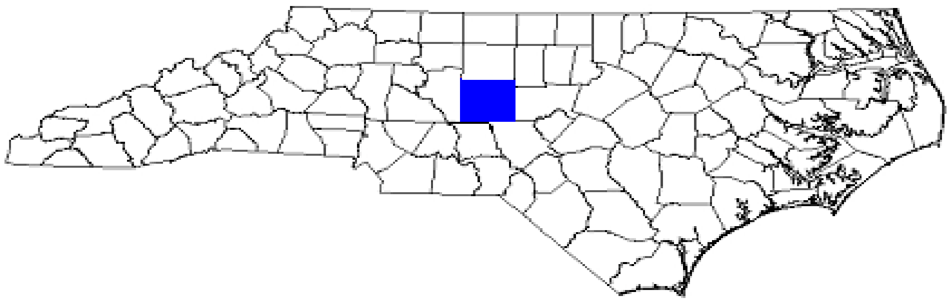
ANNUAL REPORT FOR 2004



Tulula Bog Stream Site
Graham County
Project No. 6.939004T
TIP No. A-9WM

Prepared By:
Office of Natural Environment & Roadside Environmental Unit
North Carolina Department of Transportation
October 2004

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APPENDICIES

Summary

The following report summarizes the stream monitoring activities that have occurred during the Year 2004 at the Tulula Bog Site. The site is located in Graham County, North Carolina. The stream portion of the site is being monitored by UNC-A for NCDOT through a research grant. This report provides the monitoring results for the second documented year of monitoring (Year 2004).

The site was originally constructed in 2002. The Phase I portion of the site was planted in April 2002, while Phase II was planted in March 2003. UNC-A has split the stream monitoring into eight separate reaches (I, Ia, II, III, IV, Iva, V, Va). All documented information is being presented in this report. This includes profile and cross-sectional monitoring of each identified reach.

Per the letter from the Ecosystem Enhancement Program (EEP) to NCDOT dated August 25, 2004, the EEP has accepted the transfer of all off-site mitigation projects. The EEP will be responsible for fulfilling the remaining monitoring requirements and future remediation for this project.

1.0 INTRODUCTION

1.1 Project Description

The following report summarizes the stream monitoring activities that have occurred during the Year 2004 at the Tulula Bog Site. The stream portion of the site consists of 8,639 feet of restoration and 1,248 feet of preservation. The site was constructed in order to help replace highway-related impacts in the mountain region. The site is located off of Highway 129 between Topton and Robbinsville.

1.2 Project History

July 2000	Monitoring Gauges Installed
April 2002	Phase I Planted
March 2003	Phase II Planted
March - November 2003	Hydrologic Monitoring (1 yr.)
September 2003	Vegetation Monitoring (1 yr.)
March - November 2004	Hydrologic Monitoring (2 yr.)
July 2004	Vegetation Monitoring (2 yr.)
November 2004	Four Additional Plots Set and Counted

2.0 STREAM ASSESSMENT

2.1 Success Criteria

The success criteria, as defined by both USACE and DWQ permit conditions reference the August 2000 mitigation plan (Appendix B) and specific 401 conditions (Appendix C). These conditions require channel stability analysis and reference photos. Pre and post construction benthic monitoring was conducted and submitted to the regulatory agencies for review.

Natural streams are dynamic systems that are in a constant state of change. Longitudinal profile and cross section surveys will differ from year to year based on changes in the watershed. Natural channel stability is achieved by allowing the stream to develop a proper dimension, pattern, and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades. A stable stream consistently transports its sediment load, both in size and type, associated with local deposition and scour. Channel instability occurs when the scouring process leads to degradation, or excessive sediment deposition results in aggradation (Rosgen, 1996). The following surveys were conducted in support of the monitoring assessment:

- Longitudinal Profile Survey. This survey addressed the overall slope of the reach, as well as slopes between bed features. The bed features are secondary delineative criteria describing channel configuration in terms of riffle/pools, rapids, step/pools, cascades and convergence/divergence features which are inferred from channel plan form and gradient. The surveys are compared on a yearly basis to note and/or compare aggradation, degradation, head cuts, and areas of mass wasting. The longitudinal profile is expected to change from year to year. Significant changes may require additional monitoring.
- Cross Section Surveys. These surveys addressed the following characteristics at various locations along the reach: entrenchment ratio, width/depth ratio, and dominant channel materials. The entrenchment ratio is a computed index value used to describe the degree of vertical containment. The width/depth ratio is an index value that indicates the shape of the channel cross section.   The dominant channel materials refer to a selected size index value, the D50, representing the most prevalent of one of six channel material types or size categories, as determined from a channel material size distribution index.

2.2 Stream Description

The proposed design for Tulula Bog was an E4 stream type according to the Rosgen Classification of Natural Rivers. Prior to construction, the channel was incised below the historic stream grade and was straightened. A total of 32 cross sections were established and surveyed along the stream.

Table 1. Abbreviated Morphological Summary Tulula Bog Site

Variable		*See Appendix A Reach Data for Cross Section Monitoring Results*						
		Proposed Design Range		Year 1	Year 2	Year 3	Year 4	Year 5
Drainage Area (mi²)		2.41						
Bankfull Width (ft)	Mean	8.0 - 10.0						
Bankfull Mean Depth (ft)	Mean	1.6 - 2.9						
Width/Depth Ratio	Mean	3.1 - 6.3						
Bankfull Cross Sectional Area (ft²)	Mean	15 - 20						
Maximum Bankfull Depth (ft)	Mean	2.2 - 5.3						
Width of Floodprone Area (ft)	Mean	290 - 480						
Entrenchment Ratio	Mean	31 - 64						
Slope		0.0017 - 0.002						
Particle Sizes (Riffle Sections)								
D_{16} (mm)		0.25 - 0.50						
D_{35} (mm)		0.50 - 1.0						
D_{50} (mm)		1.0 - 2.0						
D_{84} (mm)		5.0 - 8.0						
D_{95} (mm)		N/A						

2.3 Results of the Stream Assessment

2.3.1 Site Data

The assessment included the survey of four total cross sections associated with each reach, as well as the longitudinal profiles. Cross section locations were established by UNC-A and consist of two riffles and two pools for each reach. Approximately 2,000 linear feet of channel was surveyed along Tulula Creek. Benchmark stakes were installed on both the left and right stream banks for each cross section location. Pebble counts were also taken for each reach. Due to construction methods water was released in different reaches at different times. These dates are shown below.

- Reach I. Water released on September 11, 2001
  Profile data (2001, 2002, and 2004)
  Cross-section data (2001, 2002, 2003, and 2004)
  Pebble count data (2003 and 2004)

- Reach Ia. Water released on September 11, 2001
  Profile data (2001, early 2002, late 2002, 2003, and 2004)

Cross-section data (2001, 2002, 2003, and 2004)
Pebble count data (2003 and 2004)

- Reach II. Water released on October 16, 2001
  Profile data (2001, early 2002, late 2002, 2003, and 2004)
  Cross-section data (2001, 2002, 2003, and 2004)
  Pebble count data (2003 and 2004)

- Reach III. Water released on October 16, 2001
  Profile data (2001, early 2002, late 2002, 2003, and 2004)
  Cross-section data (2001, 2002, 2003, and 2004)
  Pebble count data (2003 and 2004)

- Reach IV. Water released on November 14, 2001
  Profile data (2001, early 2002, late 2002, 2003, and 2004)
  Cross-section data (2001, 2002, 2003, and 2004)
  Pebble count data (2003 and 2004)

- Reach IVa. Water released on November 14, 2001
  Profile data (2001, early 2002, late 2002, and 2004)
  Cross-section data (2001, 2002, 2003, and 2004)
  Pebble count data (2004)

- Reach V. Water released on May 27, 2002
  Profile data (2002, 2003, and 2004)
  Cross-section data (2002, 2003, and 2004)
  Pebble count data (2004)

- Reach Va. Water released on June 25, 2002
  Profile data (2004)
  Cross-section data (2002 and 2004)
  Pebble count data (2004)

The cross sections established during the monitoring survey are currently being monitored to determine the actual extent of aggradation or degradation. All of the cross section locations appeared stable with little or no active bank erosion. Some degradation was noted during initial water release but cross sections remain stable from 2003 to 2004. Longitudinal profile data has also been collected for each reach. Survey data collected during each monitoring periods may vary depending on actual location of rod placement and alignment; however, this information should remain similar in overall appearance. Longitudinal surveys, cross section comparisons, and pebble count comparisons are presented in Appendix A.

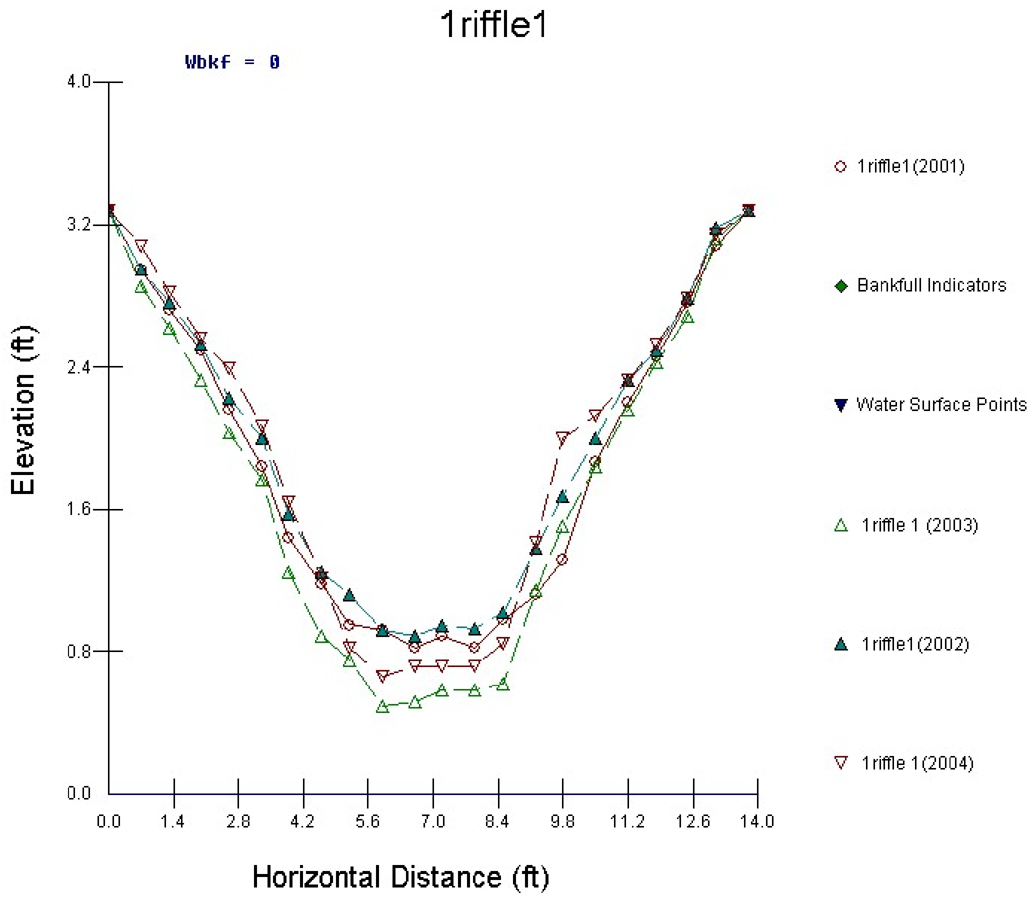
Pebble counts were taken as a means to determine the composition of bed material during the monitoring period. This data is presented within each reach.

The movement of some reaches to finer materials may be a result of beaver activity within the site.

2.4 Conclusions

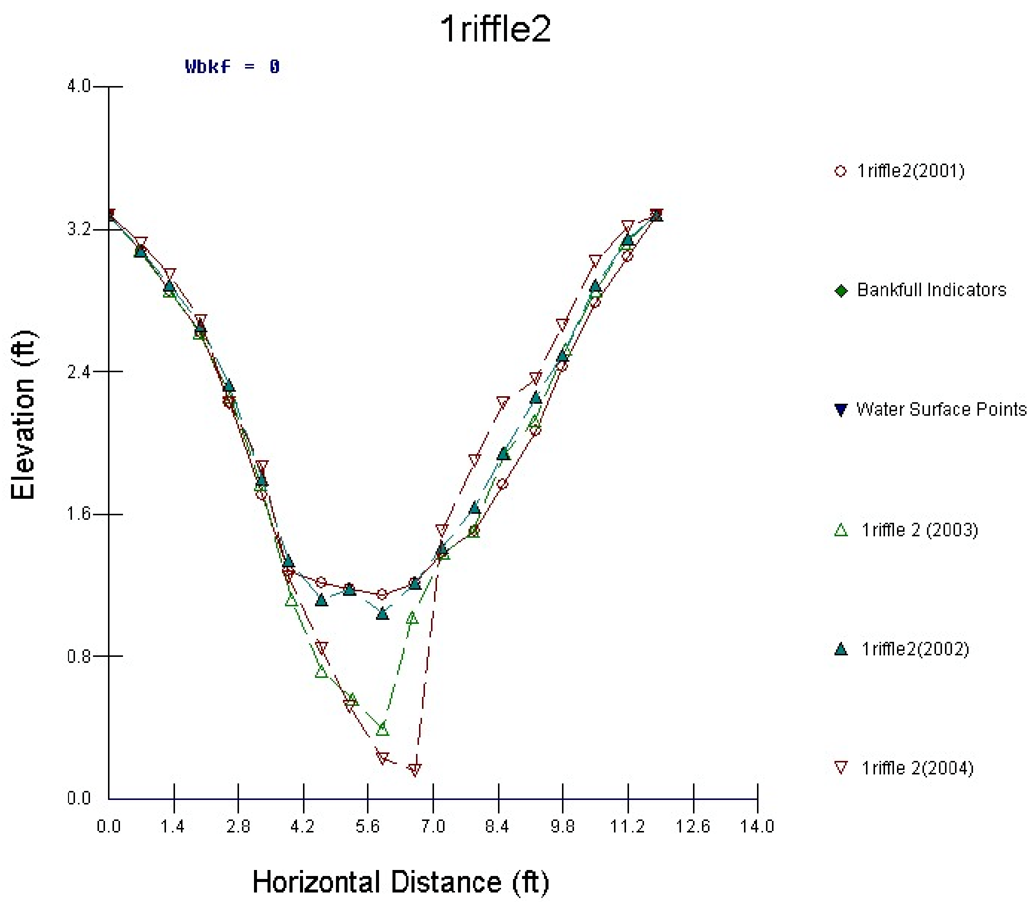
Overall, Tulula Creek remains stable. Areas of initial degradation exist along each stream reach; however, these areas seem to have stabilized. Localized areas of sloughing and erosion do exist, however work associated with corrective actions would likely cause more sedimentation than actual benefit at the current time. Beaver activity within the site is contributing to some localized stability problems. Beaver control activities are currently ongoing within the site.

The EEP will work with UNC-A to monitor stream stability monitoring at the Tulula Creek Mitigation Site in 2005.



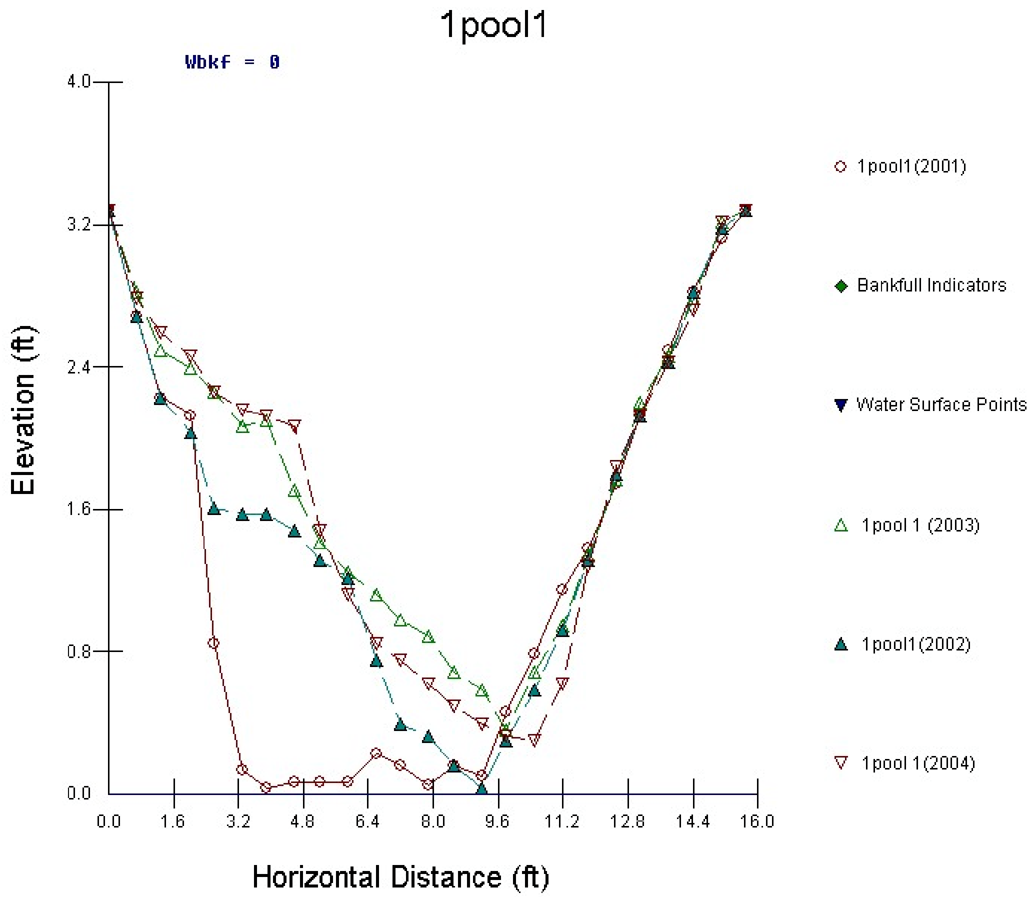
Cross-Section #1 (1Riffle1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**20.1**	**18.8**	**21.92**	**19.04**	
Maximum Bankfull Depth (ft)	**2.46**	**2.39**	**2.79**	**2.62**	
Bankfull Mean Depth (ft)	**1.46**	**1.36**	**1.59**	**1.38**	
Bankfull Width (ft)	**13.8**	**13.8**	**13.8**	**13.8**	



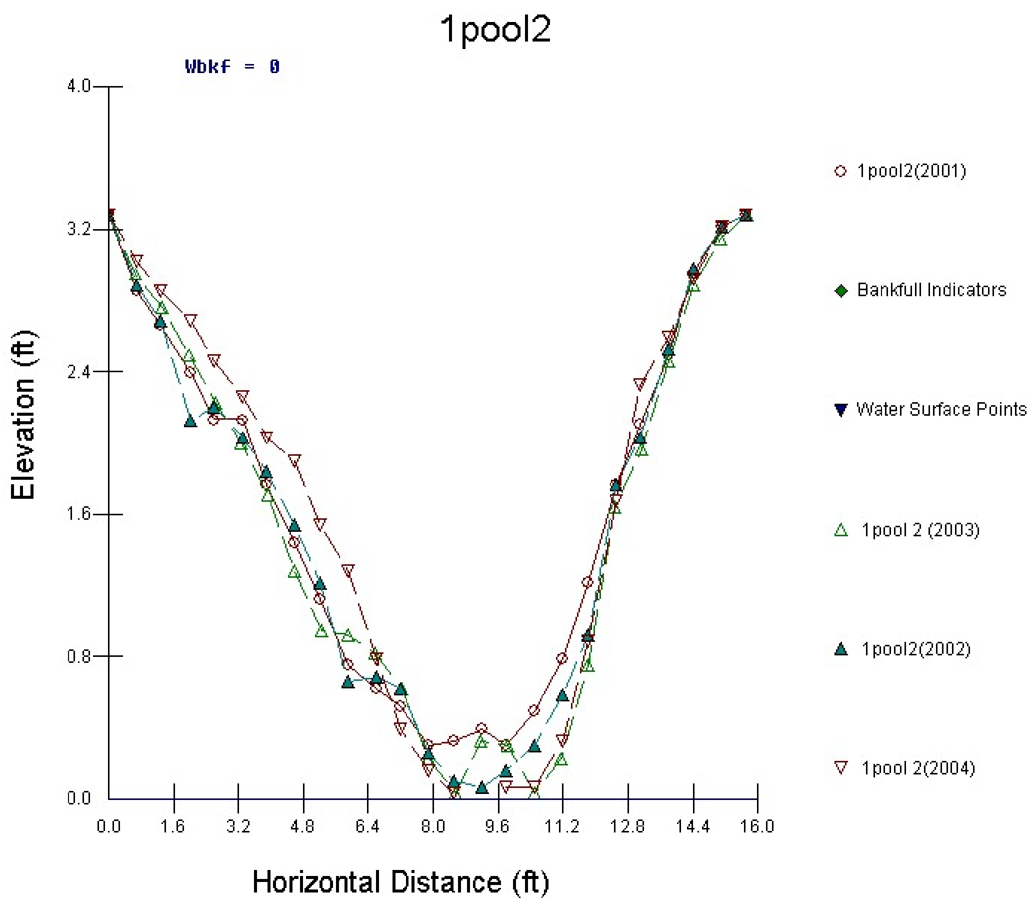
Cross-Section #2 (1Riffle2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**14.59**	**13.99**	**15.69**	**15.12**	
Maximum Bankfull Depth (ft)	**2.13**	**2.23**	**2.89**	**3.12**	
Bankfull Mean Depth (ft)	**1.24**	**1.19**	**1.33**	**1.28**	
Bankfull Width (ft)	**11.8**	**11.8**	**11.8**	**11.8**	



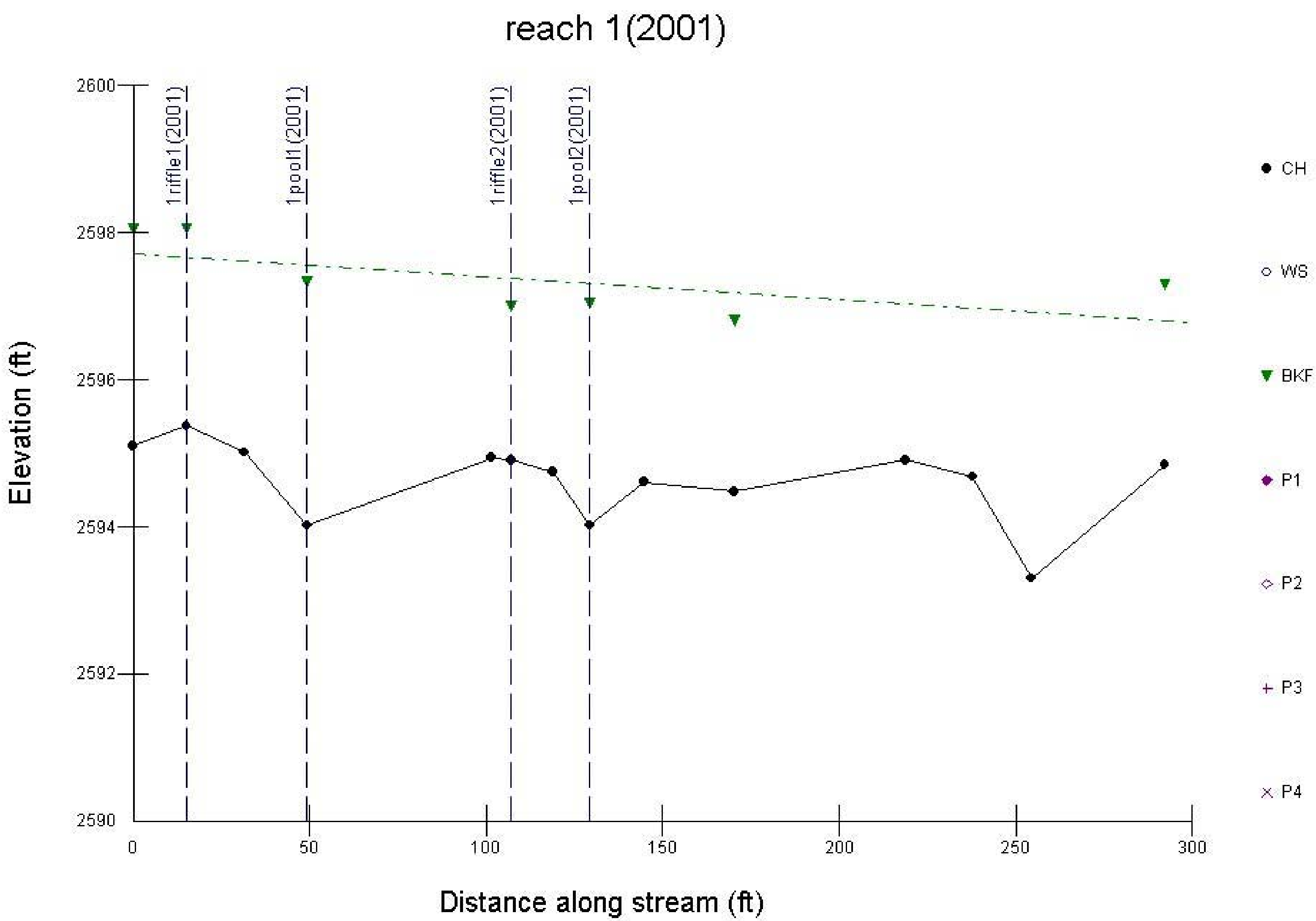
Cross-Section #3 (1Pool1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**30.74**	**27.93**	**24.22**	**25.23**	
Maximum Bankfull Depth (ft)	**3.1**	**3.25**	**2.92**	**2.98**	
Bankfull Mean Depth (ft)	**2.05**	**1.78**	**1.54**	**1.61**	
Bankfull Width (ft)	**14.96**	**15.7**	**15.7**	**15.7**	

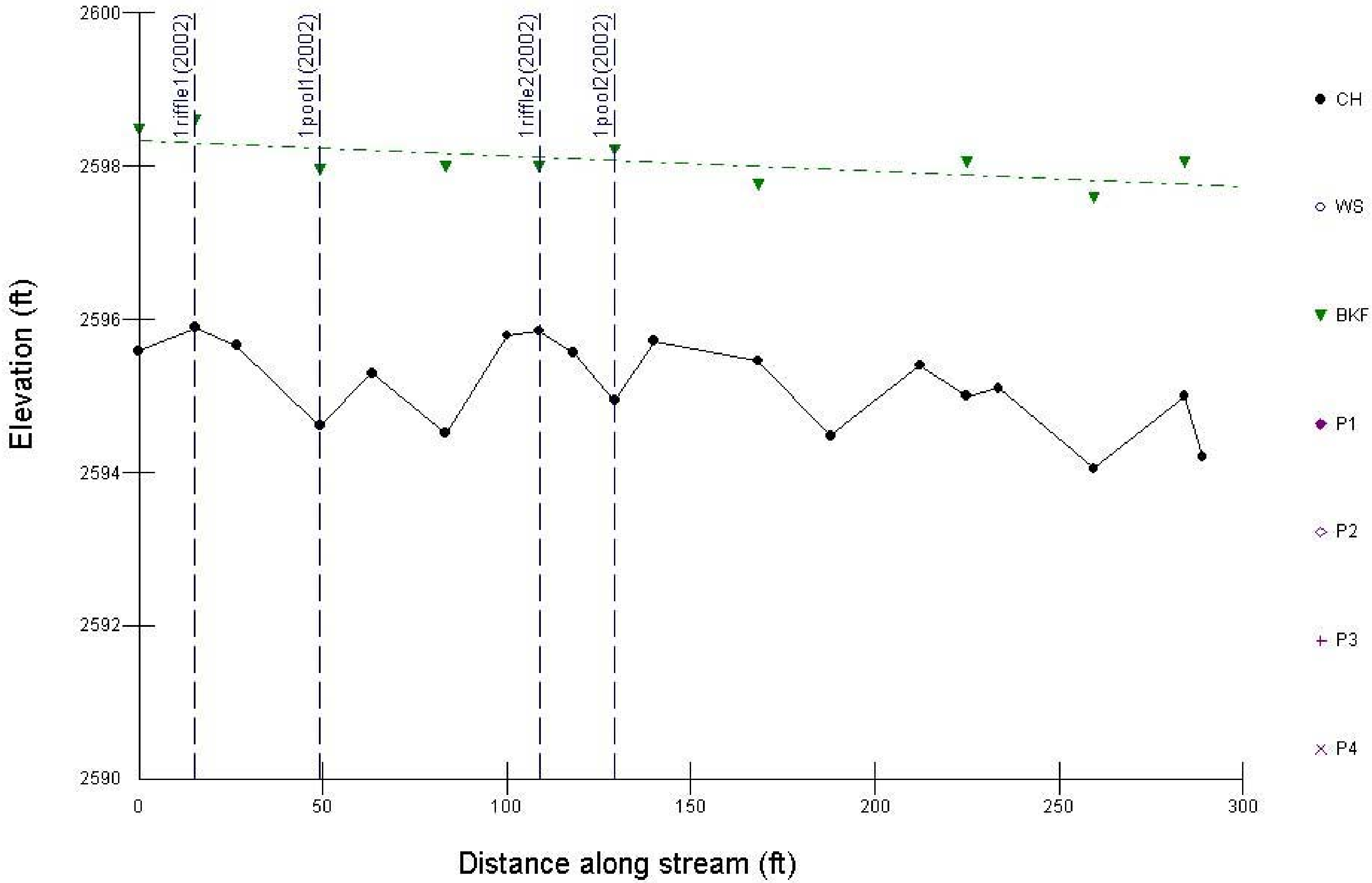


Cross-Section #4 (1Pool2) Abbreviated Morphological Summary

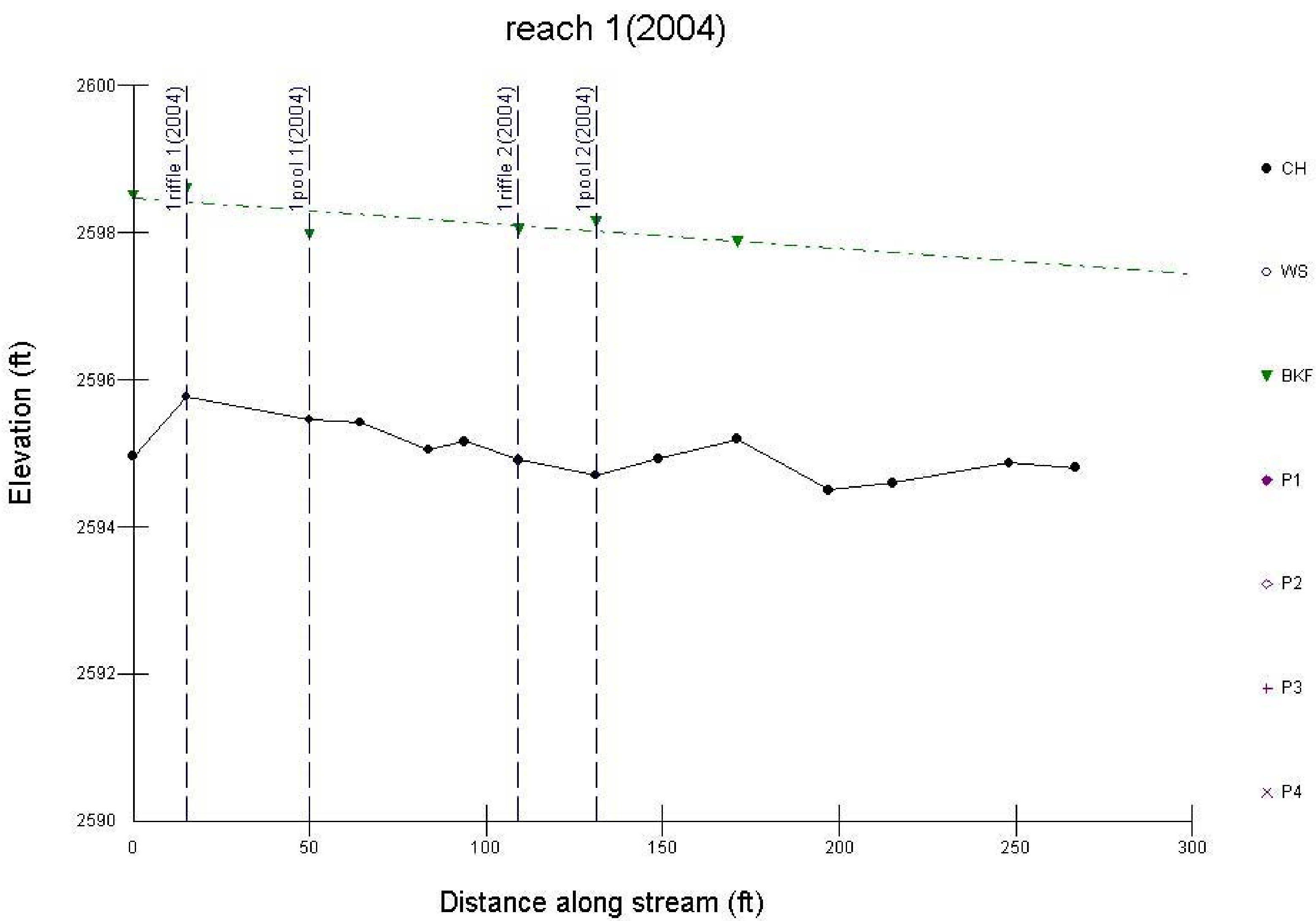
	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	26.74	27.59	28.02	26.23	
Maximum Bankfull Depth (ft)	2.98	3.21	3.25	3.28	
Bankfull Mean Depth (ft)	1.7	1.76	1.78	1.67	
Bankfull Width (ft)	15.7	15.7	15.75	15.7	


reach 1(2001)
Elevation (ft)
Distance along stream (ft)
1riffle1(2001)
1pool1(2001)
1riffle2(2001)
1pool2(2001)
2600
2598
2596
2594
2592
2590
0
50
100
150
200
250
300
CH
WS
BKF
P1
P2
P3
P4

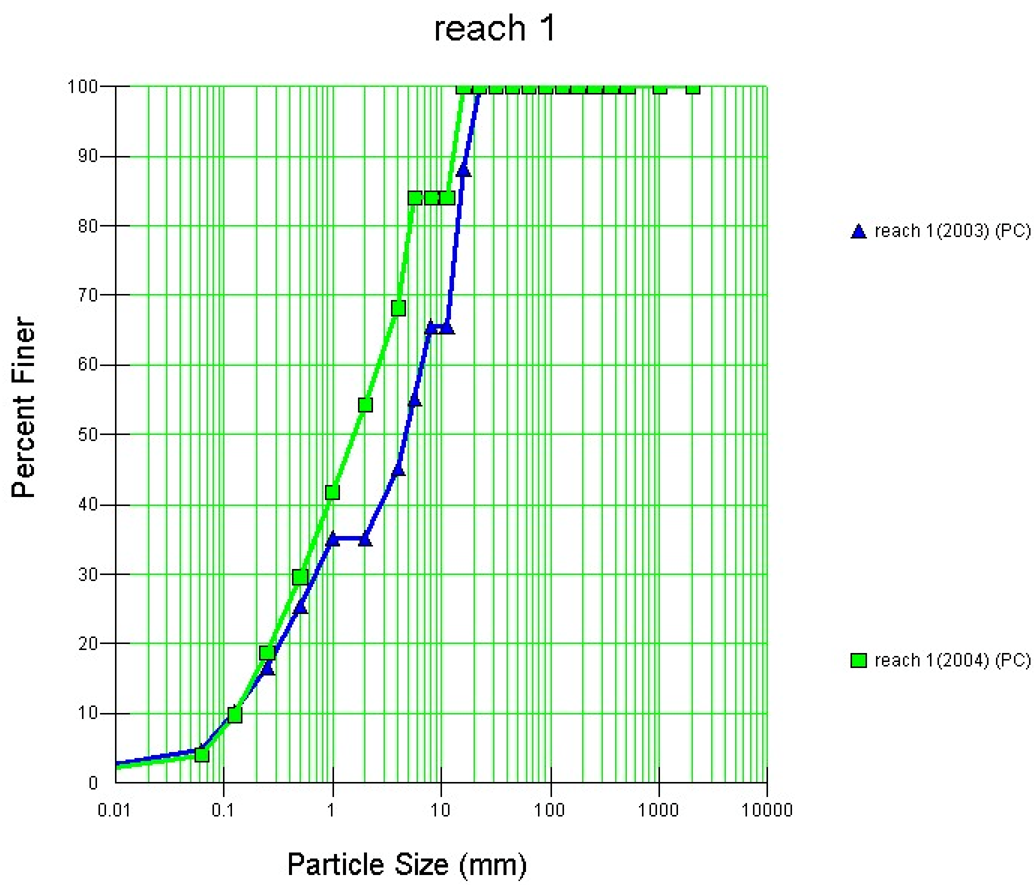
reach 1 (2002)

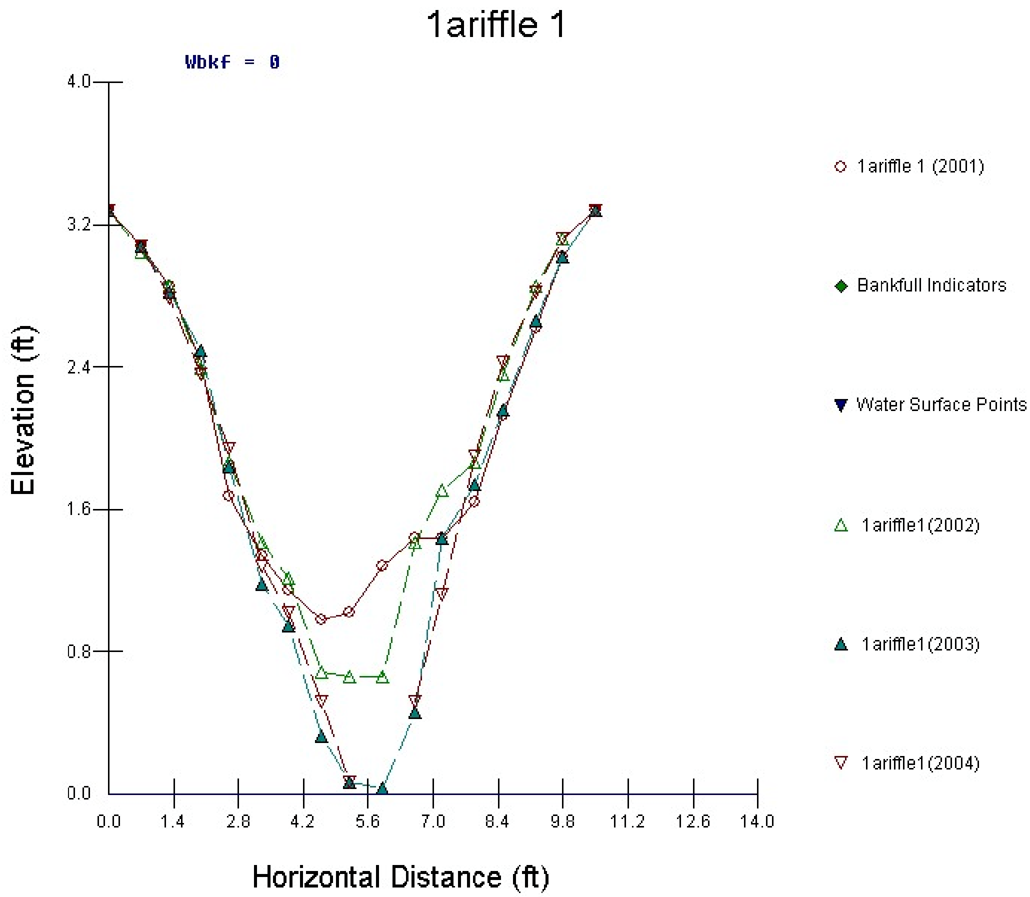


2600
2598
2596
2594
2592
2590
Elevation (ft)
0
50
100
150
200
250
300
Distance along stream (ft)
1 riffle1 (2002)
1 pool1 (2002)
1 riffle2 (2002)
1 pool2 (2002)
CH
WS
BKF
P1
P2
P3
P4



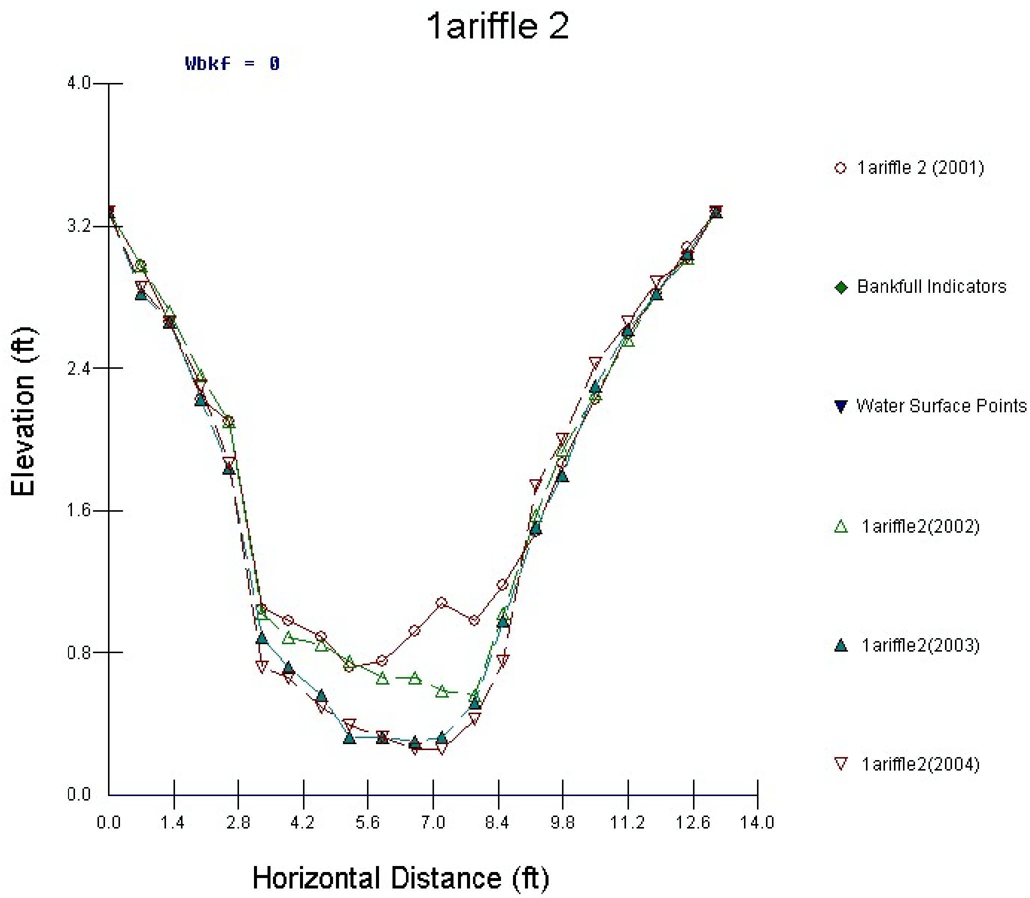
reach 1(2004)
Elevation (ft)
Distance along stream (ft)
2600
2598
2596
2594
2592
2590
0
50
100
150
200
250
300
1 riffle 1(2004)
1 pool 1(2004)
1 riffle 2(2004)
1 pool 2(2004)
CH
WS
BKF
P1
P2
P3
P4


reach 1
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)
reach 1(2003) (PC)
reach 1(2004) (PC)



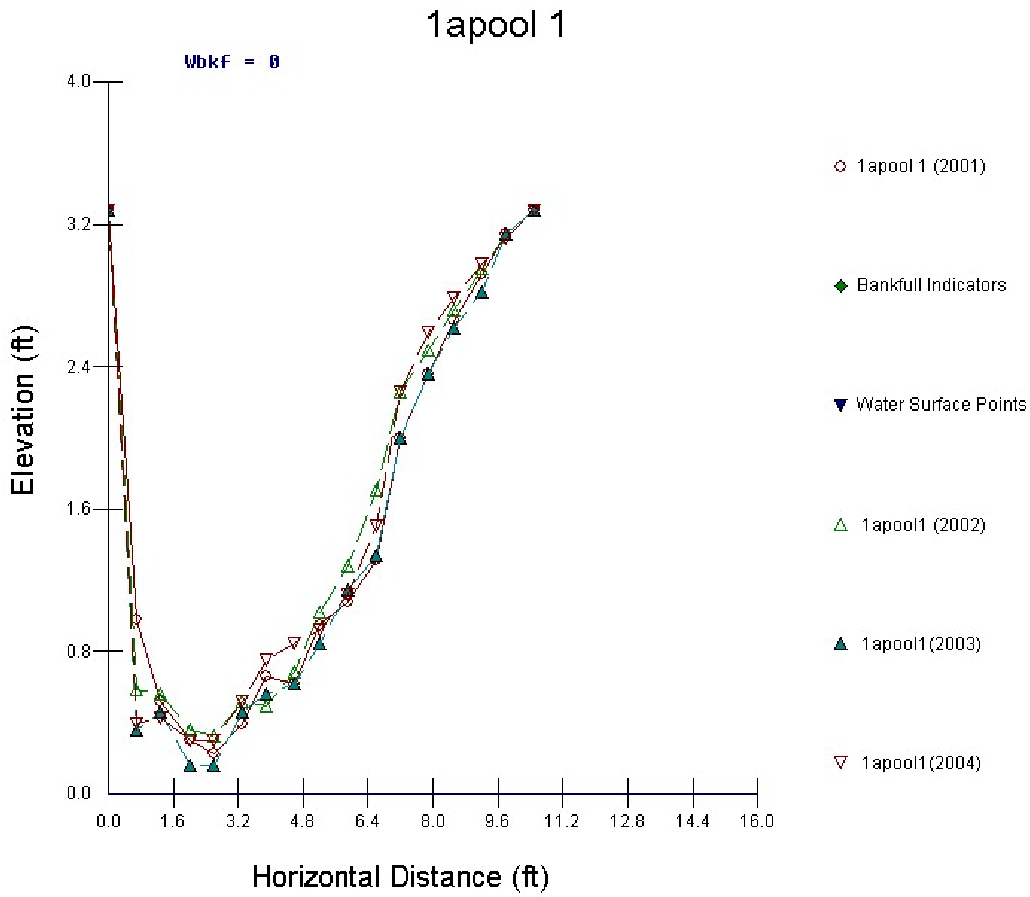
Cross-Section #1 (1aRiffle1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	13.82	13.84	16.37	15.91	
Maximum Bankfull Depth (ft)	2.3	2.62	3.25	3.28	
Bankfull Mean Depth (ft)	1.32	1.32	1.56	1.52	
Bankfull Width (ft)	10.5	10.5	10.5	10.5	



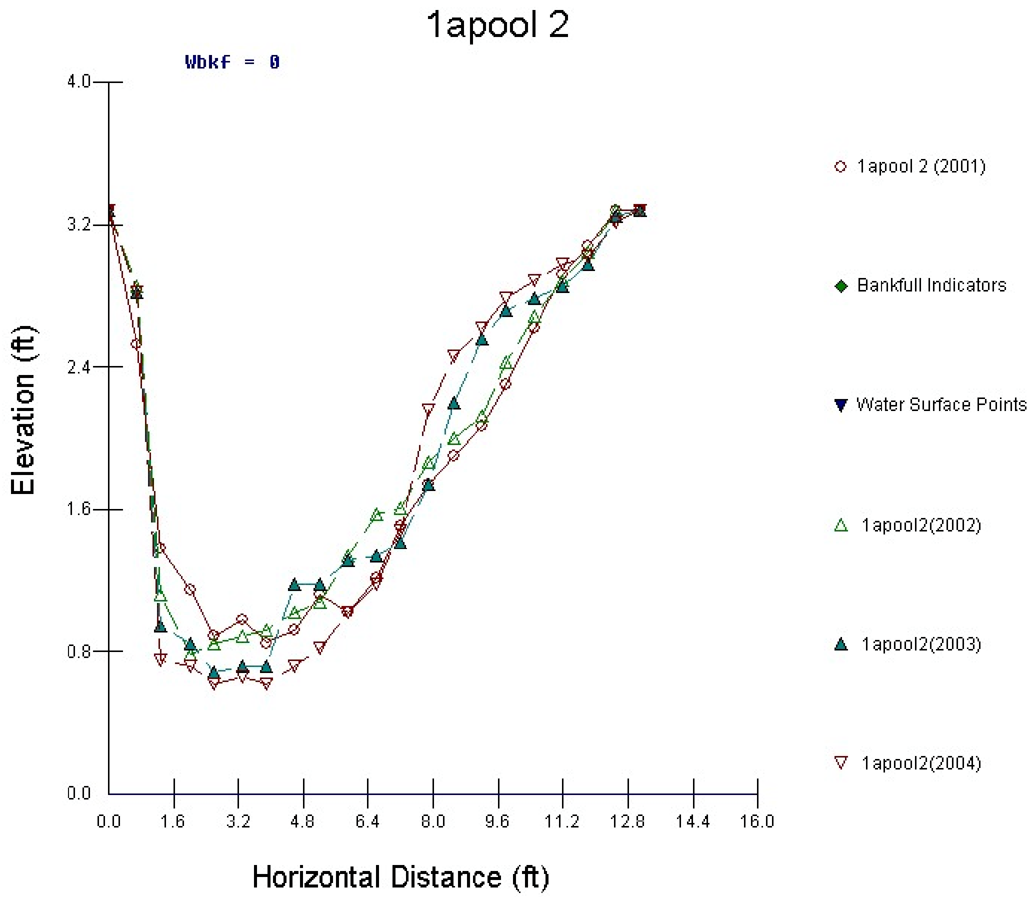
Cross-Section #2 (1aRiffle2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**19.5**	**20.33**	**22.11**	**22.04**	
Maximum Bankfull Depth (ft)	**2.56**	**2.72**	**2.98**	**3.02**	
Bankfull Mean Depth (ft)	**1.49**	**1.55**	**1.69**	**1.68**	
Bankfull Width (ft)	**13.1**	**13.1**	**13.1**	**13.1**	



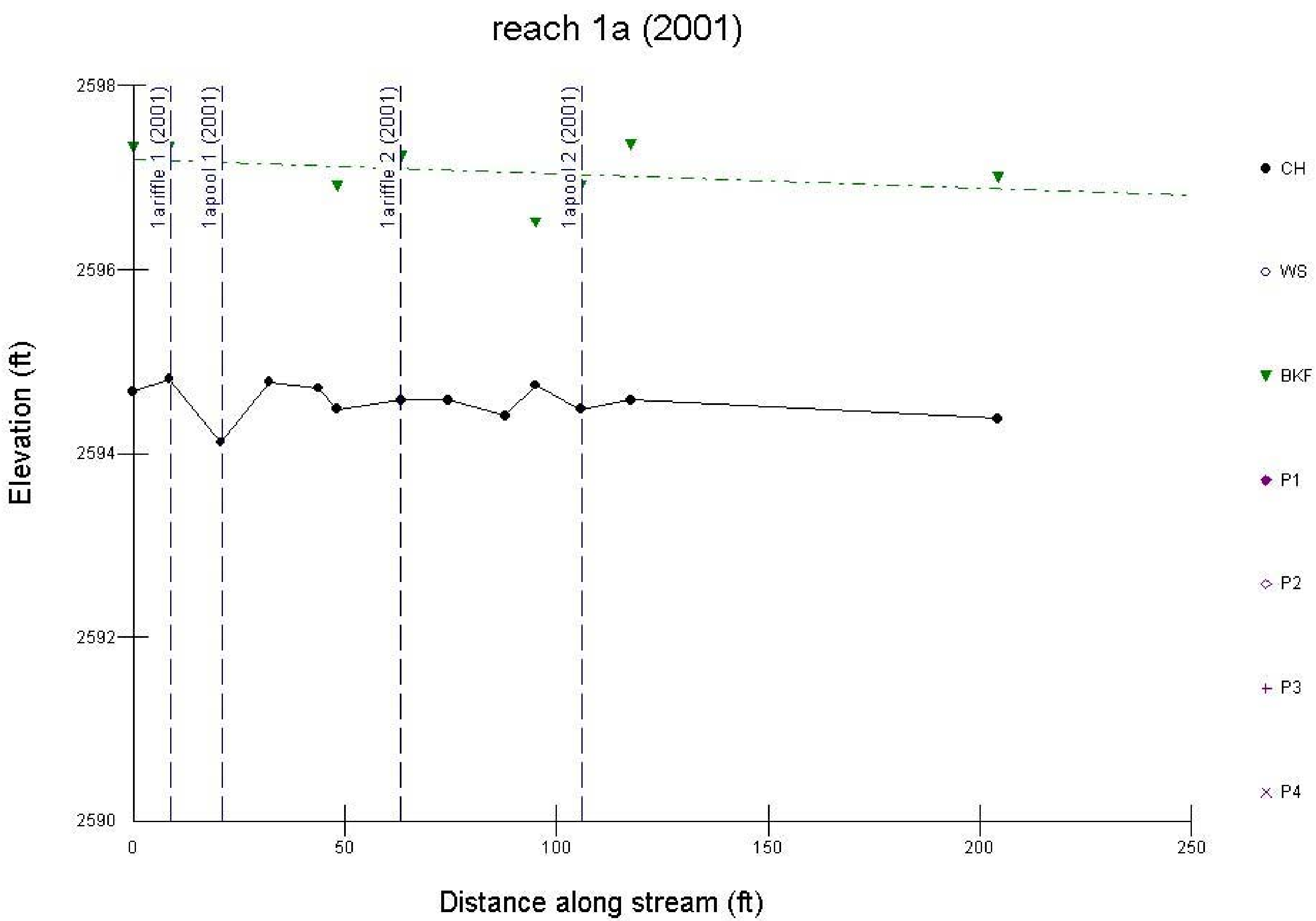
Cross-Section #3 (1aPool1) Abbreviated Morphological Summary

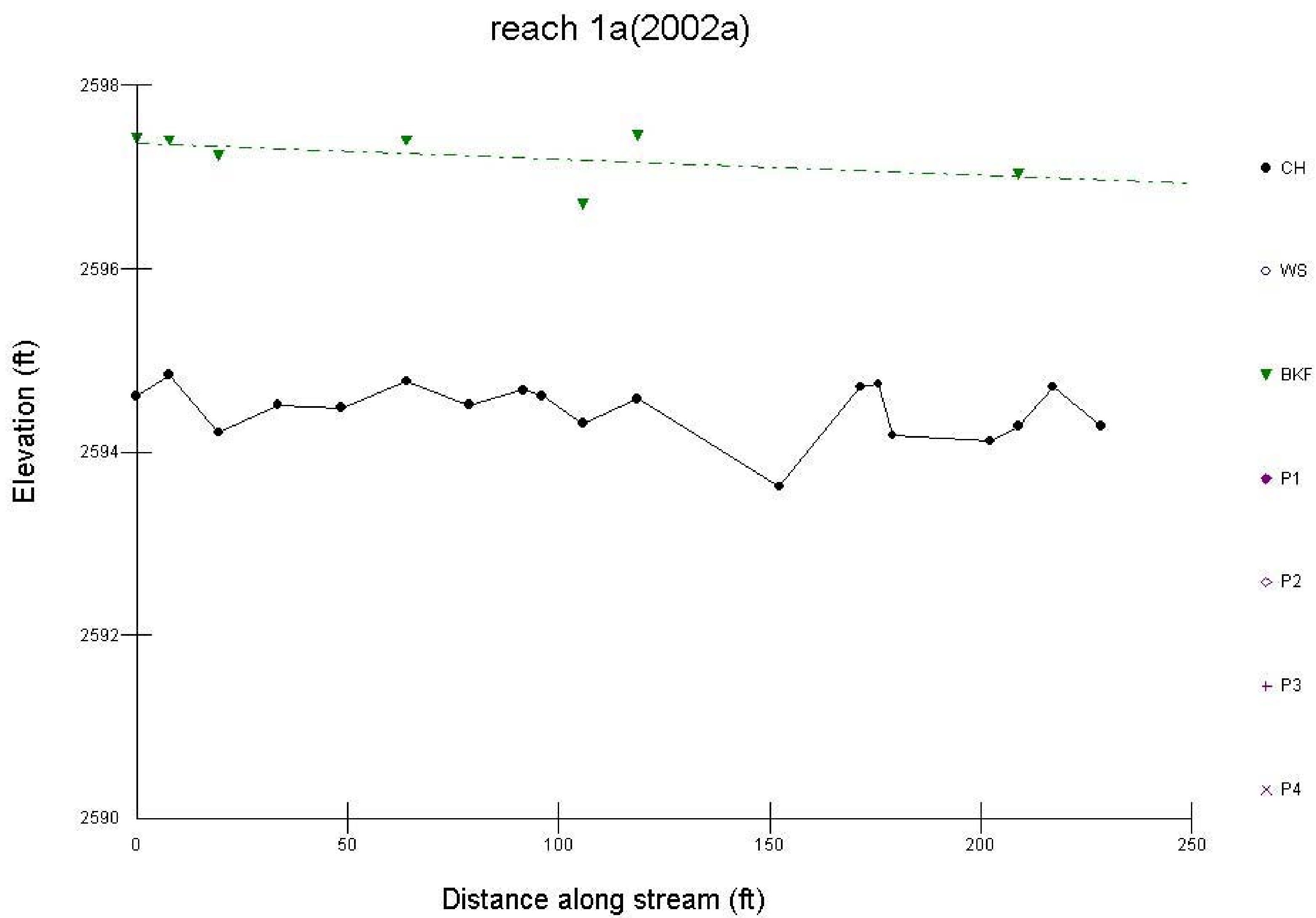
	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**19.01**	**18.35**	**19.69**	**18.55**	
Maximum Bankfull Depth (ft)	**3.05**	**2.95**	**3.12**	**2.98**	
Bankfull Mean Depth (ft)	**1.81**	**1.75**	**1.88**	**1.77**	
Bankfull Width (ft)	**10.5**	**10.5**	**10.5**	**10.5**	



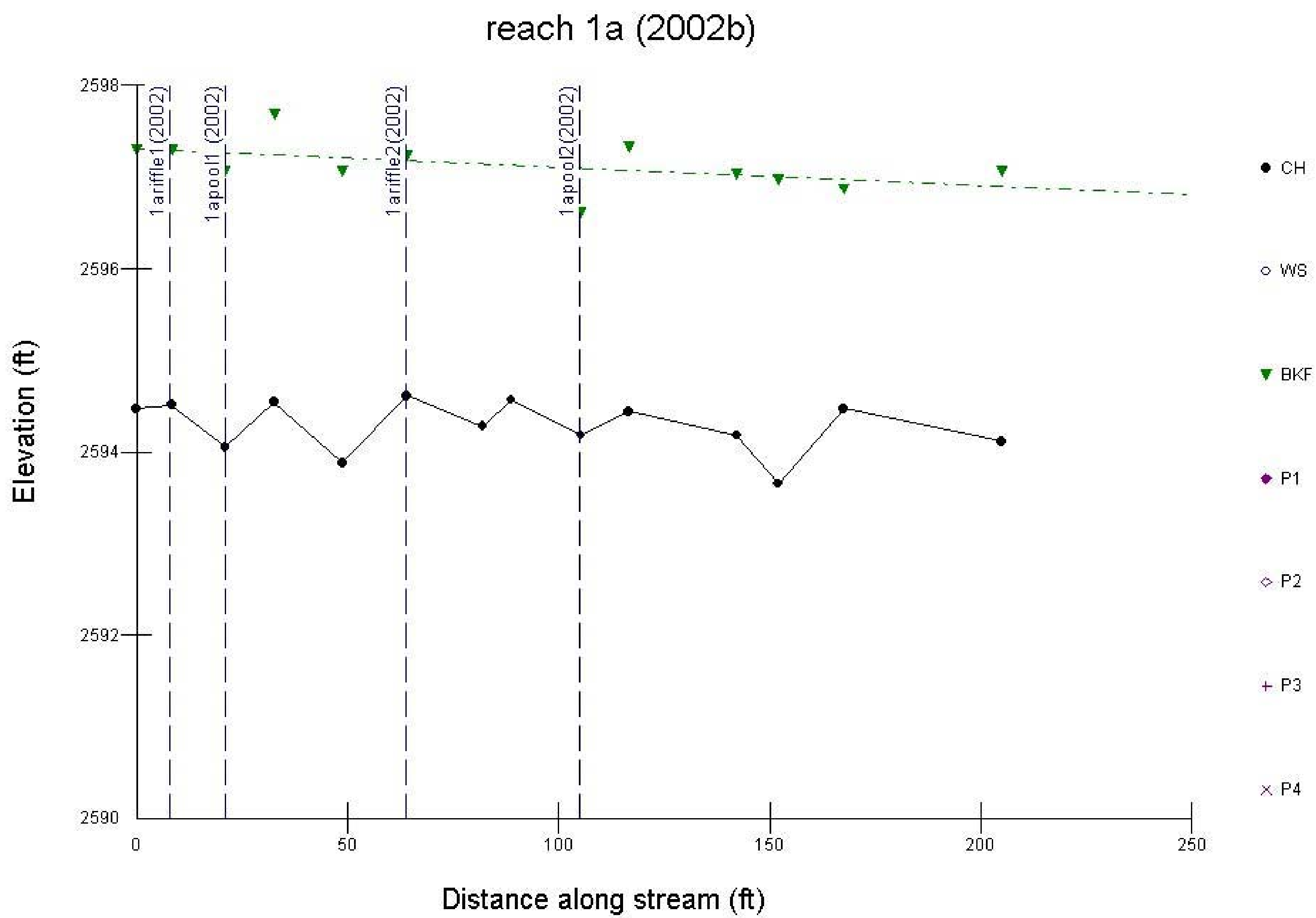
Cross-Section #4 (1aPool2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**18.9**	**18.29**	**18.36**	**18.84**	
Maximum Bankfull Depth (ft)	**2.43**	**2.49**	**2.59**	**2.66**	
Bankfull Mean Depth (ft)	**1.51**	**1.46**	**1.4**	**1.44**	
Bankfull Width (ft)	**12.5**	**12.5**	**13.1**	**13.1**	

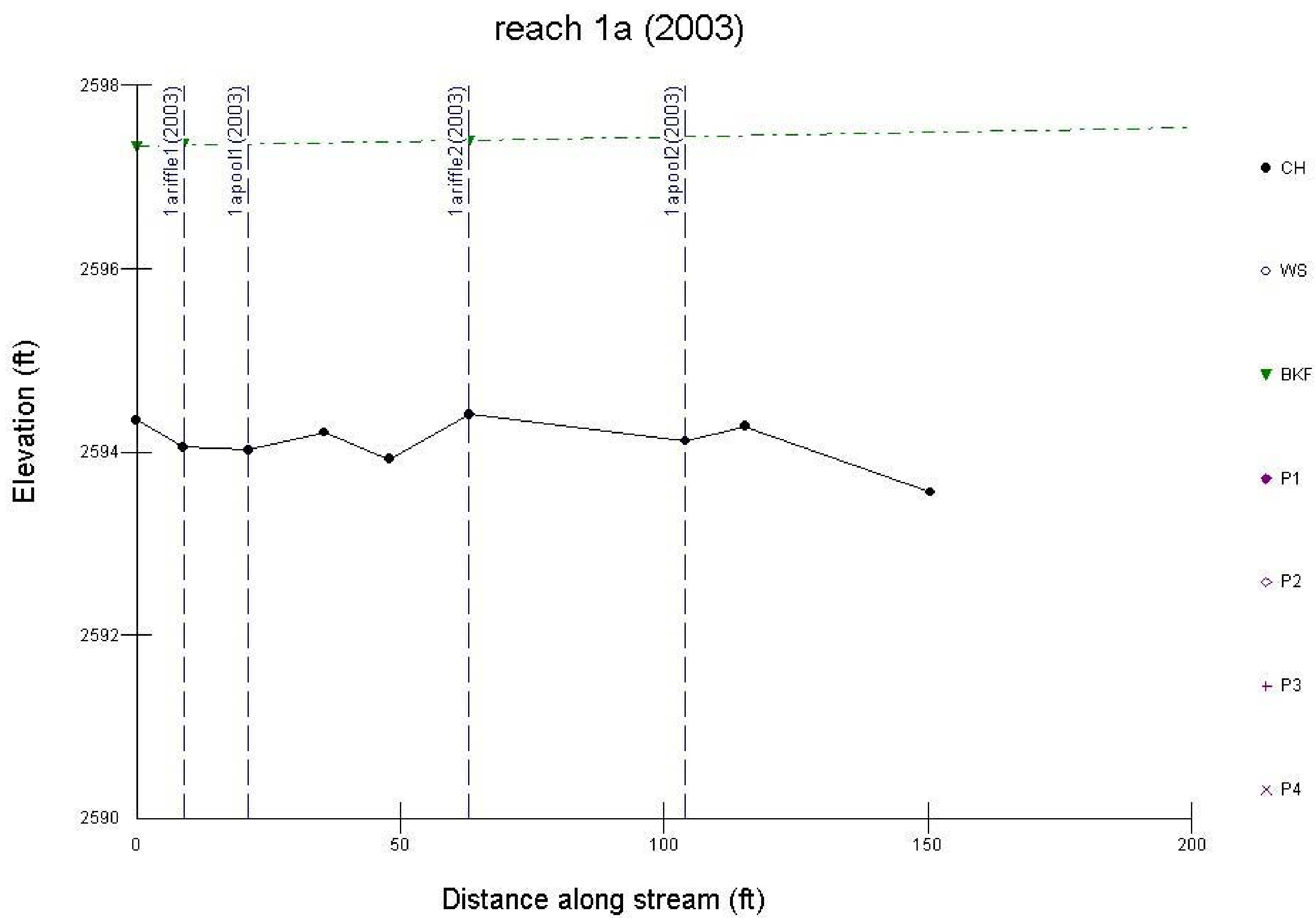

reach 1a (2001)
Elevation (ft)
2598
2596
2594
2592
2590
0
50
100
150
200
250
Distance along stream (ft)
1a riffle 1 (2001)
1a pool 1 (2001)
1a riffle 2 (2001)
1a pool 2 (2001)
CH
WS
BKF
P1
P2
P3
P4



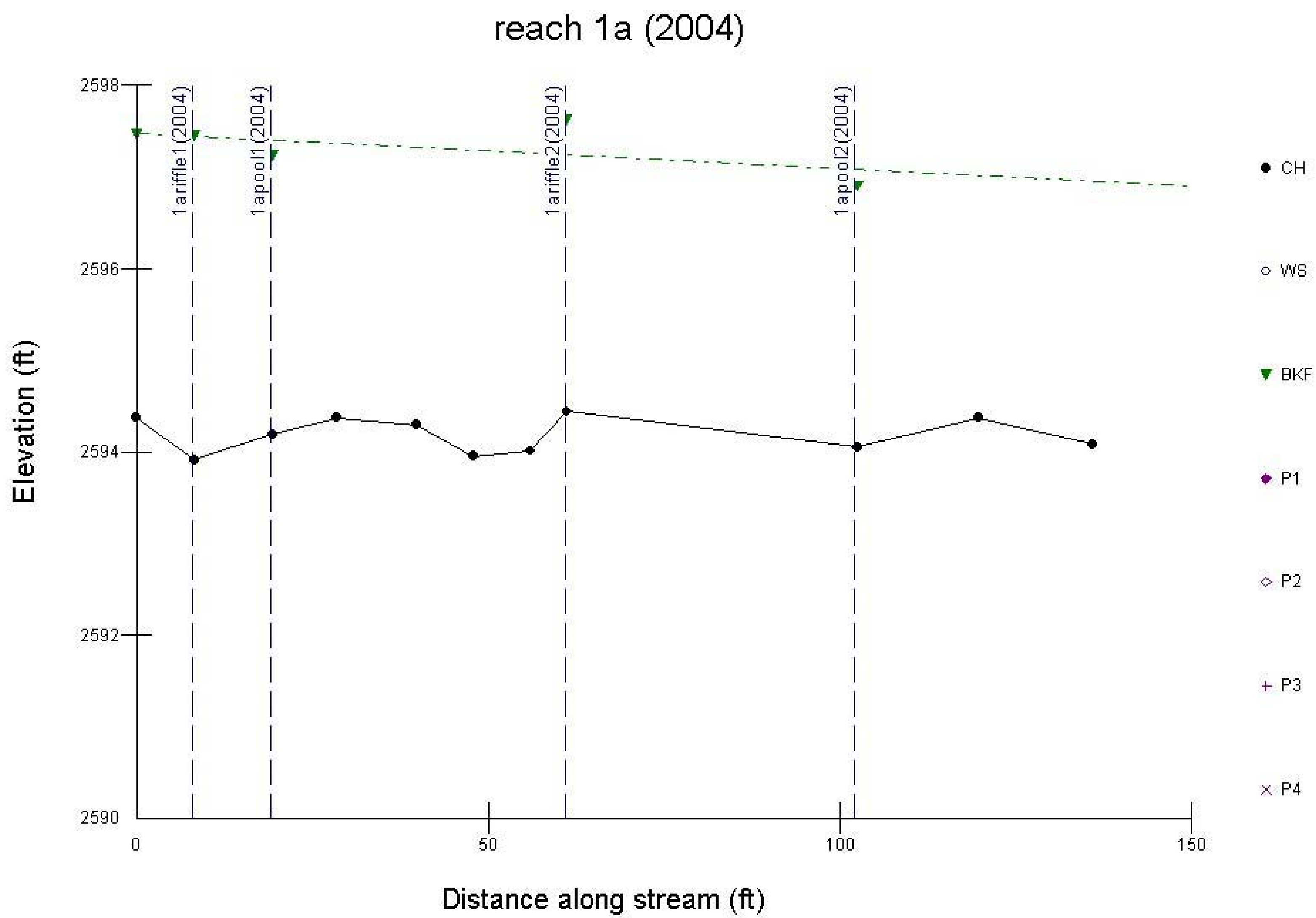
reach 1a(2002a)
Elevation (ft)
2598
2596
2594
2592
2590
0
50
100
150
200
250
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4



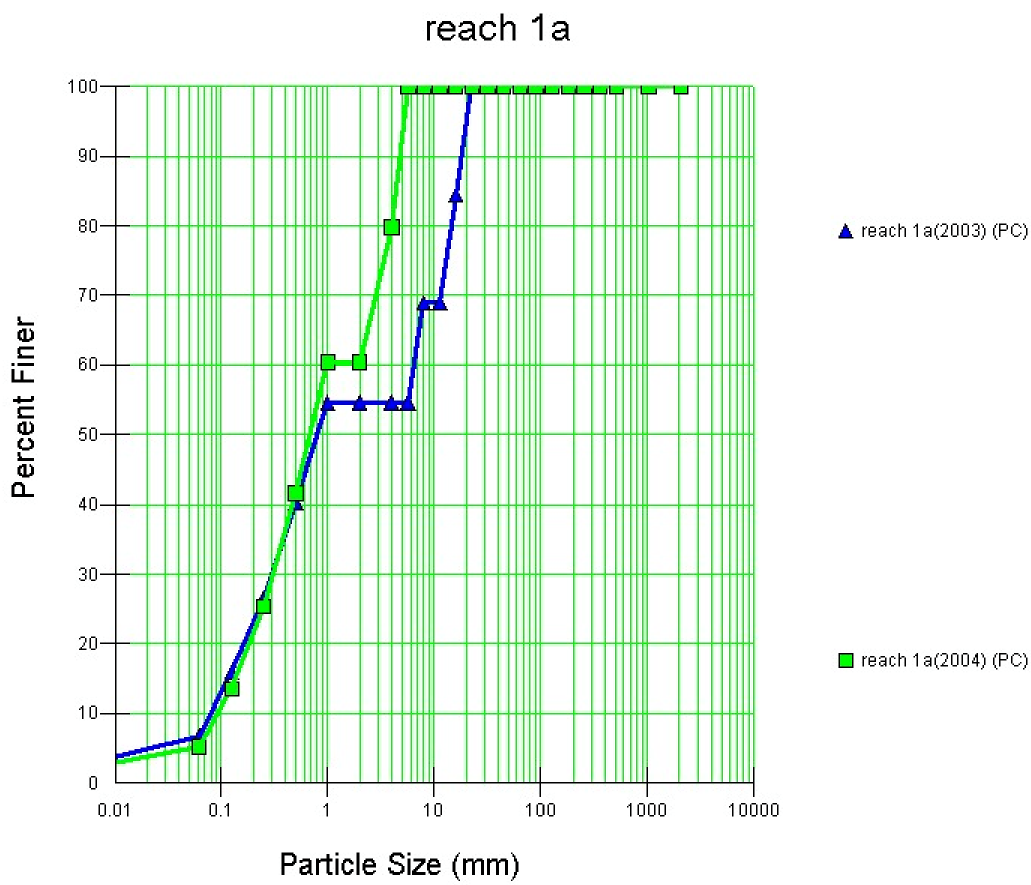
reach 1a (2002b)
Elevation (ft)
Distance along stream (ft)
2598
2596
2594
2592
2590
0
50
100
150
200
250
1 ariffle1 (2002)
1 apool1 (2002)
1 ariffle2 (2002)
1 apool2 (2002)
CH
WS
BKF
P1
P2
P3
P4

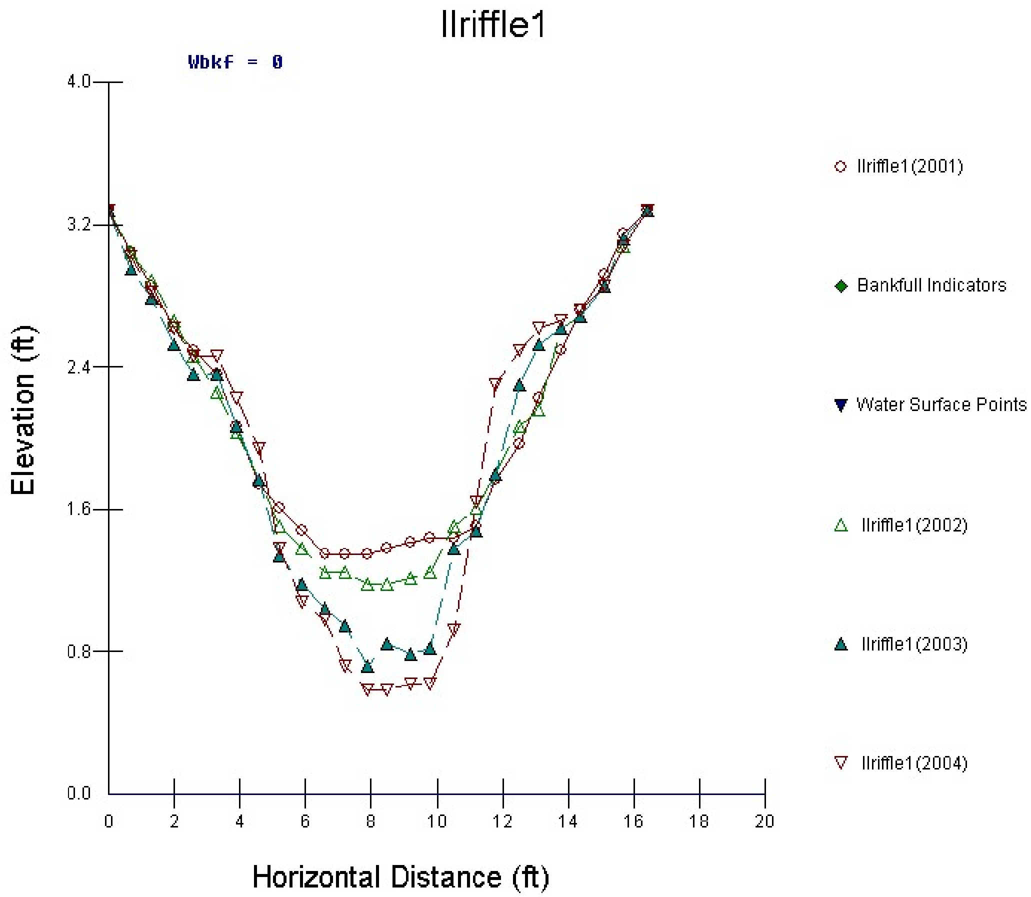


reach 1a (2003)
Elevation (ft)
2598
2596
2594
2592
2590
0
50
100
150
200
Distance along stream (ft)
1ariffle1(2003)
1apool1(2003)
1ariffle2(2003)
1apool2(2003)
CH
WS
BKF
P1
P2
P3
P4



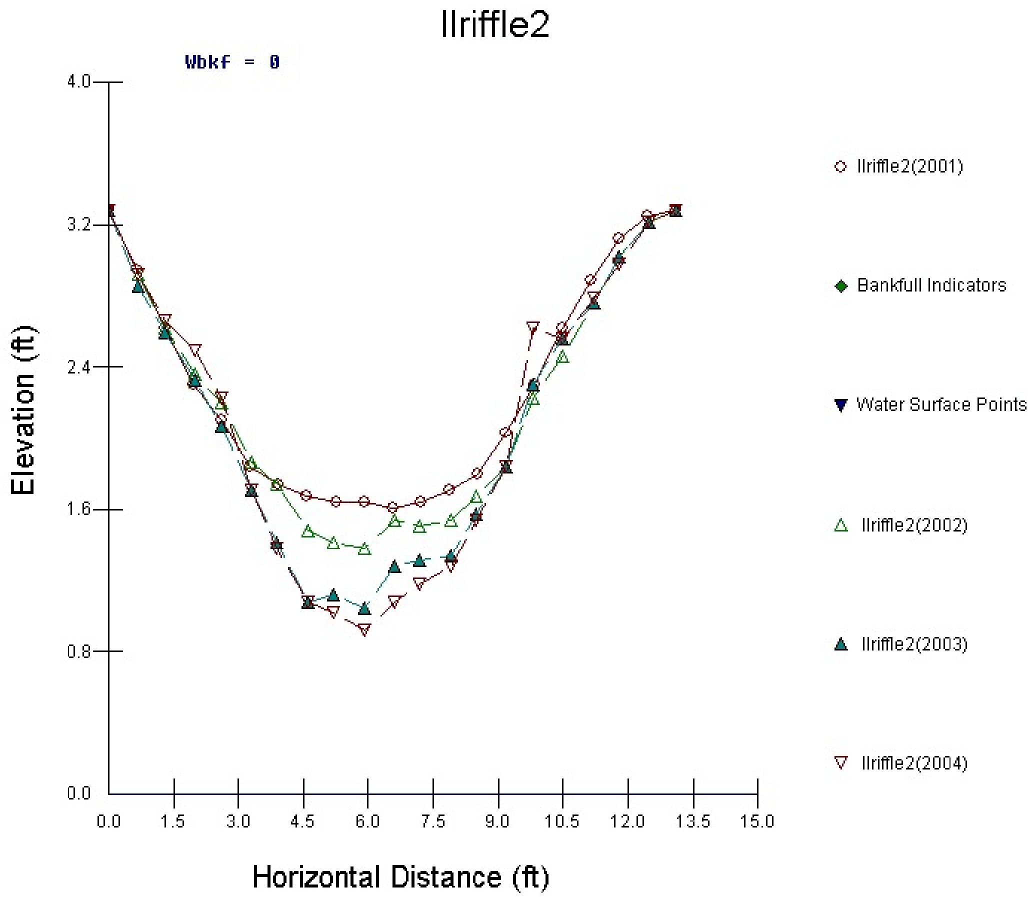
reach 1a (2004)
Elevation (ft)
Distance along stream (ft)
2598
2596
2594
2592
2590
0
50
100
150
1ariffle1(2004)
1apool1(2004)
1ariffle2(2004)
1apool2(2004)
CH
WS
BKF
P1
P2
P3
P4


reach 1a
Percent Finer
Particle Size (mm)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.1
1
10
100
1000
10000
reach 1a(2003) (PC)
reach 1a(2004) (PC)



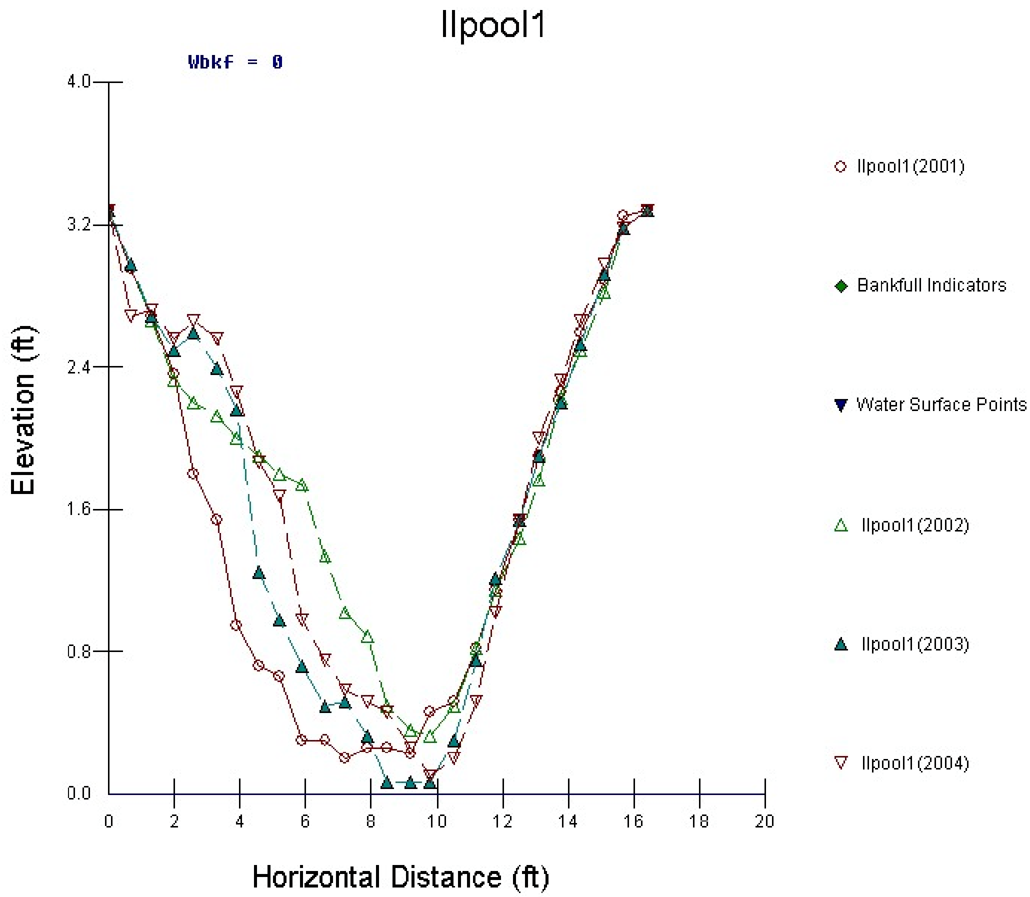
Cross-Section #1 (2Riffle1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**19.66**	**20.33**	**21.92**	**21.88**	
Maximum Bankfull Depth (ft)	**1.93**	**2.1**	**2.56**	**2.69**	
Bankfull Mean Depth (ft)	**1.2**	**1.24**	**1.34**	**1.33**	
Bankfull Width (ft)	**16.4**	**16.4**	**16.4**	**16.4**	



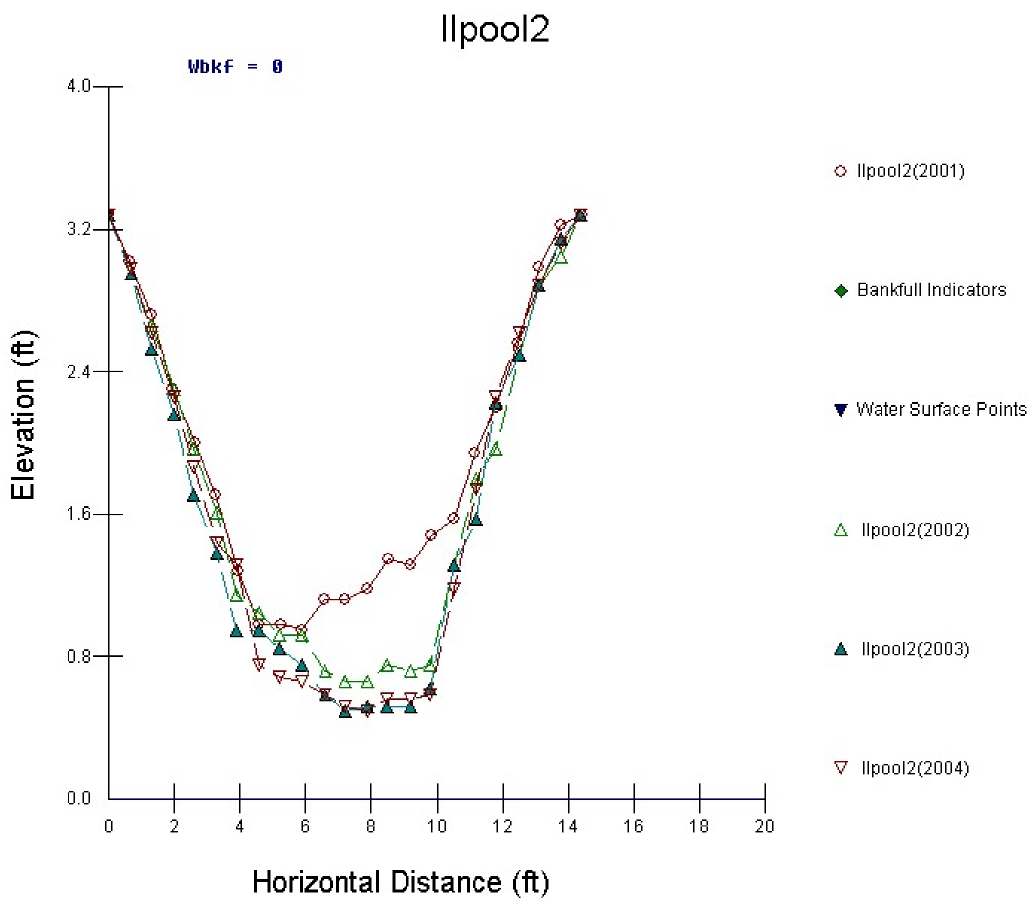
Cross-Section #2 (2Riffle2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**13.68**	**14.8**	**16.35**	**16.29**	
Maximum Bankfull Depth (ft)	**1.67**	**1.9**	**2.23**	**2.36**	
Bankfull Mean Depth (ft)	**1.04**	**1.13**	**1.25**	**1.24**	
Bankfull Width (ft)	**13.12**	**13.1**	**13.1**	**13.1**	



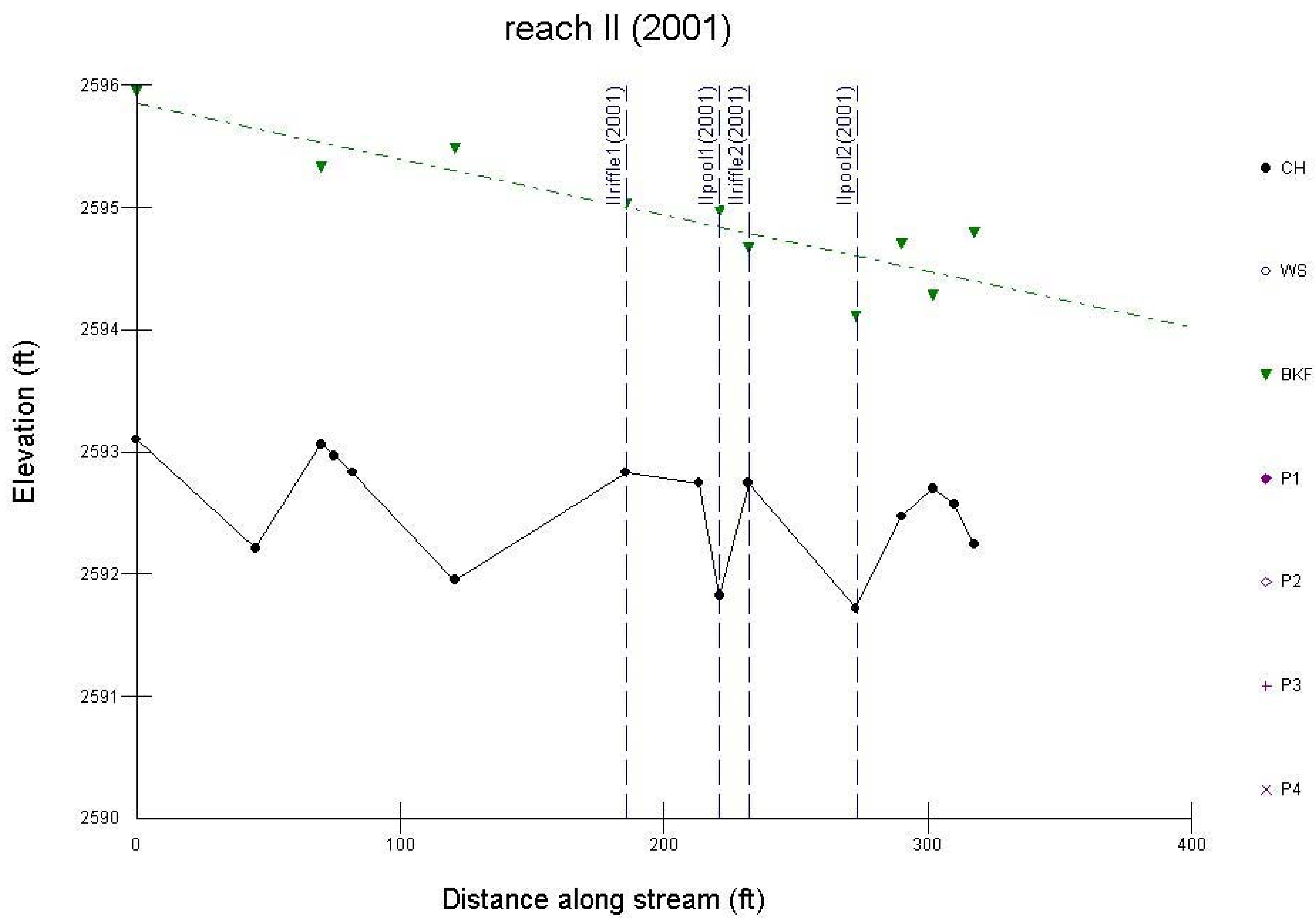
Cross-Section # 3(2Pool1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**30.26**	**25.02**	**27.83**	**26.03**	
Maximum Bankfull Depth (ft)	**3.08**	**2.95**	**3.21**	**3.18**	
Bankfull Mean Depth (ft)	**1.85**	**1.53**	**1.7**	**1.59**	
Bankfull Width (ft)	**16.4**	**16.4**	**16.4**	**16.4**	

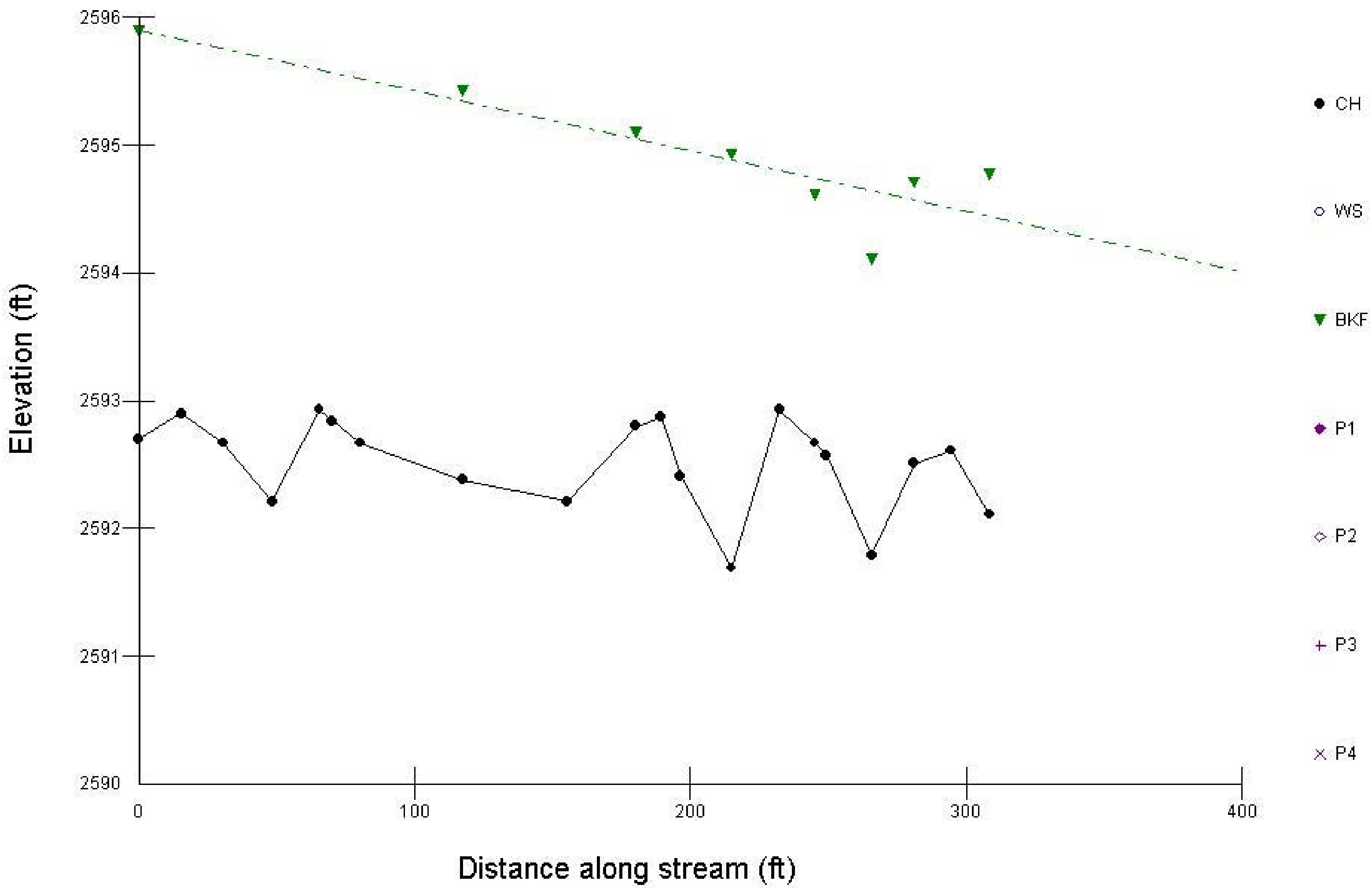


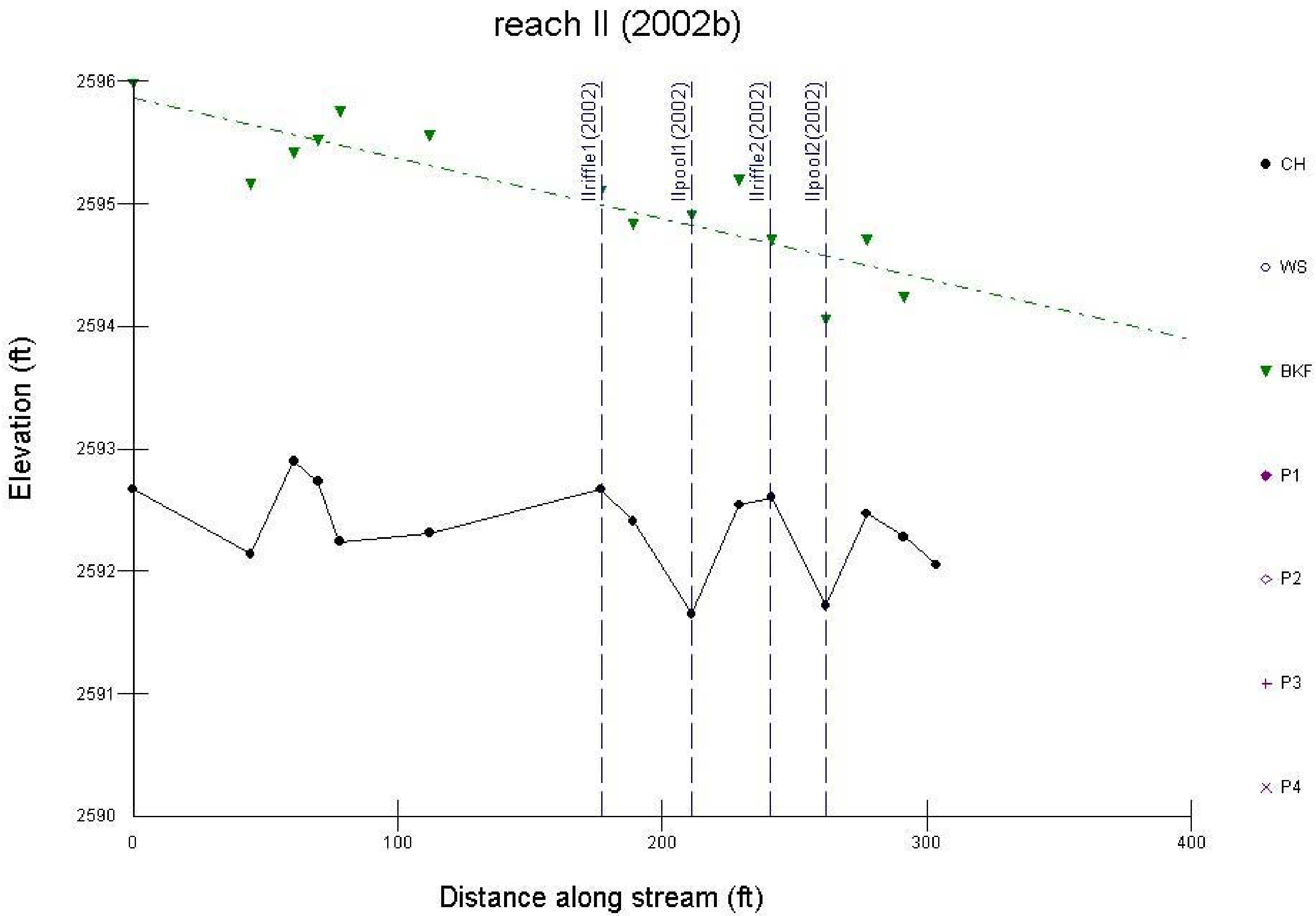
Cross-Section # 4(2Pool2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	20.28	23.34	24.76	24.4	
Maximum Bankfull Depth (ft)	2.33	2.62	2.79	2.79	
Bankfull Mean Depth (ft)	1.4	1.62	1.72	1.69	
Bankfull Width (ft)	14.44	14.4	14.4	14.4	

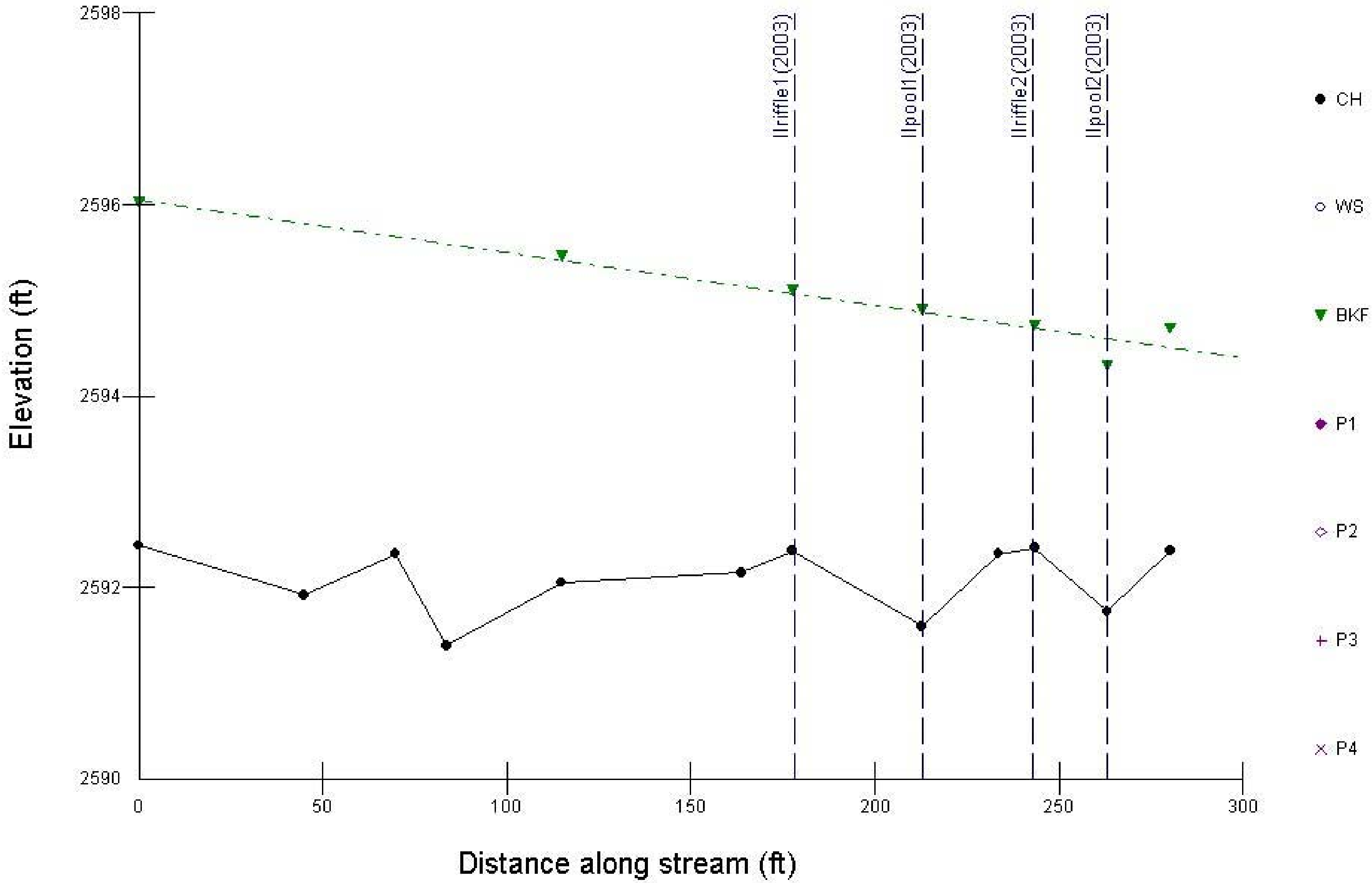

reach II (2001)
Elevation (ft)
Distance along stream (ft)
2596
2595
2594
2593
2592
2591
2590
0
100
200
300
400
IIriffle1(2001)
IIpool1(2001)
IIriffle2(2001)
IIpool2(2001)
CH
WS
BKF
P1
P2
P3
P4

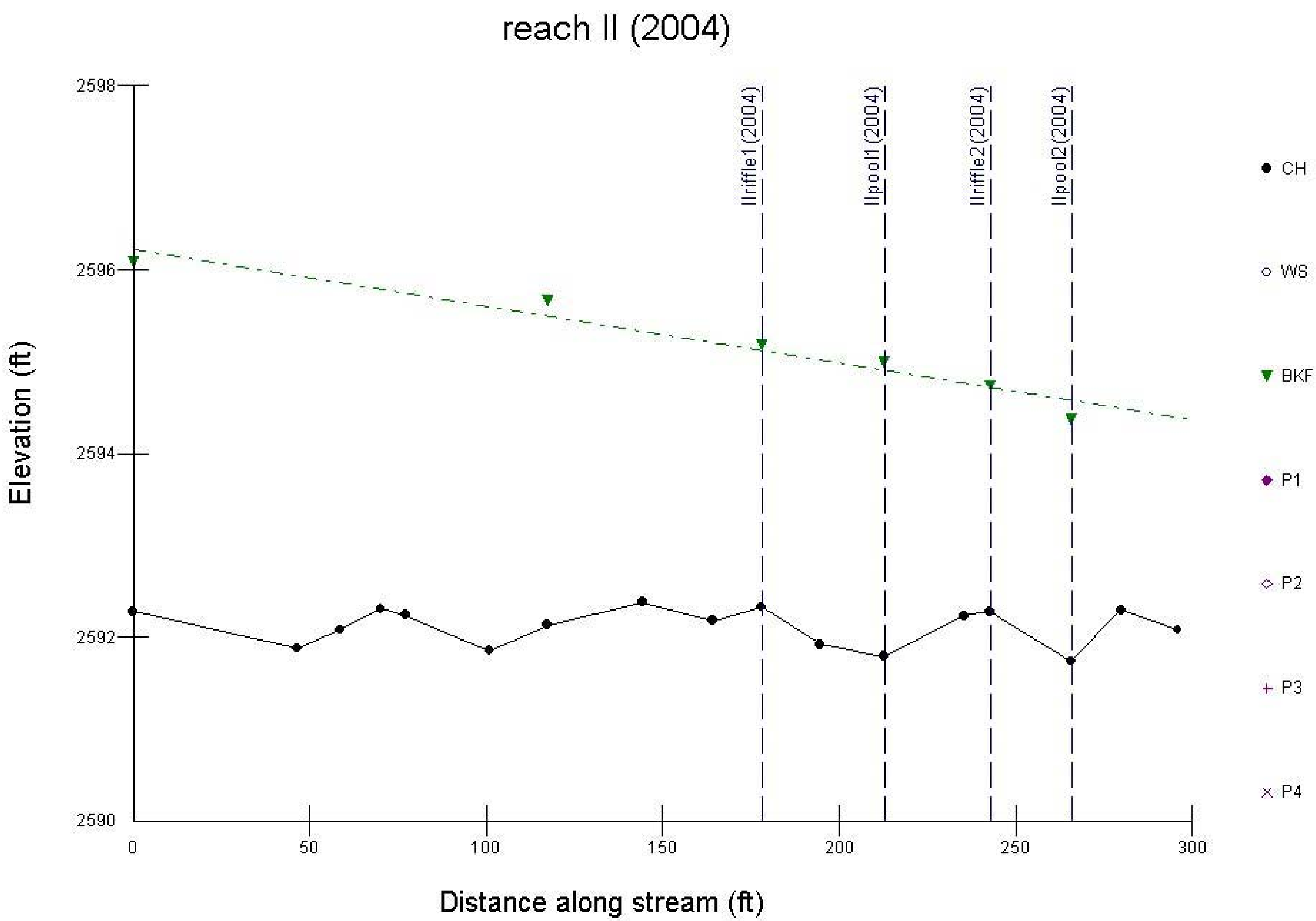
reach II (2002a)



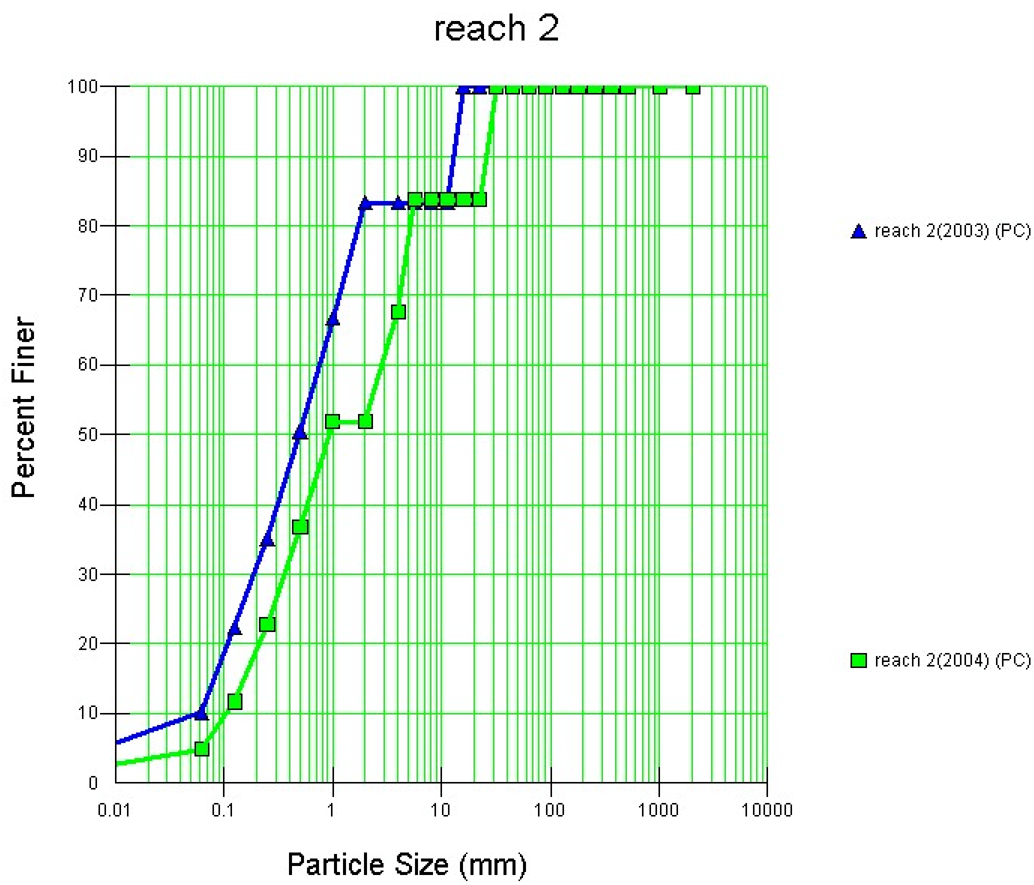

reach II (2002b)
Elevation (ft)
2596
2595
2594
2593
2592
2591
2590
0
100
200
300
400
Distance along stream (ft)
IIriffle1(2002)
IIpool1(2002)
IIriffle2(2002)
IIpool2(2002)
CH
WS
BKF
P1
P2
P3
P4

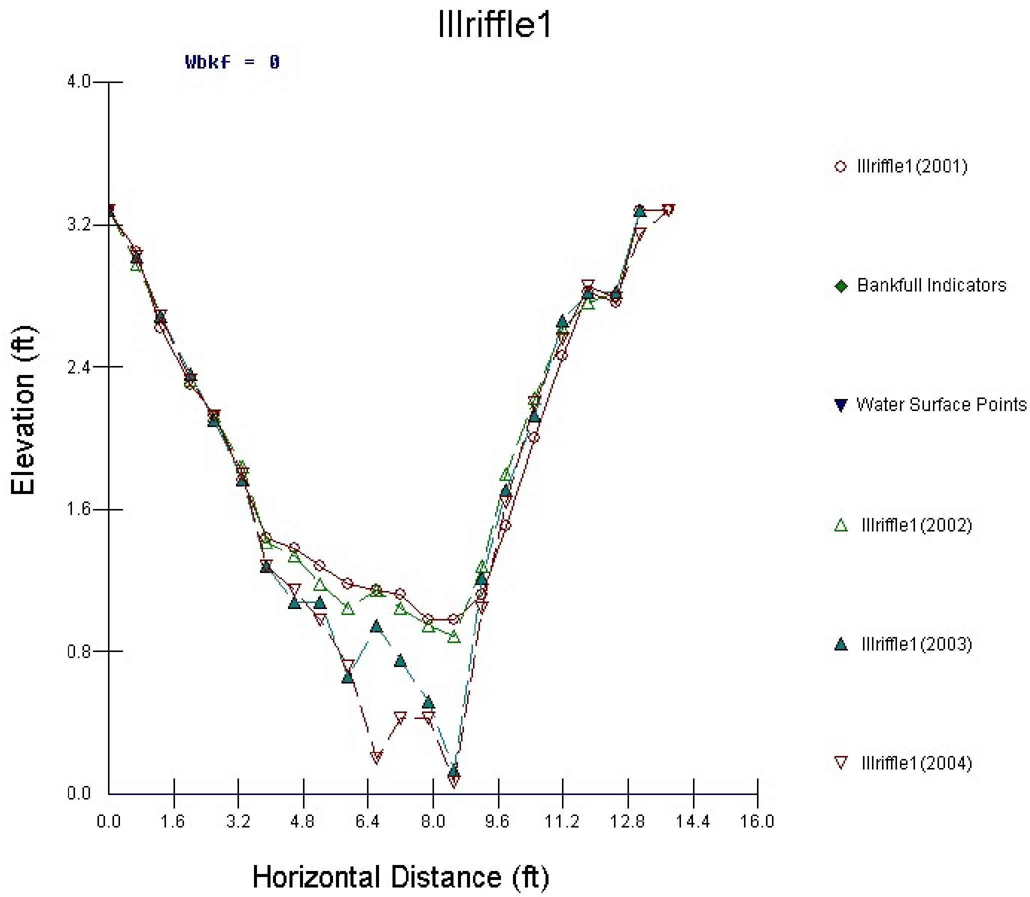
reach II (2003)





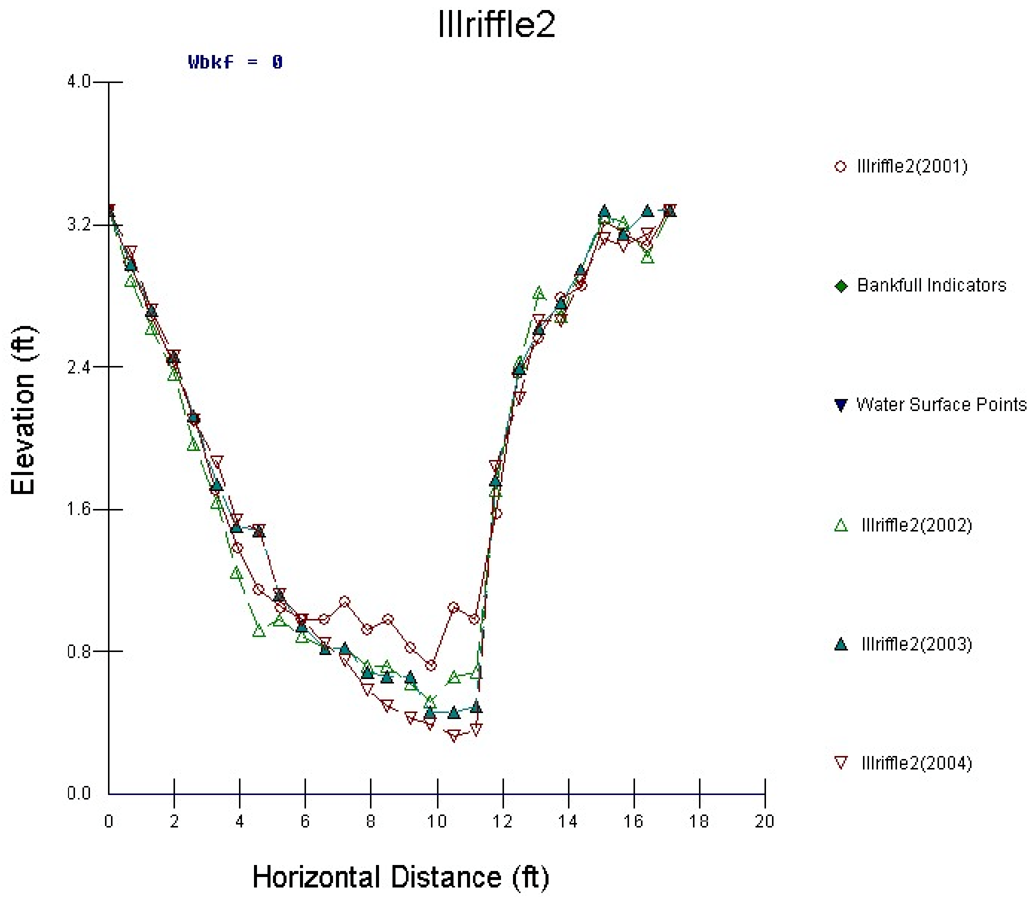
reach II (2004)
2598
2596
2594
2592
2590
Elevation (ft)
0
50
100
150
200
250
300
Distance along stream (ft)
IIriffle1(2004)
IIpool1(2004)
IIriffle2(2004)
IIpool2(2004)
CH
WS
BKF
P1
P2
P3
P4


reach 2
Percent Finer
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)
reach 2(2003) (PC)
reach 2(2004) (PC)



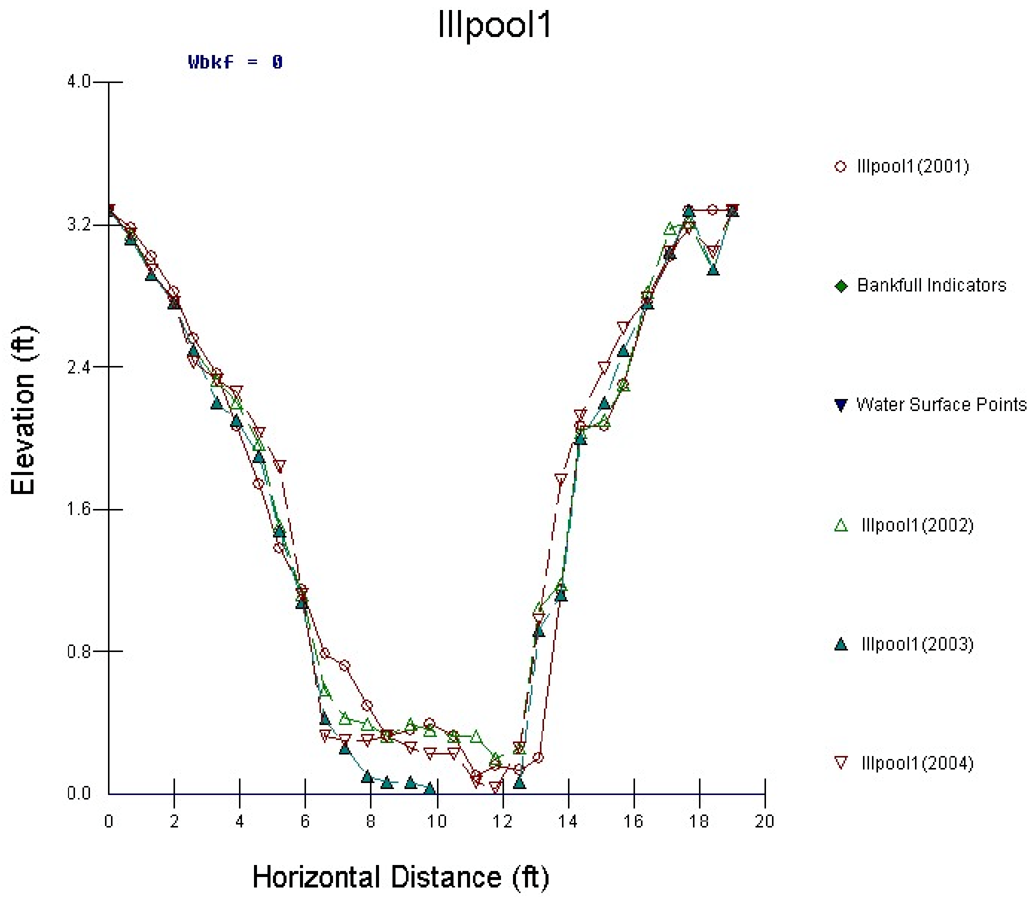
Cross-Section #1 (3Riffle1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	18.54	18.25	20.07	21.07	
Maximum Bankfull Depth (ft)	2.3	2.39	3.15	3.21	
Bankfull Mean Depth (ft)	1.42	1.39	1.53	1.53	
Bankfull Width (ft)	13.1	13.1	13.1	13.8	



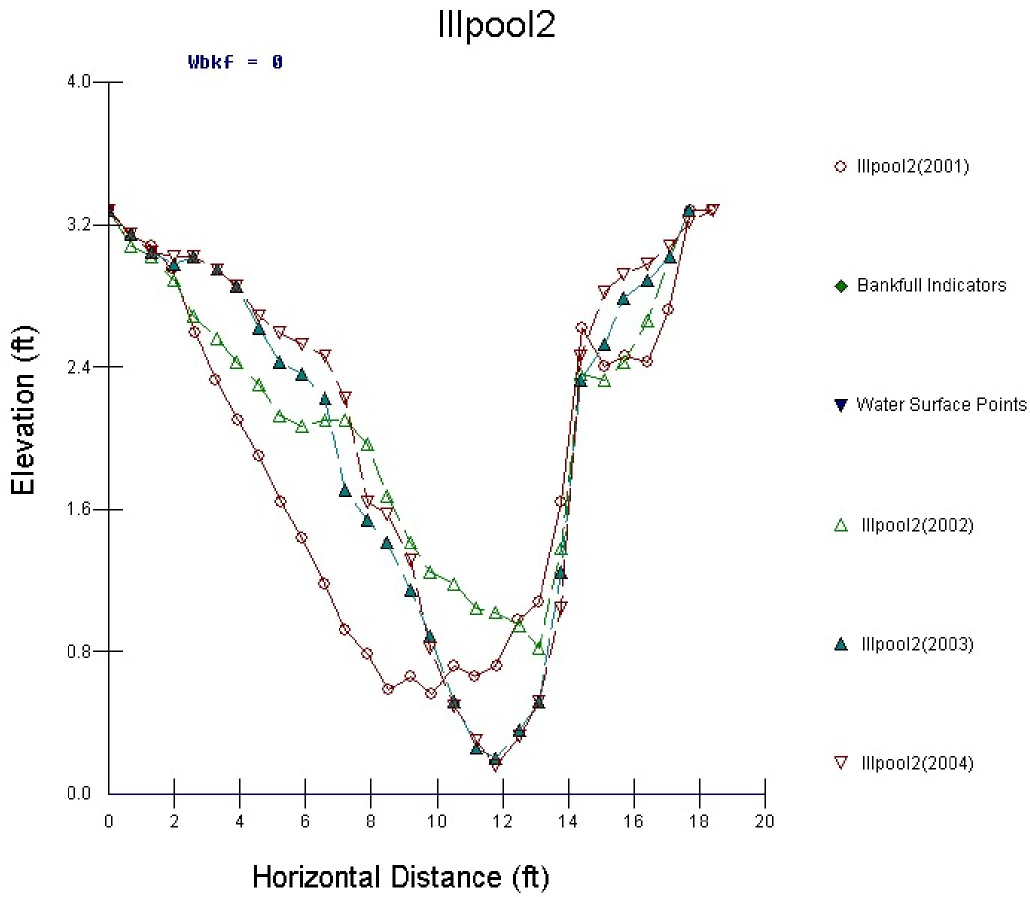
Cross-Section #2 (3Riffle2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**23.89**	**25.5**	**24.73**	**25.53**	
Maximum Bankfull Depth (ft)	**2.56**	**2.76**	**2.82**	**2.95**	
Bankfull Mean Depth (ft)	**1.4**	**1.49**	**1.51**	**1.49**	
Bankfull Width (ft)	**17.06**	**17.1**	**16.4**	**17.1**	



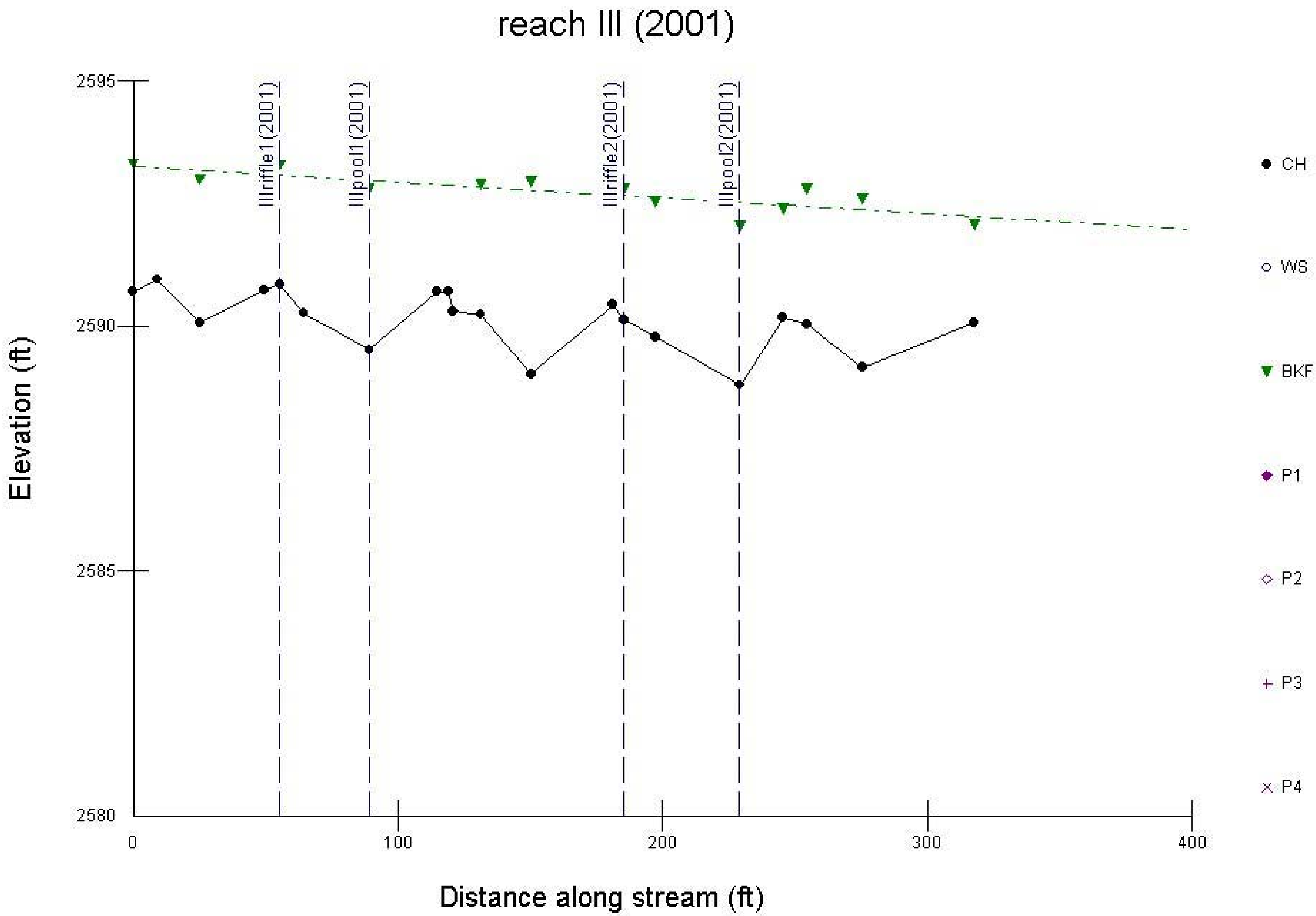
Cross-Section #3 (3Pool1) Abbreviated Morphological Summary

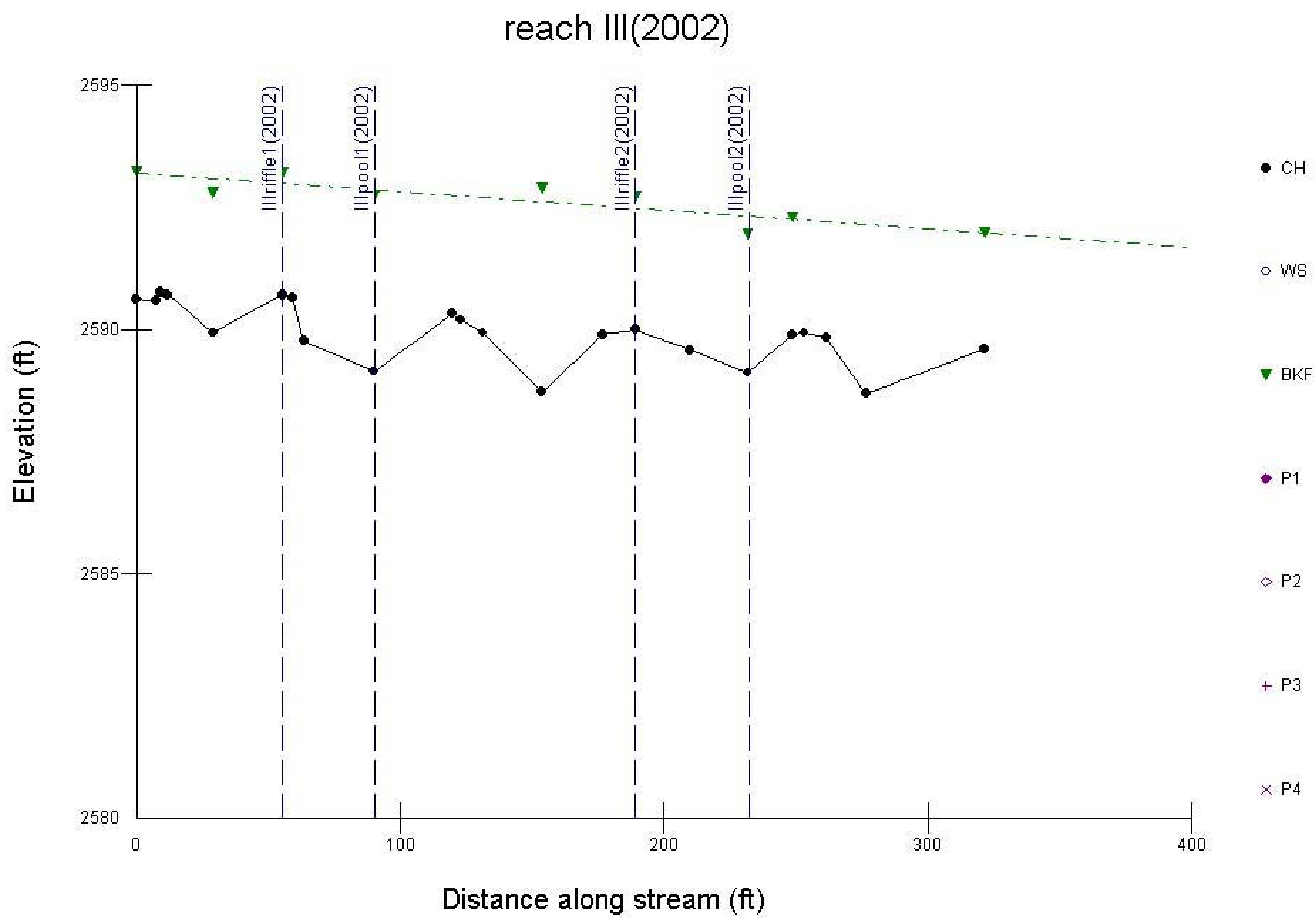
	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**31.24**	**30.8**	**32.79**	**30.62**	
Maximum Bankfull Depth (ft)	**3.18**	**3.08**	**3.28**	**3.25**	
Bankfull Mean Depth (ft)	**1.76**	**1.62**	**1.73**	**1.61**	
Bankfull Width (ft)	**17.7**	**19**	**19**	**19**	

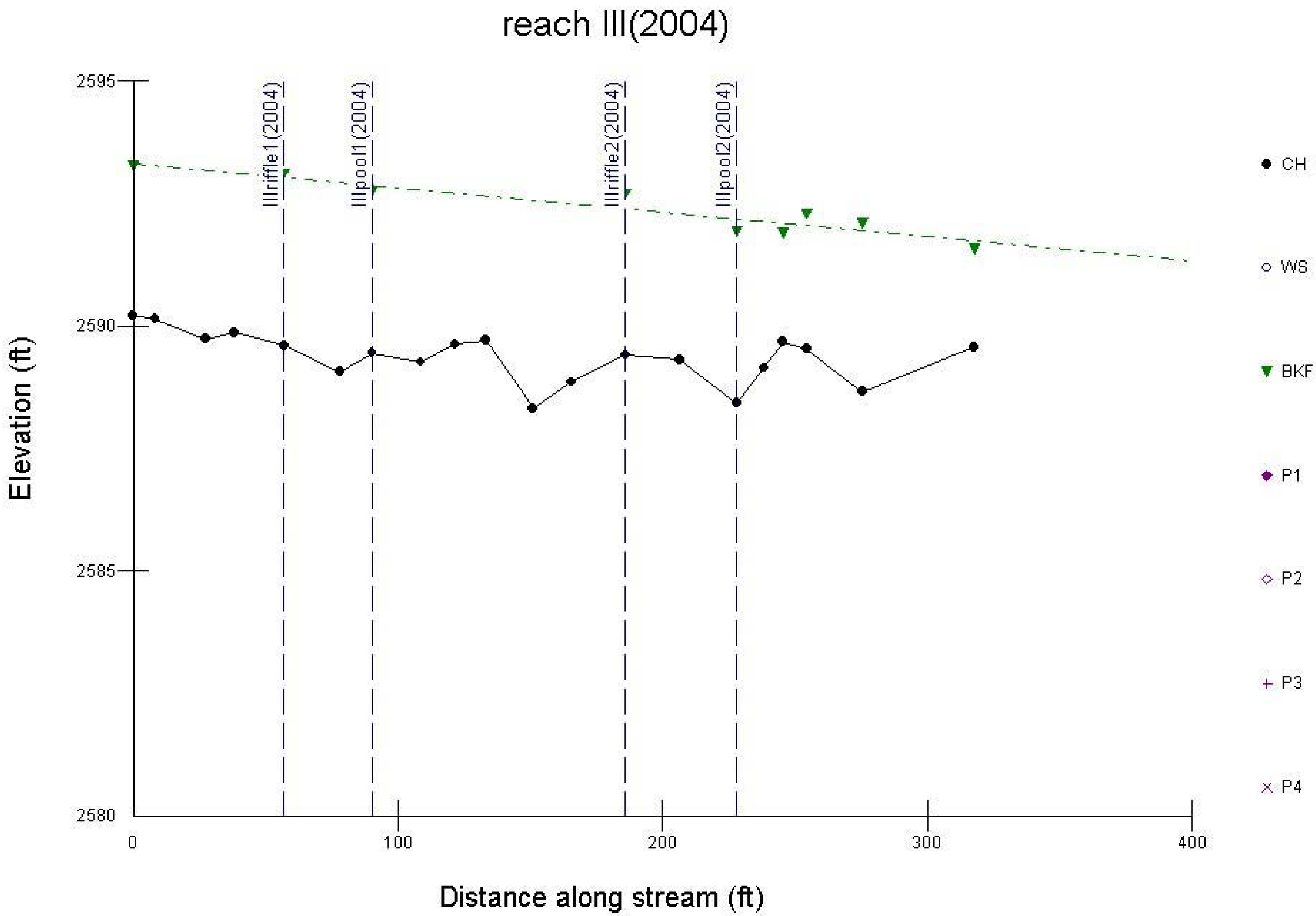


Cross-Section #4 (3Pool2) Abbreviated Morphological Summary

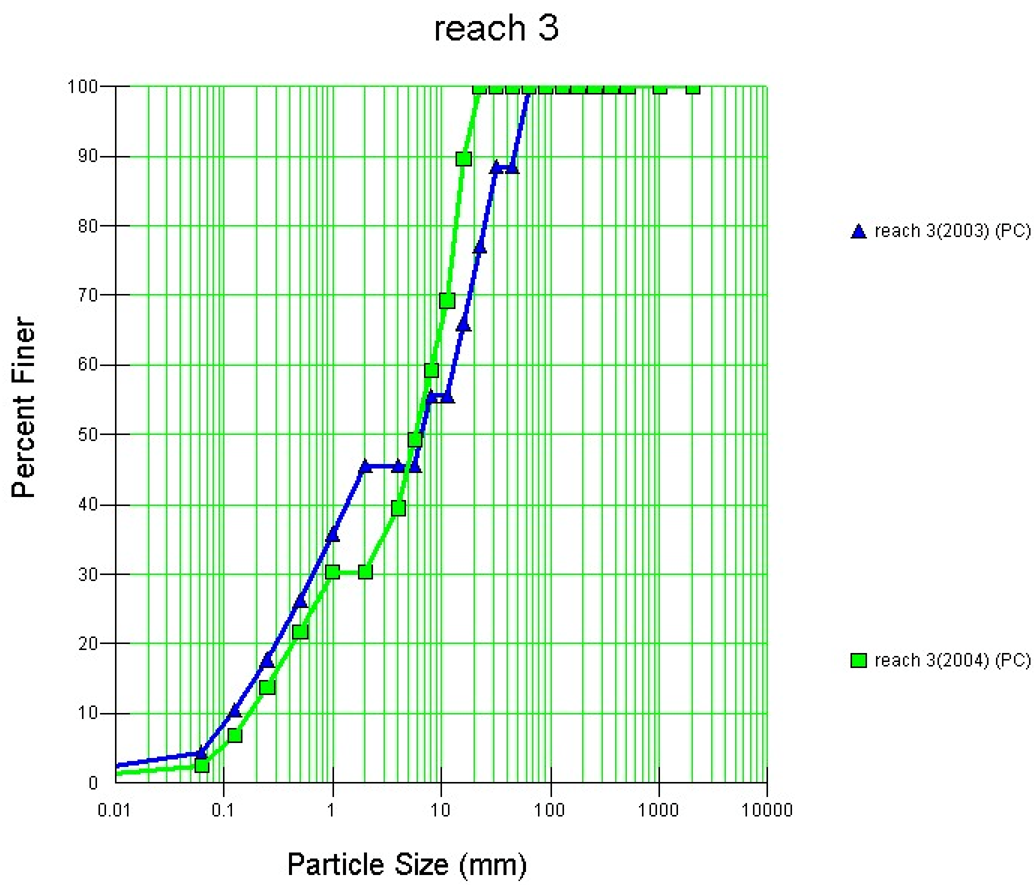
	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**26.88**	**21.26**	**22.48**	**21.23**	
Maximum Bankfull Depth (ft)	**2.72**	**2.46**	**3.08**	**3.12**	
Bankfull Mean Depth (ft)	**1.52**	**1.2**	**1.27**	**1.15**	
Bankfull Width (ft)	**17.72**	**17.7**	**17.7**	**18.4**	

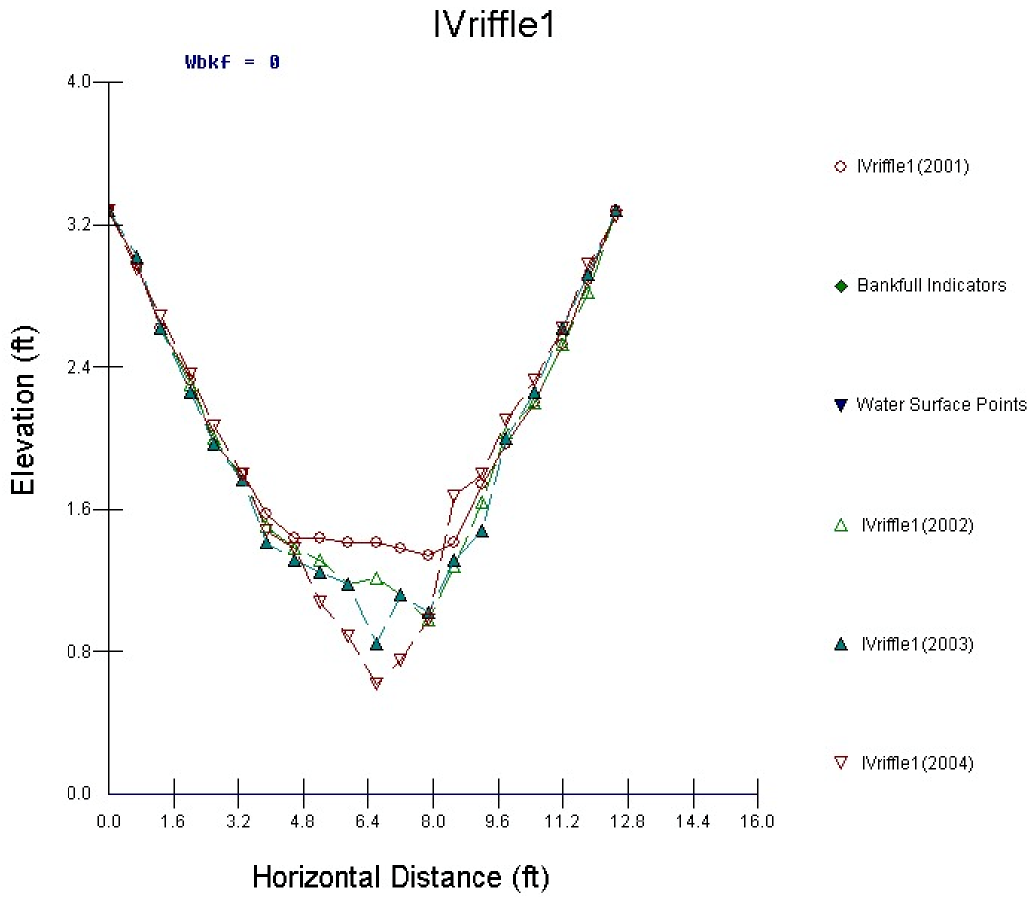

reach III (2001)
2595
2590
2585
2580
Elevation (ft)
0
100
200
300
400
Distance along stream (ft)
IIIriffle1(2001)
IIIpool1(2001)
IIIriffle2(2001)
IIIpool2(2001)
CH
WS
BKF
P1
P2
P3
P4


reach III(2002)
Elevation (ft)
2595
2590
2585
2580
IIIriffle1(2002)
IIIpool1(2002)
IIIriffle2(2002)
IIIpool2(2002)
0
100
200
300
400
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4



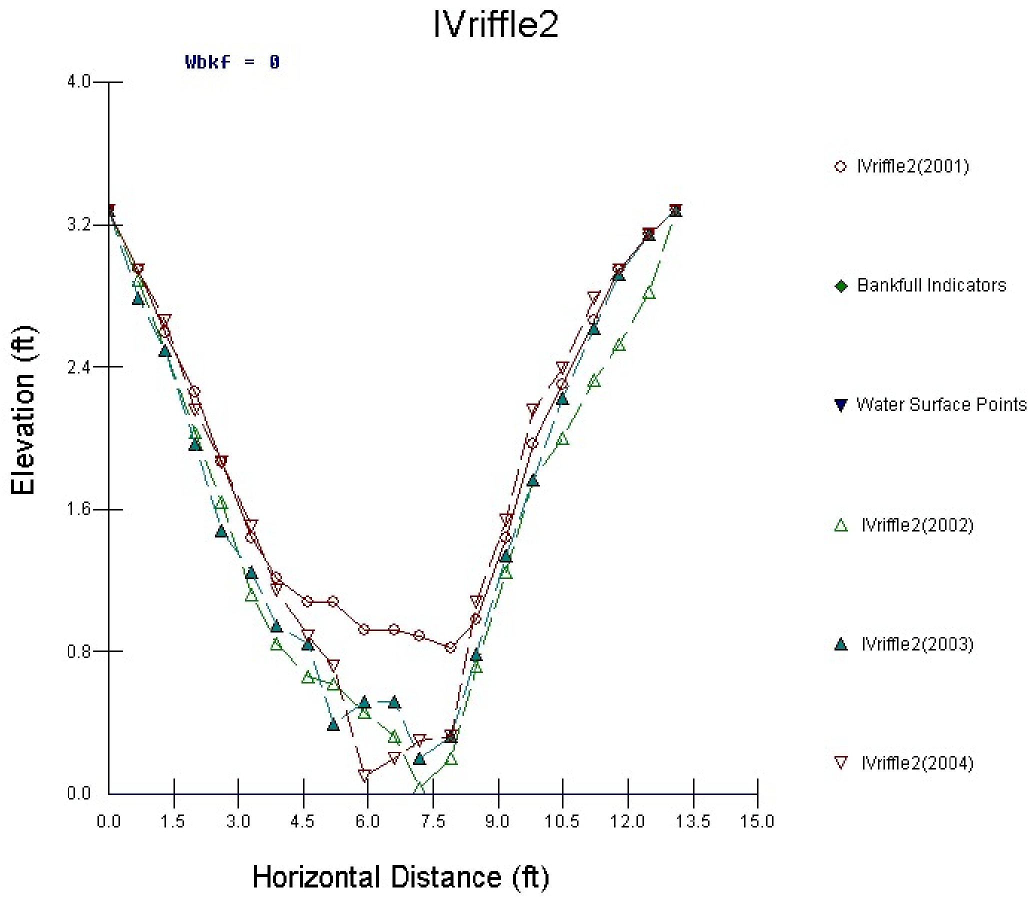
reach III(2004)
2595
2590
2585
2580
0
100
200
300
400
IIIriffle1(2004)
IIIpool1(2004)
IIIriffle2(2004)
IIIpool2(2004)
Elevation (ft)
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4


reach 3
Percent Finer
Particle Size (mm)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.1
1
10
100
1000
10000
reach 3(2003) (PC)
reach 3(2004) (PC)



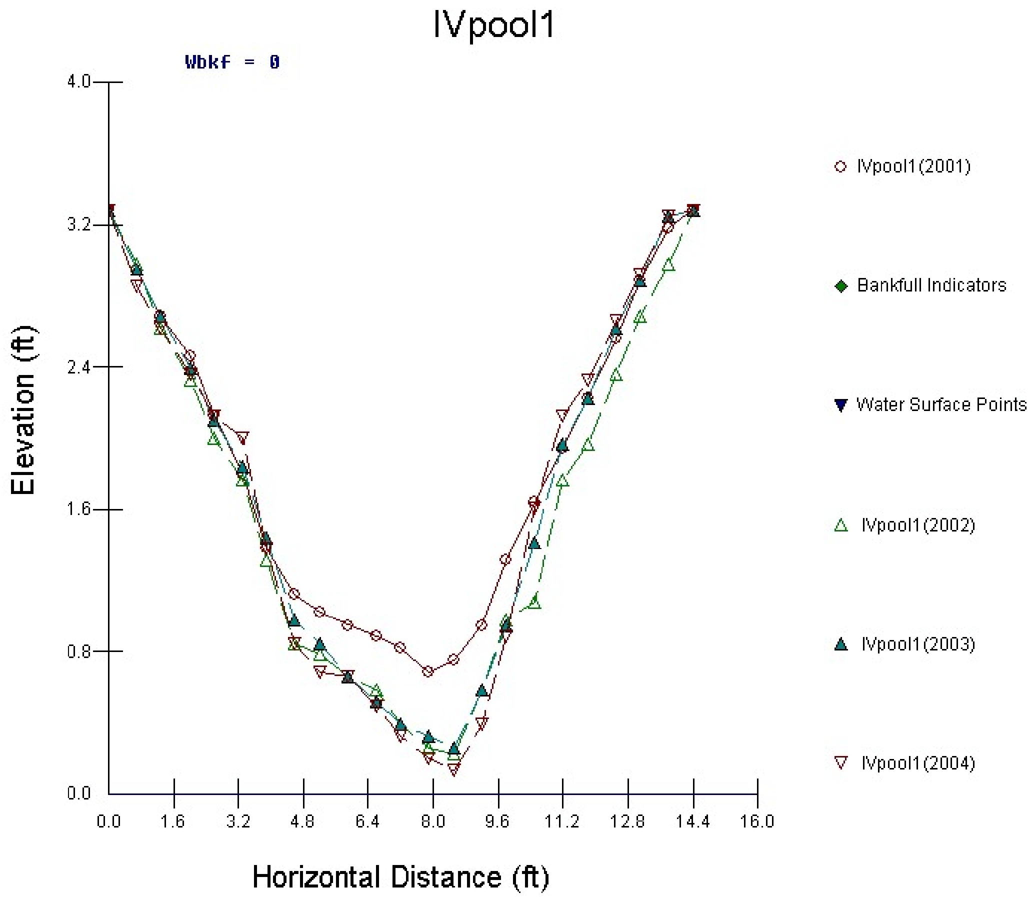
Cross-Section #1 (4Riffle1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**16.14**	**17.15**	**17.49**	**17.15**	
Maximum Bankfull Depth (ft)	**1.94**	**2.3**	**2.43**	**2.64**	
Bankfull Mean Depth (ft)	**1.29**	**1.37**	**1.4**	**1.38**	
Bankfull Width (ft)	**12.5**	**12.5**	**12.5**	**12.46**	



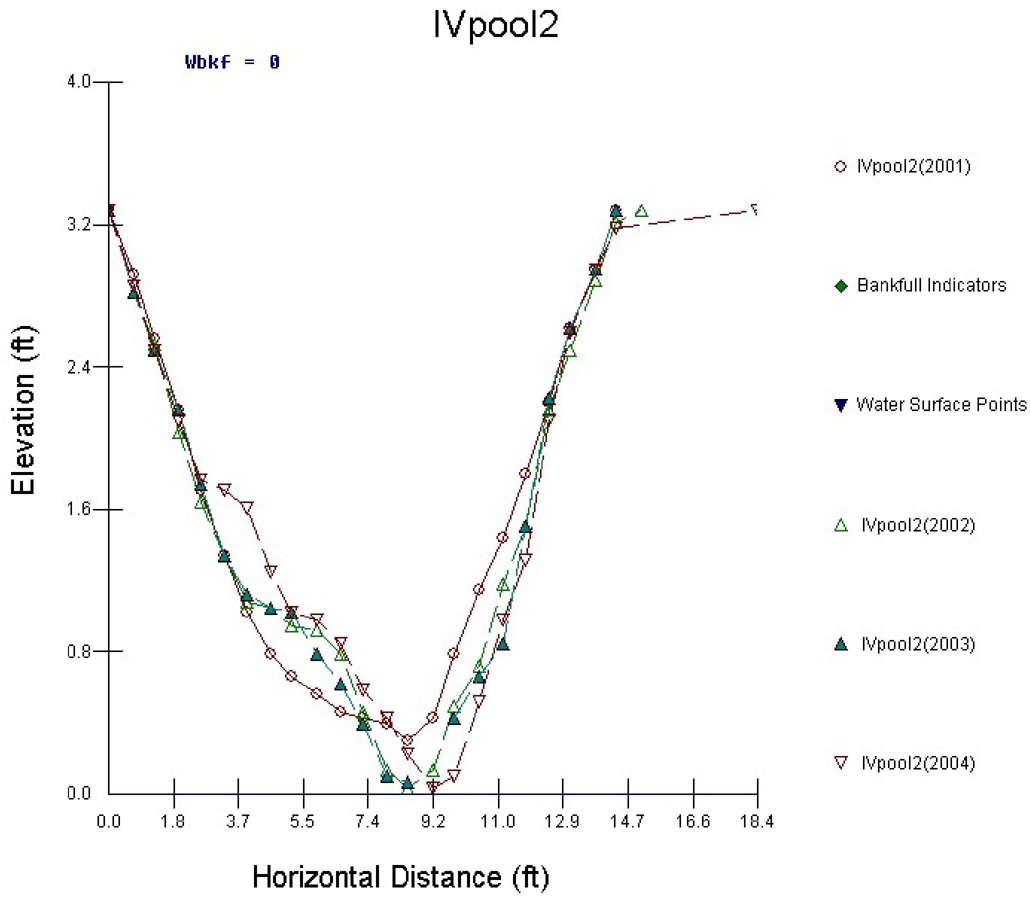
Cross-Section #2 (4Riffle2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	18.91	23.33	22.13	20.63	
Maximum Bankfull Depth (ft)	2.46	3.25	3.08	3.184	
Bankfull Mean Depth (ft)	1.44	1.78	1.69	1.57	
Bankfull Width (ft)	13.1	13.1	13.1	13.1	



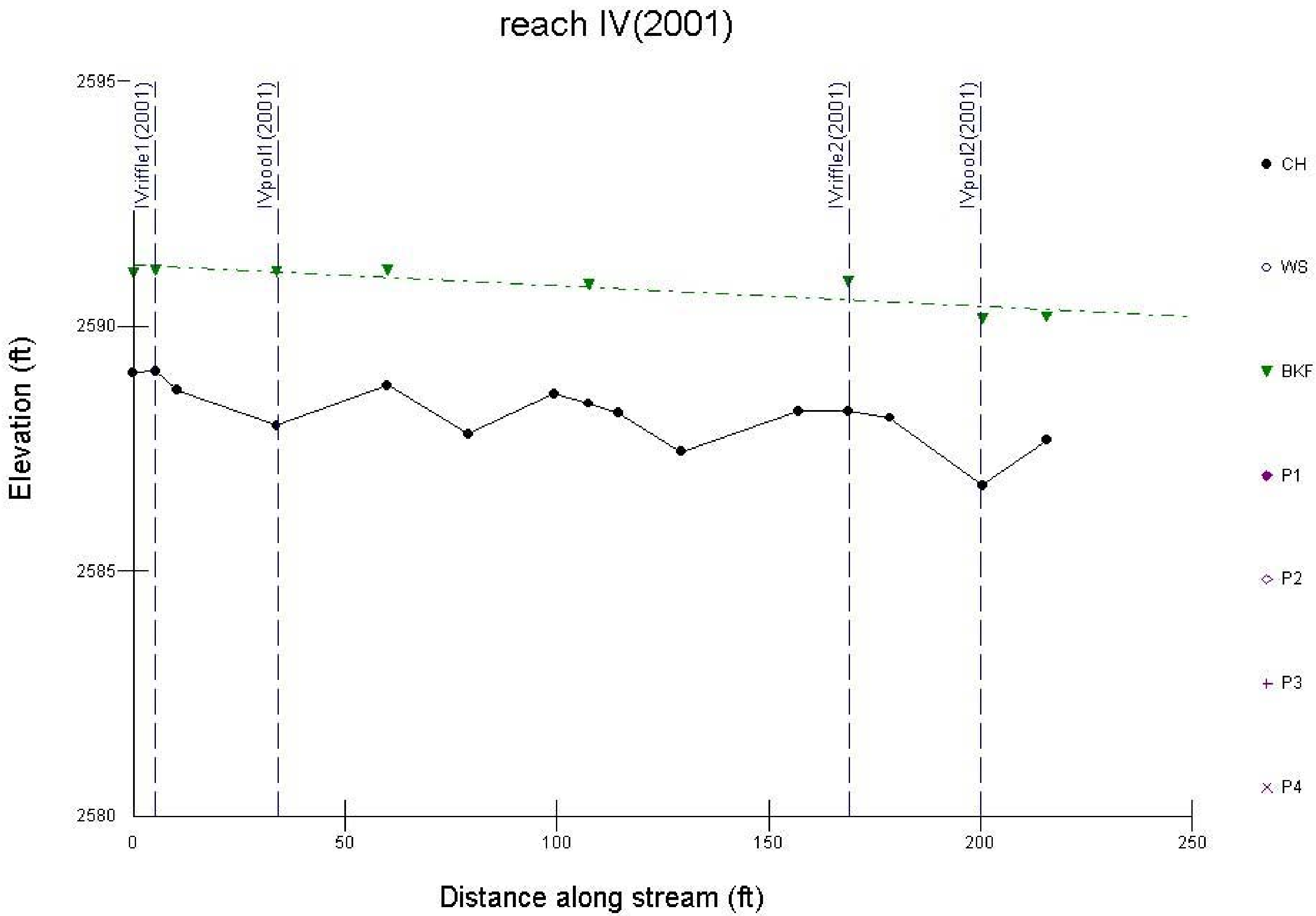
Cross-Section #3 (4Pool1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	21.34	24.73	23.35	23.62	
Maximum Bankfull Depth (ft)	2.59	3.05	3.02	3.15	
Bankfull Mean Depth (ft)	1.48	1.72	1.62	1.64	
Bankfull Width (ft)	14.4	14.4	14.4	14.4	

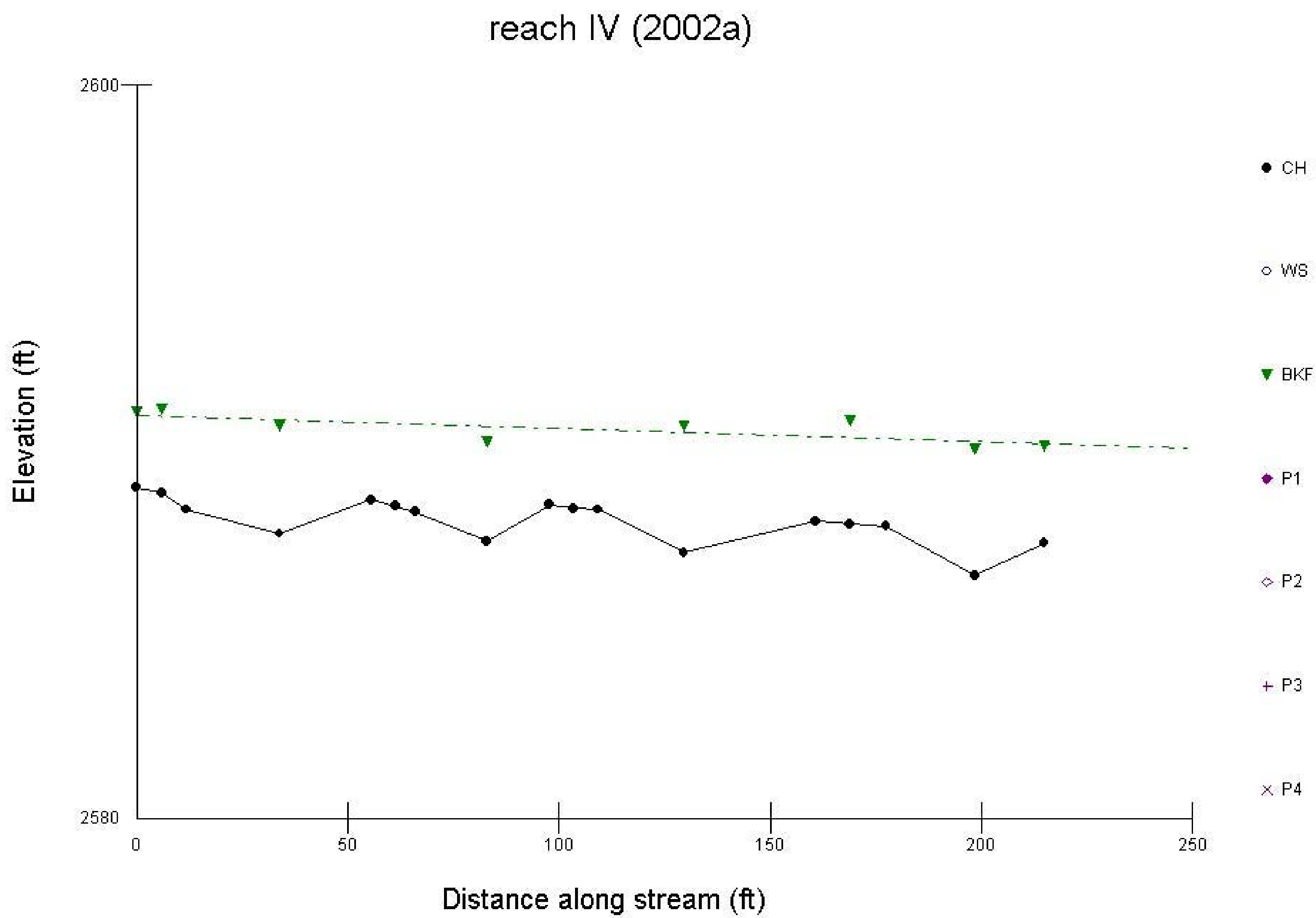


Cross-Section #4 (4Pool2) Abbreviated Morphological Summary

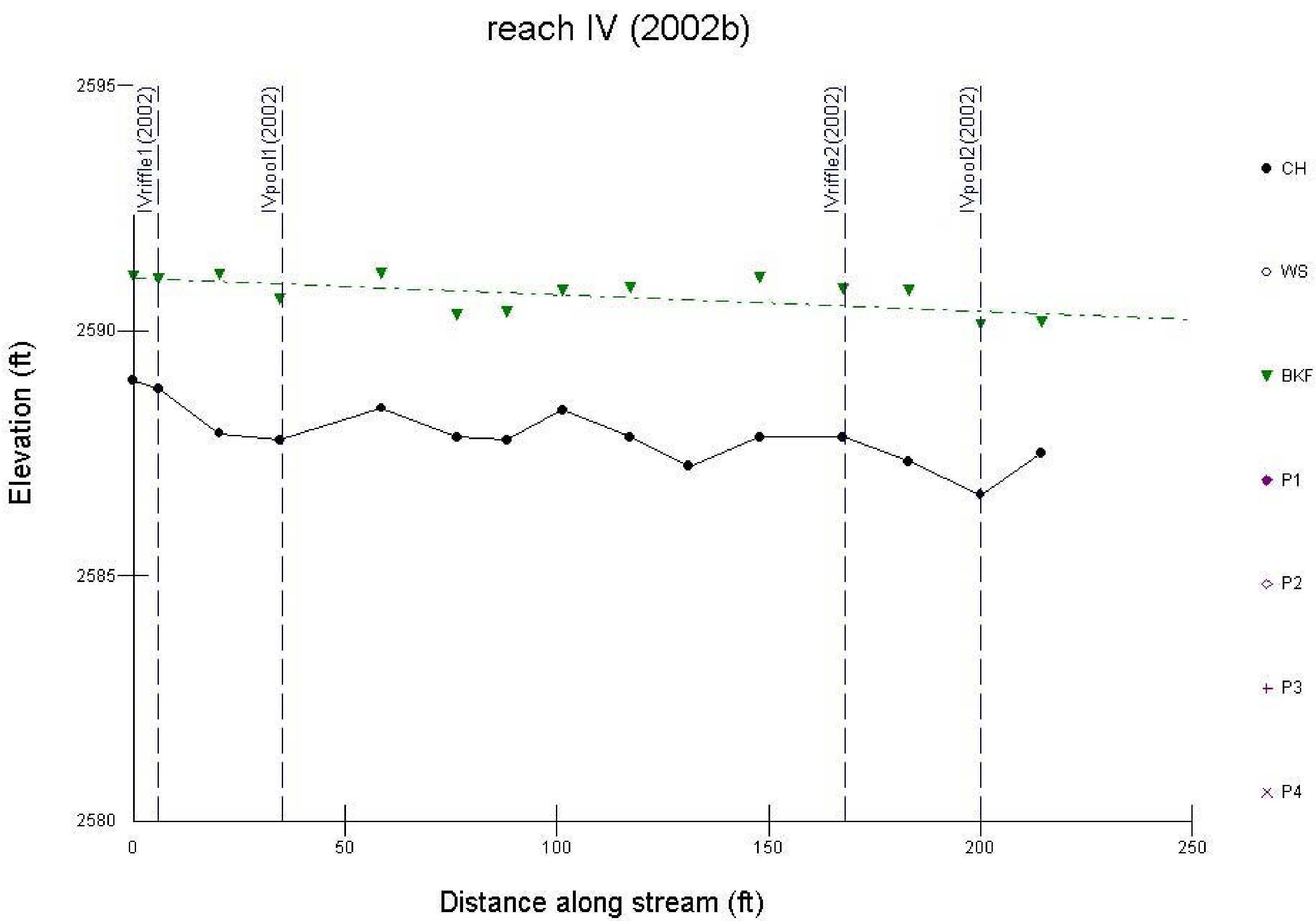
	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**26.37**	**27.29**	**27.5**	**26.76**	
Maximum Bankfull Depth (ft)	**2.98**	**3.25**	**3.28**	**3.25**	
Bankfull Mean Depth (ft)	**1.83**	**1.81**	**1.91**	**1.45**	
Bankfull Width (ft)	**14.4**	**15.1**	**14.4**	**18.4**	

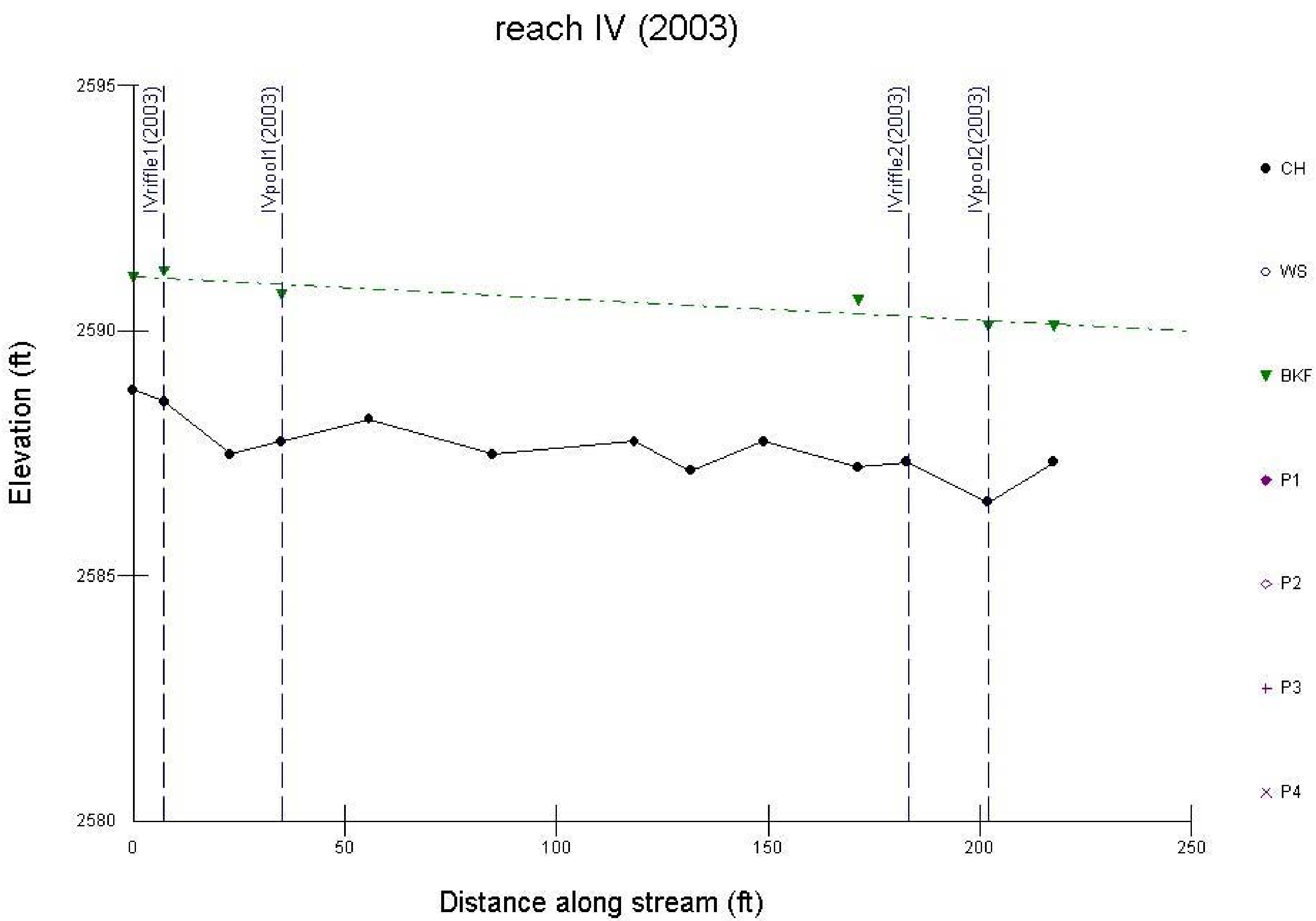


reach IV(2001)
2595
2590
2585
2580
Elevation (ft)
IVriffle1(2001)
IVpool1(2001)
IVriffle2(2001)
IVpool2(2001)
0
50
100
150
200
250
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4

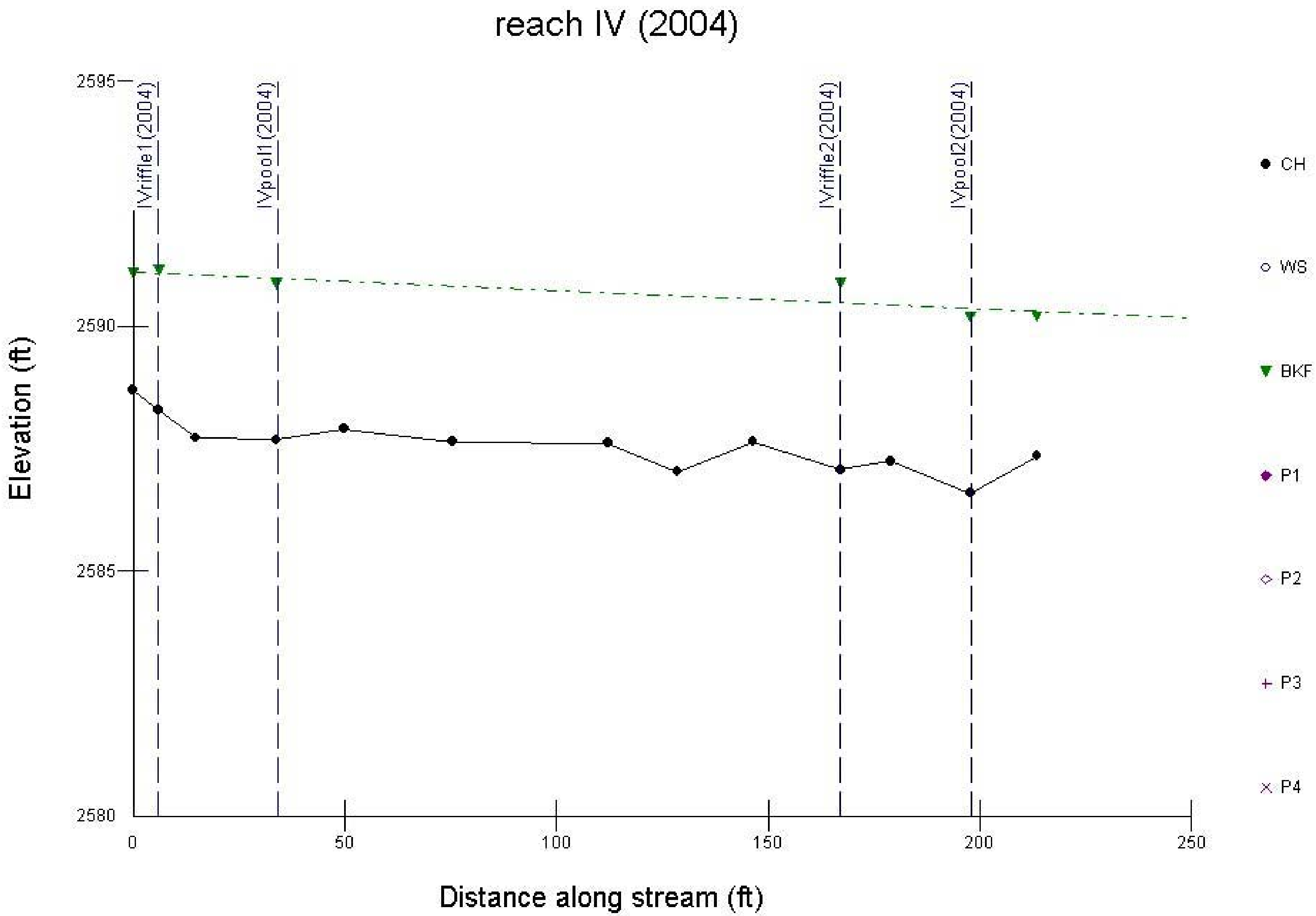


reach IV (2002a)
2600
2580
Elevation (ft)
0
50
100
150
200
250
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4

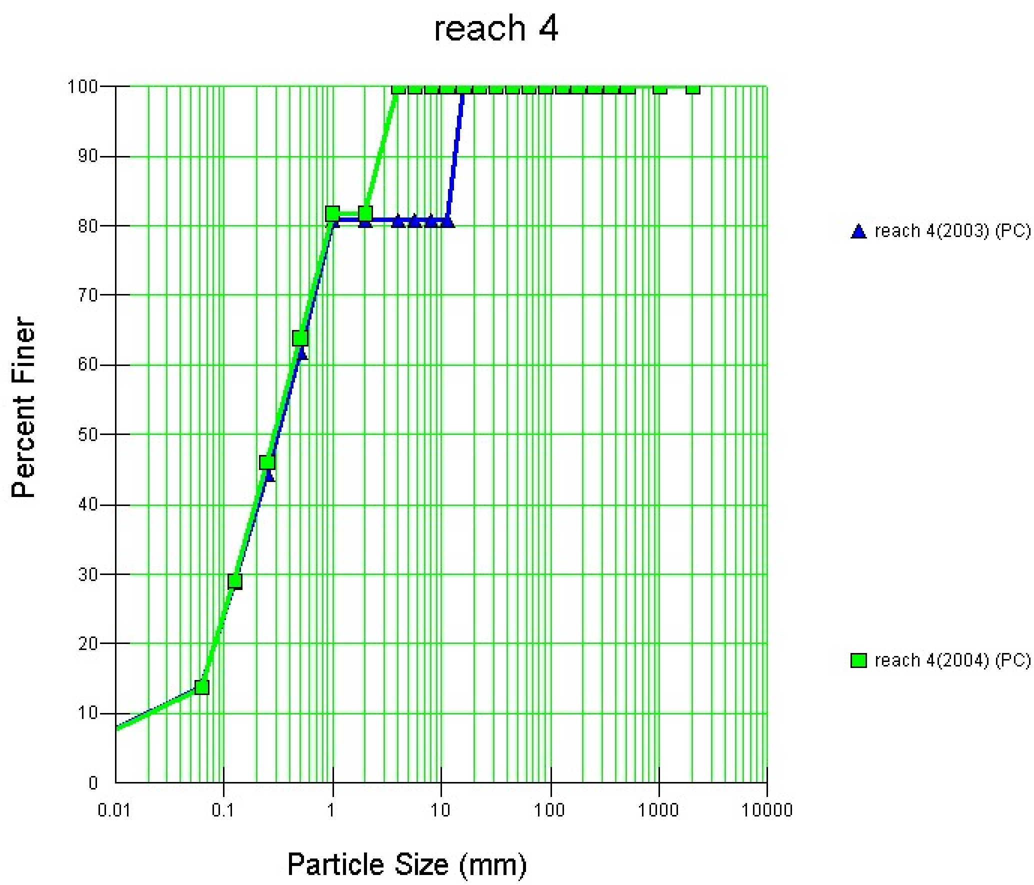

reach IV (2002b)
Elevation (ft)
Distance along stream (ft)
2595
2590
2585
2580
0
50
100
150
200
250
IVriffle1(2002)
IVpool1(2002)
IVriffle2(2002)
IVpool2(2002)
CH
WS
BKF
P1
P2
P3
P4



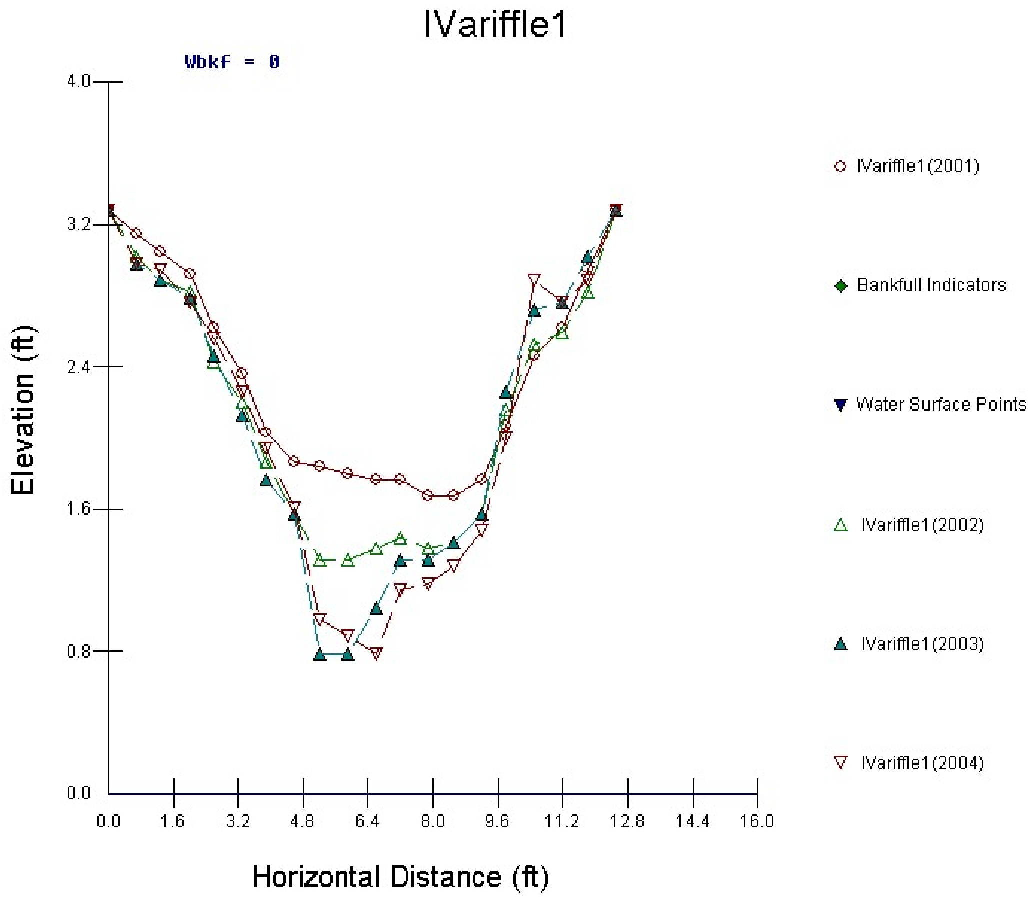
reach IV (2003)
Elevation (ft)
Distance along stream (ft)
2595
2590
2585
2580
0
50
100
150
200
250
IVriffle1(2003)
IVpool1(2003)
IVriffle2(2003)
IVpool2(2003)
CH
WS
BKF
P1
P2
P3
P4



reach IV (2004)
Elevation (ft)
Distance along stream (ft)
2595
2590
2585
2580
0
50
100
150
200
250
IVriffle1(2004)
IVpool1(2004)
IVriffle2(2004)
IVpool2(2004)
CH
WS
BKF
P1
P2
P3
P4

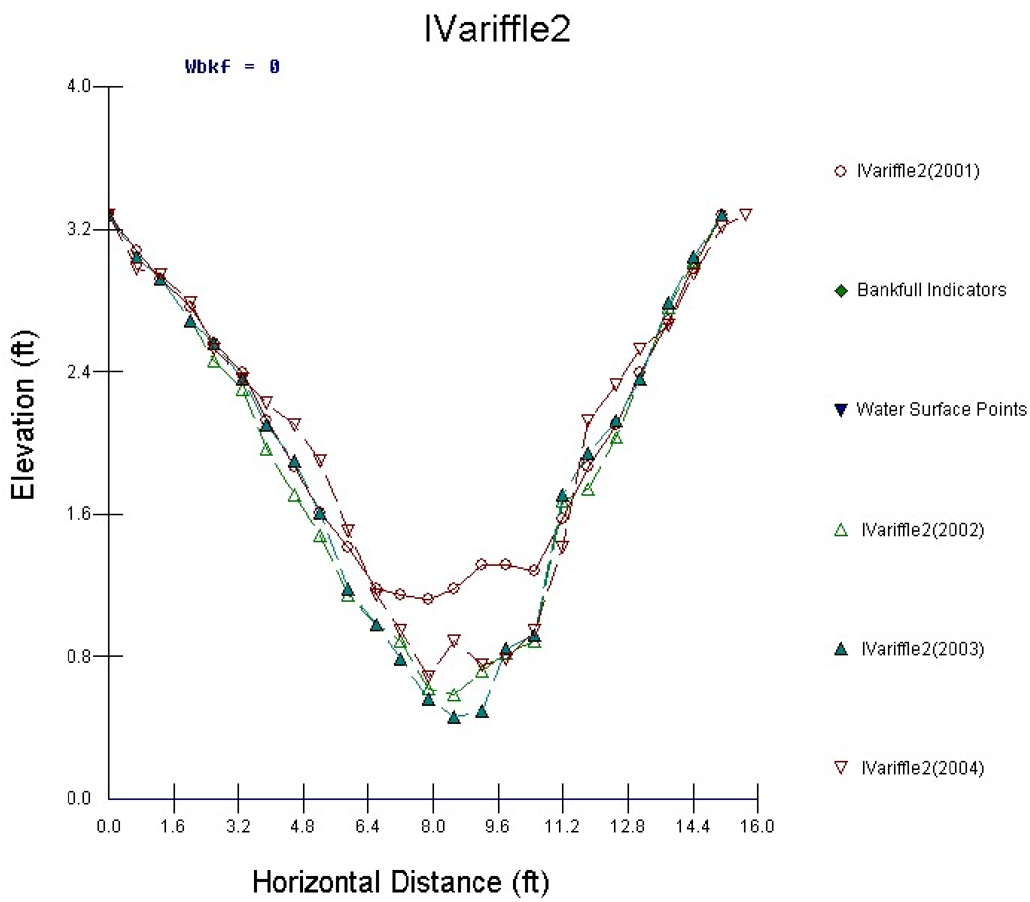


reach 4
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Percent Finer
Particle Size (mm)
reach 4(2003) (PC)
reach 4(2004) (PC)



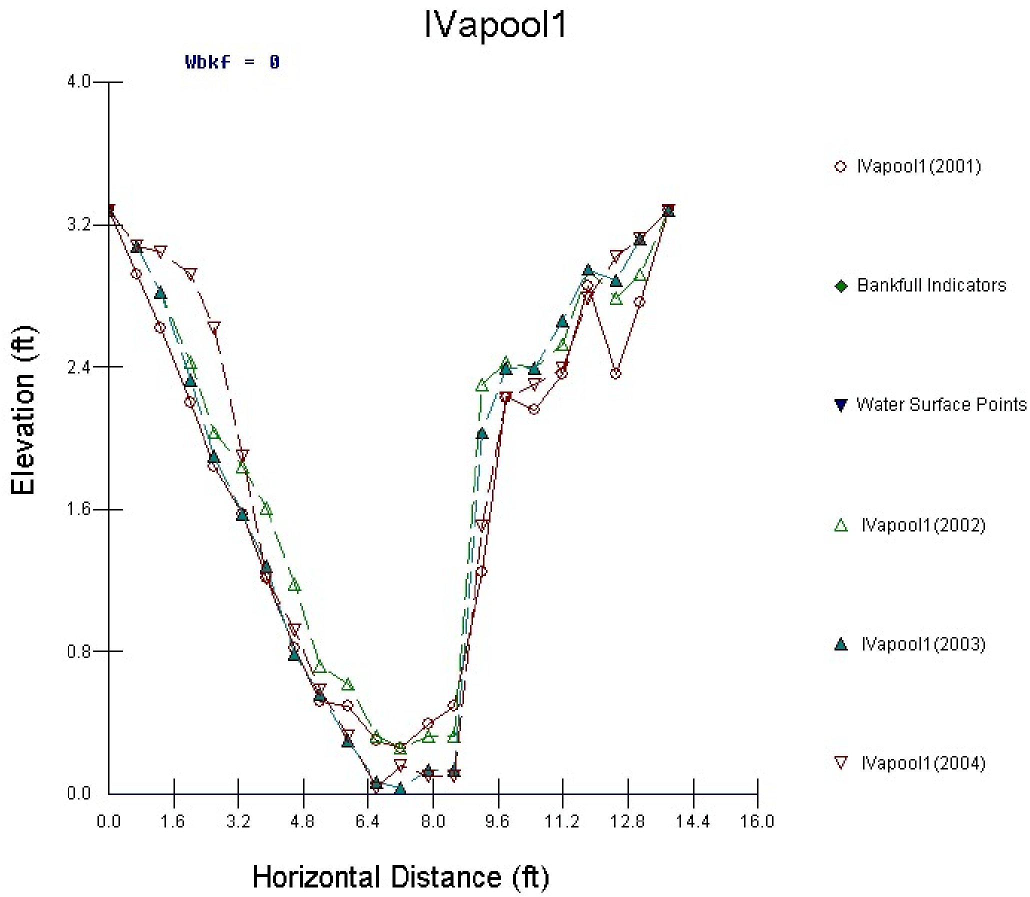
Cross-Section #1 (4aRiffle1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	12.24	14.66	15.4	15.54	
Maximum Bankfull Depth (ft)	1.61	1.97	2.49	2.49	
Bankfull Mean Depth (ft)	0.98	1.17	1.23	1.24	
Bankfull Width (ft)	12.5	12.5	12.5	12.5	



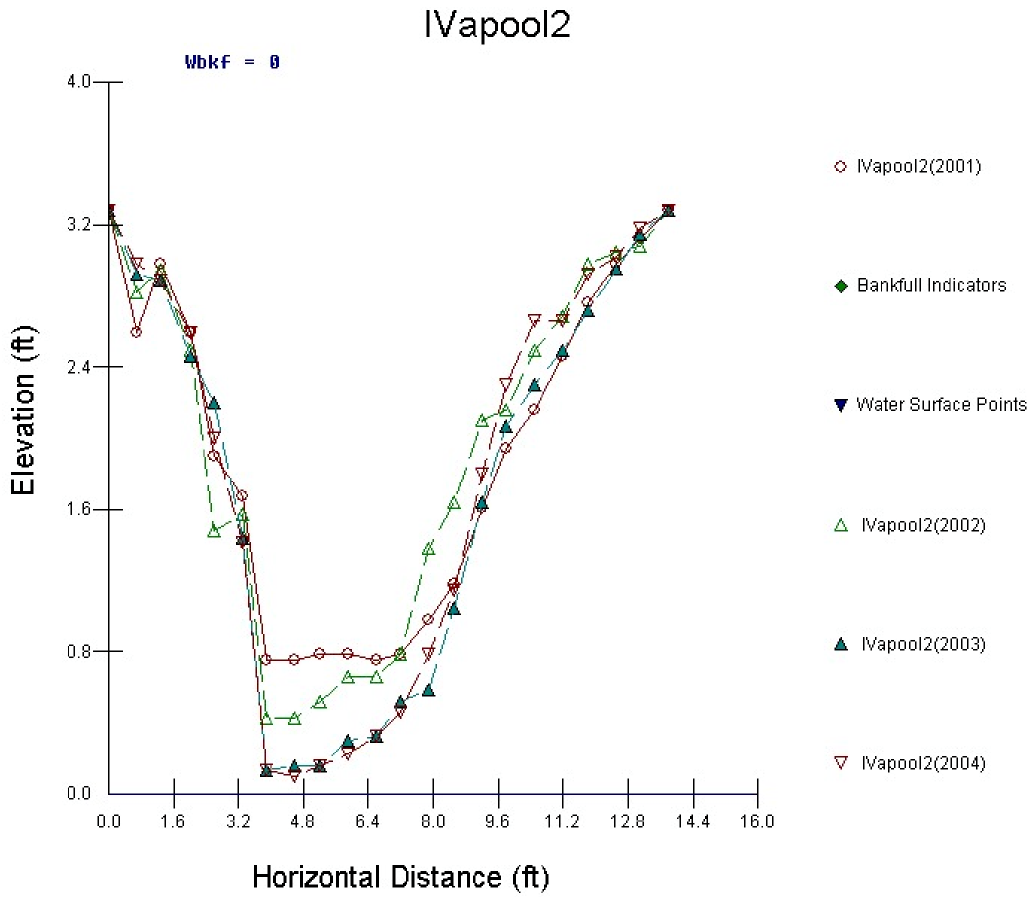
Cross-Section #2 (4aRiffle2) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	19.24	21.9	21.52	20.16	
Maximum Bankfull Depth (ft)	2.16	2.69	2.82	2.59	
Bankfull Mean Depth (ft)	1.27	1.45	1.42	1.28	
Bankfull Width (ft)	15.1	15.1	15.1	15.7	



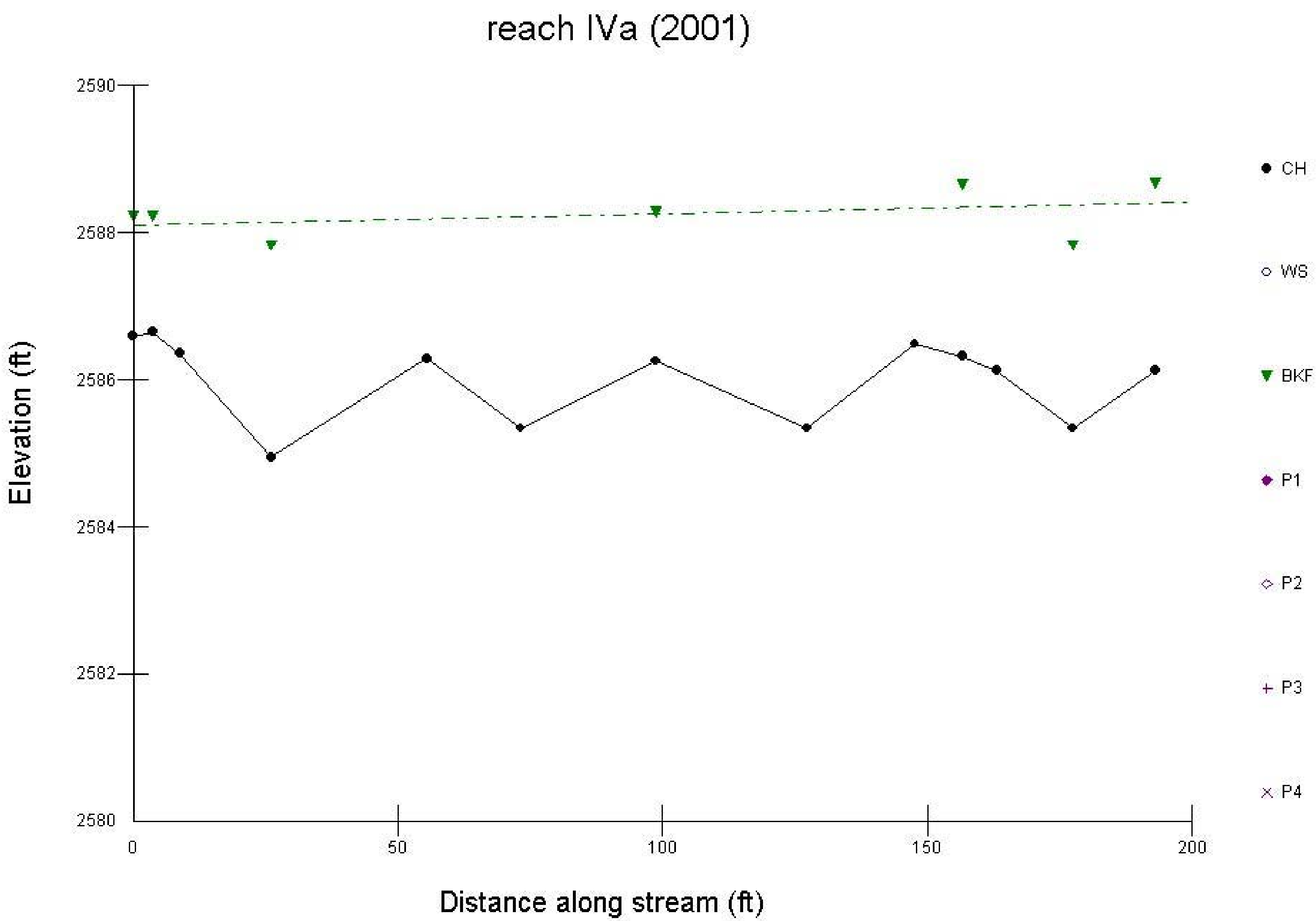
Cross-Section #3 (4aPool1) Abbreviated Morphological Summary

	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	22.3	19.49	21.11	20.5	
Maximum Bankfull Depth (ft)	3.02	3.02	3.25	3.25	
Bankfull Mean Depth (ft)	1.62	1.41	1.53	1.49	
Bankfull Width (ft)	13.8	13.8	13.8	13.8	

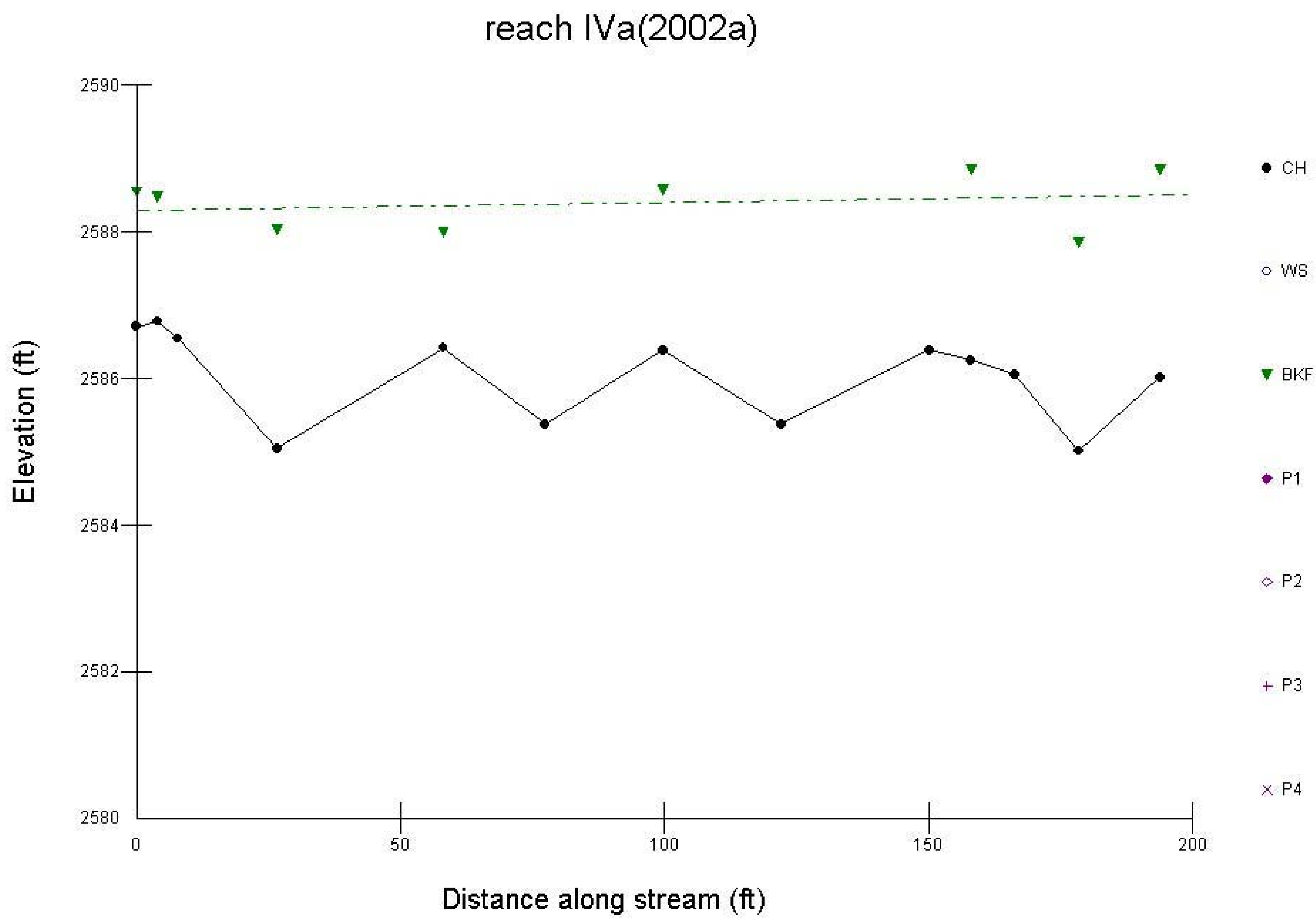


Cross-Section #4 (4aPool2) Abbreviated Morphological Summary

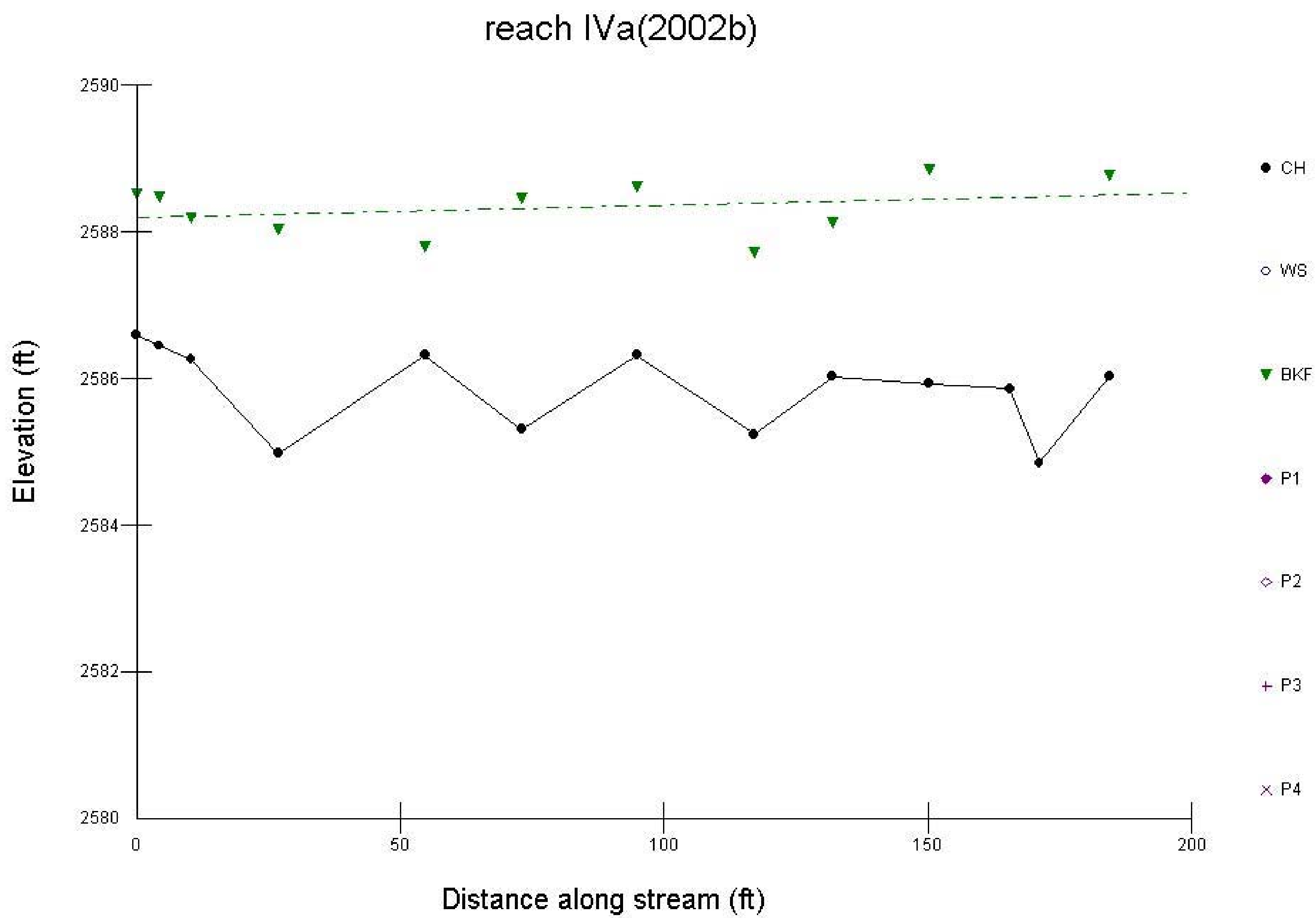
	2001	2002	2003	2004	2005
Bankfull Cross Sectional Area (ft^2)	**19.72**	**19.17**	**21.73**	**20.88**	
Maximum Bankfull Depth (ft)	**2.53**	**2.85**	**3.15**	**3.18**	
Bankfull Mean Depth (ft)	**1.43**	**1.39**	**1.57**	**1.51**	
Bankfull Width (ft)	**13.8**	**13.8**	**13.8**	**13.8**	



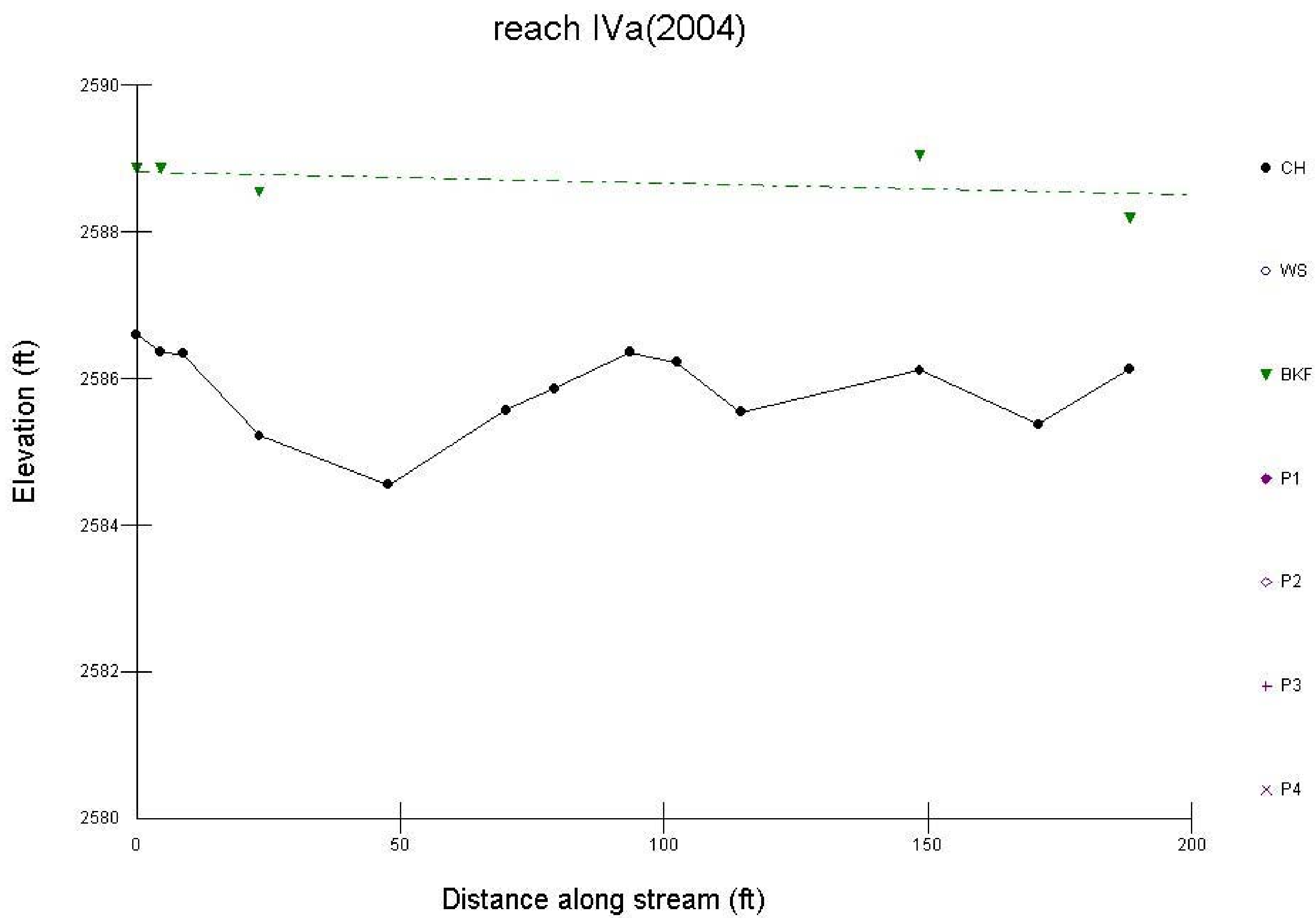
reach IVa (2001)
2590
2588
2586
2584
2582
2580
0
50
100
150
200
Elevation (ft)
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4

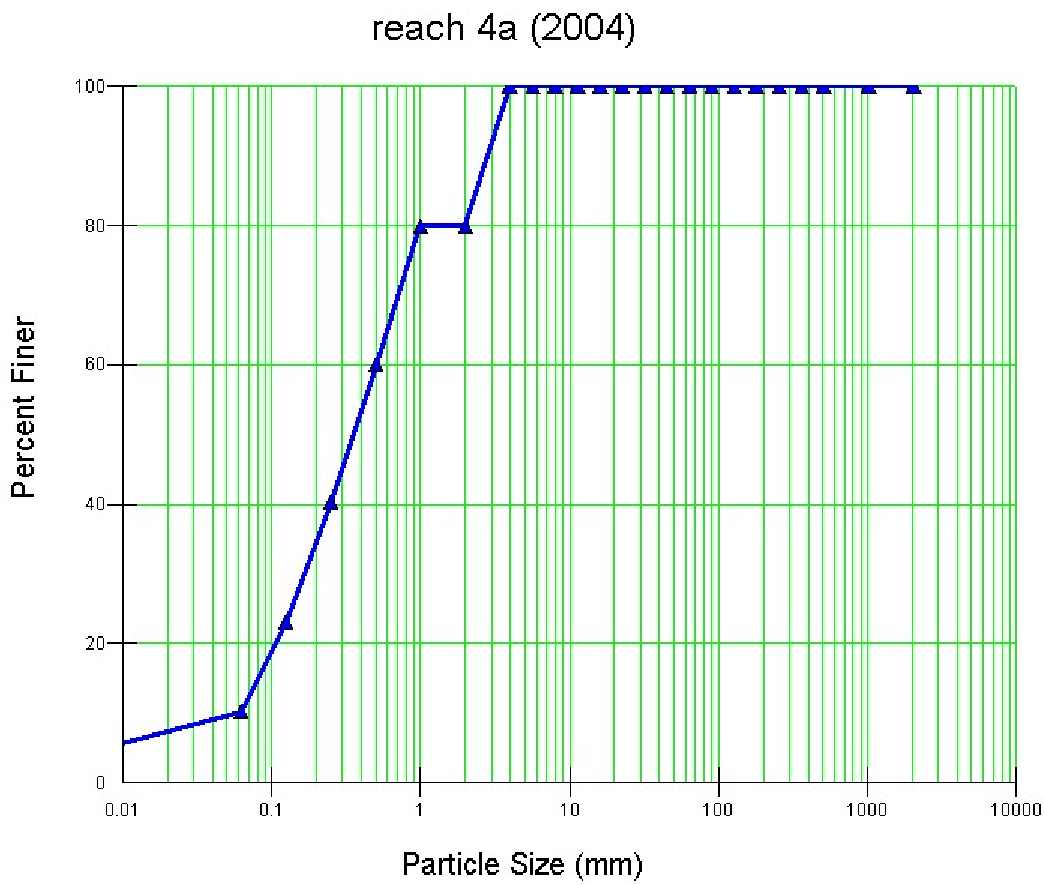


reach IVa(2002a)
2590
2588
2586
2584
2582
2580
0
50
100
150
200
Elevation (ft)
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4

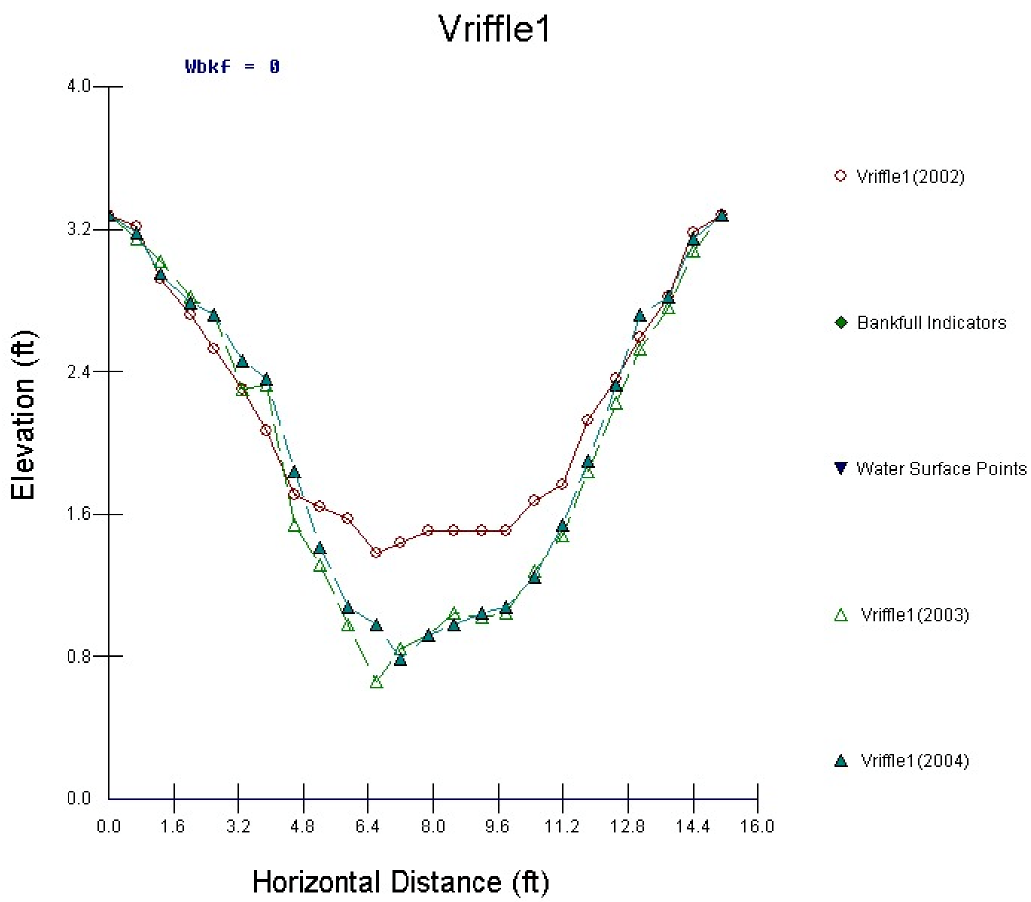


reach IVa(2002b)
Elevation (ft)
2590
2588
2586
2584
2582
2580
0
50
100
150
200
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4


reach IVa(2004)
Elevation (ft)
2590
2588
2586
2584
2582
2580
0
50
100
150
200
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4

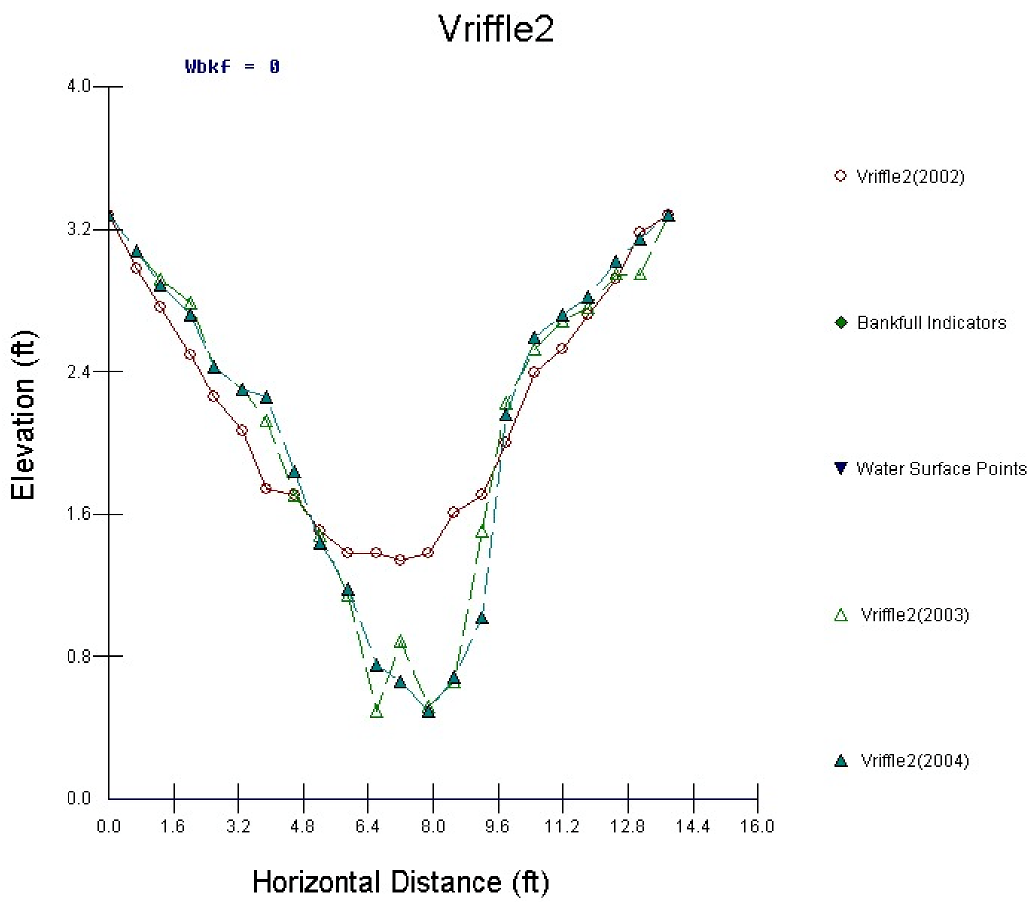


reach 4a (2004)
Percent Finer
Particle Size (mm)
0
20
40
60
80
100
0.01
0.1
1
10
100
1000
10000



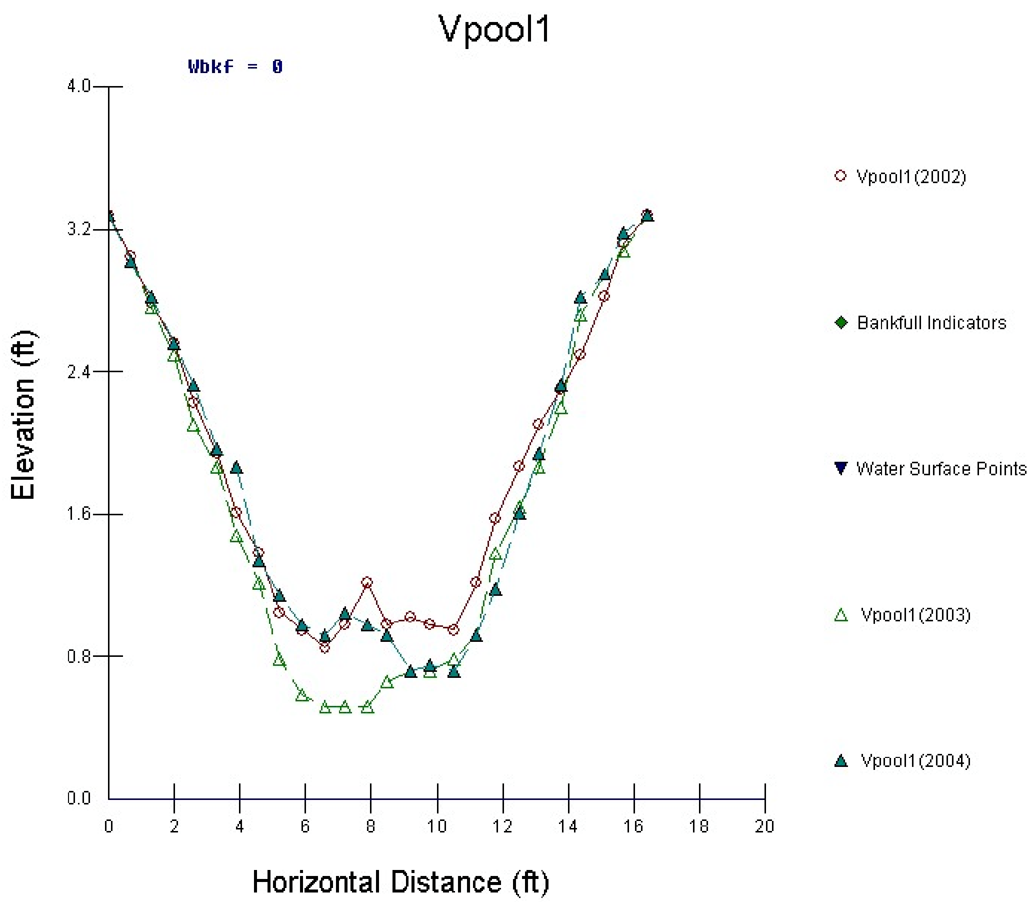
Cross-Section #1 (5Riffle1) Abbreviated Morphological Summary

	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	**17.14**	**20.52**	**19.62**		
Maximum Bankfull Depth (ft)	**1.9**	**2.62**	**2.49**		
Bankfull Mean Depth (ft)	**1.13**	**1.36**	**1.3**		
Bankfull Width (ft)	**15.1**	**15.1**	**15.1**		



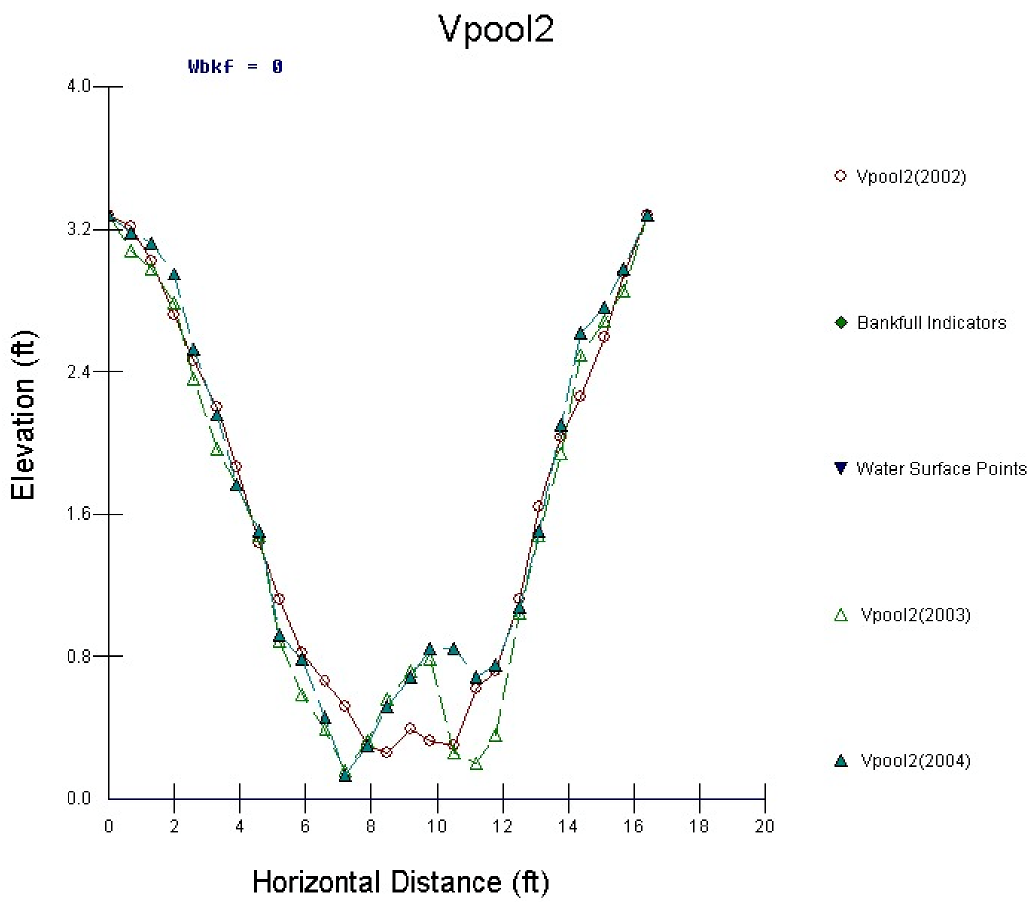
Cross-Section #2 (5Riffle2) Abbreviated Morphological Summary

	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	**15.44**	**16.67**	**16.64**		
Maximum Bankfull Depth (ft)	**1.94**	**2.79**	**2.79**		
Bankfull Mean Depth (ft)	**1.12**	**1.21**	**1.21**		
Bankfull Width (ft)	**13.8**	**13.8**	**13.8**		



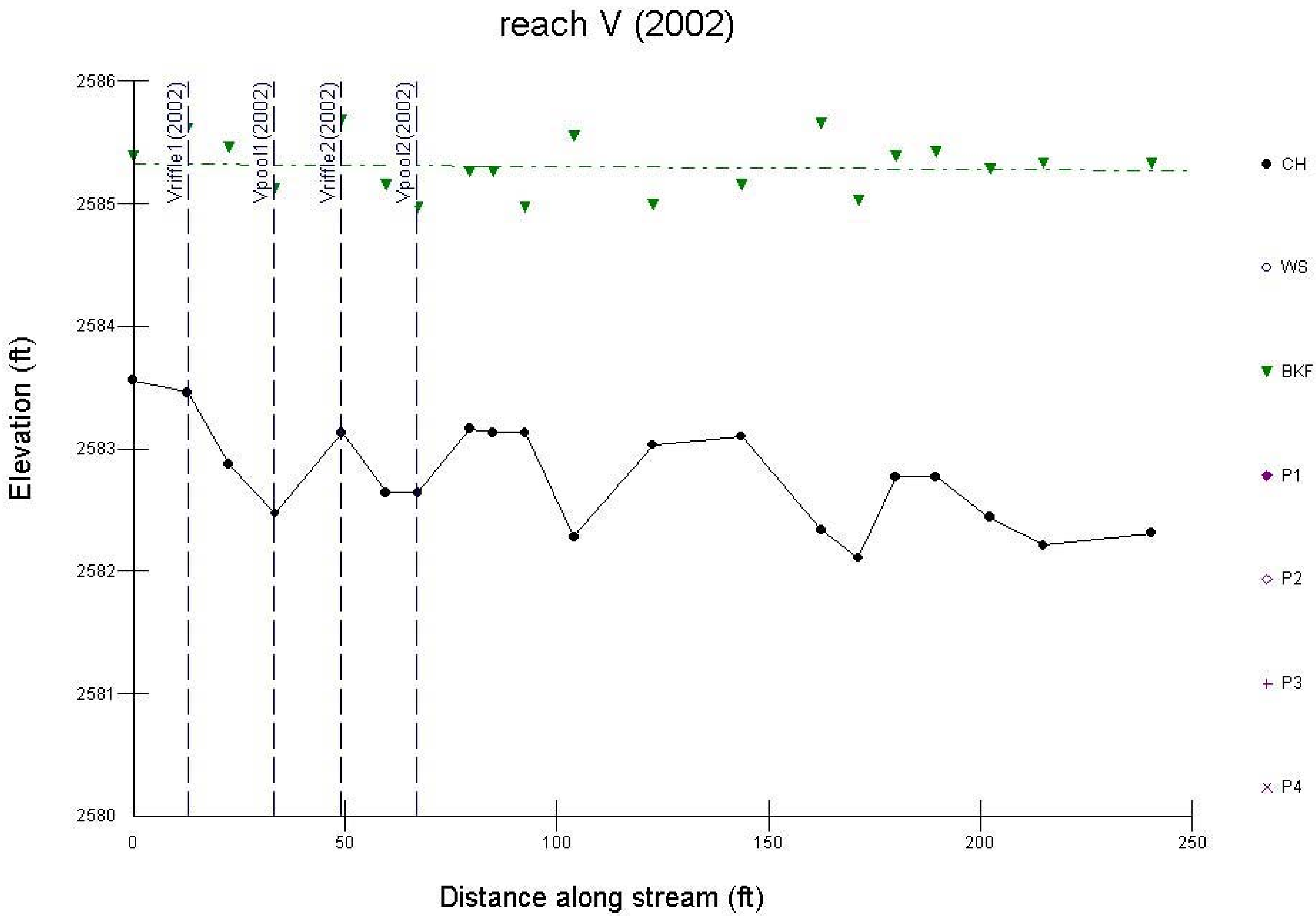
Cross-Section #3 (5Pool1) Abbreviated Morphological Summary

	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	**24.09**	**25.43**	**24.74**		
Maximum Bankfull Depth (ft)	**2.43**	**2.66**	**2.56**		
Bankfull Mean Depth (ft)	**1.47**	**1.61**	**1.51**		
Bankfull Width (ft)	**16.4**	**15.78**	**16.4**		

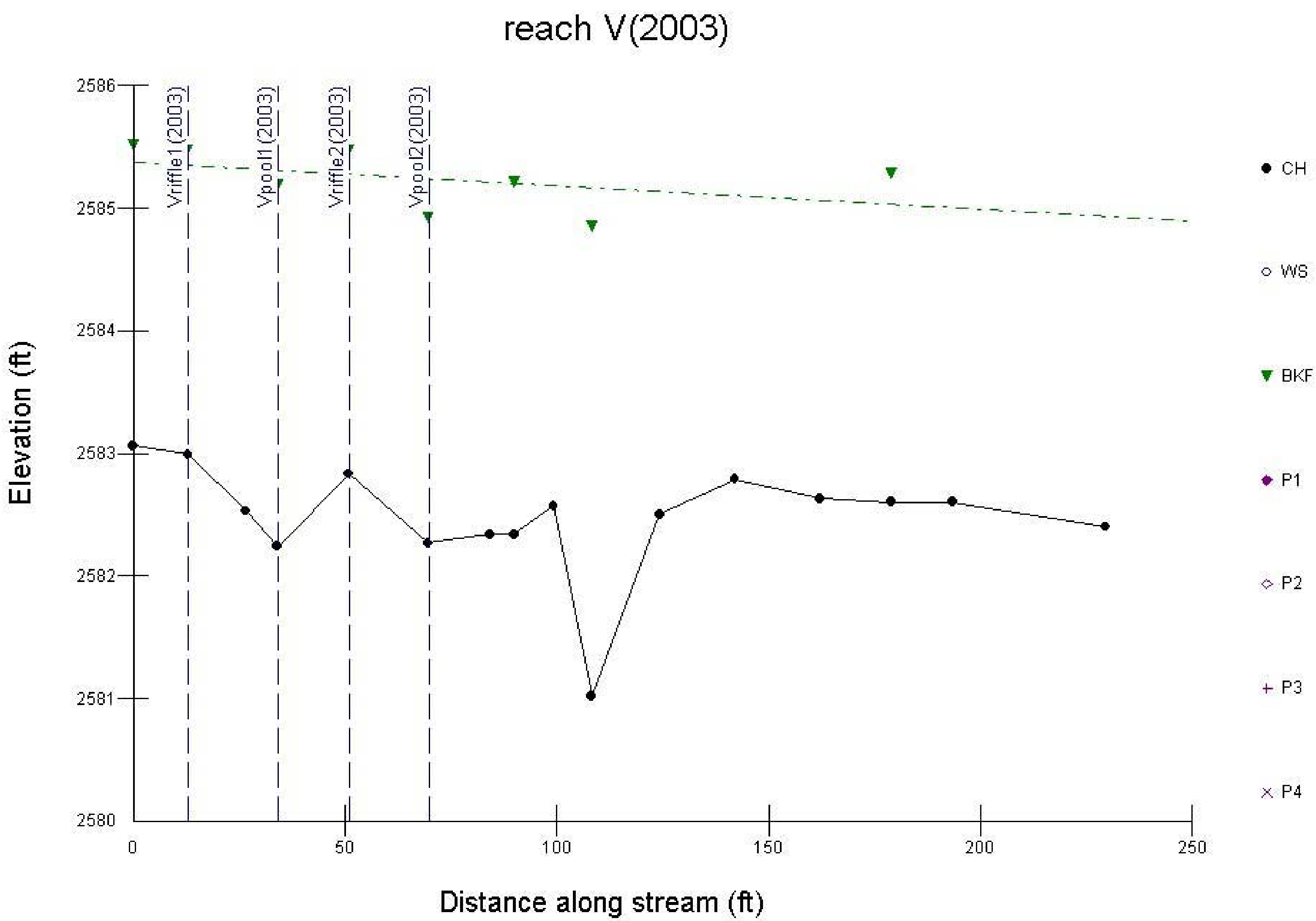


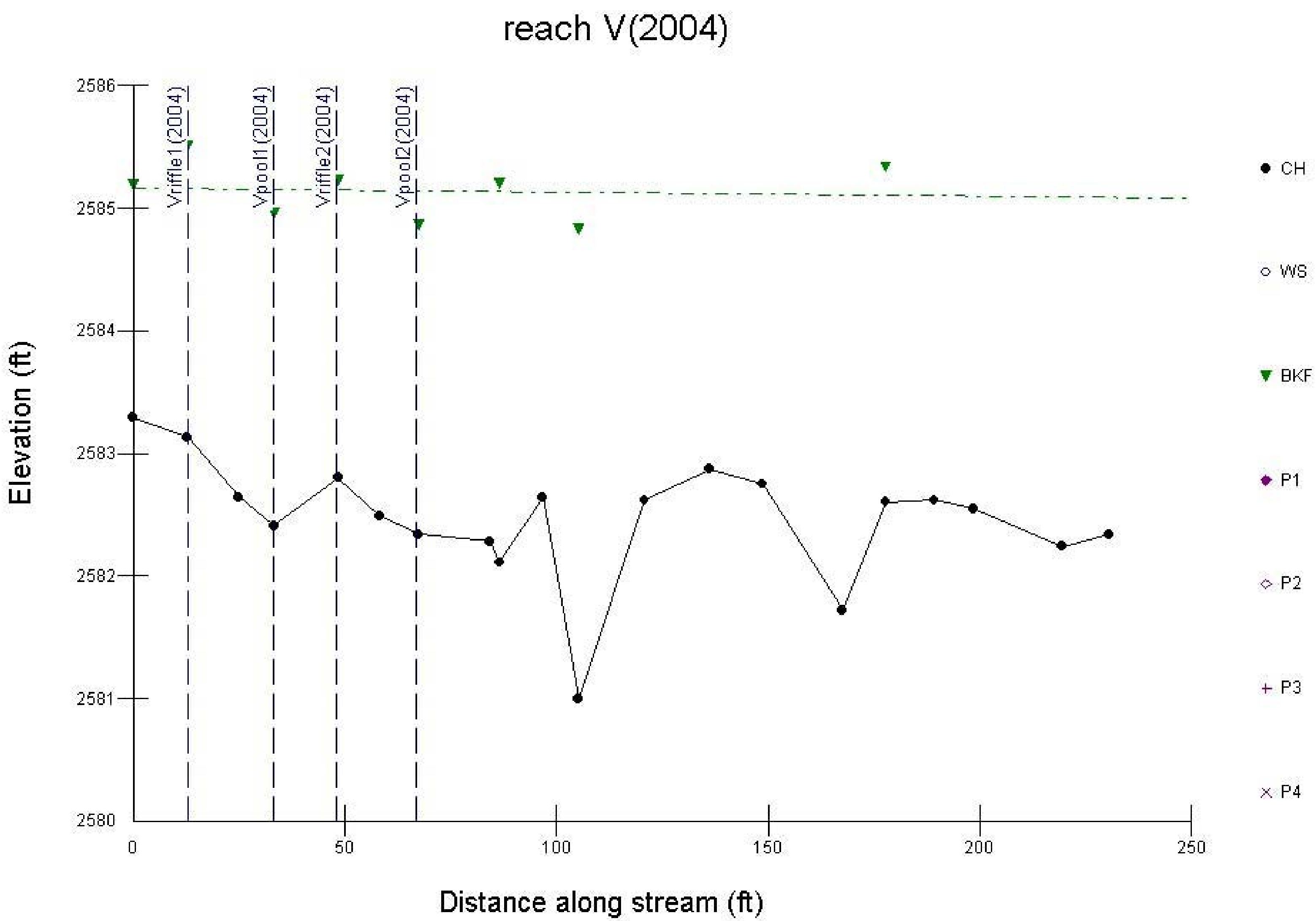
Cross-Section #4 (5Pool2) Abbreviated Morphological Summary

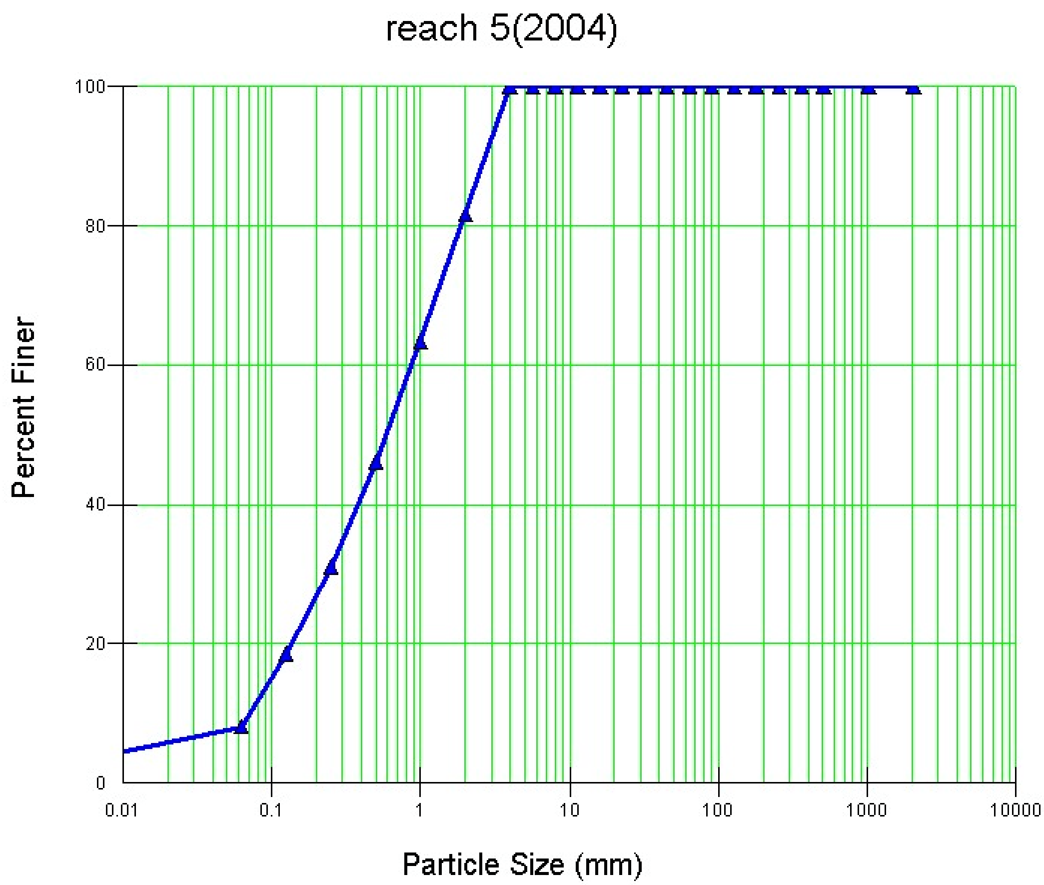
	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	**28.33**	**29.24**	**27.22**		
Maximum Bankfull Depth (ft)	**3.02**	**3.12**	**3.15**		
Bankfull Mean Depth (ft)	**1.73**	**1.78**	**1.66**		
Bankfull Width (ft)	**16.4**	**16.4**	**16.4**		



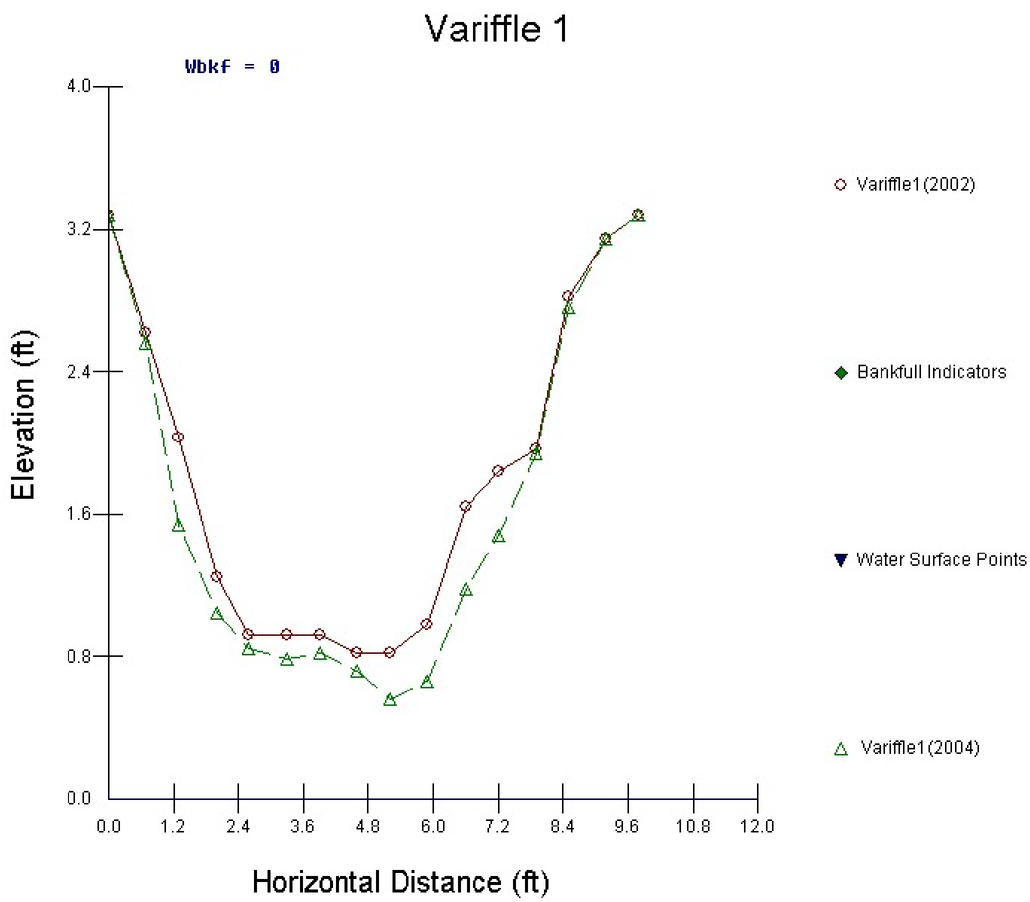
reach V (2002)
Elevation (ft)
Distance along stream (ft)
2586
2585
2584
2583
2582
2581
2580
0
50
100
150
200
250
Vriffle1(2002)
Vpool1(2002)
Vriffle2(2002)
Vpool2(2002)
CH
WS
BKF
P1
P2
P3
P4


reach V(2003)
Elevation (ft)
Distance along stream (ft)
2586
2585
2584
2583
2582
2581
2580
0
50
100
150
200
250
Vriffle1(2003)
Vpool1(2003)
Vriffle2(2003)
Vpool2(2003)
CH
WS
BKF
P1
P2
P3
P4


reach V(2004)
Elevation (ft)
2586
2585
2584
2583
2582
2581
2580
Vriffle1(2004)
Vpool1(2004)
Vriffle2(2004)
Vpool2(2004)
0
50
100
150
200
250
Distance along stream (ft)
CH
WS
BKF
P1
P2
P3
P4

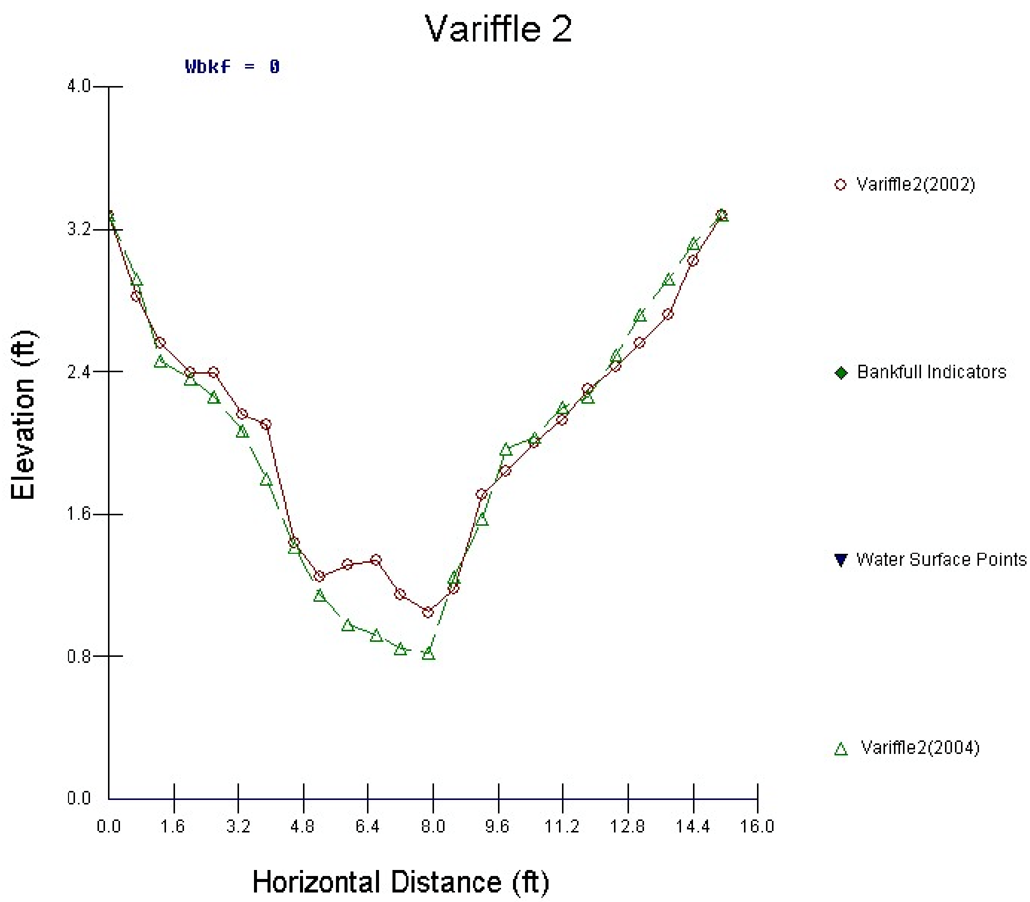


reach 5(2004)
Percent Finer
Particle Size (mm)
0
20
40
60
80
100
0.01
0.1
1
10
100
1000
10000



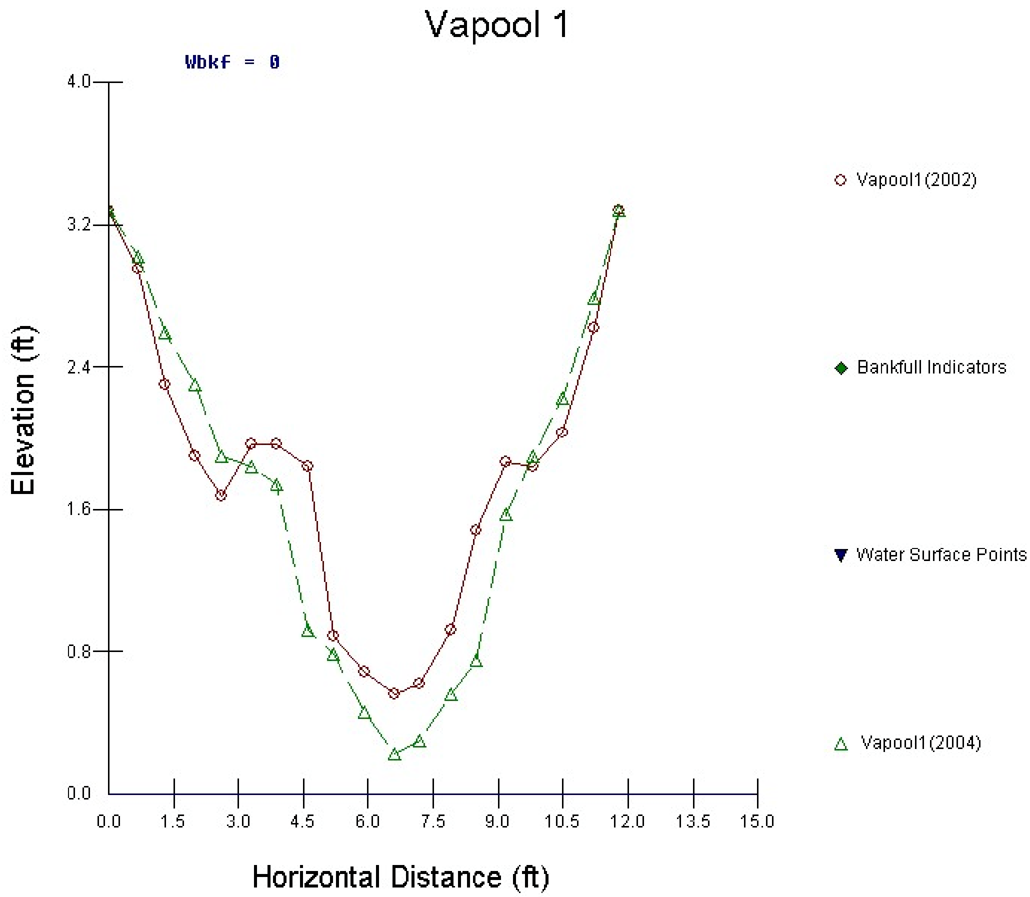
Cross-Section #1 (5aRiffle1) Abbreviated Morphological Summary

	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	15.21	N/a	16.94		
Maximum Bankfull Depth (ft)	2.46	N/a	2.72		
Bankfull Mean Depth (ft)	1.55	N/a	1.73		
Bankfull Width (ft)	9.8	N/a	9.8		



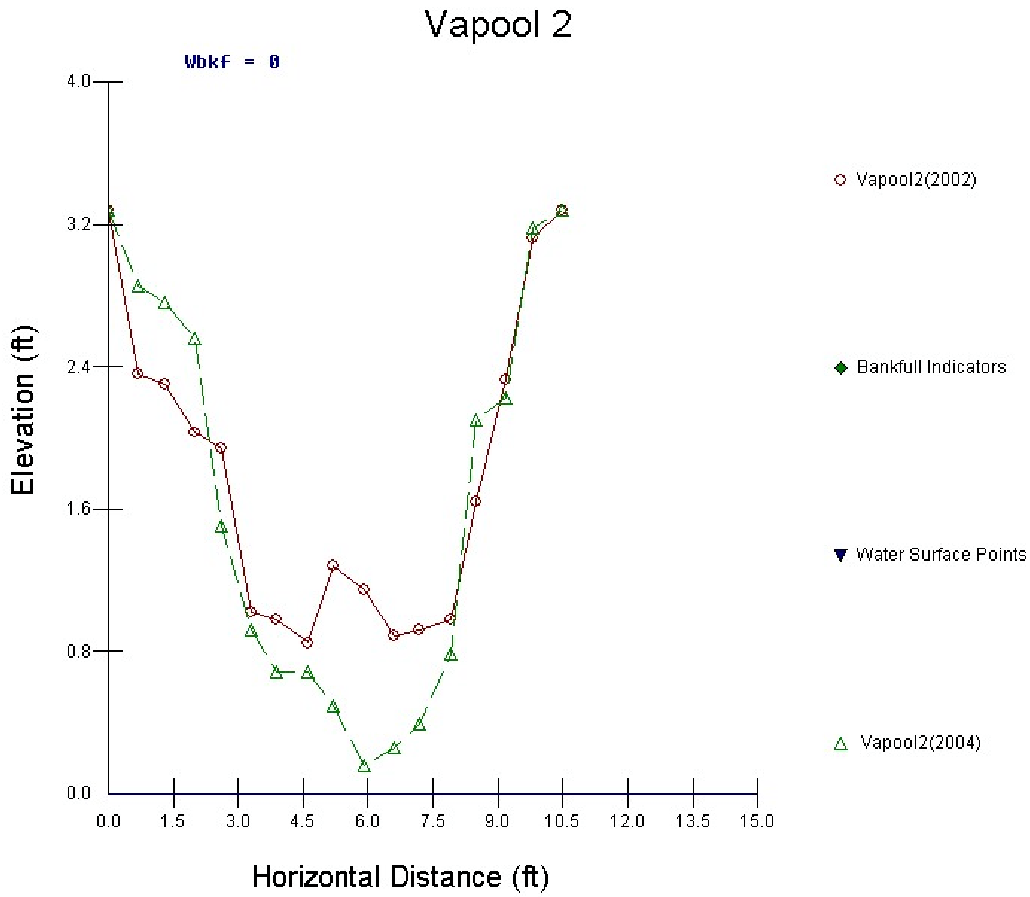
Cross-Section #2 (5aRiffle2) Abbreviated Morphological Summary

	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	18.56	N/a	19.44		
Maximum Bankfull Depth (ft)	2.23	N/a	2.46		
Bankfull Mean Depth (ft)	1.23	N/a	1.29		
Bankfull Width (ft)	15.1	N/a	15.1		



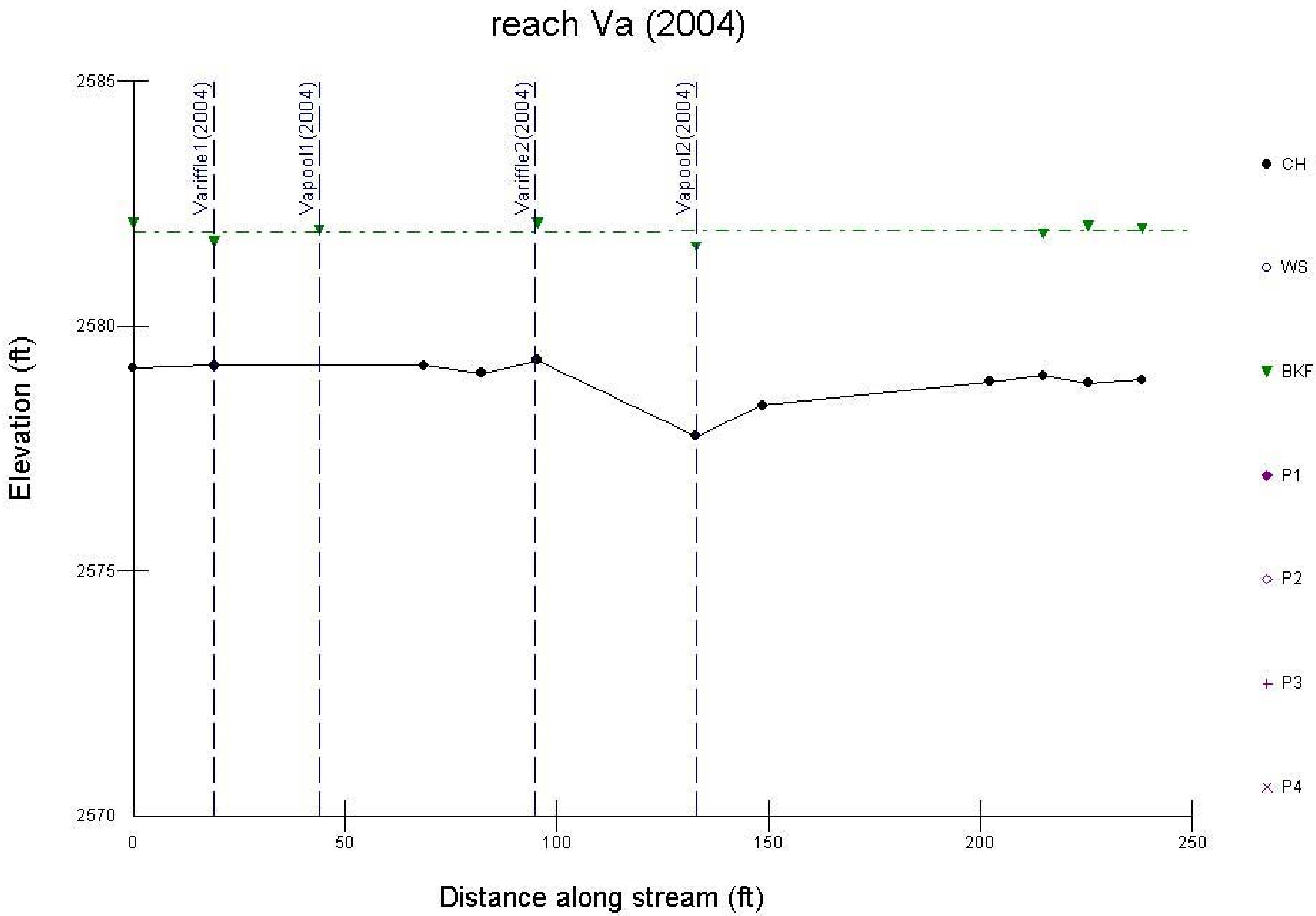
Cross-Section #3 (5aPool1) Abbreviated Morphological Summary

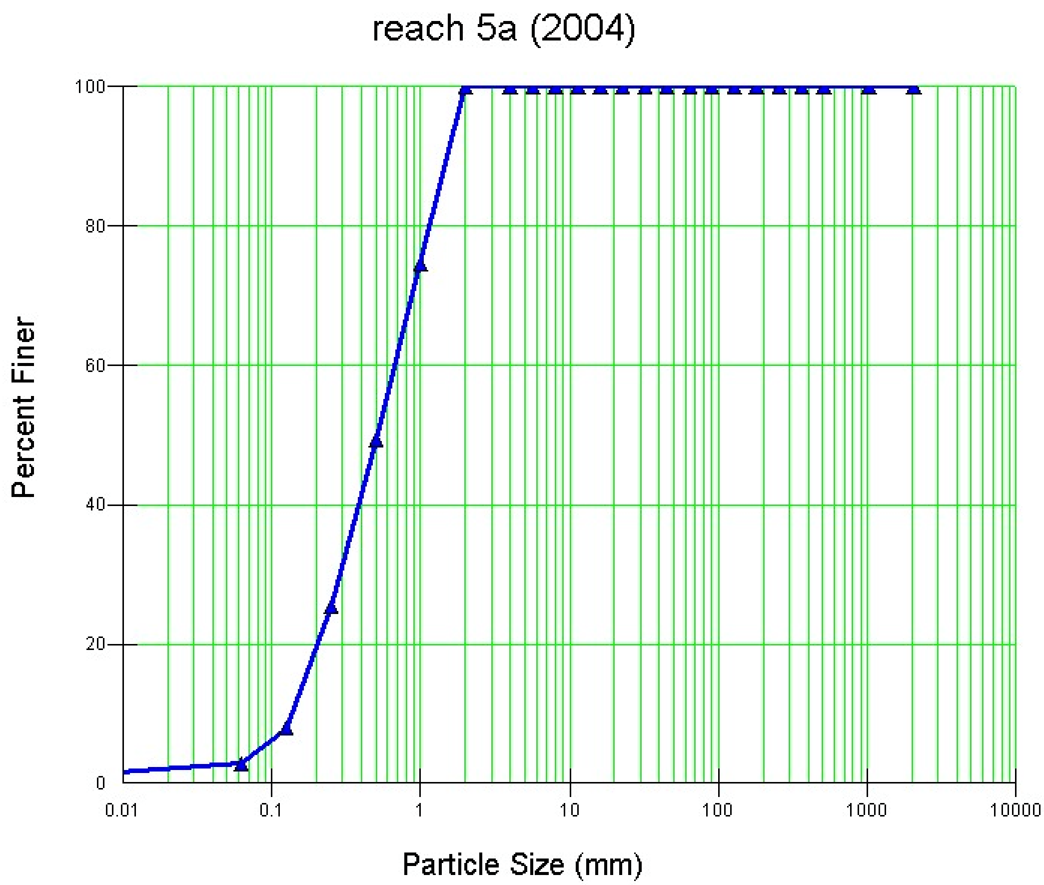
	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft²)	18.16	N/a	19.61		
Maximum Bankfull Depth (ft)	2.72	N/a	3.05		
Bankfull Mean Depth (ft)	1.54	N/a	1.66		
Bankfull Width (ft)	11.8	N/a	11.8		



Cross-Section #4 (5aPool2) Abbreviated Morphological Summary

	2002	2003	2004	2005	2006
Bankfull Cross Sectional Area (ft^2)	16.62	N/a	18.11		
Maximum Bankfull Depth (ft)	2.43	N/a	3.12		
Bankfull Mean Depth (ft)	1.58	N/a	1.72		
Bankfull Width (ft)	10.5	N/a	10.5		


reach Va (2004)
Elevation (ft)
2585
2580
2575
2570
Distance along stream (ft)
0
50
100
150
200
250
Variffle1(2004)
Vapool1(2004)
Variffle2(2004)
Vapool2(2004)
CH
WS
BKF
P1
P2
P3
P4



reach 5a (2004)
Percent Finer
Particle Size (mm)
100
80
60
40
20
0
0.01
0.1
1
10
100
1000
10000

STREAM AND WETLAND MONITORING PLAN

TULULA CREEK WETLAND MITIGATION SITE

The North Carolina Department of Transportation
Raleigh, NC

August 2000

1.0 INTRODUCTION

The Tulula Creek Wetlands Mitigation Site is a 222 acre tract in Graham County, N.C. acquired and protected by the North Carolina Department of Transportation (NCDOT). The site is being developed as a NCDOT wetland and stream restoration project designed to assist in replacing highway-related impacts in the mountain region. The mitigation site contains regionally unique mountain bogs and floodplain wetlands, known as Tulula Bog, that have been heavily degraded by human activity.

The restoration work on Tulula Creek and the adjacent wetlands will be complete by the end of 2000 and NCDOT will begin monitoring the site. NCDOT has approved a grant for the University of North Carolina at Asheville (UNCA) to conduct research on the site that will provide us with monitoring data and information. Generally, the monitoring plan for the site follows the grant proposal submitted by UNCA. However, the grant also funds additional studies beyond monitoring regulatory success criteria. NCDOTwil1 collect certain monitoring data not included in the grant proposal as discussed below.

The mitigation plan for Tulula Creek has been adjusted and modified by the Mitigation Review T earn since it was written in 1997. However, much of the information in this document is derived from Sections 7.0 and 8.0 of the mitigation plan. A revised mitigation plan reflecting the changes will be distributed along with the As-Built Package once construction is complete.

2.0 SUMMARY OF UNCA RESEARCH GRANT

UNCA's research objectives are as follows: to determine the success of the stream realignment by evaluating the geomorphology of the new channel before and after water is introduced; to track restoration of site hydrology, evaluate changes in ecosystem structure and function associated with plant community succession in the floodplain in response to a higher water table and overbank flooding; to evaluate wildlife use of the site in response to changing hydrologic conditions (amphibians) and plant community succession (birds).

In addition to monitoring stream morphology, bank erosion will be determined using random 50 m segments. Groundwater wells will be installed throughout the site to observe changes in the water table.

Plant community succession studies will be supported by data collected on hydrology and soils in vegetation plots. UNCA will examine the effect of a post-restoration increase in the water table on woody and herbaceous plants in the open and closed canopy regions of the site. The grant proposal also includes monitoring the success of naturally-regenerating woody plants in previously converted fairways and a few designated areas within the floodplain. In order to observe bird response to plant succession, UNCA will conduct breeding bird surveys and collect habitat data during the spring and summers of 2000 and 2002.

UNCA will document the amphibian response to restored hydrology. Amphibians are the most important faunal element of these systems. Fish-free ponds created by NCDOT will be monitored for amphibian reproduction, outbreaks of bacterial infections, and tracked to compare the colonization of ponds to pond size and location. UNCA has five years of baseline data to build upon. Wood frogs and spotted salamanders have been common at Tulula in the past and will be monitored during the increase in site hydrology. Also in the past five years UNCA biologists have witnessed catastrophic die-offs of amphibian larvae in ponds due to pathogenic bacteria. They will continue to investigate the outbreak of bacteria in the ponds and its effect on the amphibian population.

3.0 REGULATORY CRITERIA MONITORING PLAN

Monitoring of wetland and stream restoration efforts will be performed until success criteria are fulfilled according to the Army Corps of Engineer (CaE) guidelines. Monitoring is proposed for three wetland components, vegetation, hydrology, and stream morphology. Wetland soils currently exist within the mitigation area and monitoring soil conditions is not considered necessary to verify wetland and stream restoration success although will be monitored as part ofUNCA's research.

2.1 HYDROLOGY MONITORING

While hydrological modifications are being perfonned on the site, surficial monitoring wells will be designed and placed in accordance with specifications in U. S. Army Corps of Engineers', Installing Monitoring Wells/Piezometers in Wetlands (WRP Technical Note HY-IA- 3.1, August 1993). Monitoring wells will be set to a depth of 40 inches.

Approximately 30 continuously monitoring groundwater wells will be placed in eight transects perpendicular to the stream. The transects will be spaced out along the entire length of the newly constructed channel and extend into the adjacent wetlands of various ecosystem types. Ecosystem types support similar soils, landform, and target community structure. The groundwater wells will read daily and the data will be downloaded from each well once a month throughout the year.

A stream gauge that records stage (water surface) height will be placed in the primary' stream channel at the site outfall (Figure 3). Stream gauge data will be recorded at appropriate intervals (3-4 times a day) to determine the frequency of bankfull discharge based on the stream dimensions.

Geomorphology characteristics will be evaluated over time. The channel will be permanently staked at 50-m intervals and the sinuosity and the meander and riffle lengths will be determined for random 50-m segments. The permanent stakes will be used to collect data on cross-sectional channel characteristics. Additional discussion of hydrological monitoring can be found in the grant proposal.

In addition, NCDOT biologists conducted baseline benthic and fish sampling in the existing disturbed/channelized stream in the spring of 1998. Assuming that construction is completed in the fall of 2000, they will return to survey the restored channel in the spring of 2001 and subsequent years during the monitoring period.

3.2 HYDROLOGY SUCCESS CRITERIA

Target hydrological char.acteristics include saturation or inundation for at least 12.5% of the growing season at lower landscape positions, during average climatic conditions. Upper landscape reaches may exhibit surface saturation/inundation between 5% and 12.5% of the growing season based on well data. These 5%-12.5% areas are expected to support hydrophytic vegetation. If wetland parameters are marginal as indicated by vegetation and hydrology monitoring, a jurisdictional determination will be performed in the questionable area. Comparisons can also be made to well data collected at some locations on the site prior to construction.

Stream gauge data will be utilized to substantiate the frequency of bankfull discharge. The target frequency of bankfull discharge is anticipated to exhibit a one to two year return interval under nonnal climatic conditions. Stream gauge monitoring and bankfull calculations will require average climatic conditions including an average distribution of peak stonn events.

3.3 VEGETATION MONITORING

Restoration monitoring procedures for vegetation are designed in accordance with EP A guidelines enumerated in Mitigation Site Type (MIST) documentation (EP A 1990) and CaE Compensatory Hardwood Mitigation Guidelines (DOA 1993). A general discussion of the restoration monitoring program is provided.

Phase I and II plantings include the former pine plantation, live staking, alder transplants, erosion control seeding, and tree planting in the areas disturbed by construction. After planting has been completed in winter or early spring, an initial evaluation will be performed to verify planting methods and to determine initial species composition and density. The upland buffers and protection areas will not be monitored. Supplemental planting and additional site modifications will be implemented, if necessary .

During the first year, vegetation will receive cursory, visual evaluation on aperiodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed between September 1 and October 30 after each growing season until the vegetation success criteria is achieved.

During quantitative vegetation sampling in early fall of the first year, approximately 15 sample lots will be randomly placed within each restored ecosystem type. Sample plot distributions will be correlated with hydrological monitoring locations to provide point-related data on hydrological and vegetation parameters. **In** each sample plot, vegetation parameters to be monitored include species composition and species density. Visual observations of the percent 90ver of shrub and herbaceous species will also be recorded. Vegetation monitoring is expanded beyond the regulatory success criteria by the UNCA grant proposal.

3.4 VEGETATION SUCCESS CRITERIA

Success criteria have been established to verify that the wetland vegetation component supports community elements necessary for a jurisdictional determination. Additional success criteria are dependent upon the density and growth of characteristic forest species. Specifically, a minimum mean density of 320 characteristic tree species must be surviving for 3 years after initial planting, and no species can comprise more than 20% of the 320 stem/acre total. The required survival criterion will decrease by 10% per year after the third year of vegetation monitoring (i.e., for an expected 290 stems per acre for year 4 and 260 stems per acre for year 5). Characteristic species include planted elements along with natural recruitment of tree species identified in reference ecosystems. Supplemental plantings will be performed as needed to achieve the vegetation success criteria.

No quantitative sampling requirements are proposed for herb assemblages as part of the vegetation success criteria. However, UNCA will be sampling for herb assemblages as part of the research grant proposal. Development of a swamp forest-bog complex over several decades and wetland hydrology will dictate the success of migration and establishment of desired wetland understory and groundcover populations. Visual estimates of the percent cover of herbaceous species and photographic evidence will be reported for information purposes.

CONTINGENCY

In the event that vegetation or hydrology success criteria are not fulfilled, a mechanism for contingency will be implemented. For vegetation contingency, replanting and extended monitoring periods will be implemented if community restoration does not fulfill minimum species density and distribution requirements. A few areas are being left unplanted to study natural regeneration and succession.

Hydrological and stream contingency will require consultation with hydrologists and regulatory agencies if wetland hydrology restoration is not achieved or stream destabilization occurs during the monitoring period. For stream destabilization, additional measures to induce rev~getation of the site and channel represents the most likely contingency measure. Recommendations for contingency to establish wetland hydrology will be implemented and monitored until the Hydrology Success Criteria are achieved.

WETLAND FUNCTIONAL EVALUATIONS

Mitigation credit is typically determined based on wetland functions generated by restoration and comparison of restored functions to impacted wetland resources. An evaluation of mitigation wetlands is provided to orient crediting procedures as wetland impacts are quantified. This assessment subjectively evaluates mitigation wetland functions under existing conditions and compares these functions to the post restoration conditions. A brief summary of evaluations is provided.

Wetland functional evaluations entail subjective assessments of hydro geomorphic wetland functions outlined in various research and project literature (Brinson et at. 1995, ESI

1994b). This assessment categorizes functions into three primary areas: a) hydrodynamics; b) biogeochemical processes; and c) biotic resources.

Reference Forest Ecosystems (RFEs) were utilized as an indicator of wetland functions and wetland functional capacity. Target functions have been identified based on the types of potential wetlands present at Tulula Bog: forest gap-bogs, open bogs, seasonal inundated pools, and wet low terraces.

4.1 WETLAND FUNCTIONS UNDER EXISTING CONDITIONS

The site consists of approximately 79 ha (196 ac) of mitigation land (wetlands and upland buffers) encompassing regionally unique bog and mountain floodplain wetlands that have been heavily degraded by human activity. An additional 11 ha (26 ac) of land exists in upland areas (protection zones) along eastern and western peripheries of the wetland complex. (90 ha [222 ac] total area).

During golf course construction, a linear dredged channel was constructed through the center of the floodplain and stream flows were diverted into the drainage network (Figure 3). The dredged channel (G stream type) within the E stream valley measures approximately 1814 m (5950 ft) in length. The upstream segment on the site contains approximately 427 m (1400 ft) of additional stream channel in a B valley. This B stream segment has sustained down-cutting (conversion to G) due to a migrating head-cut. Most of the historic E channel was buried under spoil or excavated to ditches that provide accelerated drainage to the dredged channel and off the site.

During this period, vegetation was cleared and spoil was systematically placed in proposed fairways, roads, and residential areas. Identified spoil mounds and ridges, covering approximately 4 ha (10 ac), have buried historic wetland surfaces in the floodplain. The sites support spoil ranging to approximately 1.2 m (4 ft) in thickness.

Dredging and straightening of waterways has lowered the groundwater table and induced channel grade degradation on the site and in the upper watershed. Feeder tributaries on adjacent terraces are apparently adapting to the induced (lowered) flow gradient by down-cutting into subsurface materials. Floodplains have been abandoned on the site and are most likely being abandoned along certain streams above the site. The lowering of groundwater and surface water flow gradients has caused mountain bog and seasonal pools to dry prematurely, jeopardizing the site's amphibian populations. As such, important wetland hydrodynamic functions have been lost including dynamic surface water storage, long-term surface water storage, and moderation of groundwater flow or discharge (Brinson *et al.* 1995).

The abandoned floodplain has been converted to an elevated terrace with negligible potential for future influence from overbank flooding or lateral stream migration. Studies indicate that under certain conditions, over 50% of a floodplain may be re-worked by stream shifts over a period of 70 years (Everitt 1968). Soil observations suggest a similar pattern of migration by Tulula Creek. This historic wetland attribute represents a critical factor in the formation and maintenance of seasonal pools and regionally unique mountain bogs. Oxbows, discontinuous channels, feeder tributary braids, and alluvial fans appear to have modified most of the historic floodplain prior to dredging. Riverine wetland functions such as maintenance of characteristic habitat, energy dissipation, nutrient cycling, removal of imported elements and compounds, retention of particulates, and organic carbon export are considered lost.

The adjacent wetland terraces have sustained significant degradation due to down-cutting, ditching, spoil placement, and removal of vegetation. These systems contain an array of seeps, ephemeral streams, and permanent streams that appear to have degraded towards the induced downstream flow gradient. Minor floodplains (wetlands) along these terraces are also considered lost or disappearing due to disturbance. The largest terrace, situated in the northwestern portion of the property, has sustained further groundwater degradation due apparently to a large roadside ditch and white pine plantation along the old railroad bed (Figure 17).

Reduction or elimination of wetland hydrology and removal of forest vegetation throughout the site has also altered biogeochemical cycling and biological functions within the complex. The site may not support the hydroperiods required to maintain forest gap-bog communities, seasonal pools, seeps, or the wetland dependent wildlife regionally unique to the ecosystem. The site was previously classified as a swamp-bog complex prior to being partially converted into a golf course (Gaddy 1981, Schafale and Weakley 1990). Although the site still contained wetlands, it was no longer a functional swamp-bog complex prior to restoration work

4.2 PROJECTED WETLAND FUNCTIONS UNDER POST-RESTORATION CONDITION

This restoration plan is designed to restore all the wetland features and functions similar to those exhibited by the reference wetlands. The wetlands and wetland buffers will be redirected towards historically stable conditions. After implementation, the site is expected to support approximately 41 ha (102 ac) within the wetland ecosystem, approximately 38 ha (95 ac) of upland buffers, and approximately 11 ha (26 ac) of surrounding upland parcels (upland protection zones). In addition, approximately 3366 m (11,040 ft) of reconstructed E stream and repaired B stream segments will flow through the wetland system.

Projected performance of wetland and stream functions is inferred from conditions expected 20 + years after mitigation activities are completed. This assessment assumes that restoration plans are implemented and that the stream and wetland is protected from man-induced disturbances in perpetuity. These assumptions are valid if the site is deeded or donated to a conservation organization that will manage the site after wetland restoration success is achieved.

Site alterations are expected to restore near-surface and above-surface hydrodynamics throughout the floodplain and wet terraces. Stream and groundwater flow gradients will be restored in both physiographic units. Mountain bogs, seasonal pools, and in-stream habitats characteristic of reference wetlands are expected to re-establish. All the hydrodynamic, biogeochemical, and biotic functional attributes described in the preceding section will be restored, potentially returning the site to historic stream and wetland function.

Upland/wetland ecotones will also be restored within the wetland complex. Integration of wetland and upland interfaces are an important part of this mitigation plan. Upland buffer areas adjacent to the wetland complex offer an ecological gradient from uplands to wetlands and provide for ecotonal fringes. Without upland restoration/enhancement and upland buffer establishment, intrinsic functions in adjacent, restored wetlands may be diminished or lost in the future. These buffers will serve to diminish impacts from adjacent property developments, dumping, in-stream sedimentation, and noise associated with area highways. In addition, a number of biological and physical wetland parameters are also enhanced by the presence of wetland/upland ecotones on the mitigation site (Brinson et at. 1982, Cooper *et a/.* 1986, Brown *et al.* 1990, Jurik *et a/.* 1994, Karr and Schlosser 1978). Pervious studies indicate that incorporation of wetland/upland ecotones may promote as much as a 20% increase in interior wetland functions (EST 1994b).

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State of North Carolina Department of Environment and Natural Resources Division of Water Quality

James B. Hunt, Jr., Governor Bill Holman, Secretary
Kerr T. Stevens, Director

NCDENR

NORTH CAROLI NA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES

October 2, 2000
Graham County
DWQ Project No. 991423

RECEIVED
OCT 13 2000
DIVISION OF HIGHWAYS
PROJECT DEVELOPMENT AND ENVIRONMENTAL ANALYSIS BRANCH

APPROVAL OF 401Water Quality Certification

Mr. William D. Gilmore, P .E., Manager
Planning and Environmental Branch
North Carolina Department of Transportation
P.O. Box 25201
Raleigh, NC, 27611-5201

Dear Mr. Gilmore:

You have our approval, as described in your application dated September 23, 1999, your mitigation plan dated September 1997(except where modified by the design drawings received March 13,2000), your correspondence submitted July 21, 2000, your correspondence dated July 28,2000, your design drawings for project 6.939004T received March 13,2000, your monitoring plan dated August 2000, and in accordance with the attached conditions and those listed below, to place fill material in wetlands and streams for the purpose of constructing the Tulula Creek Wetland and Stream Mitigation Site in Graham County. The project should be constructed in accordance with your application dated September 23, 1999, your mitigation plan dated September 1997 (except where modified by the design drawings received March 13,2000), your correspondence submitted July 21,2000, your correspondence dated July 28,2000, your design drawings for project 6.939004T received March 13,2000, and your monitoring plan dated August 2000. After reviewing your application, we have decided that this fill is covered by General Water Quality Certification Number 3256. Certification Number 3256 corresponds to Nationwide Permit Number 27 issued by the Corps of Engineers. In addition, you should acquire any other federal, state or local permits before you proceed with your project including (but not limited to) Sediment and Erosion Control, Non- Discharge and Water Supply Watershed regulations. This approval will expire when the accompanying 404 permit expires unless otherwise specified in the General Certification.

This approval is valid solely for the purpose and design described in your application (unless modified below). Should your project change, you must notify the DWQ and submit a new application. If the property is sold, the new owner must be given a copy of this Certification and approval letter, and is thereby responsible for complying with all the conditions. This approval shall expire with the corresponding Nationwide Permit expires or as otherwise provided in the General Certification. For this approval to be valid, you must follow the conditions listed in the attached certification and any additional conditions listed below.

1, Upon completion of the project, the NCDOT shall complete and return the enclosed "Certification of Completion Form" to notify DWQ when all work included in the 401 Certification has been completed. The responsible party shall complete the attached form and return it to the 401/Wetlands Unit of the Division of Water Quality upon completion of the project.

2.) Upon completion of the proje4:t, the NC Division of Water shall be provided as builts for the referenced project within 3 months of the project's completion.

State of North Carolina Department of Environment and Natural Resources Division of Water Quality

James B. Hunt, Jr., Governor Bill Holman, Secretary
Kerr T. Stevens, Director

NORTH CAROLI NA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES

3.) Four permanent channel cross sections must be established. The cross sections must include two riffles and pools. All four channel cross section monitoring sites shall be approved in writing by the NC Division of Water Quality. Elevations ofthalwegs, bank toes, bankfull benches, point bars, bankfull widths, and cross section areas must be surveyed and recorded and submitted to DWQ annually for five years.

4. The longitudinal channel profile must be surveyed, recorded and submitted to DWQ after the first year and every two years for the next four years. Thalweg, water surface, bankfull bench, and top of bank elevations should be surveyed and recorded for all pools and riffles.

5. Channel pattern must be measured and recorded and submitted to DWQ the first year, and every two years thereafter for the next four years. Measures must include sinuosi~, meander wavelength, radius of curvature, and belt width.

6.) Pebble counts must be conducted, recorded, and submitted to DWQ on a yearly basis for the entire reach. The method utilized must be done in order to characterize the entire reach. Also, and active channel and subsurface sediment analysis should be conducted yearly at the same riffle and the results should be submitted to DWQ on a yearly basis for a total of five years from the date of issuance of the 401 Water Quality Certification. The method should be submitted to DWQ for written approval within 3 months of issuance of the 401 Water Quality Certification.

Bank stability must be evaluated at two meanders bends. The sites shall be approved by the NC DWQ in writing. The evaluation must establish permanent toe pins at these bends to which to compare any lateral bank movement of failure. The banks must be evaluated and the results submitted on a yearly basis to DWQ for a total of five years from the date of issuance of the 401 Water Quality Certificition. The locations and positions of the pins must be submitted to DWQ within 90 days of the issuance of the 401 Water Quality Certification for written approval.

8.) Photographs must be taken at the same location and orientation at four points (at the cross sections described in condition 3) and submitted to DWQ on a yearly basis.

9.) **In** addition to conditions 3 through 8, DOT will perform monitoring as described in the Stream and Wetlands Monitoring Plan dated August 2000.

11.) If the stream relocation becomes unstable, the stream shall be repaired or stabilized using only natural channel design techniques. Additionally all repair designs must be submitted to and receive written approval from the NC Division of Water Quality before the repair work is performed. If any portion of the relocated of the stream is used as compensatory mitigation for stream impacts, that portion shall be preserved in perpetuity through an easement or some other legally binding mechanism.

Wetlands/401 Unit
Telephone 919-733-1786
FAX 733-9959

1621 Mail Service Center
Raleigh, North Carolina
27699-1621

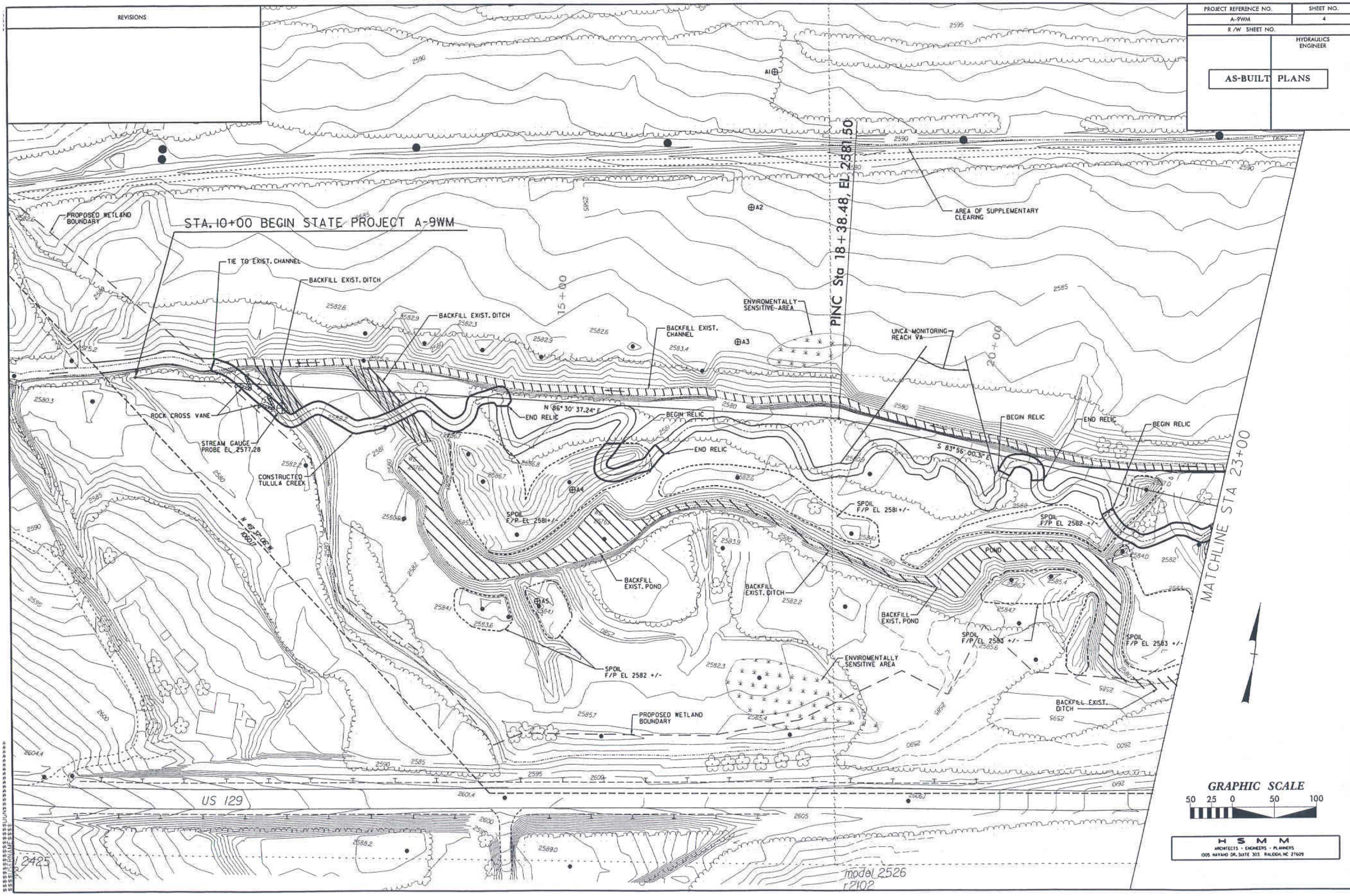
State of North Carolina Department of Environment and Natural Resources Division of Water Quality

James B. Hunt, Jr., Governor Bill Holman, Secretary
Kerr T. Stevens, Director

NORTH CAROLI NA DEPARTMENT OF
ENVIRONMENT AND NATURAL RESOURCES

Wetlands/401 Unit
Telephone 919-733-1786
FAX 733-9959

1621 Mail Service Center
Raleigh, North Carolina
27699-1621


REVISIONS
PROJECT REFERENCE NO.
SHEET NO.
A-9WM
4
R/W SHEET NO.
HYDRAULICS ENGINEER
AS-BUILT PLANS
STA. 10+00 BEGIN STATE PROJECT A-9WM
PROPOSED WETLAND BOUNDARY
TIE TO EXIST. CHANNEL
BACKFILL EXIST. DITCH
BACKFILL EXIST. DITCH
BACKFILL EXIST. CHANNEL
ENVIROMENTALLY SENSITIVE AREA
PINC Sta 18+38.48, EL 2581.50
UNCA MONITORING REACH VA
AREA OF SUPPLEMENTARY CLEARING
ROCK CROSS VANE
STREAM GAUGE PROBE EL 2577.28
CONSTRUCTED TULULA CREEK
N 86° 30' 37.24" E
END RELIC
BEGIN RELIC
END RELIC
BEGIN RELIC
END RELIC
BEGIN RELIC
S 83° 56' 00.31" E
SPOIL F/P EL 2581+/-
SPOIL F/P EL 2581 +/-
SPOIL F/P EL 2582 +/-
SPOIL F/P EL 2582 +/-
SPOIL F/P EL 2583 +/-
SPOIL F/P EL 2583 +/-
POND
BACKFILL EXIST. POND
BACKFILL EXIST. DITCH
BACKFILL EXIST. POND
ENVIROMENTALLY SENSITIVE AREA
PROPOSED WETLAND BOUNDARY
BACKFILL EXIST. DITCH
MATCHLINE STA 23+00
15+00
20+00
A1
A2
A3
A4
A5
US 129
GRAPHIC SCALE
50 25 0 50 100
H S M M
ARCHITECTS • ENGINEERS • PLANNERS
1305 NAVAHO DR. SUITE 303 RALEIGH, NC 27609
model 2526
r2102

REVISIONS

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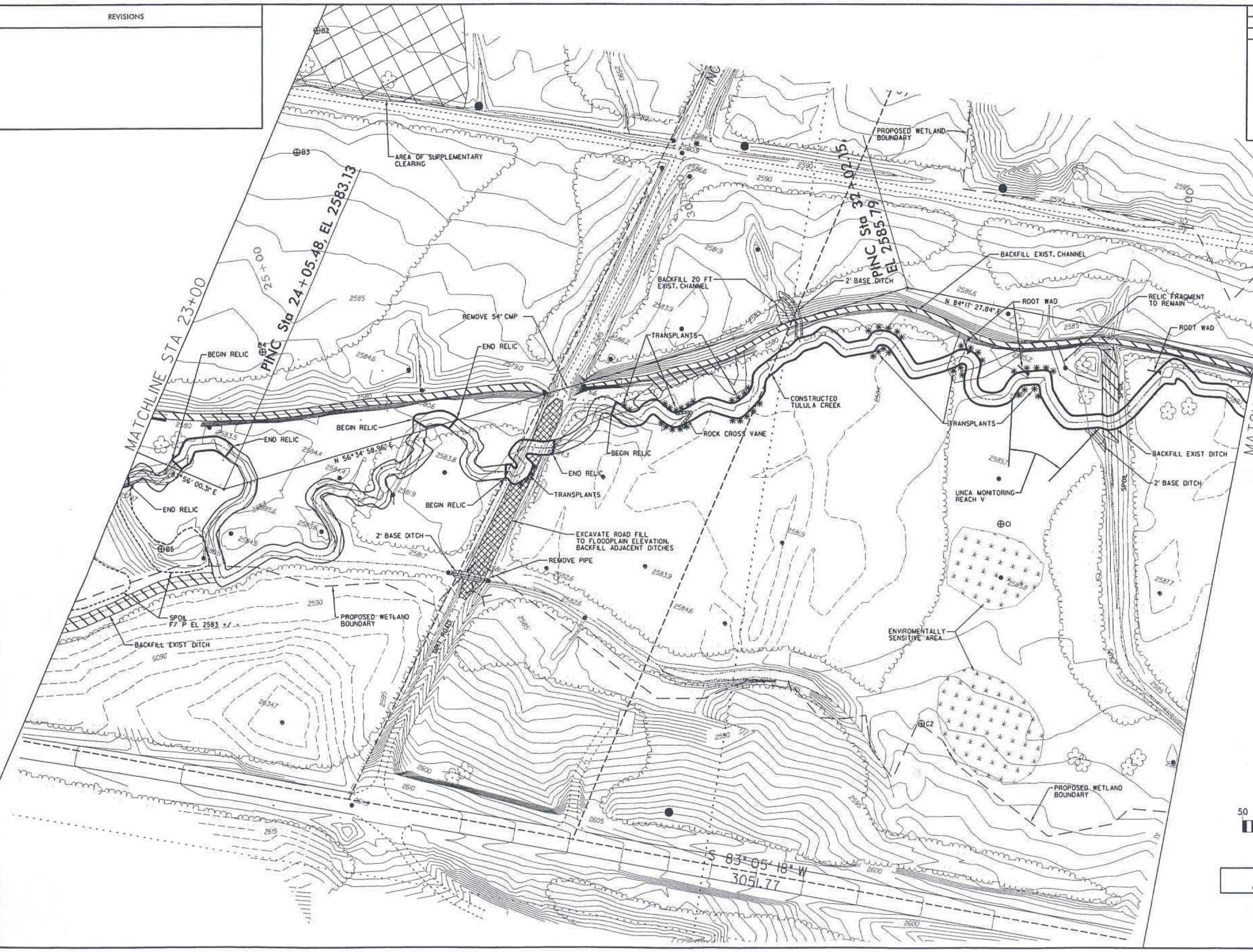
R/W SHEET NO.	
	HYDRAULICS ENGINEER

AS-BUILT PLANS



GRAPHIC SCALE

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H S M M
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REVISIONS

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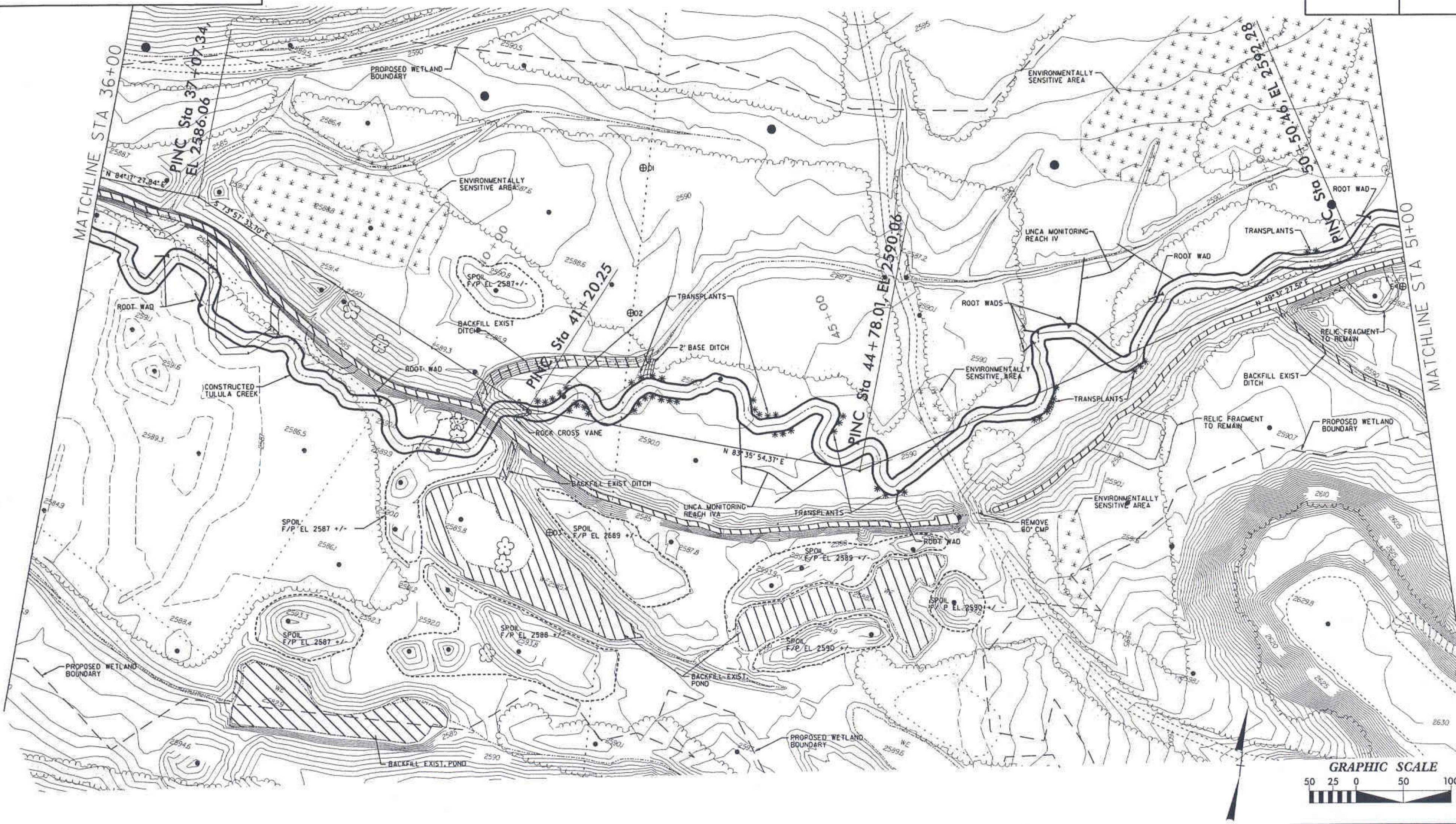
R/W SHEET NO.	
	HYDRAULICS ENGINEER

AS-BUILT PLANS



GRAPHIC SCALE

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H S M M

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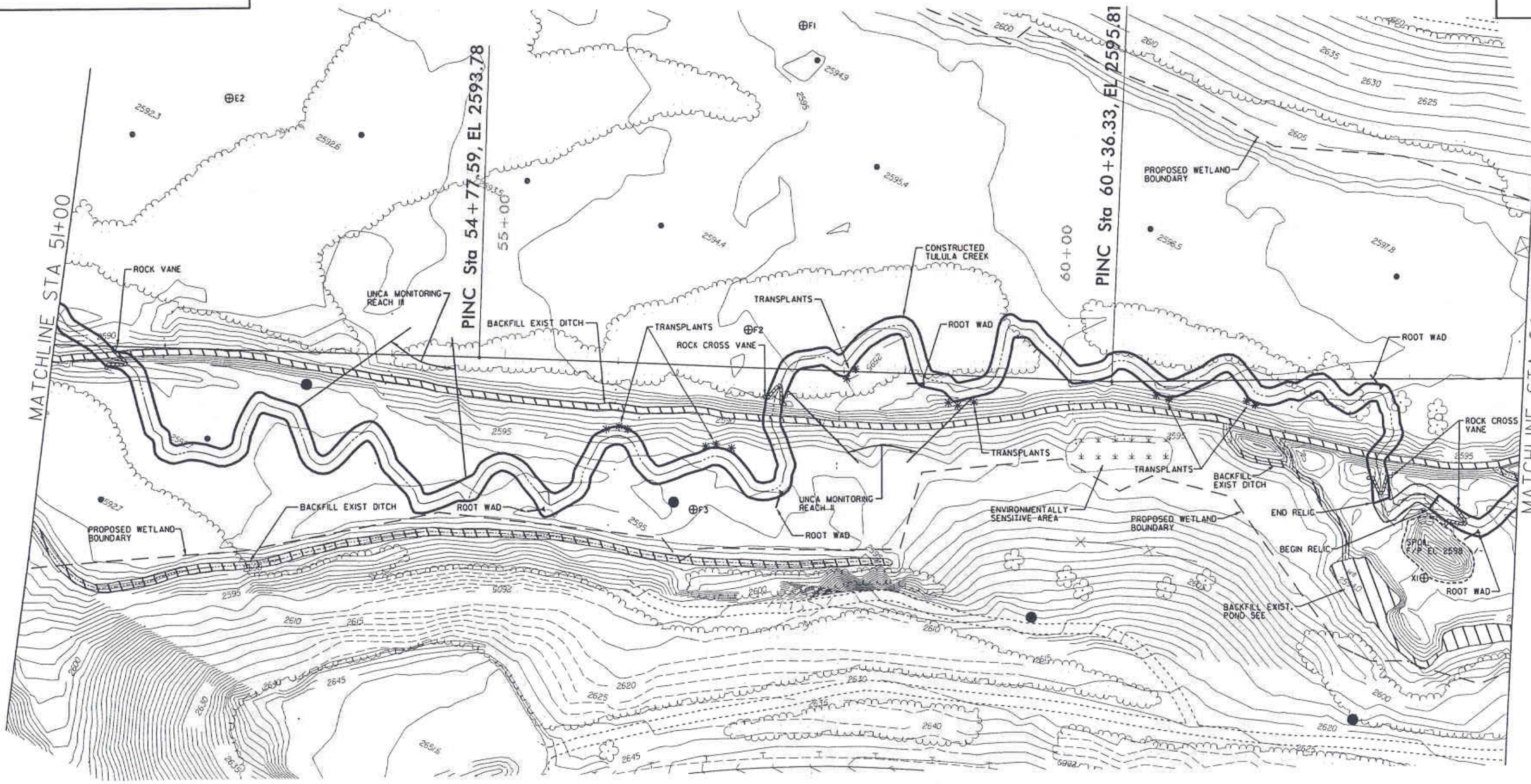
1305 NAVAHO DR. SUITE 303 RALEIGH, NC 27609

REVISIONS

PROJECT REFERENCE NO.	SHEET NO.
A-9WM	7
R/W SHEET NO.	
	HYDRAULICS ENGINEER

AS-BUILT PLANS



GRAPHIC SCALE

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HSMM

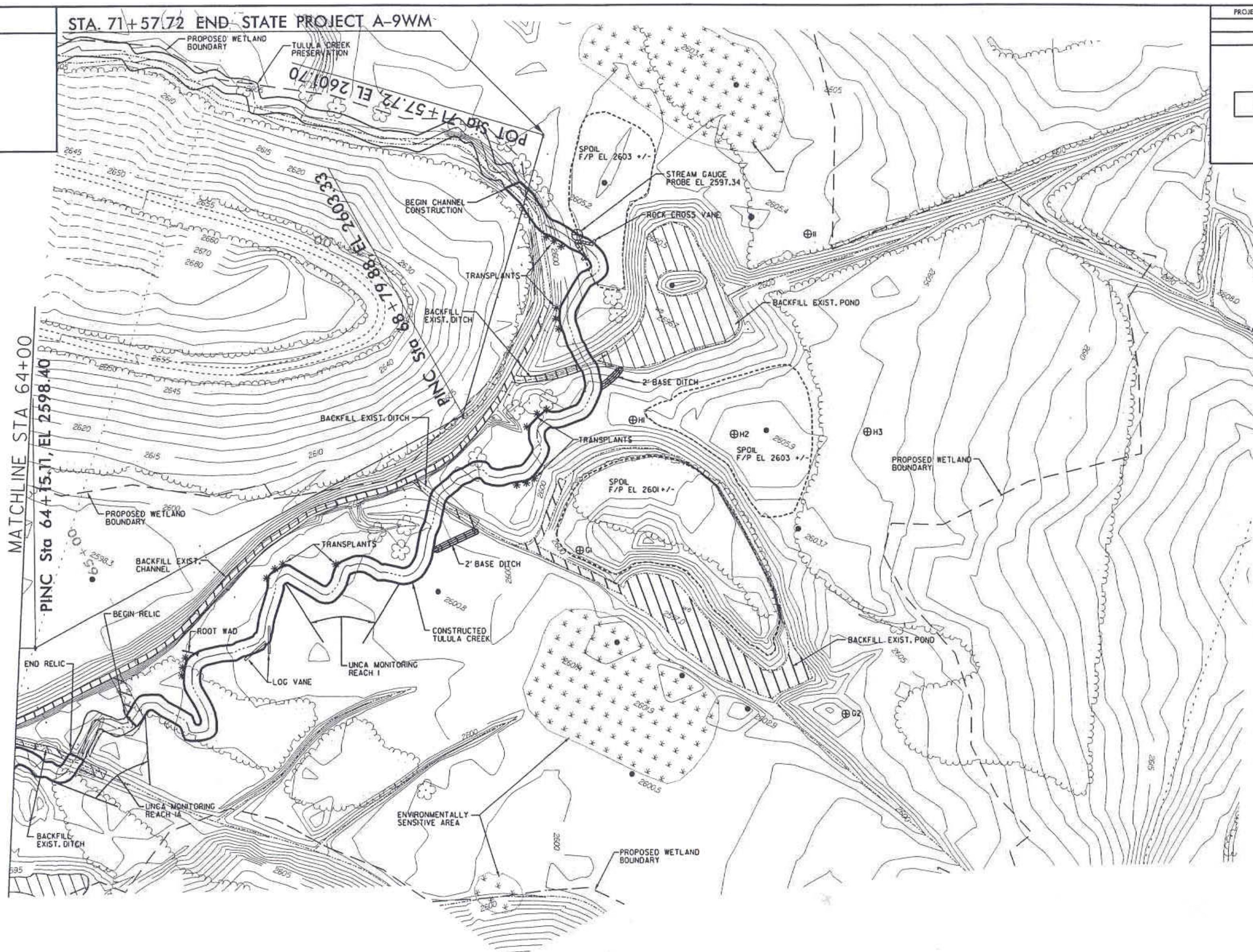
ARCHITECTS - ENGINEERS - PLANNERS

1305 NAVAHO DR. SUITE 303 RALEIGH, NC 27609

REVISIONS

PROJECT REFERENCE NO.	SHEET NO.
A-9WM	8
R/W SHEET NO.	
	HYDRAULICS ENGINEER

AS-BUILT PLANS



GRAPHIC SCALE

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H S M M
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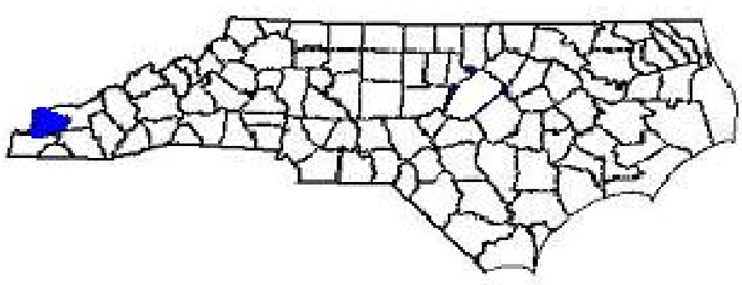
ANNUAL REPORT FOR 2004



Tulula Bog Mitigation Site
Graham County
Project No. 6.939004T
TIP No. A-9WM

Prepared By:
Office of Natural Environment & Roadside Environmental Unit
North Carolina Department of Transportation
December 2004

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SUMMARY

The following report summarizes the monitoring activities that have occurred in the past year at the Tulula Bog Mitigation Site. The site was originally constructed in 2002. The Phase I portion of the site was planted in April 2002, while Phase II was planted in March 2003. The 2004-year represents the second complete year of hydrologic and vegetation monitoring following site construction. The site must demonstrate both hydrologic and vegetation success for a minimum of five years or until the site is deemed successful. It is currently being monitored with twenty-nine groundwater gauges and seven vegetation-monitoring plots.

The daily rainfall data depicted on the monitoring gauge graphs was recorded from a local weather station located in Andrews, NC. Historical rainfall data used for the 30^{th}-70^{th} percentile analysis was provided by the Andrews weather station.

The second year of hydrologic data revealed that nineteen of the twenty-nine groundwater gauges met the success criteria for saturation (within 12" of the surface for 5% of the growing season). Conversely, ten gauges recorded saturation for less than 5% of the growing season.

Four additional plots (plots 4, 5, 6, and 7) were set in November 2004 at the request of the resource agencies. Vegetation data for the second year of monitoring revealed an average density of 385 trees per acre for the 33.3 acres that were planted. This average is above the minimum success criteria of 320 trees per acre.

The University of North Carolina at Asheville is performing the stream restoration monitoring, as a part of a grant received from the Department. Upon receipt of this information, the Department will provide appropriate documentation to the resource agencies.

Per the letter from the Ecosystem Enhancement Program (EEP) to NCDOT dated August 25, 2004, the EEP has accepted the transfer of all off-site mitigation projects. The EEP will be responsible for fulfilling the remaining monitoring requirements and future remediation for this project.

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Tulula Bog Mitigation Site is a 222-acre tract located in Graham County, NC. The site was developed as a wetland and stream mitigation project designed to assist in replacing highway-related impacts in the mountain region. The mitigation site contains 102 acres of wetland restoration, 121 acres of upland buffer protection, 8,639 feet of stream restoration and 1,248 feet of stream preservation. It is located off of Highway 129 between Topton and Robbinsville (Figure 1).

1.2 PURPOSE

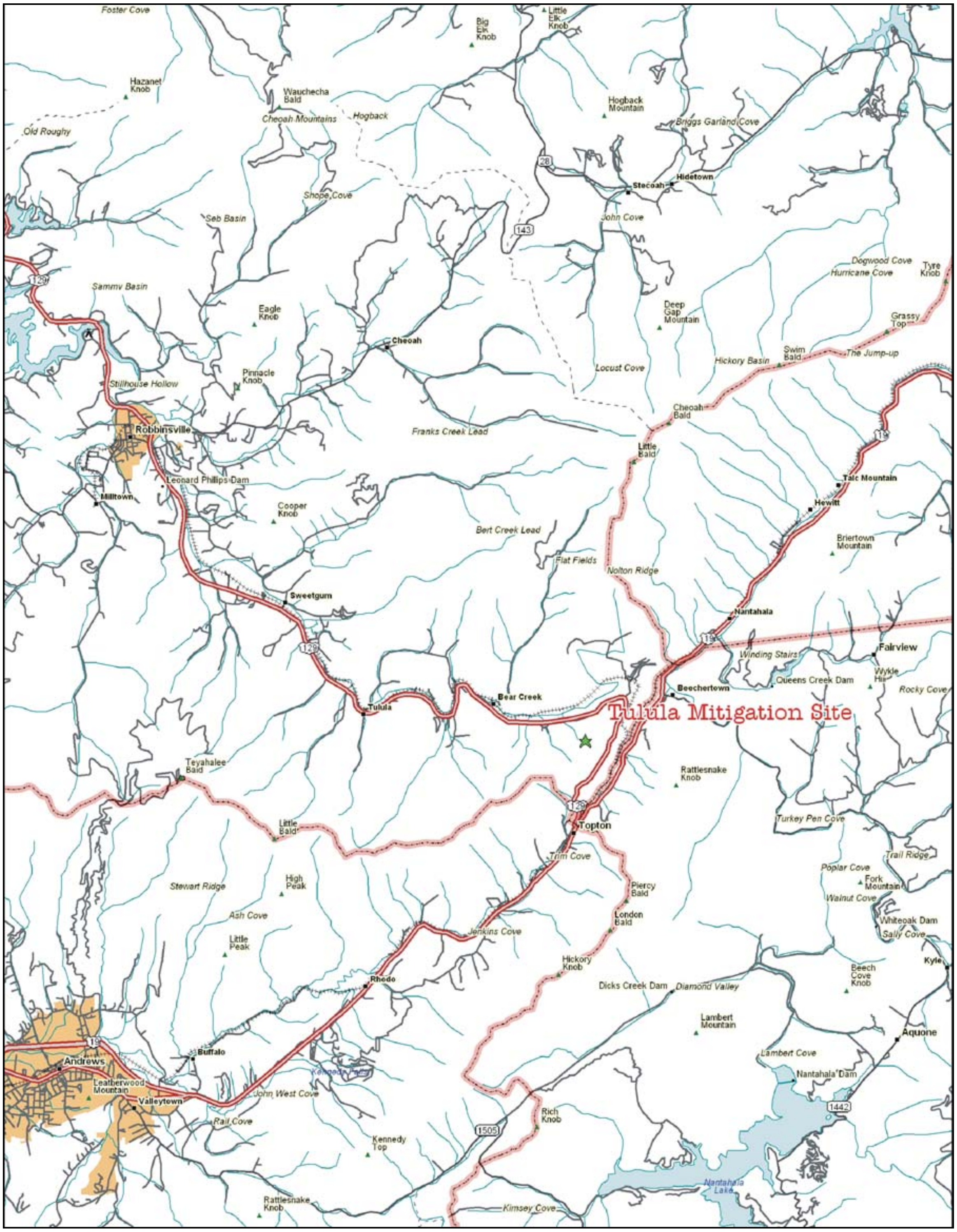
In order to demonstrate successful mitigation, hydrologic and vegetative monitoring must be conducted for a minimum of five consecutive years or until the site is deemed successful. Success criteria are based on federal guidelines for wetland mitigation. These guidelines stipulate criteria for both hydrologic conditions and vegetation survival. The following report details the results of hydrologic and vegetative monitoring during the 2004-growing season at the Tulula Bog Mitigation Site.

Activities in 2004 reflect the second year of monitoring following the restoration efforts. Included in this report are analyses of both hydrologic and vegetative monitoring results, as well as local climate conditions throughout the growing season, and site photographs.

1.3 PROJECT HISTORY: TULULA BOG

July 2000	Monitoring Gauges Installed
April 2002	Phase I Planted
March 2003	Phase II Planted
March - November 2003	Hydrologic Monitoring (1 yr.)
September 2003	Vegetation Monitoring (1 yr.)
March - November 2004	Hydrologic Monitoring (2 yr.)
July 2004	Vegetation Monitoring (2 yr.)
November 2004	Four Additional Plots Set and Counted

Figure 1. Site Location Map



2.0 HYDROLOGY

2.1 SUCCESS CRITERIA

In accordance with federal guidelines for wetland mitigation, the success criteria for hydrology state that the area must be inundated or saturated (within 12” of the surface) by surface or groundwater for at least a consecutive 5% of the growing season during a normal precipitation year. Areas inundated for less than 5% of the growing season are always classified as non-wetlands.

Stream gauge data will be utilized to substantiate the frequency of the bankfull discharge. The target frequency of the bankfull discharge is a one to two year return interval under normal climatic conditions. Stream gauge monitoring and bankfull calculations will require average climatic conditions including an average distribution of peak storm events. The University of North Carolina at Asheville is performing the stream restoration monitoring, as a part of a grant received from the Department.

The growing season in Graham County begins March 26 and ends November 10. These dates correspond to a 50% probability that temperatures will not drop to 28°F or lower after March 26 and before November 10[1]. Therefore, the growing season consists of 229 days; 5% of the growing season is equal to 12 days. Local climate must also represent average conditions for the area.

2.2 HYDROLOGIC DESCRIPTION

In July 2000, twenty-nine groundwater-monitoring gauges were installed along eight transects perpendicular to the stream (Figure 2). The automatic monitoring gauges record daily readings of groundwater and surface water depth.

The Tulula Bog Site was designed to receive hydrologic input from rainfall and water accessing the floodplain. The hydrologic monitoring should show the reaction of the groundwater level to specific rainfall events, as well as the surface water level.

2.3 RESULTS OF HYDROLOGIC MONITORING

2.3.1 Site Data

The maximum number of consecutive days that the groundwater was within twelve inches of the surface was determined for each well. This number was converted into a percentage of the 229-day growing season (March 26 – November 10). The results are presented in Table 1.

[1] Natural Resources Conservation Service, Soil Survey of Graham County, North Carolina.

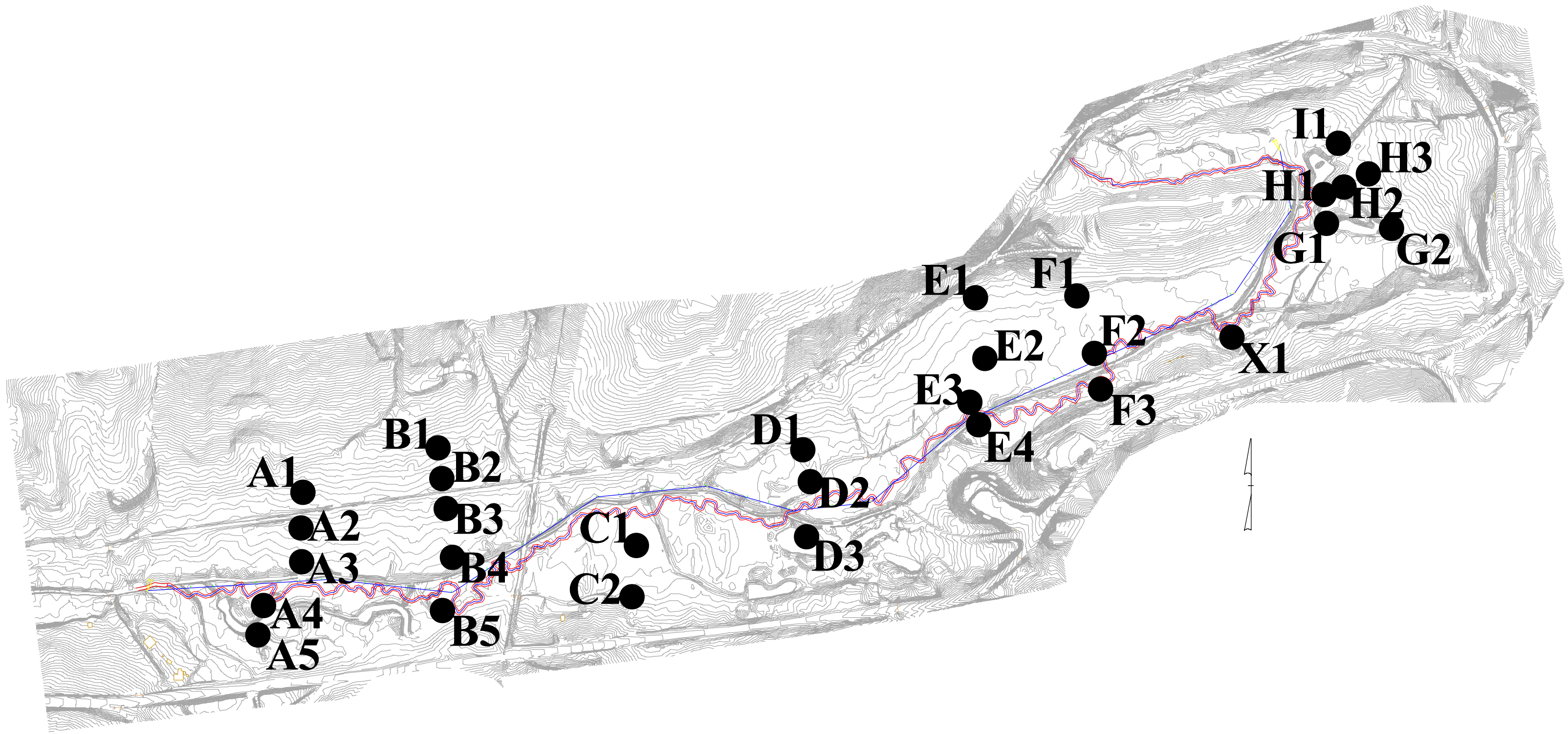


Figure 2. Gauge Location Map

Not to Scale

Table 1. Hydrologic Monitoring Results

Monitoring Well	<5%	5-8%	8-12.5%	>12.5%	Actual %	Success Dates
A1AA S3173D1+		✕			7.0	June 23-July 8
A2A S31F924	✕				0.0	
A3A S31F776+			✕		10.5	July 23-Aug 10 Oct 18-Nov 10
A4A S342C87				✕	42.8	March 26-July 1 Oct 13-Nov 10
A5A S3167A6	✕				0.9	
B1A S3166AA	✕				0.9	
B2A S317654+				✕	38.0	March 26-June 20 June 22-Sept 5
B3A S342D51	✕				0.4	
B4A S31F901+				✕	71.6	March 26-Sept 5 Sept 7-Nov 10
B5A S31F89A+				✕	62.0	March 26-June 20 June 22-Nov 10
C1A S494291+				✕	100.0	March 26-Nov 10
C2A S317659+				✕	100.0	March 26-Nov 10
D1A S3166FD	✕				0.4	
D2A S31F81A	✕				2.6	
D3A S31671B+				✕	100	March 26-Nov 10
E1A S31F7D3+				✕	48.0	March 26- July 13 July 26-Nov 10
E2A S342CE0+				✕	28.4	March 26-May 5 July 29-Sept 5 Sept 7-Nov 10
E3A S31FAA0+				✕	64.6	March 26-Aug 20 Oct 13-Nov 10
E4 S4D041C	✕				1.3	
F1A S31F764+				✕	26.2	March 26-May 24 Sept 8-Oct 7 Oct 13-Nov 10

F2A S31F813	×				3.1	
Monitoring Well	**<5%**	**5-8%**	**8-12.5%**	**>12.5%**	**Actual %**	**Success Dates**
F3AA S4CFD03	×				2.6	
G1A S31F9A1+				×	27.9	March 26-May 25 July 18-Aug 31 Sept 8-Nov 10
G2A S3169EF+				×	27.9	March 26-May 27 July 26-Aug 26 Sept 8-Nov 10
H1AA S494262		×			5.2	March 26-April 6
H2AA S31F93E		×			6.6	April 9-April 23
H3AA S31F877		×			5.2	April 17-April 28
I1A S3166B4	×				0.0	
X1A S316723+				×	28.4	March 26-May 25 Sept 7-Nov 10

+ Gauge met the success criterion during an average rainfall month (July, September, and November).

Specific Gauge Problems:

- Gauges A4A, E2A, E3A, E4A, H1AA, H2AA, and I1A experienced gauge malfunctions during the growing season as a result of dead batteries and bad data reads.

Appendix A contains a plot of the groundwater depth for each monitoring well. The maximum number of consecutive days is noted on each graph. The individual precipitation events are shown on the monitoring well graphs as bars.

Figure 3 provides a graphical representation of the hydrologic results. Gauges highlighted in blue indicate wetland hydrology for more than 12.5% of the growing season. Gauges highlighted in red show hydrology between 8% and 12.5% of the growing season, while those in green indicate hydrology between 5% and 8%. Gauges highlighted in black indicate no wetland hydrology (less than 5% of the growing season).

2.3.2 Climatic Data

Figure 4 is a comparison of monthly rainfall for the period of November 2003 through November 2004 to historical precipitation (collected between 1973 and 2004) for Andrews, North Carolina. This comparison gives an indication of how 2004 relates to historical data in terms of climate conditions. The NC State Climate Office provided all local rainfall information.

For the 2004-year, the months of November (03'), December (03'), January, February, March, April, May, June, August, and October recorded below average rainfall for the site. July, September, and November experienced average rainfall. Overall, 2004 experienced a below average rainfall year.

2.4 CONCLUSIONS

The 2004-year represents the second full growing season that hydrologic data has been examined. The second year of hydrologic data revealed that nineteen of the twenty-nine groundwater gauges met the success criteria for saturation (within 12" of the surface for 5% of the growing season). Conversely, ten gauges recorded saturation for less than 5% of the growing season.

EEP will begin monitoring the hydrology at the Tulula Bog Mitigation Site in 2005.

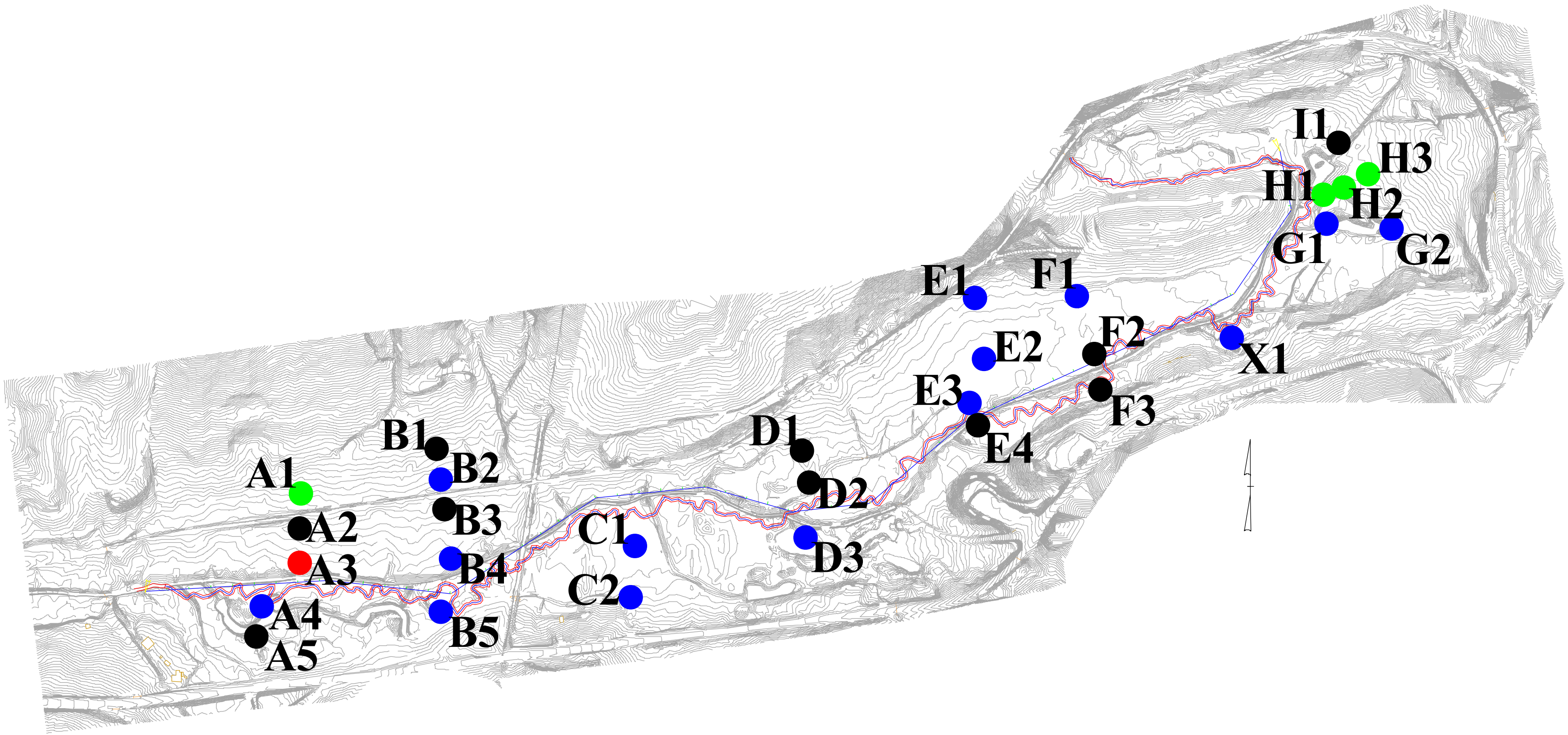
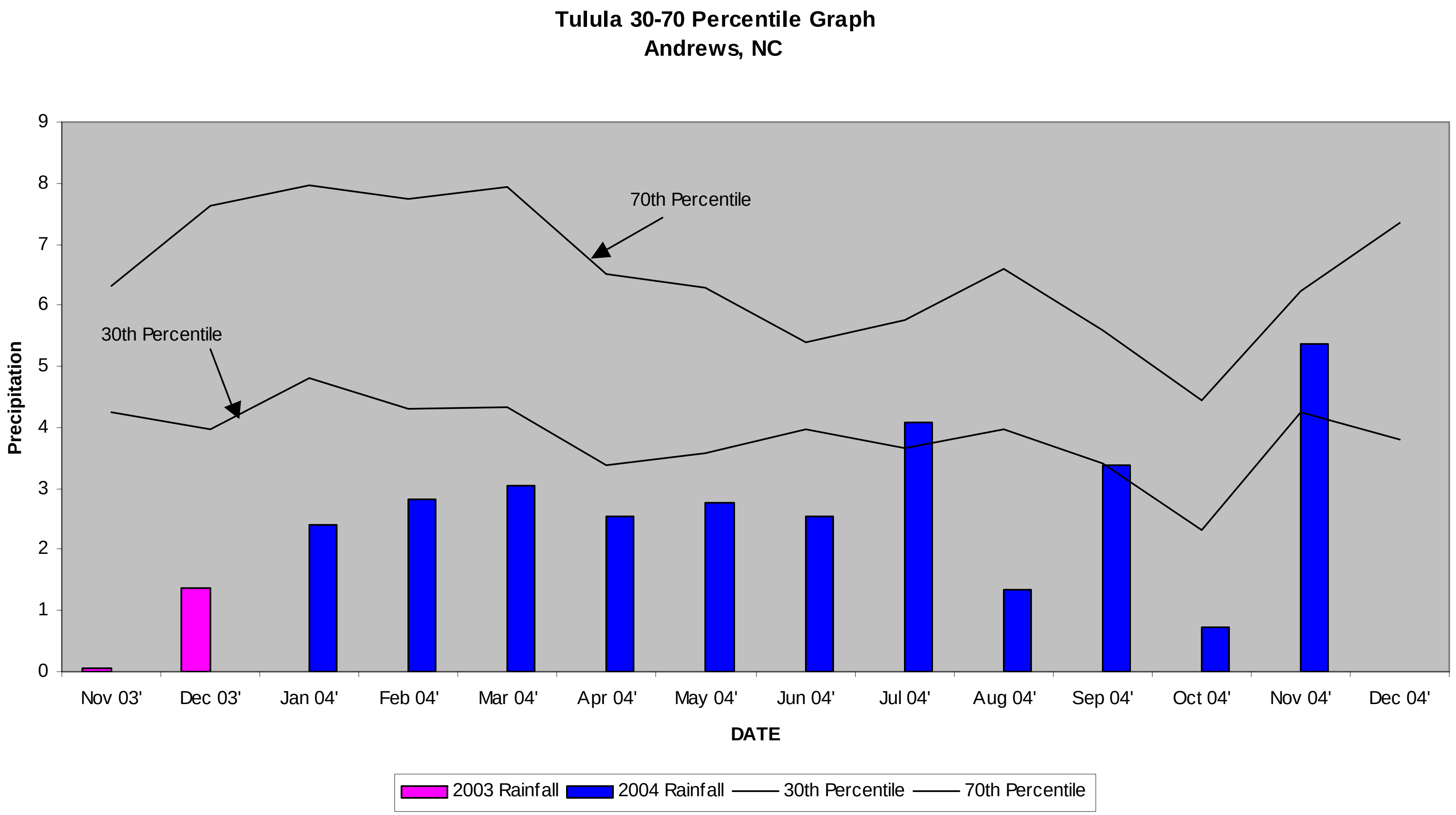


Figure 3. 2004 Hydrologic Monitoring Gauge Results

- < 5 %
- 5 - 8 %
- 8 - 12.5 %
- > 12.5 %

Not to Scale

Figure 4. Tulula Bog 30-70 Graph



3.0 VEGETATION: TULULA CREEK MITIGATION SITE (YEAR 2 MONITORING)

3.1 SUCCESS CRITERIA

The success criteria state that there must be a minimum of 320 trees per acre living for at least three consecutive years. A minimum of 290 trees per acre living at year four and a minimum of 260 trees per acre living at year five.

3.2 DESCRIPTION OF SPECIES

The following species were planted in the restoration area: (approximately 33.3 acres)

Nyssa sylvatica var*. sylvatica*, Blackgum

Quercus rubra, Northern Red Oak

Betula nigra, River Birch

Quercus alba, White Oak

Liriodendron tulipifera, Tulip Poplar

3.3 RESULTS OF VEGETATION MONITORING

Table 2. Vegetation Monitoring Statistics

Plot #	Blackgum	Northern Red Oak	River Birch	Tulip Poplar	White Oak	Black Cherry	Total (2 year)	Total (at planting)	Density (Trees/Acre)
1		14			18		32	34	640
2				17	9		26	36	491
3	1	7		15	2		25	38	447
4		8	5	3	6		22	39	384
5		1		2	1		4	39	70
6		6	2	14	1		23	39	401
7		2	3	1		9	15	39	262
						AVERAGE DENSITY			**385**

Site Notes: Other species noted: alder, elderberry, blackberry, multi-flora rose, goldenrod, *Juncus* sp., *Scirpus* sp. *Panicum* sp., black locust, Queen-Ann's lace, and various grasses.

Areas of the site, which continue to be flooded due to beaver activity, will require supplemental planting following the eradication of the beaver problem.

3.4 CONCLUSIONS

Approximately 33.3 acres of the site were planted. There were three vegetation-monitoring plots established throughout the planting areas in 2002. Four additional plots (plots 4, 5, 6, and 7) were set in November 2004 at the request of the resource agencies. There were no initial stem counts for these plots recorded at planting, therefore the stem counts are based on 39 trees per plot, which is equivalent to 680 trees per acre. The 2004 vegetation monitoring of the site revealed an average tree density of 385 trees per acre. This average is above the minimum success criteria of 320 trees per acre.

EEP will begin monitoring the vegetation at the Tulula Mitigation Site for the 2005 monitoring year.

4.0 OVERALL CONCLUSIONS/RECOMMENDATIONS

During the 2004 monitoring year, hydrologic data revealed that nineteen of the twenty-nine groundwater gauges met the success criteria for saturation (within 12” of the surface for 5% of the growing season). Conversely, ten gauges recorded saturation for less than 5% of the growing season.

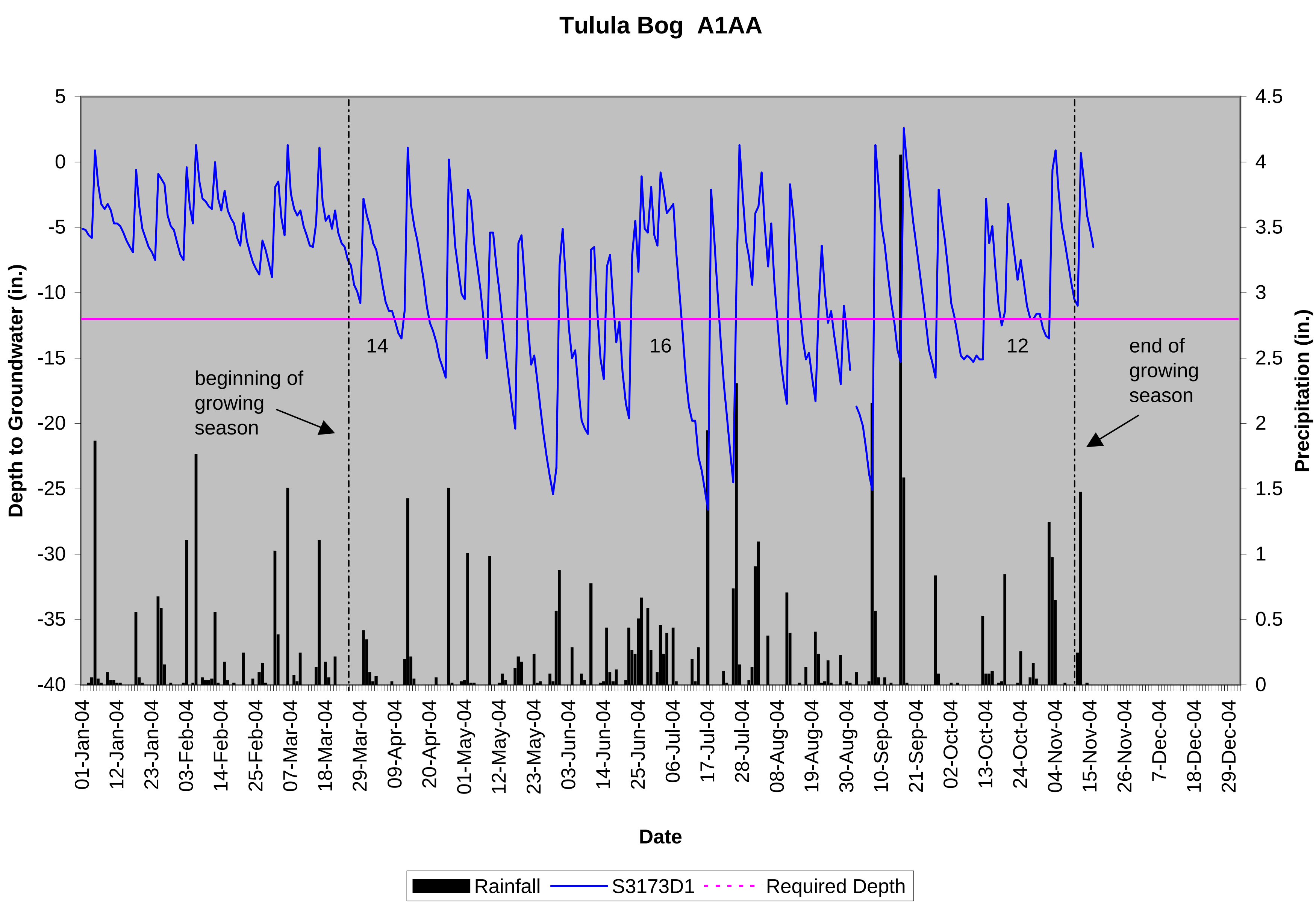
Vegetation data for the second year of monitoring revealed an average density of 385 trees per acre for the 33.3 acres that were planted. This average is above the minimum success criteria of 320 trees per acre.

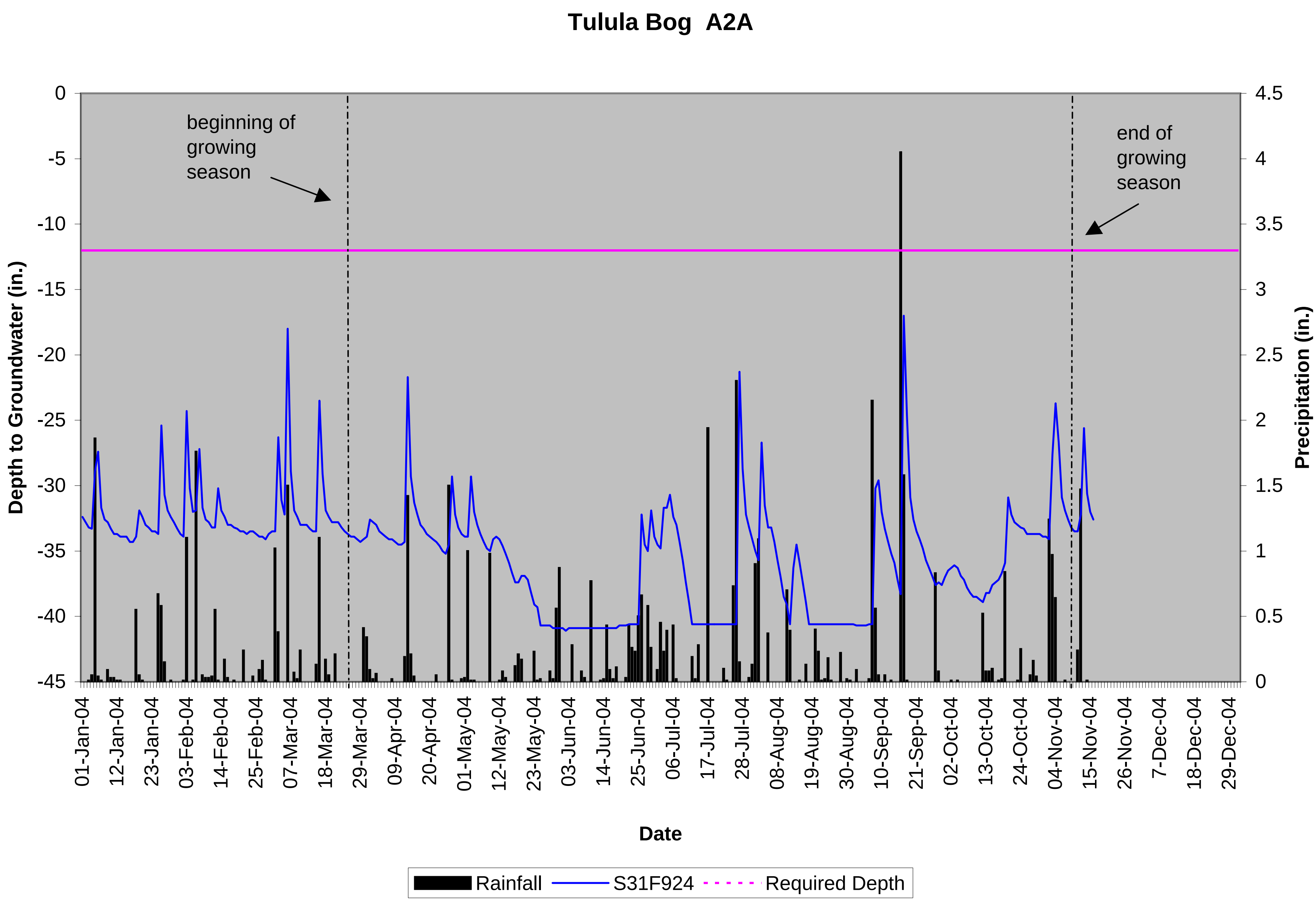
The University of North Carolina at Asheville is performing the stream restoration monitoring, as a part of a grant received from the Department. A portion of this grant is to survey and analyze the geomorphological characteristics of the stream restoration sections of the project. Upon receipt of this information, the Department will provide appropriate documentation to the resource agencies via the Department’s website.

Per the letter from the Ecosystem Enhancement Program (EEP) to NCDOT dated August 25, 2004, the EEP has accepted the transfer of all off-site mitigation projects. The EEP will be responsible for fulfilling the remaining monitoring requirements and future remediation for this project.

APPENDIX A

GAUGE DATA GRAPHS


Tulula Bog A1AA
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
14
16
12
beginning of growing season
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
S3173D1
Required Depth



Tulula Bog A2A
beginning of growing season
end of growing season
Depth to Groundwater (in.)
Precipitation (in.)
Date
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
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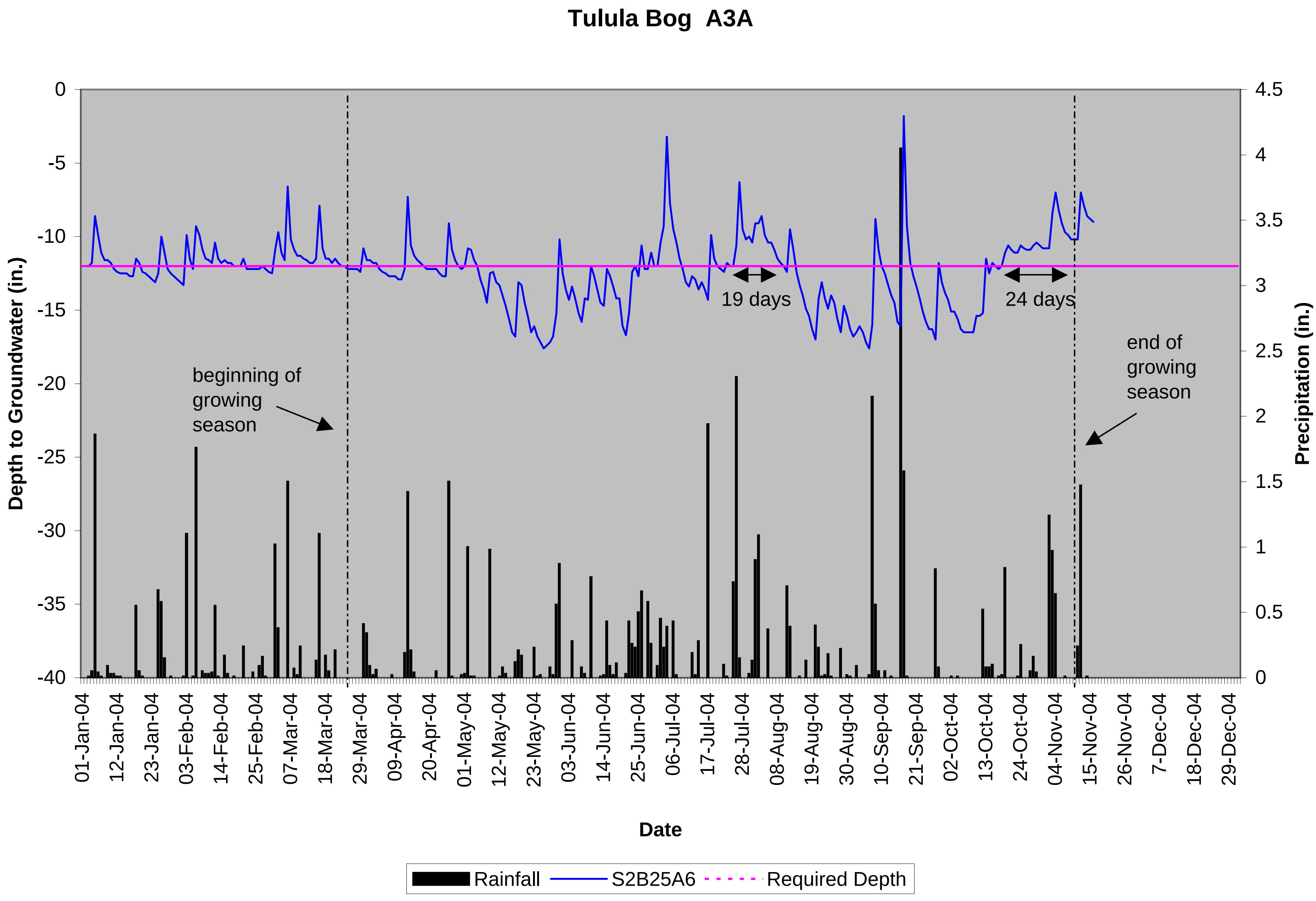
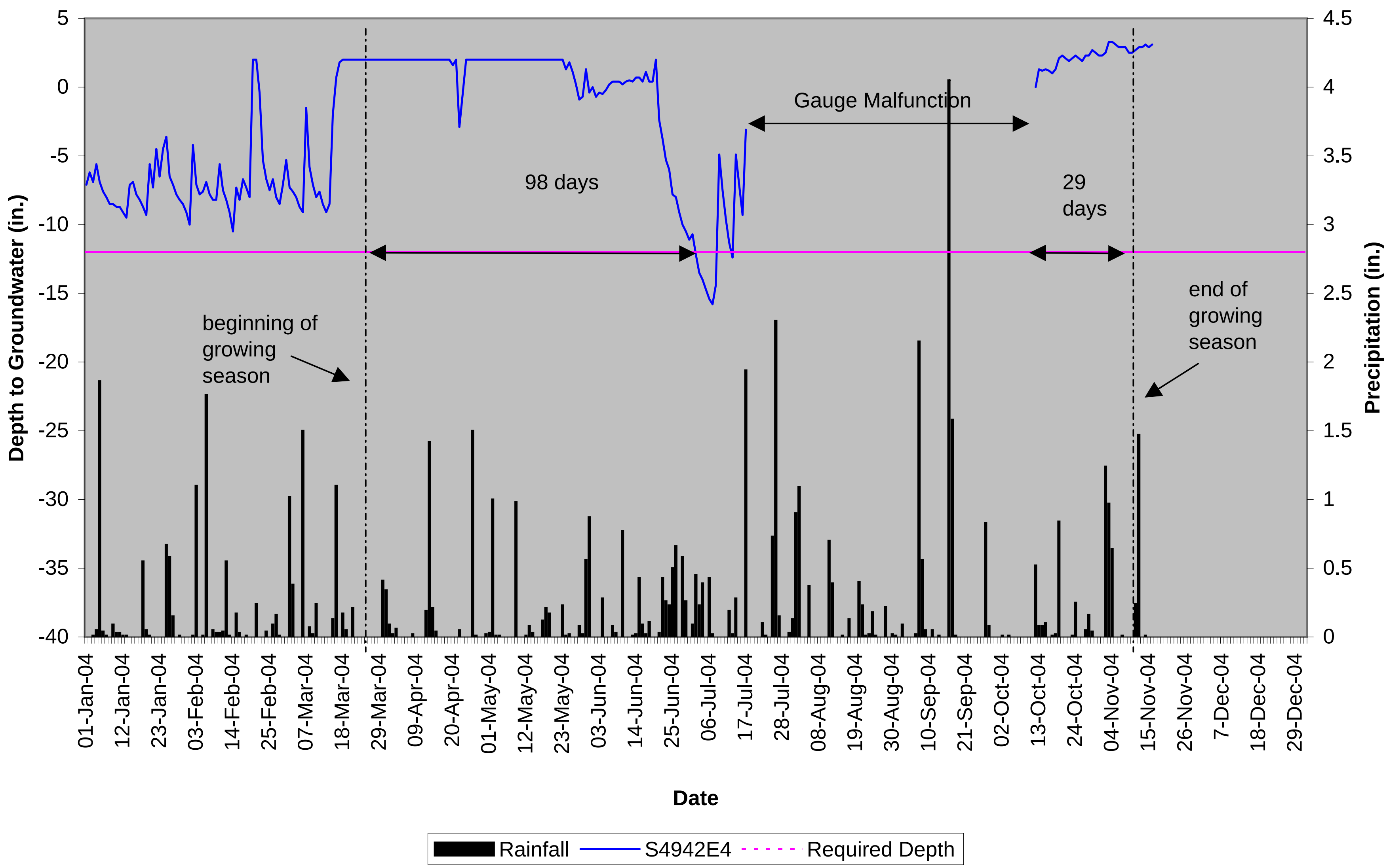
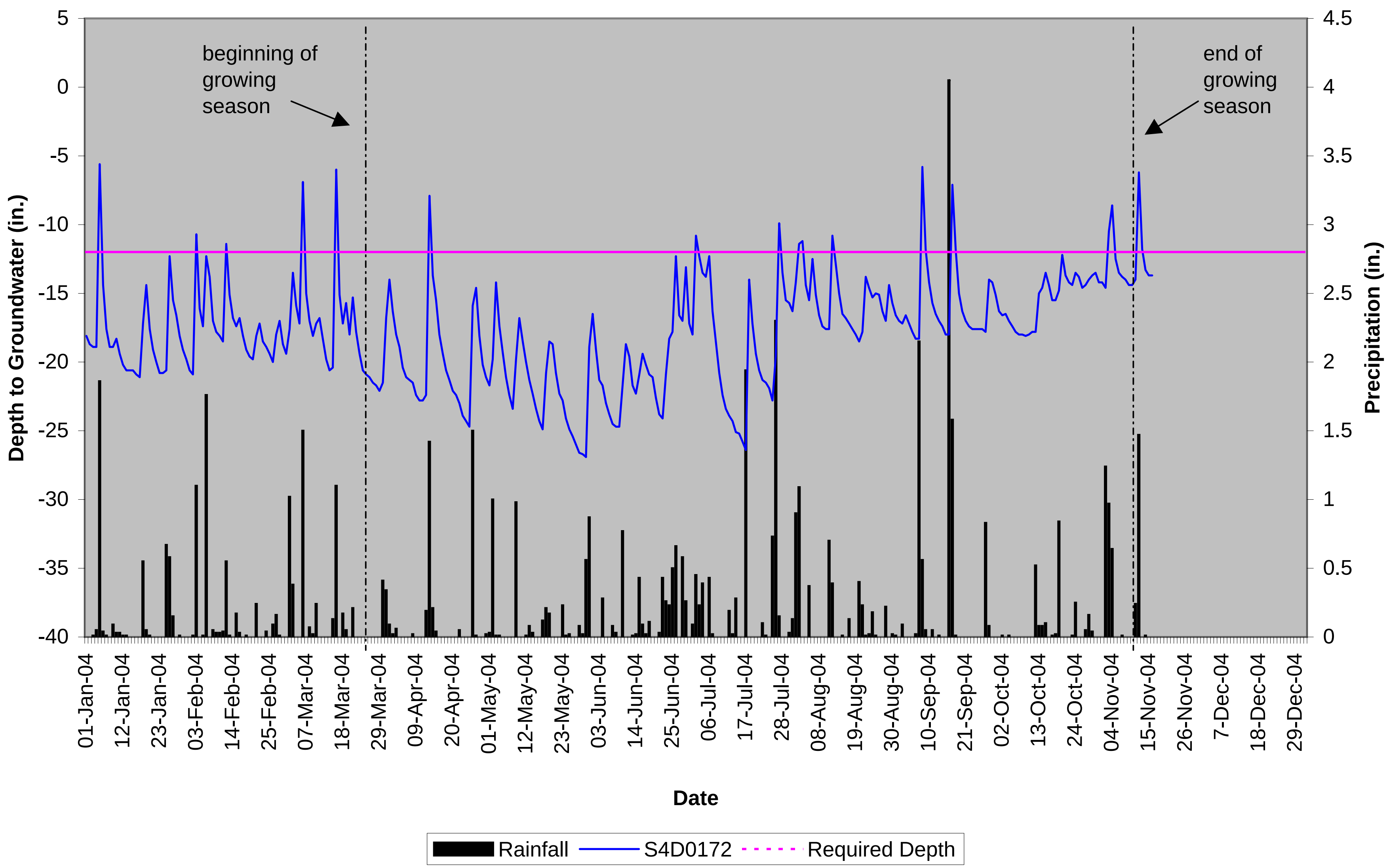
18-Dec-04
29-Dec-04
Rainfall
S31F924
Required Depth


Tulula Bog A3A
Depth to Groundwater (in.)
Precipitation (in.)
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
beginning of growing season
19 days
24 days
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
S2B25A6
Required Depth

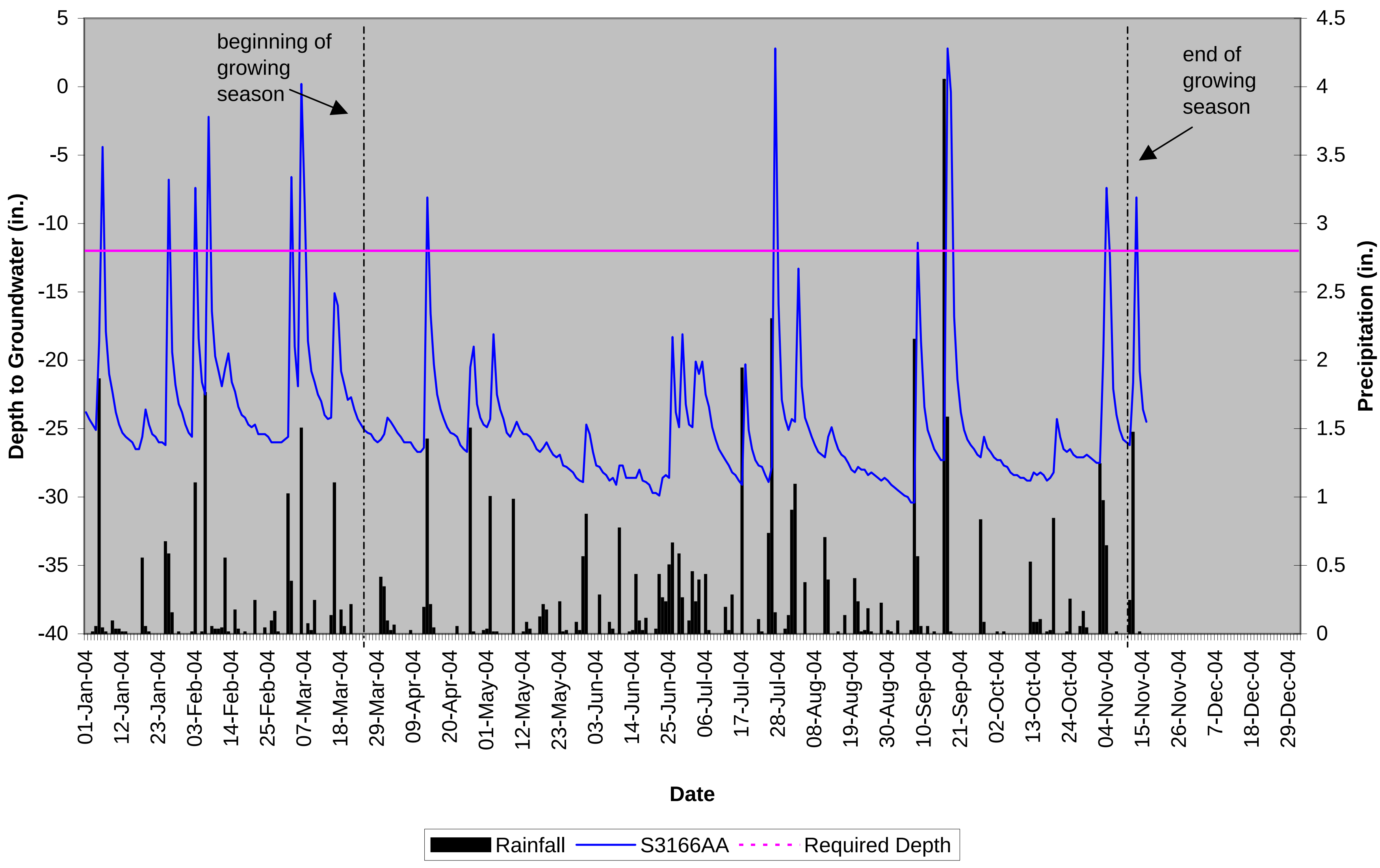
Tulula Bog A4A

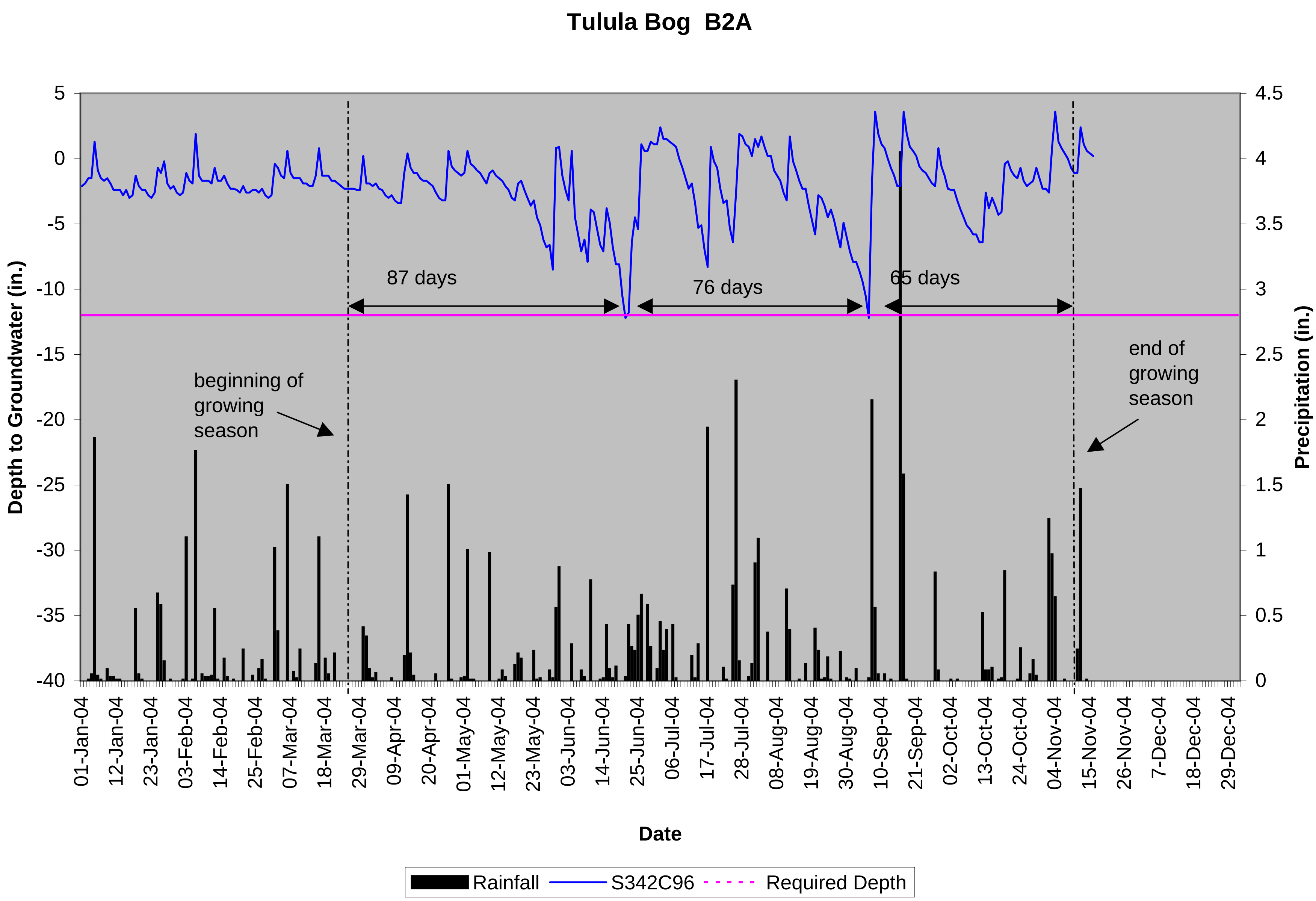


Tulula Bog A5A

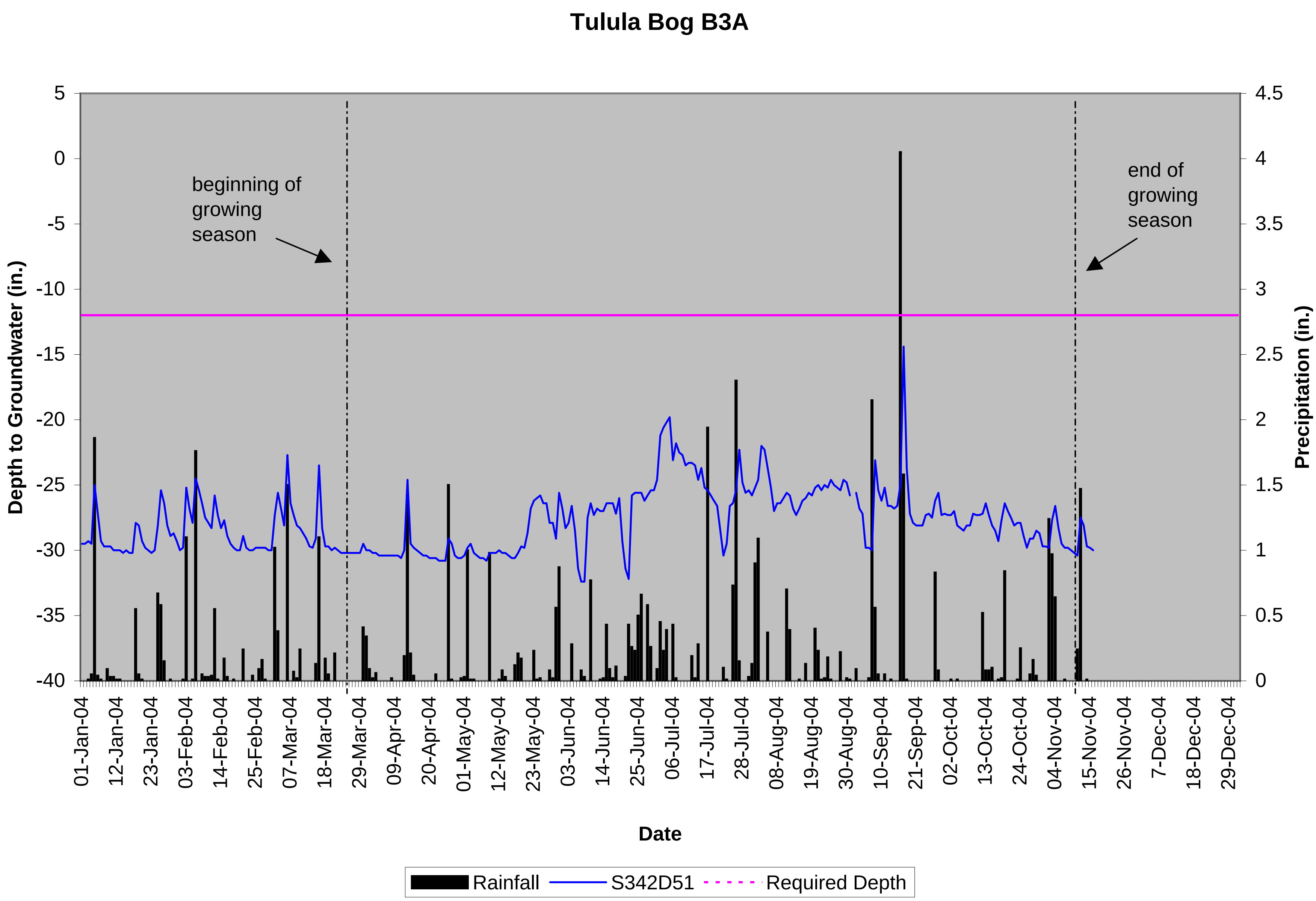


Tulula Bog B1A

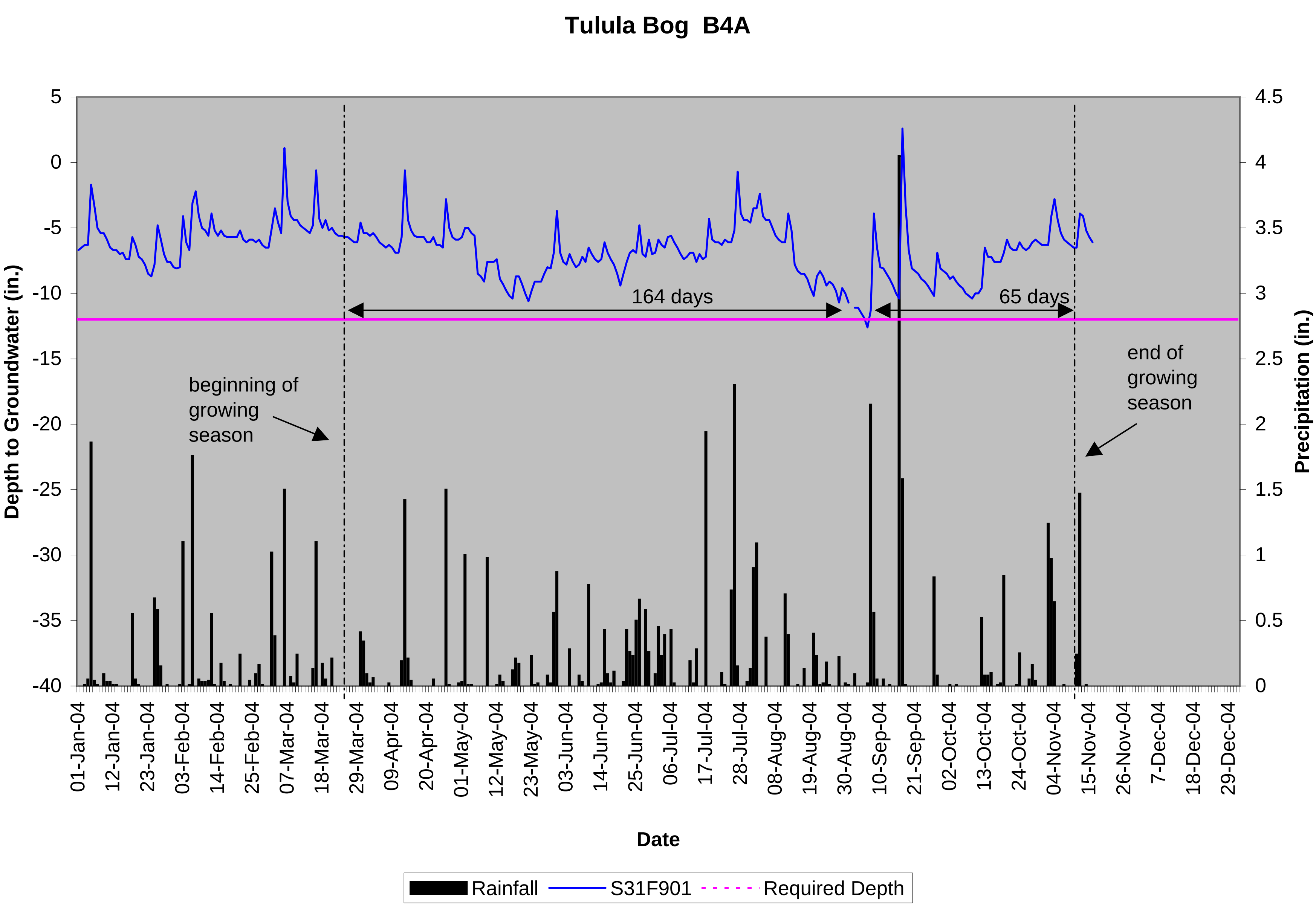


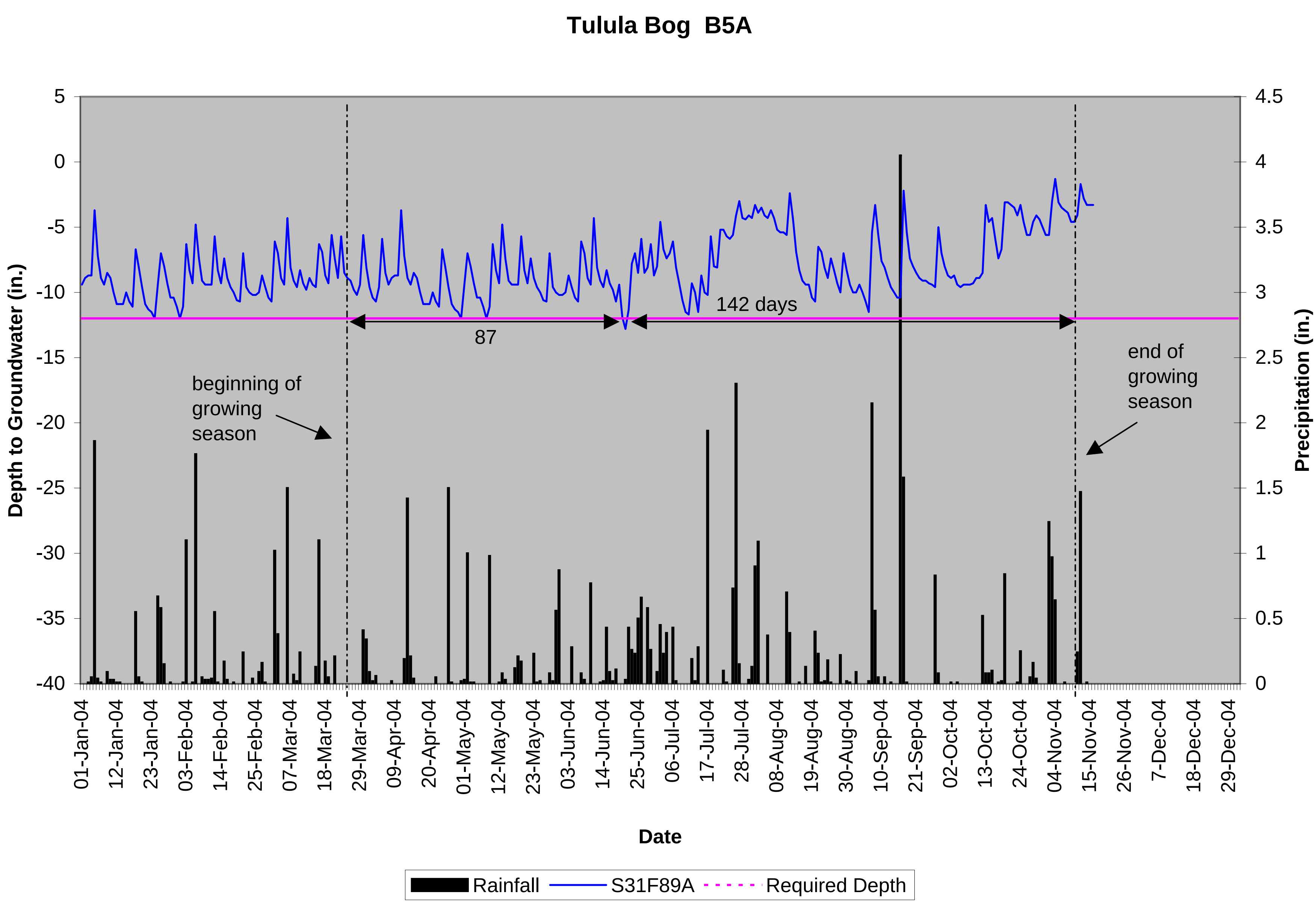


Tulula Bog B2A
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
87 days
76 days
65 days
beginning of growing season
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
S342C96
Required Depth

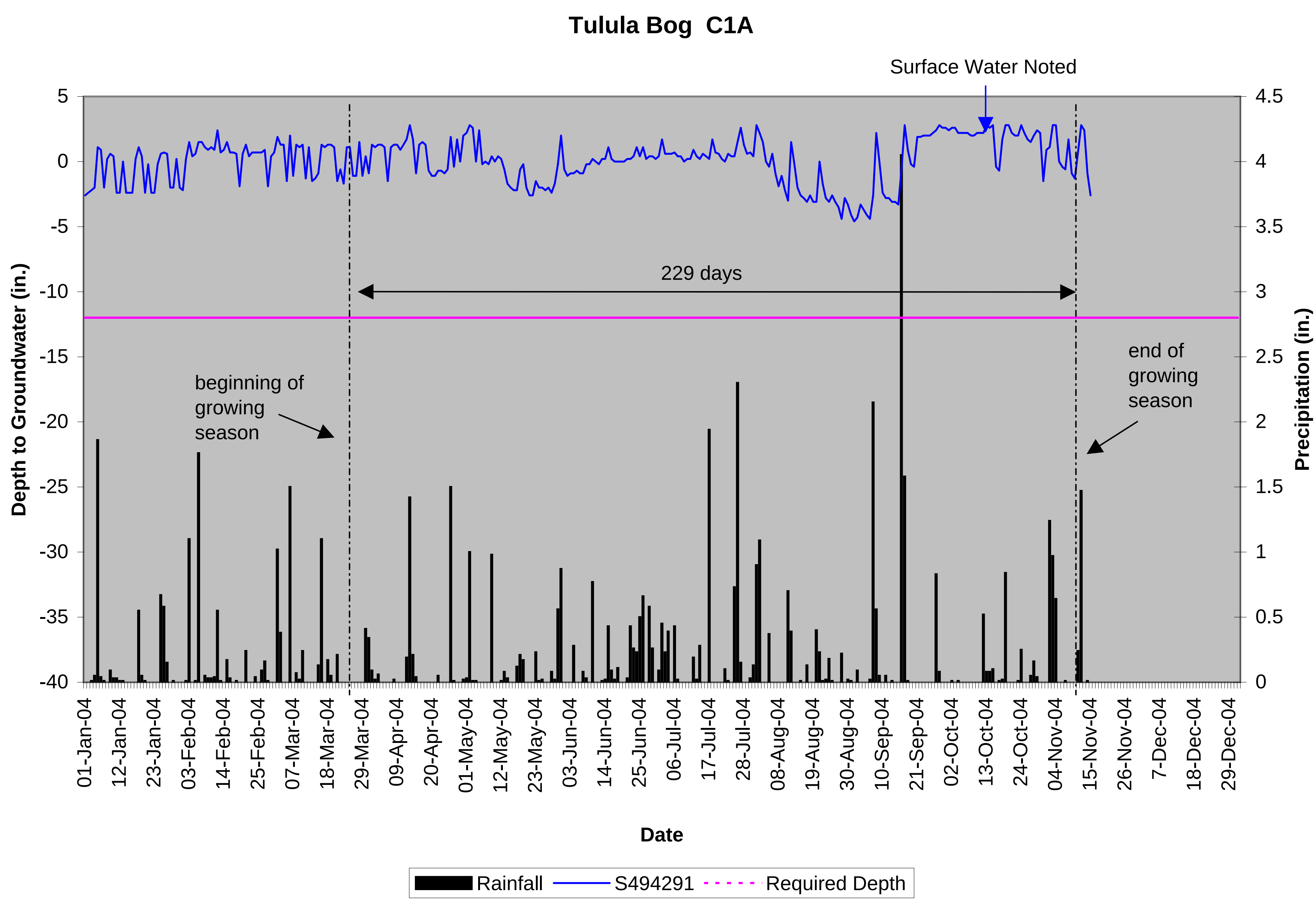


Tulula Bog B3A
Depth to Groundwater (in.)
Precipitation (in.)
Date
beginning of growing season
end of growing season
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Rainfall
S342D51
Required Depth

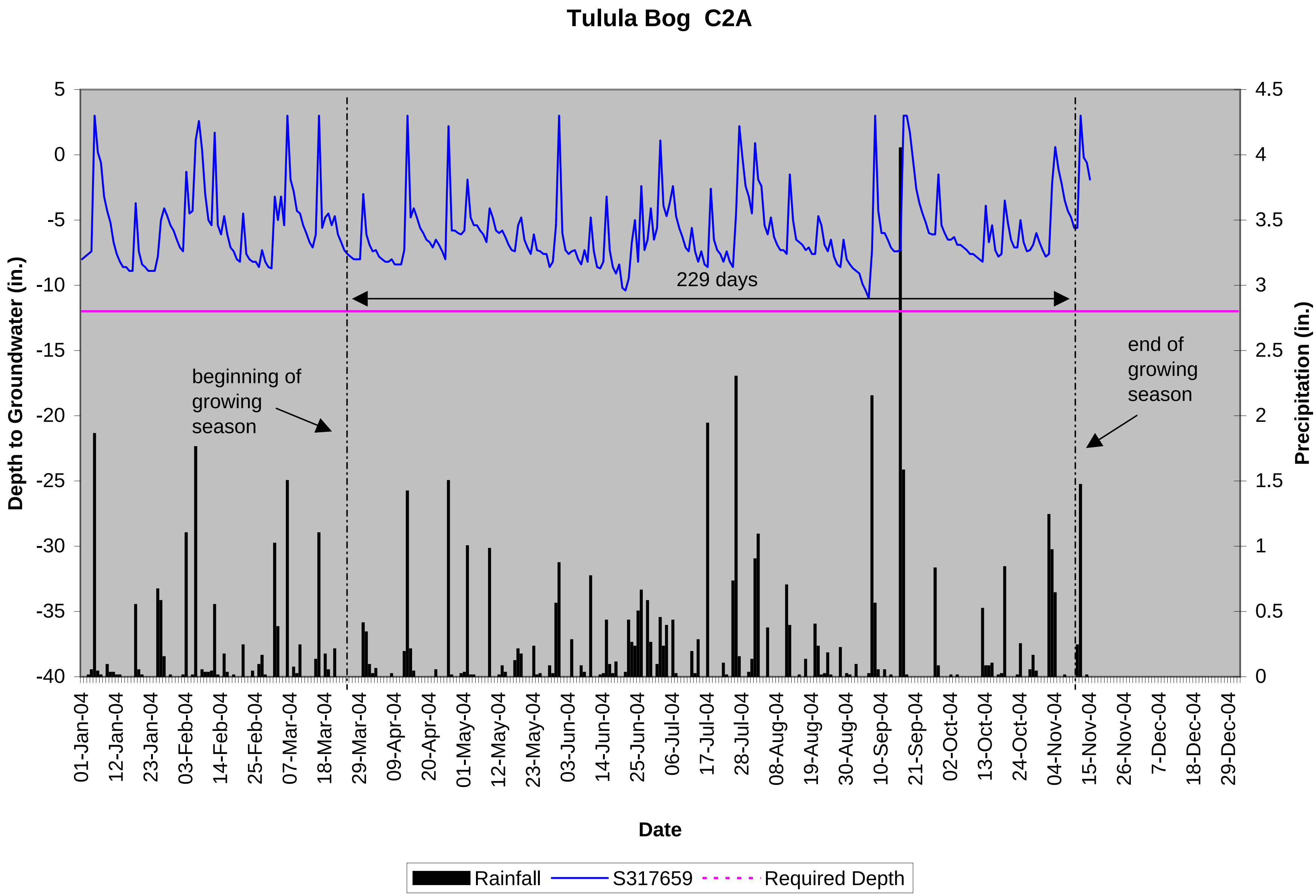

Tulula Bog B4A
Depth to Groundwater (in.)
Precipitation (in.)
Date
164 days
65 days
beginning of growing season
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Rainfall
S31F901
Required Depth



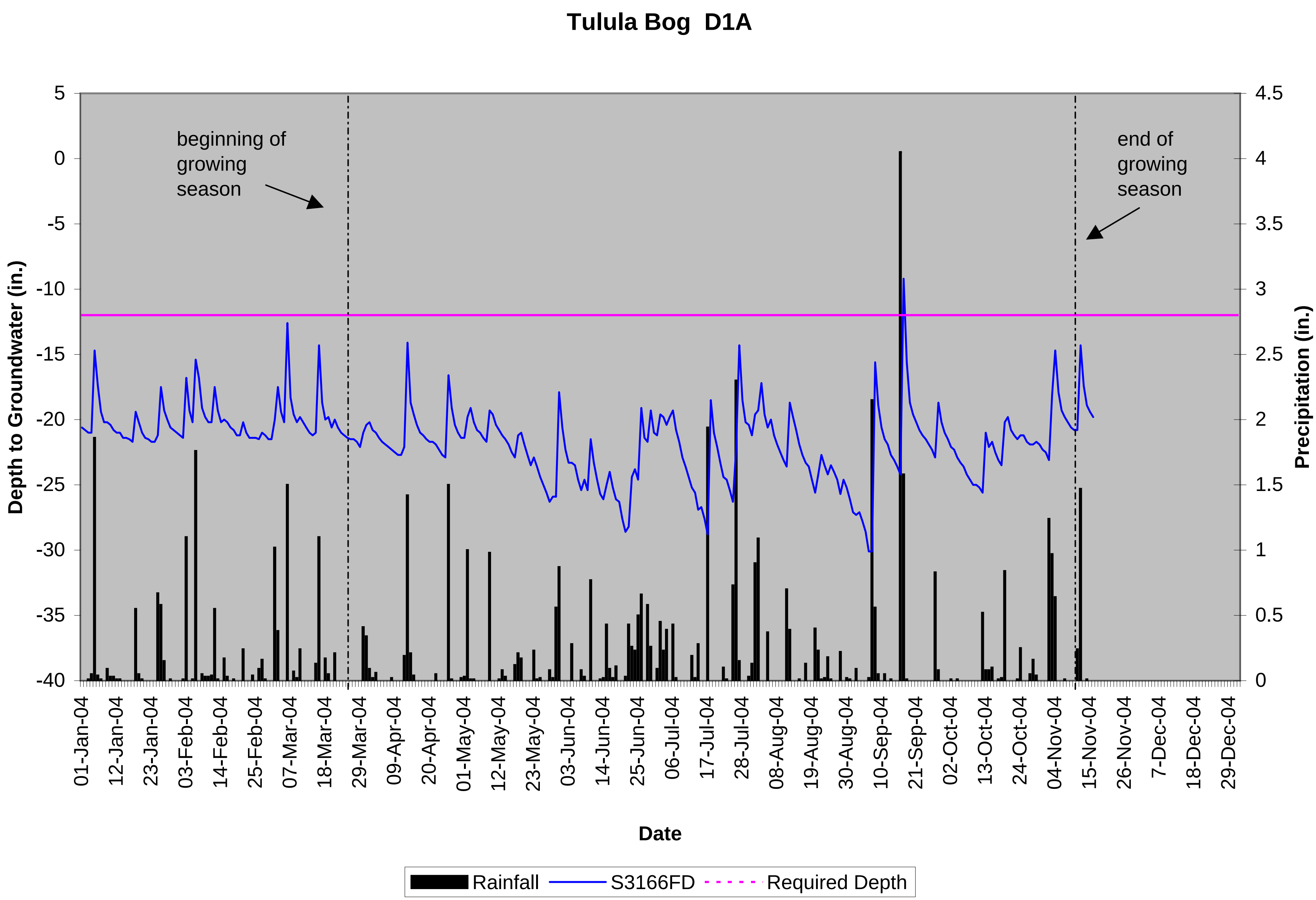
Tulula Bog B5A
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
87
142 days
beginning of growing season
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
S31F89A
Required Depth



Tulula Bog C1A
Surface Water Noted
229 days
beginning of growing season
end of growing season
Depth to Groundwater (in.)
Precipitation (in.)
Date
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Rainfall
S494291
Required Depth

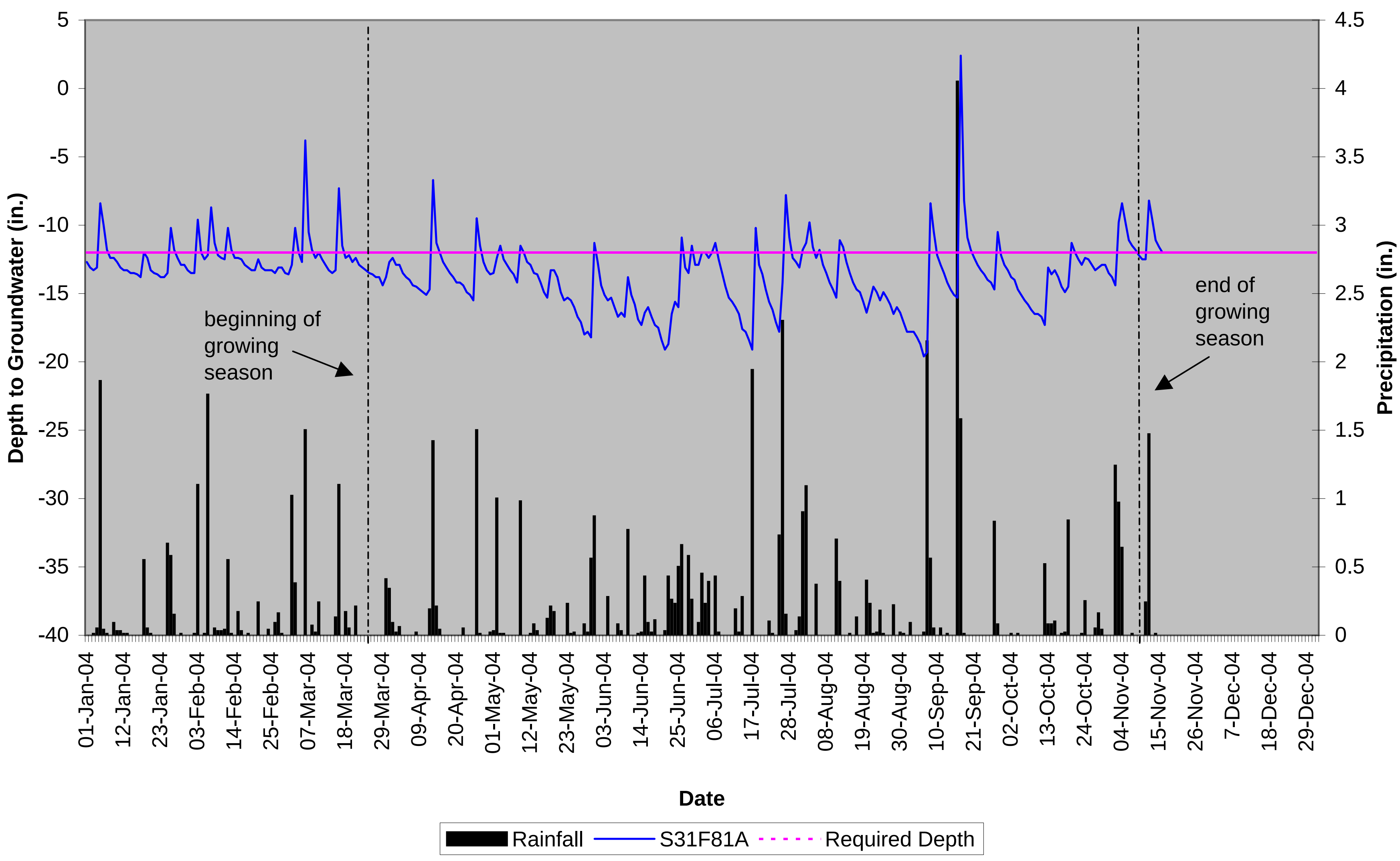


Tulula Bog C2A
229 days
beginning of growing season
end of growing season
Depth to Groundwater (in.)
Precipitation (in.)
Date
Rainfall
S317659
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04

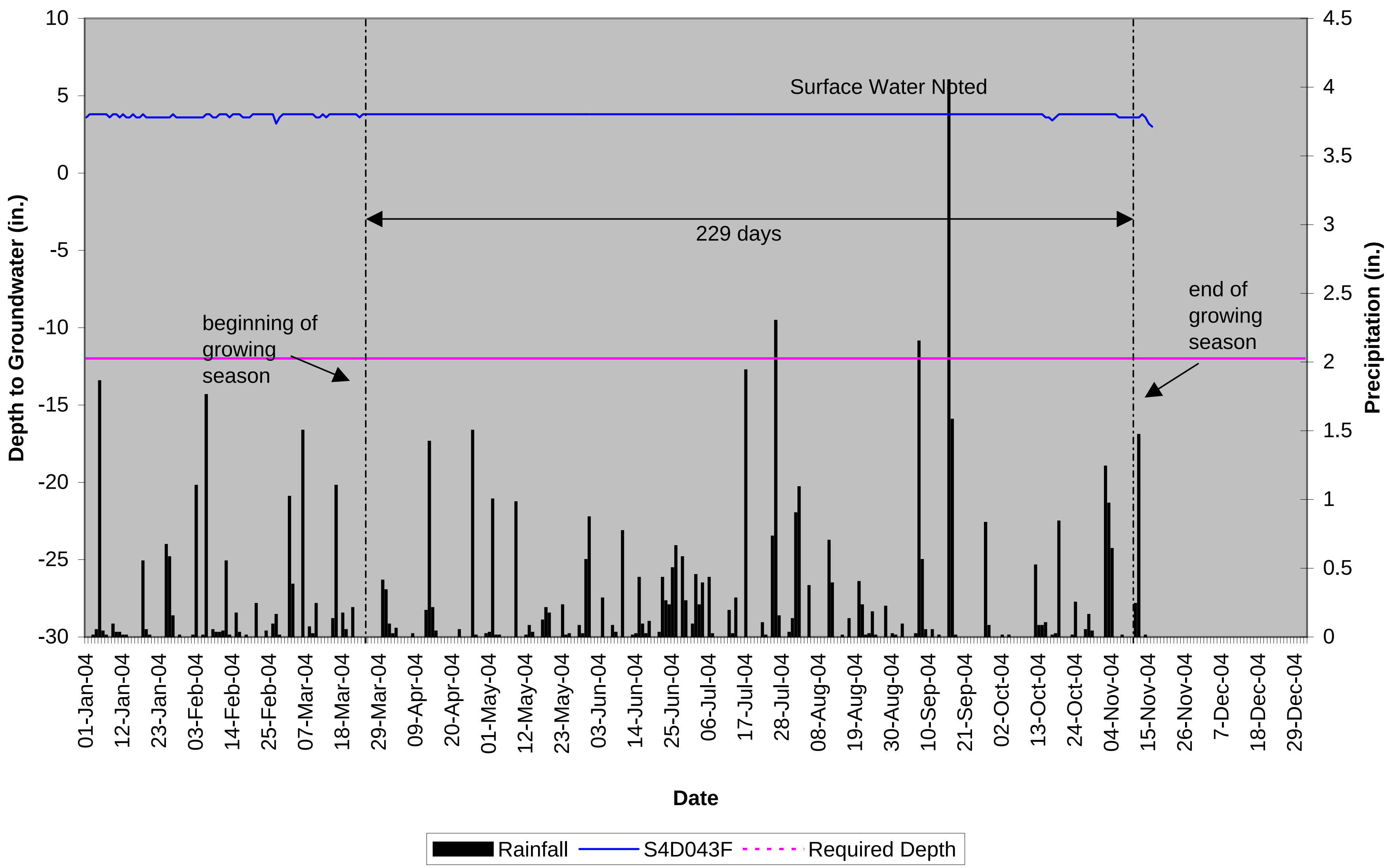


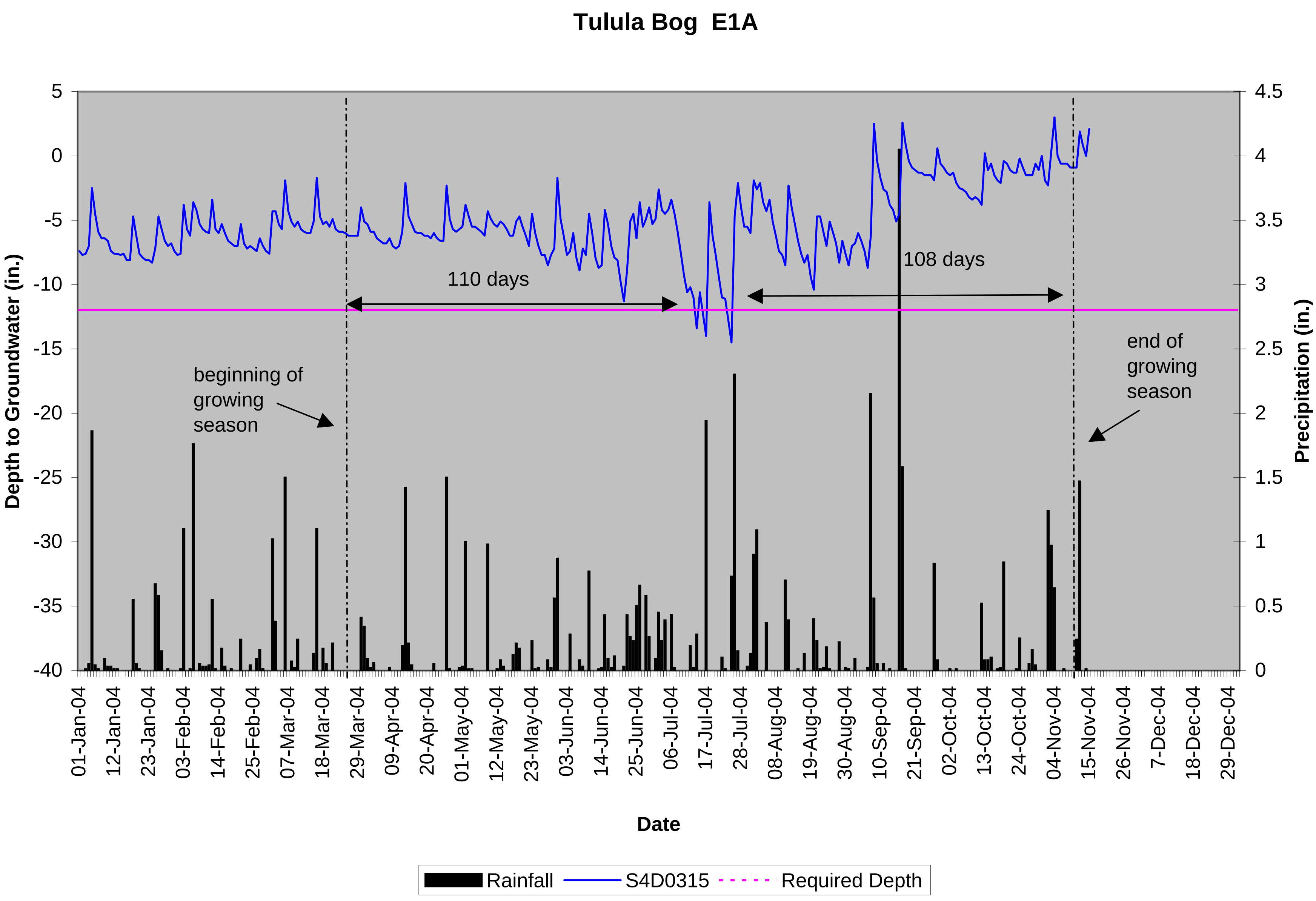
Tulula Bog D1A
beginning of growing season
end of growing season
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
S3166FD
Required Depth

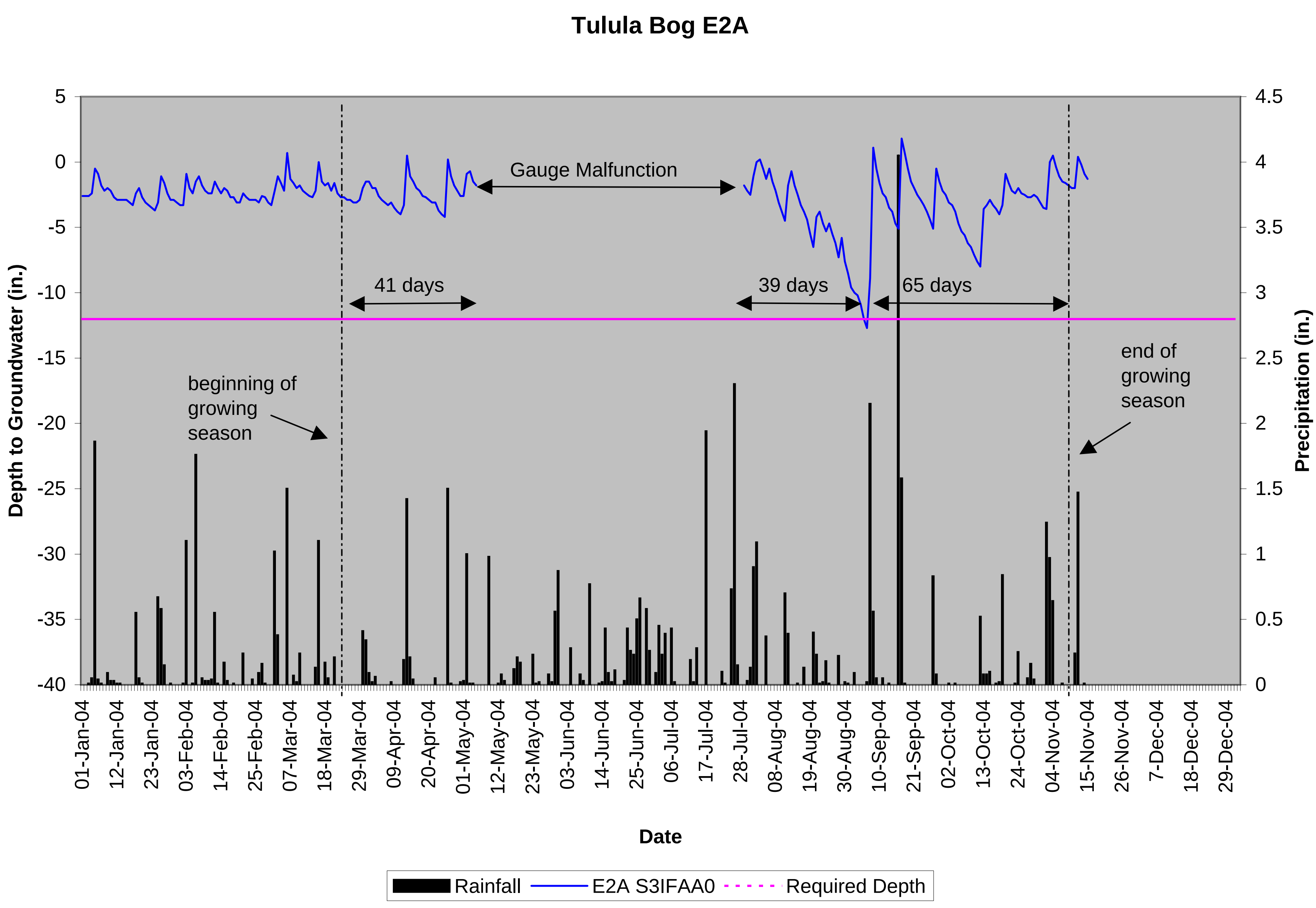
Tulula Bog D2A



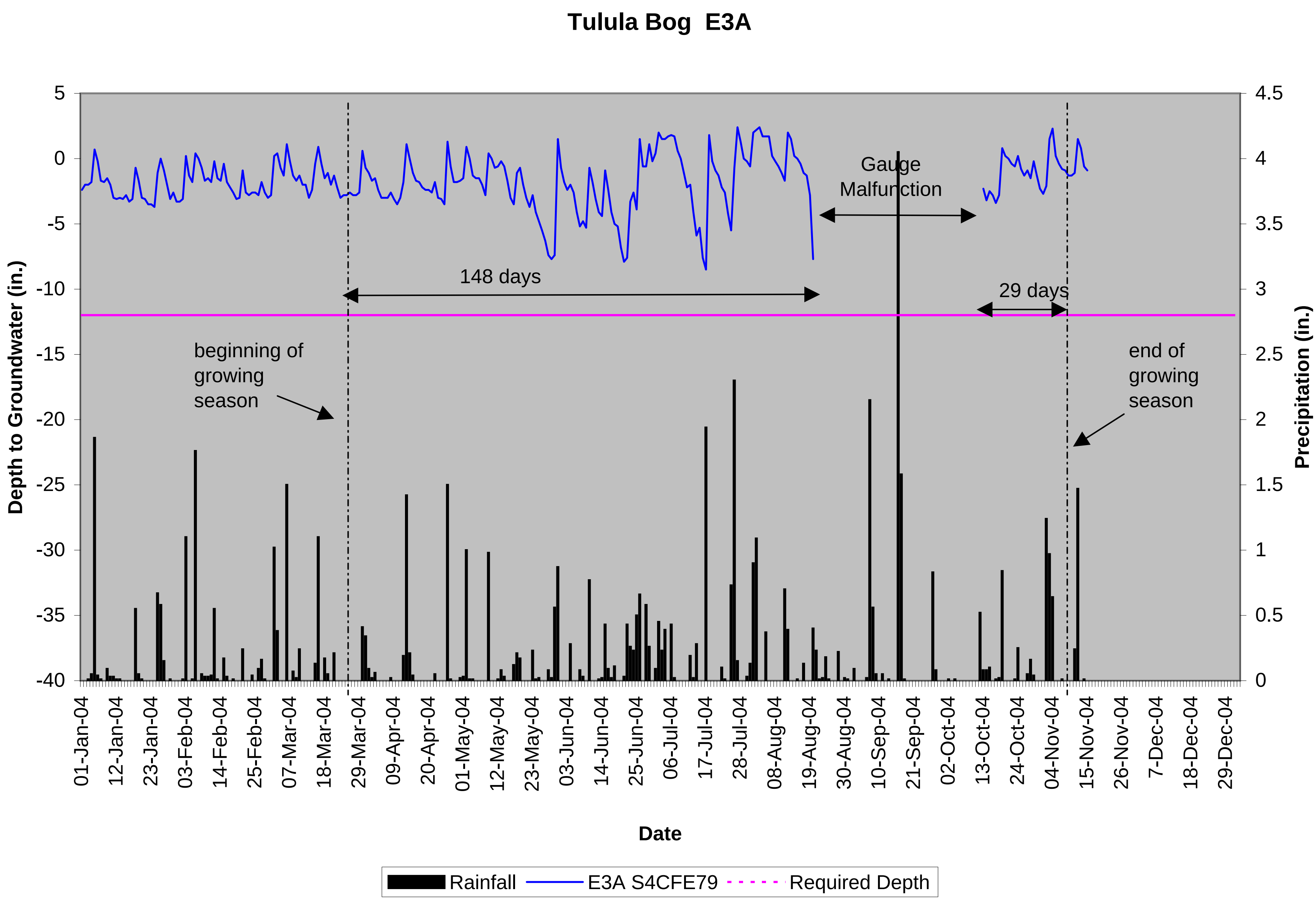
Tulula Bog D3A



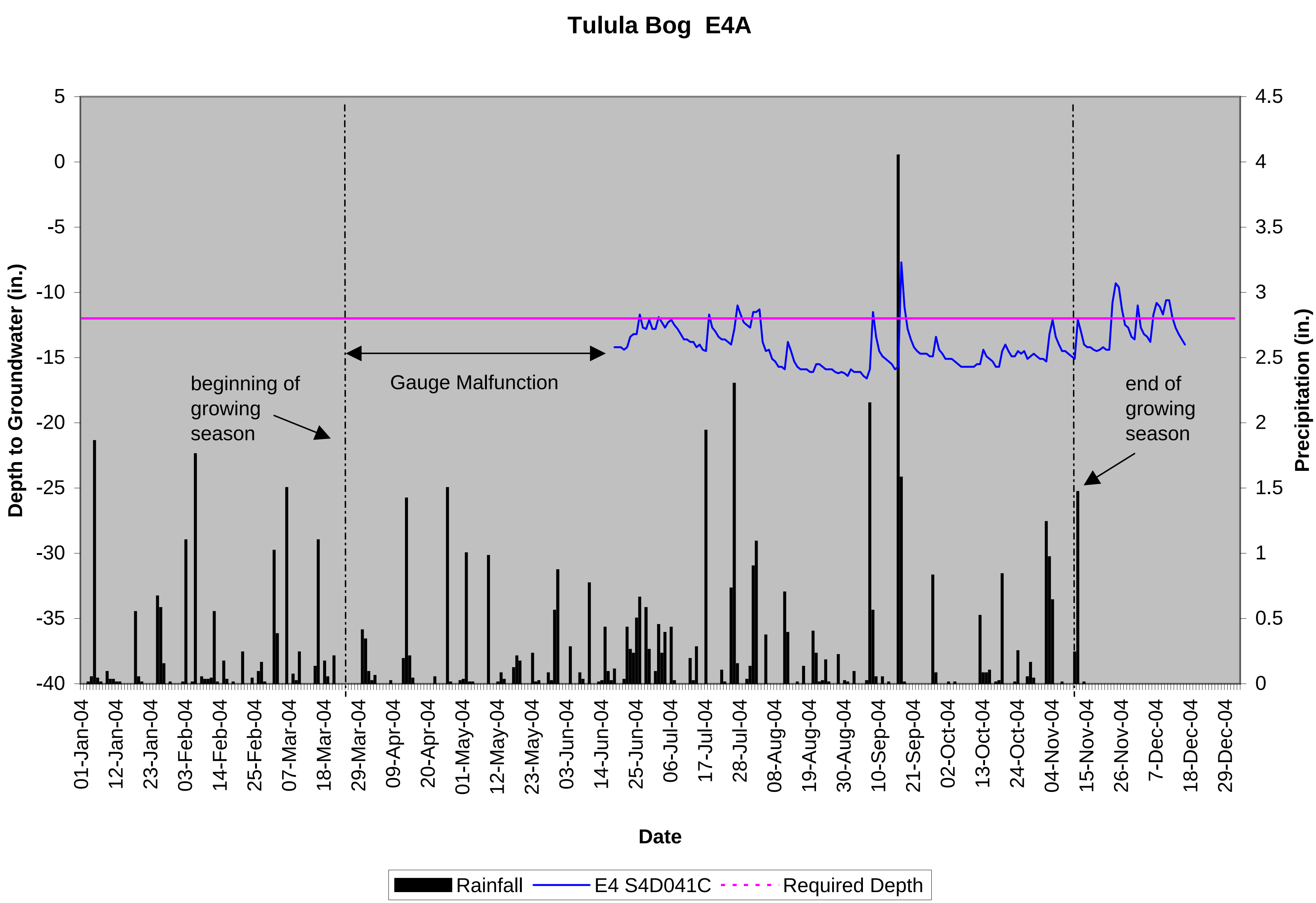

Tulula Bog E1A
Depth to Groundwater (in.)
Precipitation (in.)
Date
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
110 days
108 days
beginning of growing season
end of growing season
Rainfall
S4D0315
Required Depth



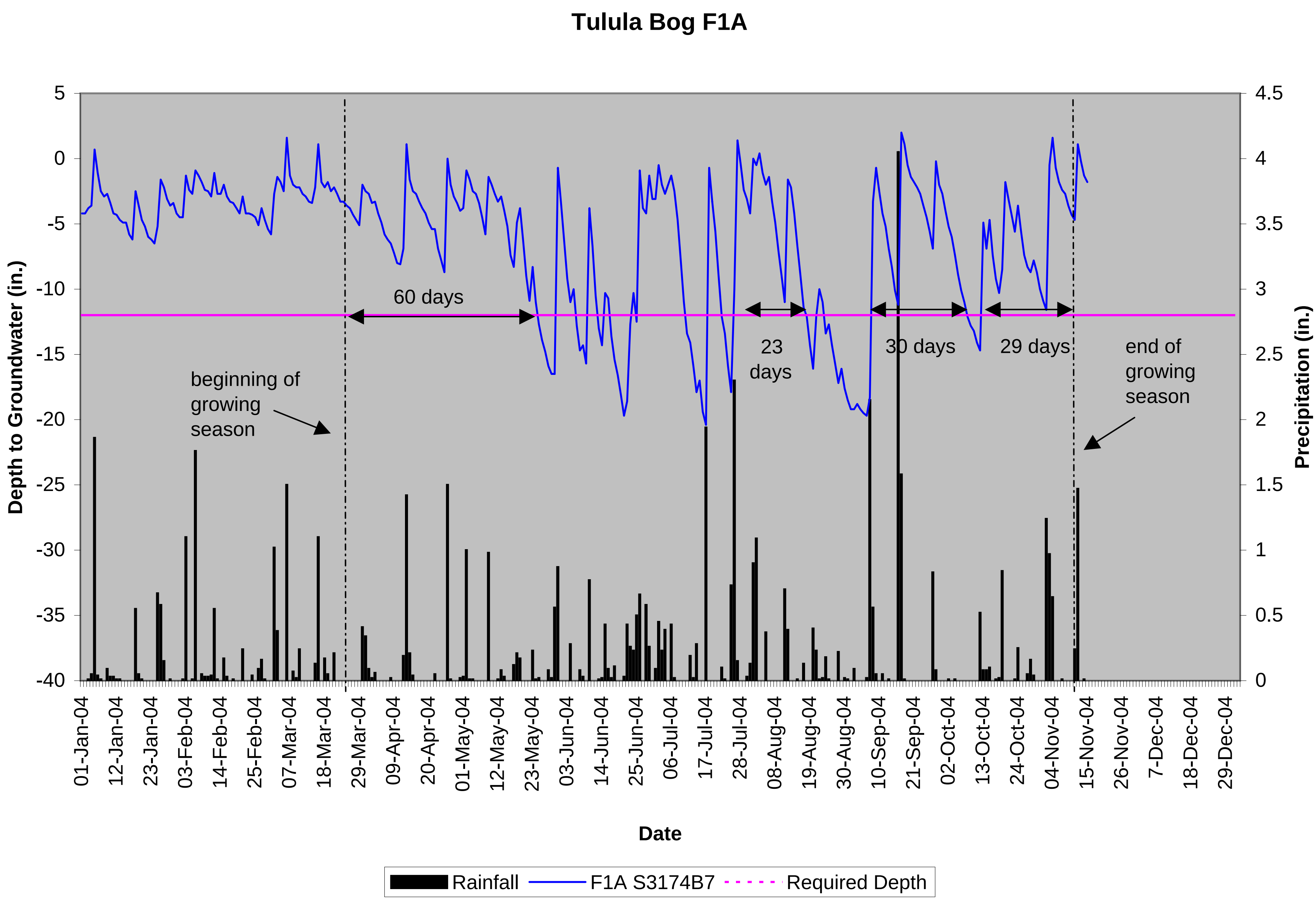
Tulula Bog E2A
Gauge Malfunction
41 days
39 days
65 days
beginning of growing season
end of growing season
Depth to Groundwater (in.)
Precipitation (in.)
Date
Rainfall
E2A S3IFAA0
Required Depth



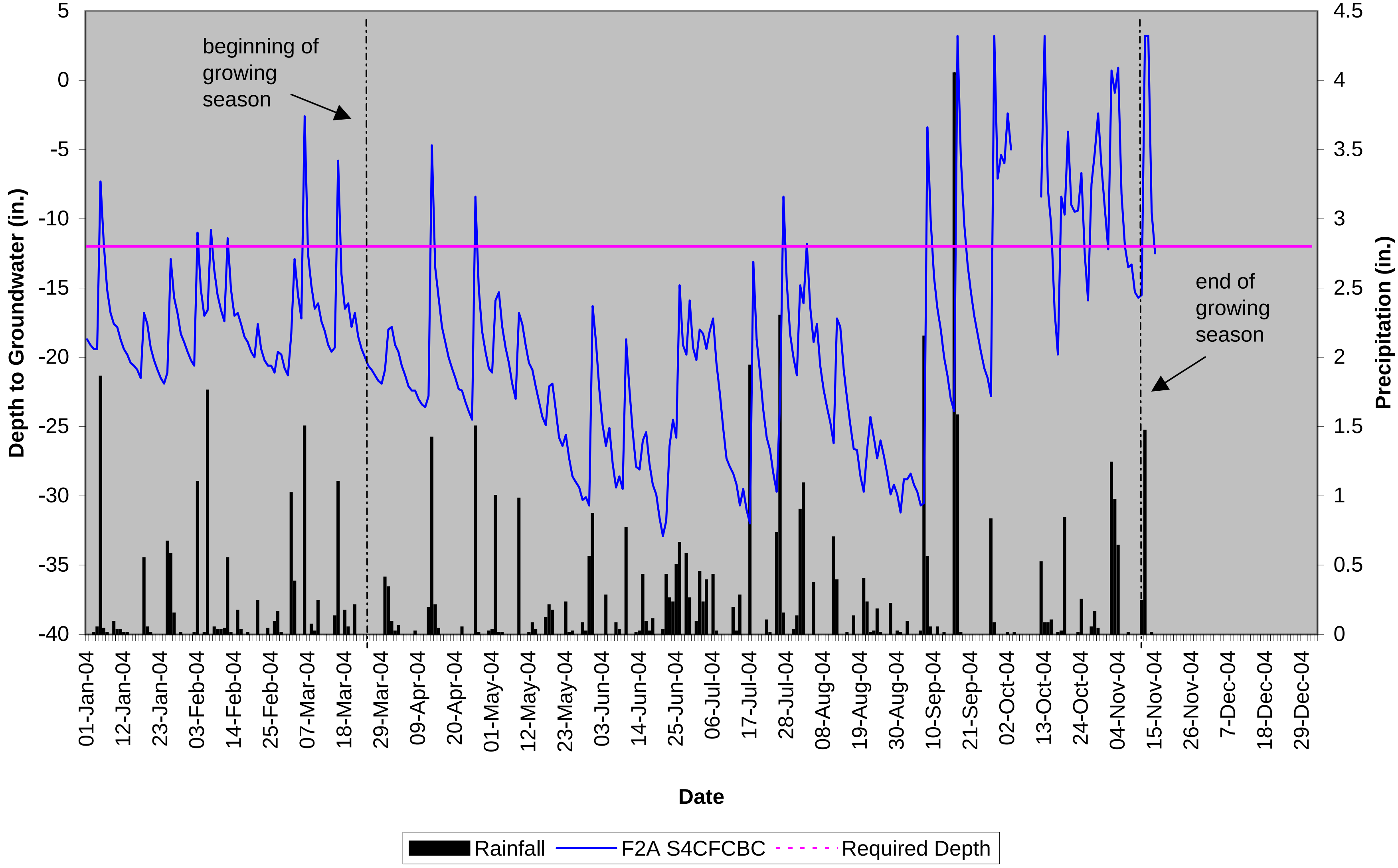
Tulula Bog E3A
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Gauge Malfunction
148 days
29 days
beginning of growing season
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
E3A S4CFE79
Required Depth

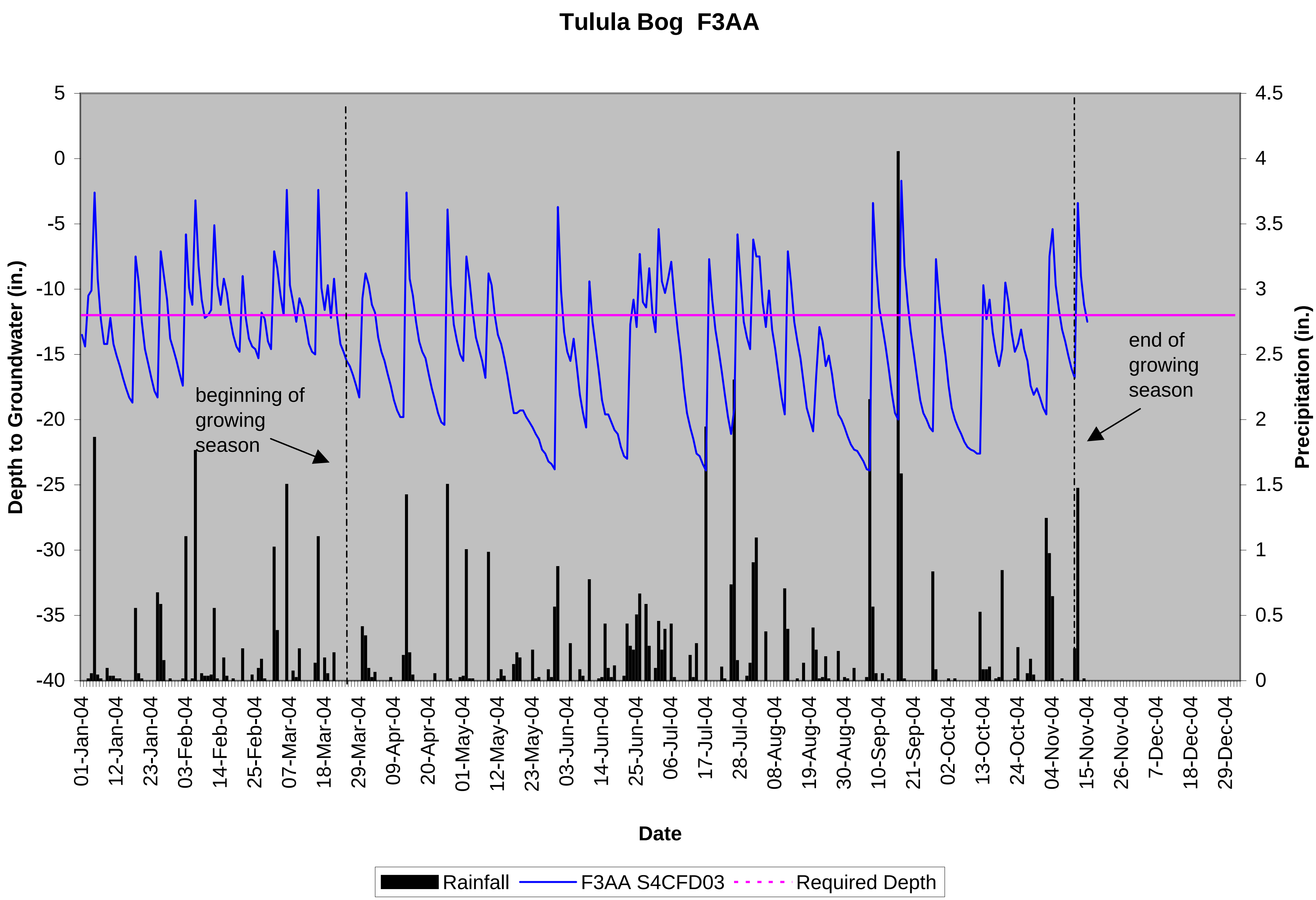


Tulula Bog E4A
Depth to Groundwater (in.)
Precipitation (in.)
Date
beginning of growing season
Gauge Malfunction
end of growing season
Rainfall
E4 S4D041C
Required Depth

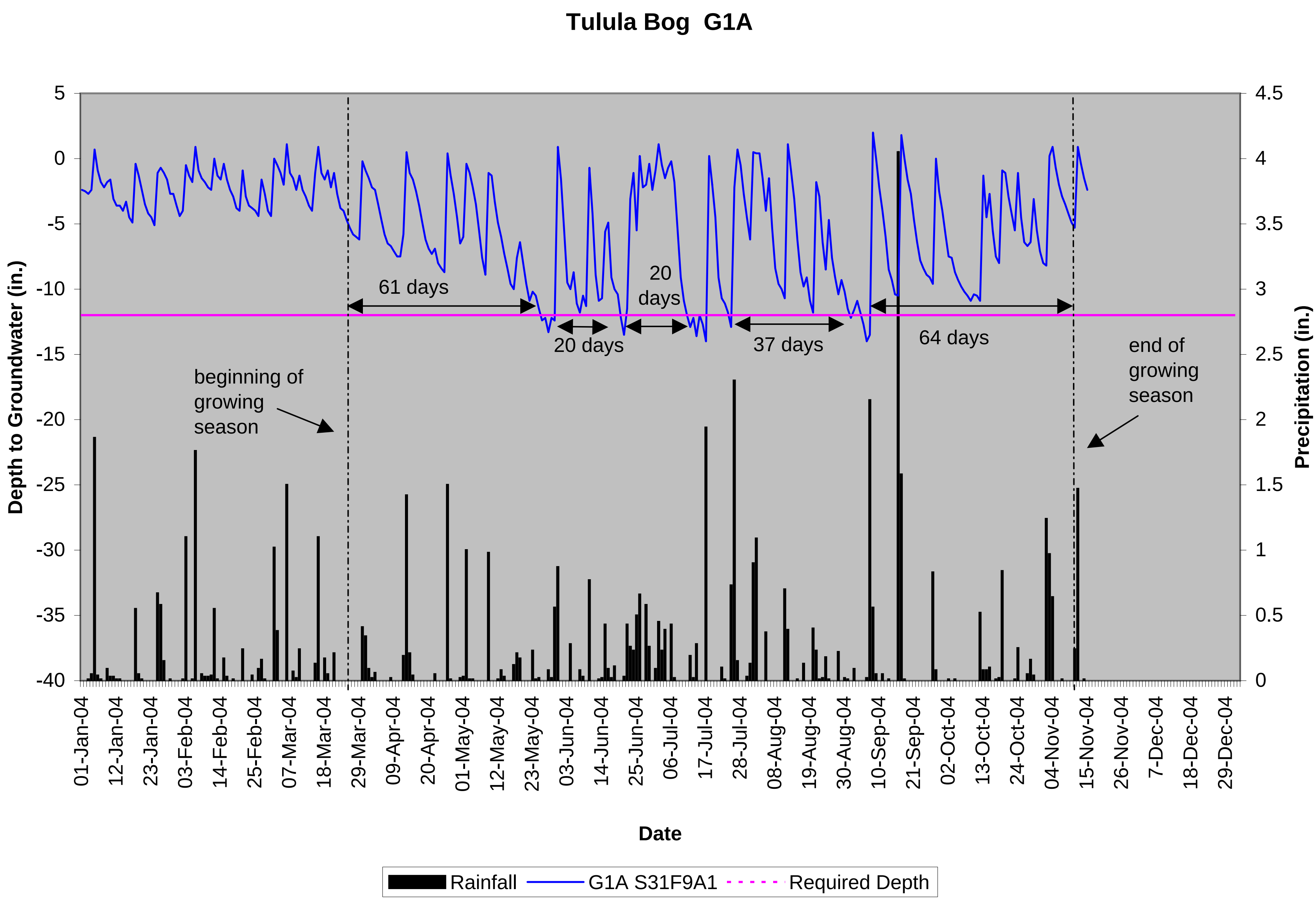

Tulula Bog F1A
Depth to Groundwater (in.)
Precipitation (in.)
Date
60 days
23 days
30 days
29 days
beginning of growing season
end of growing season
Rainfall
F1A S3174B7
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04

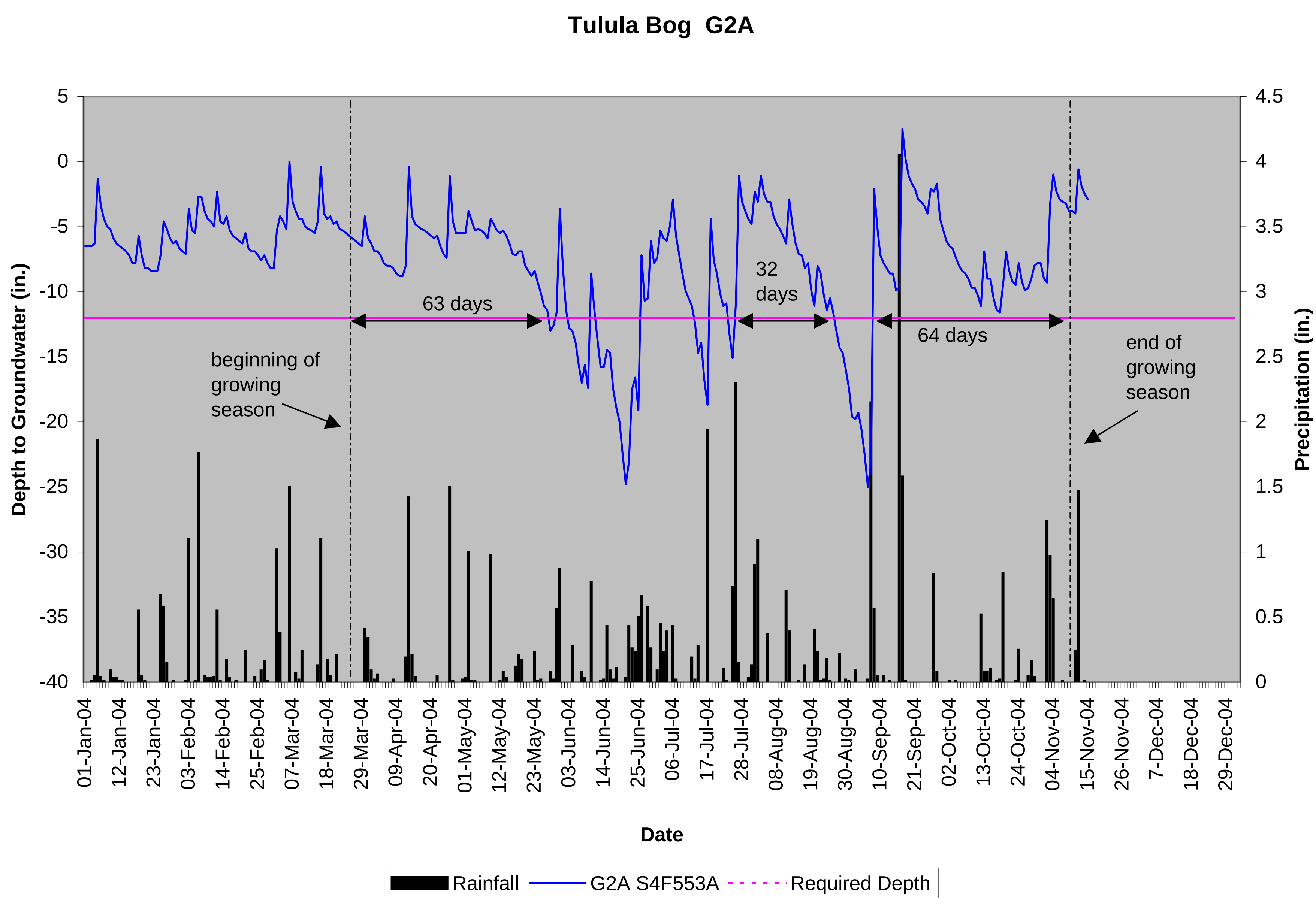
Tulula Bog F2A



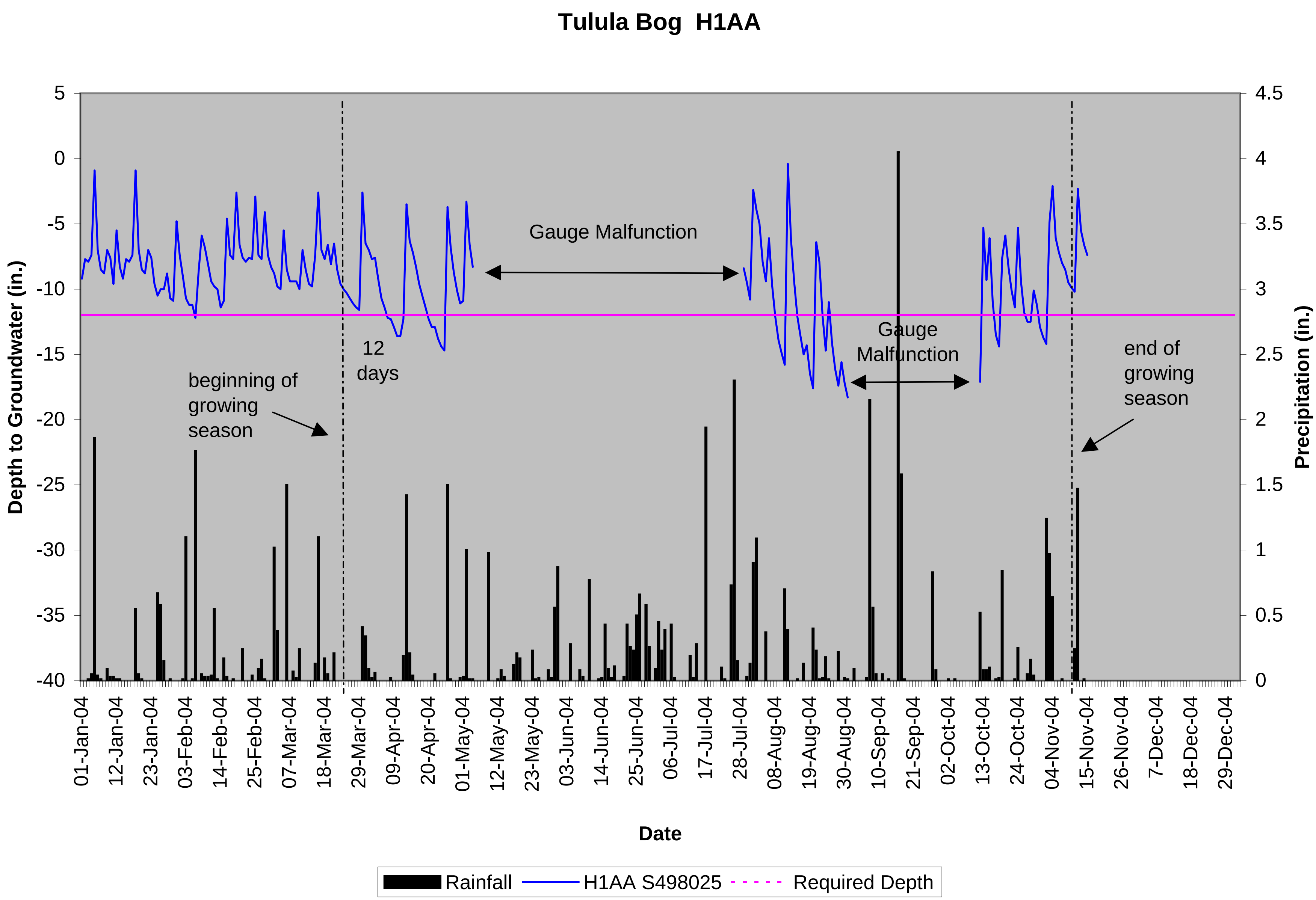


Tulula Bog F3AA
Depth to Groundwater (in.)
Precipitation (in.)
Date
beginning of growing season
end of growing season
Rainfall
F3AA S4CFD03
Required Depth

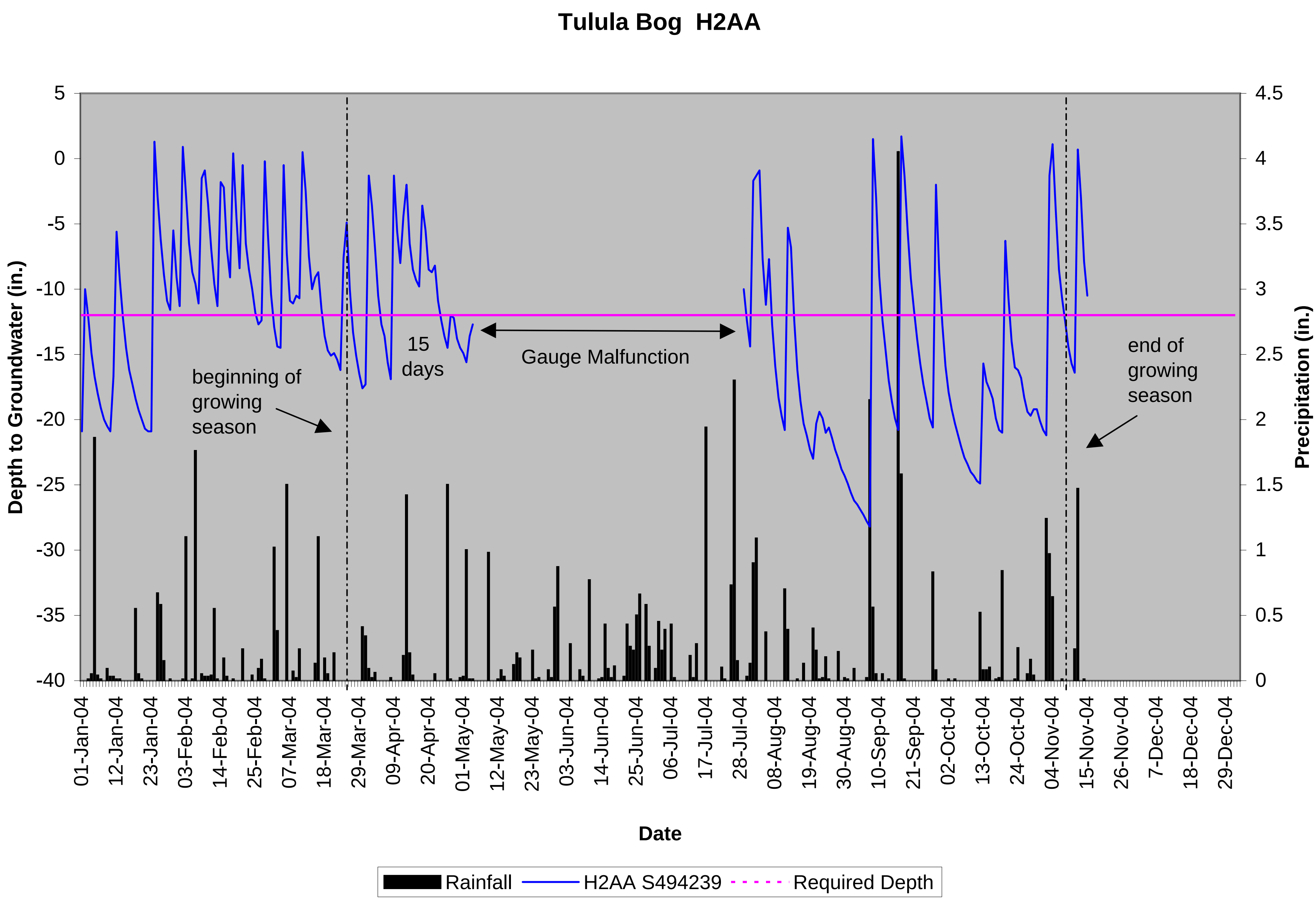

Tulula Bog G1A
Depth to Groundwater (in.)
Precipitation (in.)
Date
61 days
20 days
20 days
37 days
64 days
beginning of growing season
end of growing season
Rainfall
G1A S31F9A1
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04



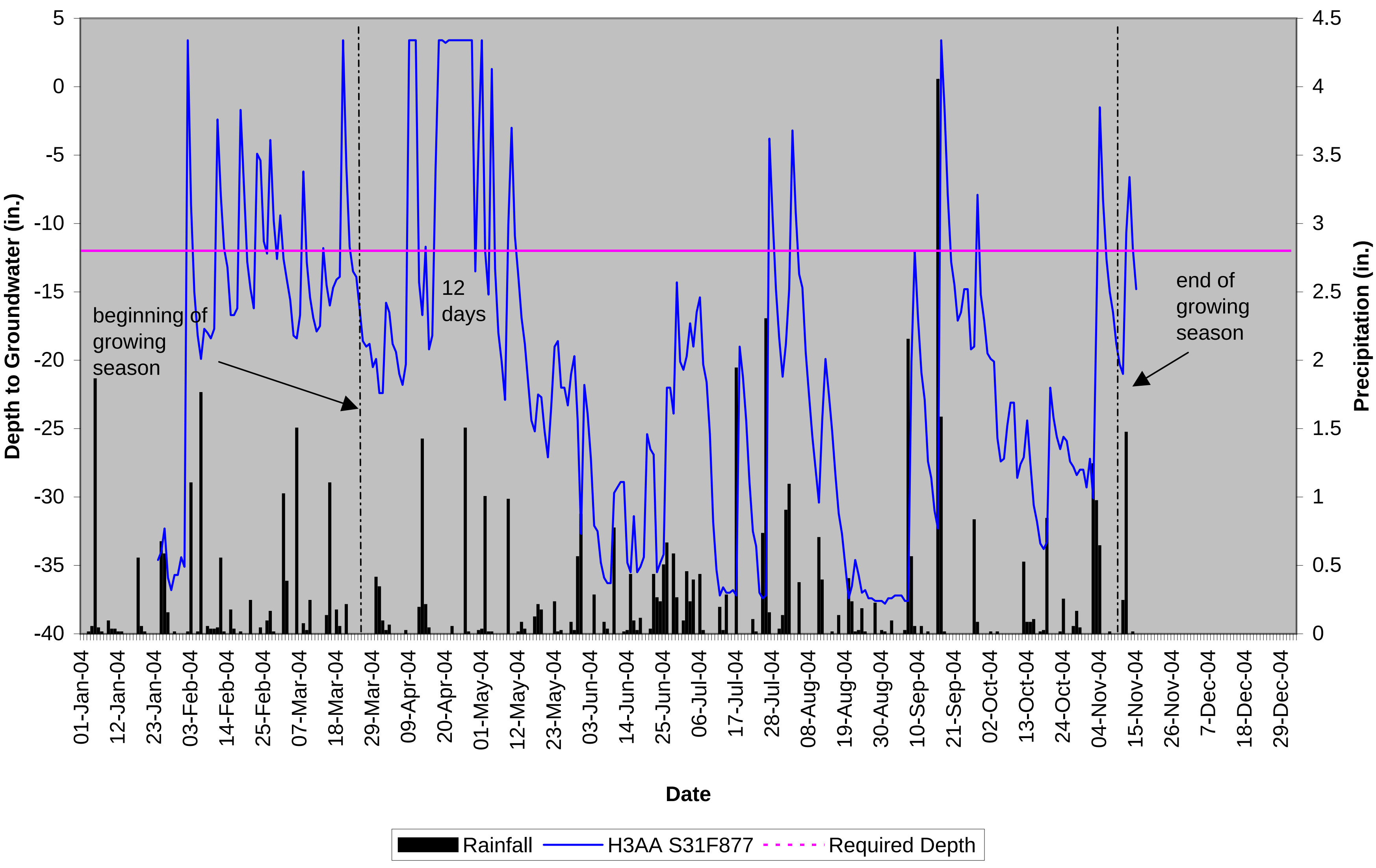
Tulula Bog G2A
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
63 days
32 days
64 days
beginning of growing season
end of growing season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
G2A S4F553A
Required Depth

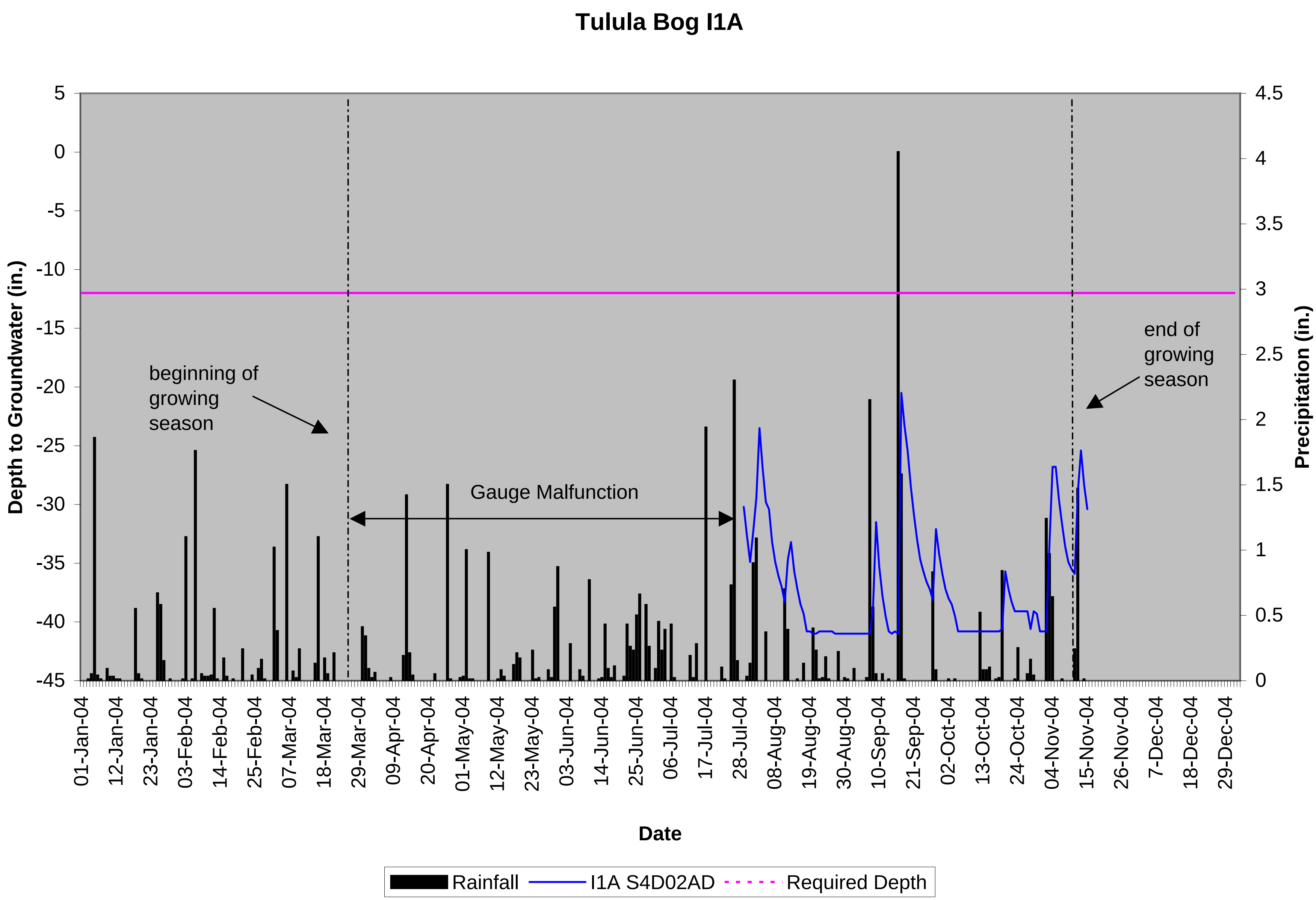


Tulula Bog H1AA
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Gauge Malfunction
12
days
beginning of
growing
season
Gauge
Malfunction
end of
growing
season
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
H1AA S498025
Required Depth

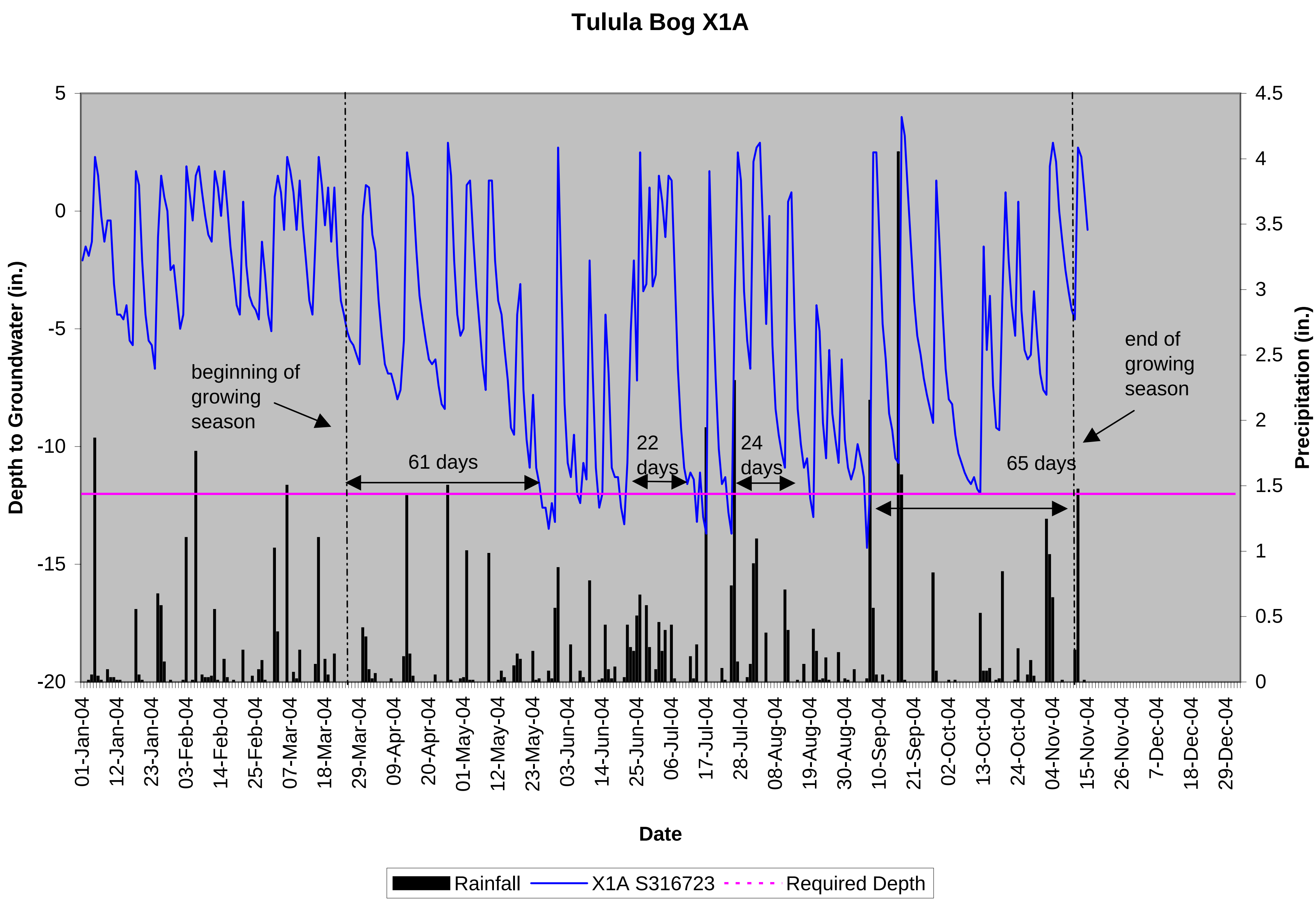

Tulula Bog H2AA
Depth to Groundwater (in.)
Precipitation (in.)
Date
beginning of growing season
15 days
Gauge Malfunction
end of growing season
Rainfall
H2AA S494239
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04

Tulula Bog H3AA





Tulula Bog I1A
Depth to Groundwater (in.)
Precipitation (in.)
Date
beginning of
growing
season
end of
growing
season
Gauge Malfunction
Rainfall
I1A S4D02AD
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04



Tulula Bog X1A
Depth to Groundwater (in.)
Precipitation (in.)
5
0
-5
-10
-15
-20
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
beginning of growing season
end of growing season
61 days
22 days
24 days
65 days
01-Jan-04
12-Jan-04
23-Jan-04
03-Feb-04
14-Feb-04
25-Feb-04
07-Mar-04
18-Mar-04
29-Mar-04
09-Apr-04
20-Apr-04
01-May-04
12-May-04
23-May-04
03-Jun-04
14-Jun-04
25-Jun-04
06-Jul-04
17-Jul-04
28-Jul-04
08-Aug-04
19-Aug-04
30-Aug-04
10-Sep-04
21-Sep-04
02-Oct-04
13-Oct-04
24-Oct-04
04-Nov-04
15-Nov-04
26-Nov-04
7-Dec-04
18-Dec-04
29-Dec-04
Date
Rainfall
X1A S316723
Required Depth

APPENDIX B

SITE PHOTOS & PLANTING PLAN


PHOTO 1


PHOTO 2

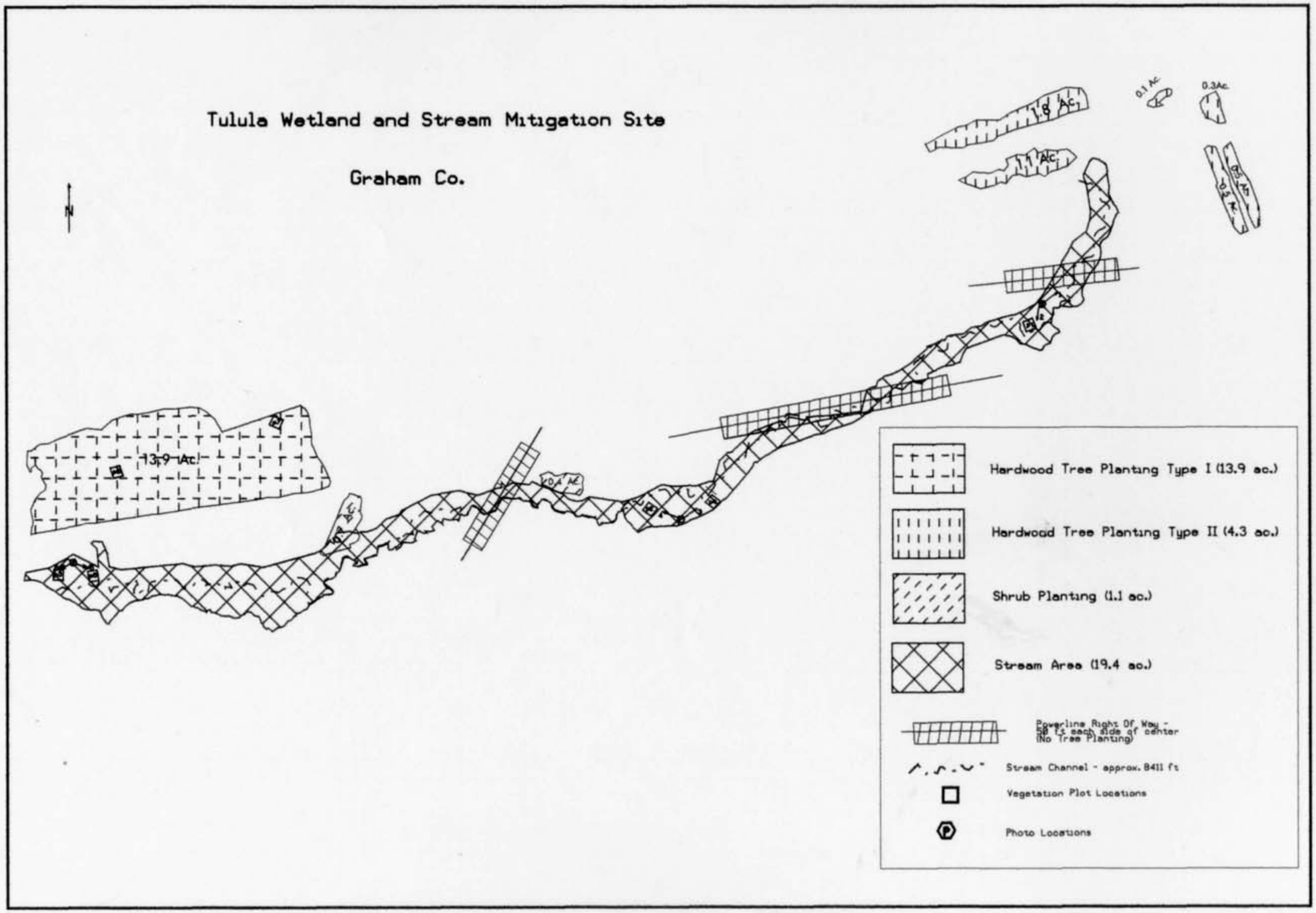

PHOTO 3


PHOTO 4


PHOTO 5


PHOTO 6

2004



Tulula Wetland and Stream Mitigation Site
Graham Co.
N
13.9 Ac.
1.8 Ac.
1.1 Ac.
0.1 Ac.
0.3Ac.
Hardwood Tree Planting Type I (13.9 ac.)
Hardwood Tree Planting Type II (4.3 ac.)
Shrub Planting (1.1 ac.)
Stream Area (19.4 ac.)
Powerline Right Of Way - 50 ft each side of center (No Tree Planting)
Stream Channel - approx. 8411 ft
Vegetation Plot Locations
Photo Locations