Buffalo Creek Watershed
Phase I
Stream Mitigation Plan
Greensboro, North Carolina

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

Ecosystem Enhancement Program

Prepared By:

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February 2005

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Project Engineer

Executive Summary

In 2003, the North Carolina Ecosystem Enhancement Program (EEP) restored 11,235 feet of streams at two sites in the Buffalo and South Buffalo Creek Watersheds in Greensboro, North Carolina. The specific reaches in Phase I are located in Gillespie Golf Course and Hillsdale Park. Construction began on February 4, 2003 and was completed on March 15, 2004. Phase II of the project consists of streams in Brown Bark and Benbow Parks with a completion date of March 2005.

The existing stream channels had low sinuosity and varying levels of incision due to historic channelization. The stream restoration design was based on natural channel design principles and considered differences in drainage area, adjacent land uses, urban constraints, and future development potential. The design addressed the channel dimension, pattern, and profile based on reference reach parameters and hydraulic geometry relationships. When considering design alternatives, the alternative of creating a stable meandering channel with bankfull stage located at the existing floodplain elevation was evaluated. However, in both of these steams, valley or development restrictions did not allow for new channel pattern to be established. The existing incised channels were enhanced by excavating new floodplain benches at the bankfull stage and installing structures to improve bed features and control channel grade.

A summary of existing and design reach lengths with restoration design approaches is provided in the table below.

Sub-Project	Existing Length (ft)	Restored Length (ft)	Restoration Approach
Gillespie Golf Course (Main channel)	2,634	2,634	Rosgen Priority 3-Buffer restoration, Bankfull benches & In-stream structures
Gillespie Golf Course (Tributaries GR2 & 3B)	475	475	Rosgen Priority 3-Buffer restoration, Bankfull benches & In-Stream structures
Gillespie Golf Course (Tributaries GR3A, 4, & 5)	2,686	2,686	Bank stabilization
Hillsdale Park (Main channel)	5,302	5,302	Priority 3 – Buffer Restoration, Bankfull benches & In-stream structures
Hillsdale Park Tributary HR3	529	138	Bank Stabilization
Total	**11,901**	**11,235**	

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1 Introduction

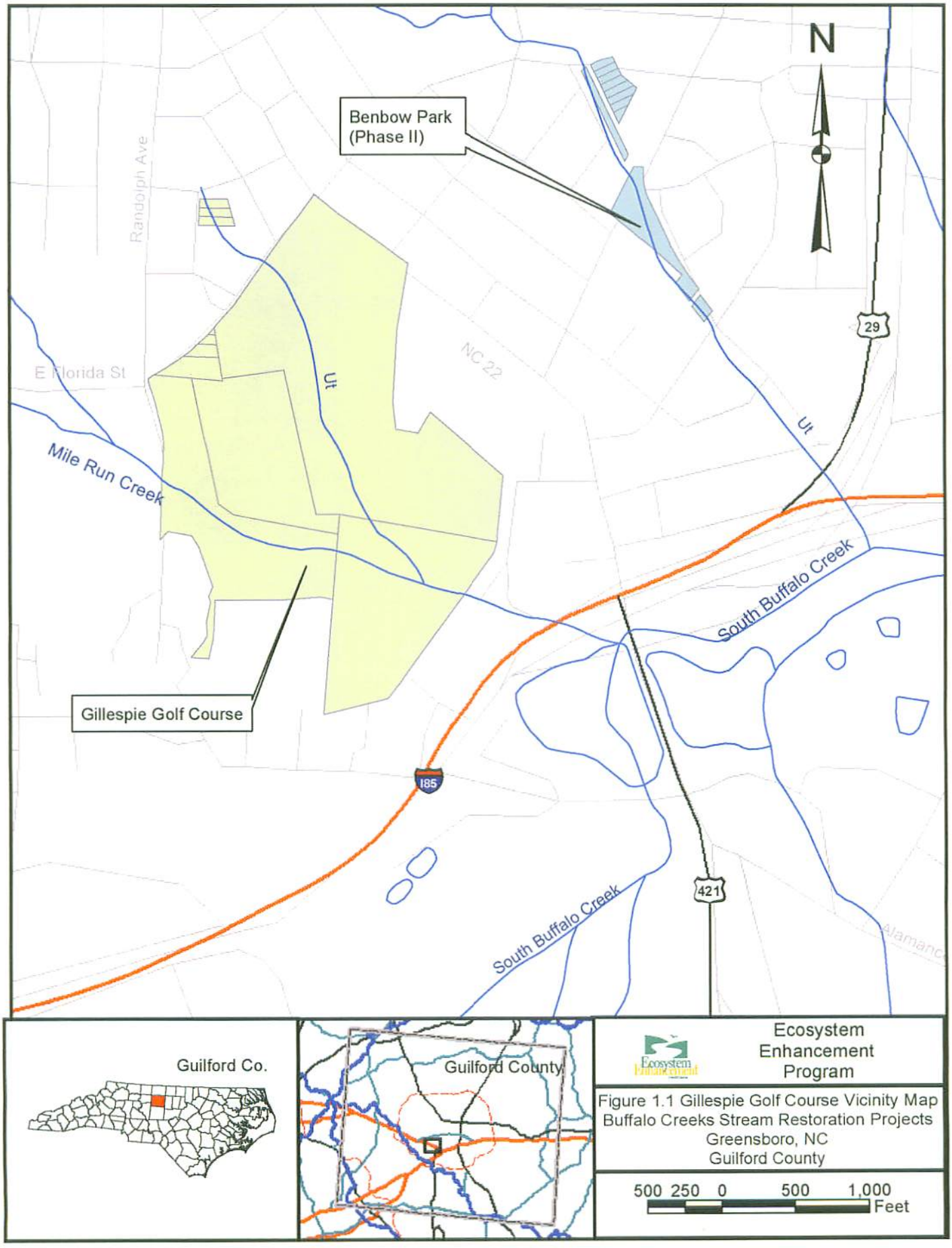
1.1 Project Goals

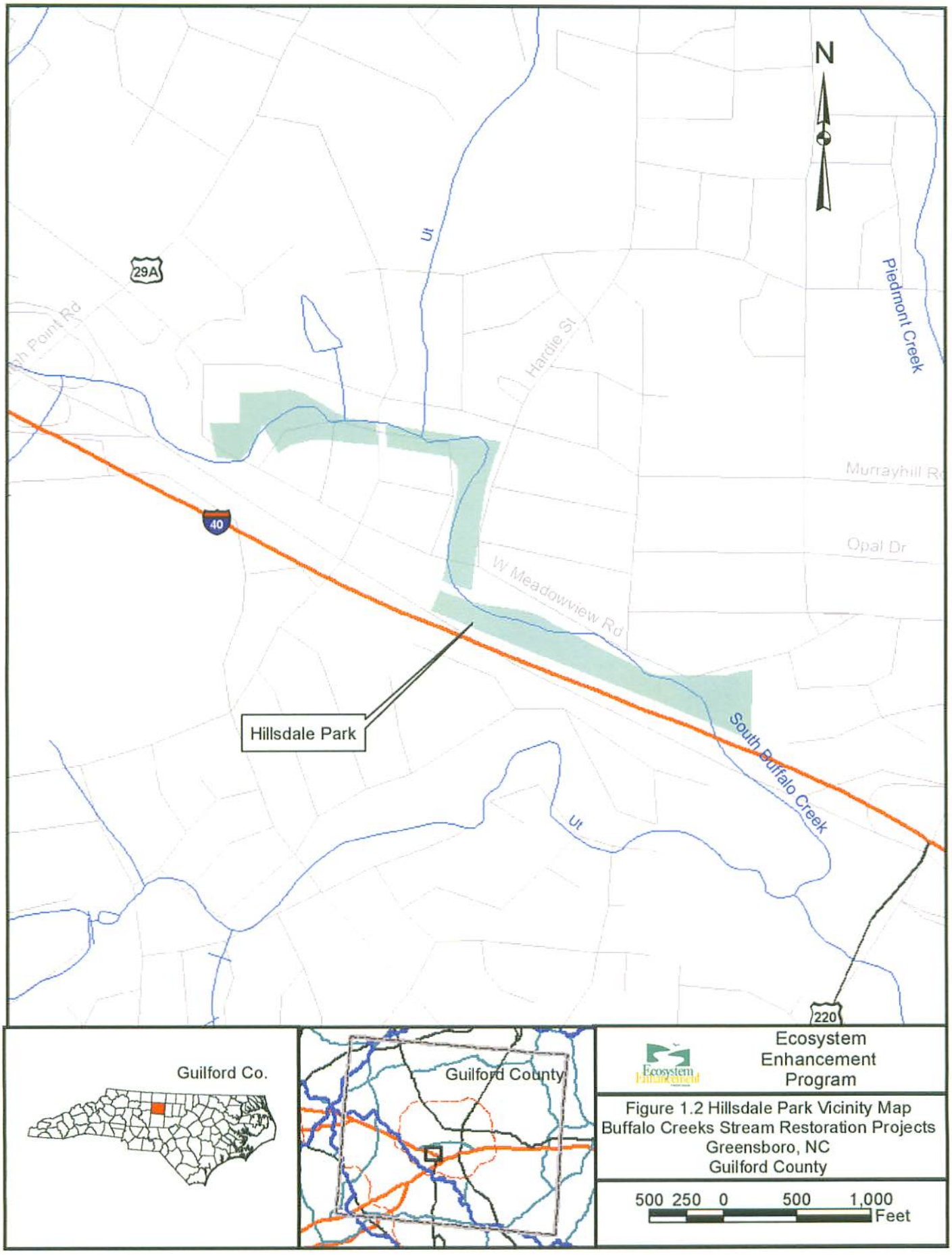
The objectives of Phase I of the Buffalo Creek Watershed stream restoration project were to:

1. Restore unstable stream channels to natural stable forms by modifying dimension. pattern, and/or profile based on reference reach parameters.
2. Improve floodplain functionality by matching bankfull stage with floodplain elevation.
3. Establish native floodplain vegetation through a forested riparian buffer.
4. Improve the natural aesthetics of the stream corridor.
5. Obtain mitigation credits for unavoidable impacts to streams within the same Hydrologic Unit Code (HUC).

1.2 Project Location

The project streams are located in the town of Greensboro in Guilford County, North Carolina (Figure 1.1). These streams are tributaries to the Haw River (USGS Hydrologic Unit 03030002) and are in the Cape Fear River basin.


N
Benbow Park
(Phase II)
Randolph Ave
E Florida St
NC 22
UT
UT
Mile Run Creek
South Buffalo Creek
Gillespie Golf Course
29
I85
421
South Buffalo Creek
Alamance
Guilford Co.
Guilford County
Ecosystem
Enhancement
Program
Figure 1.1 Gillespie Golf Course Vicinity Map
Buffalo Creeks Stream Restoration Projects
Greensboro, NC
Guilford County
500 250 0 500 1,000
Feet


N
29A
40
220
Ut
Piedmont Creek
Hardie St
W Meadowview Rd
Murrayhill Rd
Opal Dr
Hillsdale Park
South Buffalo Creek
Ut
Guilford Co.
Guilford County
Ecosystem Enhancement Program
Figure 1.2 Hillsdale Park Vicinity Map
Buffalo Creeks Stream Restoration Projects
Greensboro, NC
Guilford County
500 250 0 500 1,000
Feet

2 Summary

2.1 Project Description and Watershed

The project is divided into two locations: Gillespie Golf Course and Hillsdale Park. The sites are shown in Figures 1.1 and 1.2. The stream channel lengths and respective drainage areas are listed in Table 2.1.

Table 2.1 Sites with Existing Stream Lengths and Drainage Areas.

Sub-Project Name and Location	Existing Length (ft)	Drainage Area (mi^2)
Gillespie Golf Course – main channel	2,634	2.2
Tributaries	3,436	
Hillsdale Park – main channel	5,302	10.0
Tributary	529	
Total	**11,901**	

2.2 Methodologies Used

Buck Engineering used natural channel design principles and considered differences in drainage area, adjacent land uses, upstream impoundments, and future development potential to restore the stream to the highest level of restoration within the given constraints. The design addressed channel dimension, pattern, and profile based on reference reach parameters and hydraulic geometry relationships. When considering design alternatives, the alternative of creating a stable meandering channel with bankfull stage located at the existing floodplain elevation was evaluated. In both of these steams, valley or development restrictions did not allow for new channel pattern to be established. The existing incised channels were enhanced by excavating new floodplain benches at the bankfull stage and installing structures to improve bed features and control channel grade.

This process included extensive planning beginning with the existing condition survey. Field data collected included: longitudinal profile and cross sections, bed material analysis, valley morphology, stream classification, channel stability assessment, channel evolution, riparian conditions, water quality impacts, and photographs. Other data

analyzed included watershed analysis and land use survey (historical and present; see Figures 2.1 and 2.2). The second step in the planning process was an analysis of stream potential and restoration alternatives (priority levels of restoration, urban considerations, and build-out scenarios). We conducted the design procedures concurrently with planning. These included reference reach analysis, verification of bankfull using the rural and urban Piedmont regional curves, restored channel morphology design (channel dimension, pattern, and profile), sediment transport analysis, structure design and placement, streambank stabilization/bioengineering, design of an erosion and sediment control plan, flood impact analysis, and completion of design plans. Finally, Buck Engineering conducted construction management including field layout, construction observation, preparation of the as-built survey, and collection of photographs.

2.3 Plan View

See plan sheets included under tabs 6 and 11.

2.4 Points of Contact

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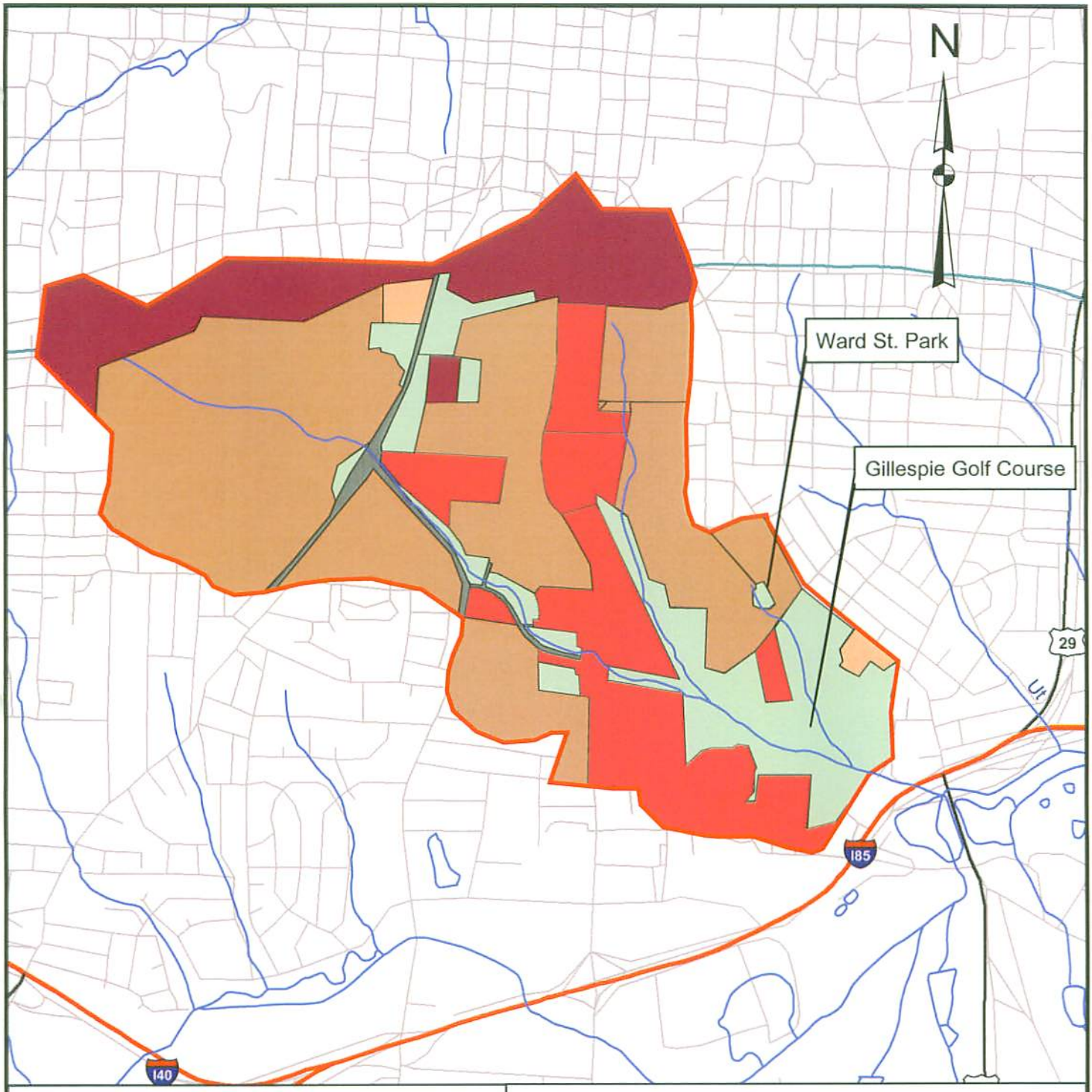


Gillespie Watershed
Hydrography - Rivers/Streams
Roads

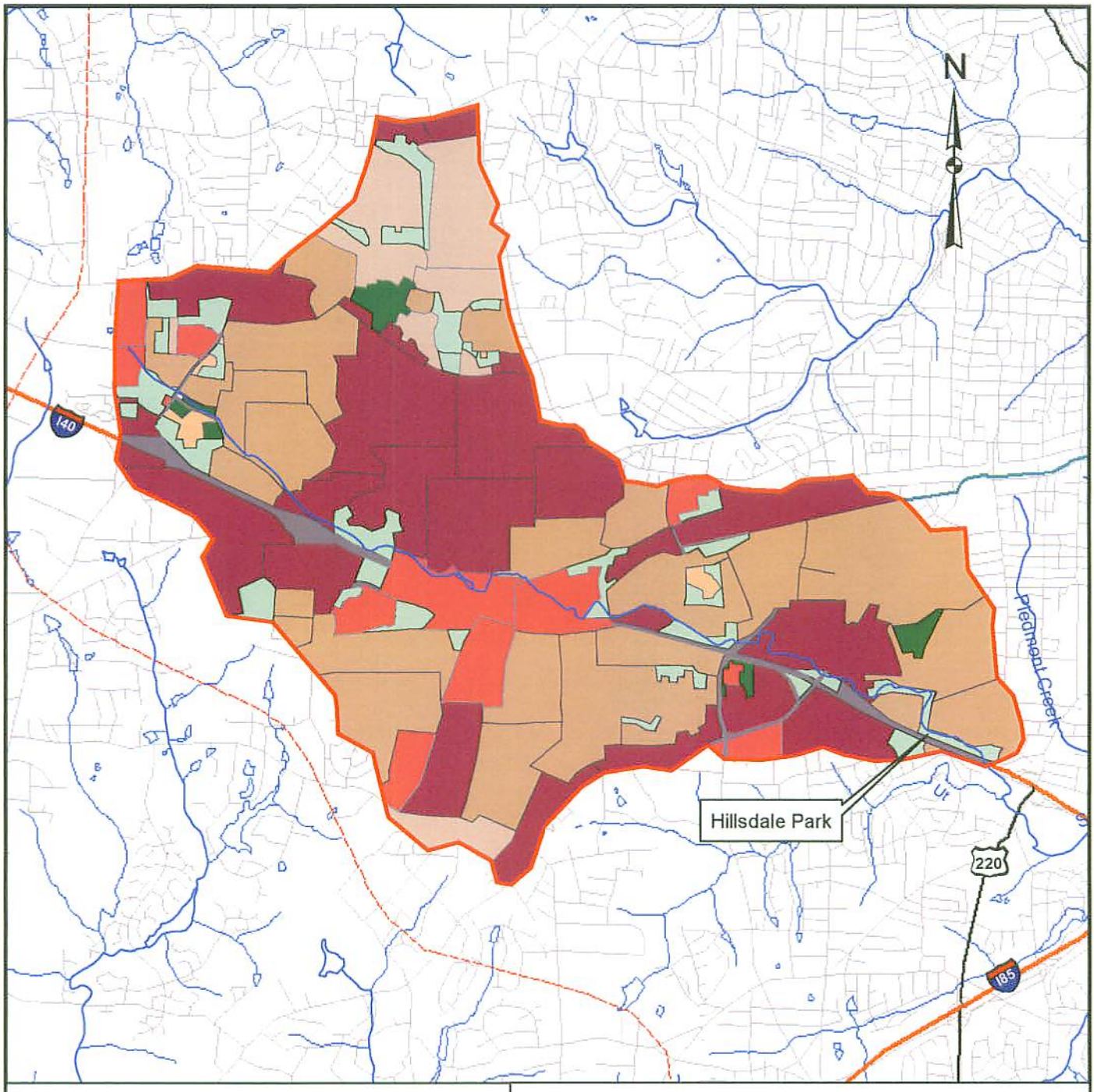
LANDUSE

Open Space
Residential - 2 acre
Residential - <=1/8 acre
Commercial
Industrial
Paved Spaces

Ecosystem Enhancement Program

Figure 2.1 Gillespie Golf Course Watershed Map
Buffalo Creeks Stream Restoration Projects
Greensboro, NC
Guilford County

2,000 1,000 0 2,000 4,000 Feet



Hillsdale Watershed
Hydrography - Rivers/Streams
Roads

LANDUSE

- Forested
- Open Space
- Residential - 2 acre
- Residential - 1/4 acre
- Residential - <=1/8 acre
- Commercial
- Industrial
- Paved Spaces

Ecosystem Enhancement Program

Figure 2.2 Hillsdale Park Watershed Map
Buffalo Creeks Stream Restoration Projects
Greensboro, NC
Guilford County

4,000 2,000 0 4,000 8,000 Feet

3 Success Criteria

Environmental components monitored in this project are those that allow an evaluation of channel stability and riparian survivability. Specifically, the success of channel modification, erosion control, seeding, and woody vegetation plantings will be evaluated. This will be accomplished through the following activities for five years after the project is built.

3.1 Dimension

Permanent cross-sections were established with approximately two riffles and two pools per reach, for a total of 18. Each cross-section is marked on both banks with permanent pins set in concrete to establish the exact transect used. A common benchmark is used for cross-sections to facilitate easy comparison of year-to-year data. The annual cross-section survey includes points measured at all breaks in slope, including top of bank, bankfull, and thalweg. Riffle cross-sections will be classified using the Rosgen stream classification system.

Success Criteria: There should be little or no change in as-built cross-sections. If changes do take place they should be evaluated to determine if they represent a movement toward a more unstable condition (down-cutting, erosion) or are minor changes that represent an increase in stability (settling, increase in vegetative density, deposition along the banks, decrease in width/depth ratio, decrease in cross sectional area).

3.2 Pattern and Profile

A longitudinal profile was completed after construction and will be conducted at the end of years one, three, and five (for a total of four times). Measurements include thalweg, water surface, bankfull, and top of low bank. Each measurement is taken at the head of facets, e.g. riffle, run, pool, and glide, and the maximum pool depth. The survey is tied to a permanent benchmark. The survey is also used to calculate sinuosity.

Success Criteria: The longitudinal profiles should show that the bedform features are remaining stable, e.g., they are not aggrading or degrading over the 5-year period. Short term aggradation/degradation may occur depending on the peak annual discharge. The gravel bed pools should remain deep with flat water surface slopes and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed in "E" and "C" type channels. The pattern should not change and there should be no change in sinuosity. The pool/riffle sequence should also remain constant.

3.3 Bed Material Analysis

We did not complete a bed material analysis since this is a sand/small gravel stream. We do not expect significant coarsening over time.

3.4 Photo Reference Sites

Photographs used to evaluate restored sites will be made with a 35-mm camera using slide film, or a digital camera. Reference sites were photographed before construction and will be taken once a year for at least 5 years following construction. After construction, reference sites were marked with wooden stakes.

Longitudinal reference photos: Photographs will be taken looking downstream at designated locations. Reference photo locations were marked and described for future reference. Points are close enough together to provide an overall view of the reach. The angle of the shot depended on what angle provided the best view and was noted for future shots. When modifications to reference photo have to be made due to obstructions or other reasons, the position will be noted along with any landmarks and the same position used in the future.

Lateral reference photos: Reference photo transects will be taken at each permanent cross-section. Photographs will show both banks at each cross-section. The survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame and as much of the bank as possible included in each photo. Photographers should make an effort to consistently maintain the same area in each photo over time. These locations were also marked with wooden stakes.

Success Criteria: Photographs will be used to qualitatively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Longitudinal photos should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the bank over time. A series of photos over time should indicate successional maturation of riparian vegetation. Vegetative succession should include initial herbaceous growth, followed by increasing densities of woody vegetation and then ultimately a mature overstory with herbaceous understory.

3.5 Vegetation Survival Plots

Survival of planted vegetation will be evaluated using survival plots and counts.

Survival of live stakes will be evaluated using plots that include a stake count that covers at least 100 linear feet of stream in each plot. Evaluations of live stake survival will continue for at least 5 years. When stakes do not survive a determination will be made as to the need for replacement; in general if greater than 25% die, replacement will be done.

Survival of rooted vegetation will be evaluated using three plots and will continue for at least 5 years to determine survival. The plots are 25 ft by 100 ft for forested buffer (bare roots), 50 ft by 50 ft for the managed buffer (shrubs), and vary in size for the sections of managed buffer (herbaceous perennials) due to the unique planting plan required for Gillespie Golf Course. All stems were flagged or marked with pin flags and counted. When rooted vegetation does not survive, a determination will be made as to the need for replacement; in general, if greater than 25% die, replacement will be done.

Success Criteria: The interim measure of vegetative success will be the survival of at least 320 3-year old planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260 5-year old planted trees per acre at the end of year five of the monitoring period. In addition, for the five year monitoring period, the presence of volunteer facultative softwood species such as red maple, sweet gum, and loblolly pine will be limited to less than 10% each of the total number of trees utilized to determine success. These trees may contribute more than 10% of the total trees on the site, but they will not constitute more than 10% each of the 260 trees per acre.

3.6 Benthic Macroinvertebrate Monitoring

The NC Division of Water Quality will conduct Benthic macroinvertebrate monitoring.

4 Monitoring Schedule and Methods

Monitoring will be conducted annually for five years. Buck Engineering conducted the as-built survey and will conduct the first year survey. Annual surveys will be conducted in March starting in 2005 and ending in September 2008.

The cross sections will be surveyed each year using a tape and level between the permanent cross section pins. The longitudinal survey will be done using a Total Station or level for the first year and then every two years for a total of four times (As-built is completed, then March of 2005, September of 2006, and September of 2008).

The photographs will be taken every year (Buck Engineering will use a digital camera for the first year). They include the cross sections listed above as well as longitudinal photographs taken from the photo locations listed on the plan view. These supplement the cross section photos to ensure the entire reach is covered.

Vegetation survival plots will be counted annually. The plots for both bare root plantings and live stakes are shown on the plan view. For success criteria, the 3-year period is through September 2006, and the 5-year period is through September 2008.

5 Mitigation

5.1 Mitigation Proposal

The following tables list the proposed mitigation available after completing the project.

Table 5-1a Proposed Mitigation for Hillsdale Park (South Buffalo Creek).

Reach	Restored Length (ft)	Category
HR1	3037	Enhancement
HR2	2265	Enhancement
HR3	138	Stabilization
Total	**5,540**	**Enhancement/Stabilization**

Table 5.1b Proposed Mitigation for Gillespie Golf Course (Mile Run Creek).

Reach	Restored Length (ft)	Category
GR1a	484	Enhancement
GR1b	500	Enhancement
GR1c	400	Enhancement
GR1d	550	Enhancement
GR1e	300	Enhancement
GR1f	400	Stabilization
GR2	250	Enhancement
GR3a	461	Stabilization
GR3b	225	Enhancement
GR4	1425	Stabilization

GR5	800	Stabilization
Total	**5795**	**Enhancement/Stabilization**

5.2 Design Summary

The stream restoration design for Gillespie Golf Course (Mile Run Creek) and Hillsdale Park (South Buffalo Creek) Creeks was based on natural channel design principals. The design took into account differences in drainage area, adjacent land uses, upstream impoundments, and future development potential. The streambank, bankfull bench, and terrace scarp were seeded with millet or rye to provide temporary erosion control. The streambank and terrace scarp were covered with erosion control matting.

Cross vanes were used throughout the reaches to provide grade control, provide bank protection, narrow the low flow channel and improve the riffle/pool sequence. J-hooks and root wads divert velocity vectors in the channel away from the banks. Double wing deflectors were used to narrow the low flow channel and provide some bank protection. The stormwater outfalls were stabilized by mimicking a step / pool channel as shown in the plan sheets.

5.3 Reach HR1

The natural channel design for Reach HR1 of South Buffalo Creek was based on a Rosgen Priority 3 restoration approach. A new floodplain was created at a lower elevation by excavating a stable bankfull bench of varying width. The resulting bank height ratio is 1.0. Reach HR1 was broken into sub-reaches as HR1a and HR1b. The break between the sub-reaches is the Vanstory Street culvert. Reach HR1a from station 10+00 to 23+75 was converted from an incised E4/B4c to a B4c channel as part of the restoration work. The existing channel functioned like a Gc due to the high banks. Bedform was improved through the use of instream structures. Root wads were used to stabilize the streambanks and improve aquatic habitat. Instream structures were used to provide grade control, protect streambanks, and enhance bedform.

5.4 Reach HR2

The existing straight channel in South Buffalo Creek Reach 2 (HR2) ran from West Meadow View Road to the I-40 culvert. The reach was stabilized by using rock cross vanes, J- hooks, and root wads for bank stability. Woody transplants and sod mats were also used to stabilize the streambanks along the channel. Reach HR2 from station 52+00 to 62+12 was converted from a B4c/E4/F4 to a B4c.

5.5 Reach HR3

The existing channel of Reach 3 (HR3) was an unnamed tributary to South Buffalo Creek, flowing into the creek at the end of Reach 2 just prior to the I-40 culvert. There were no changes in dimension, pattern, or profile for this reach. However, three rock cross vanes were used to stabilize the channel upstream of its confluence with Reach HR2.

5.6 Reach GR1

The natural channel design for Mile Run Creek Reach GR1 in Gillespie Golf Course was based on a Rosgen Priority 3 restoration approach. Bankfull benches of varying width were constructed along both banks. Instream structures, including root wads, double wing deflectors, and rock vanes were used to stabilize eroding streambanks and improve the channel profile and bedform. Cross vanes were installed upstream and downstream of the golf cart bridge to prevent near bank scour at the bridge. A cross vane was constructed upstream of the box culverts to decrease the width of the low flow channel. Reach GR1 from station 0+00 to 24+34 was converted from an incised E5/C5 to a C5. Managed and unmanaged forested buffers consisting of herbaceous perennials, shrubs, and bare roots were planted along the banks to provide stabilization.

5.7 Reach GR2

The natural channel design for Reach GR2 of Mile Run Creek was based on a Rosgen Priority 3 restoration approach. Reach GR2 is an unnamed tributary that drains off of the city maintenance yard and flows into Reach 1 at Station 17+00. Seven rock vanes were used to stabilized the streambanks and improve bedform diversity. A forested buffer 25 feet wide was planted to provide additional bank stabilization.

5.8 Reach GR3

The natural channel design for Reach GR3 of Mile Run Creek was based on a Rosgen Priority 3 restoration approach. Reach GR3 is an unnamed tributary that is 450 feet long. A forested buffer, varying in width from 50 to 55 feet, was planted for additional stabilization.

5.9 Reach GR4

The natural channel design for Reach GR4 of Mile Run Creek was based on a bank stabilization restoration approach. Reach GR4 is an unnamed tributary that runs 1,300 feet before it intersects with Reach GR5 and then runs 300 feet into Mile Run Creek. Forested and herbaceous buffers, varying in width from 20 to 50 feet, were planted along the reach to provide stability.

5.10 Reach GR5

The natural channel design for Reach GR5 of Mile Run Creek was based on a bank stabilization restoration approach. Reach GR5 is an unnamed tributary that runs 800 feet before it intersects with Reach 4 and then runs 300 feet into Mile Run Creek. Forested and herbaceous buffers, varying in width from 20 to 50 feet, were planted along the reach to provide stability.

5.11 Riparian Restoration Design

The riparian restoration design for Hillsdale Park is at Tab 5 and Gillespie Golf Course is at Tab 10.

5.12 Mitigation Credit

The NC EEP will complete the mitigation credit proposal. Buck Engineering has provided a plan view showing reaches and sub-reaches for their use.

6 Maintenance and Contingency Plans

The project was subject to three large storm events directly after construction without the benefit of vegetation beyond temporary seeding. Ninety-four percent of the rock structures had no damage and are functioning as planned. In addition, 98% of the restored streambanks are stable and functioning properly. To address the problem areas, Buck Engineering conducted construction supervision at the site from September through December 2003. Work included minor repair to structures, installing new structures, and stabilizing streambanks (through shaping, seeding, matting, and bioengineering). The plan view was updated to reflect all changes. A summary of key changes to instream structures by reach is provided below.

Gillespie Reach 1: addition of 14,870 square feet of temporary/permanent grass seed, fertilizer, lime, and mulch; 14.4 tons of Class A/B stone to reinforce structures; 305 square yards of coconut fiber blanket to replace damaged matting; and minor grading.

Hillsdale Reach 1A and B: minor grading, seeding and matting. Reach 2: minor grading, seeding and matting successfully repaired all damage.

Buck Engineering will report maintenance concerns during the first year of monitoring. After that time, the NC EEP will be responsible for maintenance reporting.

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Hillsdale Park
Cross Section Summary

Reach 1A (from Meadow View Road to Vanstory Street)

Cross Section 1	Pool Below Vane #2	Photo Point 2
Cross Section 2	Riffle in Constructed Riffle #1	Photo Point 4
Cross Section 3	Pool on Arm of Vane #5	Photo Point 6
Cross Section 4	Riffle in Constructed Riffle #2	Photo Point 9

Reach 1B (from Vanstory Street to Meadow View Road)

Cross Section 5	Riffle in Double Wing Deflector (DWD) #1	Photo Point 15
Cross Section 6	Pool Below DWD #1	Photo Point 16
Cross Section 7	Riffle Above Vane #1	Photo Point 19A
Cross Section 8	Pool Below Vane #1	Photo Point 20

Reach 2 (from Meadow View Drive to Interstate 40)

Cross Section 9	Riffle Above Cross Vane (CV) #1	Photo Point 31
Cross Section 10	Pool Below CV #1	Photo Point 32
Cross Section 11	Riffle Above CV #3	Photo Point 39
Cross Section 12	Pool Between Arms of CV #3	Photo Point 40

Notes:

1. All cross sections are marked on each bank by permanent pins set in concrete.
2. All pins are shown on the plan views (with North Carolina State plane and elevation coordinates) and are marked in the field with wooden stakes with orange flagging tape.
3. Photo point locations are shown on the plan views.

Hillsdale Cross Section Pin Locations

Point#	Northing	Easting	Elevation	Decscription	Stationing
8900	835752.1382	1753147.886	761.1481	X1-LPIN	12+01.26
8901	835703.7899	1753201.363	760.9648	X1-RPIN	
8902	835970.7633	1753243.501	759.9601	X2-LPIN	14+61.36
8894	835943.6117	1753324.756	760.8312	X2-RPIN	
8895	836094.5846	1753384.276	758.4273	X3-LPIN	16+30.57
8893	836019.8979	1753399.713	760.0804	X3-RPIN	
8889	835945.2474	1753757.608	758.9343	X4-LPIN	20+30.64
8888	835853.0495	1753669.33	761.5428	X4-RPIN	
8884	835859.2519	1754213.249	759.0016	X5-LPIN	25+42.85
8883	835764.1522	1754206.222	759.6819	X5-RPIN	
8885	835855.5873	1754253.408	758.7675	X6-LPIN	25+82.28
8886	835763.4917	1754244.426	759.0965	X6-RPIN	
9175	835696.7957	1754757.952	757.7009	X7-LPIN	30+88.70
9172	835641.3152	1754684.438	756.6987	X7-RPIN	
9174	835575.1663	1754779.482	757.334	X8-LPIN	31+81.14
9173	835592.7996	1754689.241	756.2497	X8-RPIN	
9094	834557.4582	1754875.487	753.7234	X9-LPIN	44+40.89
9097	834487.0356	1754839.223	750.7299	X9-RPIN	
9095	834527.1273	1754957.206	752.9958	X10-LPIN	45+37.80
9096	834447.6264	1754928.289	751.0701	X10-RPIN	
9331	834214.3318	1755828.635	751.1528	X-11-LPIN	54+95.55
9350	8341164.409	1755812.226	747.8203	X11-RPIN	
9333	834204.3903	1755873.728	751.368	X12-LPIN	55+43.29
9337	834139.9146	1755855.799	750.4006	X12-RPIN	

Hillsdale R1A

Cross Section Dimension Summary

XSEC	STA	Date	Feature	Str Type	Wfpa	Wbkf	Dbkf	W/D	Abkf	Dmax	ER	BHR
1	12+01	9/16/2003	Pool		95	33.5	3.8	8.8	126.9	5.8	2.8	1.0
	12+01		Pool									
	12+01		Pool									
	12+01		Pool									
	12+01		Pool									
2	14+61	8/28/2003	Riffle	B4c	68	38.0	2.8	13.8	104.7	3.8	1.8	1.0
	14+61		Riffle									
	14+61		Riffle									
	14+61		Riffle									
	14+61		Riffle									
3	16+31	8/25/2003	Pool		110	33.8	3.4	10.0	114.2	5.5	3.3	1.0
	16+31		Pool									
	16+31		Pool									
	16+31		Pool									
	16+31		Pool									
4	20+31	8/28/2003	Riffle	B4c	75	37.9	2.6	14.7	97.8	3.4	2.0	1.0
	20+31		Riffle									
	20+31		Riffle									
	20+31		Riffle									
	20+31		Riffle									

Str Type = Rosgen Classification

Wfpa = Width Flood Prone Area (ft)

Wbkf = Bankfull Width (ft)

Dbkf = Bankfull Mean Depth (ft)

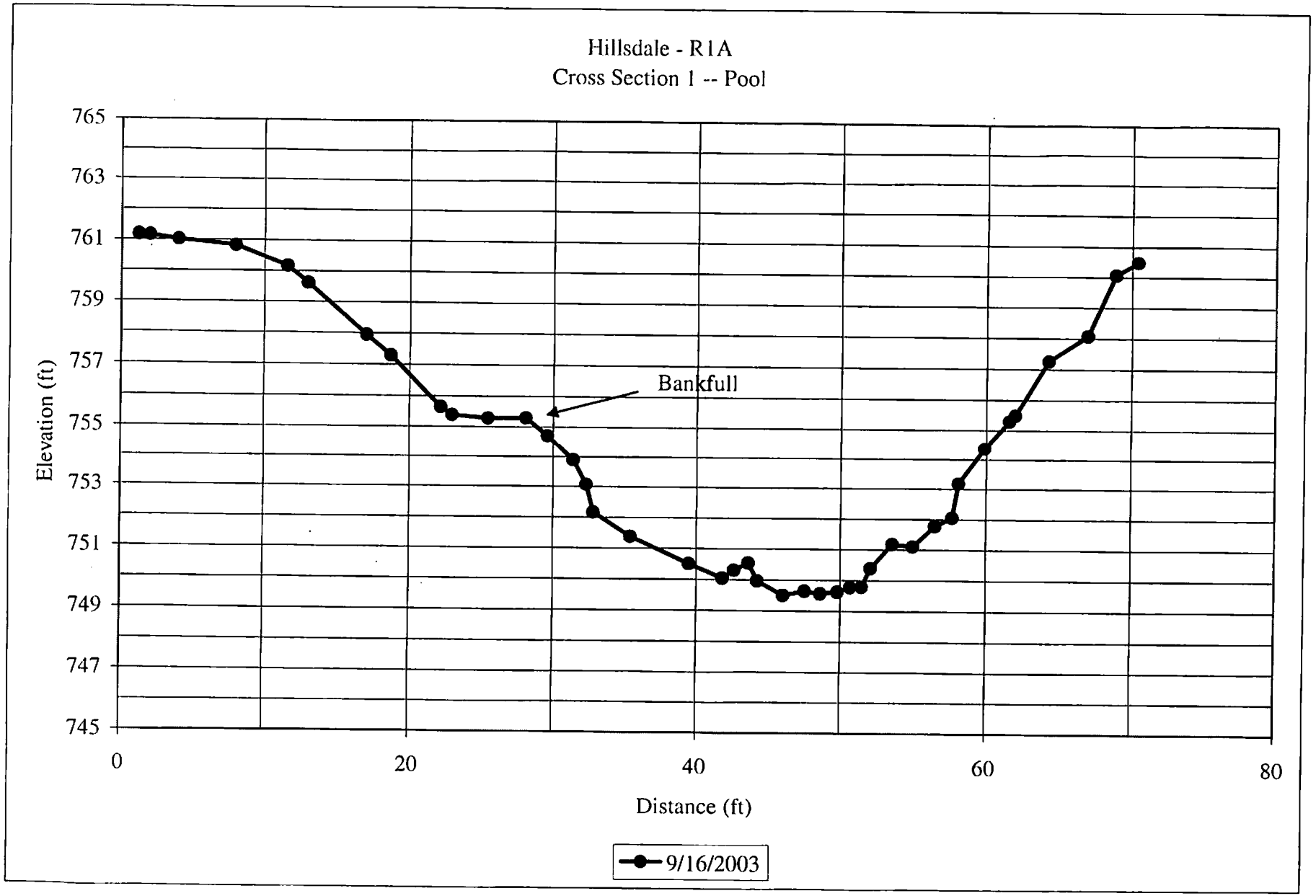
W/D = Bkf Width to Depth Ratio (ft/ft)

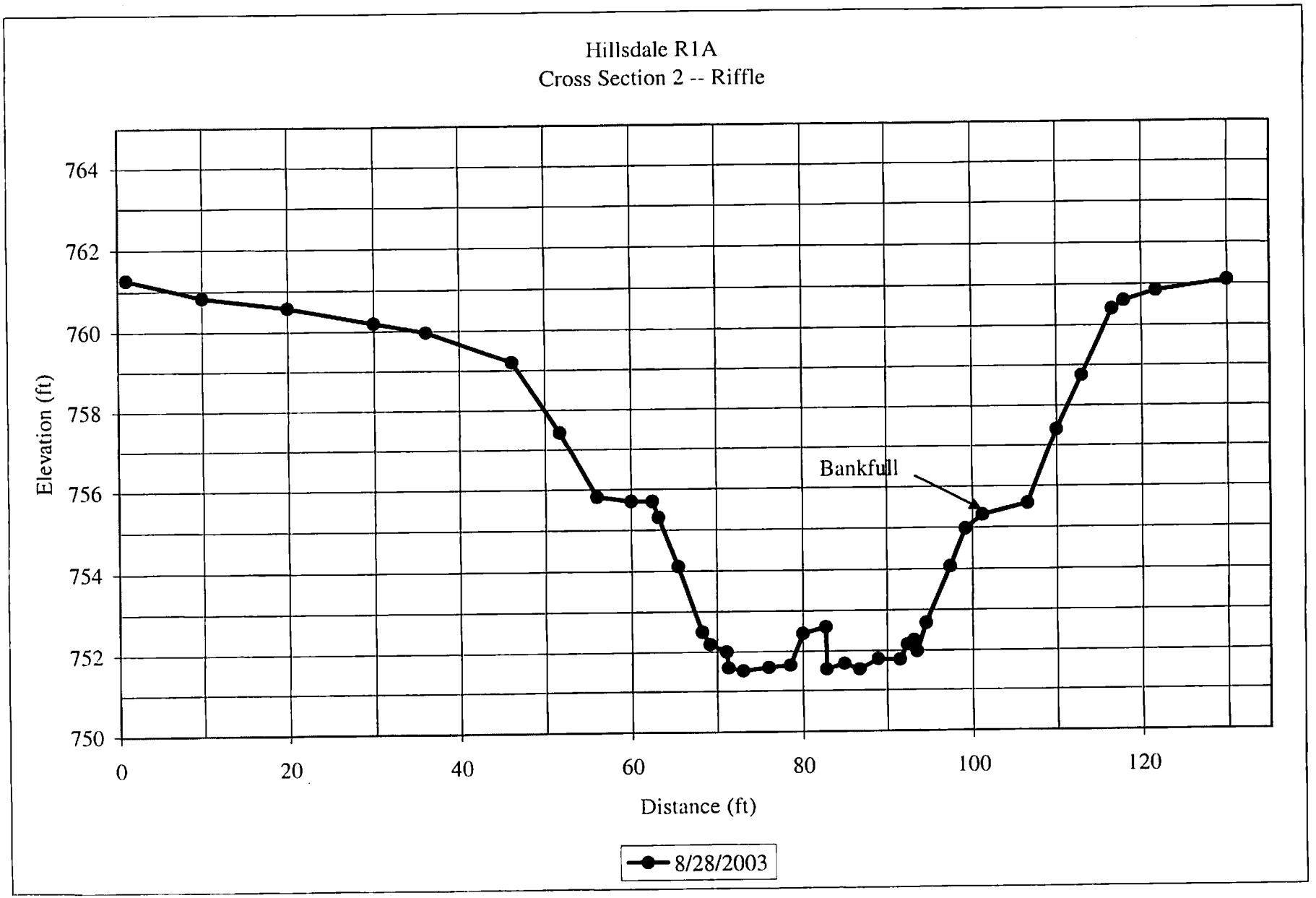
Abkf = Bkf Cross Section Area (sq ft)

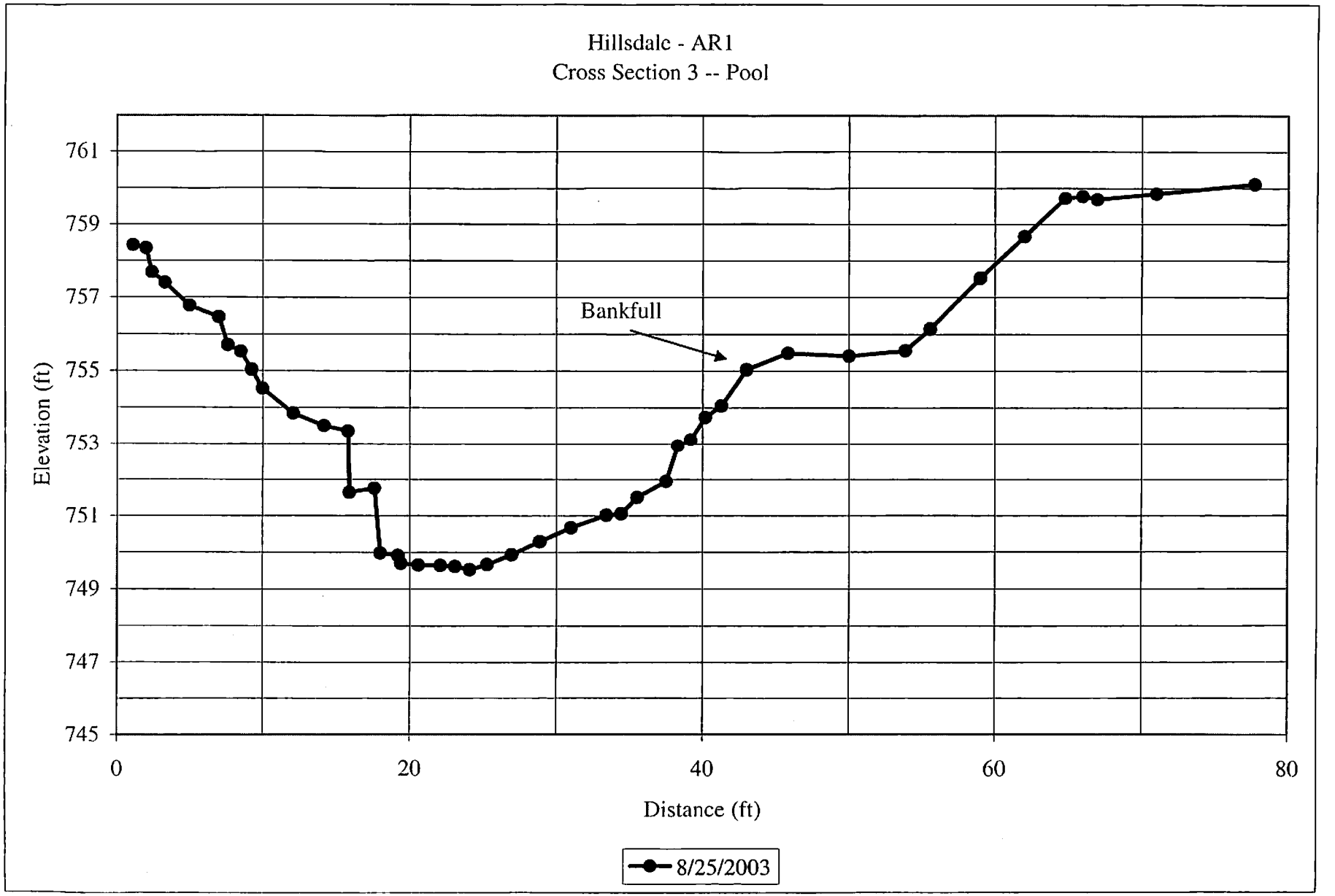
Dmax = Bankfull Maximum Depth (ft)

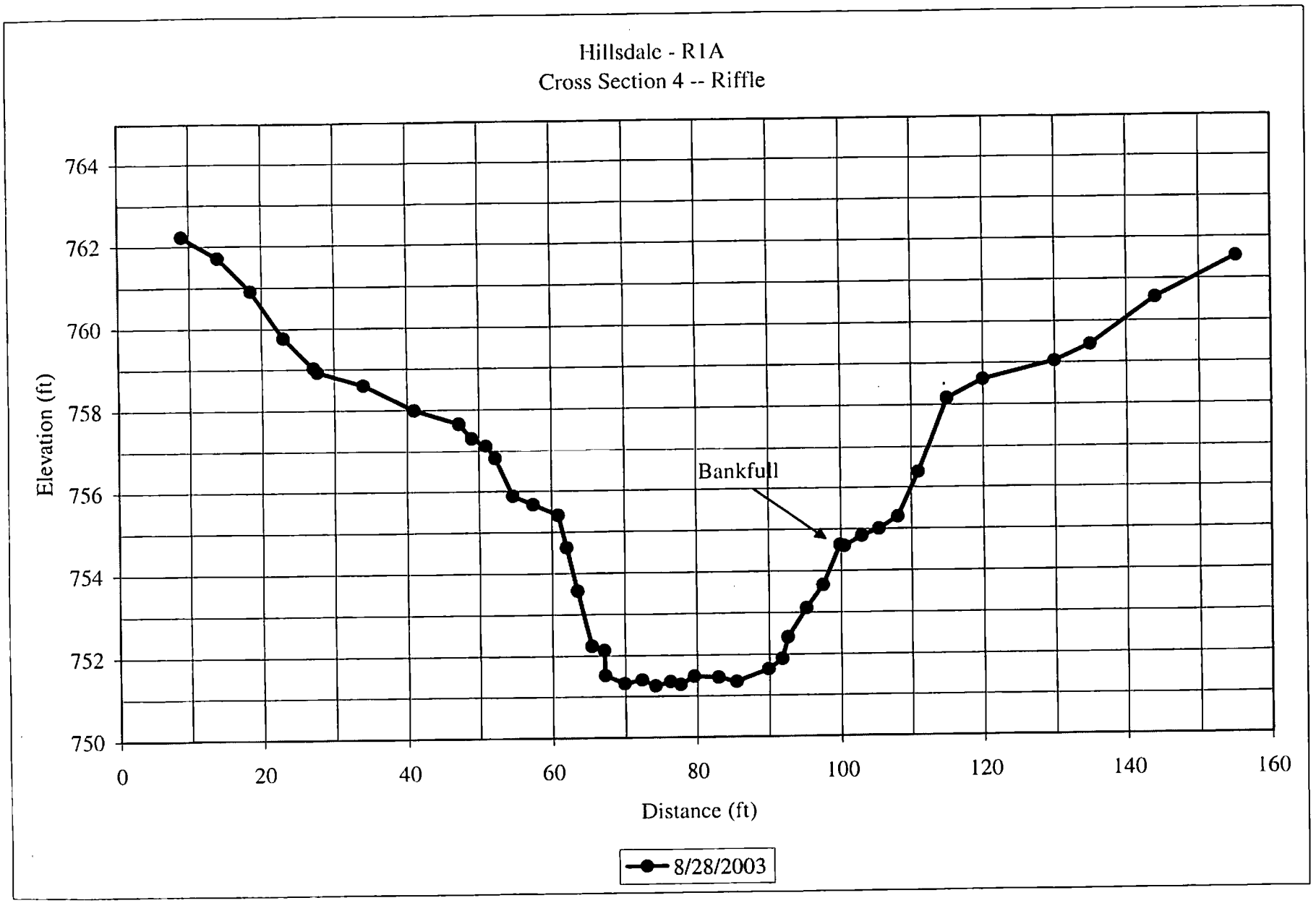
ER = Entrenchment Ratio, Wfpa/Wbkf (ft/ft)

BHR = Bank Height Ratio, Dtob/Dmax (ft/ft)


Hillsdale - R1A
Cross Section 1 -- Pool
765
763
761
759
757
755
753
751
749
747
745
Elevation (ft)
Bankfull
0
20
40
60
80
Distance (ft)
9/16/2003


Hillsdale R1A
Cross Section 2 -- Riffle
Elevation (ft)
764
762
760
758
756
754
752
750
0
20
40
60
80
100
120
Distance (ft)
Bankfull
8/28/2003


Hillsdale - AR1
Cross Section 3 -- Pool
761
759
757
755
753
751
749
747
745
Elevation (ft)
Bankfull
0
20
40
60
80
Distance (ft)
8/25/2003

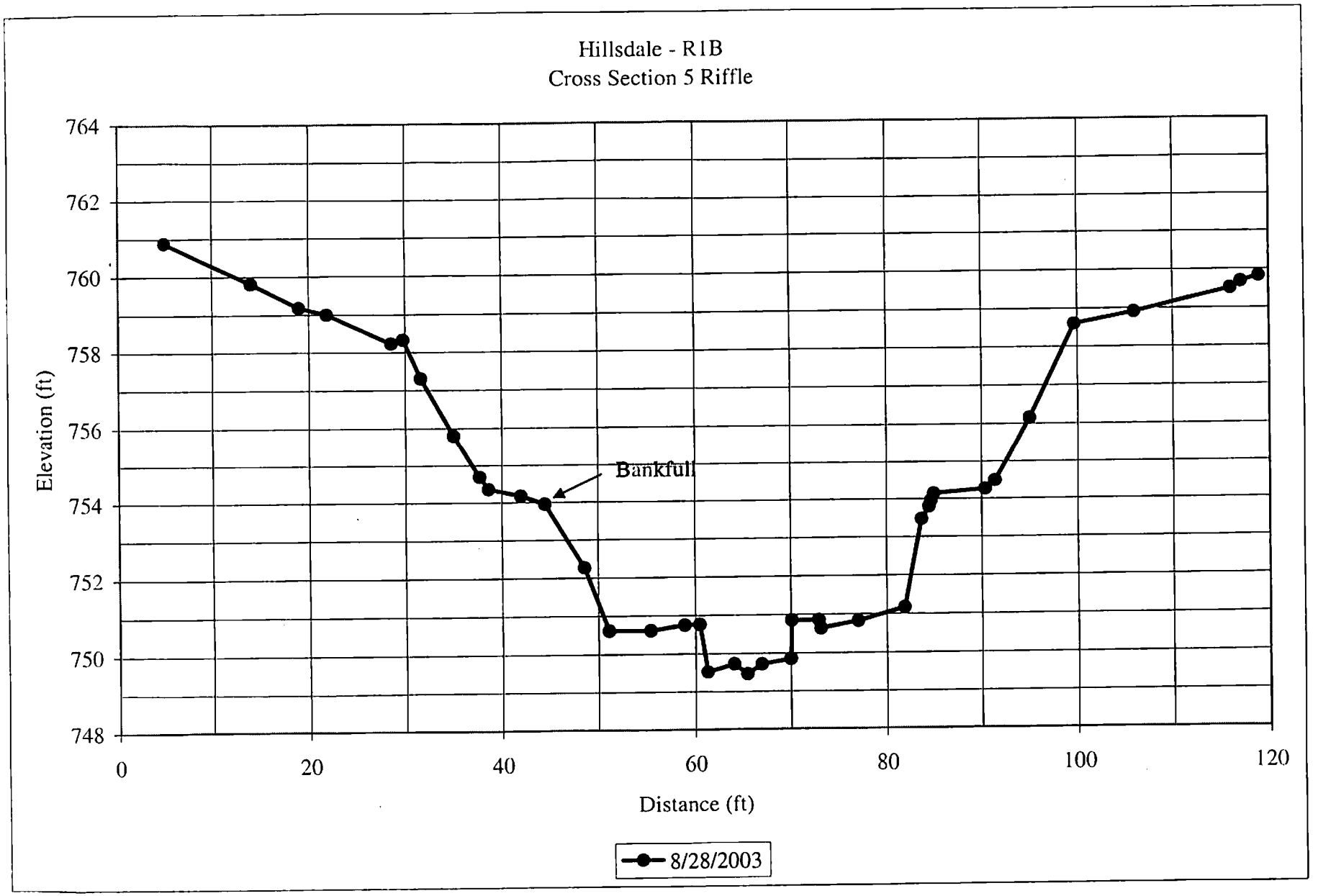

Hillsdale - R1A
Cross Section 4 -- Riffle
Elevation (ft)
764
762
760
758
756
754
752
750
0
20
40
60
80
100
120
140
160
Distance (ft)
Bankfull
8/28/2003

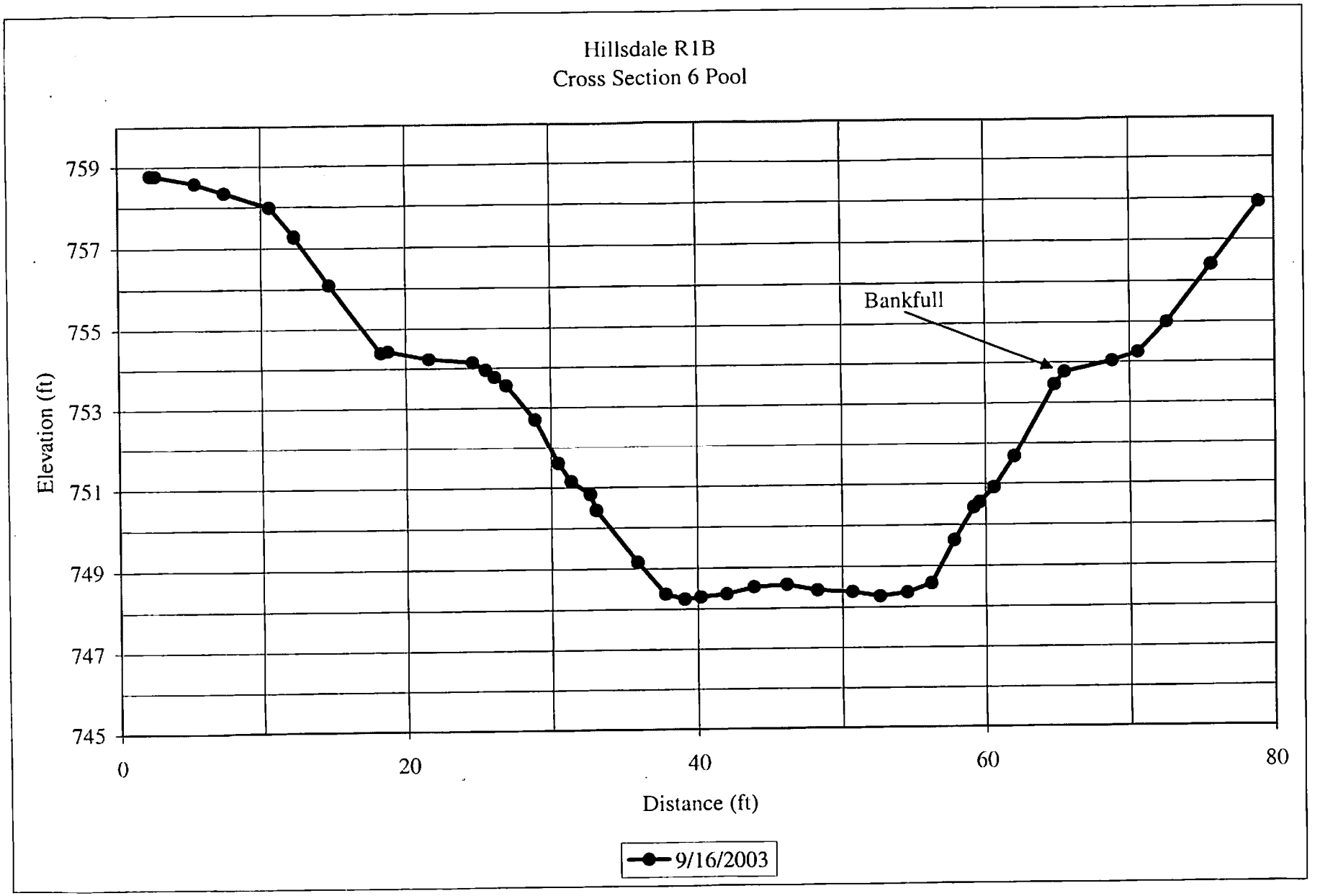
Hillsdale R1B

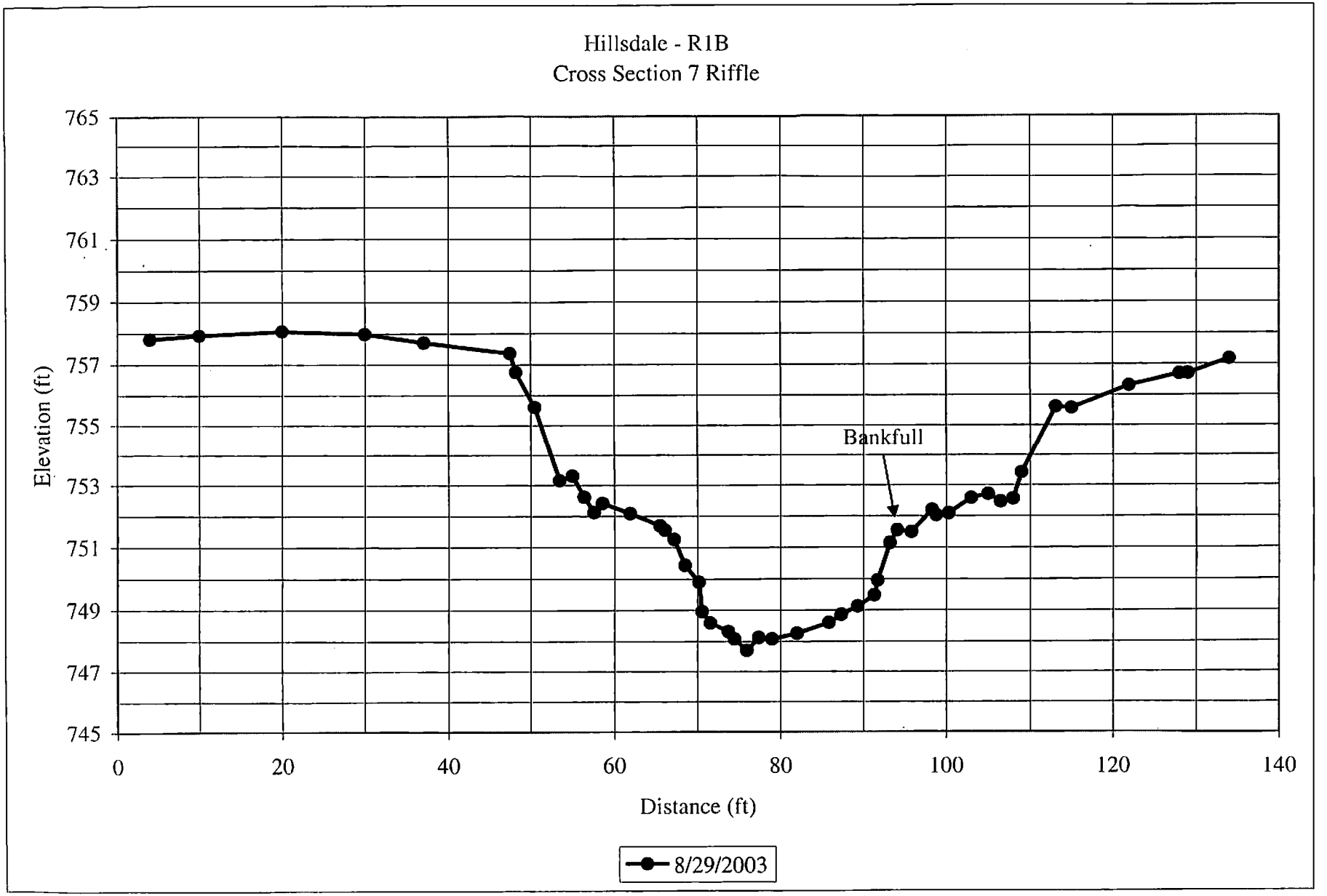
Cross Section Dimension Summary

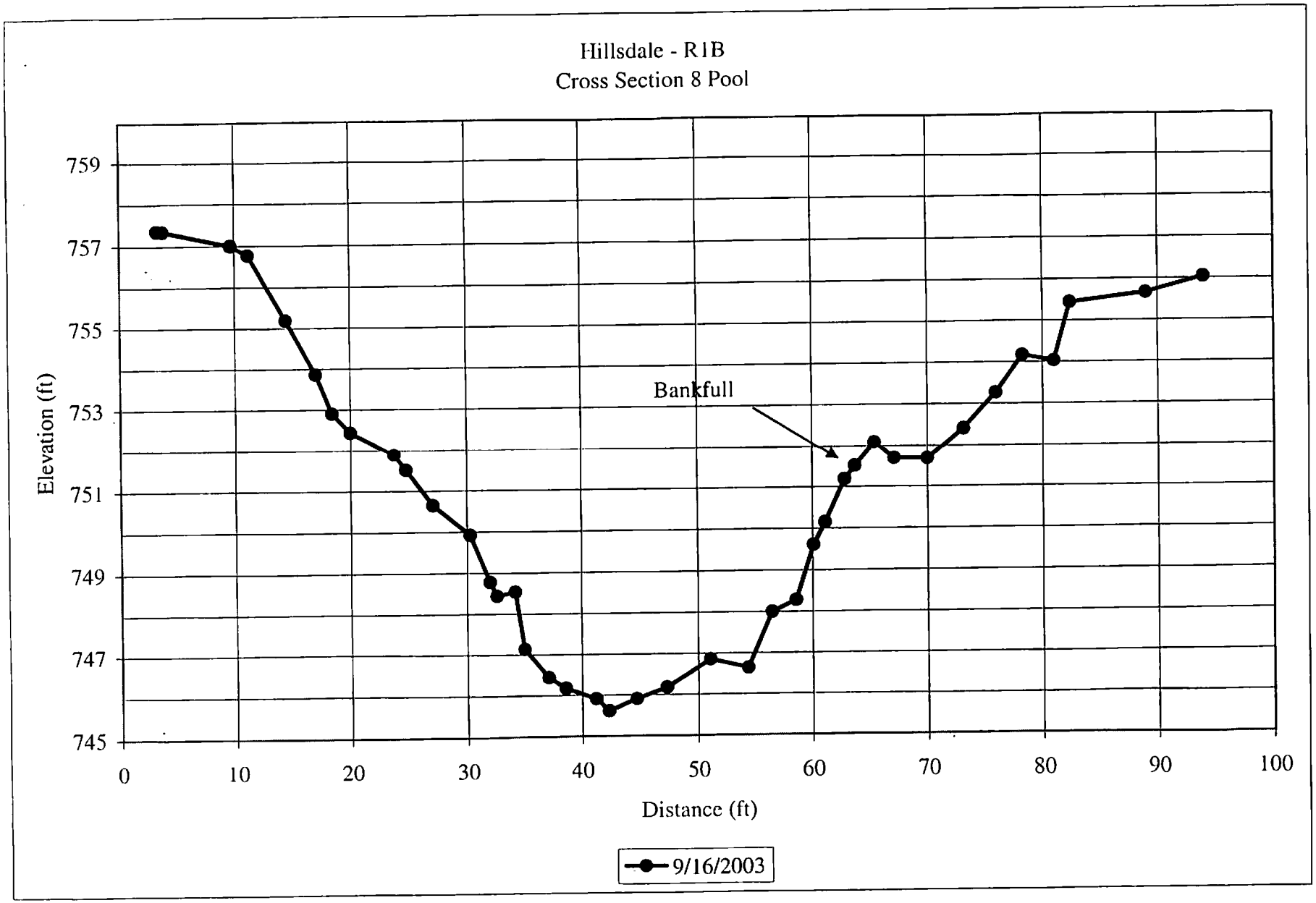
XSEC	STA	Date	Feature	Str Type	Wfpa	Wbkf	Dbkf	W/D	Abkf	Dmax	ER	BHR
5	25+43	8/28/2003	Riffle	B5c	73	40.2	3.0	13.4	120.9	4.5	1.8	1.0
	25+43		Riffle									
	25+43		Riffle									
	25+43		Riffle									
	25+43		Riffle									
6	25+82	9/16/2003	Pool		110	39.4	3.9	10.1	154.4	5.5	2.8	1.0
	25+82		Pool									
	25+82		Pool									
	25+82		Pool									
	25+82		Pool									
7	30+89	8/29/2003	Riffle	B5c	62	28.0	2.5	11.1	70.7	3.8	2.2	1.0
	30+89		Riffle									
	30+89		Riffle									
	30+89		Riffle									
	30+89		Riffle									
8	31+81	9/16/2003	Pool		130	38.9	3.7	10.7	142.1	5.9	3.3	1.0
	31+81		Pool									
	31+81		Pool									
	31+81		Pool									
	31+81		Pool									

Str Type = Rosgen Classification
Wfpa = Width Flood Prone Area (ft)
Wbkf = Bankfull Width (ft)
Dbkf = Bankfull Mean Depth (ft)
W/D = Bkf Width to Depth Ratio (ft/ft)
Abkf = Bkf Cross Section Area (sq ft)
Dmax = Bankfull Maximum Depth (ft)
ER = Entrenchment Ratio, Wfpa/Wbkf (ft/ft)
BHR = Bank Height Ratio, Dtob/Dmax (ft/ft)


Hillsdale - R1B
Cross Section 5 Riffle
764
762
760
758
756
754
752
750
748
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
Distance (ft)
8/28/2003


Hillsdale R1B
Cross Section 6 Pool
759
757
755
753
751
749
747
745
Elevation (ft)
0
20
40
60
80
Distance (ft)
Bankfull
9/16/2003


Hillsdale - R1B
Cross Section 7 Riffle
765
763
761
759
757
755
753
751
749
747
745
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
140
Distance (ft)
8/29/2003


Hillsdale - R1B
Cross Section 8 Pool
759
757
755
753
751
749
747
745
Elevation (ft)
Bankfull
0
10
20
30
40
50
60
70
80
90
100
Distance (ft)
9/16/2003

Hillsdale R1B

Cross Section Dimension Summary

XSEC	STA	Date	Feature	Str Type	Wfpa	Wbkf	Dbkf	W/D	Abkf	Dmax	ER	BHR
9	44+41	8/29/2003	Riffle	B4c	80	52.4	2.3	22.6	121.5	2.9	1.5	1.0
	44+41		Riffle									
	44+41		Riffle									
	44+41		Riffle									
	44+41		Riffle									
10	45+39	9/16/2003	Pool		210	48.6	5.0	9.8	242.3	7.4	4.3	1.0
	45+39		Pool									
	45+39		Pool									
	45+39		Pool									
	45+39		Pool									
11	54+96	9/16/2003	Riffle	B4c	55	33.6	3.1	10.8	104.3	4.4	1.6	1.0
	54+96		Riffle									
	54+96		Riffle									
	54+96		Riffle									
	54+96		Riffle									
12	55+43	9/16/2003	Pool		53	19.7	3.7	5.3	72.6	5.1	2.7	1.0
	55+43		Pool									
	55+43		Pool									
	55+43		Pool									
	55+43		Pool									

Str Type = Rosgen Classification

Wfpa = Width Flood Prone Area (ft)

Wbkf = Bankfull Width (ft)

Dbkf = Bankfull Mean Depth (ft)

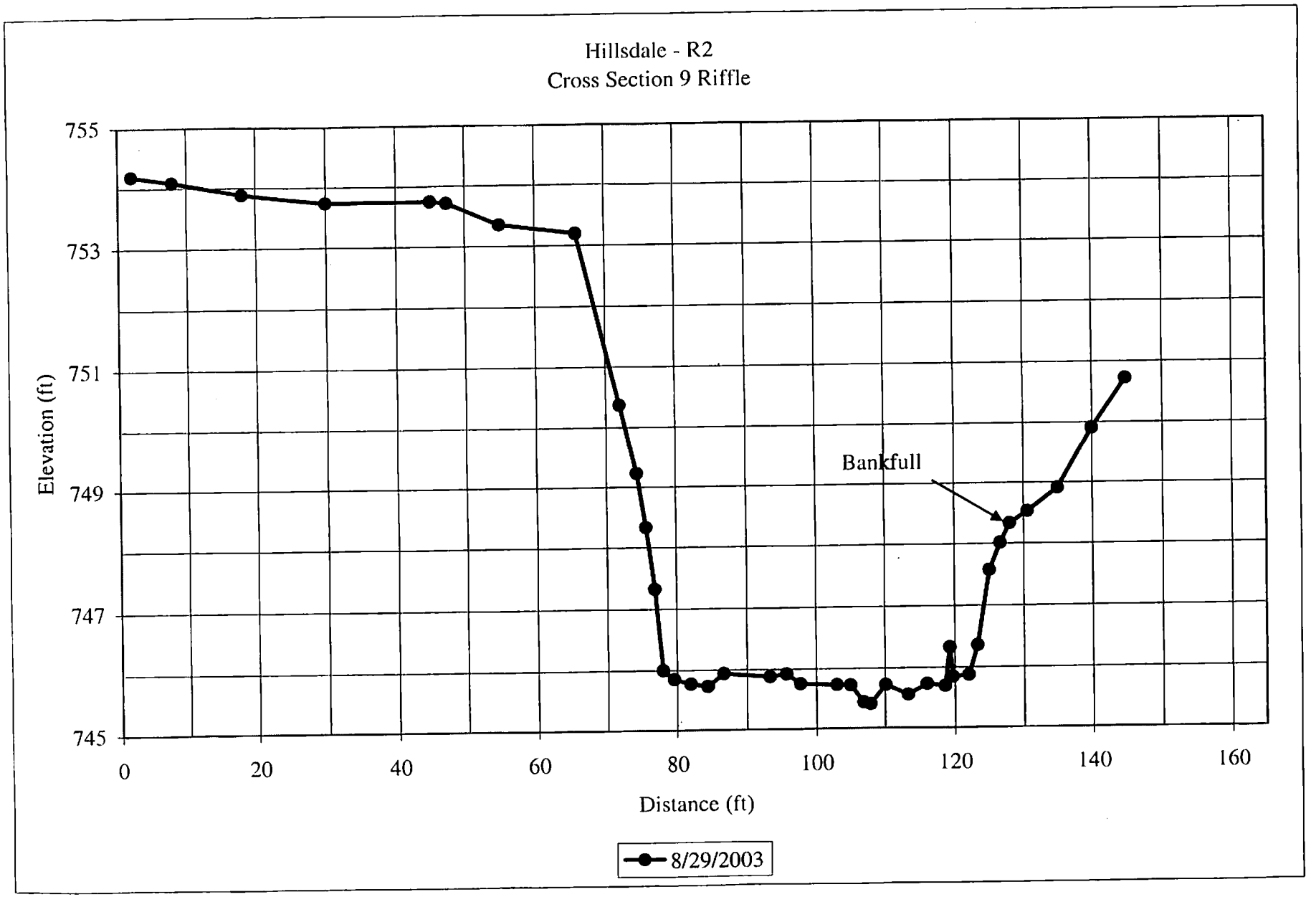
W/D = Bkf Width to Depth Ratio (ft/ft)

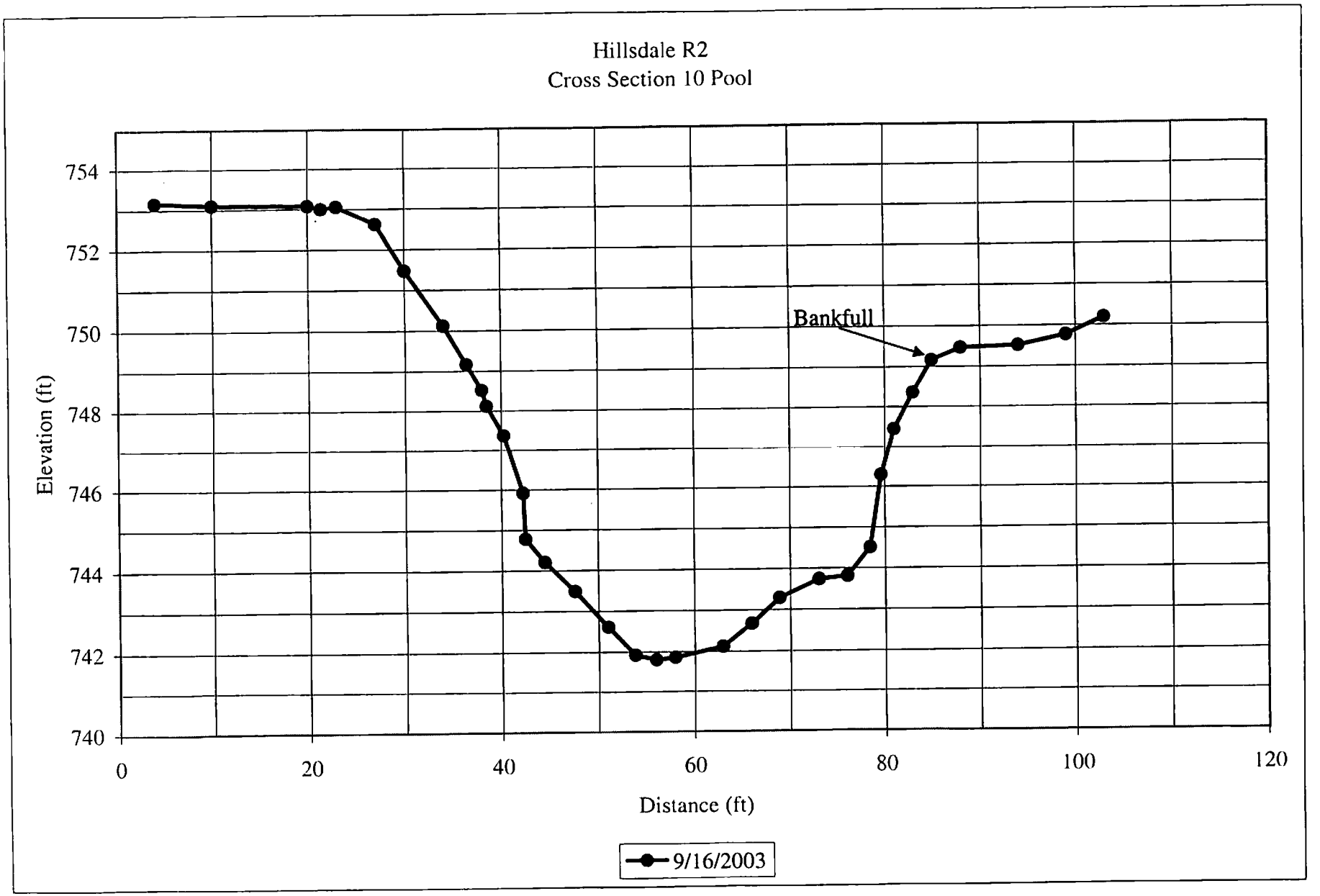
Abkf = Bkf Cross Section Area (sq ft)

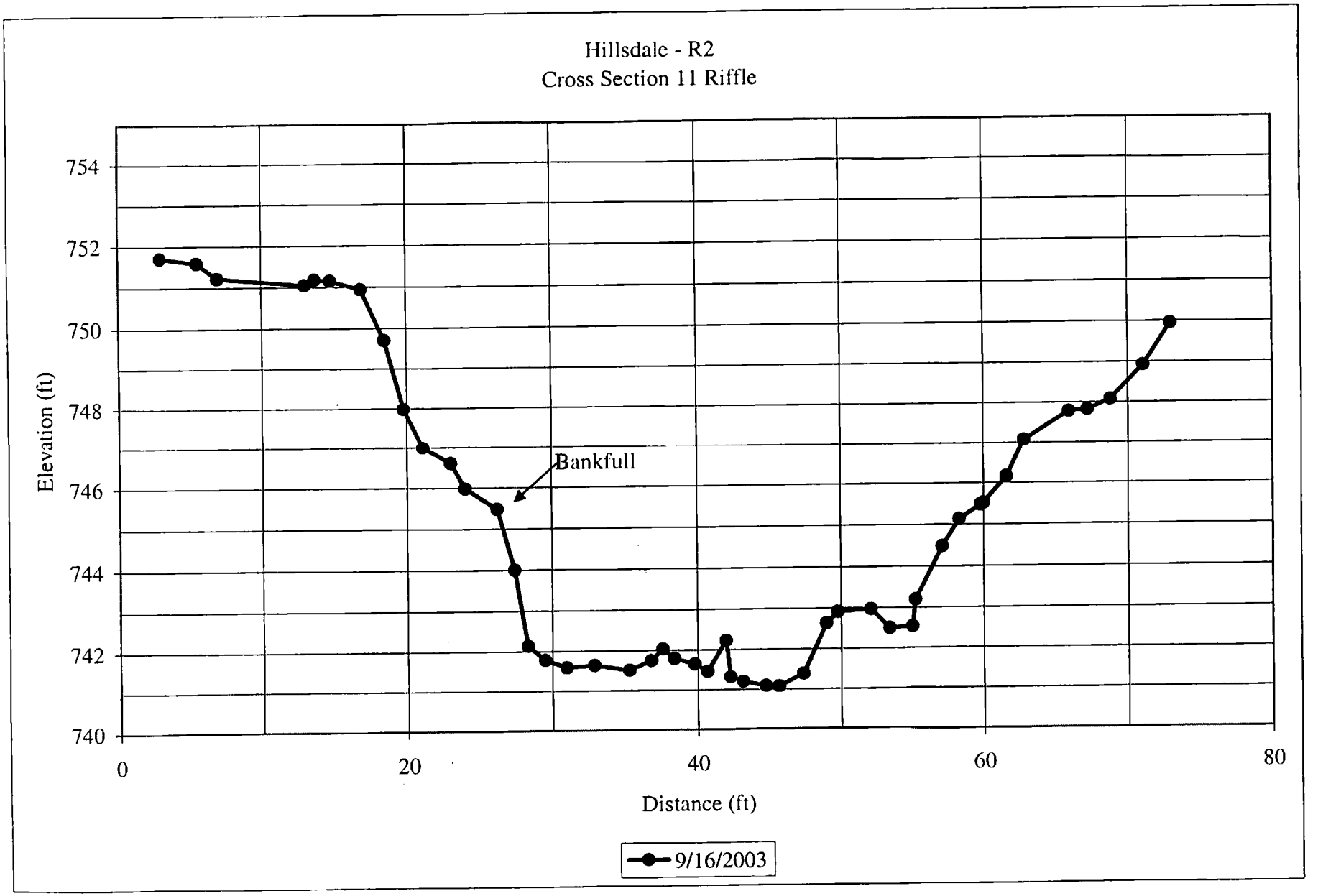
Dmax = Bankfull Maximum Depth (ft)

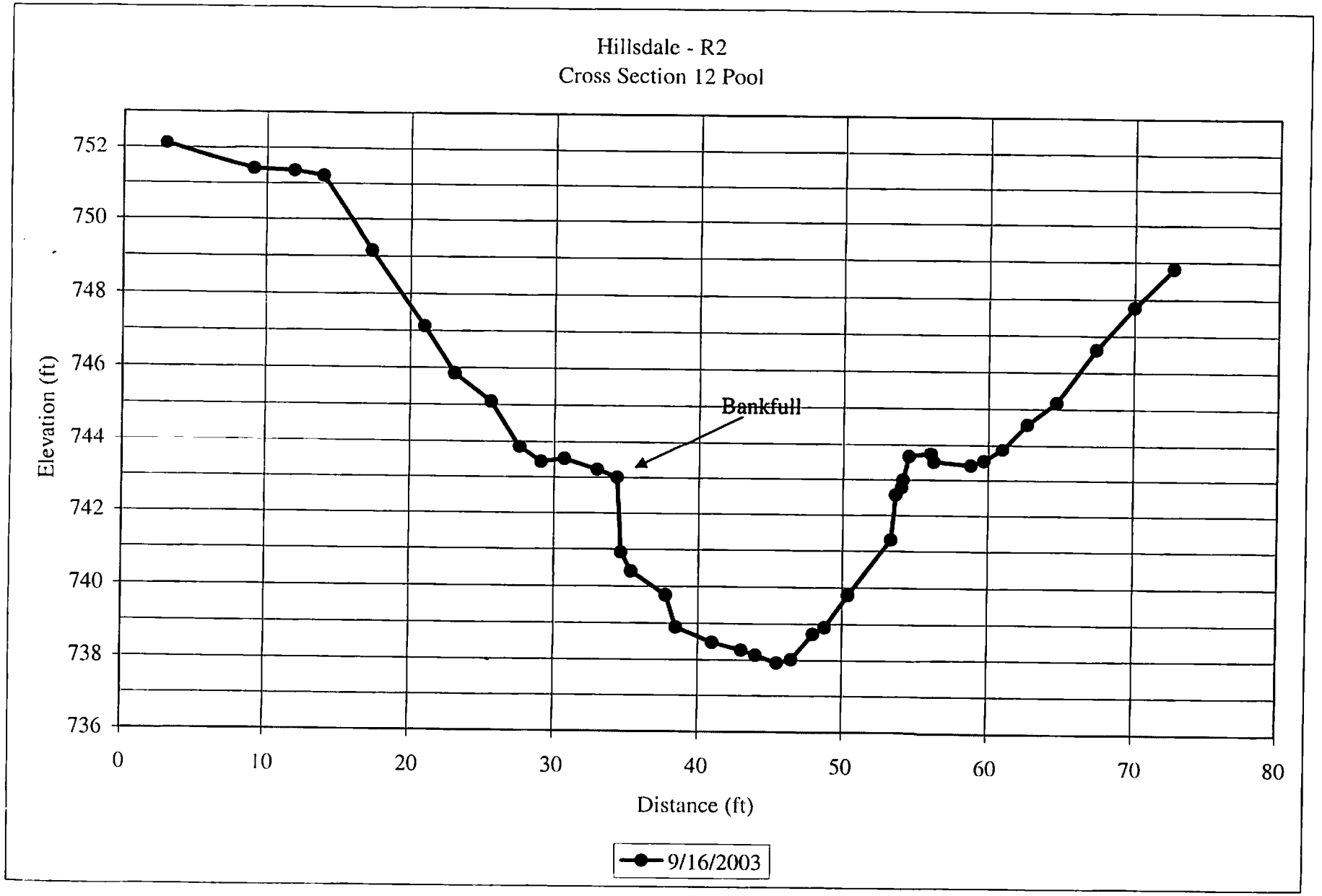
ER = Entrenchment Ratio, Wfpa/Wbkf (ft/ft)

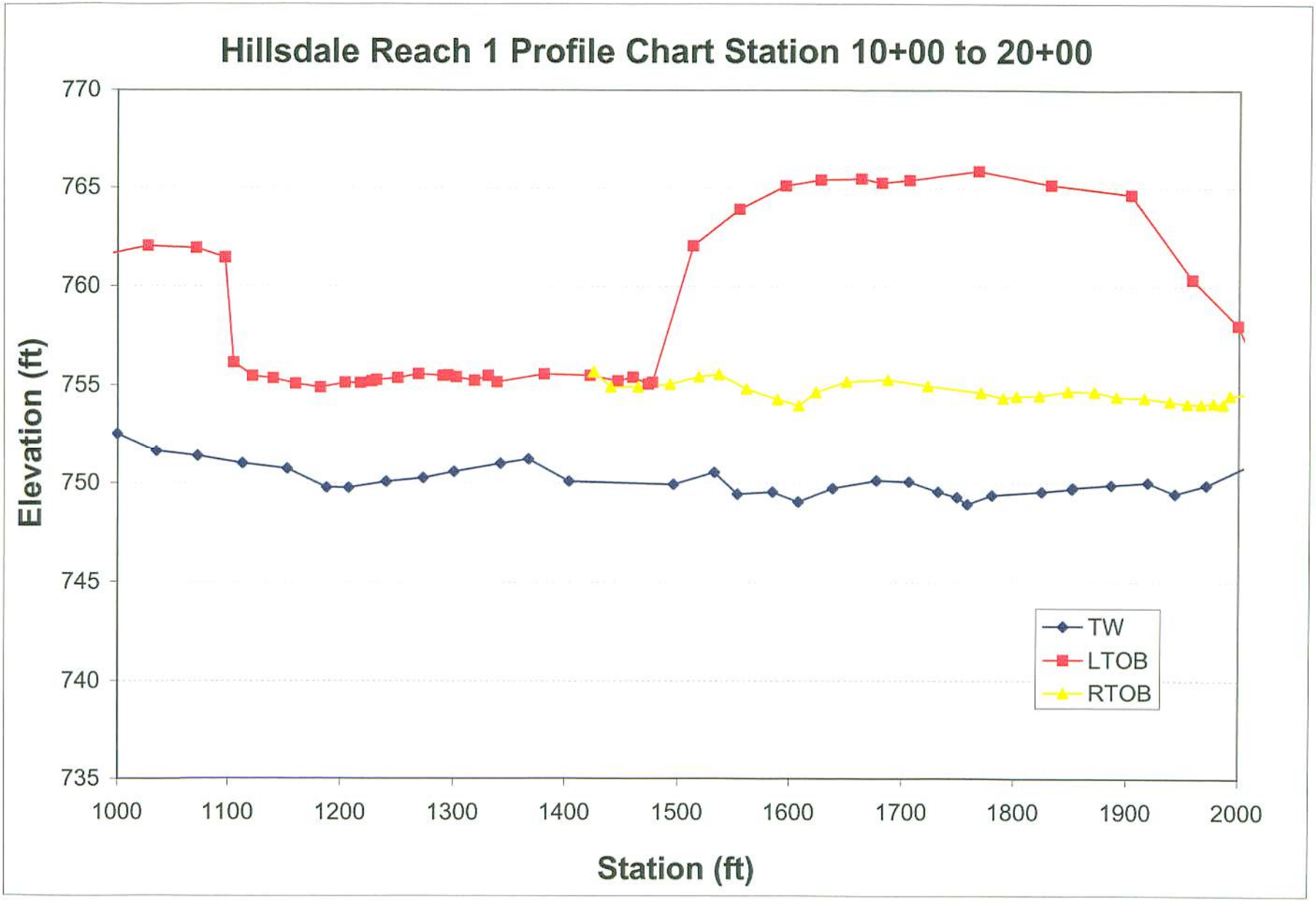
BHR = Bank Height Ratio, Dtob/Dmax (ft/ft)

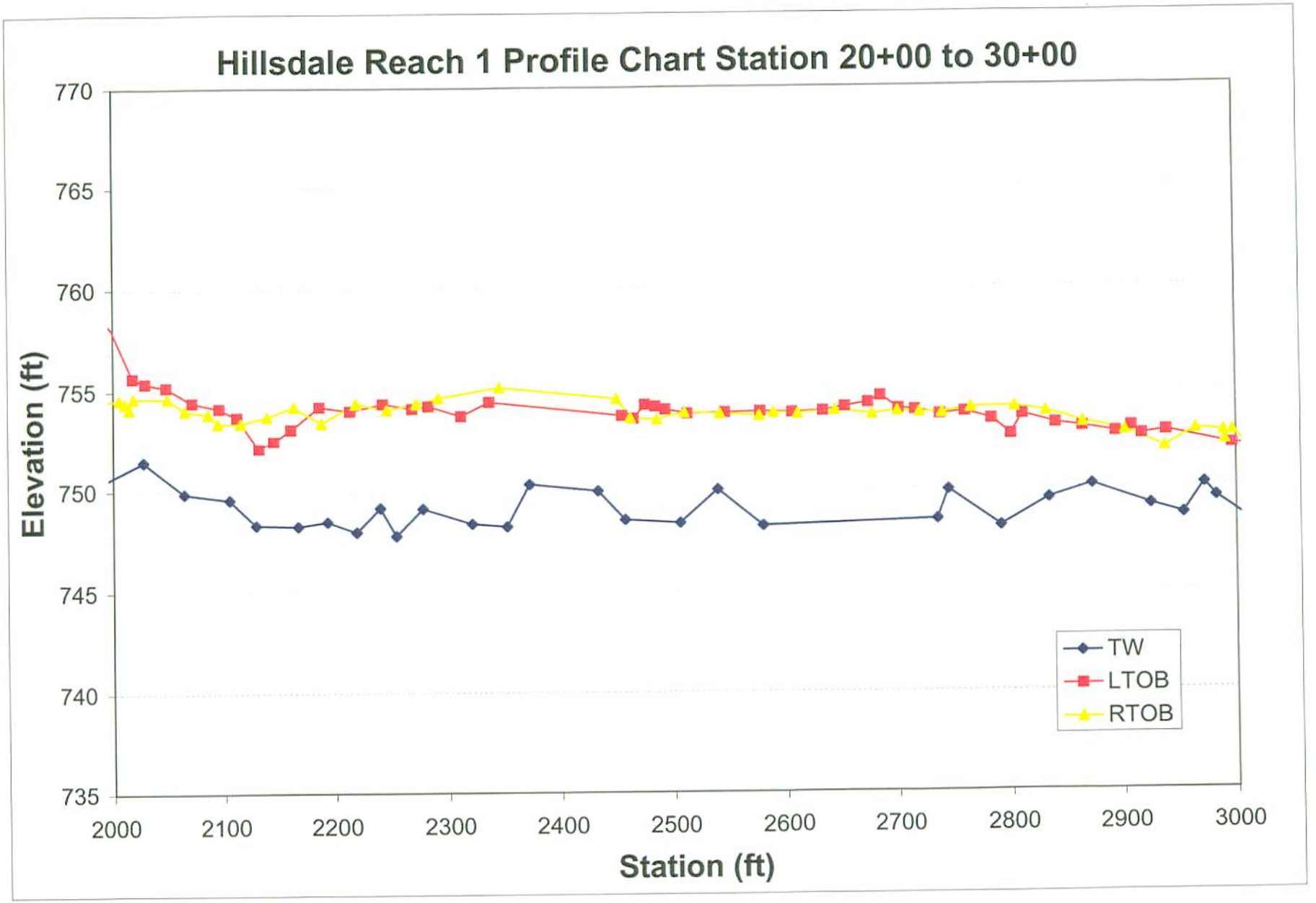

Hillsdale - R2
Cross Section 9 Riffle
755
753
751
749
747
745
Elevation (ft)
0
20
40
60
80
100
120
140
160
Distance (ft)
Bankfull
8/29/2003

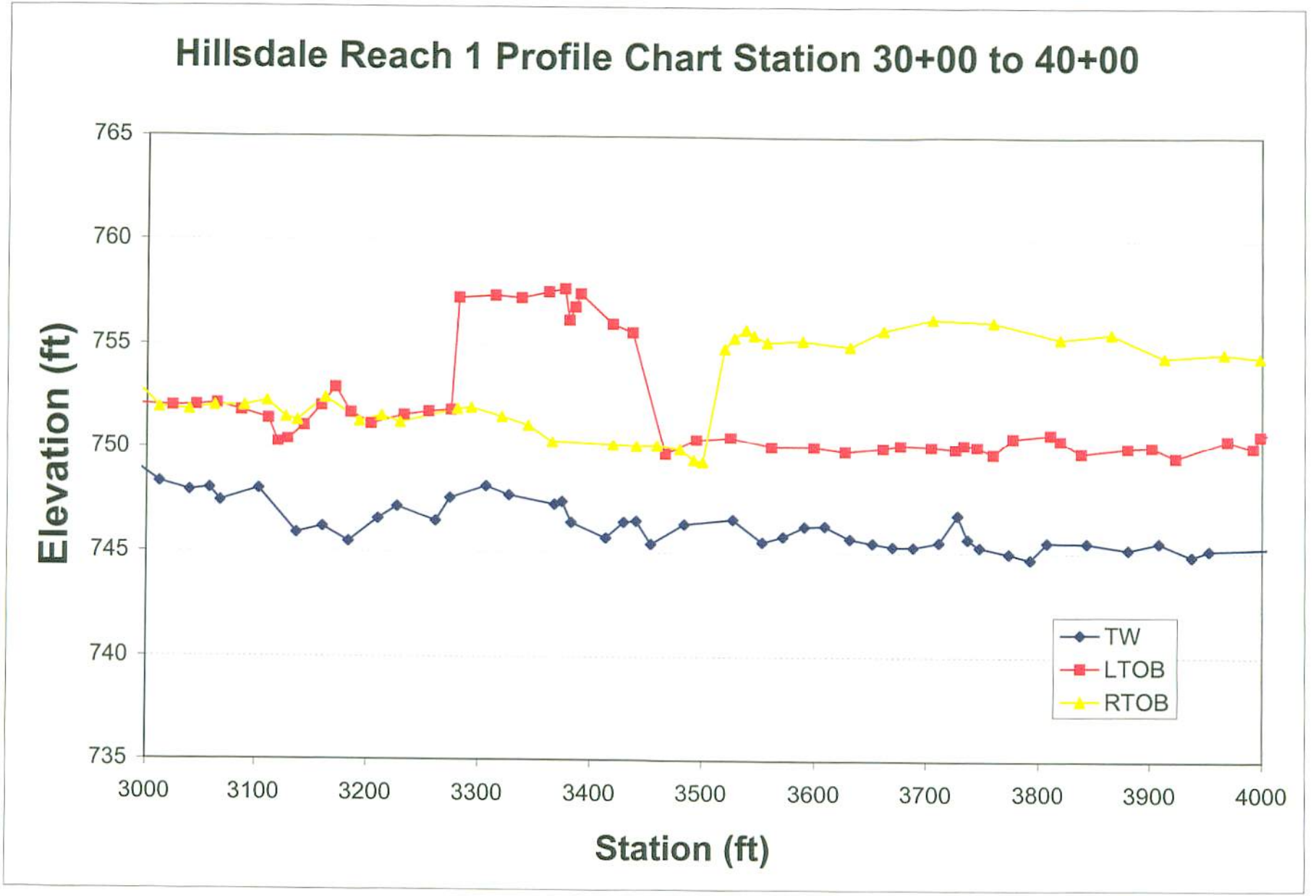

Hillsdale R2
Cross Section 10 Pool
754
752
750
748
746
744
742
740
Elevation (ft)
0
20
40
60
80
100
120
Distance (ft)
Bankfull
9/16/2003

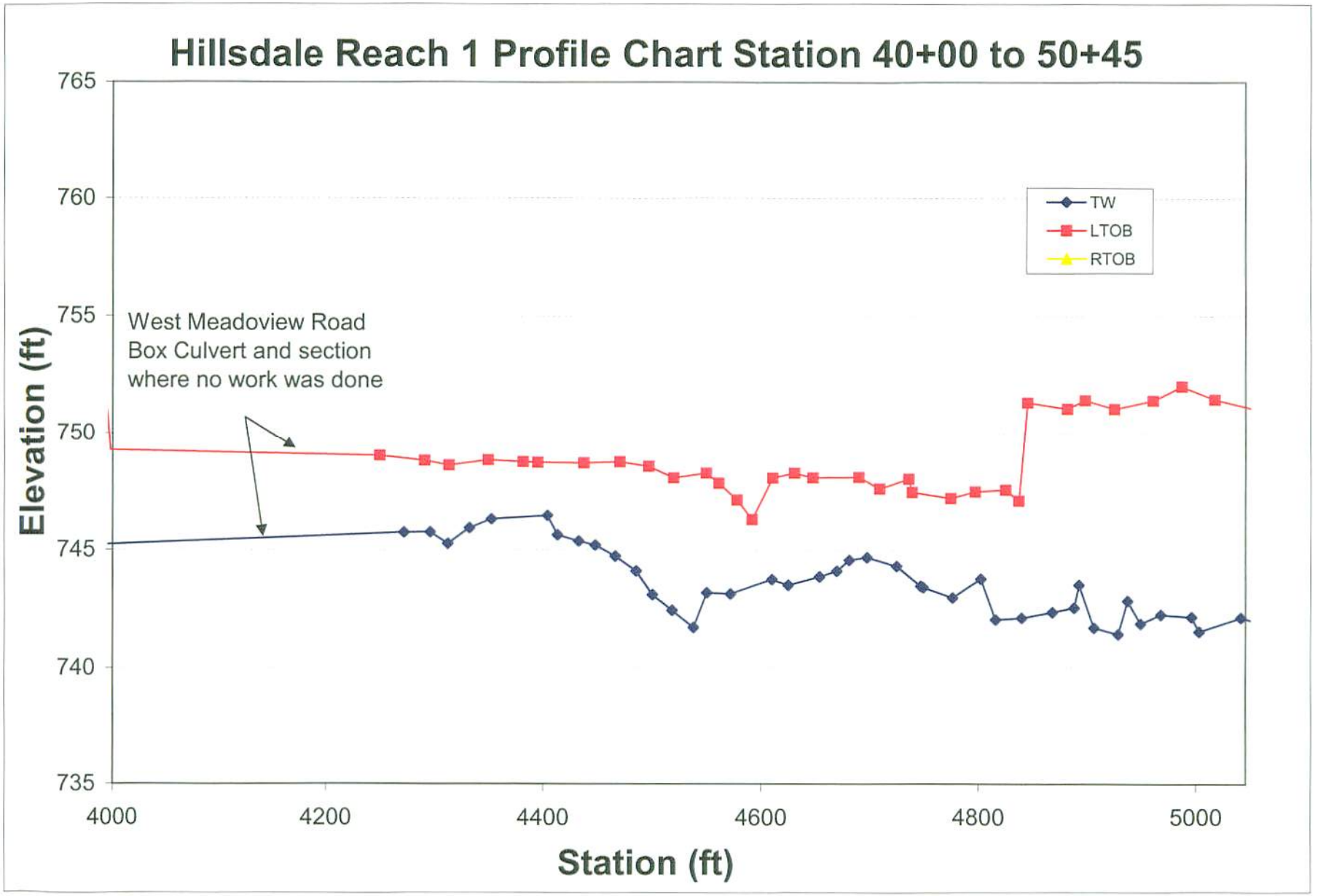

Hillsdale - R2
Cross Section 11 Riffle
754
752
750
748
746
744
742
740
Elevation (ft)
Bankfull
0
20
40
60
80
Distance (ft)
9/16/2003

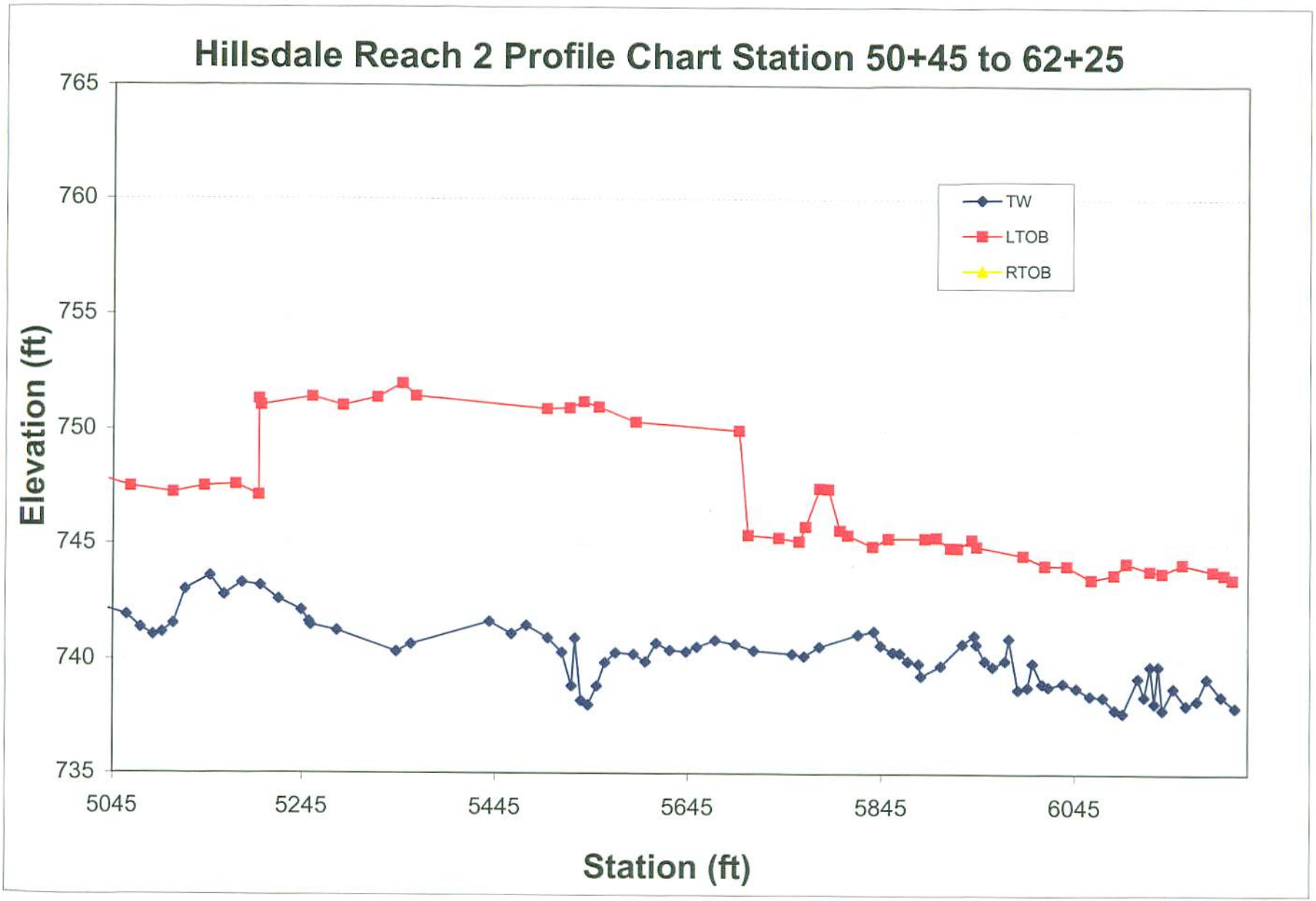

Hillsdale - R2
Cross Section 12 Pool
Elevation (ft)
752
750
748
746
744
742
740
738
736
Bankfull
0
10
20
30
40
50
60
70
80
Distance (ft)
9/16/2003


Hillsdale Reach 1 Profile Chart Station 10+00 to 20+00
Elevation (ft)
770
765
760
755
750
745
740
735
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Station (ft)
TW
LTOB
RTOB


Hillsdale Reach 1 Profile Chart Station 20+00 to 30+00
Elevation (ft)
770
765
760
755
750
745
740
735
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
Station (ft)
TW
LTOB
RTOB


Hillsdale Reach 1 Profile Chart Station 30+00 to 40+00
765
760
755
750
745
740
735
Elevation (ft)
3000
3100
3200
3300
3400
3500
3600
3700
3800
3900
4000
Station (ft)
TW
LTOB
RTOB


Hillsdale Reach 1 Profile Chart Station 40+00 to 50+45
765
760
755
750
745
740
735
Elevation (ft)
West Meadoview Road
Box Culvert and section
where no work was done
TW
LTOB
RTOB
4000
4200
4400
4600
4800
5000
Station (ft)


Hillsdale Reach 2 Profile Chart Station 50+45 to 62+25
765
760
755
750
745
740
735
Elevation (ft)
5045
5245
5445
5645
5845
6045
Station (ft)
TW
LTOB
RTOB

South Buffalo Creek
Hillsdale Park
Photo Log

Reach 1A

Photo Points 1-13

Reach 1B

Photo Points 14-27

Reach 2

Photo Points 28-45A

Reach 3

Photo Point 45B-46

Notes:

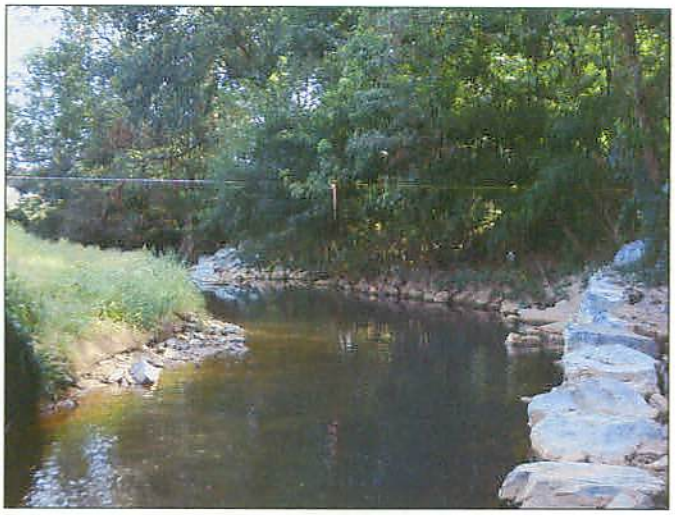
1. Photo point locations are shown on the plan views in the actual location the picture was taken. Descriptive locations and views follow on the next two pages.
2. All photos are oriented downstream (unless otherwise noted).
3. Photo locations include longitudinal photos and cross sections.

South Buffalo Creek
Hillsdale Park
Photo Point Locations

Photo Point	Location	View
Reach 1A		
1	Top of Meadow View Road Culvert	Project Start
2	Thalweg (TW) at invert of Vane #1	Cross Section (XSEC) 1
3	TW at Vane #2 Tie-in	Vane #3
4	TW at STA 14+00, 50' above Constructed Riffle (CR) #1	XSEC 2
5	Left Top of Terrace by manhole cover	CR #1 and Step Pool #1
6	TW at invert of Vane #4	XSEC 3
7	TW at Vane #5 Tie-in	Vane #6
8A	TW at Vane #6 Tie-in	Bedrock knick point
8B	Top of terrace at Station 18+00	Vegetation Plot
9	TW 2' above Bedrock knick point	XSEC 4
10A	TW at Step Pool #2	Vane #7
10B	TW at Step Pool #2 looking to Right	Step Pool #2
11A	TW at Step Pool #3	Cross Vane (CV) #1
11B	TW at Step Pool #3 looking to Left	Step Pool #3
12	TW at Invert of CV #1	CV #1 and Culvert
13	Top of Vanstory St. Culvert, upstream side	Looking Upstream
Reach 1B		
14	Top of Vanstory St. Culvert, downstream side	Reach 1B Start
15	TW at STA 24+75, 50' above DWD #1	XSEC 5
16A	TW at STA 25+00, 25' above DWD #1	XSEC 6
16B	Left Wing of DWD#1 looking downstream	Vegetation Plot
17A	TW at Step Pool #1	CV #1
17B	TW at Step Pool #1 looking to Right	Step Pool # 1
18A	TW at Step Pool #2	Riffle below CV #1
18B	TW at Step Pool #2 looking to Left	Step Pool #2
19A	TW at Step Pool #3	XSEC 7
19B	TW at Step Pool #3 looking to Left	Step Pool #3
20	TW at invert of Vane #1	XSEC 8
21	On top of Reinforced Concrete Pipe (RCP) off unnamed Tributary	Unnamed Tributary behind Vane #1
22A	TW at Step Pool #4	Boulder Cluster
22B	TW at Step Pool #4 looking to Left	Step Pool #4
23A	TW at Step Pool #5	DWD #2
23B	TW at Step Pool #5 looking to Left	Step Pool #5
24A	TW at Step Pool #6	DWD #3

Photo Point	Location	View
24B	TW at Step Pool #6 looking to Right	Step Pool #6
25A	TW at Step Pool #7	CV #2
25B	TW at Step Pool #7 looking to Left	Step Pool #7
26A	TW at Step Pool #8	Vanes #2 and #3
26B	TW at Step Pool #8 looking to Right	Step Pool #8
27	Top of Meadow View Road Culvert, upstream side	Looking upstream
Reach 2		
28	Top of Meadow View Road Culvert, downstream side	Reach 2 Start, J-Hook #1
29	TW above J-Hook #1 at Left Bench Start	J-Hook #1 and Bedrock
30A	TW above Bedrock	Riffle
30B	TW above Bedrock looking to back Left	Step Pool #1
30C	TW above Bedrock looking to Left	Rootwads #1
31	TW below Bedrock	XSEC 9
32	TW at Tail of Riffle above CV #1	XSEC 10, Boulder Cluster #1
33A	TW at Rootwads #2	J-Hook #2
33B	TW at Rootwads #2 looking to Left	Rootwads #2
34A	TW between Rootwads #3 and Step Pool #2	CV #2, Boulder Cluster #2
34B	TW between Rootwads #3 and Step Pool #2 looking to back Left	Rootwads #3
34C	TW between Rootwads #3 and Step Pool #2 looking to Left	Step Pool #2
35	TW below Boulder Cluster #2	J-Hook #3
36	TW at Head of Riffle below J-Hook #3	Riffle
37	TW at Tail of Riffle 100'above J-Hook #4	J-Hook #4
38A	TW at Step Pool #3	Riffle
38B	TW at Step Pool #3 looking to Left	Step Pool #3
39	TW at Head of Riffle below Step Pool #3	XSEC 11
40	TW at center of Riffle below Step Pool #3	XSEC 12, CV #3
41	TW at Bedrock 10' below CV #3	Riffle
42	TW at Left Bench Start	J-Hook #5
43A	TW at Step Pool #4	Riffle
43B	TW at Step Pool #4 looking to Left	Step Pool #4
44	TW at Water Line Crossing	CV #4
45A	Center Left I-40 Culvert, Left side	Looking upstream Reach 2
Reach 3		
45B	Center Left I-40 Culvert, Left side	Looking upstream Reach 3
46	Top of Aerial Sewer Line Crossing	Reach 3 Start

PP1 Reach 1A Start



PP2 Reach 1A Cross Section 1 (Pool)

PP3 Reach 1AVane #3

PP4 Reach 1A Cross Section #2 (Riffle)

PP5 Reach 1A Constructed Riffle #1 & Step Pool #1

PP6 Reach 1A Cross Section #3 (Pool)

PP7 Reach 1A Vane #6

PP8A Reach 1A Bedrock Knickpoint

PP8B Forested Buffer Bareroot Vegetation Plot Looking Upstream From Top of Terrace at Station 18+00

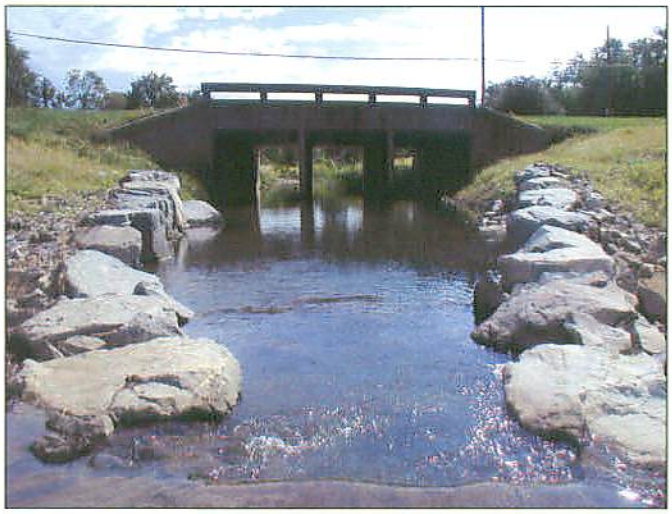
PP9 Reach 1A Cross Section #4 (Riffle)

PP10A Reach 1A Vane # 7

PP10B Reach 1A Step Pool #2

PP11A Reach 1A Cross Vane #1

PP11B Reach 1A Step Pool #3



PP12 Reach 1A Cross Vane #1 & Vanstory Culvert

PP13 Reach 1A End (Upstream view)

PP14 Reach 1B Start

PP15 Reach 1B Cross Section 5 (Riffle)

PP16A Reach 1B Cross Section 6 (Pool)

PP16B Forrested Buffer Bareroot Vegetation Plot

PP17A Reach 1B Cross Vane #1

PP17B Reach 1B Step Pool #2

PP18A Reach 1B Riffle

PP18B Reach 1B Step Pool #2

PP19A Reach 1B Cross Section #7

PP19B Reach 1B Step Pool #3

PP20 Reach 1B Cross Section #8 (Pool)

PP21 Reach 1B Unnamed Tributary

PP22A Reach 1 B Boulder Cluster

PP22B Reach 1B Step Pool #4

PP23A Reach 1B DWD #2

PP23B Reach 1B Step Pool #5

PP24A Reach 1B DWD #3

PP24B Reach 1B Step Pool #6

PP25A Reach 1B Cross Vane #2

PP25B Reach 1B Step Pool #7

PP26A Reach 1B Vanes #2 & #3

PP26B Reach 1B Step Pool #8

PP27 Reach 1B End (Upstream View)

PP28 Reach 2 Start

PP29 Reach 2 J-Hook #1

PP30A Reach 2 Riffle

PP30B Reach 2 Step Pool #1 Before Repairs

PP30C Reach 2 Rootwad #1 Before Repairs

PP31 Reach 2 Cross Section #9 (Riffle)

PP32 Reach 2 Cross Section #10 (Pool)

PP33A Reach 2 J-Hook #2

PP33B Reach 2 Rootwad #2 Before Repairs

PP34A Reach 2 Cross Vane #2

PP34B Reach 2 Rootwad #3 Before Repairs

PP34C Reach 2 Step Pool #2 Before Repairs

PP35 Reach 2 J-hook #3

PP36 Reach 2 Riffle

PP37 Reach 2 J-hook #4

PP38A Reach 2 Riffle

PP38B Reach 2 Step Pool #3

PP39 Cross Section #11 (Riffle)

PP40 Reach 2 Cross Section 12 (Pool)

PP41 Reach 2 Riffle

PP42 Reach 2 J-hook #5

PP43A Reach 2 Riffle

PP43B Reach 2 Step Pool #4

PP44 Reach 2 Cross Vane #4

PP45A Reach 2 End (Upstream View)

PP45B Reach 3 End (Upstream View)

PP46 Reach 3

South Buffalo Creek
Hillsdale Park
Vegetation Survival Plots

Bare Root Plantings

Reach 1	Photo Point (#)	Planted (stems)	Year 1 (stems)	Year 2 (stems)	Year 3 (stems)	Year 4 (stems)	Year 5 (stems)
Plot #1	8B	38					
Plot #2	16A	53					

Livestakes

Reach 1	Photo Point (#)	Planted (stakes)	Year 1 (stakes)	Year 2 (stakes)	Year 3 (stakes)	Year 4 (stakes)	Year 5 (stakes)
Plot #2	16A	98					

Note: Livestakes counted from eastern end of plot down to culvert at Vanstory Street

Notes:

1. All plots are shown on the plan views. All plot corners are marked with wooden stakes with orange flagging tape.
2. Each counted stem or live stake is marked with pink flagging tape.
3. Photo point locations are shown on the plan views and marked with wooden stakes with orange flagging tape.
4. Use successive columns for survivability from year to year.

PROJECT REFERENCE NO.	SHEET NO.
0000532601	8

PROJECT ENGINEER

VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

NAD 83

MURRAY HILL RD

WEST MEADOW VIEW RD

REACH 1

BANKFULL

0+00

STA 0+00
BEGIN CONSTRUCTION

MATCH LINE STA 14+85 SHT 8

EMERALD DR

FAWN ST

VANSTORY ST

25' FORESTED BUFFER

SEE SHEETS 1-C FOR PLANTING SPECS

PROJECT REFERENCE NO.	SHEET NO.
0000532601	9

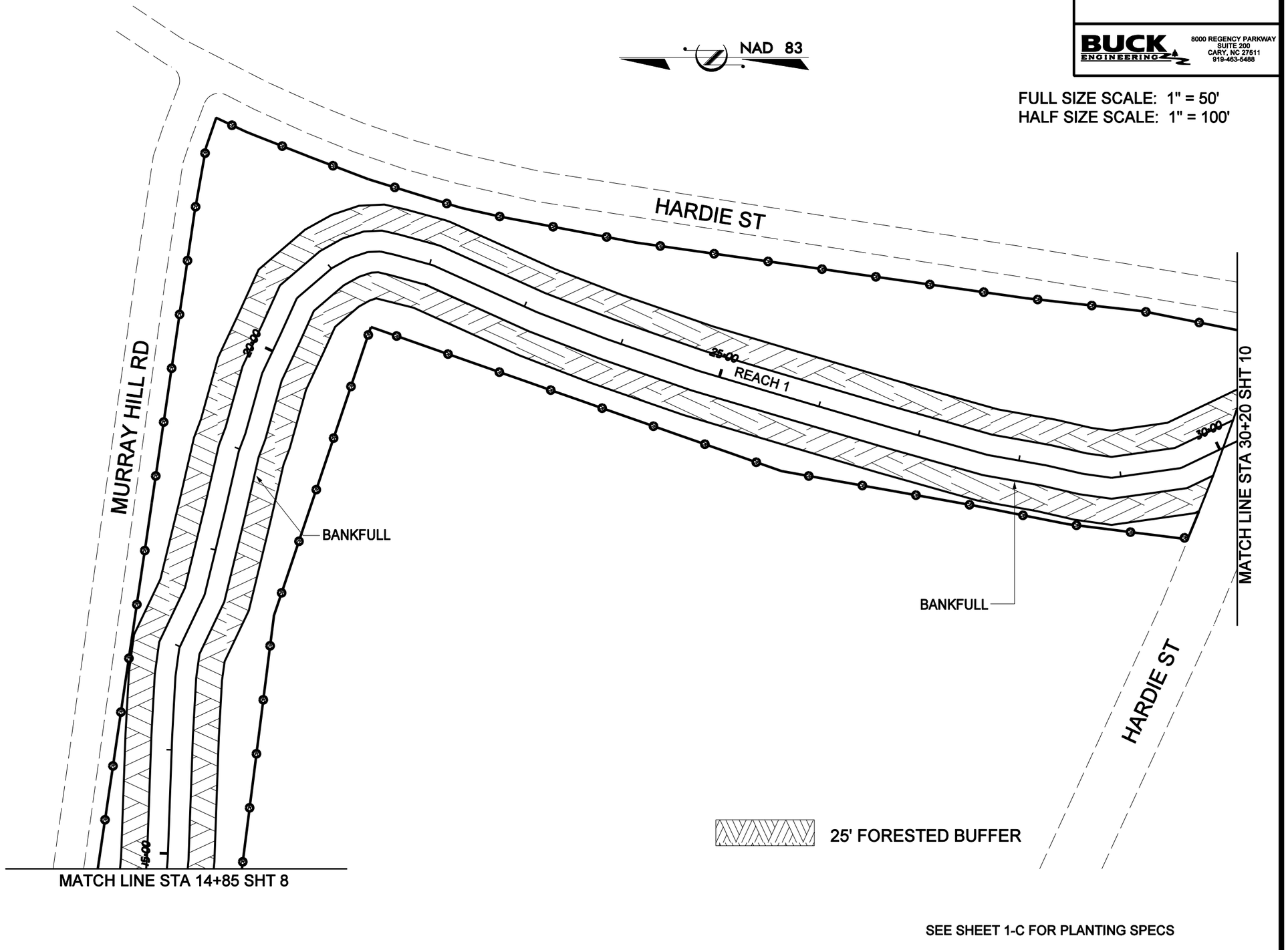
PROJECT ENGINEER

VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

NAD 83

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'



SEE SHEET 1-C FOR PLANTING SPECS

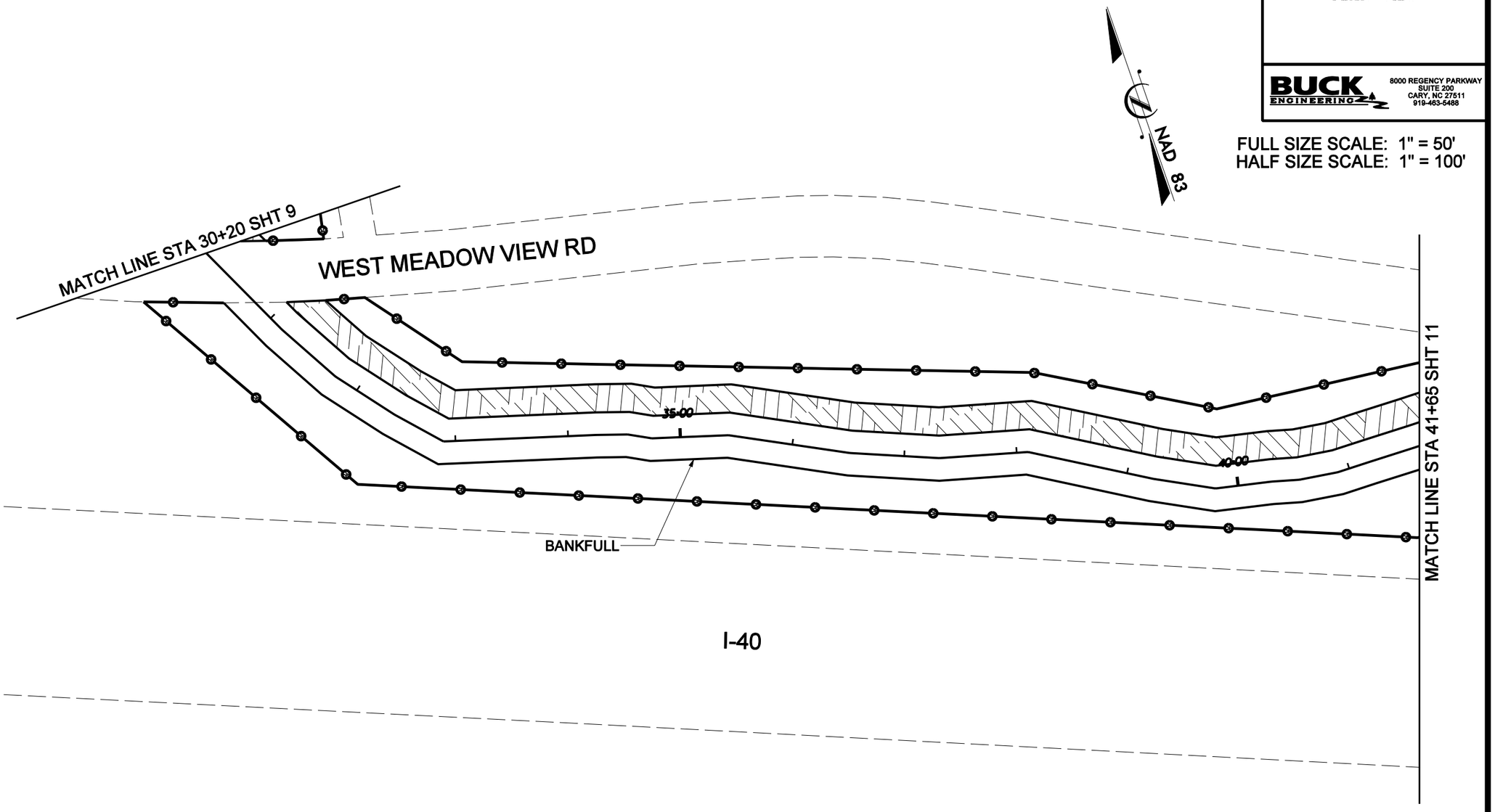
PROJECT REFERENCE NO.	SHEET NO.
0000532601	10

PROJECT ENGINEER

VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'



25' FORESTED BUFFER

SEE SHEET 1-C FOR PLANTING SPECS

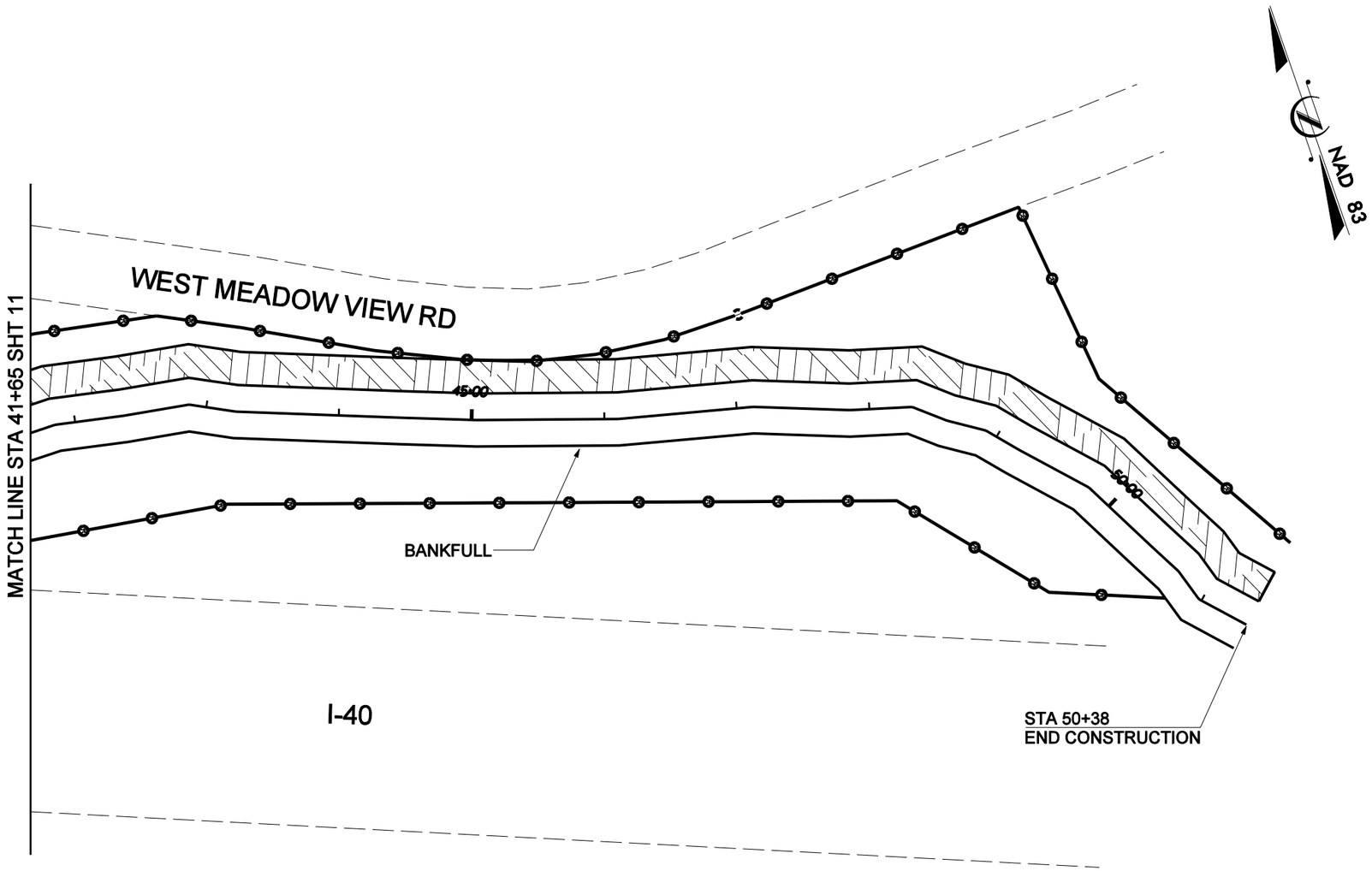
PROJECT REFERENCE NO.	SHEET NO.
0000532601	11

PROJECT ENGINEER

VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'



25' FORESTED BUFFER

SEE SHEET 1-C FOR PLANTING SPECS

PROJECT REFERENCE NO.	SHEET NO.
000532601	4

PROJECT ENGINEER

AS-BUILT PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

NAD 83

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS

MURRAY HILL RD

PARK BOUNDARY

WEST MEADOW VIEW RD

REACH 1 STATION 10+00
BEGIN CONSTRUCTION

X-SECTION 1

X-SECTION 2

X-SECTION 3

X-SECTION 4

PHOTO POINT 1

PHOTO POINT 2

PHOTO POINT 3

PHOTO POINT 4

PHOTO POINT 5

PHOTO POINT 6

PHOTO POINT 7

PHOTO POINT 8

PHOTO POINT 9

PHOTO POINT 10

PHOTO POINT 11

PHOTO POINT 12

PHOTO POINT 13
3 - 13'(W) X 11'(H) X RCBC

PHOTO POINT 14

BEDROCK

VEG PLOT #1
25' X 100'

EMERALD DR

FAWN ST

VANSTORY ST

MATCH LINE STA 24+75 SHT 5

BUCK ENGINEERING | USER | DATE | TIME | FILE

PROJECT REFERENCE NO.	SHEET NO.
000532601	5

PROJECT ENGINEER

AS-BUILT PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS

HARDIE ST
CRESTRIDGE RD
MURRAY HILL RD
WOODBURY ST
WEST MEADOW VIEW RD
TENNIS COURT
DO NOT DISTURB MANHOLE
PARK BOUNDARY
PARK BOUNDARY

PHOTO POINT 15
PHOTO POINT 16
PHOTO POINT 17
PHOTO POINT 18
PHOTO POINT 19
PHOTO POINT 20
PHOTO POINT 21
PHOTO POINT 22
PHOTO POINT 23
PHOTO POINT 24
PHOTO POINT 25
PHOTO POINT 26
PHOTO POINT 27

X-SECTION 5
X-SECTION 6
X-SECTION 7
X-SECTION 8

VEG PLOT #2
25' X 100'

4 - 12'(W) X 10'(H) RCBC

END REACH 1
STATION 40+45

MATCH LINE STA 24+75 SHT 4
MATCH LINE STA 40+45 SHT 6

NAD 83

PROJECT REFERENCE NO.	SHEET NO.
0000532601	6

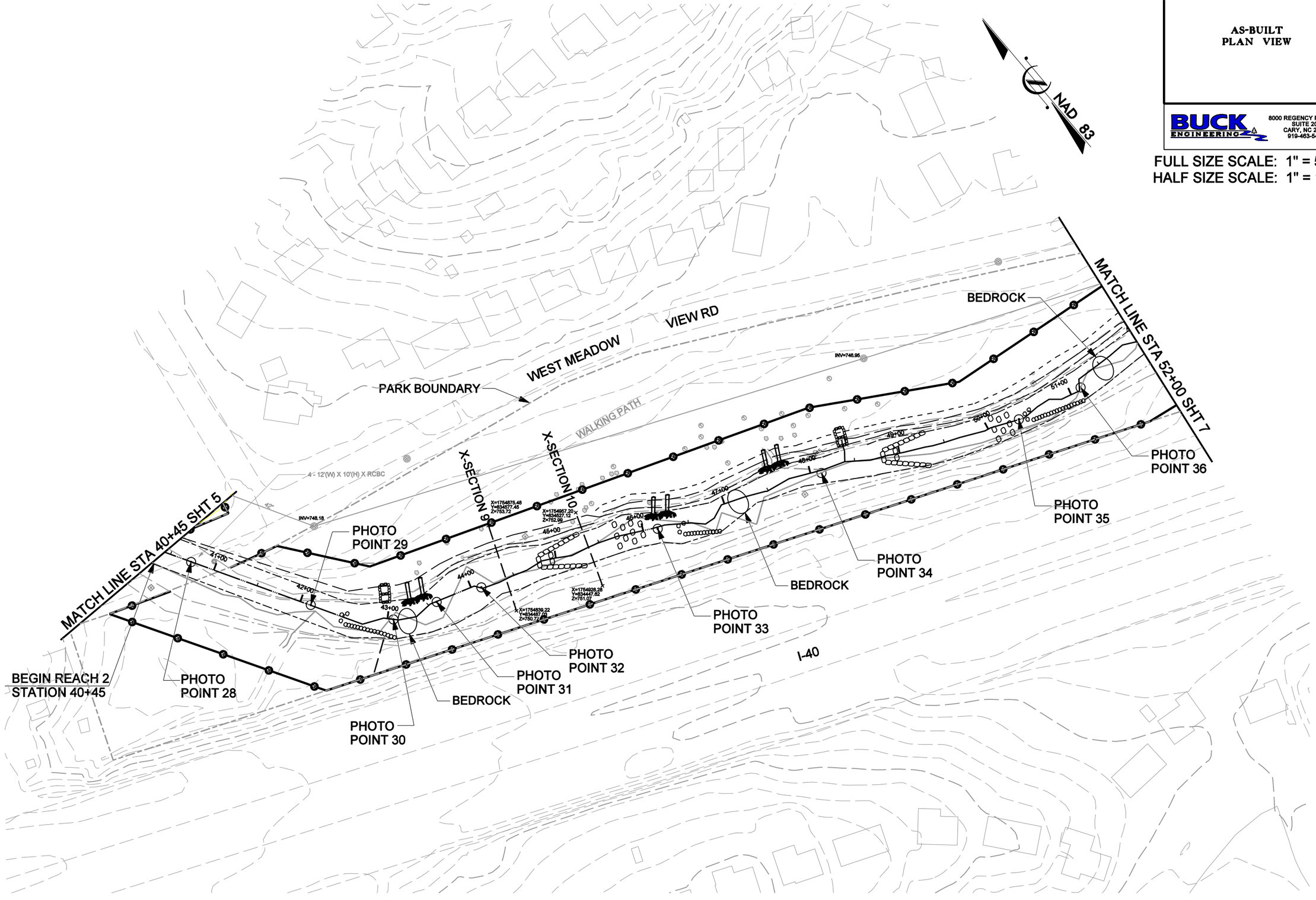
PROJECT ENGINEER

AS-BUILT
PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS



PROJECT REFERENCE NO.	SHEET NO.
000532601	7

PROJECT ENGINEER

AS-BUILT
PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS

EMERYWOOD RD

WEST MEADOW VIEW RD

WALKING PATH

REACH 3

NAD 83

MATCH LINE STA 52+00 SHT 6

X-SECTION 11

X-SECTION 12

X=1755873.72
Y=834204.38
Z=751.36

X=1755828.83
Y=834214.33
Z=751.15

X=1755828.83
Y=1755812.22
Z=747.82

X=1755855.79
Y=834139.91
Z=750.40

INV=745.78
INV=745.85
INV=745.85
INV=740.40 SIPHON
INV=745.04
INV=741.00 SIPHON
INV=745.07
INV=744.87
INV=744.41
INV=744.63
INV= 738.80 SIPHON
INV=744.28
INV=744.05

52+00
53+00
54+00
55+00
56+00
57+00
58+00
59+00
60+00
61+00
62+00

BEDROCK

PARK BOUNDARY

PHOTO POINT 37
PHOTO POINT 38
PHOTO POINT 39
PHOTO POINT 40
PHOTO POINT 41
PHOTO POINT 42
PHOTO POINT 43
PHOTO POINT 44
PHOTO POINT 45
PHOTO POINT 46

PARK BOUNDARY

REACH 2 STATION 62+12
END CONSTRUCTION

I-40

Mile Run Creek
Gillespie Golf Course
Cross Section Summary

Reach 1A (from Randolph Avenue to Bridge 1)

Cross Section 1	Pool between arms of Cross Vane (CV) #3	Photo Point 2

Reach 1B (from Bridge 1 to Bridge 2)

Cross Section 2	Riffle in Double Wing Deflector (DWD) #1	Photo Point 5
Cross Section 3	Riffle in DWD #3	Photo Point 6

Reach 1C (from Bridge 2 to Concrete Crossing at STA 13+05)

Cross Section 4	Pool below DWD #1	Photo Point 8B
Cross Section 5	Riffle in DWD #3	Photo Point 10

Reach 2

Cross Section 6	Riffle between CV #5 and #6	Photo Point 22

Notes:

1. All cross sections are marked on each bank by permanent pins set in concrete.
2. All pins are shown on the plan views (with North Carolina State plane and elevation coordinates) and are marked in the field with wooden stakes with orange flagging tape.
3. Photo point locations are shown on the plan views.

Gillespie Cross Section Pin Locations

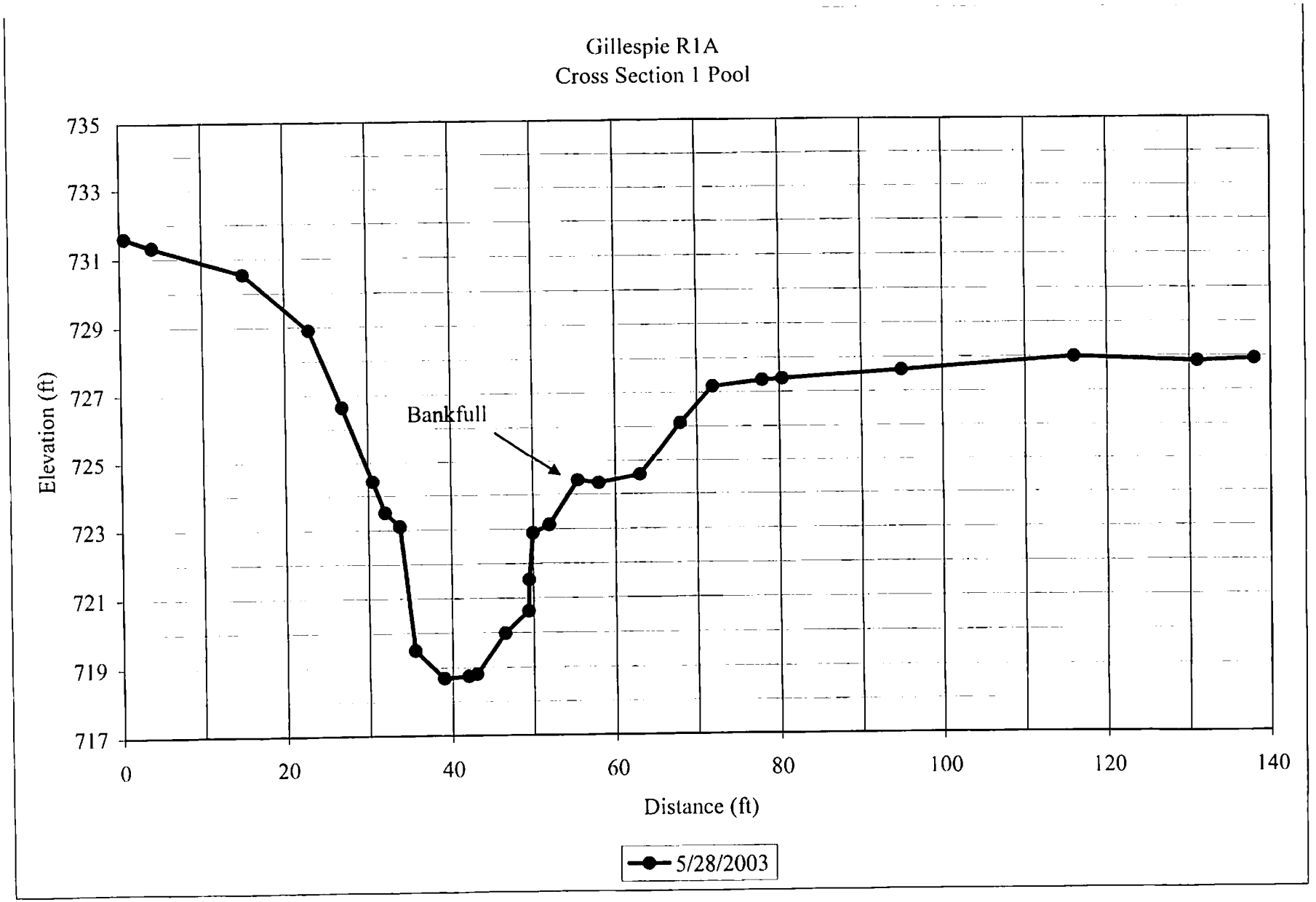
Point#	Northing	Easting	Elevation	Decscription	Stationing
6962	836721.2408	1768240.768	731.593021	X1-LPIN	2+09.41
6959	836661.4391	1768188.143	727.386603	X2-RPIN	
6958	836547.672	1768574.591	727.323399	X2-LPIN	5+85.75
6957	836455.5351	1768498.907	726.222079	X2-RPIN	
6955	836450.0104	1768663.792	727.584322	X3-LPIN	7+31.09
6956	836379.1641	1768627.222	726.94595	X3-RPIN	
6954	836373.6691	1768866.661	727.000947	X4-LPIN	9+64.85
6953	836308.9286	1768847.733	724.7526	X4-RPIN	
7290	836336.2576	1769164.713	723.878659	X5-LPIN	12+76.23
6952	836152.7361	1769152.928	725.460507	X5-RPIN	
7332	836035.9265	1769389.533	733.438601	X6-LPIN	no stationing
7337	8359978.245	1769468.044	730.65315	X6-RPIN	on Reach 2

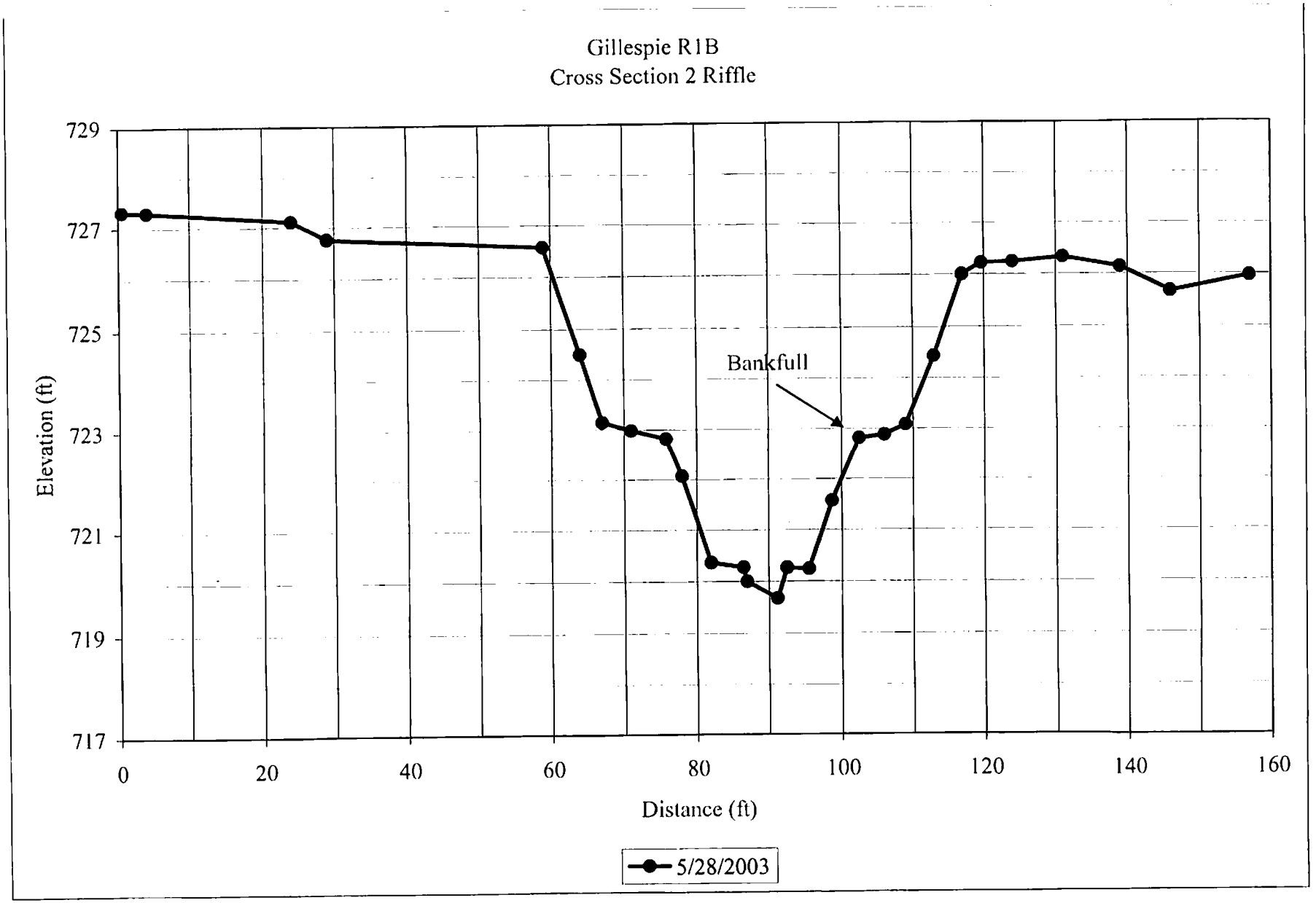
Gillespie Golf Course

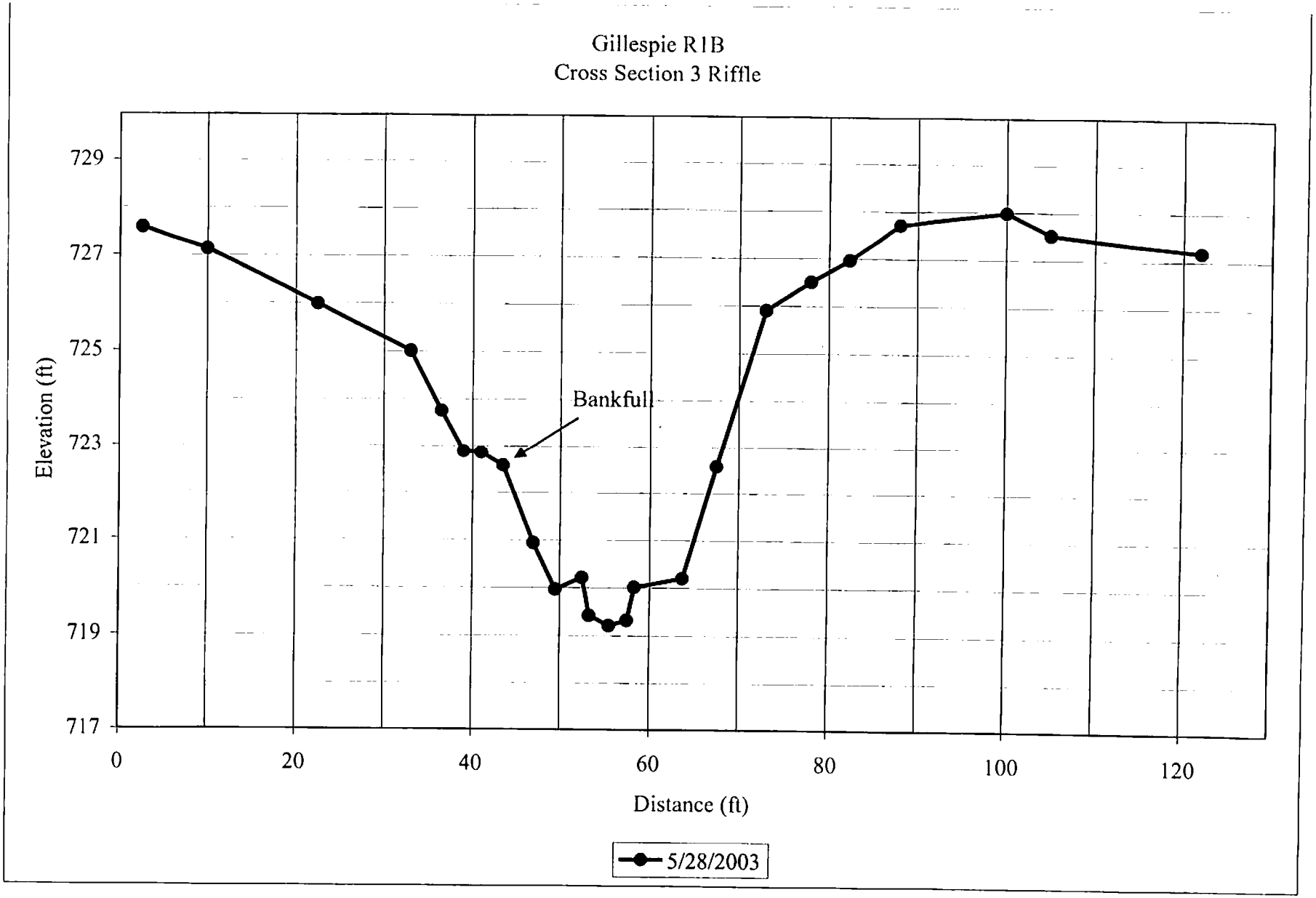
Cross Section Dimension Summary

XSEC	STA	Date	Feature	Str Type	Wfpa	Wbkf	Dbkf	W/D	Abkf	Dmax	ER	BHR
1	2+09	5/28/2003	Pool		235	24.9	3.4	7.3	85.5	5.7	9.4	1.0
	2+09	Y1	Pool									
	2+09	Y2	Pool									
	2+09	Y3	Pool									
	2+09	Y4	Pool									
2	5+86	5/28/2003	Riffle	B5c	56	26.7	2.0	13.6	52.3	3.1	2.1	1.0
	5+86	Y1	Riffle									
	5+86	Y2	Riffle									
	5+86	Y3	Riffle									
	5+86	Y4	Riffle									
3	7+31	5/28/2003	Riffle	B5c	52	24.0	2.2	11.1	51.9	3.4	2.2	1.0
	7+31	Y1	Riffle									
	7+31	Y2	Riffle									
	7+31	Y3	Riffle									
	7+31	Y4	Riffle									

Str Type = Rosgen Classification
Wfpa = Width Flood Prone Area (ft)
Wbkf = Bankfull Width (ft)
Dbkf = Bankfull Mean Depth (ft)
W/D = Bkf Width to Depth Ratio (ft/ft)
Abkf = Bkf Cross Section Area (sq ft)
Dmax = Bankfull Maximum Depth (ft)
ER = Entrenchment Ratio, Wfpa/Wbkf (ft/ft)
BHR = Bank Height Ratio, Dtob/Dmax (ft/ft)


Gillespie R1A
Cross Section 1 Pool
735
733
731
729
727
725
723
721
719
717
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
140
Distance (ft)
5/28/2003


Gillespie R1B
Cross Section 2 Riffle
729
727
725
723
721
719
717
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
140
160
Distance (ft)
5/28/2003


Gillespie R1B
Cross Section 3 Riffle
729
727
725
723
721
719
717
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
Distance (ft)
5/28/2003

Gillespie Golf Course

Cross Section Dimension Summary

XSEC	STA	Date	Feature	Str Type	Wfpa	Wbkf	Dbkf	W/D	Abkf	Dmax	ER	BHR
4	9+65	5/28/2003	Pool		262	28.5	2.9	9.8	82.6	4.4	9.2	1.0
	9+65	Y1	Pool									
	9+65	Y2	Pool									
	9+65	Y3	Pool									
	9+65	Y4	Pool									
5	12+76	5/28/2003	Riffle	E5	115	26.3	1.9	13.9	49.9	2.9	4.4	1.0
	12+76	Y1	Riffle									
	12+76	Y2	Riffle									
	12+76	Y3	Riffle									
	12+76	Y4	Riffle									
6	n/a	5/28/2003	Riffle	E5b	22	7.2	0.6	11.2	4.6	1.0	3.1	1.0
		Y1	Riffle									
		Y2	Riffle									
		Y3	Riffle									
		Y4	Riffle									

Str Type = Rosgen Classification

Wfpa = Width Flood Prone Area (ft)

Wbkf = Bankfull Width (ft)

Dbkf = Bankfull Mean Depth (ft)

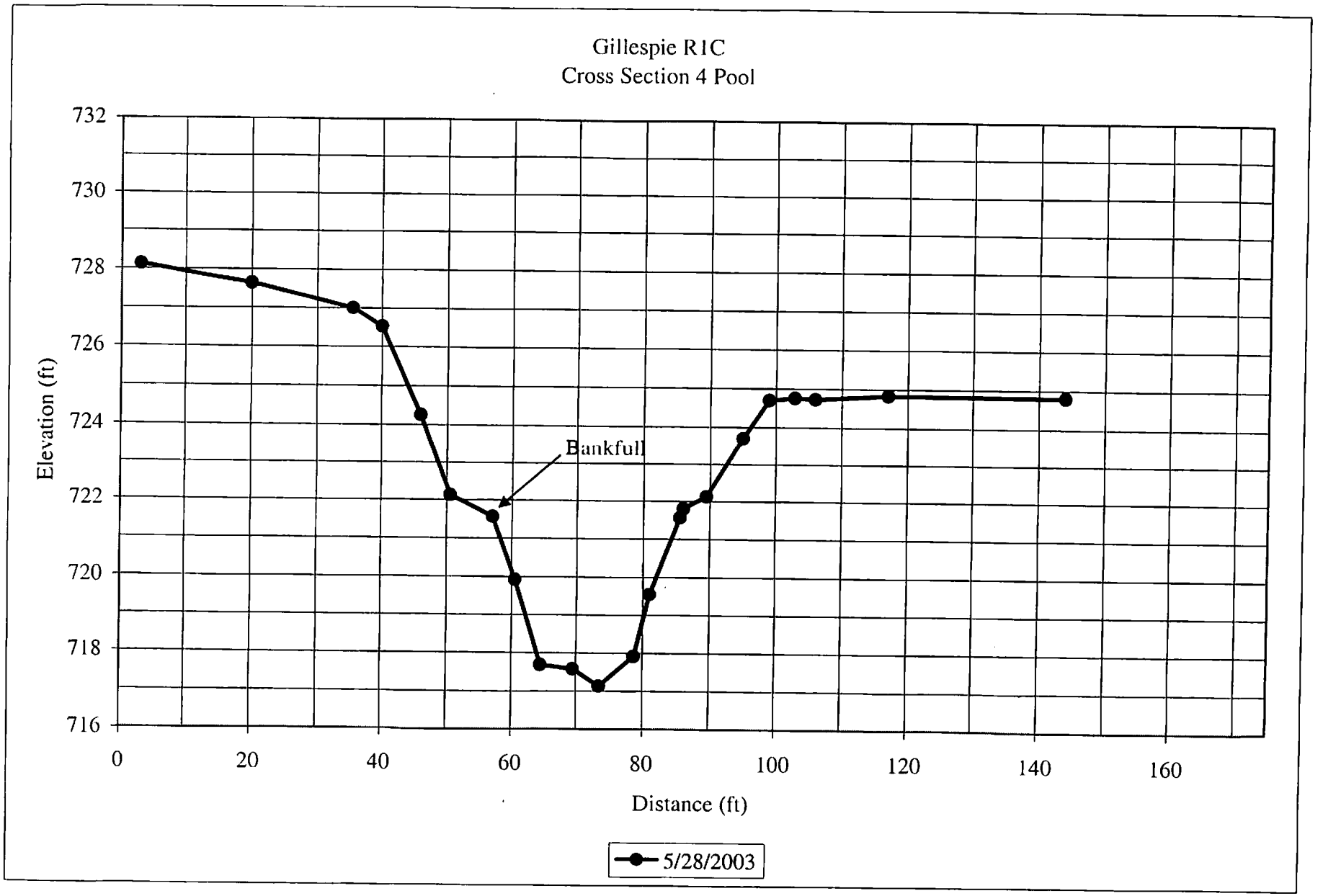
W/D = Bkf Width to Depth Ratio (ft/ft)

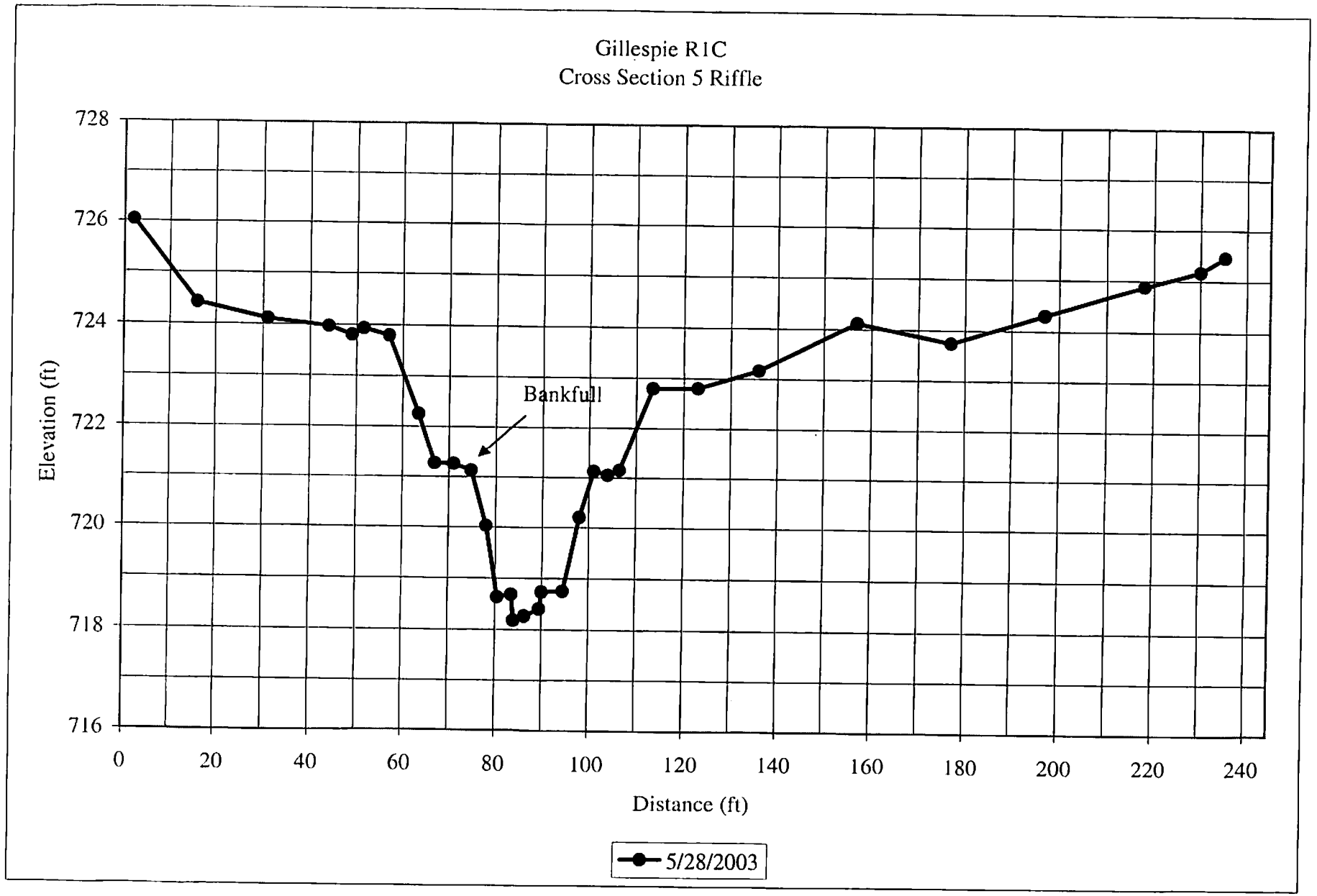
Abkf = Bkf Cross Section Area (sq ft)

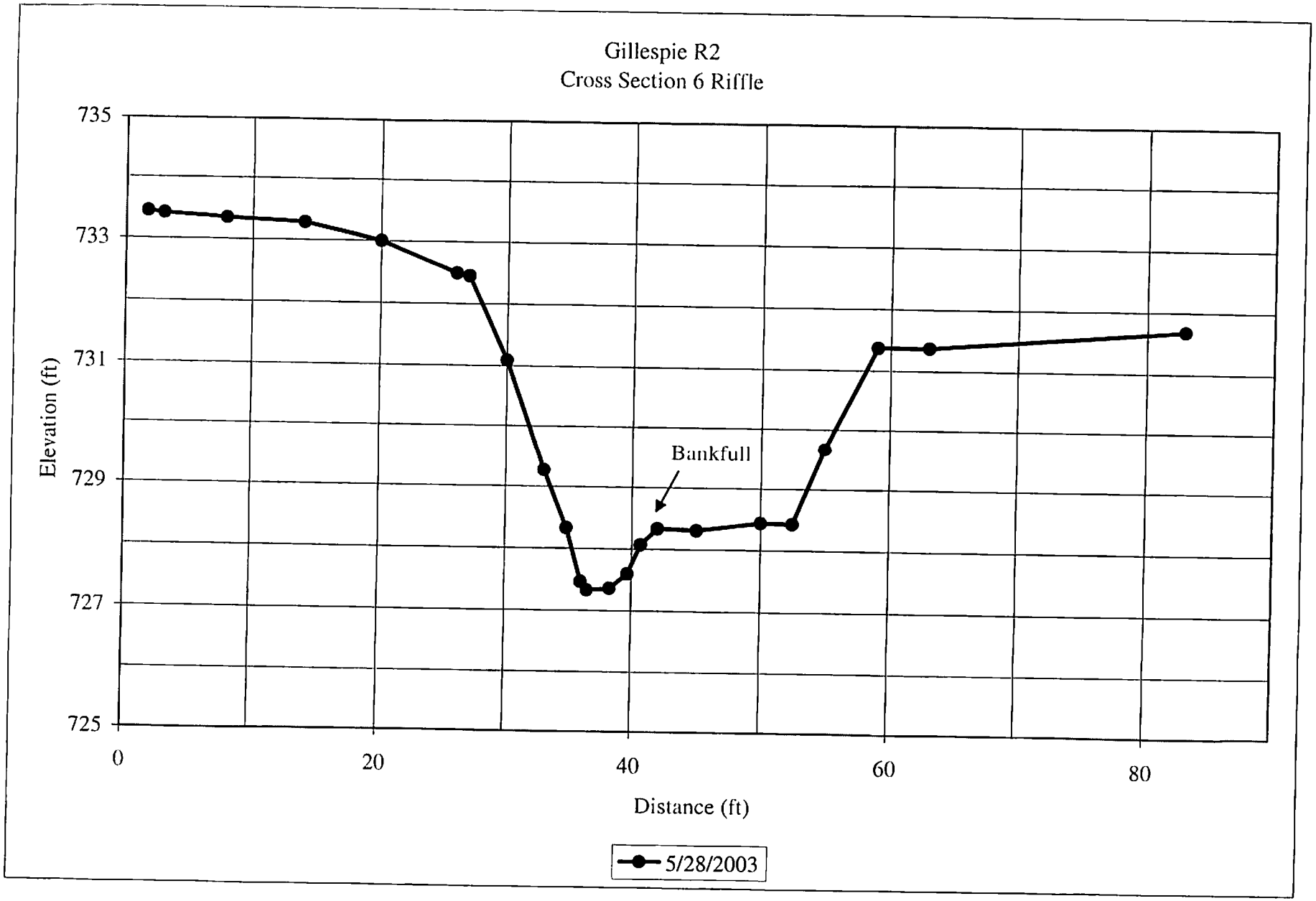
Dmax = Bankfull Maximum Depth (ft)

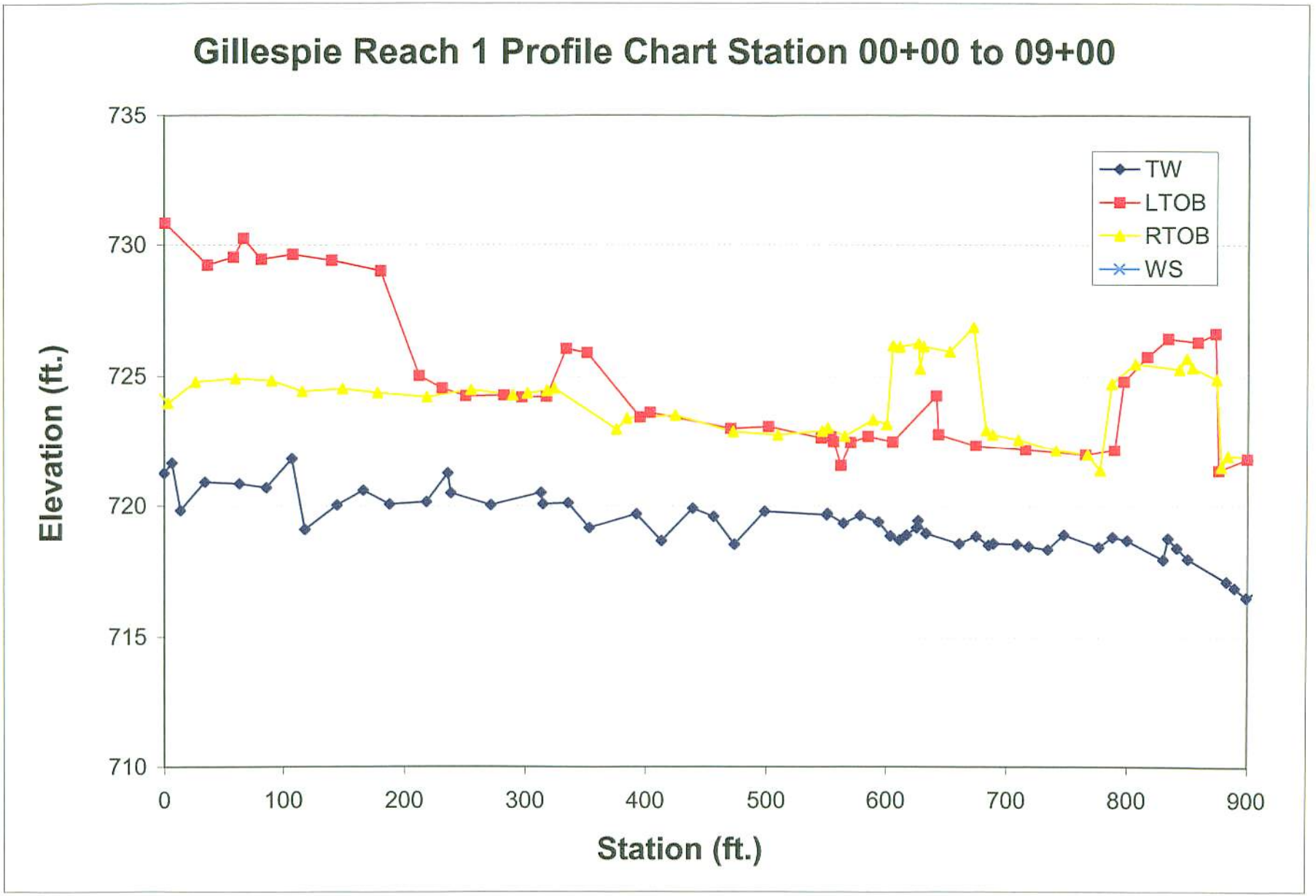
ER = Entrenchment Ratio, Wfpa/Wbkf (ft/ft)

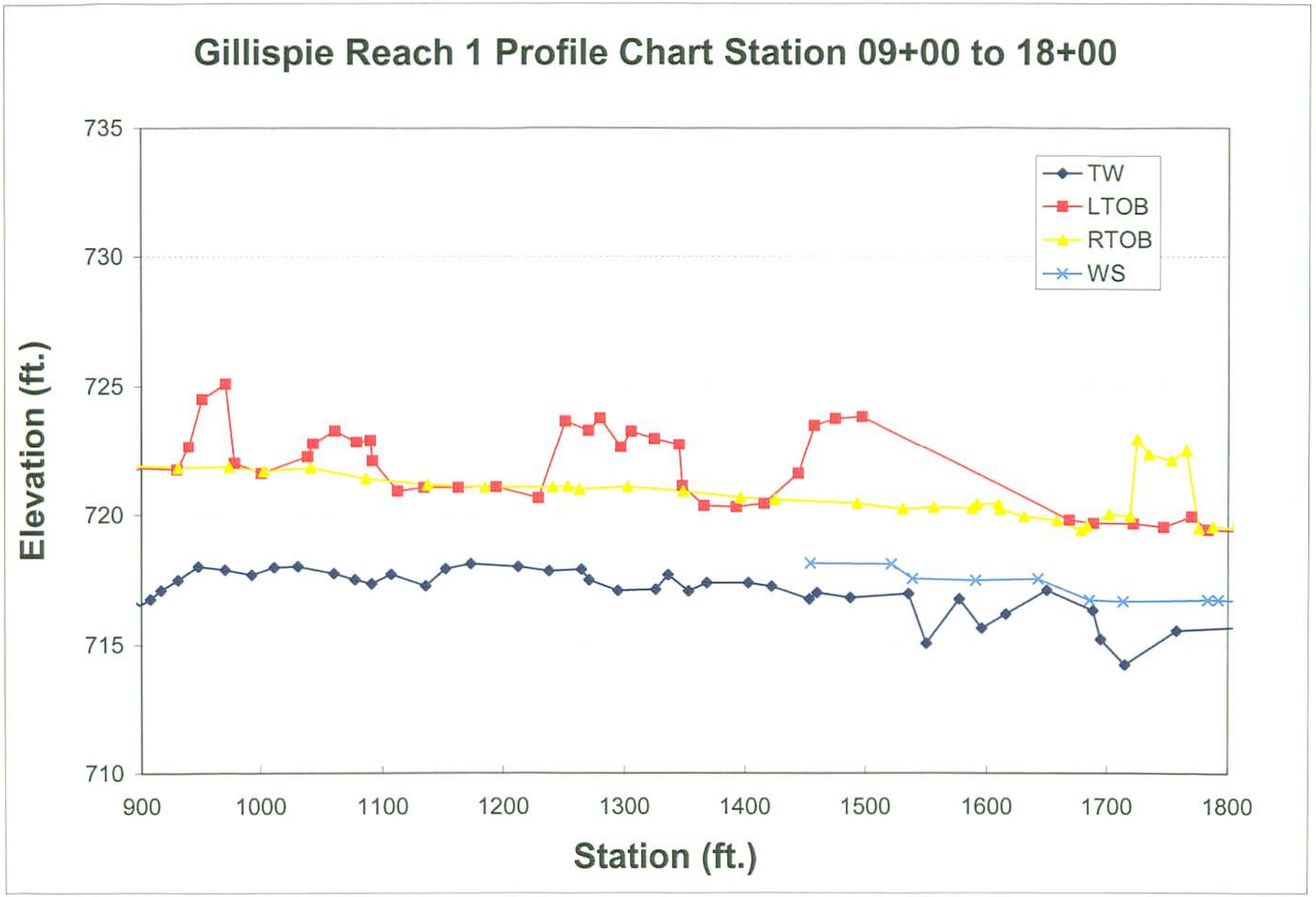
BHR = Bank Height Ratio, Dtob/Dmax (ft/ft)

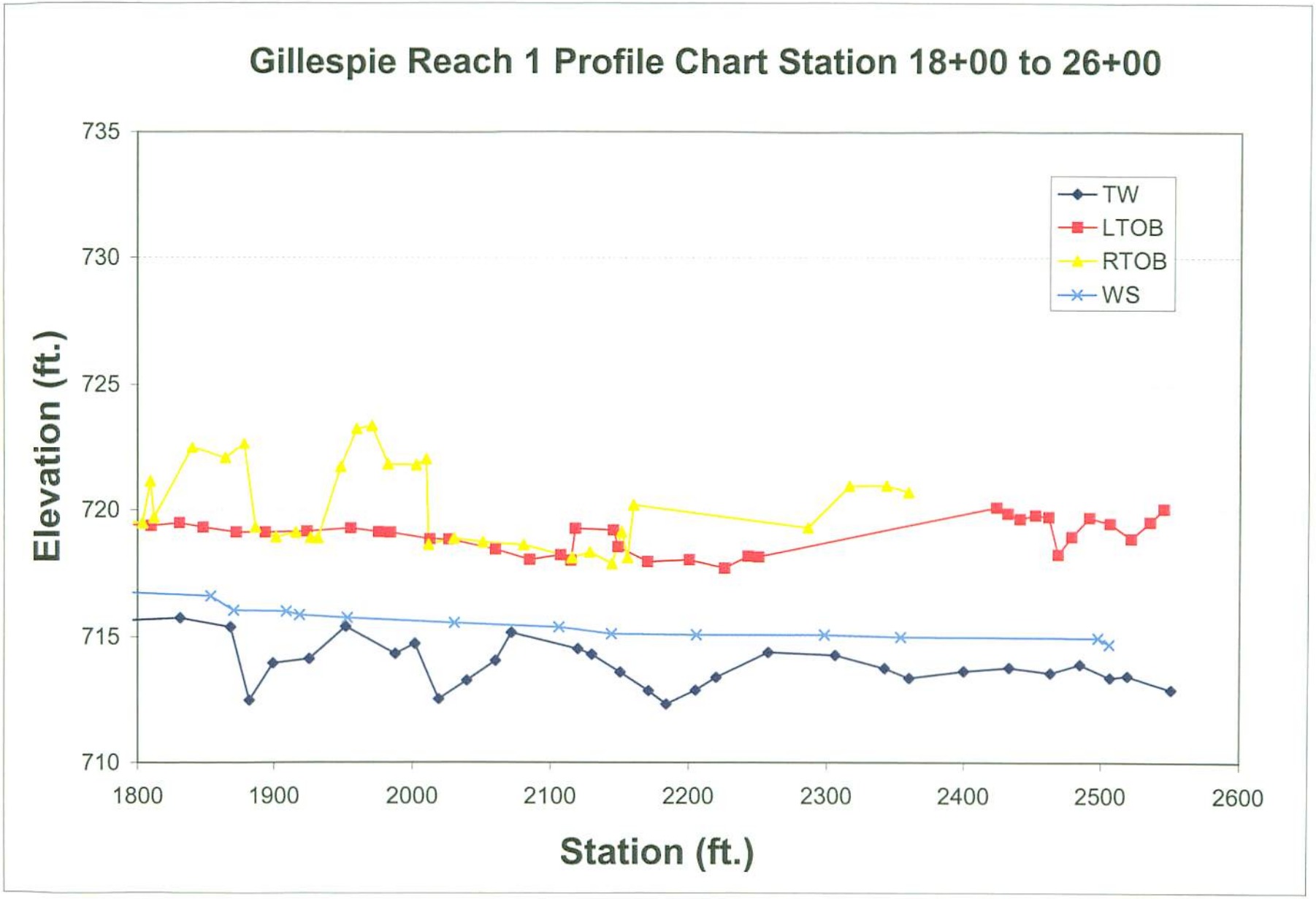

Gillespie R1C
Cross Section 4 Pool
732
730
728
726
724
722
720
718
716
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
140
160
Distance (ft)
5/28/2003


Gillespie R1C
Cross Section 5 Riffle
728
726
724
722
720
718
716
Elevation (ft)
Bankfull
0
20
40
60
80
100
120
140
160
180
200
220
240
Distance (ft)
5/28/2003


Gillespie R2
Cross Section 6 Riffle
735
733
731
729
727
725
Elevation (ft)
Bankfull
0
20
40
60
80
Distance (ft)
5/28/2003


Gillespie Reach 1 Profile Chart Station 00+00 to 09+00
Elevation (ft.)
735
730
725
720
715
710
0
100
200
300
400
500
600
700
800
900
Station (ft.)
TW
LTOB
RTOB
WS


Gillispie Reach 1 Profile Chart Station 09+00 to 18+00
735
730
725
720
715
710
Elevation (ft.)
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
Station (ft.)
TW
LTOB
RTOB
WS


Gillespie Reach 1 Profile Chart Station 18+00 to 26+00
735
730
725
720
715
710
Elevation (ft.)
1800
1900
2000
2100
2200
2300
2400
2500
2600
Station (ft.)
TW
LTOB
RTOB
WS

Mile Run Creek
Gillespie Golf Course
Photo Log

Reach 1A

Photo Points 1-4A

Reach 1B

Photo Points 4B-8A

Reach 1C

Photo Points 8B-10

Reach 1D

Photo Points 11-13

Reach 1E

Photo Points 14-15B

Reach 1F

Photo Points 16-19

Reach 2

Photo Points 20-22

Reach 3

Photo Points 23-25

Reach 4

Photo Points 26-31

Reach 5

Photo Points 32-34

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken. Descriptive locations and views follow on the next two pages.
2. All photos are oriented downstream (unless otherwise noted).
3. Photo locations include longitudinal photos and cross sections.

Mile Run Creek
Gillespie Golf Course
Photo Point Locations

Photo Point	Location	View
Reach 1A		
1	Top of Culvert at Randolph Avenue	Project Start
2	Thalweg (TW) at Double Wing Deflector (DWD) #1	Cross Section (XSEC 1) XSEC 1
3A	TW at invert of Cross Vane (CV) #4	Towards Bridge 1
3B	TW at invert of CV #4	Looking upstream at Bare root vegetation plot
4A	Top of Bridge 1, upstream side	Looking upstream
Reach 1B		
4B	Top of Bridge 1, downstream side	Start of Reach 1B
5	TW at invert of CV #2	XSEC 2
6	TW 20' upstream of Aerial Sewer Line Crossing	XSEC 3
7	Top of Aerial Sewer Line Crossing	Towards Bridge 2
8A	Top of Bridge 2, downstream side	Looking upstream
Reach 1C		
8B	Top of Bridge 2, upstream side	Start of Reach 1C, XSEC 4
9A	TW at invert of DWD #2	CV #2
9B	Left Wing of DWD #2	Looking downstream at bareroot vegetation plot
10	TW at STA 12+00, 75' above DWD #3	XSEC 5
Reach 1D		
11	TW at invert of CV #1	DWD #1
12	TW at invert of DWD #2	J-Hook #1
13	TW at confluence with Reach 2 RCP	Constructed Riffle
Reach 1E		
14	TW at confluence with Reach 4	Towards Bridge 3
15A	Top of Bridge 3, upstream side	Looking upstream
15B	Top of Bridge 3, downstream side	Looking downstream
Reach 1F		
16	TW at invert of vane #1	J-Hook #1
17	TW at invert of J-Hook #1	CV #1
18	TW at invert of CV #1	CV #2 and #3
19	TW at invert of CV #3	Project End

Photo Point	Location	View
Reach 2		
20	TW 10' above invert of CV #1	Reach 2 Start
21	TW at invert of CV #2	CV #3 and #4
22	TW at invert of CV #4	XSEC 6
Reach 3		
23	Top of Culvert	Reach 3A Start
24A	Top of Pedestrian Bridge, upstream side	Looking upstream
24B	Top of Pedestrian Bridge, downstream side	Reach 3B Start
25	TW at invert of CV #2	Confluence with Reach 1
Reach 4		
26	Top of Cart Path Crossing	Reach 4 Start
27A	Top of Cart Path Crossing below 12th Tee Box, upstream side	Looking upstream
27B	Top of Cart Path Crossing below 12th Tee Box, downstream side	Looking downstream
27C	Top of Cart Path Crossing Below 12th Tee Box, downstream side	Looking at Shrub Vegetation Plot
28	Top of Cart Path Crossing below 3d Tee Box	Looking downstream
29	Right Top of Bank at Bend to left	Confluence with Reach 5
30A	Left Top of Bank at confluence with Reach 5	Looking downstream
30B	4Cart Path at Confluence with Reach 5	Looking upstream at Reach 4 Herbaceous/Livestake Plot
31	Top of Cart Path Crossing on Fairway 2	Confluence with Reach 1
Reach 5		
32	TW at Fence Line on left side of Fairway 6	Reach 5 Start
33	Top of Cart Path Crossing on right side of Fairway 6	Looking downstream
34	Left Top of Bank at Bend to Right	Confluence with Reach 4

PP1 Reach 1A Project Start

PP2 Reach 1A Cross Section 1

PP3A Reach 1A Towards Bridge 1

PP3B Reach 1A Forrested Buffer
Bareroot/Livestake Plot Looking Upstream

PP4A Reach 1A Looking Upstream

PP4B Reach 1B Start

PP5 Reach 1B Cross Section 2

PP6 Reach 1B Cross Section 3

PP7 Reach 1B Towards Bridge 2

PP8A Reach 1B Looking Upstream

PP8B Reach 1C Start, Cross Section 4

PP9A Reach 1C Cross Vane #2

PP9B Managed Buffer
Livestakes/Shrubs/Herbaceous Perennials
Vegetation Plot Looking Downstream

PP10 Reach 1C Cross Section 5

PP11 Reach 1D Double Wing Deflector #1

PP12 Reach 1D J-hook #1

PP13 Reach 1D Constructed Riffle

PP14 Reach 1E Towards Bridge 3

PP15A Reach 1E Looking Upstream

PP15B Reach 1E Looking Downstream

PP16 Reach 1F J-hook #1

PP17 Reach 1F Cross Vane #1

PP18 Reach 1F Cross Vanes #2 and #3

PP19 Reach 1F Project End

PP 20 Reach 2 Start

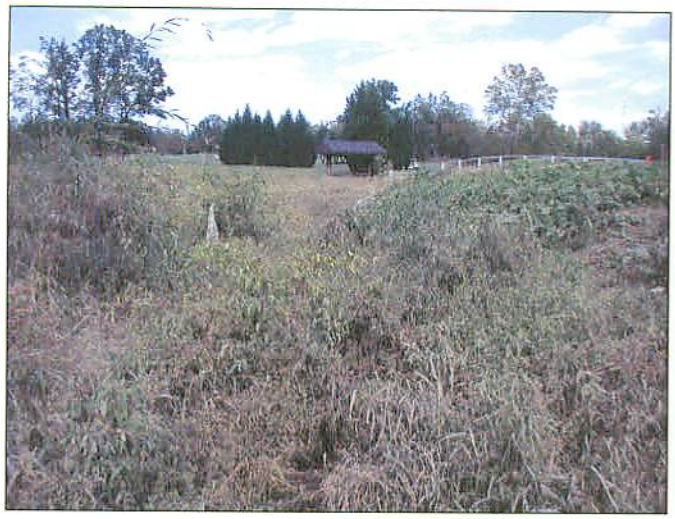
PP 21 Reach 2 Cross Vanes #3 and #4

PP22 Reach 2 Cross Section 6

PP23 Reach 3A Start

PP24A Reach 3A Looking Upstream

PP24B Reach 3B Start



PP25 Reach 3B Confluence with Reach 1

PP26 Reach 4 Start Looking Downstream

PP27A Reach 4 Looking Upstream

PP27B Reach 4 Looking Downstream

PP27C Managed Buffer Vegetation Shrub Plot Looking Downstream

PP28 Reach 4 Looking Downstream

PP29 Reach 4 Confluence with Reach 5

PP30A Reach 4 Looking Downstream

PP30B Managed Buffer Herbaceous Perennials/Livestakes Plot Looking Upstream to Reach 4 from Confluence with Reach 5

PP31 Reach 4 Confluence with Reach 1

PP32 Reach 5 Start

PP33 Reach 5 Looking Downstream

PP34 Reach 5 Confluence with Reach 4

Mile Run Creek
Gillespie Golf Course
Vegetation Survival Plots

Live Stakes

Reach	Photo Point (#)	Planted (stakes)	Year 1 (stakes)	Year 2 (stakes)	Year 3 (stakes)	Year (stakes)	Year 5 (stakes)
R1C Plot #2	9B	95					
R1A Plot #1	3B	66					
R4 Plot #3	30B	62					

Bare Root Plantings

Reach	Photo Point (#)	Planted (stems)	Year 1 (stems)	Year 2 (stems)	Year 3 (stems)	Year 4 (stems)	Year 5 (stems)
R1A Plot #1	3B	31					

Managed Buffer Shrub Plot

Reach	Photo Point (#)	Planted (shrubs)	Year 1 (shrubs)	Year 2 (shrubs)	Year 3 (shrubs)	Year (shrubs)	Year 5 (shrubs)
R4 Plot #4	27B	101					
R1C Plot #2	9B	61					

Managed Buffer Herbaceous Perennials

Reach	Photo Point (#)	Planted (plants)	Year 1 (plants)	Year 2 (plants)	Year 3 (plants)	Year (plants)	Year 5 (plants)
R4 Plot #3	30B	113					
R1C* Plot#2	9B	63					

*in a 2 foot buffer along the top of terrace

Notes:

1. All plots are shown on the plan views. All plot corners are marked with wooden stakes with orange flagging tape.
2. Each counted stem or live stake is marked with pink flagging tape or pin flags.
3. Photo point locations are shown on the plan views and marked with wooden stakes with orange flagging tape.
4. Use successive columns for survivability from year to year.

PROJECT REFERENCE NO.	SHEET NO.
0000532601	6

PROJECT ENGINEER

VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS

NAD 83

REACH 1A STA 0+00
BEGIN CONSTRUCTION

FAIRWAY 9 & 18

REACH 1A

25 ' FORESTED BUFFER

BRIDGE 1

25' MANAGED BUFFER
(2' WIDE COORIDOR ALONG THE TERRACE
OF 1' HIGH VEGETATION AND GRASS FROM THERE TO 25')

FAIRWAY

25 ' FORESTED BUFFER

BANKFULL

5:00

RANDOLPH AVE

FAIRWAY

BRIDGE 2

FORESTED BUFFER TO EXISTING TREE LINE

REACH 1B

REACH 1C

CART PATH

FAIRWAY 9 & 18

MATCH LINE STA 11+35 SHT 7

25' MANAGED BUFFER
(2' WIDE COORIDOR ALONG THE TERRACE
OF 1' HIGH VEGETATION AND GRASS FROM THERE TO 25')

FAIRWAY 9 & 18

CART PATH

MANAGED BUFFER

FORESTED BUFFER

SEE SHEET 1-C FOR PLANTING SPECS

PROJECT REFERENCE NO.	SHEET NO.
000532601	7

PROJECT ENGINEER

VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS

MATCH LINE SHEET 8

MATCH LINE SHEET 8

MATCH LINE STA 11+35 SHT 6

REACH 1C

BANKFULL

REACH 1D

15.00

FORESTED BUFFER TO EXISTING TREE LINE DOWN TO REACH 4

25' MANAGED BUFFER
(2' WIDE COORIDOR ALONG THE TERRACE OF 1' HIGH VEGETATION AND GRASS FROM THERE TO 25')

25' FORESTED BUFFER DOWN TO BRIDGE 3

FORESTED BUFFER OUT TO 5' FROM TOP OF TERRACE

REACH 2

25' FORESTED BUFFER

FAIRWAY 2

REACH 4

10' MANAGED BUFFER ON BOTH BANKS (DAY LILLIES)

REACH 5

25' FORESTED BUFFER

FAIRWAY 6

NAD 83

CART PATHS

10' MANAGED BUFFER ON BOTH BANKS (DAY LILLIES)

REACH 1E

20.00

25' FORESTED BUFFER FROM REACH 4 TO BRIDGE 3

15' MANAGED BUFFER OF GRASS

25' FORESTED BUFFER

REACH 1F

25.00

15' MANAGED BUFFER OF GRASS

BRIDGE 3

25' FORESTED BUFFER

25' FORESTED BUFFER

REACH 3B

FAIRWAY 8

7' FORESTED BUFFER OF UNDERSTORY TREES

REACH 3A

FAIRWAY BREAK

7' FORESTED BUFFER OF 3' HIGH TREES TO FAIRWAY

43' FORESTED BUFFER

30' FORESTED BUFFER

FAIRWAY 7

PEDESTRIAN BRIDGE

MANAGED BUFFER

FORESTED BUFFER

SEE SHEET 1-C FOR PLANTING SPECS

PROJECT REFERENCE NO.	SHEET NO.
0000532601	8

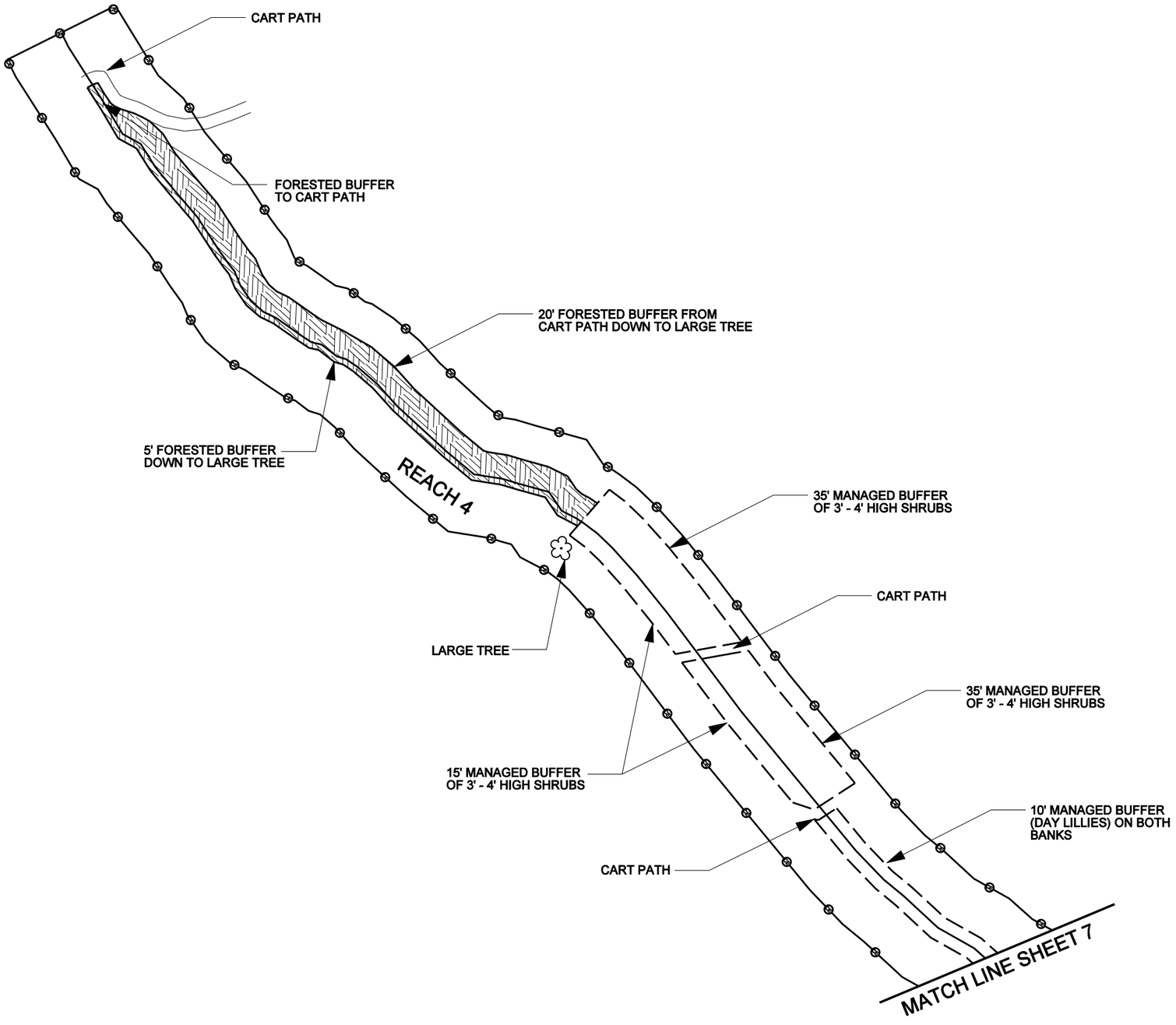
PROJECT ENGINEER

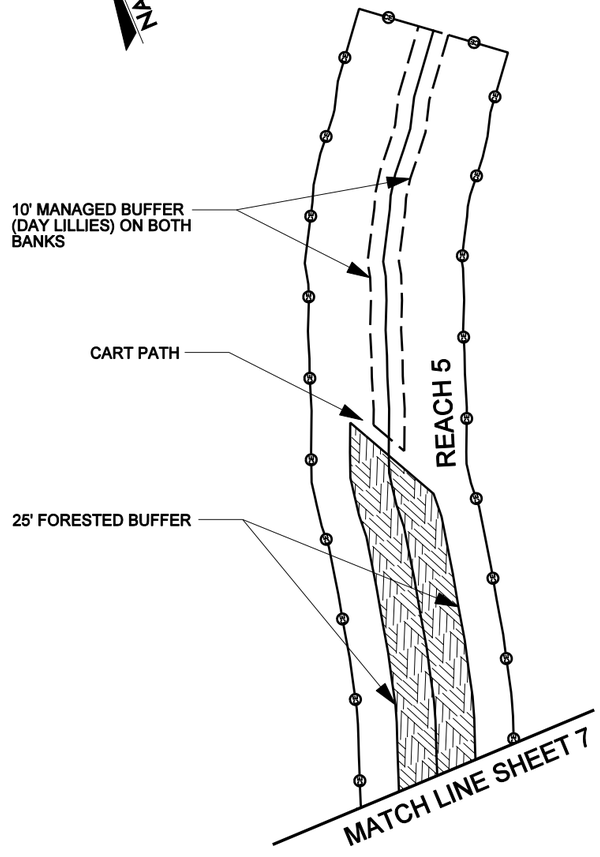
VEGETATION PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

NAD 83





MANAGED BUFFER

FORESTED BUFFER

SEE SHEET 1-C PLANTING SPECS

REVISIONS

PROJECT REFERENCE NO.	SHEET NO.
000532601	4

PROJECT ENGINEER

AS-BUILT PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-483-5488

FULL SIZE SCALE: 1"= 50'
HALF SIZE SCALE: 1"= 100'

REVISIONS

REACH 1A STATION 0+00
BEGIN CONSTRUCTION

REACH 1A
REACH 1B
REACH 1C

X-SECTION 1
X-SECTION 2
X-SECTION 3
X-SECTION 4
X-SECTION 5

BRIDGE #1
BRIDGE #2

PHOTO POINT 1
PHOTO POINT 2
PHOTO POINT 3
PHOTO POINT 4
PHOTO POINT 5
PHOTO POINT 6
PHOTO POINT 7
PHOTO POINT 8
PHOTO POINT 9
PHOTO POINT 10

VEG PLOT #1
25' X 100'

VEG PLOT #2
25' X 100'

MATCH LINE STA 13+00.38 SHT 5

CART PATH

FAIRWAY 9 & 18

RANDOLPH AVE

NAD 83

PROJECT REFERENCE NO.	SHEET NO.
0000532601	5

PROJECT ENGINEER

AS-BUILT PLAN VIEW

BUCK ENGINEERING
8000 REGENCY PARKWAY
SUITE 200
CARY, NC 27511
919-463-5488

FULL SIZE SCALE: 1" = 50'
HALF SIZE SCALE: 1" = 100'

REVISIONS

PHOTO POINT 26
LOCATED 712' UPSTREAM
OF PHOTO POINT 27 AT
CART PATH CROSSING

PHOTO POINT 27
CART PATH CROSSING

PHOTO POINT 28
CART PATH CROSSING

VEG PLOT #4
50' X 50'

PHOTO POINT 32
LOCATED 270' UPSTREAM
OF PHOTO POINT 33
AT FENCE

PHOTO POINT 33
LOCATED 360' UPSTREAM
OF PHOTO POINT 34
AT CULVERT

REACH 5

FAIRWAY 6

PHOTO POINT 34

PHOTO POINT 30
CART PATH CROSSING

REACH 4

PHOTO POINT 29

FAIRWAY 2

VEG PLOT #3
50' X 50'

CART PATH CROSSING

PHOTO POINT 31
CART PATH CROSSING

REACH 1E

BRIDGE #3

REACH 1F STATION 26+34.26
END CONSTRUCTION

REACH 1F

MATCH LINE STA 13+00.38 SHT 4

REACH 1D

PHOTO POINT 11

PHOTO POINT 12

PHOTO POINT 13

PHOTO POINT 14

REACH 3B

PHOTO POINT 15

PHOTO POINT 16

PHOTO POINT 17

PHOTO POINT 18

PHOTO POINT 19

X-SECTION 6

ACCESS ROAD

REACH 2

PHOTO POINT 22

PHOTO POINT 21

PHOTO POINT 20

FAIRWAY 8

REACH 3A

PHOTO POINT 25

FAIRWAY 7

PEDESTRIAN BRIDGE
PHOTO POINT 24

PHOTO POINT 23
LOCATED 445' UPSTREAM
OF PHOTO POINT 24

I-40

NAD 83

BUCK ENGINEERING | USER | DATE | TIME | FILE