BROWN BRANCH
STREAM RESTORATION

FIRST YEAR
MONITORING REPORT

Prepared For:

N.C. Wetlands Restoration Program
NCDENR DWQ

Wetlands Restoration Program
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SUMMARY

In September 2002, a stream restoration design and construction project using natural stream channel geometry was completed on Brown Branch in Caldwell County, NC. The project area extends approximately 1 mile from the confluence of two first-order tributaries downstream to Mulberry Creek. The purpose of the stream restoration was to reduce bank erosion and improve water quality and habitat in Brown Branch.

Brown Branch will be monitored annually for 5 years following construction. Each monitoring report will contain field data and technical data collected during the annual monitoring report, methodologies, data interpretations, photographs, surveyed topography, and recommendations for remedial action. This first annual monitoring report was prepared by Biohabitats, Inc. This document presents data collected by Biohabitats during October 2003, and compares it to conditions surveyed following the September 2002 construction.

There are several problems that will require some repair work to restore the proper function to the design and prevent further erosional damage. Rainfall during the past year has been significantly above average. The most frequent problems at the site include the lack of vegetation on the channel banks and floodplain and rilling that has occurred across extensive portions of the floodplain surface. In some locations, overland flow has eroded bank materials from behind bank protection structures. In addition, there are localized areas where bank erosion due to high streamflow is occurring. Despite these problems, at the time of monitoring in October 2003, the project was found to be meeting most of its intended goals. The restored channel has greatly diminished sediment loads and enhanced aquatic habitats of the rural stream.

Table 1 summarizes the success criteria presented in the original monitoring plan, and the degree to which these criteria have been met throughout the mile-long restoration project. Specific recommendations for repair work based on the first-year monitoring results are presented at the end of this report.

Table 1. Summary of Project Performance

Parameter (Basis of Evaluation)	Success Criteria	Criteria Met, Degree of Success?	Notes
Channel Dimension (permanent cross sections, photographs)	Pools are maintained in meanders; riffles persist in straight cross sections.	Y, but with localized problems	Continue to monitor.
	Measured bankfull dimensions are similar (+/-25%) to that of design and/or within range of ratios for reference reaches	Y, but with localized problems	30% increase in cross-sectional area at X/S 1, see Table 4.
	No rapid, chronic bank erosion (> ½ ft/yr) and/or imminent threat to bank stability	Y, but with localized problems	4 feet of bank erosion along right bank at X/S 1, see Table 4.
	No significant mid-channel bar development in riffles; thalweg does not bifurcate	Y, but with localized problems	Continue to monitor, see Table 4.
	No significant chronic sedimentation in pools	Y, but with localized problems	Continue to monitor.
	Stream type persists	Y, but with localized problems	W/D ratio low at X/S 1, see Table 4.
Channel Planform Pattern (longitudinal profile, photographs)	Measured sinuosity is same as as-built design (+/- 0.1 ft/ft)	Y	None
	No major change in planform pattern, e.g. channel avulsions	Y	None
	No significant changes in radius of curvature	Y	None
	Valley and stream type persists	Y	None
	No threat to structural stability of structures	Y, with localized problems	Continue to monitor.
Longitudinal Profile	Pool-riffle sequences persist in sequence with planform pattern	Y	None
	No development of headcuts	Y	None
	Riffles slopes do not exceed reference reach and/or design values	Y	None
	Measured thalweg length undergoes little change (+/- <200 feet)	Y	None
Channel Bed Material (pebble counts)	D_{50} and D_{84} measurements remain gravel-sized	Y	None
Vegetation Survival (vegetation plots, photos)	Tree density of 320 trees/acre	Y	Meets requirement due to volunteer species.
	At least 6 planted species are represented in surviving species	Results vary.	Continue to monitor.

Parameter (Basis of Evaluation)	Success Criteria	Criteria Met, Degree of Success?	Notes
	Vegetation growth evident throughout planted zones	N	See Table 4 for additional planting.
	Vegetation forms contiguous riparian zone	N	See Table 4 for additional planting.

1.0 INTRODUCTION

In September 2003 a stream restoration design and construction project using natural stream channel geometry design parameters was completed on Brown Branch, a tributary to Mulberry Creek in Caldwell County, North Carolina near Lenoir. The study reach begins at the confluence of two 1st-order tributaries and follows the 2nd-order channel downstream for a mile through an alluvial valley. The project was undertaken by the Wetlands Restoration Program (WRP) of the North Carolina Department of Environment and Natural Resources.

The stream restoration was motivated by an unstable channel configuration that was causing poor water quality, a featureless bed, a lack of riparian cover, and poor habitat. The overarching goal of the project was to establish a stable planform, cross-sectional, and profile pattern that would improve water quality, enhance in-stream habitat, and improve the functional and aesthetic value of the riparian corridor. Brown Branch is believed to have supported a trout population historically. By creating a range of aquatic niches, the project is also intended to provide in-stream habitat that could support trout populations in the future.

Under the direction of WRP, Biohabitats has established the monitoring stations and protocol, and collected baseline and first-year monitoring data. The monitoring plan described in this monitoring report is intended to provide a framework for documenting channel and riparian conditions in the five year period following project construction. This information is needed to diagnose unforeseen problems resulting from the design and construction of the project and/or changes in the stream environment. First-year data provided in this report are the basis for some immediate adaptive management recommendations, such as planting of live stakes. Data collected in the next four years can be used to further assess project success and evaluate the need for any additional repairs.

2.0 METHODS

The following section describes the methods applied to establish monitoring stations and collect monitoring data. Parameters to be monitored annually include longitudinal profile, channel cross sections, pebble counts, photographs, and vegetative plots. Locations of all monitoring stations are depicted in the planform maps in Appendix A. All baseline data are included in the March 2003 report "Brown Branch Stream Restoration Post-Construction Mitigation Plan" prepared for WRP by Biohabitats.

As previously mentioned, Appendix A includes scaled 11" by 17" planform maps adapted from the as-built drawings to reflect monitoring locations. The plots show the as-built topography superimposed on the design plans for reference. The maps show the locations of all in-stream structures, photo stations, vegetation planting zones, vegetation sample plots, and the permanent benchmark.

Many changes were made during construction in the field with the agreement of the Designer and the Contractor based on the unexpected presence of bedrock, low availability of logs at the downstream end of the project, and professional judgment of what would improve the installation. These changes are noted as callouts on the plan sheets to add clarity, especially where bank and in-stream structures changed from the original design.

2.1 Longitudinal Profile and Cross Sections

Surveying of the longitudinal profile and selected cross sections was conducted with a standard survey level, survey rod and measuring tapes. Several convenient semi-permanent monuments persisted following construction. The associated benchmark elevations were made available to Biohabitats by the Contractor's surveyor, WK Dickson, and these elevations were used to tie the longitudinal profile into real vertical space during survey data reduction. There is one permanent benchmark at the project site, also established by WK Dickson. The benchmark consists of a large "X" chiseled into the concrete pad of an outdoor pavilion at the upstream end of the project site (see Sheet 4 of Appendix A). Future surveying for this monitoring plan can tie into this benchmark.

One continuous profile was surveyed through the project reach along the thalweg to establish baseline streambed elevations. To construct the baseline profile survey shown in Appendix B, measuring tapes were stretched end-to-end along the thalweg to record cumulative distance downstream. Features such at riffles and pools were noted in the survey. The elevation of flow deflection and grade control structures such as log vanes and rock cross vanes were also surveyed. Stationing of features shown in the baseline profile (Appendix B) differs slightly from stationing shown in the as-built (Appendix A) due to minor differences in the field interpretation of thalweg.

Monumented cross sections were also installed at six (6) locations along the restored channel. Beginning at the upstream end of Brown Branch, the cross sections alternate between riffle and pool channel units, for a total of three (3) riffle and three (3) pool cross sections. The baseline cross sections are intended to document a range of adjustments in cross sectional geometry with downstream distance. Cross-sectional features measured during the surveying efforts included monumented cross-sectional endpoints (rebar with yellow plastic cap), topographic breaks in slope, bankfull indicators, edge of water at time of survey, and channel features that may influence the direction and/or speed of flow in the channel. The locations of monumented cross sections are shown by purple line segments in Appendix A. Results from the cross-sectional measurements are shown in Appendix C.

Repeat photographs (and field observations) helped to identify changes visible from specific vantages along Brown Branch. Photographs were helpful in identifying the extent and severity of bank erosion throughout the project, and determining where corrective action should be taken.

2.2 Pebble Counts

To evaluate textural properties of the bed following completion of construction, pebble counts were conducted at three locations using standard Wolman pebble count methodology (Wolman, 1954). The 100 particles selected for sampling were chosen from pool and riffle units in proportion to the percentage area that the channel units represented through the sample area (e.g., for a reach with 40% riffle and 60% pool, 40 particles were selected from the riffle and 60 particles were selected from the pool). Pebble counts taken during the monitoring period are compared with baseline data in this report to establish changes in particle size and persistence of riffle armoring.

2.3 Photographs

To document the overall channel stability and development of the riparian zone with time, twenty-two (22) permanent photo stations were established along the length of the project reach. A color photograph was taken at each photo station to document baseline conditions. Each photo station location is marked in the field by a partially embedded 4-foot long rebar with a 4-inch by 4-inch plastic orange cap. The locations of photo stations are depicted by numbered red dots in Appendix A.

A photograph was also taken at each series of bed and bank structures to document post-construction conditions. These photographs were not monumented, but taken from the clearest vantage at that time. The vantages of these structures photographs may change with time if conditions (e.g. vegetation growth, bank erosion) warrant it.

2.4 Vegetation Plots

Seven (7) sample vegetation plots were established in the field. The locations of vegetation sampling were selected using predetermined sample plot locations to straddle the range of planting zones. The locations of vegetation plots are shown on Sheets 5 through 8 of Appendix A. At each monitoring location, a center point and four (4) additional points were identified around which to configure the sampling. The center points of the sample plots each are marked in the field by a partially embedded 4-foot long rebar with a 4-inch by 4-inch plastic orange cap, and will be reoccupied annually.

The four sample points around the center point were located due North, South, East and West of the center point, each approximately 37 feet from the center point. The 37-foot radial distance equates to approximately 1/10 of an acre. At each of the five points, a 6-foot diameter circle was established to estimate percent understory cover, canopy closure, and herbaceous cover. All trees and shrubs within the 37-foot radius were identified and tallied and the overall condition of the tree or shrub was assessed to identify mortality, herbivory, disease, and/or infestation. A sampling data worksheet was used to compile the data gathered at each of the 7 sample plots.

3.0 RESULTS

3.1 Channel Dimension

Results from monumented cross sections provide the best means for evaluating channel dimension changes at specific locations during the monitoring period. Appendix C compares baseline with first-year monitoring data for each of the 6 cross sections. Cross-sectional data shows mixed results. Half of the cross sections (#2, #3, and #4) show only minor net changes in the channel shape, well within the expected range of fluvial adjustment in a stable channel system.

In contrast, cross section #1 shows approximately 4 feet of erosion along the right bank and approximately half a foot of bed degradation in the riffle. This site represents one of a handful of erosional hotspots that will require treatment to stabilize the channel locally, and even more importantly, to preserve the integrity of the remainder of the project length. Installation of an upstream rock vane is recommended as treatment at this site, along with regrading, reseeding, and replanting the bank. The same treatment is recommended at cross section #5, also a riffle, which has experienced the same type and magnitude of response.

Cross section #6, situated in a meander bend, has experienced approximately 1 foot of aggradation via the deposition of a small bar in the middle of the bend. While the partial filling of the pool is not ideal, it does not pose a problem to channel stability at this location. Therefore, no treatment is recommended, aside from continued monitoring of the location in future years.

Field observations of channel dimension are more broadly documented in the photographs of Appendix E. For the most part, channel dimension appears to be stable through the project, despite the many intense storm events during the past year. Depositional patterns along gravel bars indicate that sediment transport has been active up to the bankfull elevation. However, gravel bars have maintained their overall elevation and size, suggesting that sediment supply is roughly balanced with sediment transport rates. Such observations are a positive indicator of likely channel stability over the longer term.

Generally speaking, the most significant and widespread problem concerning channel geometry is patches of bank erosion throughout the project length. The majority of these problems can be rectified by minor regrading, revegetation, and/or use of live stakes. In three locations, the installation of a rock vane or rock cross vane is recommended to ameliorate severe bank erosion. The locations of these areas and associated recommended treatments are shown in Table 4.

3.2 Channel Planform Pattern

Monitoring results show that the overall bankfull channel pattern has remained stable in the first monitoring year. At present, there have been no channel avulsions or significant changes in the radius of curvature. As a result, the sinuosity of Brown Branch has not changed.

Within the low flow channel, the position of the thalweg has fluctuated somewhat. In some locations, this has resulted in a migration of the thalweg from the center of the riffle, for example, several feet closer to the bank. These minor changes are expected to be ongoing and do not characterize a problem with the larger planform pattern. At as-built station 50+75, a shallow meander cutoff has occurred across the back of the meander bar; however, the thalweg remains along the outside of the bend. This location should be monitored in future years to ensure that the thalweg itself does not migrate across the point bar.

In several locations, photographs show scour problems around the end of log vanes, or conversely, deposition that reduces the ability of a log vane to deflect flow from the bank. However, these situations do not constitute a serious threat to the stability of the structures, so only continued monitoring is recommended.

3.3 Longitudinal Profile

Baseline and first-year longitudinal profile data are shown in Appendix B. Results from the longitudinal profile survey show that the channel bed elevation along the thalweg has undergone minor fluctuations throughout the length of the project. Such fluctuations are characteristic of a pool-riffle channel system in which sediment is incrementally entrained and then deposited over the course of individual flow events with variable hydrograph shapes and sizes.

Despite these small scale (<0.5') shifts in bed elevation, the overall pool-riffle sequence has persisted through the first monitoring year. Straight sections designed as riffles areas are steeper than their pool counterparts, and convey shallow, wide flow over a relatively rough substrate (i.e. gravel and cobble). Pools generally also have held their positions along the outsides of meander bends.

Recurring deviations from the design include the extension of riffles downstream towards the pool and moderate sedimentation in pools. Many pools have not maintained the same depth to which they were designed (e.g., 0.5 ft shallower than design). However, the pools do not appear to be chronically shrinking, just adjusting alluvially to the most efficient size and shape given the governing sediment and flow regimes. Of greatest concern has been the lack of continuity of a pool through an individual bend. In many bends, what was intended to be an elongated pool has been interrupted by a short riffle-like feature. Although such features were not an intended part of the design, they do not seem to be posing any significant problems to channel stability. We recommend that monitoring in the following years evaluates the persistence of these features to establish if design changes should be made to future similar projects to better promote sediment transport through pools.

There are currently no significant headcuts along the mile-long longitudinal profile. Particularly on the upper half of the project, the channel is intermittently in contact with the bedrock horizon. This will help inhibit any serious downcutting that would normally cause the channel to incise incrementally upstream.

The biggest changes in the channel profile have occurred where the project was closely constructed following the design elevations. In these locations, the channel has adjusted downward closer to the design grade. Examples of these areas include stations 49+00 and 29+00 on the longitudinal profile.

The biggest, extended reach undergoing changes in profile elevation occurs from Station 8+00 downstream to the confluence with Mulberry Creek. In this section, riffle elevations appear to have been built approximately 1 to 1.5 feet higher than was specified in the design documents.

The channel has responded to the lower than intended gradient by attempting to deepen and widen riffles in these areas. Further, sediment generated in these areas has filled a greater volume of these pools than in upstream reaches. This section may take additional time to equilibrate, and should be watched closely in future monitoring years. With time, perhaps pools will be able to pass the accumulated sediment and deepen along the meander bends. In the meantime, some minor additional erosion along riffles and adjacent banks is likely to continue.

Only at one location along the channel length is a change to the profile recommended. The riffle from as-built station 6+50 – 5+25 has downcut approximately 1.5 feet. This has created a steep, bare toe of slope on the adjacent banks. This riffle should be filled with cobble-sized riffle material to a depth of at least 1 foot to prevent additional bank stability problems.

3.4 Channel Bed Materials

As expected, there have been some minor fluctuations in the grain-size distribution of channel bed materials at the 3 monitoring locations where pebble counts were conducted. However, none of these adjustments are outside of the success criteria. Table 2 compares sampling results following construction with those measurements taken during the first year monitoring.

Table 2. Results from Pebble Counts

Pebble Count Location	Parameter	As- built Conditions	First Year Conditions	Notes
A	D_{50} (mm)	18	14	Minor changes only.
	D_{84} (mm)	43	60	
B	D_{50} (mm)	9	7	Negligible changes.
	D_{84} (mm)	42	40	
C	D_{50} (mm)	14	4	More fines (<2mm), fewer mid-size gravels.
	D_{84} (mm)	31	33	

The greatest changes in sediment texture were observed in Pebble Count C, the downstream-most site. At this location, the relative abundance of sand increased, thereby reducing the median grain size from 14 to 4 mm. Despite the shift, the results still satisfy the success criteria since both size classes remain gravel-sized.

3.5 Vegetation Survival

The survival of planted bare root species seems to be the most disappointing of the monitored variables. Planted bare root species were often difficult to locate, particularly where herbaceous cover had grown up to the height of a bare root planting. Measurements of tree densities from sample plots show low survival rates, ranging from 10 to 60% (33% average, Table 3). Without volunteer species, the survival rates would be inadequate to fulfill State requirements of 320 stems/acre. However, volunteer species such as American sycamore (*Platanus occidentalis*), tulip poplar (*Liriodendron tulipifera*), and river birch (*Betula nigra*) have significantly augmented the surviving bare root plants, resulting in a density of >2500 stems per acre (Appendix F). If these volunteer species survive in the next few years, it may be unnecessary to undertake widespread replanting throughout the project area.

Table 3. Survival Rates from Vegetation Monitoring

Monitoring Plot Number	Percent Survival Relative to Baseline Monitoring	True Survival Rate (relative to densities in as-built planting plan)
1	30	30
2	50	35
3	30	30
4	30	10
5	30	15
6	80	60
7	80	50
Average	**47%**	**33%**

There are no detailed monitoring data available from which to infer the cause of high rates of bare root mortality. The cause for low survival of bare root species may be a combination of lack of mulch, poor soil conditions (compaction, low levels of organic material), poor initial plant health, competition with herbaceous species, and deer browse. The amount of light available to plants is not believed to be an inhibiting factor.

In 5 of the 7 vegetation plots, at least six different planted tree species were identified. These results suggest that although species diversity is not consistent throughout the site, most areas have a diversity of tree species and meet the success criterion. No additional planting is necessary in those areas where the diversity criterion have not been met, since the stability of the project is not threatened.

The germination and survival of herbaceous species has also been patchy. Shortly after individual areas were seeded during construction, the majority of seed germinated and covered the upstream portions of the site, as intended, with some larger barren areas along the lowermost 1,500 feet of the project. However, during a subsequent dry period during late fall, new grasses abruptly died back and left the site mostly bare through the winter.

During spring, planted species and volunteer grasses colonized the site. During the November 2003 monitoring, these grasses were observed to cover most of the site. There are, however, extensive areas within which grasses have not regenerated and surface soils are extremely vulnerable to erosion. These areas should be reseeded to create continuous herbaceous coverage. Many of the sparsest areas are still along the downstream portion of the project. The monitoring photographs illustrate many sparsely vegetated areas near the channel that should receive additional plantings to stabilize the streambanks and immediate floodplain. Problem spots identified in the field and documented with photographs are included in Table 4.

4.0 DISCUSSION & CONTINGENCY REPAIRS

The completion of construction in September 2002 coincided with a shift from exceptional drought conditions (which began in 1998 in the State) to above-average precipitation. Remnants of several tropical storms passed over the State in September, followed by an early winter El Nino pattern lasting several months. These weather patterns produced high intensity rainfall events and resulted in rainfall ranging from 1 to 3 inches above average on a monthly basis. Elevated rainfall amounts helped to water vegetation planted at the project site. However, coverage due to vegetation was still not contiguous and dense enough to prevent extensive surface erosion from areas adjacent to the stream.

The first year monitoring results provide a 'snapshot' view of the performance of the Brown Branch stream restoration in October 2003. Results show that most of the success criteria established for the project have been met (Table 1). In particular, the channel geometry, planform pattern, and longitudinal profile appear to be functioning well for the given supply of water and sediment. However, there are widespread problems with herbaceous colonization and bare root survival, and local problems with bank erosion, as outlined in Table 4 below.

Problems with vegetation include the delayed growth of herbaceous cover throughout the project area. Land use adjacent to the project is mostly pasture. The lack of a canopy cover acts causes a relatively high percentage of rainfall to be converted to surface runoff. When adjacent bare and pasture areas were coupled with intense, prolonged rainstorms during the 2003 water year, surface soils were unprotected and vulnerable to erosion. This led to the formation of rills across the sandy soil, leading down to the channel. In several cases, rills evolved into deeper gullies, which began to incise upslope from the lower floodplain to the terrace. These gullies will need to be filled with material, reseeded, and revegetated to prevent additional erosion.

An additional concern regarding vegetation is the poor survival rates noted throughout the project area. First year monitoring suggests that only 33% of the planted bare root stock has survived. Offsetting these losses are the abundant volunteer species, including American sycamore, sweet birch, American holly, silky dogwood, Eastern hemlock, tulip poplar, fringetree, and American hophornbeam. Since volunteer species increase the tree density to above the State standard of 320 stems/acre, widespread planting of additional bare root species is not warranted. However, where lack of vegetation is believed to compromise channel stability, particularly along the outsides of meander bends and riffle banks that are eroding, additional plantings are recommended in Table 4.

Bank erosion is worst where surface runoff removed soil behind a structure and destabilized the portion of the structure that was keyed into the bank. This resulted in rocks from rock toe protection rolling into the channel in some locations and created void spaces behind rootwads and log toe protection.

Of the many structures used to protect streambanks (e.g., rock toe protection, rock J vane, log toe protection, rootwad), log vanes seem to have been the least successful. At many locations, scour has occurred at the end of the log originally buried under the thalweg such that the cut end is visible. The log vanes are not currently unstable or undercut, but the degradation of the channel bed in the vicinity of the log vane could become more pronounced with time, and should be monitored closely during the next monitoring period. Log toe protection looks very good, with the exception of one location where a log has shifted from its footer log. Rock toe protection, rock J vanes, and rock cross vanes are also functioning well, except in a few locations were overland flow has scoured out soil on the upslope side.

Table 4. Recommended Maintenance Repairs

As-built Station, bank(s)	Problem	Action
51+00 – 50+50, L/B	Secondary flow over back of point bar.	None. Does not threaten banks. Continue to monitor.
50+50 – 50+25, L/B	Bank erosion along riffle	None. Erosion is minor and occurs along riffle. Continue to monitor.
48+60 – 48+10, L/B & R/B	Bank erosion along riffle	Regrade (4:1 or less), reseed, and replant banks (containerized plants preferred).
46+75 – 46+00, R/B	Severe bank erosion along riffle. Rootwad footer exposed.	Regrade bank to lower slope, reseed, and revegetate banks. Add rock vane along R/B to deflect flow.
46+00 – 45+75, L/B	Bank erosion along meander	None. Erosion is minor, and downstream of large placed rock. Continue to monitor.
44+20 – 43+75, L/B	Severe bank erosion along riffle	Regrade (3:1 or less), reseed, and replant banks (containerized plants preferred).

As-built Station, bank(s)	Problem	Action
43+50, R/B	Bare soil along meander bend	Plant live stakes along banks.
43+00 –42+75, R/B; 42+75 – 41+75, L/B	Lack of vegetation along riffle	Plant live stakes along banks.
40+25 – 38+25, R/B; rill at 39+25	Lack of vegetation along riffles and meander bend. Deep rill in floodplain.	Place fill in rill. Place matting along meander. Reseed and replant with containerized plants, plus live stakes along meander bend.
37+50, R/B	Rill in floodplain	Place fill in rill, reseed, and revegetate.
37+25, R/B	Severe bank erosion along meander bend	Plant live stakes.
36+25 – 35+65, R/B	Bank erosion along meander, lack of vegetation	Place fill behind log toe protection. Reseed, place matting, plant live stakes.
30+75 – 30+50, R/B	Two gullies on floodplain/terrace	Place fill in gullies to return to grade. Reseed and replant (containerized plants preferred).
30+75 – 28+75, L/B & R/B	Lack of vegetation	Remove matting, reseed, remat meander areas, revegetate (containerized plants preferred).
25+25 – 25+00, L/B & R/B	Severe bank erosion on L/B, lack of vegetation on both banks.	Remove matting, regrade, reseed, remat, and replant.
23+50 – 21+75, L/B & R/B	Lack of vegetation. Small rill.	Fill small rill at 22+80. Remove matting, reseed, replace matting, and replant 15’ wide corridor on each bank above bankfull elevation.
21+75, R/B	Large gully	Remove matting. Fill gully to return to grade, reseed, replace matting, and replant (containerized plants preferred).
18+75 – 19+00, R/B	Lack of vegetation, bank erosion	Reseed and replant 15-foot wide corridor on bank above bankfull.
17+75 – 16+75, R/B	Bank erosion, large gully	Fill gully at 17+50, R/B to grade. Plant live stakes along meander. Reseed, place matting, and revegetate.
14+25 – 13+50	Bank erosion	Plant live stakes along meander.
12+50 – 12+00, L/B	Severe bank erosion	Plant live stakes.
11+90 – 11+25, L/B & R/B	Lack of vegetation, local bank erosion	Reseed and revegetate both banks (containerized plants preferred).
11+15 – 10+75, L/B & R/B	Bank erosion, rocks in rock toe protection rolled into channel	Remove matting. Regrade slope behind rocks. Reseed both banks. Remat R/B. Revegetate both banks.
10+75 – 10+25, L/B & R/B	Channel has widened via bank erosion and incised.	Add rock vane or rock cross vane. Reseed and revegetate both banks (containerized plants preferred).
9+50 – 7+25, L/B & R/B	Lack of vegetation, local bank erosion.	Add rock vane or rock cross vane. Regrade banks in riffles. Reseed and revegetate.
6+50 – 5+25, L/B and R/B	Channel incision. Bank erosion on R/B.	Refill riffle with riffle material to at least 1 foot depth. Reseed and revegetate both banks.
4+90 – 3+30, R/B	Rilling behind rock toe protection and rootwads.	Place fill in rills. Reseed and replant.

As-built Station, bank(s)	Problem	Action
4+10 – 3+60, L/B	Rilling behind rootwads.	Place fill in rills. Reseed and replant.
5+50 – 0+00, R/B	Lack of vegetation	Reseed and revegetate banks and floodplain within corridor of 20 feet from bankfull on each side of channel.
3+00, R/B	Gully	Place fill. Reseed and revegetate.

Repair work outlined in Table 4 should follow the procedures described in the final design documents for Brown Branch, unless a contractor is otherwise directed. When working in the stream (e.g., to install a rock vane), flow should be diverted away from the work area or pumped around. Topsoil placed in the eroded areas along banks and in floodplain rills should have normal nutrient content, be free of contaminants, and have organic matter content from 2 to 10% to allow vegetation growth. Placed topsoil should be tamped to prevent subsequent surface erosion. Where existing matting interferes with repairs, existing matting should be removed prior to earthwork or seeding. Upon completion of earthwork, permanent seeding, and planting, new biodegradable matting should be installed in these areas.

Containerized plantings are strongly preferred for all revegetation efforts below (except those areas to receive live stakes). However, where containerized plantings are not possible, dense bare root plantings could be used. The application densities, installation procedure, and tree species to be used for live stakes or other revegetation must be approved by WRP or its designee.

At this preliminary stage, the Brown Branch stream restoration has been successful in reducing sediment supply, improving channel stability, and enhancing habitat. Based on results from the first year of monitoring, Table 4 recommends repairs in problem areas that would greatly improve the integrity of the construction project. Addressing problems outlined in Table 4 is extremely important to ensure that the project stays on track and that existing problems are not exacerbated or new problems originate from lack of adaptive management.

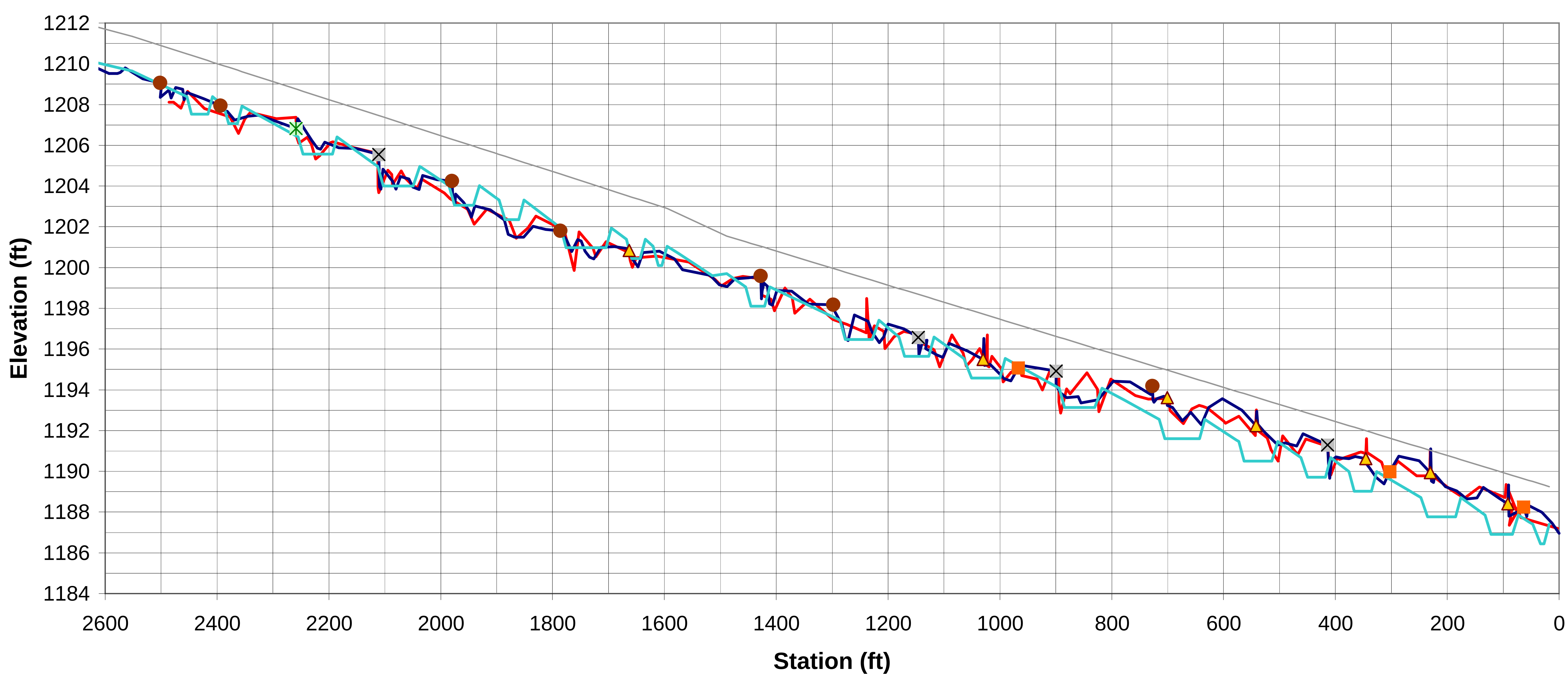
5.0 REFERENCES

Internal Technical Guide for Stream Work in North Carolina, The Division of Land Resources (DLR) and The Division of Water Quality (DWQ), NCDENR, Version 3.0, April 2001.

Wolman, M.G., 1954. A method of sampling coarse river-bed material, Transactions of the American Geophysical Union, 35: 951-956.

Appendix A
PLANFORM MAPS

Appendix B
LONGITUDINAL PROFILE



LEGEND

- First Year Monitoring
- As-Built Thalweg Profile
- Design Thalweg Profile
- Design Bankfull Slope
- Log Vane
- Cross Vane
- Rock Vane
- Rock J Vane
- Rootwad/Log J Vane

NOTES:

1) Stationing of features shown above differs slightly from stationing shown in the as-built drawings (Appendix A) due to minor differences in the field interpretation of thalweg.

2) Due to minor differences in the cumulative length of the thalweg in the design versus as-built drawings, an individual feature (e.g., top of riffle) may not plot at the same station in the two profiles (design and as-built) shown above.

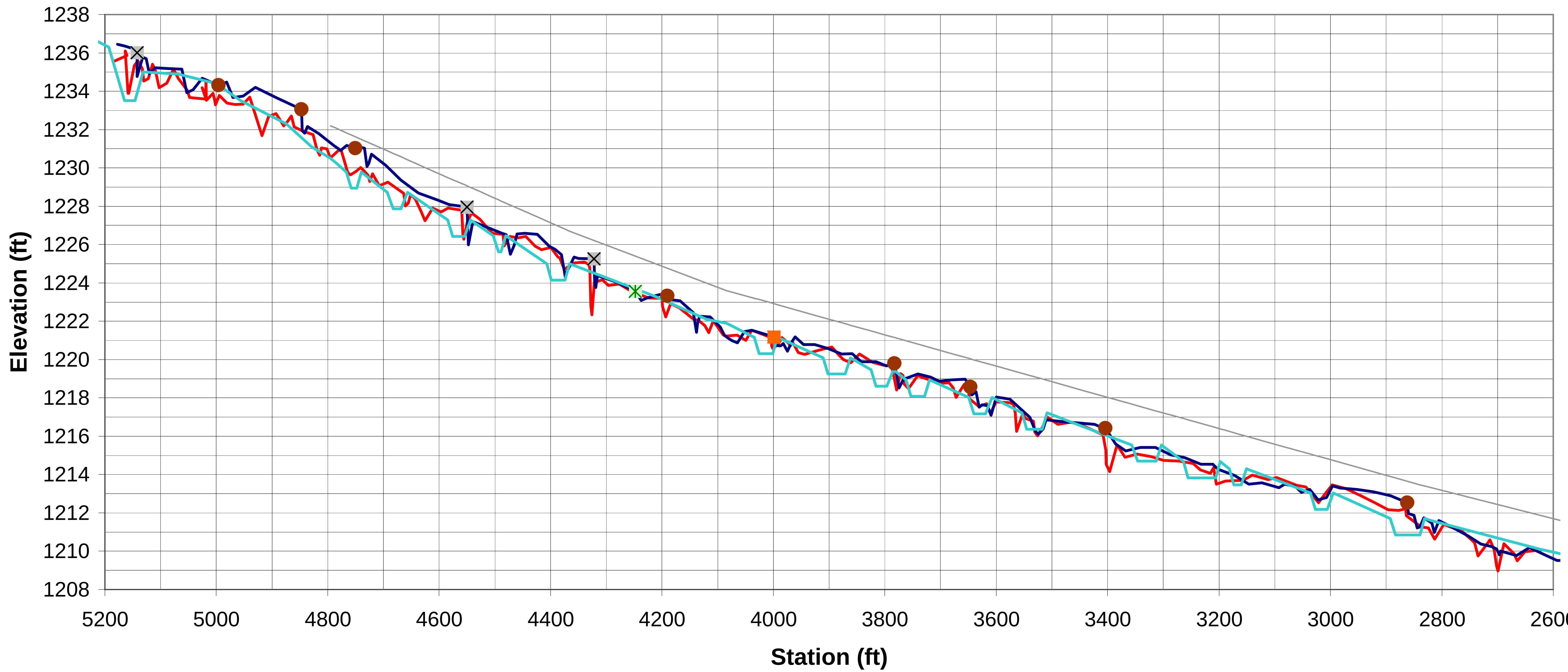
3) Vertical segments shown above Rock "J" Vanes indicate elevation of the top of the middle rock.

Longitudinal Profile
Downstream Portion of Brown Branch

First Year Monitoring Conditions

Survey Date: October 23, 2003

Biohabitats Incorporated



LEGEND

- First Year Monitoring
- As-Built Thalweg Profile
- Design Thalweg Profile
- Design Bankfull Slope
- Log Vane
- Cross Vane
- Rock Vane
- Rock J Vane
- Rootwad/Log J Vane

NOTES:

1) Stationing of features shown above differs slightly from stationing shown in the as-built drawings (Appendix A) due to minor differences in the field interpretation of thalweg.

2) Due to minor differences in the cumulative length of the thalweg in the design versus as-built drawings, an individual feature (e.g., top of riffle) may not plot at the same station in the two profiles (design and as-built) shown above.

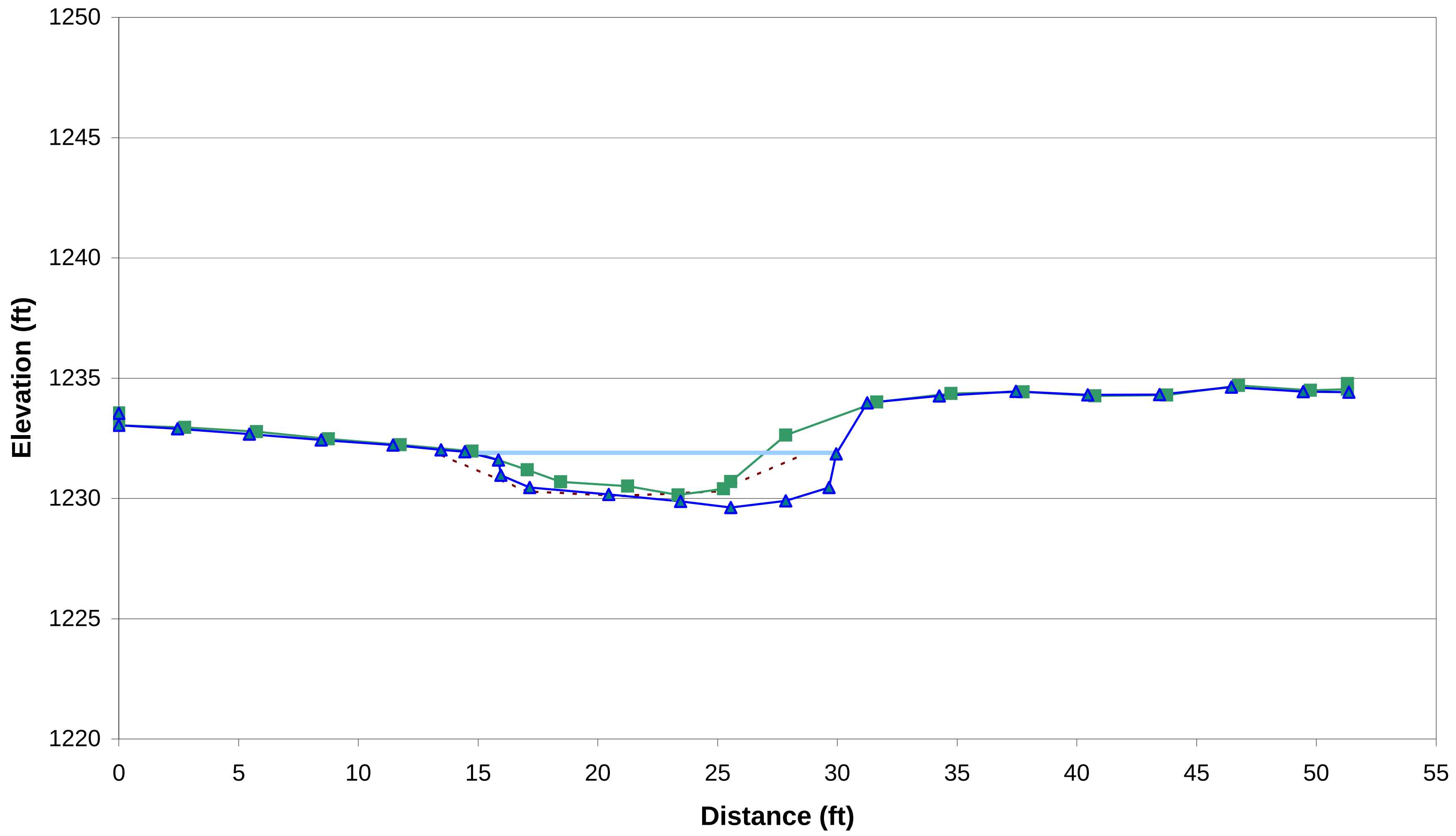
Longitudinal Profile
Upstream Portion of Brown Branch

First Year Monitoring Conditions

Survey Date: October 23, 2003

Biohabitats Incorporated

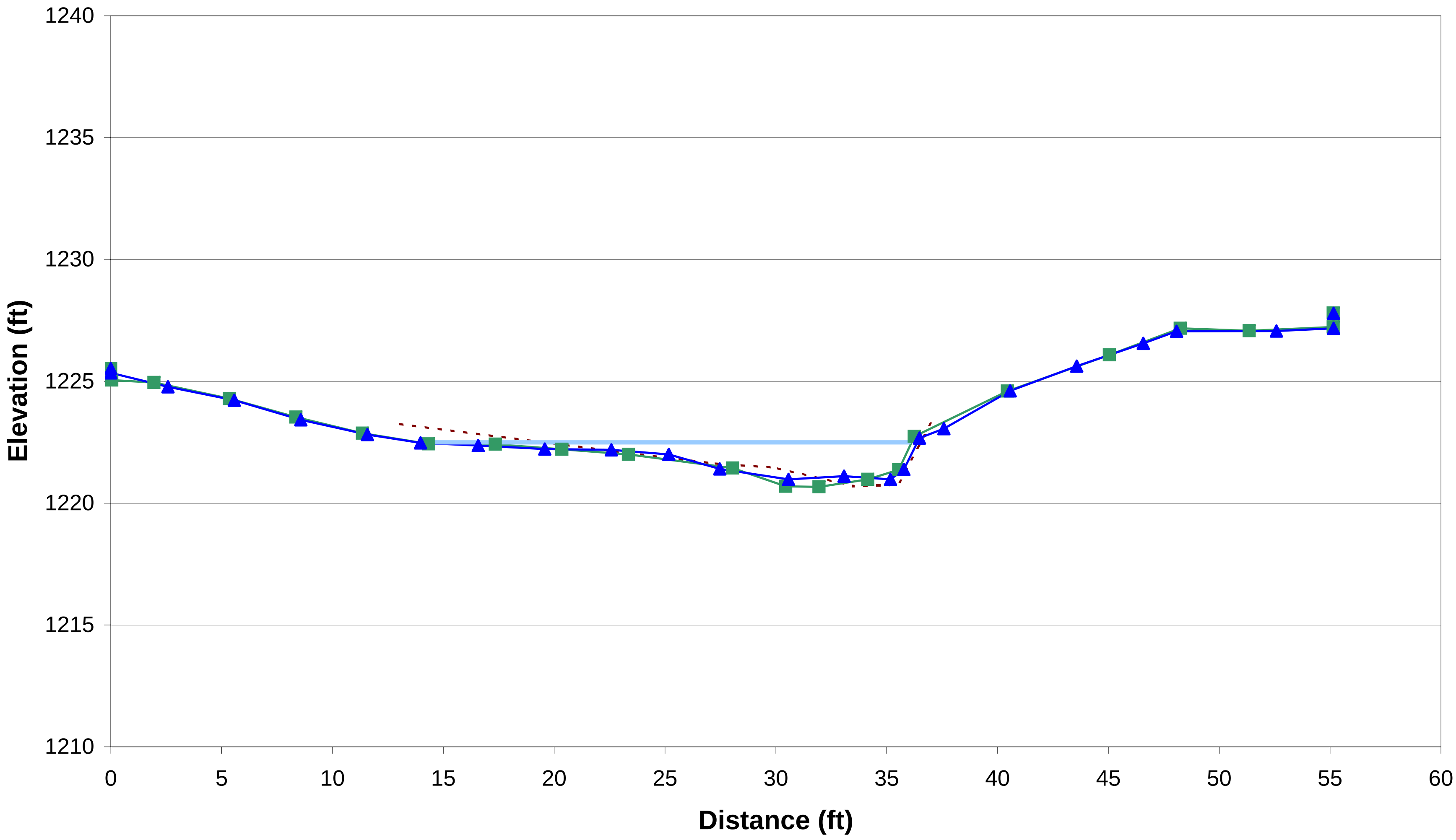
Appendix C
CROSS SECTIONS



LEGEND
- Typical Design X/S
- Baseline Survey
- First Year Monitoring
- Bankfull, First Year

NOTES:
1) All data points represent ground, except for vertical endpoints which indicate the top of rebar protruding from ground at monumented stations. During first year monitoring, the rebar on the right bank was bent down.
2) The perspective shown is looking downstream.

Cross Section #1, Riffle
As-Built Thalweg STA 46+50
First Year Monitoring Conditions
Survey Dates: 1/15/2003, 10/23/2003



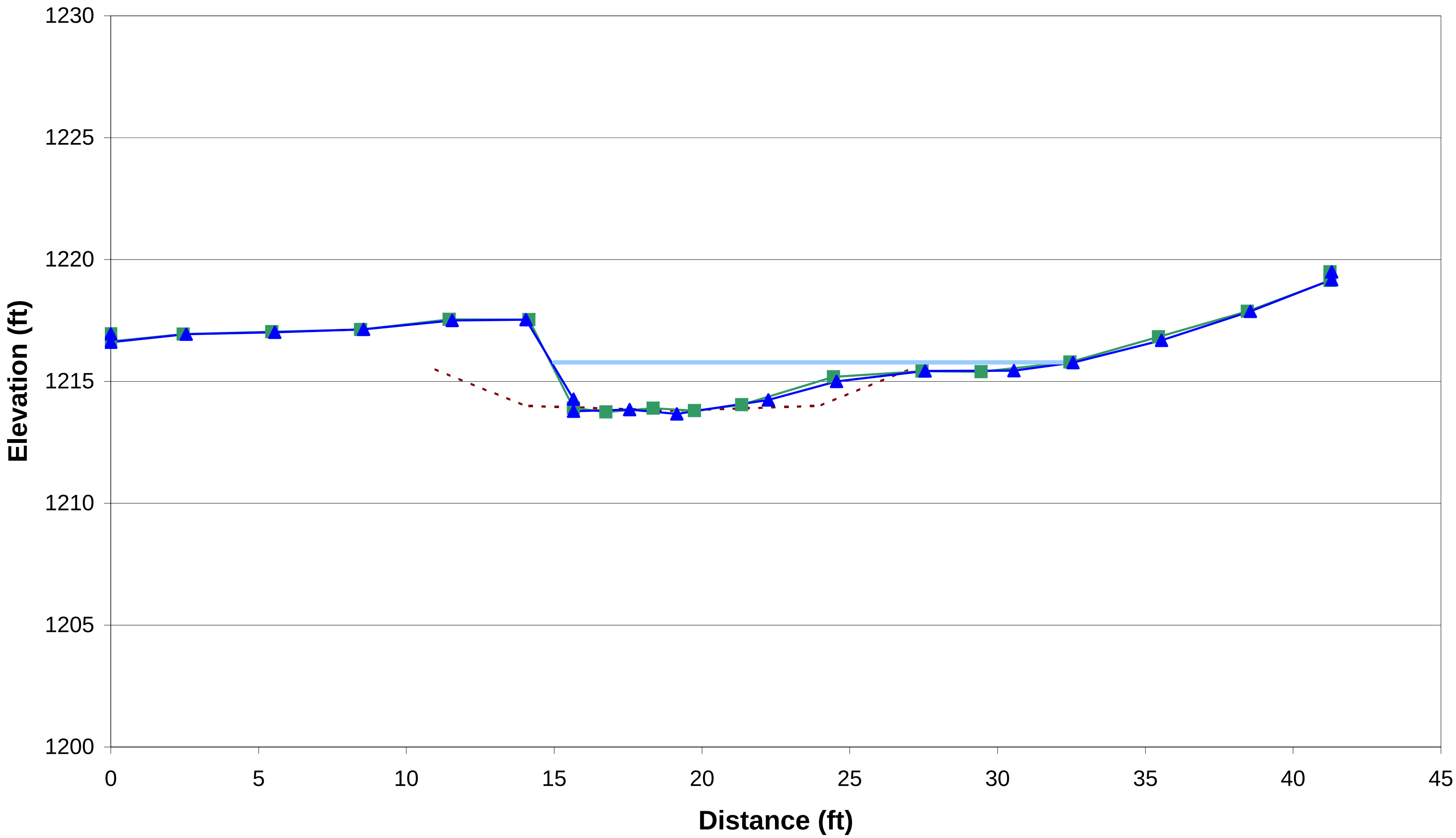
LEGEND

- Typical Design X/S
- Baseline Survey
- First Year Monitoring
- Bankfull, First Year

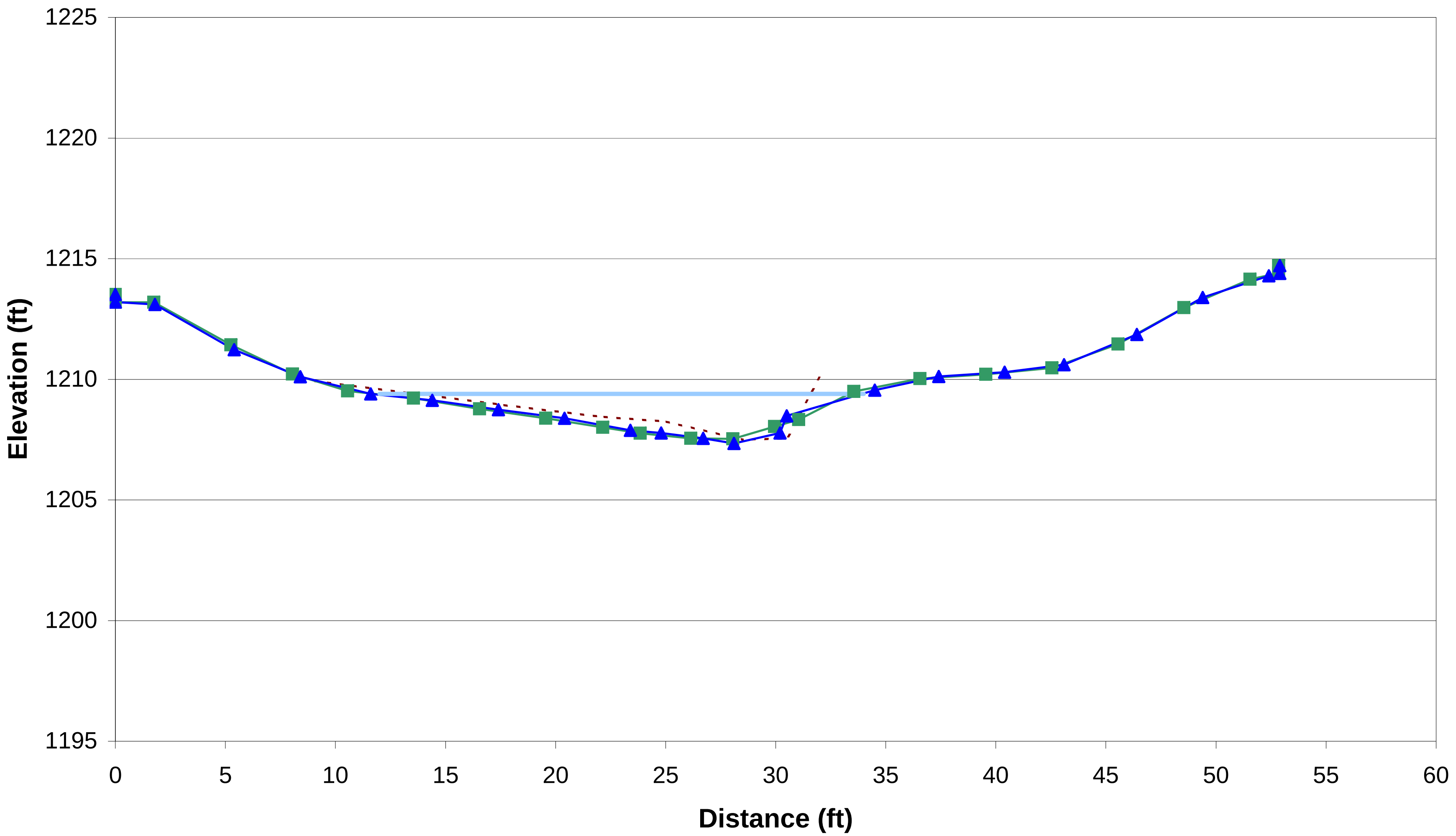
NOTES:

1) All data points represent ground, except for vertical endpoints which indicate the top of rebar protruding from ground at monumented stations.
2) The perspective shown is looking downstream.

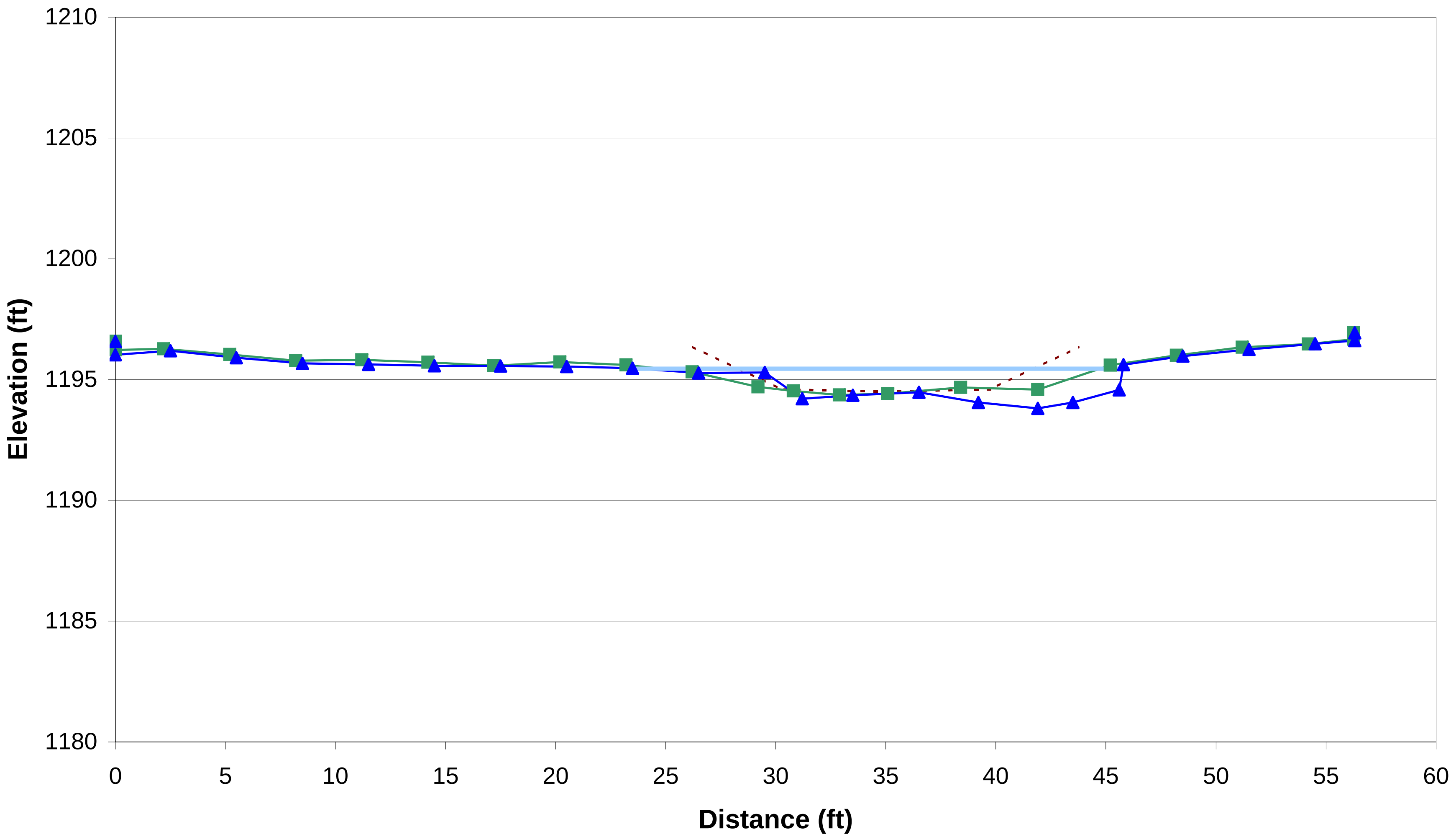
Cross Section #2, Meander
As-Built Thalweg STA 39+40
First Year Monitoring Conditions
Survey Dates: 1/15/2003, 10/23/2003



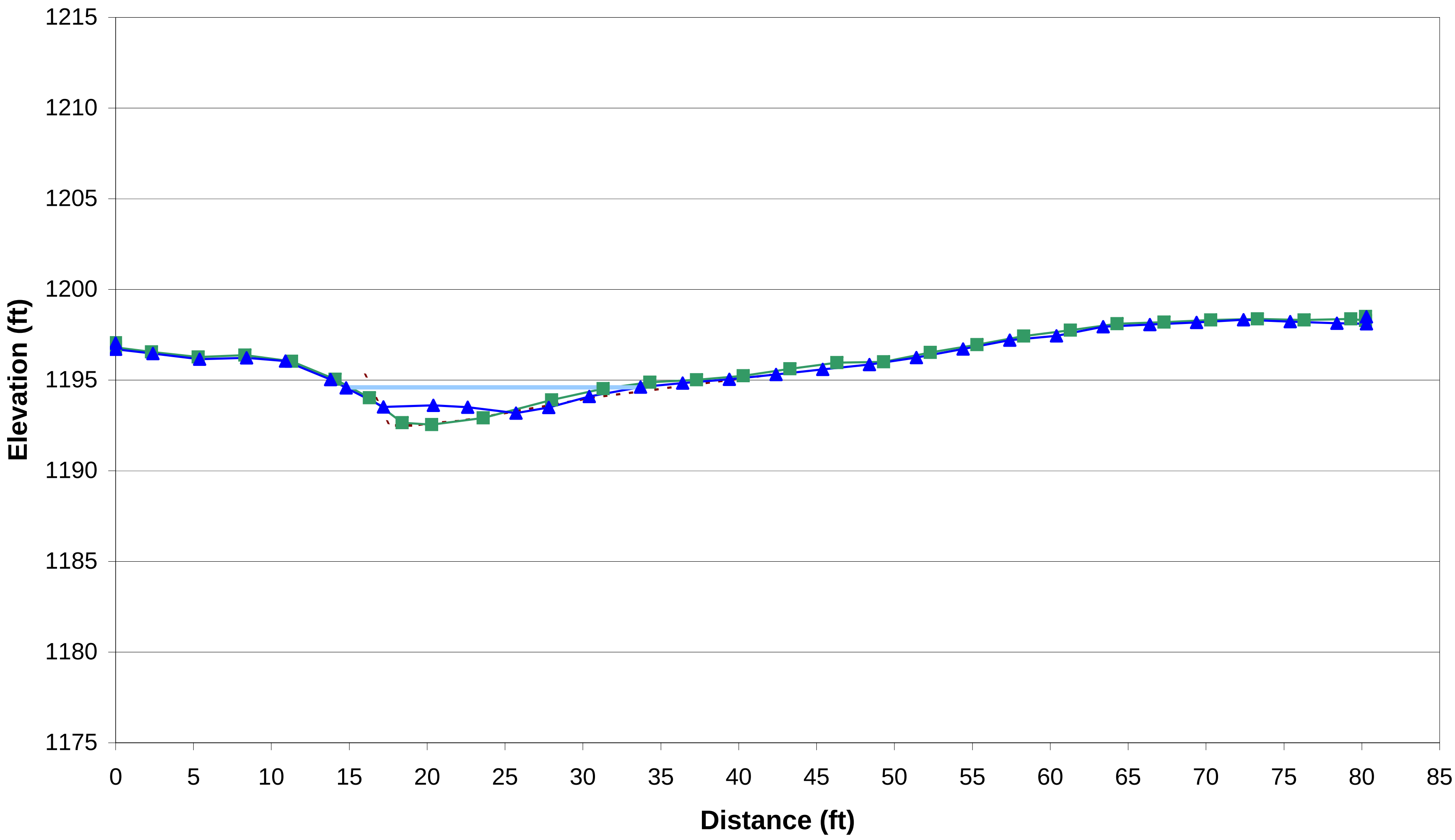
LEGEND	NOTES:	Cross Section #3, Riffle
Typical Design X/S Baseline Survey First Year Monitoring Bankfull, First Year	1) All data points represent ground, except for vertical endpoints which indicate the top of rebar protruding from ground at monumented stations. 2) The perspective shown is looking downstream.	**As-Built Thalweg STA 30+85** **First Year Monitoring Conditions** **Survey Dates: 1/5/2003, 10/23/2003**



LEGEND	NOTES:	
Typical Design X/S Baseline Survey First Year Monitoring Bankfull, First Year	1) All data points represent ground, except for vertical endpoints which indicate the top of rebar protruding from ground at monumented stations. 2) The perspective shown is looking downstream.	**Cross Section #4, Meander** **As-Built Thalweg STA 24+40** **First Year Monitoring Conditions** **Survey Dates: 1/15/2003, 10/23/2003**



LEGEND	**NOTES:**	
Typical Design X/S Baseline Survey First Year Monitoring Bankfull, First Year	1) All data points represent ground, except for vertical endpoints which indicate the top of rebar protruding from ground at monumented stations. 2) The perspective shown is looking downstream.	**Cross Section #5, Riffle** **As-Built Thalweg STA 7+55** **First Year Monitoring Conditions** **Survey Dates: 1/15/2003, 10/23/2003**



LEGEND
- Typical Design X/S
- Baseline Survey
- First Year Monitoring
- Bankfull, First Year

NOTES:
1) All data points represent ground, except for vertical endpoints which indicate the top of rebar protruding from ground at monumented stations.
2) The perspective shown is looking downstream.

Cross Section #6, Meander
As-Built Thalweg STA 6+45

First Year Monitoring Conditions
Survey Dates: 1/15/2003, 10/23/2003

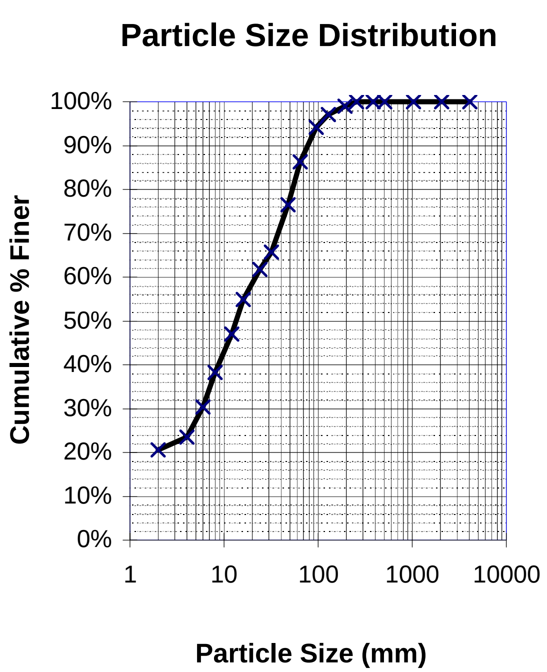
Appendix D
PEBBLE COUNTS

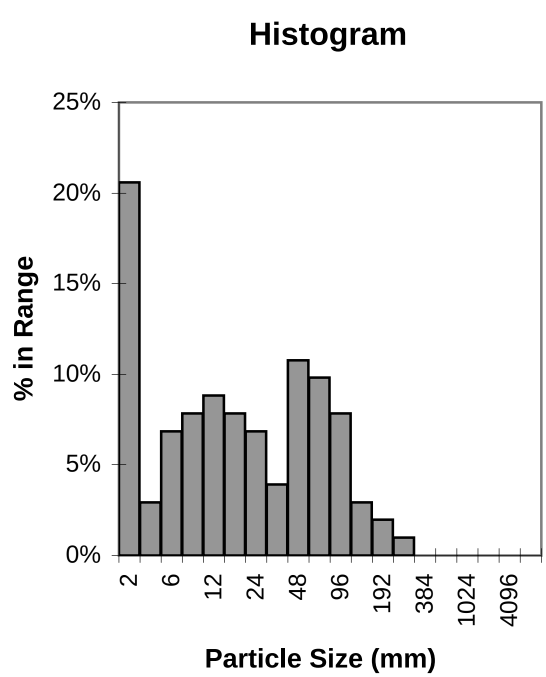
YEAR 1 MONITORING, PEBBLE COUNT A

Site Name:	Brown Branch	Biohabitats, Inc.
Project No:	01015.01	Pebble Count Data Sheet
Date:	10/24/2003	As-Built STA 46+30-46+90, Pool 5%, Riffle 95%

	Particle Size [mm]	Total #	% in Range	% Cumulative
Sand and Silt	< 2	21	21%	21%
Gravels	2 - 4	3	3%	24%
	4 - 6	7	7%	30%
	6 - 8	8	8%	38%
	8 - 12	9	9%	47%
	12 - 16	8	8%	55%
	16 - 24	7	7%	62%
	24 - 32	4	4%	66%
	32 - 48	11	11%	76%
	48 - 64	10	10%	86%
Cobbles	64 - 96	8	8%	94%
	96 - 128	3	3%	97%
	128 - 192	2	2%	99%
	192 - 256	1	1%	100%
Boulders	256 - 384	0	0%	100%
	384 - 512	0	0%	100%
	512 - 1024	0	0%	100%
	1024 - 2048	0	0%	100%
	2048 - 4096	0	0%	100%
Bedrock		0	0%	100%
	TOTALS:	102	100%	

D_{50} = 13.5 mm, D_{75} = 45.8 mm, D_{84} = 60.3 mm, D_{90} = 79.2 mm



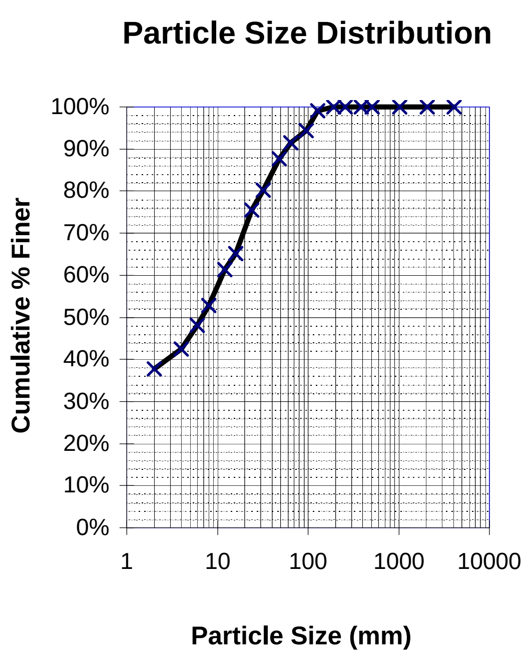


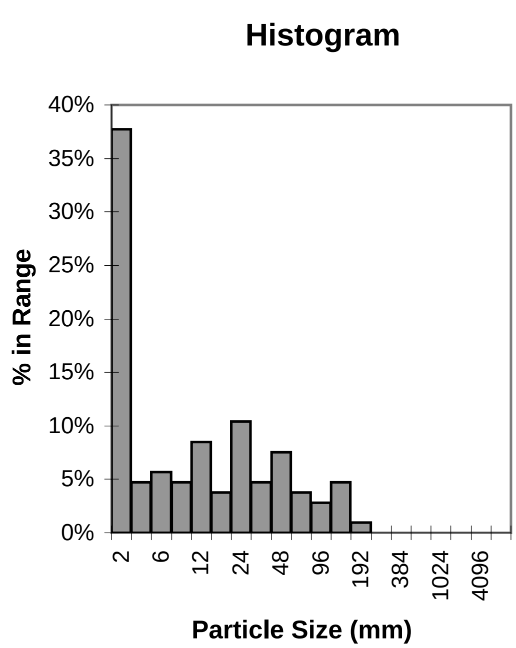
YEAR 1 MONITORING, PEBBLE COUNT B

Site Name:	Brown Branch	Biohabitats, Inc.
Project No:	01015.01	Pebble Count Data Sheet
Date:	10/21/2003	As-built STA 24+45-25+30, Pool 40%, Riffle 60%

	Particle Size [mm]	Total #	% in Range	% Cumulative
Sand and Silt	< 2	40	38%	38%
Gravels	2 - 4	5	5%	42%
	4 - 6	6	6%	48%
	6 - 8	5	5%	53%
	8 - 12	9	8%	61%
	12 - 16	4	4%	65%
	16 - 24	11	10%	75%
	24 - 32	5	5%	80%
	32 - 48	8	8%	88%
	48 - 64	4	4%	92%
Cobbles	64 - 96	3	3%	94%
	96 - 128	5	5%	99%
	128 - 192	1	1%	100%
	192 - 256	0	0%	100%
Boulders	256 - 384	0	0%	100%
	384 - 512	0	0%	100%
	512 - 1024	0	0%	100%
	1024 - 2048	0	0%	100%
	2048 - 4096	0	0%	100%
Bedrock		0	0%	100%
	TOTALS:	106	100%	

D_{50} = 6.8 mm, D_{75} = 23.6 mm, D_{84} = 40.1 mm, D_{90} = 57.6 mm





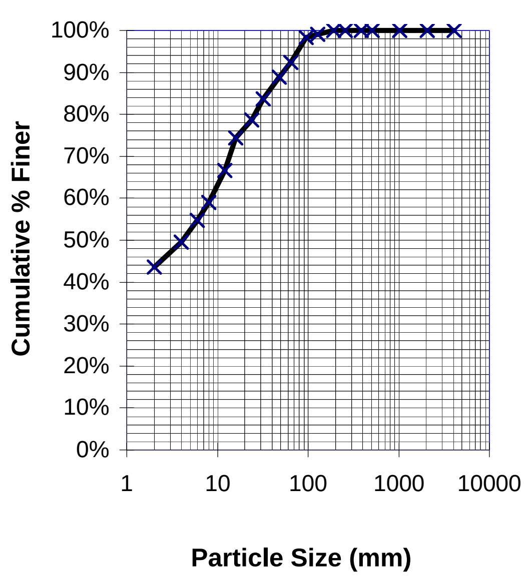
YEAR 1 MONITORING, PEBBLE COUNT C

Site Name:	Brown Branch	Biohabitats, Inc.
Project No:	01015.01	Pebble Count Data Sheet
Date:	10/21/2003	As-built STA 11+30-12+20, Pool 40%, Riffle 60%

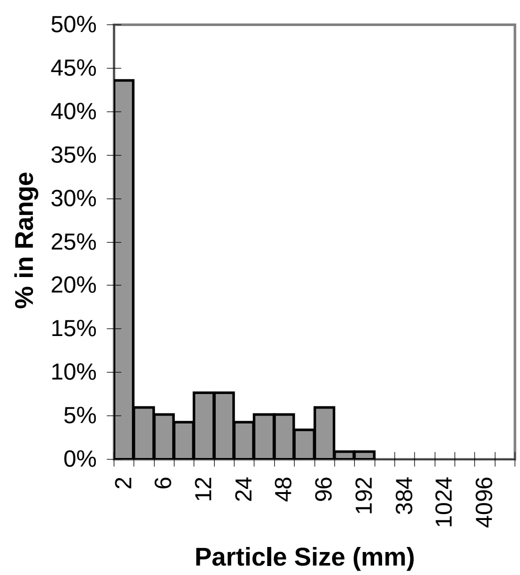
	Particle Size [mm]	Total #	% in Range	% Cumulative
Sand and Silt	< 2	51	44%	44%
Gravels	2 - 4	7	6%	50%
	4 - 6	6	5%	55%
	6 - 8	5	4%	59%
	8 - 12	9	8%	67%
	12 - 16	9	8%	74%
	16 - 24	5	4%	79%
	24 - 32	6	5%	84%
	32 - 48	6	5%	89%
	48 - 64	4	3%	92%
Cobbles	64 - 96	7	6%	98%
	96 - 128	1	1%	99%
	128 - 192	1	1%	100%
	192 - 256	0	0%	100%
Boulders	256 - 384	0	0%	100%
	384 - 512	0	0%	100%
	512 - 1024	0	0%	100%
	1024 - 2048	0	0%	100%
	2048 - 4096	0	0%	100%
Bedrock		0	0%	100%
	TOTALS:	117	100%	

D_{50} = 4.2 mm, D_{75} = 17.2 mm, D_{84} = 32.7 mm, D_{90} = 53.2 mm

Particle Size Distribution



Histogram



Appendix E
PHOTOGRAPHS

Photo Station #1. Looking downstream from as-built Station ~51+00.

Photo Station #2. Looking downstream from as-built Station ~49+30.

Photo Station #3. Looking downstream from as-built Station ~47+90.

Photo Station #4. Looking downstream from as-built Station ~44+00. Oxbow wetland in foreground.

Photo Station #5. Looking downstream at channel plug protection from as-built Station ~41+25.

Photo Station #6. Looking downstream from as-built Station ~38+00.

Photo Station #7. Looking downstream from as-built Station ~36+10.

Photo Station #8. Looking downstream from as-built Station ~35+15.

Photo Station #9. Looking downstream from as-built Station ~31+10 near gravel roadway.

Photo Station #10. Looking downstream from as-built Station ~28+25.

Photo Station #11. Looking downstream from as-built Station ~25+85.

Photo Station #12. Looking downstream from as-built Station ~24+50.

Photographs from Monumented Photo Stations #1 through #22
Brown Branch Stream Restoration
Post-Construction Photographs taken October 2003


Photo Station #13. Looking downstream from as-built Station ~22+20.


Photo Station #14. Looking downstream from as-built Station ~20+70. Small tributary confluence to left.


Photo Station #15. Looking downstream from as-built Station ~17+75.


Photo Station #16. Looking downstream from as-built Station ~14+25.


Photo Station #17. Looking downstream from as-built Station ~12+50. Tributary confluence to left. Rock has rolled from bank into channel from left.


Photo Station #18. Looking downstream from as-built Station ~10+05.

Photo Station #19. Looking downstream from as-built Station ~8+30.

Photo Station #20. Looking downstream from as-built Station ~5+05.

Photo Station #21. Looking downstream from as-built Station ~3+25.

Photo Station #22. Looking downstream from as-built Station 1+60.

Photograph NM-1. Looking upstream at cross vane from as-built Station ~51+00.

Photograph NM-2. Looking downstream at rootwads and log toe protection from as-built Station ~51+00.

Photograph NM-3. Looking downstream at rootwads and log toe protection from as-built Station ~49+25.

Photograph NM-4. Looking upstream at buried log vane from as-built Station ~49+25.

Photograph NM-5. Looking upstream at log vane from as-built Station ~48+25.

Photograph NM-6. Looking downstream at log vane from as-built Station ~47+25. Severe erosion along right bank.

Photograph NM-7. Looking upstream at cross vane from as-built Station ~44+80.

Photograph NM-8. Looking downstream at rootwad and rock toe protection from pedestrian bridge at as-built Station ~44+60.

Photograph NM-9. Looking downstream at rootwads and rock toe protection from as-built Station ~43+80.

Photograph NM-10. View of oxbow wetland from as-built Station ~43+40.

Photograph NM-11. Looking down outlet channel draining oxbow wetland into mainstem channel, at as-built Station ~43+40.

Photograph NM-12. Looking upstream at cross vane from as-built Station ~42+50.

Photograph NM-13. Looking downstream at rootwad/log "J" vane from as-built Station ~42+25.

Photograph NM-14. Looking downstream at log vane at as-built Station ~41+50.

Photograph NM-15. Looking up tributary at confluence with Brown Branch, as-built Station ~41+00.

Photograph NM-16. Looking downstream at channel plug protection along opposite bank, view from as-built Station ~41+00.

Photograph NM-17. Looking downstream at rock vane, rootwads, and log toe protection from as-built Station ~39+75.

Photograph NM-18. Looking downstream at log vane and rootwads from as-built Station 37+75.

Photograph NM-19. Looking upstream at log vane from as-built Station ~37+50.

Photograph NM-20. Looking downstream at log vane, rootwad, and log toe protection from as-built Station ~36+25.

Photograph NM-21. Looking downstream at rootwads from as-built Station ~35+00.

Photograph NM-22. Looking downstream at log vane and log toe protection from as-built Station ~34+00.

Photograph NM-23. Looking upstream at log toe protection from as-built Station ~32+50.

Photograph NM-24. Looking downstream at channel plug protection from as-built Station ~32+00.

Photographs from Non-Monumented Locations
Brown Branch Stream Restoration
Post-Construction Photographs taken October 2003

Photograph NM-25. Looking downstream at log toe protection from as-built Station ~31+00.

Photograph NM-26. Looking downstream at log toe protection from as-built Station ~30+85.

Photograph NM-27. Looking downstream at rootwad and log toe protection from as-built Station ~ 30+50.

Photograph NM-28. Looking upstream at log vane from as-built Station ~28+10.

Photograph NM-29. Looking downstream at log toe protection and rootwad from as-built Station ~27+25.

Photograph NM-30. Looking upstream at log vane and rock toe protection from as-built Station ~24+60.

Photograph NM-31. Looking downstream at log vane and rootwads from as-built Station 24+60.

Photograph NM-32. Looking upstream at log vane from as-built Station ~23+30.

Photograph NM-33. Looking upstream at channel plug protection from as-built Station ~23+00.

Photograph NM-34. Looking downstream at rootwad and rootwad/log "J" vane from as-built Station ~22+50.

Photograph NM-35. Looking upstream at cross vane from as-built Station ~20+50.

Photograph NM-36. Looking upstream at rootwads and rock toe protection from as-built Station ~20+00.

Photograph NM-37. Looking downstream at log toe protection and log vane from Station ~19+70.

Photograph NM-38. Looking downstream at channel plug protection from as-built Station ~19+00.

Photograph NM-39. Looking downstream at log vane and rootwad from as-built Station ~17+75.

Photograph NM-40. Looking upstream at rock "J" vane from as-built Station ~16+00.

Photograph NM-41. Looking upstream at channel plug protection from as-built Station ~14+50.

Photograph NM-42. Looking downstream at log vane from as-built Station ~14+25.

Photograph NM-43. Looking upstream at log vane from as-built Station ~14+00.

Photograph NM-44. Looking upstream at log vane from as-built Station ~12+75.

Photograph NM-45. Looking upstream into tributary that joins Brown Branch at as-built Station ~12+50.

Photograph NM-46. Looking downstream at rootwads from as-built Station ~12+25.

Photograph NM-47. Looking downstream at rock cross vane from as-built Station ~11+30.

Photograph NM-48. Looking downstream at rock "J" vane from as-built Station ~10+25.

Photograph NM-49. Looking downstream at rootwads and rock vane from as-built Station ~10+00.

Photograph NM-50. Photograph not available. **(**Looking upstream at rock vane and rootwads from as-built Station ~9+50.)

Photograph NM-51. Looking downstream at cross vane and rootwads from as-built Station ~9+00.

Photograph NM-52. Looking upstream at rock vane and rootwads from as-built Station ~8+75.

Photograph NM-53. Looking north across wetland near as-built Station ~8+00.

Photograph NM-54. Looking west across wetland near as-built Station ~8+00.

Photograph NM-55. Looking downstream at rootwads from as-built Station ~8+50.

Photograph NM-56. Looking downstream along riffle from as-built Station ~8+00.

Photograph NM-57. Looking upstream at log vane from as-built Station ~7+00.

Photograph NM-58. Looking downstream at rock "J" vane from as-built Station ~6+80.

Photograph NM-59. Looking upstream at rock "J" vane from as-built Station ~6+80.

Photograph NM-60. Looking upstream at rock "J" vane and wetland from as-built Station ~ 6+50.

Photograph NM-61. Looking downstream at rootwads and rock toe protection from as-built Station ~6+50.

Photograph NM-62. Looking downstream at rock “J” vane, rock toe protection, and rootwad from as-built Station ~5+50.

Photograph NM-63. Looking upstream at rock “J” vane from as-built Station ~5+25.

Photograph NM-64. Looking downstream at log toe protection and rootwad from as-built Station ~5+25.

Photograph NM-65. Looking upstream at log toe protection, rootwad, and rock vane from as-built Station ~4+50.

Photograph NM-66. Looking upstream at cross vane from as-built Station ~4+00.

Photograph NM-67. Looking downstream at rootwad from as-built Station ~4+00.

Photograph NM-68. Looking upstream at rock “J” vane from as-built Station ~3+25.

Photograph NM-69. Looking downstream at rock “J”vane from as-built Station ~3+25.

Photograph NM-70. Looking upstream from as-built Station ~2+75.

Photograph NM-71. Looking downstream at rock vane from as-built Station ~2+75.

Photograph NM-72. Looking upstream at rock “J” vane from as-built Station ~2+00.

Photograph NM-73. Looking downstream at rock "J" vane and rootwad from as-built Station ~1+00.

Photograph NM-74. Looking upstream at rock "J" vane from as-built Station ~0+85.

Photograph NM-75. Looking upstream at rock vane and rootwad from as-built Station ~0+65.


Looking downstream at existing log and channel from as-built Station ~50+00.


Looking upstream at log wall damage from as-built Station ~49+00.


Looking downstream at bank erosion from as-built Station ~49+25.


Looking downstream at bank erosion from as-built Station ~47+00.


Looking upstream at bank erosion from as-built Station ~46+50.


Looking downstream at bank erosion from as-built Station ~46+00.

Photographs from Non-Monumented Locations
Brown Branch Stream Restoration
Post-Construction Photographs taken October 2003


Looking downstream at erosion from as-built Station ~44+00.


Looking at birds in brush pile from as-built Station ~44+00.


Looking at floodplain depression with wetland plants from as-built Station ~42+50.


Looking upstream at log vane at as-built Station ~41+50.


Looking upstream at stable banks in meander at as-built Station ~38+00.


Looking upstream at bank erosion at as-built Station ~36+00.

Looking downstream at erosion between rootwad and log vane at as-built Station ~36+00.

Looking upstream at bank erosion at as-built Station ~36+00.

Looking upstream at dry oxbow wetland at as-built Station ~36+00.

Looking downstream at rootwads from as-built Station ~35+00.

Looking downstream at gully erosion at as-built Station ~31+10.

Looking upstream at slumping log wall at as-built Station ~30+50.

Photographs from Non-Monumented Locations
Brown Branch Stream Restoration
Post-Construction Photographs taken October 2003


Looking downstream at log vane from as-built Station ~30+25.


Looking upstream at erosion behind rootwads from as-built Station ~29+90.


Looking upstream at oxbow wetland with no plants at as-built Station ~29+00.


Looking downstream at good pool and rootwad from as-built Station ~26+50.


Looking upstream at erosion behind rootwads at as-built Station ~24+00.


Looking upstream at log and snag at as-built Station ~22+00.


Looking upstream at oxbow wetland with wetland plants at as-built Station ~22+00.


Looking downstream at erosion behind rootwads at as-built Station ~22+00.


Gully erosion on right bank at as-built Station ~21+75.


Looking upstream at lateral channel movement and erosion at as-built Station ~19+00.


Looking downstream gully erosion at as-built Station ~17+25.


Looking upstream at erosion behind rootwad at as-built Station ~14+00.

Looking upstream at oxbow wetland with snag at as-built Station ~13+50.

Looking downstream at erosion on left bank from as-built Station ~12+50.

Looking downstream at as-built Station ~12+25.

Looking downstream at rolled rocks at as-built Station ~11+00.

Looking upstream at rolled rocks at as-built Station ~11+00.

Looking downstream at channel widening at as-built Station ~10+50.

Looking upstream at channel widening and rock “J” vane from as-built Station ~10+25.

Looking upstream at oxbow wetland with brush pile at as-built Station ~11+00.

Looking east at wetland at as-built Station ~8+00.

Looking downstream at wetland at as-built Station ~8+00.

Looking downstream at gully erosion at as-built Station ~7+25.

Looking upstream at rock vane and root wads from as-built Station ~6+50.

Photographs from Non-Monumented Locations
Brown Branch Stream Restoration
Post-Construction Photographs taken October 2003


Looking downstream at wetland with snags and brush piles at as-built Station ~5+25.


Looking upstream at gully erosion at as-built Station ~5+25.


Looking downstream at gully erosion at as-built Station ~3+00.


Looking downstream at rock wall at as-built Station ~1+50.


Example of a bare root sycamore in good health.


Looking downstream at wet depression from grading near barn at as-built Station ~16+00.

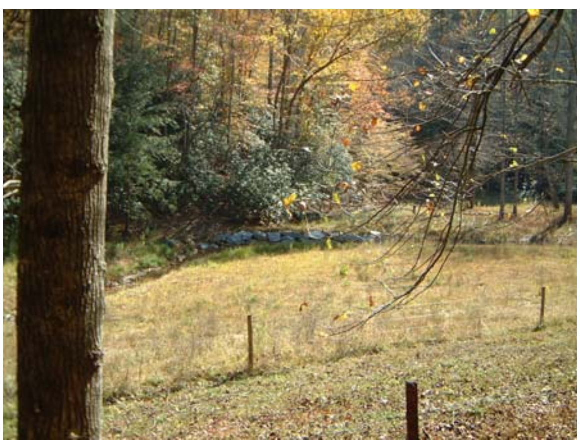
Photographs from Non-Monumented Locations
Brown Branch Stream Restoration
Post-Construction Photographs taken October 2003


Looking upstream at wet depression from grading near barn at as-built Station ~16+00.


Looking downstream at fenceline vegetation differences near as-built Station ~19+00.


Poor quality bare root plant.


Looking downstream from access road near as-built Station ~25+00.


Looking downstream from access road near as-built Station ~25+00.


Looking upstream from access road near as-built Station ~25+00.


Looking downstream from access road near as-built Station ~27+00.


Looking upstream at pond near as-built Station ~31+00.

Appendix F
VEGETATION PLOTS

Project: Brown Branch Stream Restoration
Monitoring Year: First Year
Sampling Date: 22 Oct 2003

SUMMARY OF MEASURED TREE DENSITIES BASELINE MONITORING			
Vegetation Transect Number	**Plot Size**	**Stems/ 0.1 Acre**	**Stems/ Acre**
1	1/10 ac	220	2200
2	1/10 ac	64	640
3	1/10 ac	182	1820
4	1/10 ac	8	80
5	1/10 ac	186	1860
6	1/10 ac	113	1130
7	1/10 ac	1036	10360
Current Average Tree Stems/Acre =			**2584**
Required Tree Density After 5 Years =			**320**
CONCLUSION: ***This project currently meets tree density requirements.***			

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #1
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #1

Tree Species		Planting Plan Strata (or Volunteer only)	# of Trees																TOTAL
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	5																5
Betula lenta	Sweet birch	(volunteer only)	6																6
Betula nigra	River birch	Midstory Tree																	0
Carpinus caroliniana	Ironwood	Midstory Tree	41			4			2			1							48
Chionanthus virginicus	Fringetree	Midstory Tree																	0
Cornus amonum	Silky dogwood	(volunteer only)	6																6
Cornus florida	Flowering dogwood	Midstory Tree	1																1
Fraxinus americana	White ash	Tree																	0
Fraxinus pennsylvanica	Green ash	Tree	1																1
Ilex opaca	American holly	(volunteer only)	5																5
Liriodendron tulipifera	Tulip poplar	Tree	72								1								73
Nyssa sylvatica	Black gum	Tree																	0
Ostrya virginiana	American hophornbeam	Midstory Tree																	0
Platanus occidentalis	American sycamore	Tree	58					1			1								60
Prunus serotina	Black cherry	Tree	11																11
Quercus falcata	Southern red oak	Tree																	0
Quercus falcata var. pagoda	Cherrybark oak	Tree	4																4
TOTAL			210		4			3			3			0			0		220

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 2200 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zones 1 (mesic riparian woodlands), 2 (lower floodplain riparian woodlands), 3 (lower floodplain meander buffer), and 4 (scrub shrub wetland).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled). Species sampled that were not in the planting plan are indicated as "volunteer only."
3) Survival of planted species is approximately 30% in this plot.
4) One sprig of privet was identified and removed from this plot.

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #2
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #2

Tree Species		Planting Plan Strata (or Volunteer)	# of Trees																TOTAL
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	8																8
Betula nigra	River birch	Midstory Tree																	0
Carpinus caroliniana	Ironwood	Midstory Tree	3																3
Chionanthus virginicus	Fringetree	Midstory Tree																	0
Cornus amonum	Silky dogwood	(volunteer only)	1																1
Cornus florida	Flowering dogwood	Midstory Tree	1																1
Fraxinus americana	White ash	Tree	2																2
Fraxinus pennsylvanica	Green ash	Tree																	0
Liriodendron tulipifera	Tulip poplar	Tree	6																6
Nyssa sylvatica	Black gum	Tree	4																4
Ostrya virginiana	American hophornbeam	Midstory Tree																	0
Platanus occidentalis	American sycamore	Tree	35																35
Prunus serotina	Black cherry	Tree																	0
Quercus falcata	Southern red oak	Tree																	0
Quercus pagoda	Cherrybark oak	Tree	4																4
TOTAL			64	0			0			0			0			0			64

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 640 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zones 1 (mesic riparian woodlands), 2 (lower floodplain riparian woodlands), and 3 (lower floodplain meander buffer).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled). Species sampled that were not in the planting plan are indicated as "volunteer only."
3) Survival of planted species is approximately 35% in this plot.
4) Where sufficient visual clues were not available to differentiate species, trees were identified to the Genus level.

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #3
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #3

Tree Species		Planting Plan Strata (or Volunteer)	# of Trees																TOTAL
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	5																5
Betula lenta	Sweet birch	(volunteer only)	13			2		1											16
Betula nigra	River birch	Midstory Tree	*100*			2					1								103
Carpinus caroliniana	Ironwood	Midstory Tree	3			1													4
Chionanthus virginicus	Fringetree	Midstory Tree																	0
Cornus amonum	Silky dogwood	(volunteer only)	2																2
Cornus florida	Flowering dogwood	Midstory Tree																	0
Fagus grandifolia	American beech	(volunteer only)	2																2
Fraxinus americana	White ash	Tree																	0
Fraxinus pennsylvanica	Green ash	Tree																	0
Ilex opaca	American holly	(volunteer only)	4																4
Liriodendron tulipifera	Tulip poplar	Tree	20								1								21
Nyssa sylvatica	Black gum	Tree	2																2
Ostrya virginiana	American hophornbeam	Midstory Tree																	0
Platanus occidentalis	American sycamore	Tree	4								1								5
Prunus serotina	Black cherry	Tree	1																1
Quercus falcata	Southern red oak	Tree	0																0
Quercus pagoda	Cherrybark oak	Tree	3																3
Tsuga canadensis	Eastern hemlock	(volunteer only)	14			4													18
TOTAL			173	5			1			3			0			0			182

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 1820 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zones 1 (mesic riparian woodlands), 2 (lower floodplain riparian woodlands), and 4 (scrub shrub wetland).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled). Species sampled that were not in the planting plan are indicated as "volunteer only."
3) Italicized number(s) indicates *minimum* number present, where high density of volunteer species precluded exact count.
4) Survival of planted species is approximately 30% in this plot.
5) Two sprigs of privet was identified and removed from this plot.

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #4
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #4

Tree Species		Planting Plan Strata (or Volunteer)	# of Trees																TOTAL
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	1																1
Betula nigra	River birch	Midstory Tree																	0
Carpinus caroliniana	Ironwood	Midstory Tree	1																1
Chionanthus virginicus	Fringetree	Midstory Tree																	0
Cornus florida	Flowering dogwood	Midstory Tree	3																3
Fraxinus americana	White ash	Tree																	0
Fraxinus pennsylvanica	Green ash	Tree	2																2
Liriodendron tulipifera	Tulip poplar	Tree																	0
Nyssa sylvatica	Black gum	Tree																	0
Ostrya virginiana	American hophornbeam	Midstory Tree																	0
Platanus occidentalis	American sycamore	Tree																	0
Prunus serotina	Black cherry	Tree																	0
Quercus falcata	Southern red oak	Tree																	0
Quercus pagoda	Cherrybark oak	Tree	1																1
TOTAL			8		0			0			0			0			0		8

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 80 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zones 1 (mesic riparian woodlands), 2 (lower floodplain riparian woodlands), and 3 (lower floodplain meander buffer).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled).
3) Survival of planted species is approximately 10% in this plot.

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #5
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #5

Tree Species		**Planting Plan Strata (or Volunteer)**	**# of Trees**																**TOTAL**
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	3																3
Betula lenta	Sweet birch	(volunteer only)	1																1
Betula nigra	River birch	Midstory Tree																	0
Carpinus caroliniana	Ironwood	Midstory Tree																	0
Fraxinus pennsylvanica	Green ash	Tree																	0
Ilex opaca	American holly	(volunteer only)	1																1
Liriodendron tulipifera	Tulip poplar	(volunteer only)	75								2			3					80
Nyssa sylvatica	Black gum	Tree																	0
Platanus occidentalis	American sycamore	Tree	*100*														1		101
Quercus pagoda	Cherrybark oak	Tree																	0
TOTAL			180	0			0			2			3			1			186

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 1860 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zones 2 (lower floodplain riparian woodlands), 4 (scrub shrub wetland), and 5 (vernal pool).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled).
3) Species sampled that were not in the planting plan are indicated as "volunteer only."
4) Italicized number indicates *minimum* number present, where high density of volunteer species precluded exact count.
5) Survival of planted species is approximately 15% in this plot.
6) Invasive species are present in this plot.

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #6
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #6

Tree Species		**Planting Plan Strata (or Volunteer)**	**# of Trees**																**TOTAL**
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	4																4
Betula lenta	Sweet birch	(volunteer only)	1																1
Betula nigra	River birch	Midstory Tree	2																2
Carpinus caroliniana	Ironwood	Midstory Tree	1																1
Cornus florida	Flowering dogwood	(volunteer only)	1																1
Fraxinus pennsylvanica	Green ash	Tree	6																6
Liriodendron tulipifera	Tulip poplar	(volunteer only)	9																9
Nyssa sylvatica	Black gum	Tree	1																1
Platanus occidentalis	American sycamore	Tree	45			6													51
Quercus pagoda	Cherrybark oak	Tree																	0
Salix sp.	Willow	(volunteer only)	35																35
Tsuga canadensis	Eastern hemlock	(volunteer only)	2																2
TOTAL			107	6			0			0			0			0			113

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 1130 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zones 2 (lower floodplain riparian woodlands), 4 (scrub shrub wetland), and 5 (vernal pool).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled). Species sampled that were not in the planting plan are indicated as "volunteer only."
3) Where sufficient visual clues were not available to differentiate species, trees were identified to the Genus level.
4) Survival of planted species is approximately 60% in this plot.
5) Invasive species are present in this plot, including greenbrier, multiflora rose, and honeysuckle.

Project: Brown Branch Stream Restoration
Monitoring Year: Post-Planting, Year 1
Sampling Date: 22 Oct 2003
Vegetation Plot: #7
Plot Size: 1/10 acre

FIRST YEAR CONDITIONS, VEGETATION PLOT #7

Tree Species		**Planting Plan Strata (or Volunteer)**	**# of Trees**																**TOTAL**
			Saplings	2-5.9" dbh			6-11.9" dbh			12-19.9" dbh			20-29.9" dbh			>30" dbh			
Scientific Name	Common Name	Crown Position*	N/A	D	C	O	D	C	O	D	C	O	D	C	O	D	C	O	
Acer rubrum	Red maple	Tree	7																7
Betula nigra	River birch	Midstory Tree	6																6
Carpinus caroliniana	Ironwood	Midstory Tree	1																1
Chionanthus virginicus	Fringetree	(volunteer only)	13																13
Cornus florida	Flowering dogwood	(volunteer only)	4																4
Fraxinus pennsylvanica	Green ash	Tree																	0
Liriodendron tulipifera	Tulip poplar	Tree	2																2
Nyssa sylvatica	Black gum	Tree																	0
Ostrya virginiana	American hophornbeam	(volunteer only)	2																2
Platanus occidentalis	American sycamore	Tree	*1000*																1000
Quercus pagoda	Cherrybark oak	Tree	1																1
TOTAL			1036		0			0			0			0			0		1036

*(N/A= Not applicable, D= Dominant, CoD= Co-Dominant, O= Other)

NET TREE DENSITY= 10360 trees/acre

NOTES:
1) This sample plot includes portions of Planting Zone 2 (lower floodplain riparian woodlands).
2) Tree species listed include all species in the planting plan for the corresponding zones (even if none were sampled). Species sampled that were not in the planting plan are indicated as "volunteer only."
3) Italicized number(s) indicates *minimum* number present, where high density of volunteer species precluded exact count.
4) Survival of planted species is approximately 50% in this plot.
5) Tearthumb species noted in this plot.