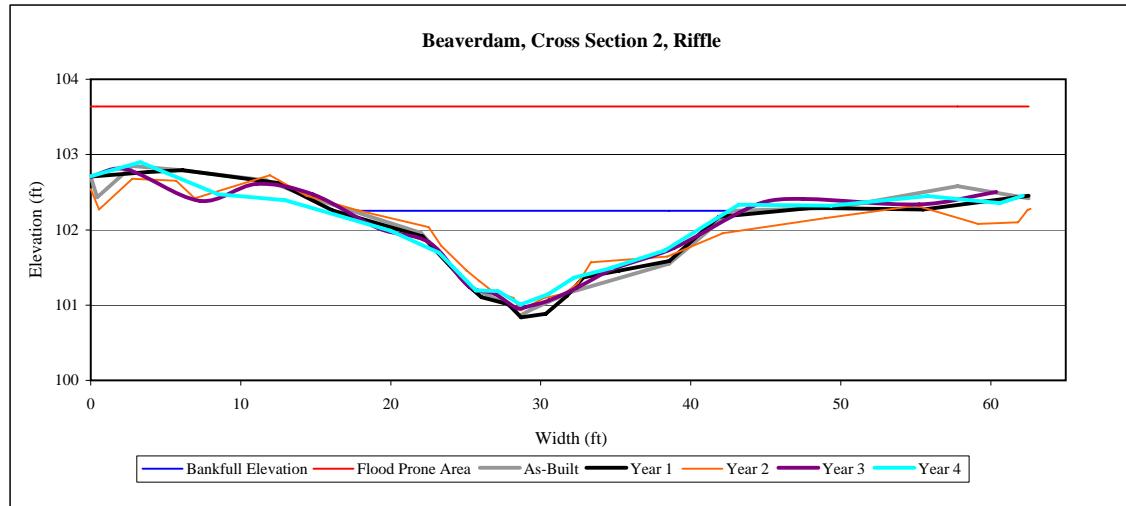
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



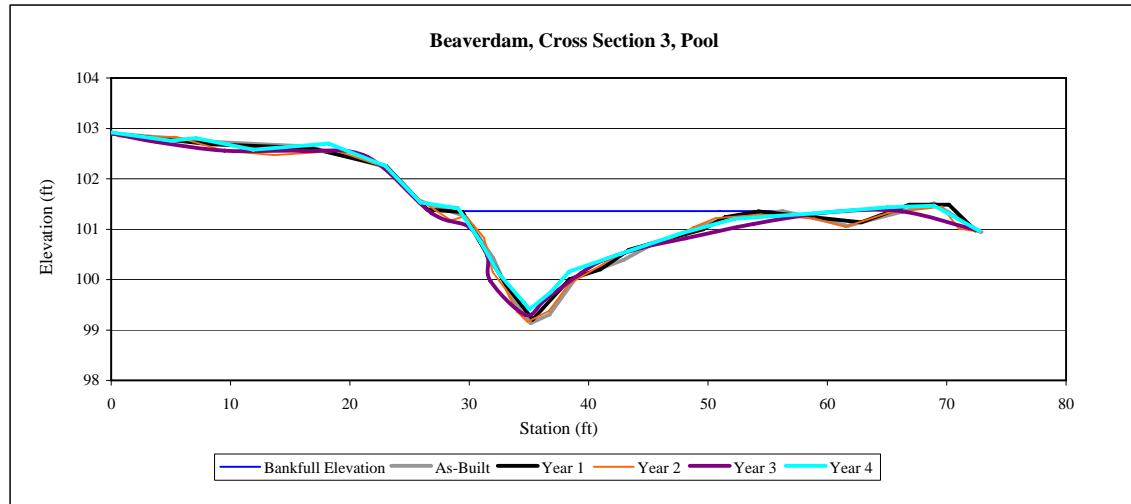
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



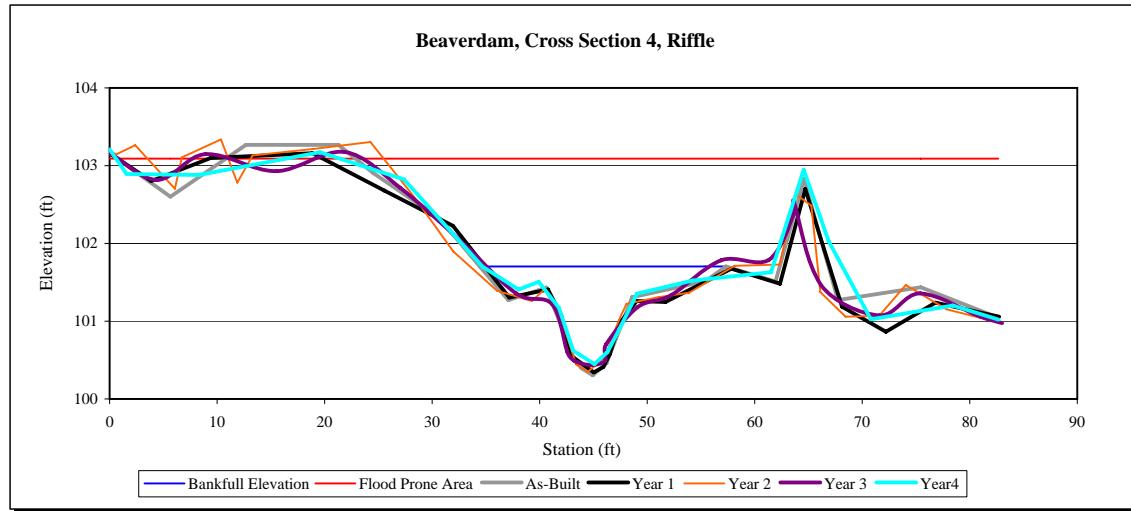
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



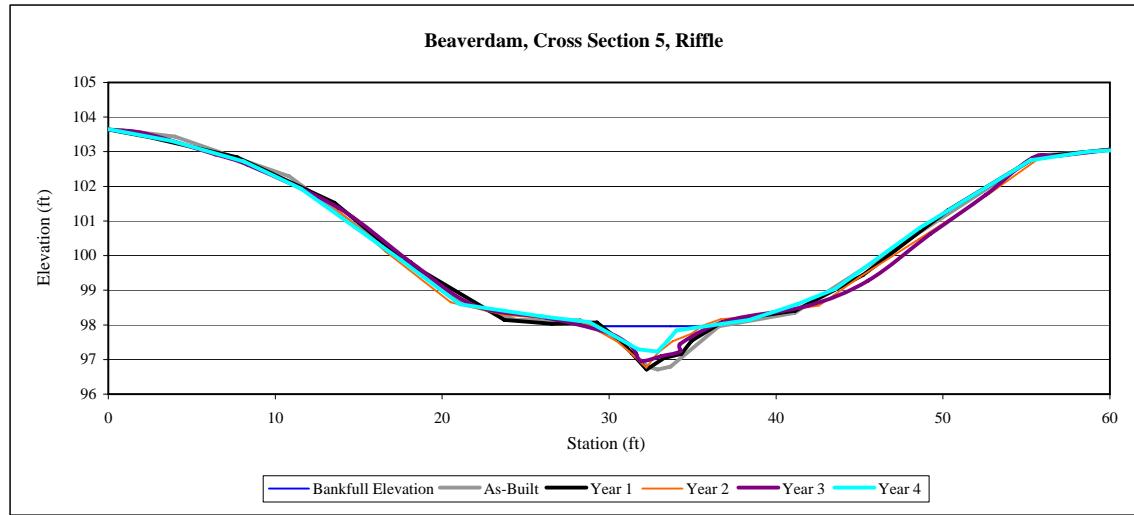
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



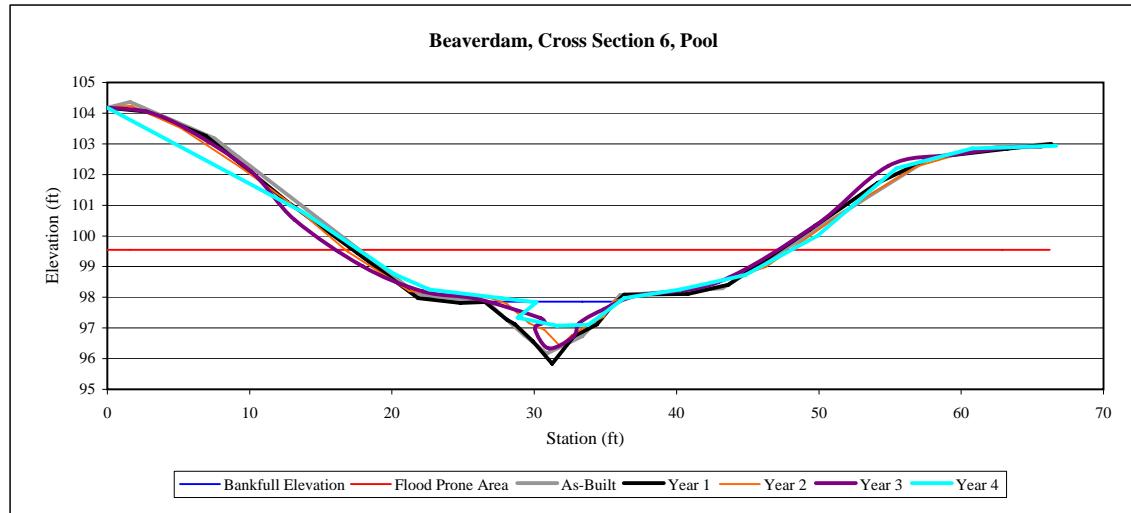
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



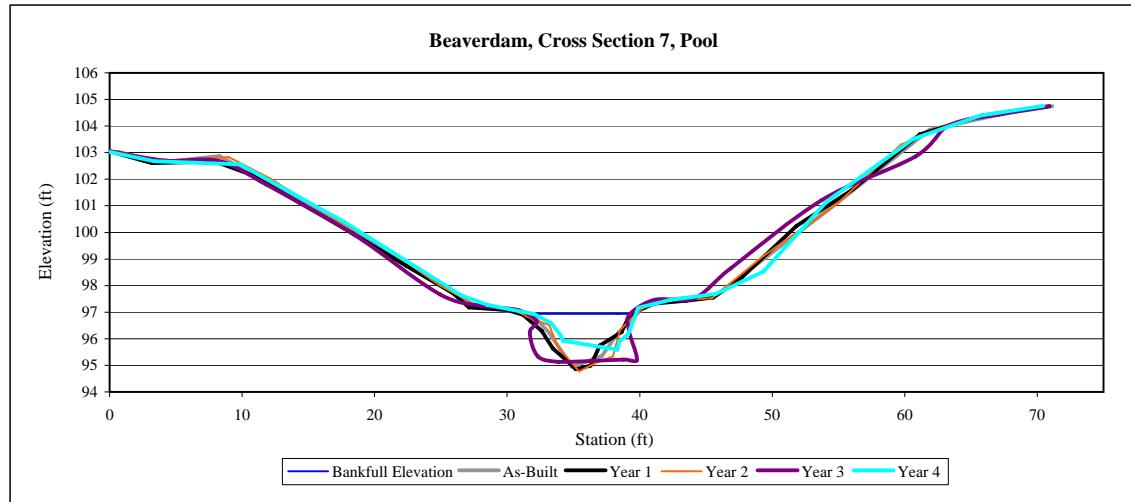
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



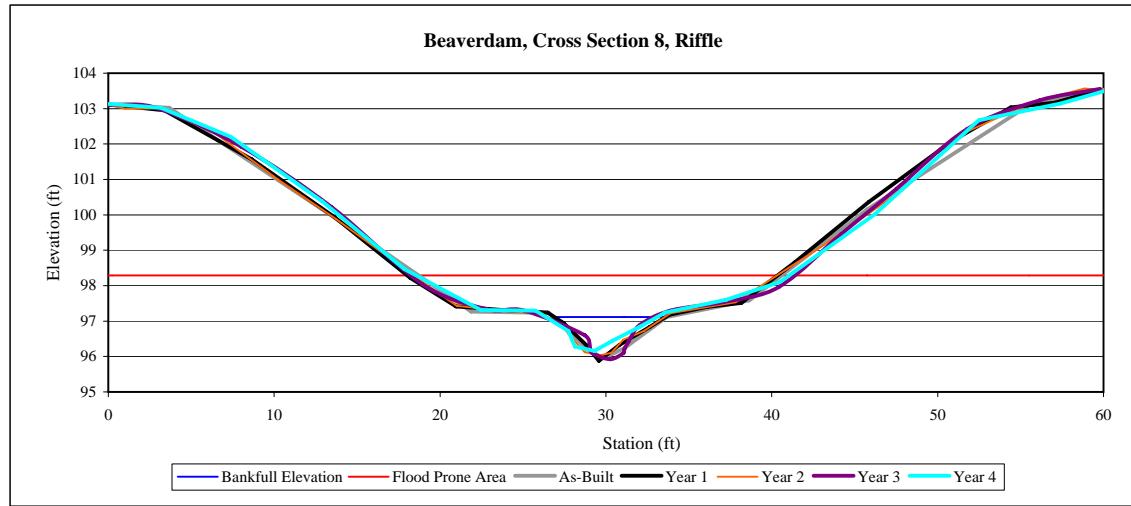
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



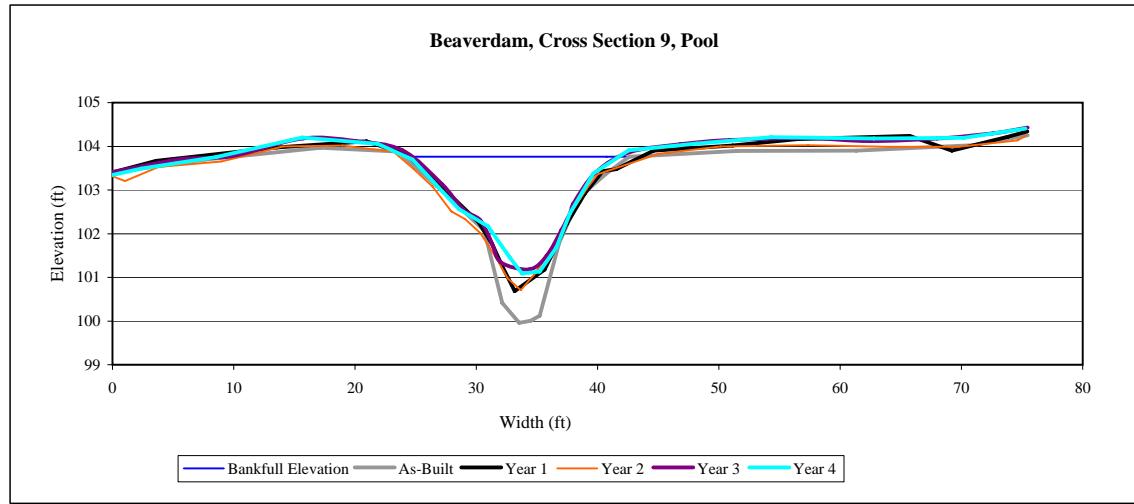
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



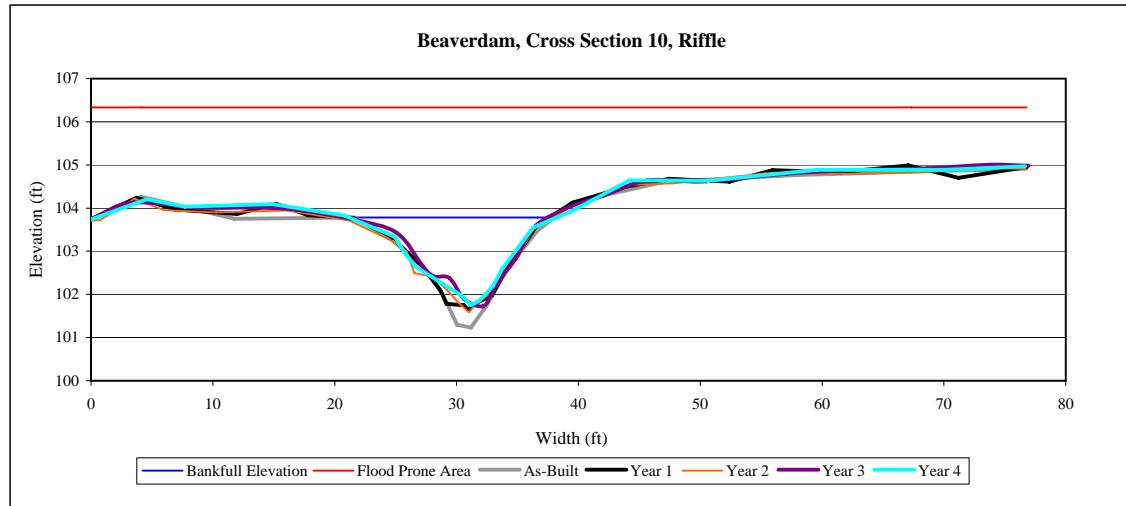
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



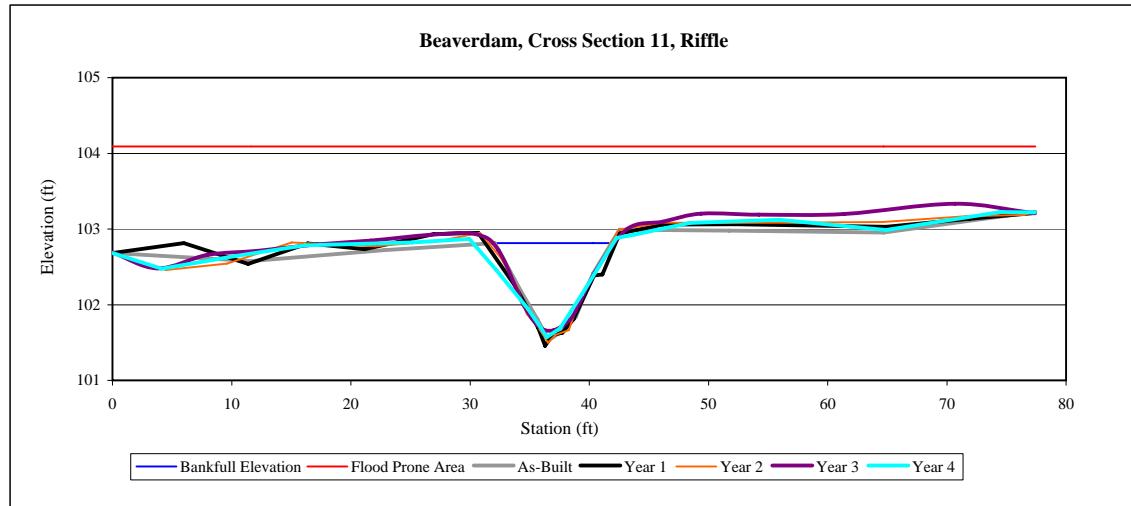
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



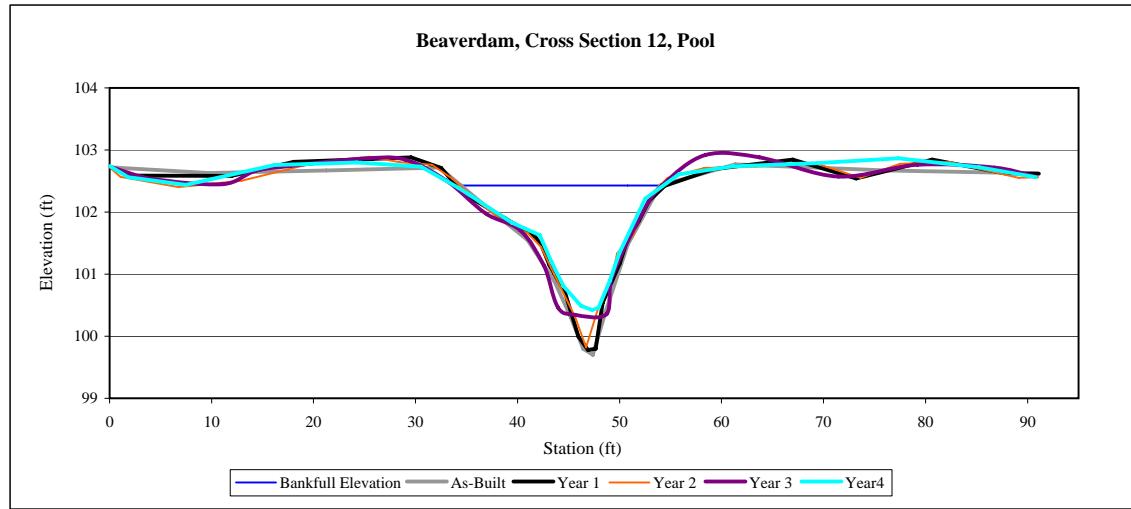
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



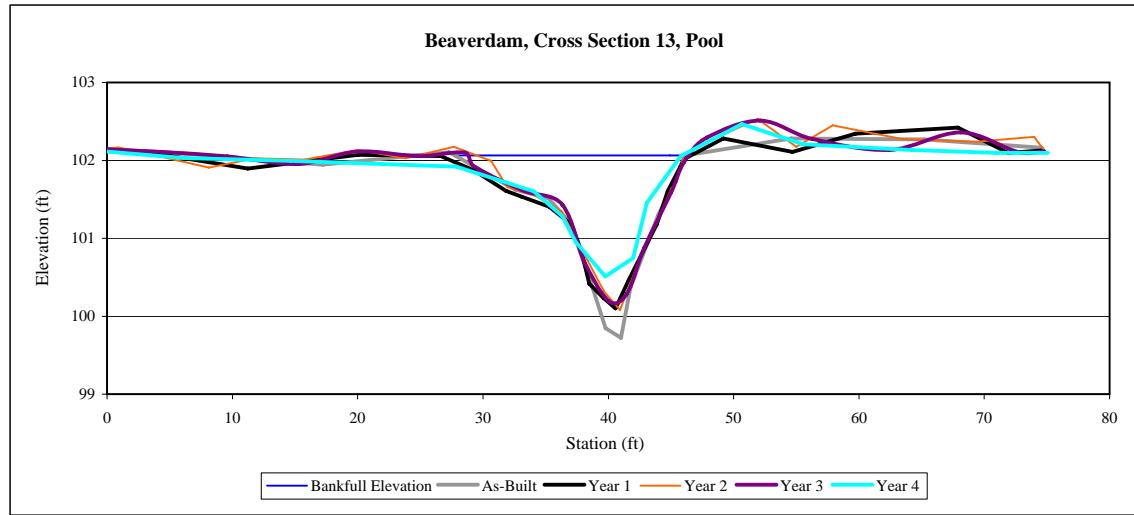
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



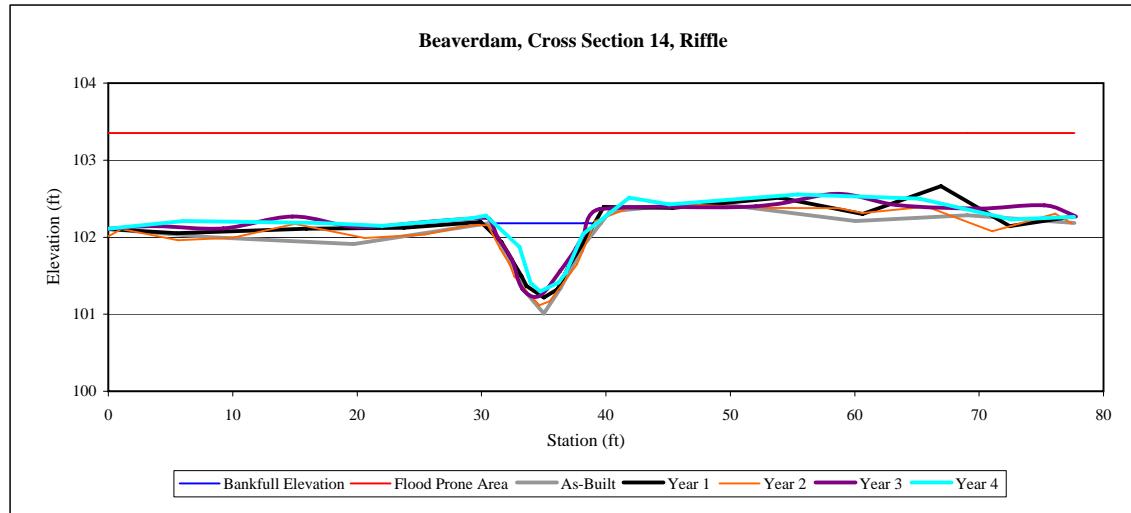
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



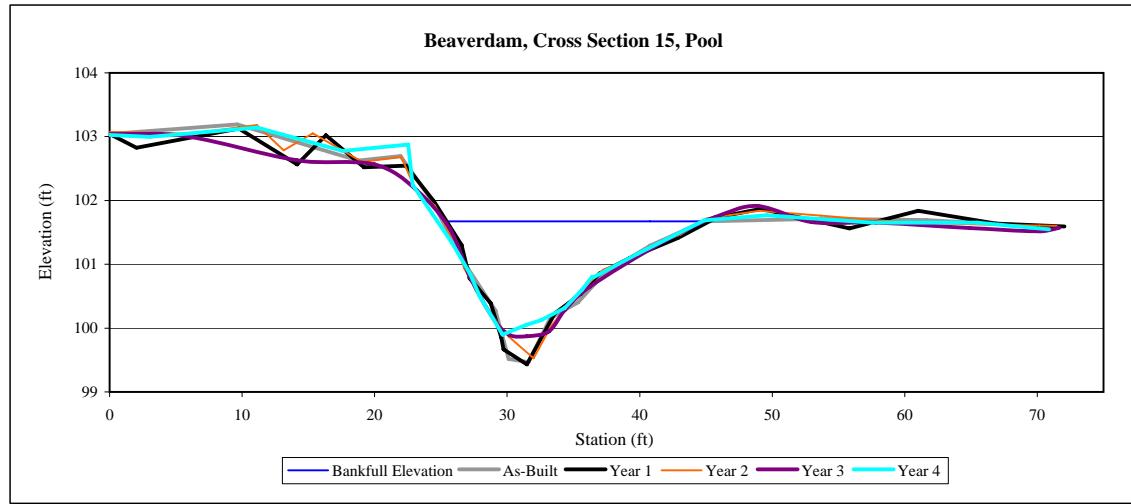
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



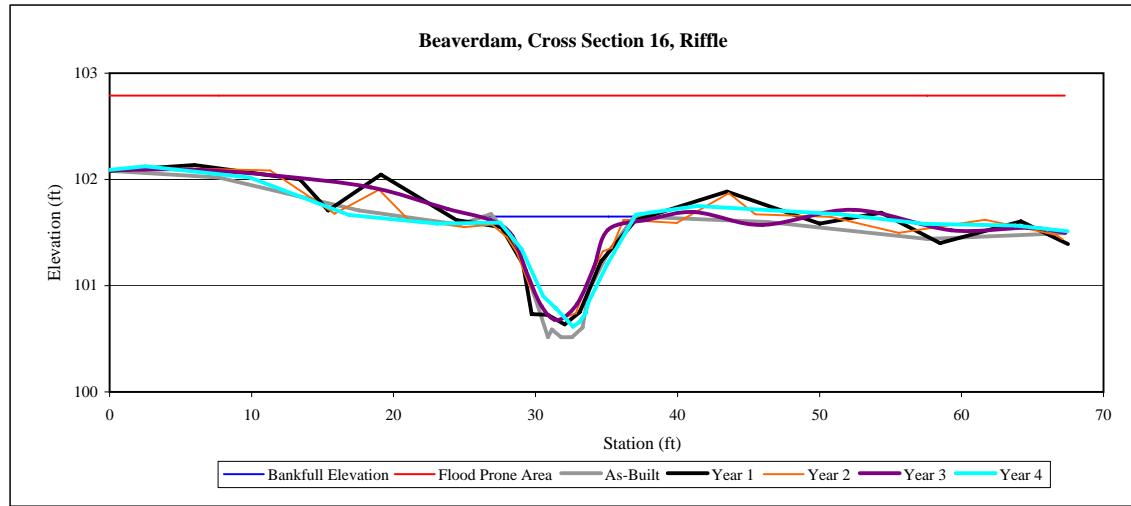
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



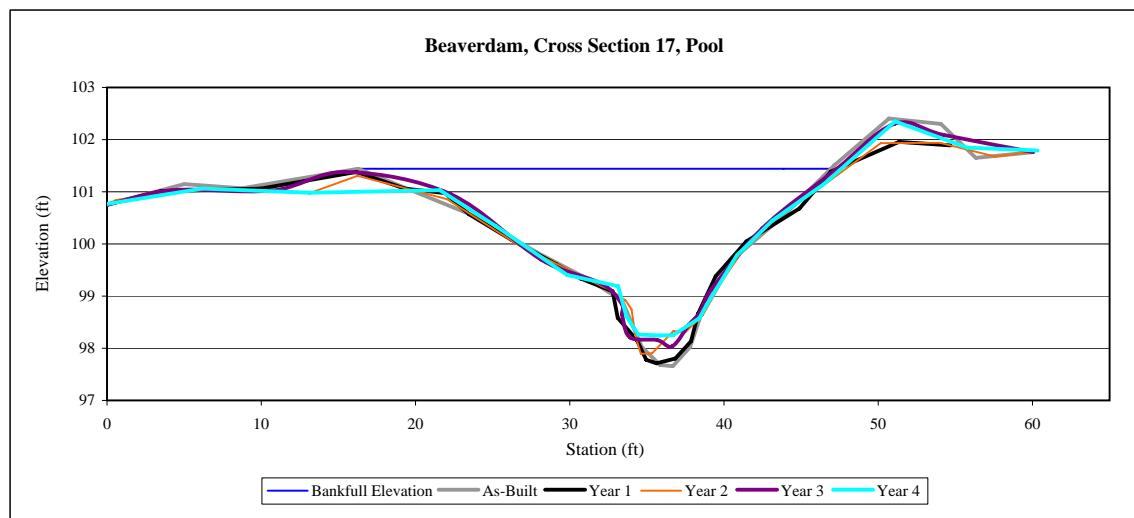
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



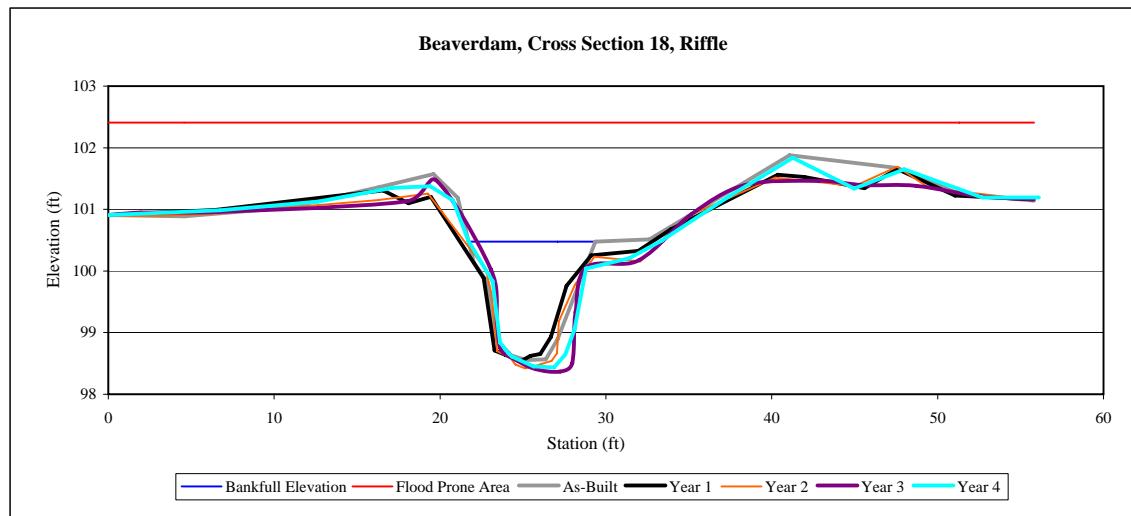
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



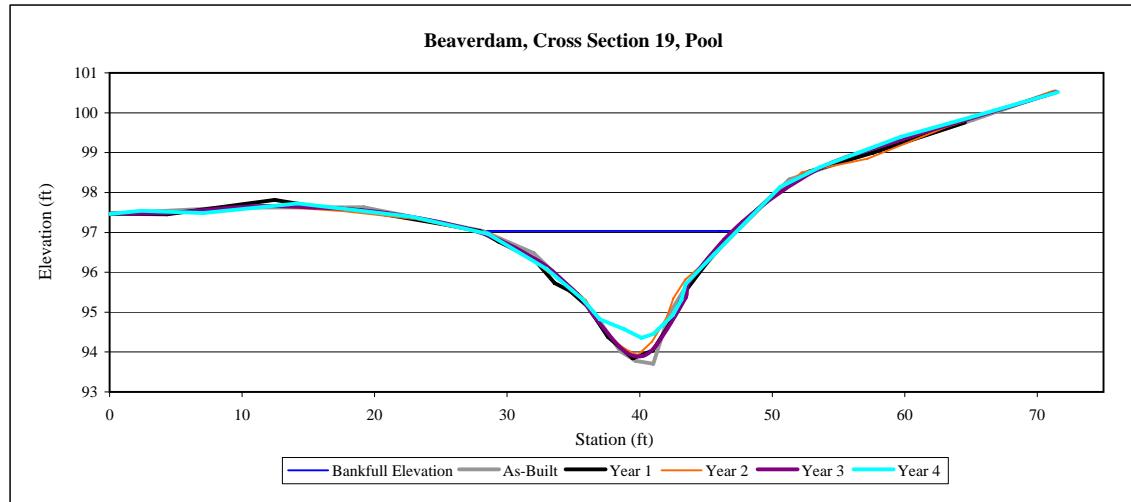
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



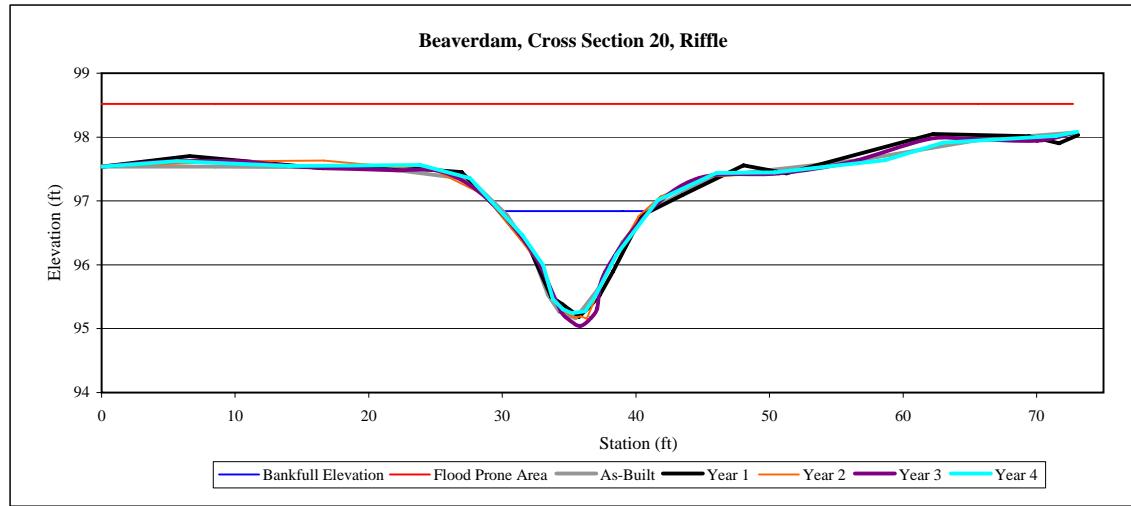
Beaverdam Mitigation Site  
Annual Monitoring Report for 2011 (Year 4)



Left bank



Right bank



## **APPENDIX C**

### **2011 Gauge Data**



































## **APPENDIX D**

### **2011 Site Photos**



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SOA1 – Sparse vegetation on left and right banks at Sta. 153+00 – 153+30 (UT1-A)



SOA2 – Easement fencing is loose at Sta. 118+90 (UT1-B)

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SOA3 – Sparse vegetation on left and right banks at Sta. 304+30 – 304+50 (UT3)



SOA4 – Sparse vegetation on left bank at Sta. 329+50 – 329+80 (UT3)

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SOA5 – Localized erosion on right bank at Sta. 335+10 – 335+40 (UT3)



Log Cross Vane (typical)

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Pool (typical)



Riffle (typical)

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Log weir (typical)



Root wad (typical)

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Rock cross vane (typical)



Vegetation Plot #1

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Vegetation Plot #2



Vegetation Plot #3

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Vegetation Plot #4



Vegetation Plot #5

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Vegetation Plot #6



Vegetation Plot #7

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Vegetation Plot #8



Vegetation Plot #9

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Vegetation Plot #10



Vegetation Plot #11

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Vegetation Plot #12



Vegetation Plot #13

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Vegetation Plot #14

## **APPENDIX E**

### **2011 Morphologic Monitoring Parameters**

| Parameter                                  | Cross Section 1<br>Pool   |      |      |      |      |     | Cross Section 2<br>Riffle  |      |      |      |      |     | Cross Section 3<br>Pool    |      |      |      |      |     | Cross Section 4<br>Riffle  |      |      |      |      |     |      |     |     |     |     |     |
|--|---------------------------|------|------|------|------|-----|----------------------------|------|------|------|------|-----|----------------------------|------|------|------|------|-----|----------------------------|------|------|------|------|-----|------|-----|-----|-----|-----|-----|
| Dimension                                  | Base                      | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base | MY1 | MY2 | MY3 | MY4 | MY5 |
| BF Width (ft)                              | 28.4                      | 26.4 | 25.0 | 22.3 | 23.0 |     | 25.3                       | 24.4 | 22.8 | 26.2 | 29.1 |     | 26.6                       | 21.8 | 20.8 | 27.5 | 22.5 |     | 22.8                       | 22.8 | 24.8 | 22.1 | 14.3 |     |      |     |     |     |     |     |
| BF Cross Sectional Area (ft <sup>2</sup> ) | 31.7                      | 26.4 | 23.4 | 20.7 | 20.3 |     | 18.1                       | 16.2 | 11.4 | 16.8 | 18.7 |     | 22.8                       | 19.2 | 19.0 | 19.2 | 16.8 |     | 11.7                       | 11.6 | 12.9 | 13.2 | 6.3  |     |      |     |     |     |     |     |
| BF Mean Depth (ft)                         | 1.1                       | 1.0  | 0.9  | 0.9  | 0.9  |     | 0.7                        | 0.7  | 0.5  | 0.6  | 0.6  |     | 0.9                        | 0.9  | 0.9  | 0.7  | 0.7  |     | 0.5                        | 0.5  | 0.5  | 0.6  | 0.4  |     |      |     |     |     |     |     |
| BF Max Depth (ft)                          | 2.6                       | 2.5  | 2.4  | 2.0  | 2.0  |     | 1.4                        | 1.3  | 1.1  | 1.3  | 1.3  |     | 2.2                        | 2.0  | 2.1  | 1.9  | 1.8  |     | 1.4                        | 1.3  | 1.4  | 1.3  | 1.1  |     |      |     |     |     |     |     |
| Width/Depth Ratio                          | 25.5                      | 26.2 | 26.8 | 24.0 | 26.1 |     | 35.2                       | 36.6 | 45.9 | 40.8 | 45.3 |     | 31.0                       | 24.7 | 22.7 | 39.3 | 30.1 |     | 44.4                       | 44.8 | 47.7 | 37.1 | 32.6 |     |      |     |     |     |     |     |
| Parameter                                  | Cross Section 5<br>Riffle |      |      |      |      |     | Cross Section 6<br>Pool    |      |      |      |      |     | Cross Section 7<br>Pool    |      |      |      |      |     | Cross Section 8<br>Riffle  |      |      |      |      |     |      |     |     |     |     |     |
| Dimension                                  | Base                      | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base | MY1 | MY2 | MY3 | MY4 | MY5 |
| BF Width (ft)                              | 7.6                       | 7.5  | 8.7  | 10.0 | 9.0  |     | 9.0                        | 9.2  | 9.7  | 11.2 | 8.6  |     | 7.9                        | 9.8  | 9.4  | 10.7 | 10.2 |     | 6.9                        | 7.3  | 7.7  | 8.7  | 8.3  |     |      |     |     |     |     |     |
| BF Cross Sectional Area (ft <sup>2</sup> ) | 5.0                       | 5.0  | 4.7  | 5.1  | 3.4  |     | 8.4                        | 8.7  | 6.9  | 7.4  | 5.4  |     | 8.7                        | 10.7 | 10.6 | 15.4 | 8.7  |     | 4.4                        | 4.7  | 4.8  | 5.2  | 4.7  |     |      |     |     |     |     |     |
| BF Mean Depth (ft)                         | 0.7                       | 0.7  | 0.5  | 0.5  | 0.4  |     | 0.9                        | 0.9  | 0.7  | 0.7  | 0.6  |     | 1.1                        | 1.1  | 1.1  | 1.4  | 0.8  |     | 0.6                        | 0.6  | 0.6  | 0.6  | 0.6  |     |      |     |     |     |     |     |
| BF Max Depth (ft)                          | 1.2                       | 1.4  | 1.4  | 1.2  | 0.9  |     | 1.7                        | 2.0  | 1.6  | 1.7  | 1.0  |     | 2.0                        | 2.2  | 2.3  | 2.1  | 1.6  |     | 1.2                        | 1.4  | 1.2  | 1.4  | 1.1  |     |      |     |     |     |     |     |
| Width/Depth Ratio                          | 11.4                      | 11.1 | 16.3 | 19.6 | 24.3 |     | 9.5                        | 9.8  | 13.6 | 16.9 | 13.8 |     | 7.2                        | 9.0  | 8.3  | 7.5  | 12.0 |     | 10.7                       | 11.3 | 12.4 | 14.7 | 14.8 |     |      |     |     |     |     |     |
| Parameter                                  | Cross Section 9<br>Pool   |      |      |      |      |     | Cross Section 10<br>Riffle |      |      |      |      |     | Cross Section 11<br>Riffle |      |      |      |      |     | Cross Section 12<br>Pool   |      |      |      |      |     |      |     |     |     |     |     |
| Dimension                                  | Base                      | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base | MY1 | MY2 | MY3 | MY4 | MY5 |
| BF Width (ft)                              | 18.5                      | 19.7 | 19.9 | 18.4 | 18.7 |     | 16.4                       | 15.1 | 16.1 | 16.9 | 16.8 |     | 9.8                        | 11.8 | 11.5 | 12.4 | 12.2 |     | 19.5                       | 19.8 | 18.8 | 20.5 | 19.6 |     |      |     |     |     |     |     |
| BF Cross Sectional Area (ft <sup>2</sup> ) | 29.3                      | 25.9 | 25.0 | 24.0 | 24.4 |     | 18.4                       | 16.5 | 15.8 | 15.1 | 15.5 |     | 6.8                        | 9.0  | 8.7  | 8.3  | 8.1  |     | 22.2                       | 20.4 | 18.5 | 21.2 | 16.9 |     |      |     |     |     |     |     |
| BF Mean Depth (ft)                         | 1.6                       | 1.3  | 1.3  | 1.0  | 1.3  |     | 1.1                        | 1.1  | 1.0  | 0.8  | 0.9  |     | 0.7                        | 0.8  | 0.8  | 0.7  | 0.7  |     | 1.1                        | 1.0  | 1.0  | 1.1  | 0.9  |     |      |     |     |     |     |     |
| BF Max Depth (ft)                          | 3.8                       | 3.1  | 3.0  | 3.0  | 2.8  |     | 2.5                        | 2.1  | 2.1  | 2.3  | 2.0  |     | 1.3                        | 1.5  | 1.5  | 1.3  | 1.3  |     | 2.7                        | 2.6  | 2.5  | 2.5  | 2.0  |     |      |     |     |     |     |     |
| Width/Depth Ratio                          | 11.8                      | 14.9 | 15.8 | 14.1 | 14.4 |     | 14.6                       | 13.7 | 16.3 | 18.8 | 18.3 |     | 14.0                       | 15.4 | 15.1 | 18.4 | 18.5 |     | 17.2                       | 19.2 | 19.7 | 19.7 | 22.7 |     |      |     |     |     |     |     |
| Parameter                                  | Cross Section 13<br>Pool  |      |      |      |      |     | Cross Section 14<br>Riffle |      |      |      |      |     | Cross Section 15<br>Pool   |      |      |      |      |     | Cross Section 16<br>Riffle |      |      |      |      |     |      |     |     |     |     |     |
| Dimension                                  | Base                      | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base                       | MY1  | MY2  | MY3  | MY4  | MY5 | Base | MY1 | MY2 | MY3 | MY4 | MY5 |
| BF Width (ft)                              | 18.3                      | 19.4 | 19.5 | 18.2 | 17.3 |     | 9.0                        | 9.2  | 9.9  | 8.9  | 9.6  |     | 19.7                       | 24.2 | 24.3 | 24.6 | 24.5 |     | 9.9                        | 9.0  | 9.1  | 11.2 | 9.3  |     |      |     |     |     |     |     |
| BF Cross Sectional Area (ft <sup>2</sup> ) | 15.8                      | 15.3 | 16.3 | 15.2 | 10.0 |     | 5.4                        | 4.8  | 5.2  | 4.8  | 4.5  |     | 18.8                       | 23.0 | 22.2 | 23.7 | 19.5 |     | 5.8                        | 4.6  | 4.4  | 4.5  | 5.0  |     |      |     |     |     |     |     |
| BF Mean Depth (ft)                         | 0.9                       | 0.8  | 0.8  | 0.8  | 0.6  |     | 0.6                        | 0.5  | 0.5  | 0.5  | 0.5  |     | 1.0                        | 1.0  | 0.9  | 1.0  | 0.8  |     | 0.6                        | 0.5  | 0.5  | 0.4  | 0.5  |     |      |     |     |     |     |     |
| BF Max Depth (ft)                          | 2.3                       | 2.0  | 2.1  | 1.9  | 1.4  |     | 1.2                        | 1.0  | 1.0  | 1.0  | 1.0  |     | 2.2                        | 2.4  | 2.3  | 2.0  | 1.9  |     | 1.1                        | 0.9  | 0.9  | 0.9  | 1.0  |     |      |     |     |     |     |     |
| Width/Depth Ratio                          | 21.3                      | 24.6 | 23.2 | 21.8 | 29.9 |     | 15.1                       | 17.4 | 18.7 | 16.5 | 20.4 |     | 20.7                       | 25.4 | 26.5 | 25.6 | 30.8 |     | 16.9                       | 17.5 | 18.8 | 28.1 | 17.6 |     |      |     |     |     |     |     |

| Parameter                                  | Cross Section 17<br>Pool |      |      |      |      | Cross Section 18<br>Riffle |      |     |     |     | Cross Section 19<br>Pool |     |      |      |      | Cross Section 20<br>Riffle |      |     |      |      |      |      |      |     |
|--|--------------------------|------|------|------|------|----------------------------|------|-----|-----|-----|--------------------------|-----|------|------|------|----------------------------|------|-----|------|------|------|------|------|-----|
| Dimension                                  | Base                     | MY1  | MY2  | MY3  | MY4  | MY5                        | Base | MY1 | MY2 | MY3 | MY4                      | MY5 | Base | MY1  | MY2  | MY3                        | MY4  | MY5 | Base | MY1  | MY2  | MY3  | MY4  | MY5 |
| BF Width (ft)                              | 30.6                     | 30.7 | 31.3 | 31.4 | 24.3 |                            | 7.6  | 7.4 | 7.1 | 9.1 | 8.4                      |     | 19.2 | 18.5 | 20.5 | 19.5                       | 18.6 |     | 10.5 | 10.4 | 10.4 | 10.7 | 10.5 |     |
| BF Cross Sectional Area (ft <sup>2</sup> ) | 46.3                     | 45.8 | 44.6 | 43.5 | 33.6 |                            | 9.6  | 7.5 | 7.9 | 8.5 | 8.2                      |     | 28.2 | 28.9 | 27.4 | 28.2                       | 24.8 |     | 9.5  | 9.1  | 8.9  | 9.2  | 8.4  |     |
| BF Mean Depth (ft)                         | 1.5                      | 1.5  | 1.4  | 1.4  | 1.4  |                            | 1.3  | 1.0 | 1.1 | 0.9 | 1.0                      |     | 1.5  | 1.6  | 1.3  | 1.4                        | 1.3  |     | 0.9  | 0.9  | 0.9  | 0.9  | 0.8  |     |
| BF Max Depth (ft)                          | 3.7                      | 3.7  | 3.5  | 3.3  | 2.8  |                            | 1.9  | 1.7 | 1.8 | 1.8 | 1.7                      |     | 3.3  | 3.2  | 3.1  | 3.1                        | 2.6  |     | 1.7  | 1.6  | 1.6  | 1.7  | 1.5  |     |
| Width/Depth Ratio                          | 19.7                     | 20.6 | 22.0 | 22.6 | 17.6 |                            | 6.1  | 7.3 | 6.5 | 9.8 | 8.6                      |     | 13.1 | 11.8 | 15.3 | 13.5                       | 13.9 |     | 11.6 | 11.9 | 12.1 | 12.4 | 13.1 |     |