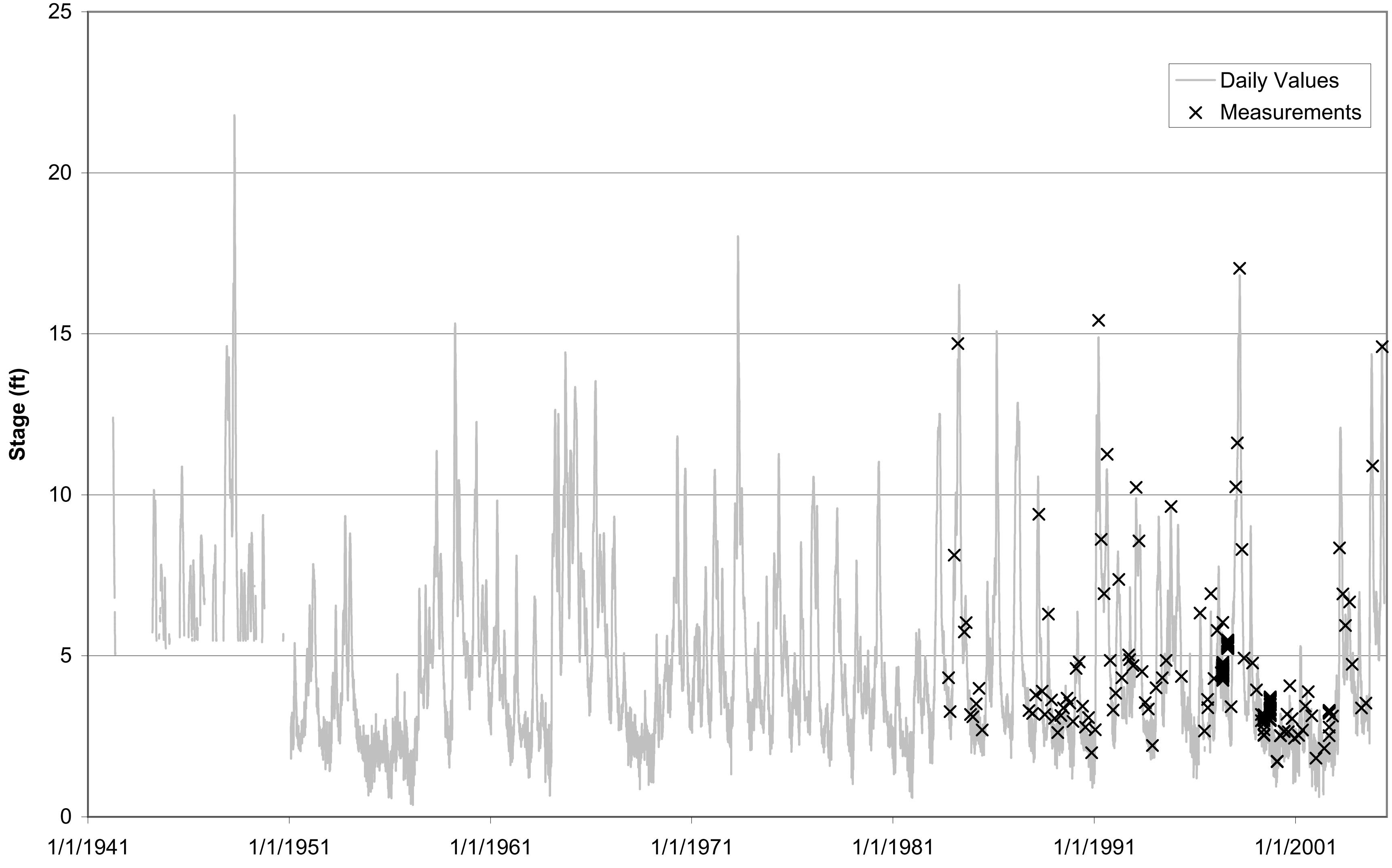
APPENDICES

Appendix A - Stream Measurements

Figure A-1 Stage at the Suwannee River Gage Near Wilcox (#02323500)



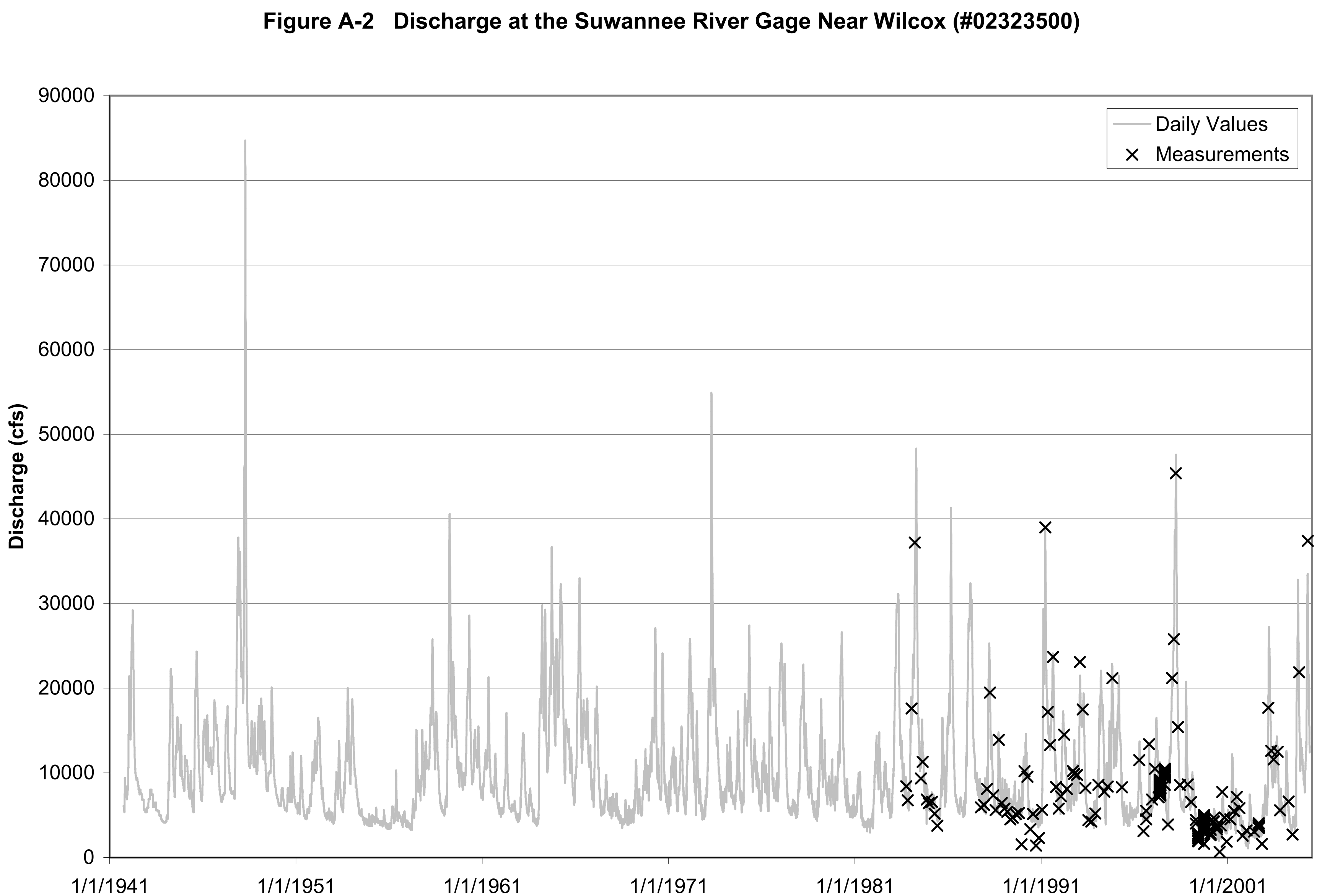


Figure A-2 Discharge at the Suwannee River Gage Near Wilcox (#02323500)
Daily Values
Measurements
Discharge (cfs)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1/1/1941
1/1/1951
1/1/1961
1/1/1971
1/1/1981
1/1/1991
1/1/2001

Figure A-3 Stage at the Fanning Spring gage (#02323502)

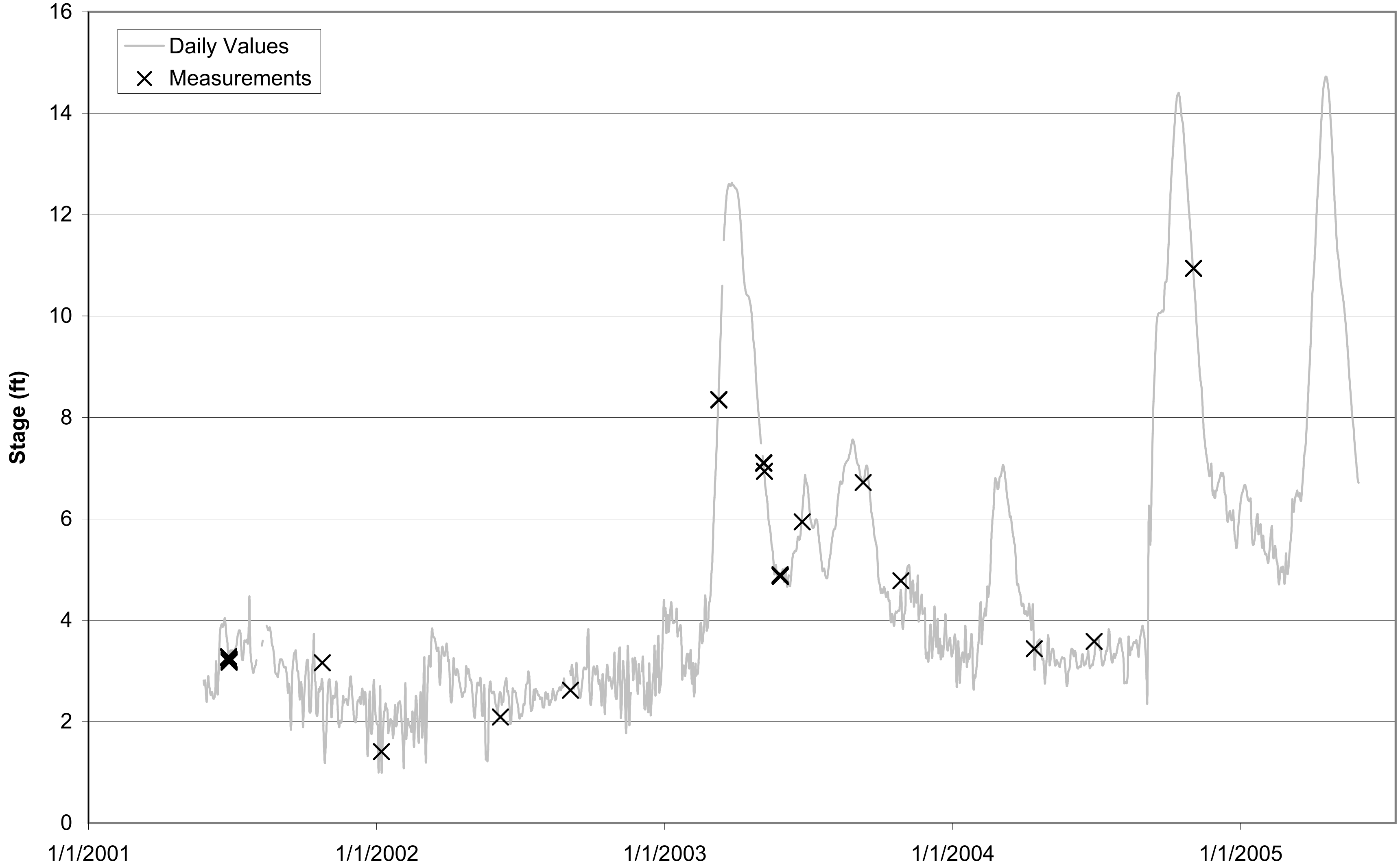


Figure A-4 Discharge at the Fanning Spring gage (#02323502)

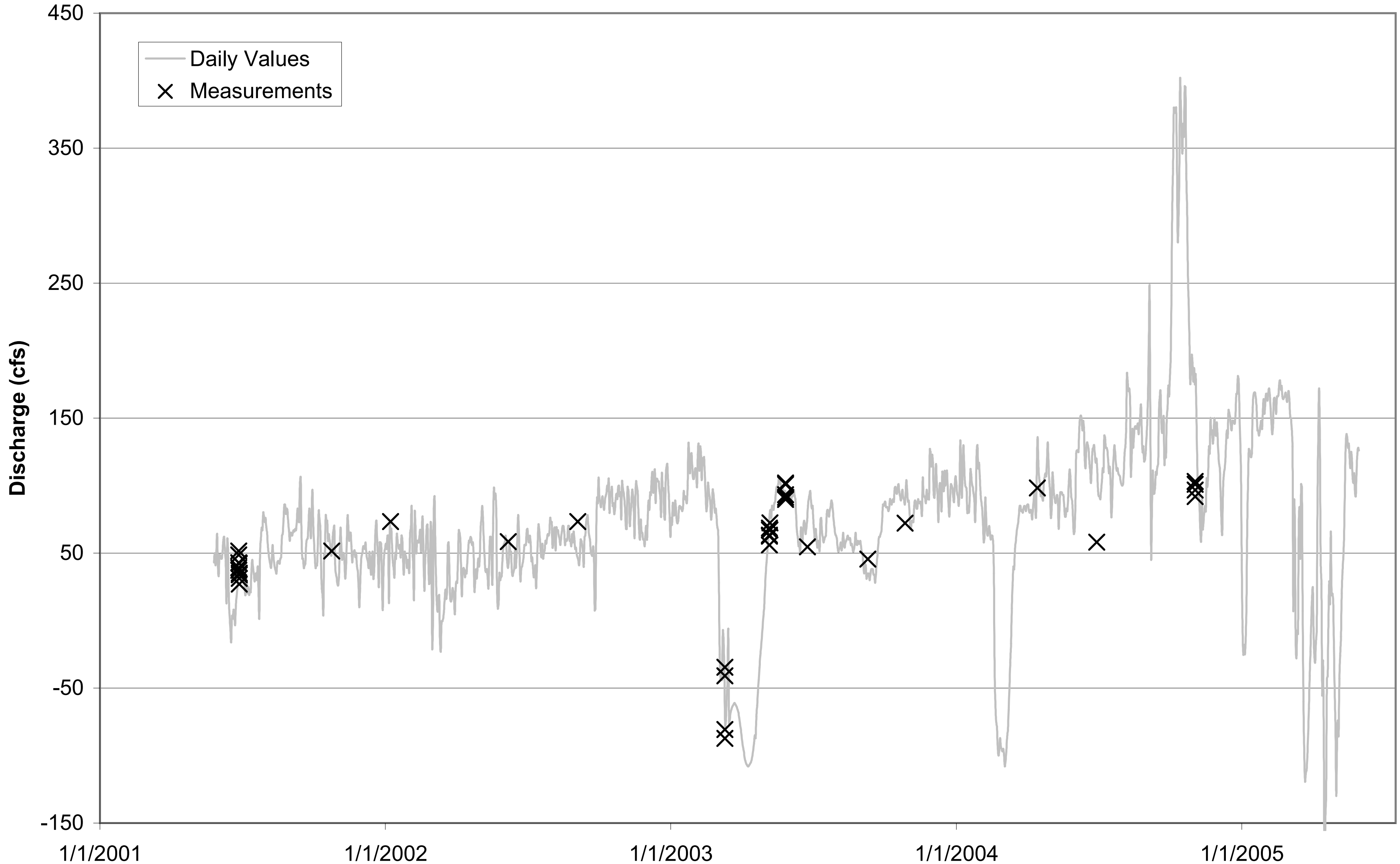


Figure A-5 Stage at the Manatee Springs Gage (#02323556)

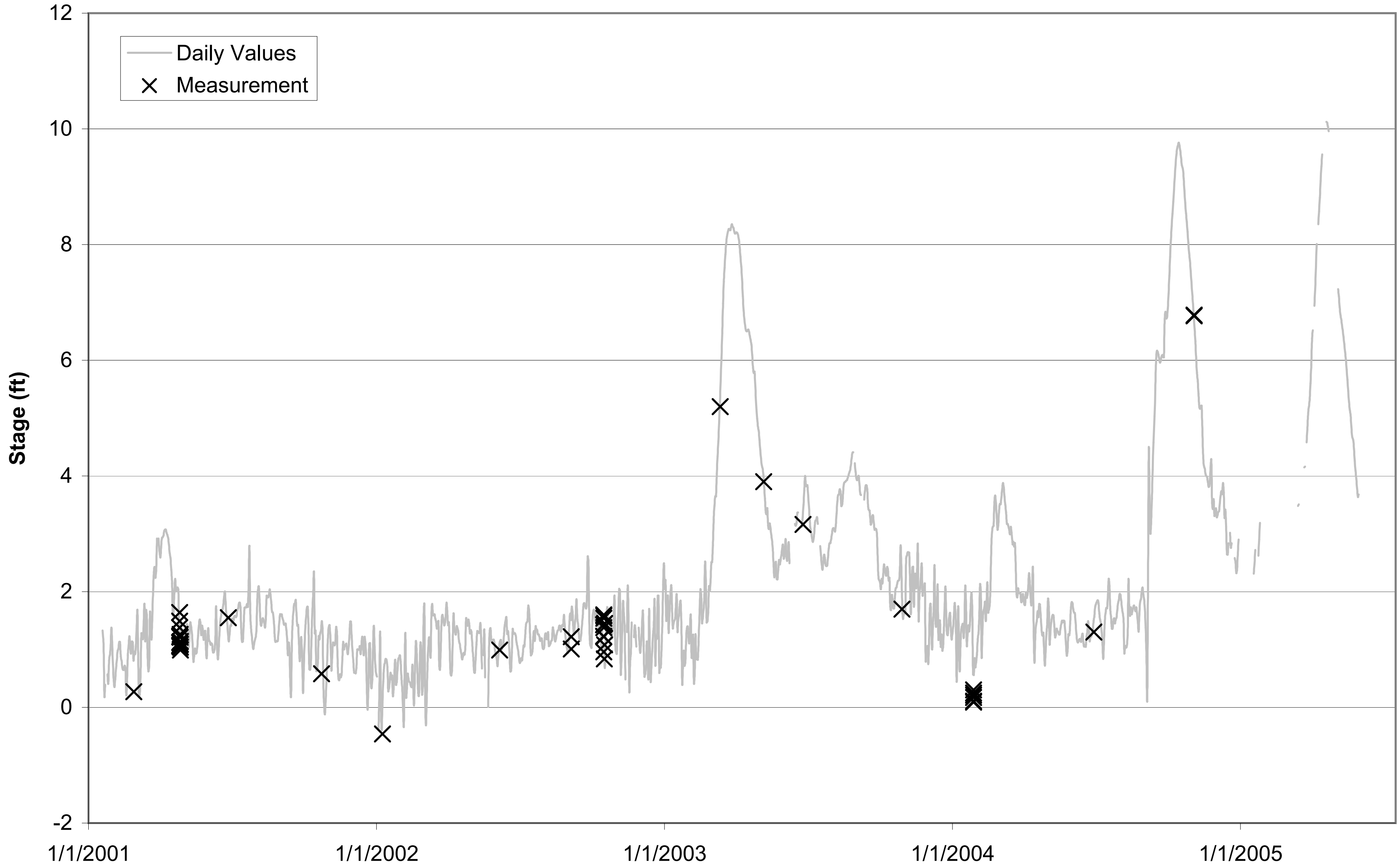
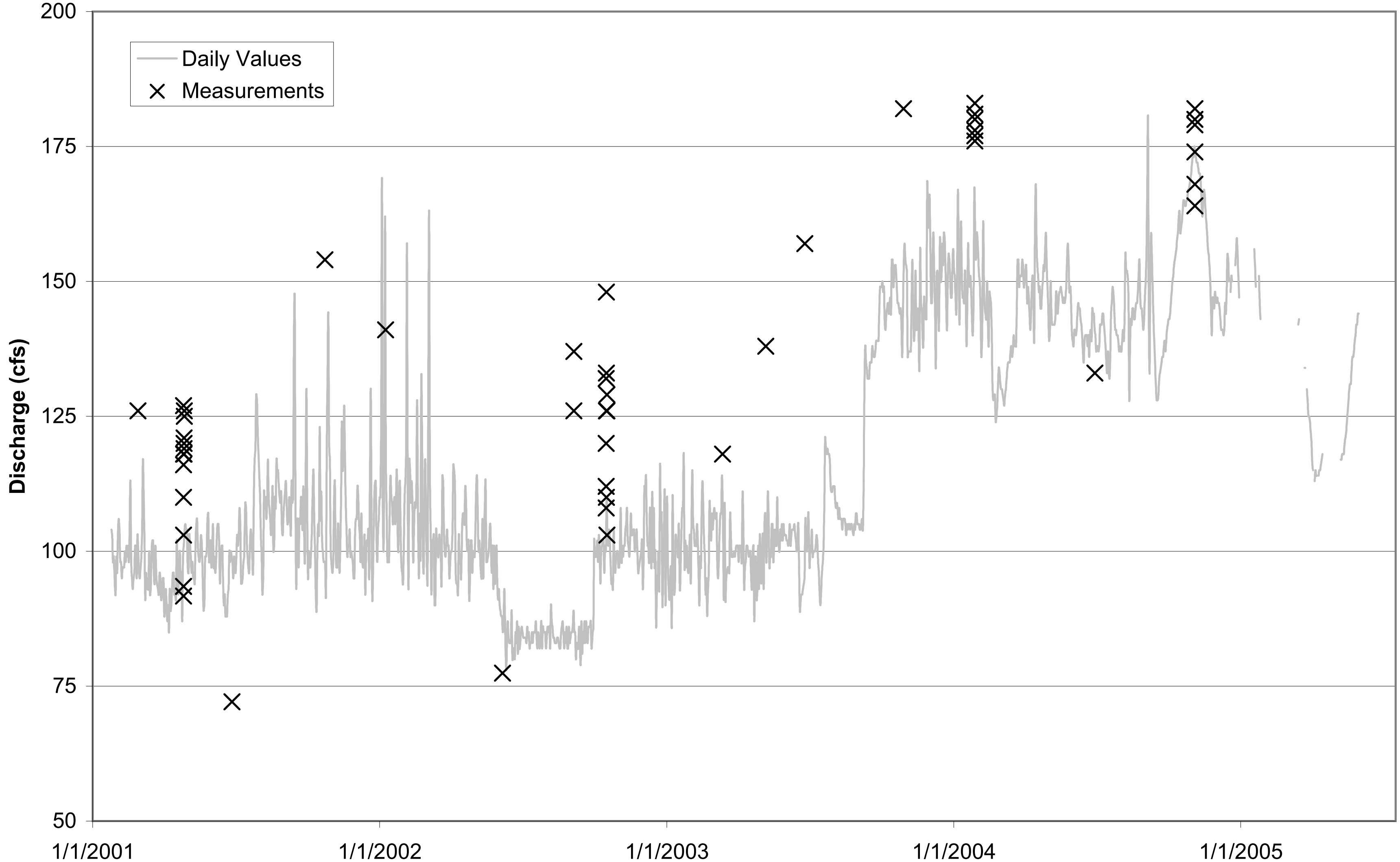
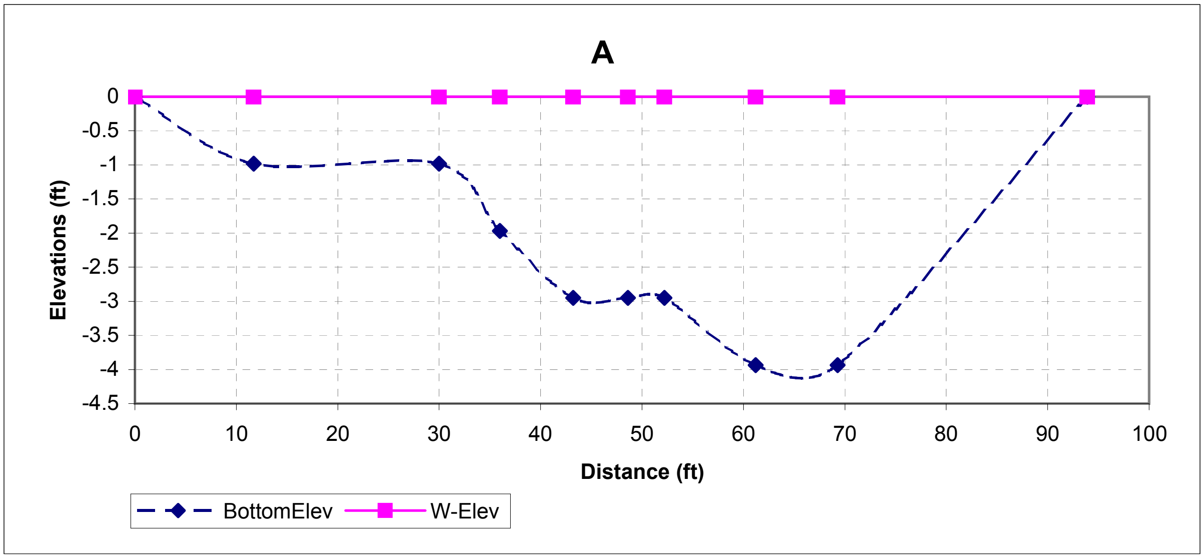
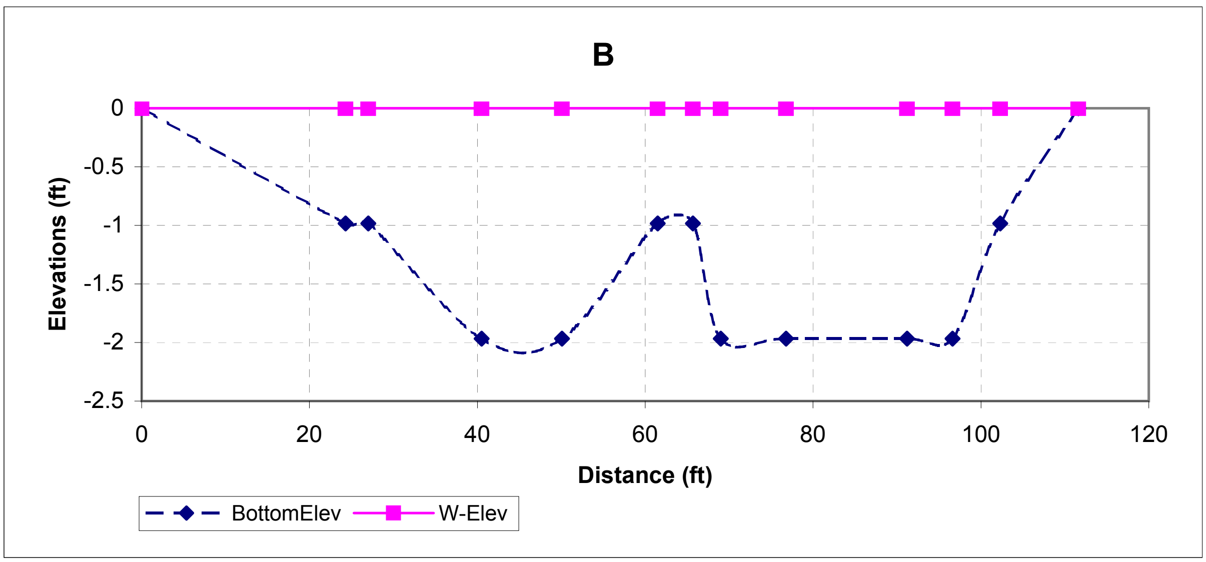


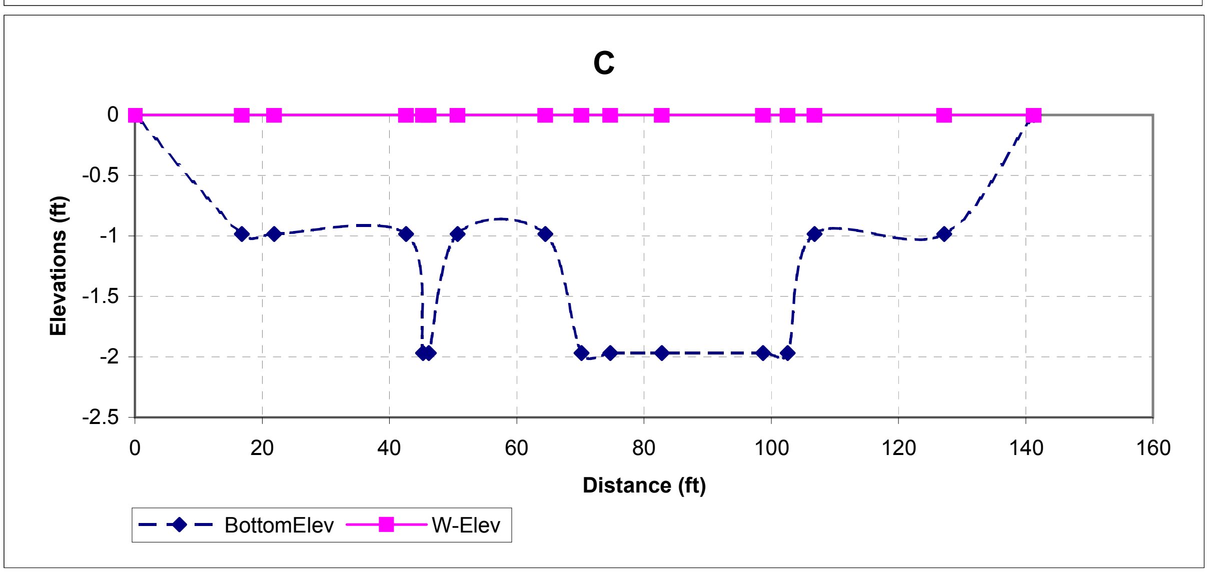
Figure A-6 Discharge at the Manatee Springs gage (#02323556)

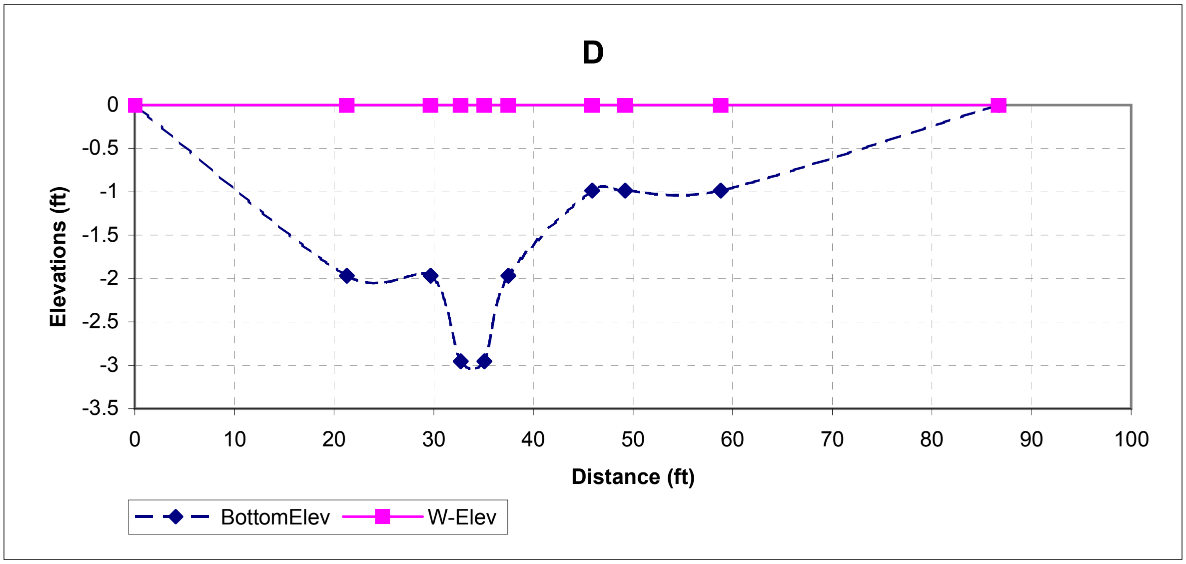


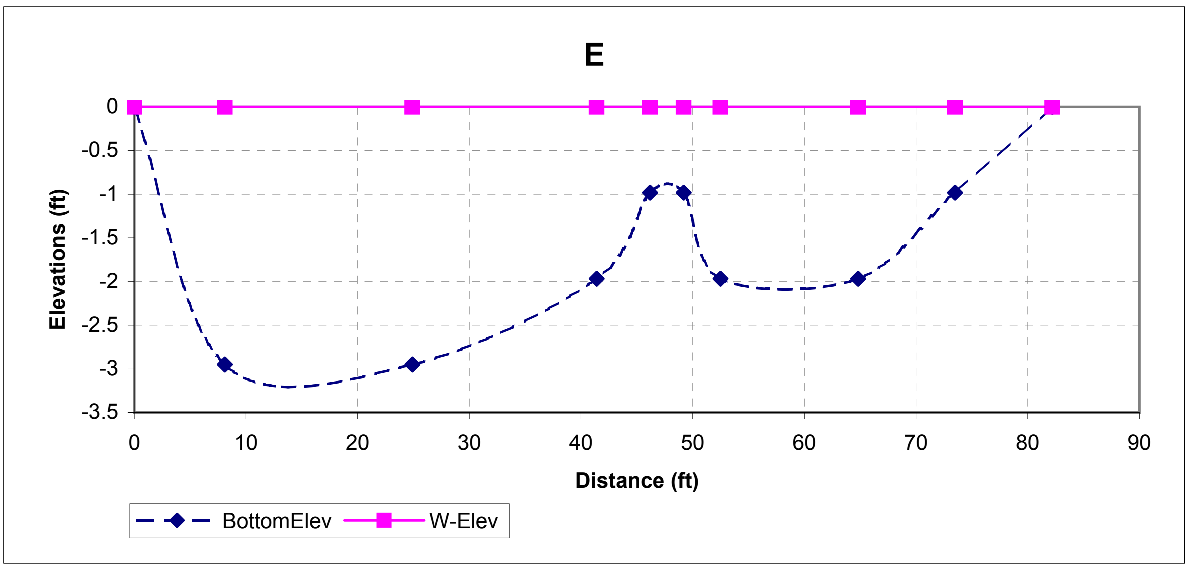
Appendix B - Manatee Spring Run Topographic Profiles


A
Elevations (ft)
Distance (ft)
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
0
10
20
30
40
50
60
70
80
90
100
BottomElev
W-Elev

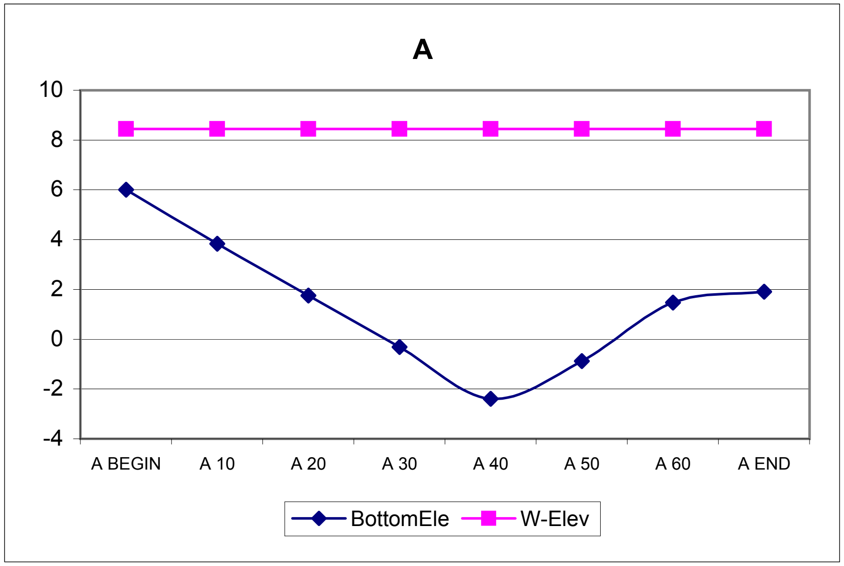

B
Elevations (ft)
Distance (ft)
0
-0.5
-1
-1.5
-2
-2.5
0
20
40
60
80
100
120
BottomElev
W-Elev

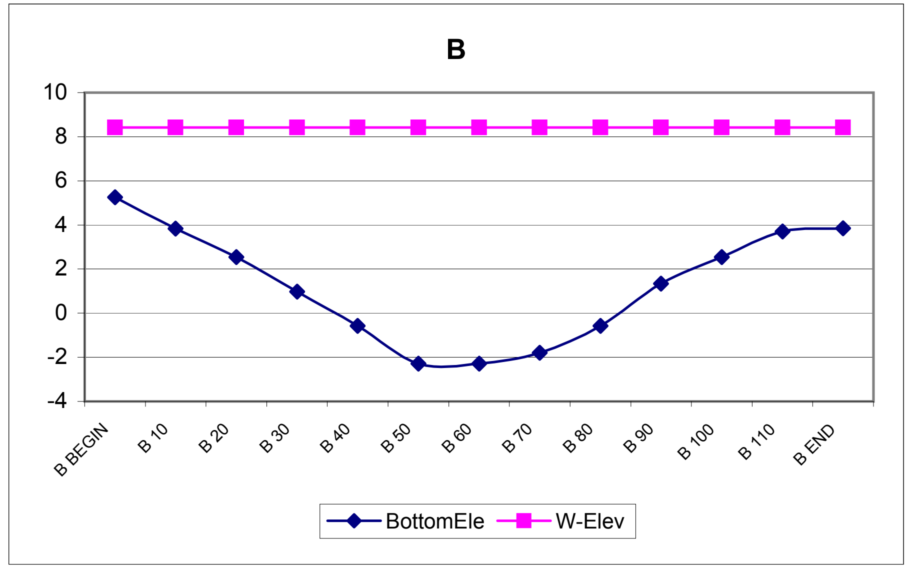

C
Elevations (ft)
Distance (ft)
0
-0.5
-1
-1.5
-2
-2.5
0
20
40
60
80
100
120
140
160
BottomElev
W-Elev

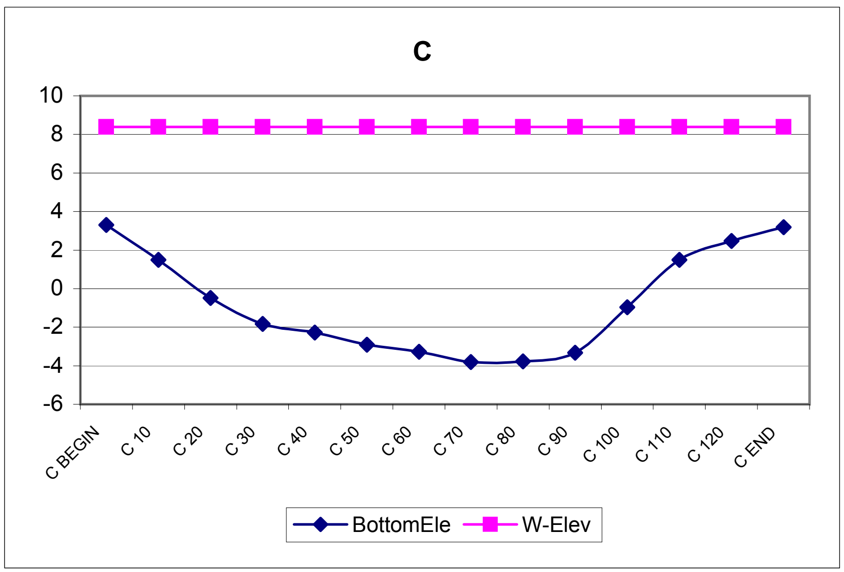

D
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Elevations (ft)
0
10
20
30
40
50
60
70
80
90
100
Distance (ft)
BottomElev
W-Elev

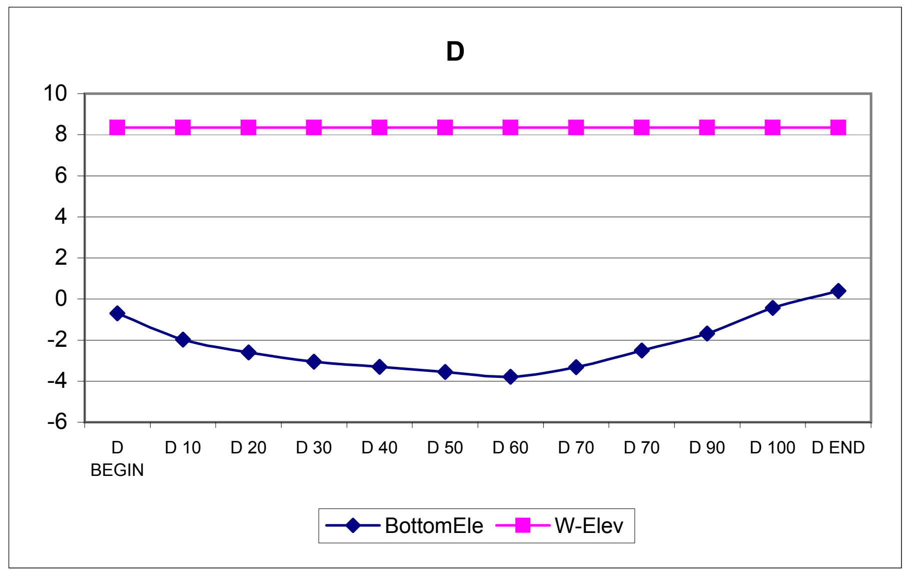

E
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
Elevations (ft)
0
10
20
30
40
50
60
70
80
90
Distance (ft)
BottomElev
W-Elev

Appendix C - Fanning Spring Run Topographic Profiles

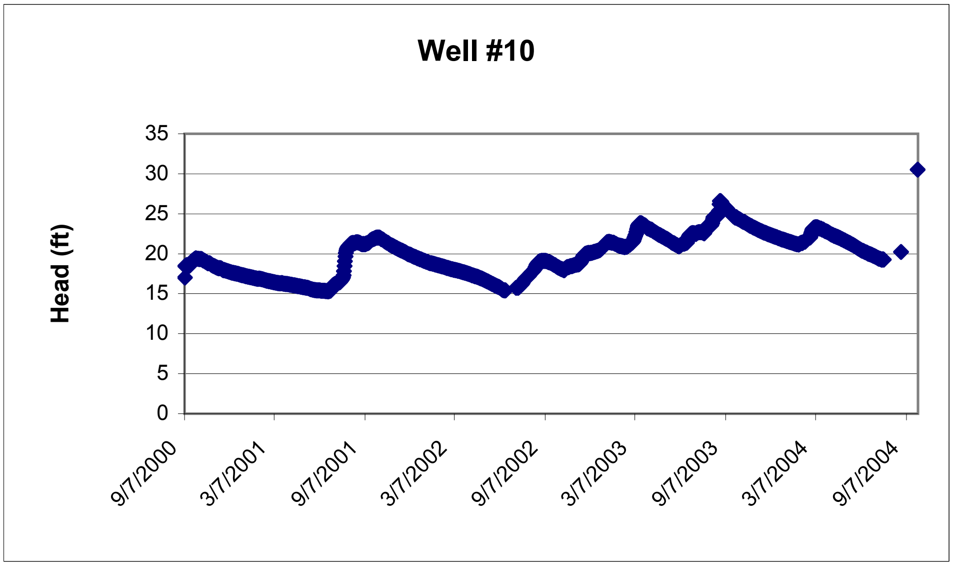

A
10
8
6
4
2
0
-2
-4
A BEGIN
A 10
A 20
A 30
A 40
A 50
A 60
A END
BottomEle
W-Elev


B
10
8
6
4
2
0
-2
-4
B BEGIN
B 10
B 20
B 30
B 40
B 50
B 60
B 70
B 80
B 90
B 100
B 110
B END
BottomEle
W-Elev

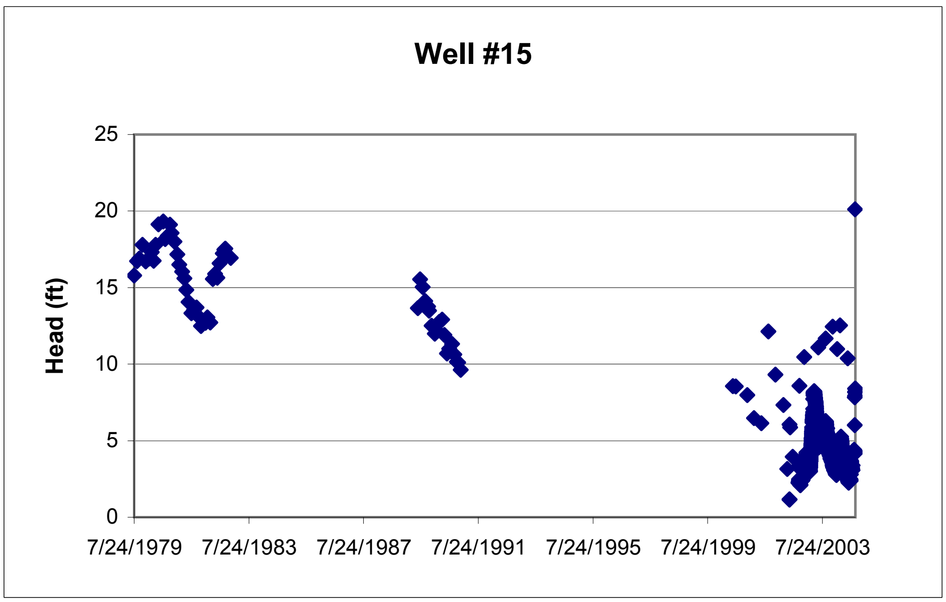

C
10
8
6
4
2
0
-2
-4
-6
C BEGIN
C 10
C 20
C 30
C 40
C 50
C 60
C 70
C 80
C 90
C 100
C 110
C 120
C END
BottomEle
W-Elev


D
10
8
6
4
2
0
-2
-4
-6
D BEGIN
D 10
D 20
D 30
D 40
D 50
D 60
D 70
D 70
D 90
D 100
D END
BottomEle
W-Elev

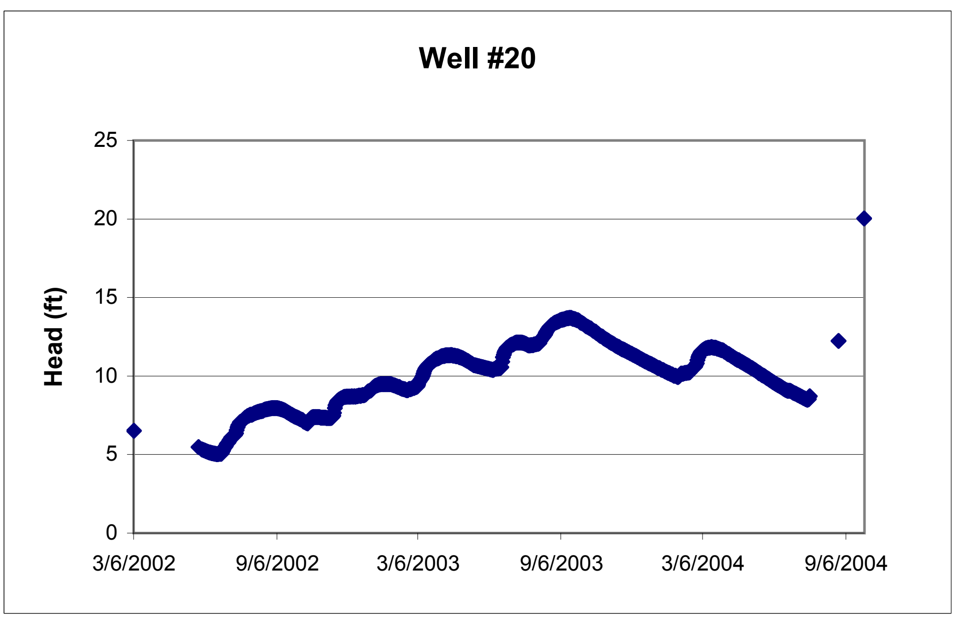
Appendix D - Ground Water Data



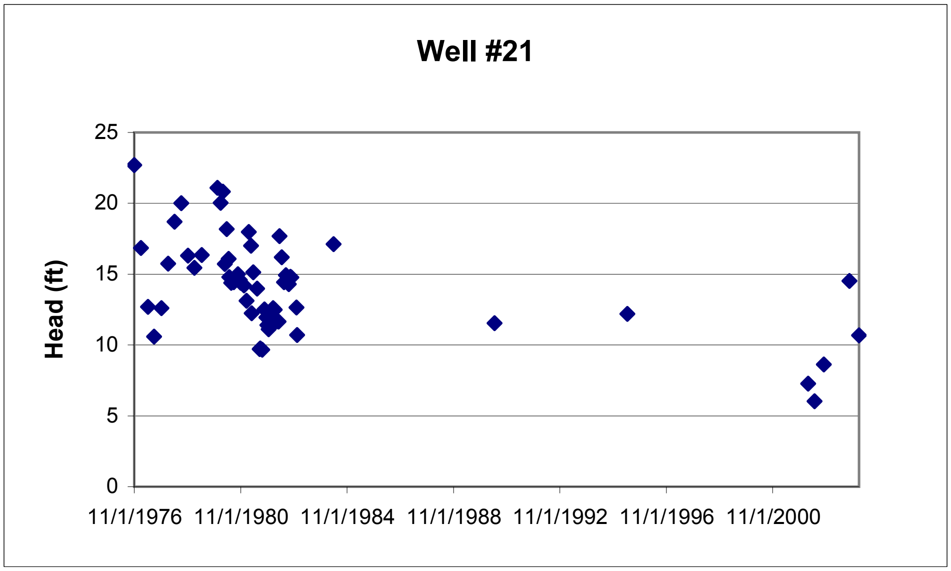
Well #10
Head (ft)
35
30
25
20
15
10
5
0
9/7/2000
3/7/2001
9/7/2001
3/7/2002
9/7/2002
3/7/2003
9/7/2003
3/7/2004
9/7/2004

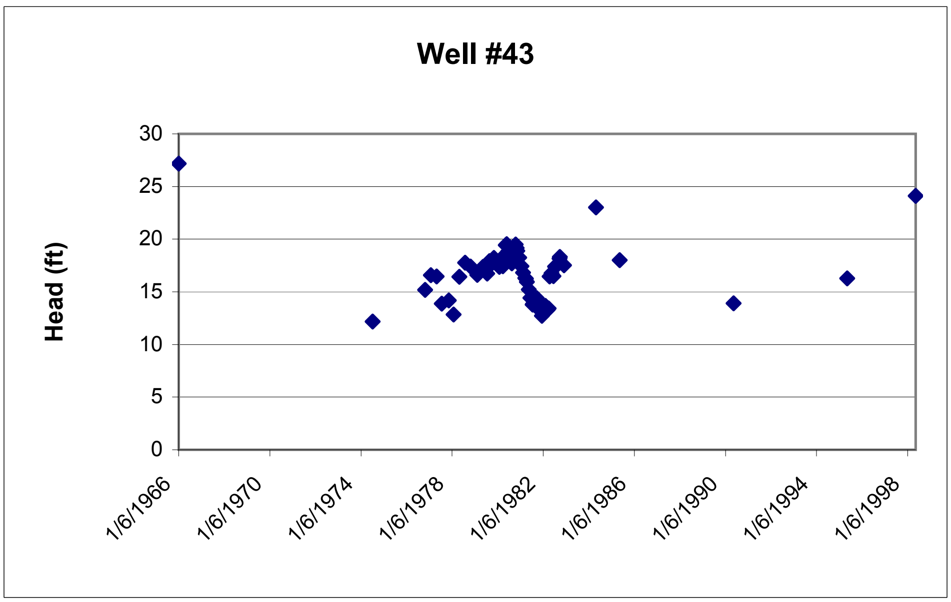


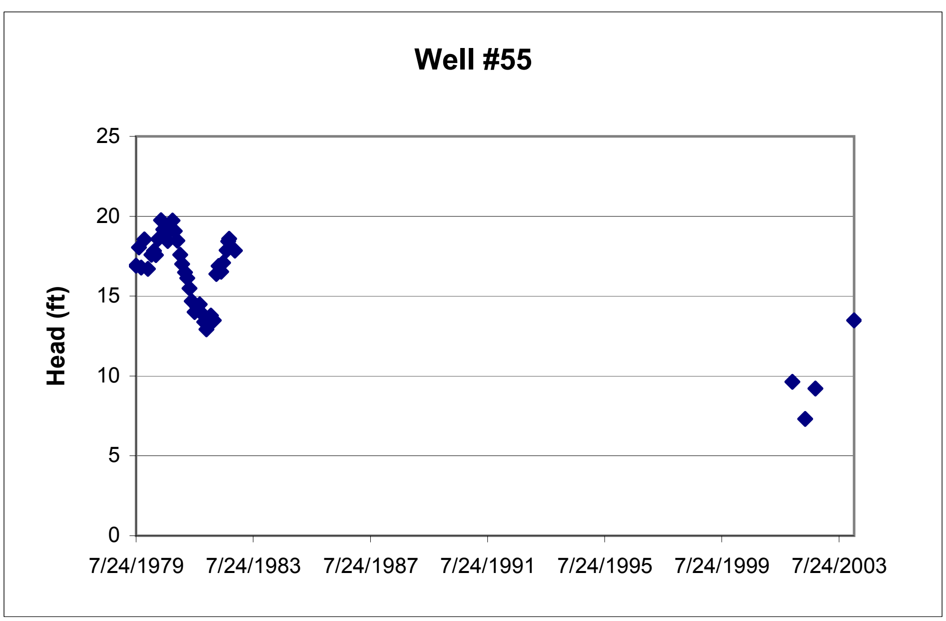
Well #15
Head (ft)
25
20
15
10
5
0
7/24/1979
7/24/1983
7/24/1987
7/24/1991
7/24/1995
7/24/1999
7/24/2003

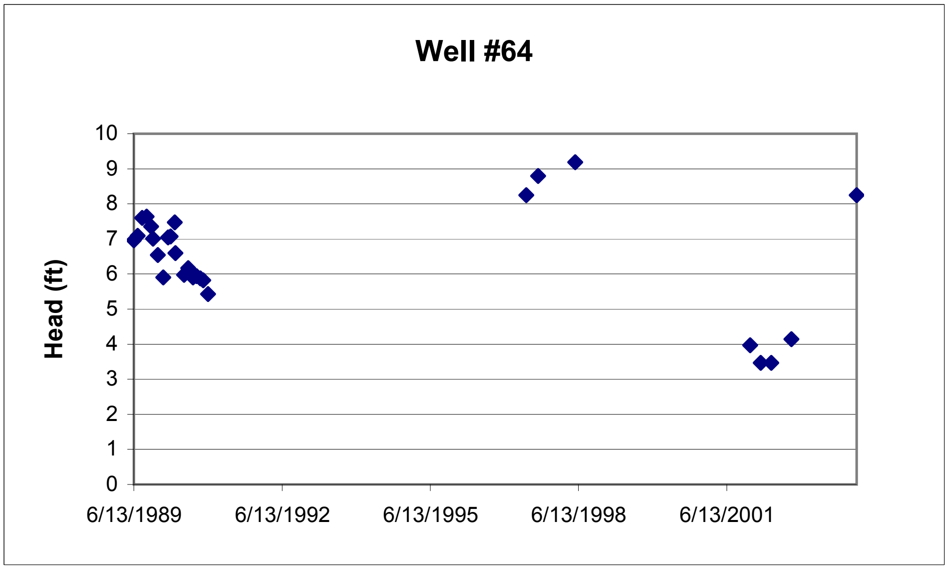


Well #20
Head (ft)
25
20
15
10
5
0
3/6/2002
9/6/2002
3/6/2003
9/6/2003
3/6/2004
9/6/2004

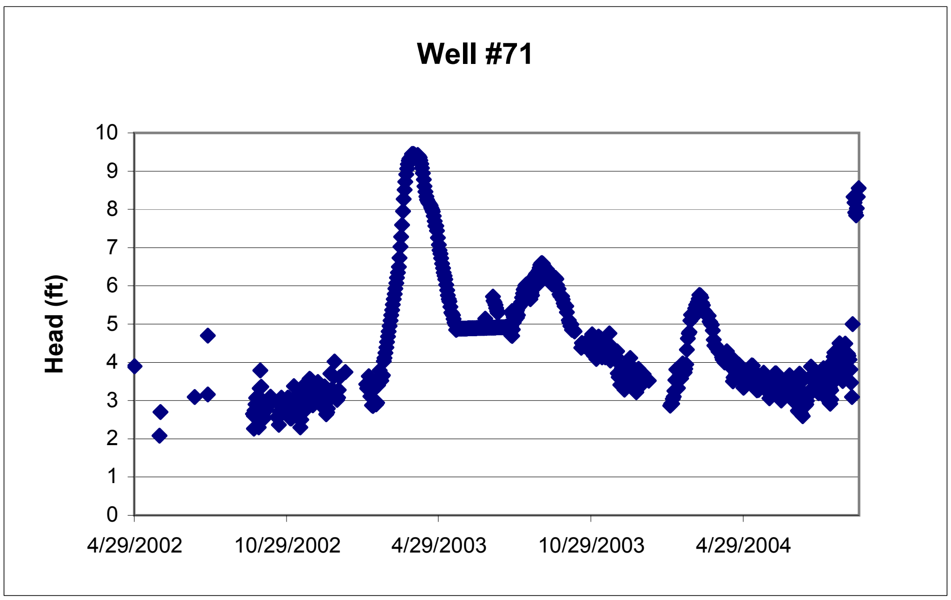

Well #21
Head (ft)
25
20
15
10
5
0
11/1/1976
11/1/1980
11/1/1984
11/1/1988
11/1/1992
11/1/1996
11/1/2000


Well #43
Head (ft)
30
25
20
15
10
5
0
1/6/1966
1/6/1970
1/6/1974
1/6/1978
1/6/1982
1/6/1986
1/6/1990
1/6/1994
1/6/1998

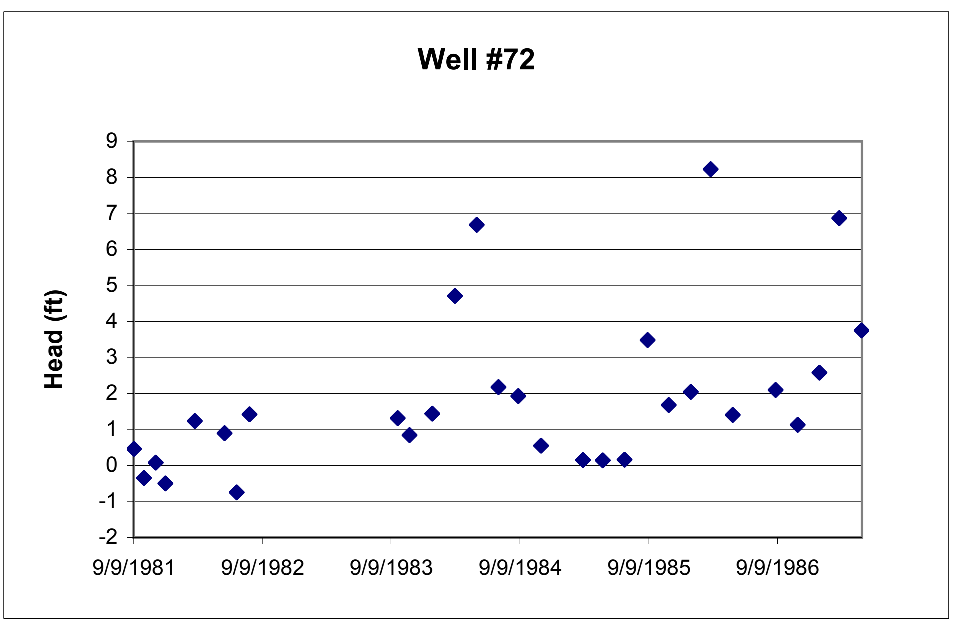

Well #55
Head (ft)
25
20
15
10
5
0
7/24/1979
7/24/1983
7/24/1987
7/24/1991
7/24/1995
7/24/1999
7/24/2003



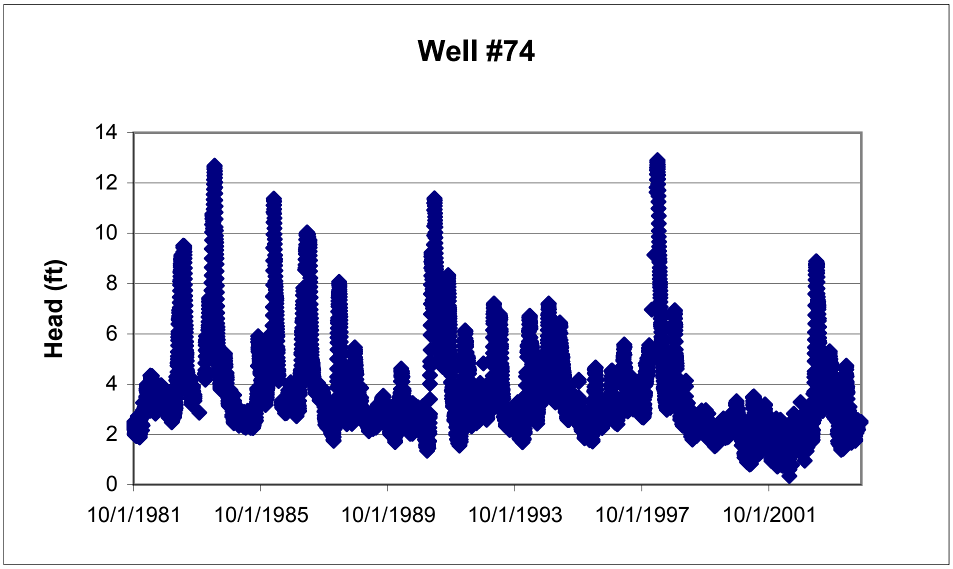
Well #64
Head (ft)
10
9
8
7
6
5
4
3
2
1
0
6/13/1989
6/13/1992
6/13/1995
6/13/1998
6/13/2001

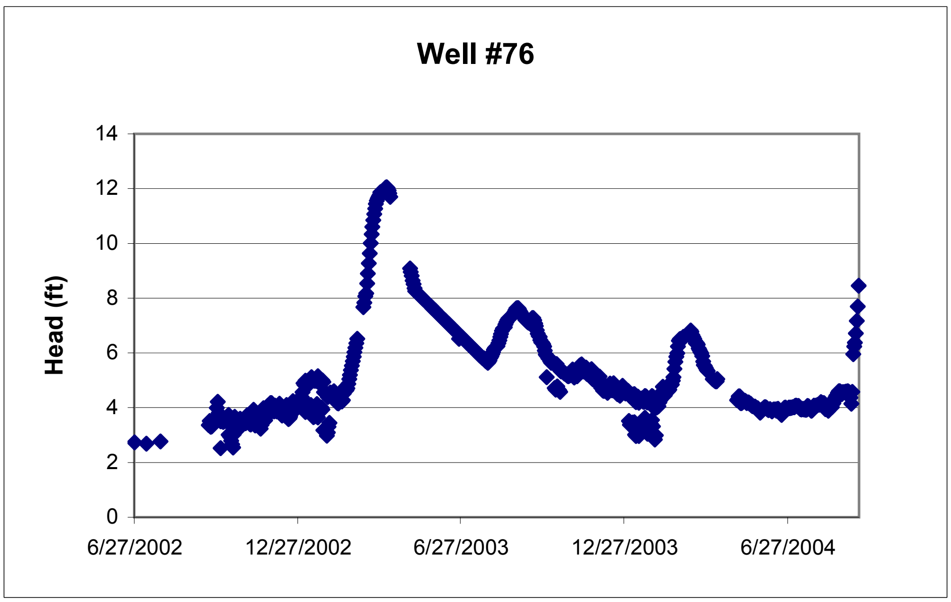


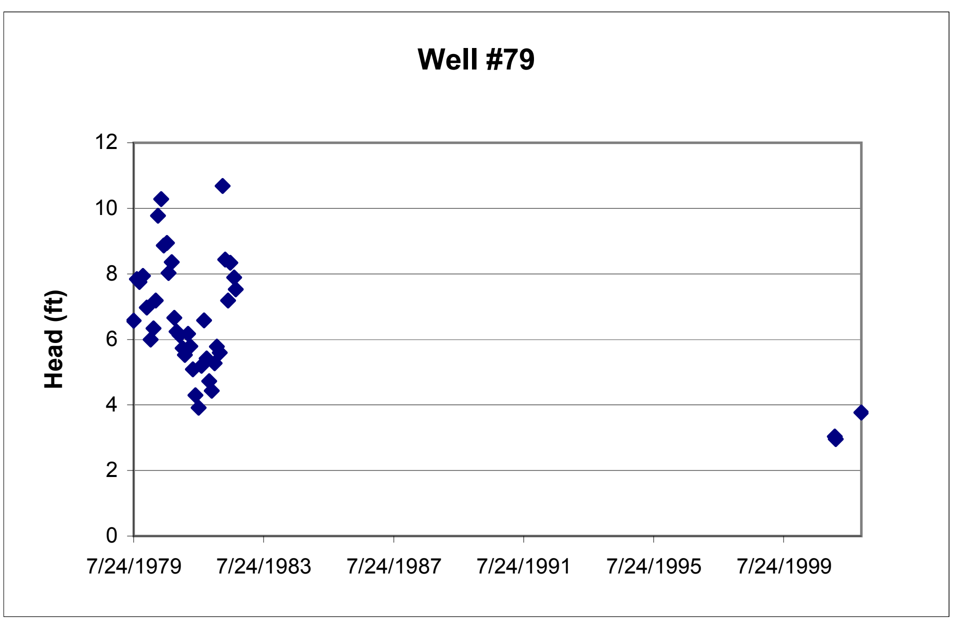
Well #71
Head (ft)
10
9
8
7
6
5
4
3
2
1
0
4/29/2002
10/29/2002
4/29/2003
10/29/2003
4/29/2004

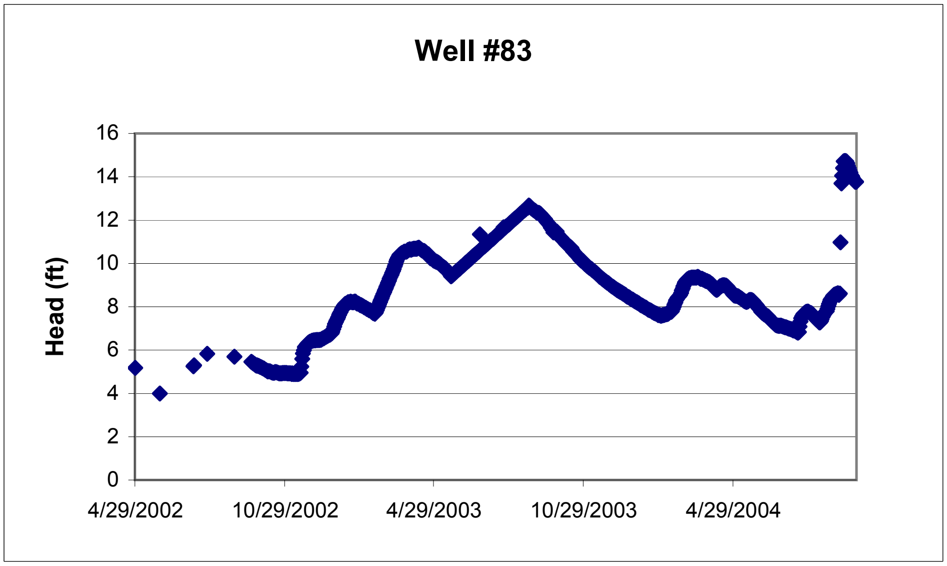


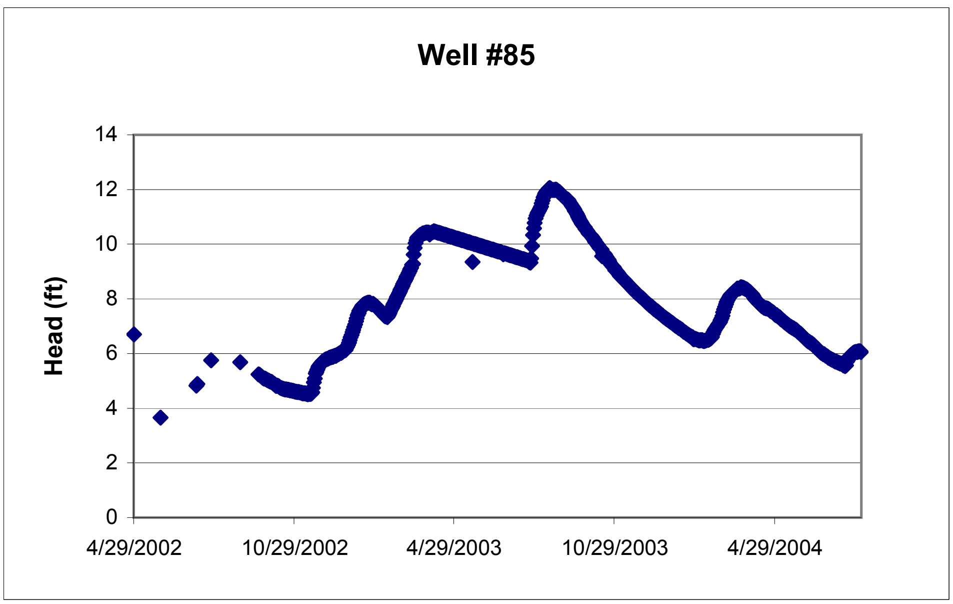
Well #72
Head (ft)
9
8
7
6
5
4
3
2
1
0
-1
-2
9/9/1981
9/9/1982
9/9/1983
9/9/1984
9/9/1985
9/9/1986

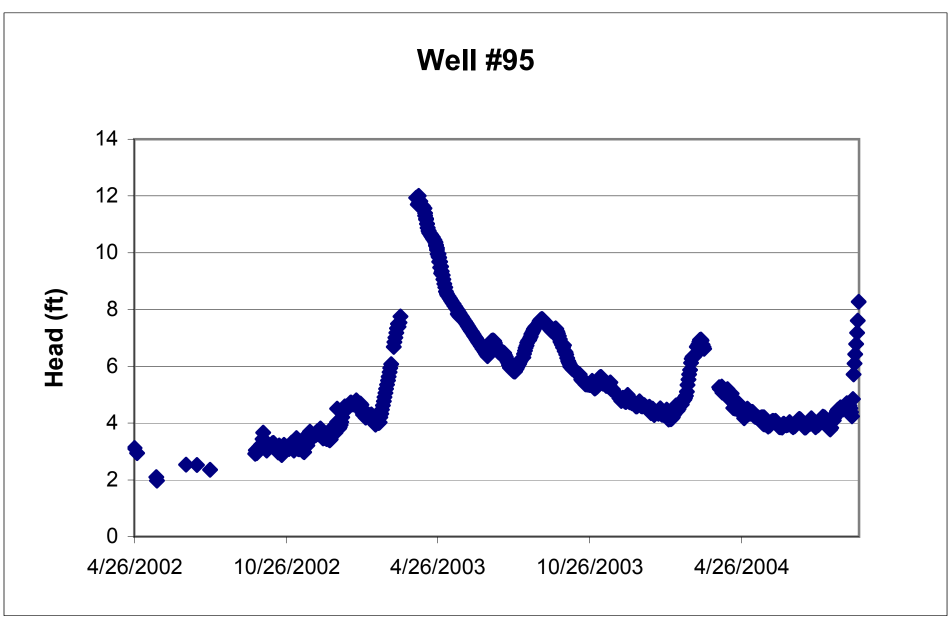

Well #74
Head (ft)
14
12
10
8
6
4
2
0
10/1/1981
10/1/1985
10/1/1989
10/1/1993
10/1/1997
10/1/2001

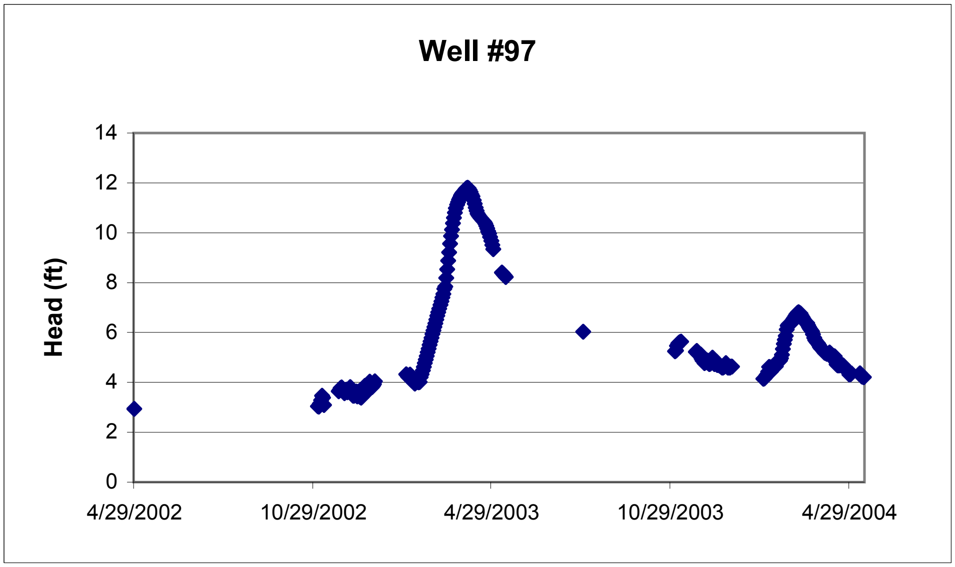

Well #76
Head (ft)
14
12
10
8
6
4
2
0
6/27/2002
12/27/2002
6/27/2003
12/27/2003
6/27/2004

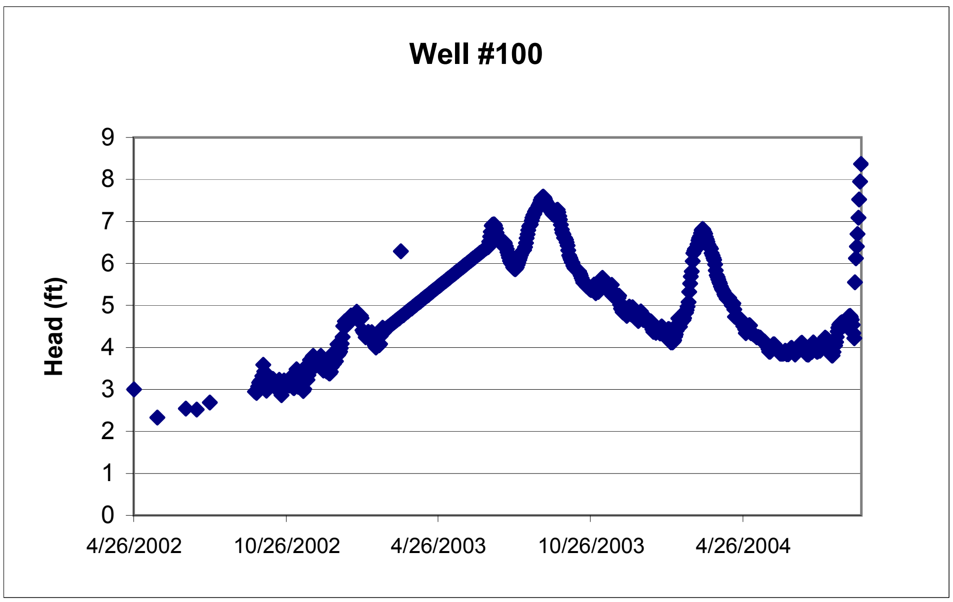

Well #79
Head (ft)
12
10
8
6
4
2
0
7/24/1979
7/24/1983
7/24/1987
7/24/1991
7/24/1995
7/24/1999

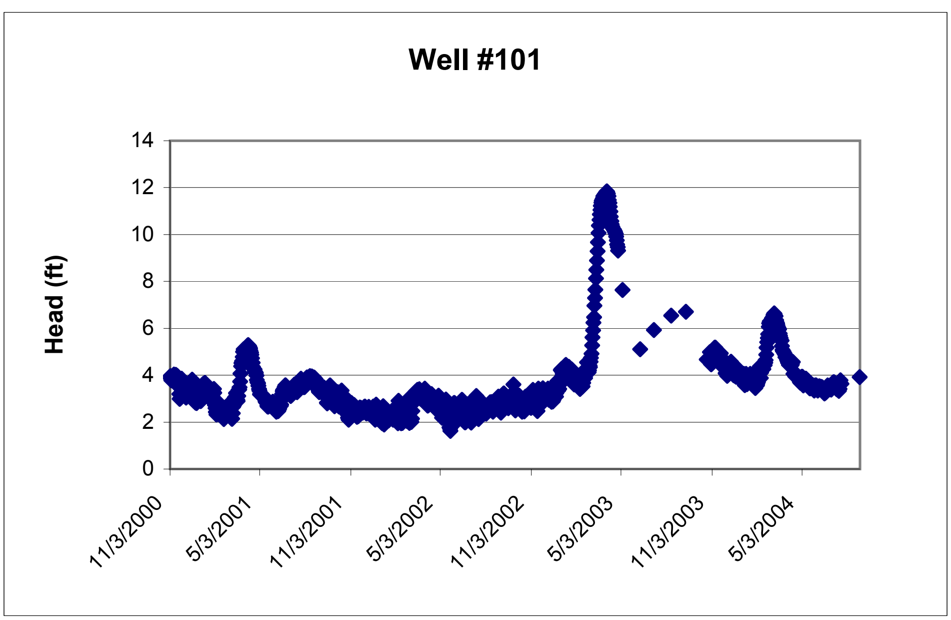

Well #83
Head (ft)
16
14
12
10
8
6
4
2
0
4/29/2002
10/29/2002
4/29/2003
10/29/2003
4/29/2004

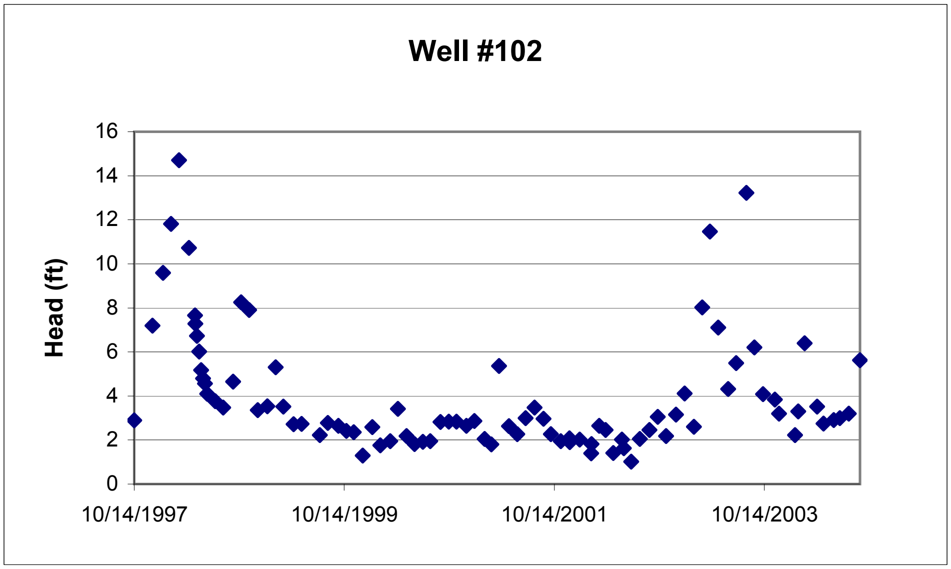

Well #85
Head (ft)
14
12
10
8
6
4
2
0
4/29/2002
10/29/2002
4/29/2003
10/29/2003
4/29/2004

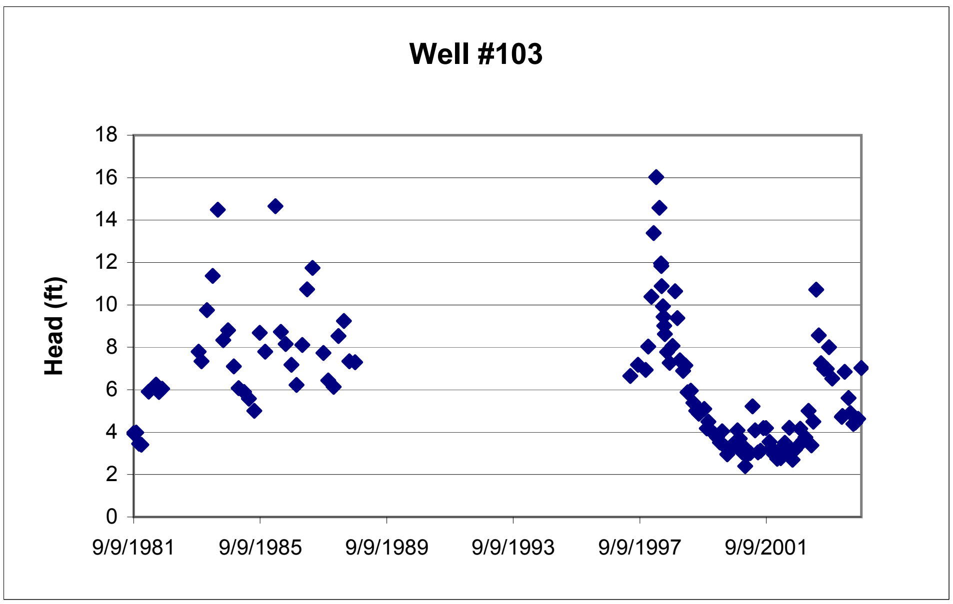

Well #95
Head (ft)
14
12
10
8
6
4
2
0
4/26/2002
10/26/2002
4/26/2003
10/26/2003
4/26/2004

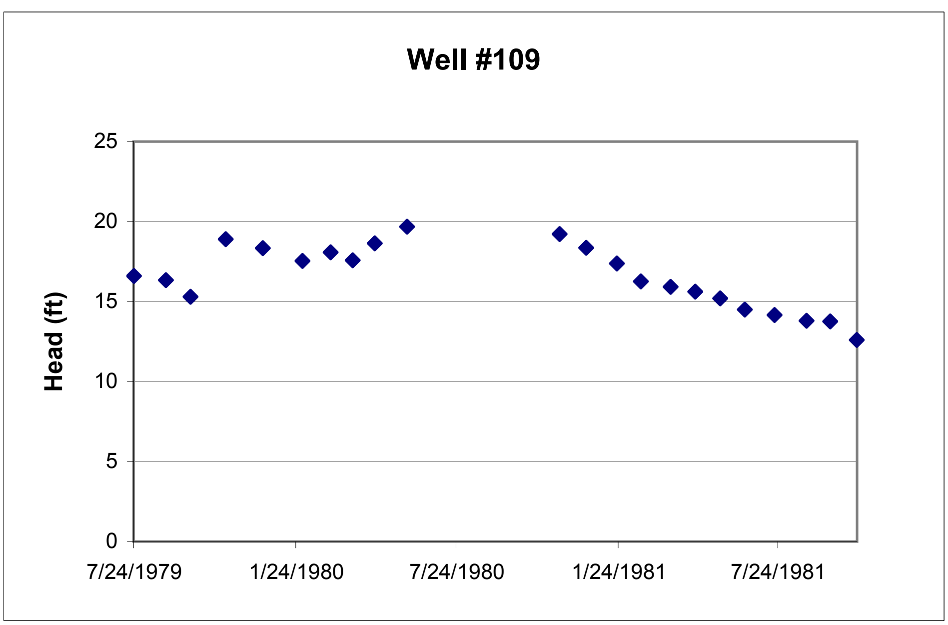

Well #97
Head (ft)
0
2
4
6
8
10
12
14
4/29/2002
10/29/2002
4/29/2003
10/29/2003
4/29/2004

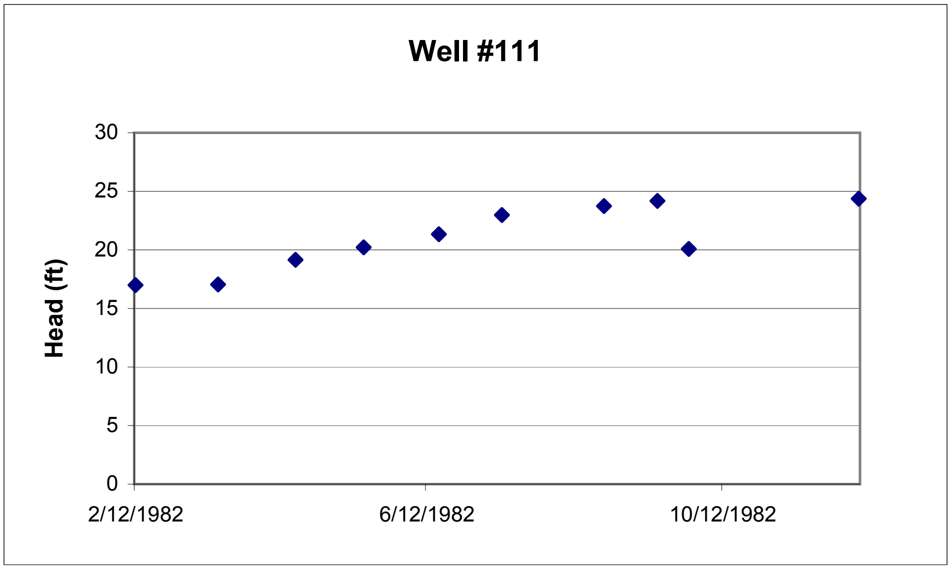

Well #100
Head (ft)
0
1
2
3
4
5
6
7
8
9
4/26/2002
10/26/2002
4/26/2003
10/26/2003
4/26/2004

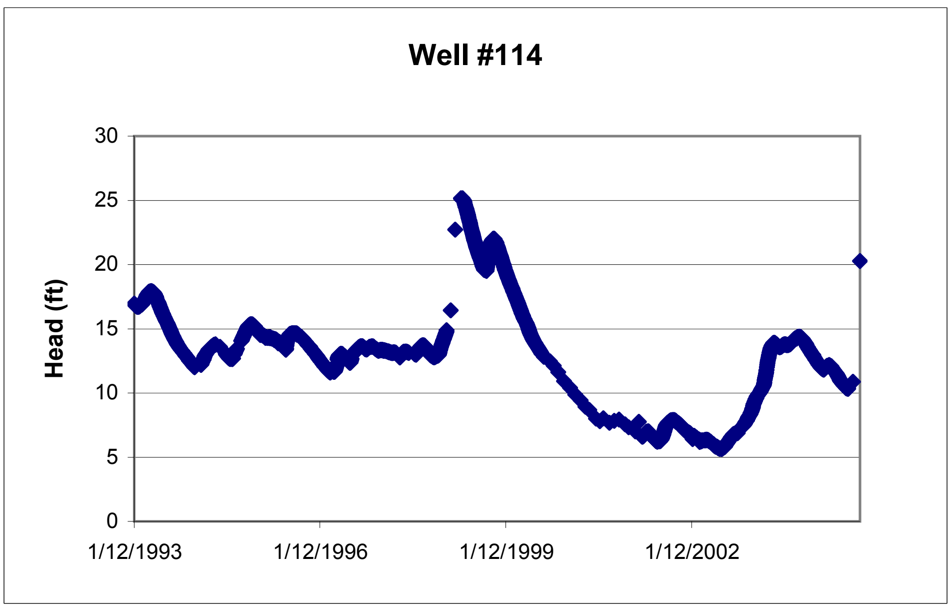

Well #101
Head (ft)
0
2
4
6
8
10
12
14
11/3/2000
5/3/2001
11/3/2001
5/3/2002
11/3/2002
5/3/2003
11/3/2003
5/3/2004

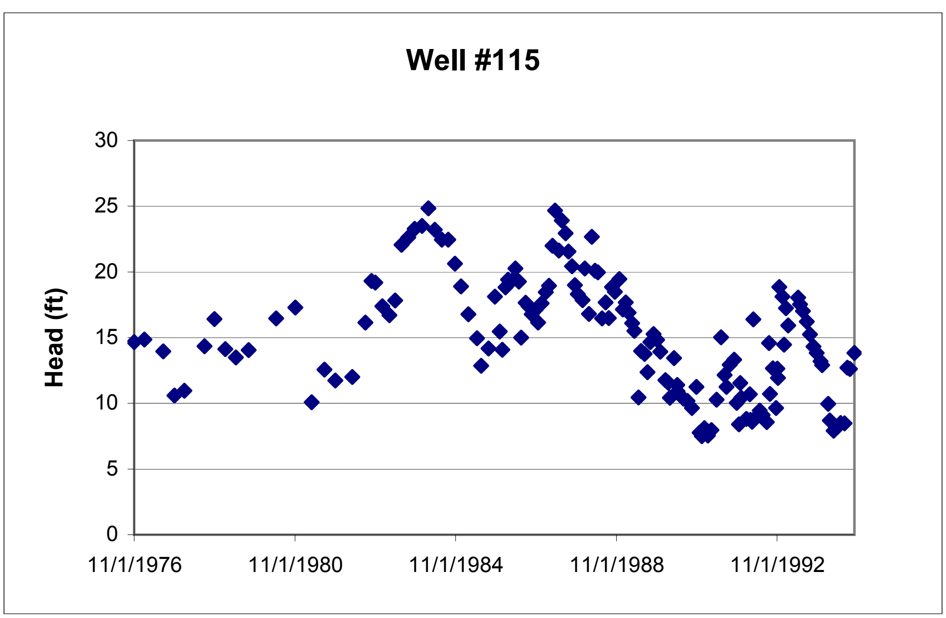

Well #102
Head (ft)
16
14
12
10
8
6
4
2
0
10/14/1997
10/14/1999
10/14/2001
10/14/2003

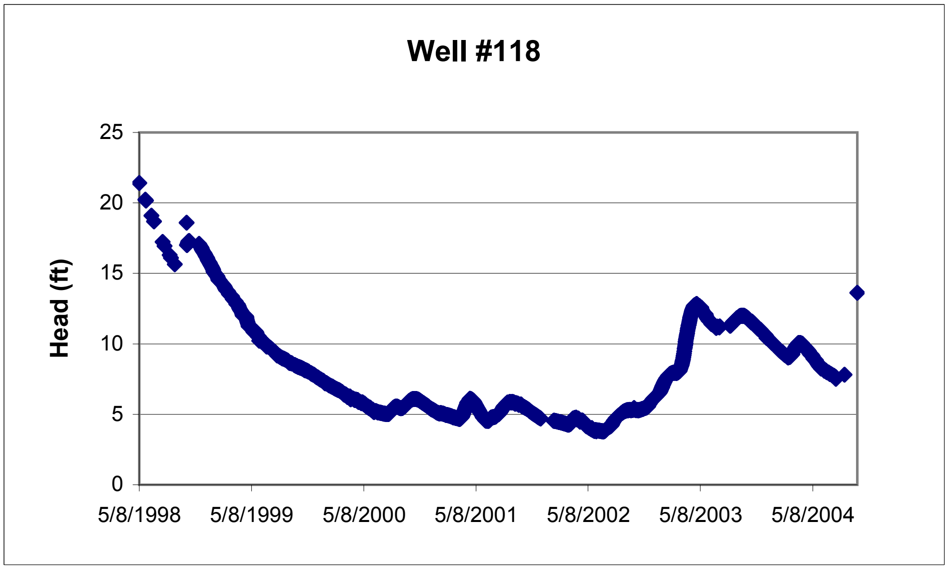

Well #103
Head (ft)
18
16
14
12
10
8
6
4
2
0
9/9/1981
9/9/1985
9/9/1989
9/9/1993
9/9/1997
9/9/2001

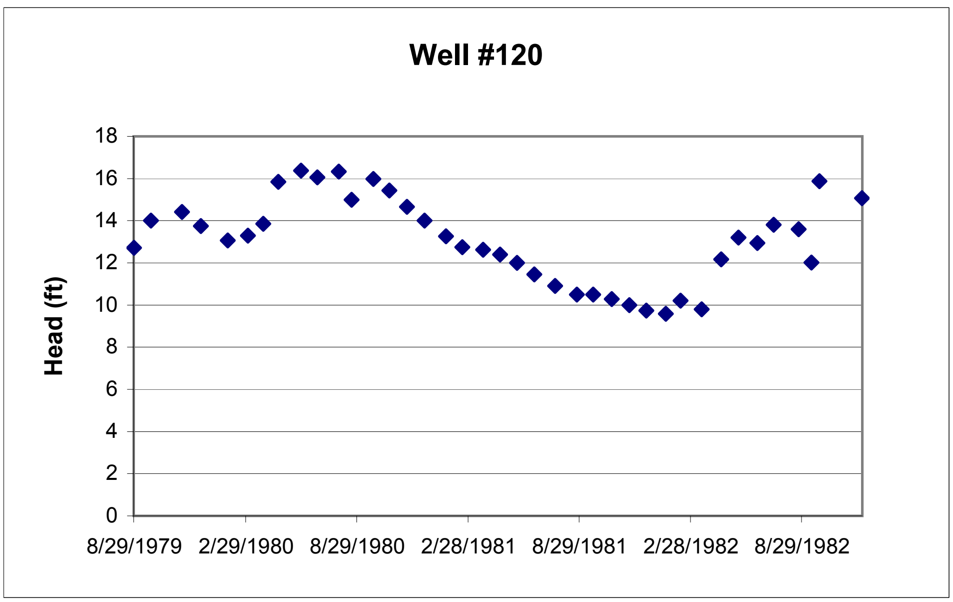

Well #109
Head (ft)
25
20
15
10
5
0
7/24/1979
1/24/1980
7/24/1980
1/24/1981
7/24/1981

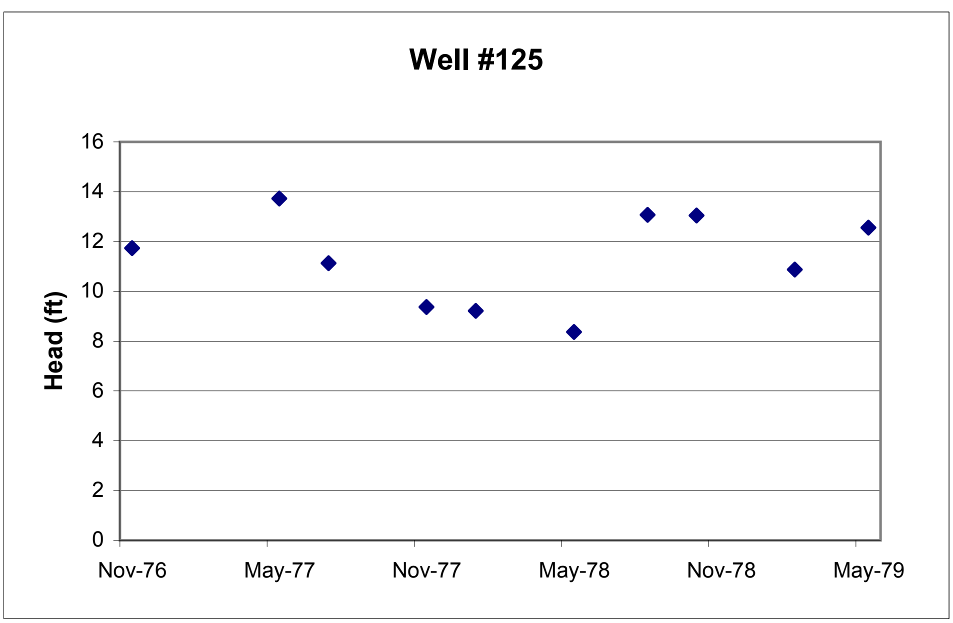

Well #111
Head (ft)
30
25
20
15
10
5
0
2/12/1982
6/12/1982
10/12/1982

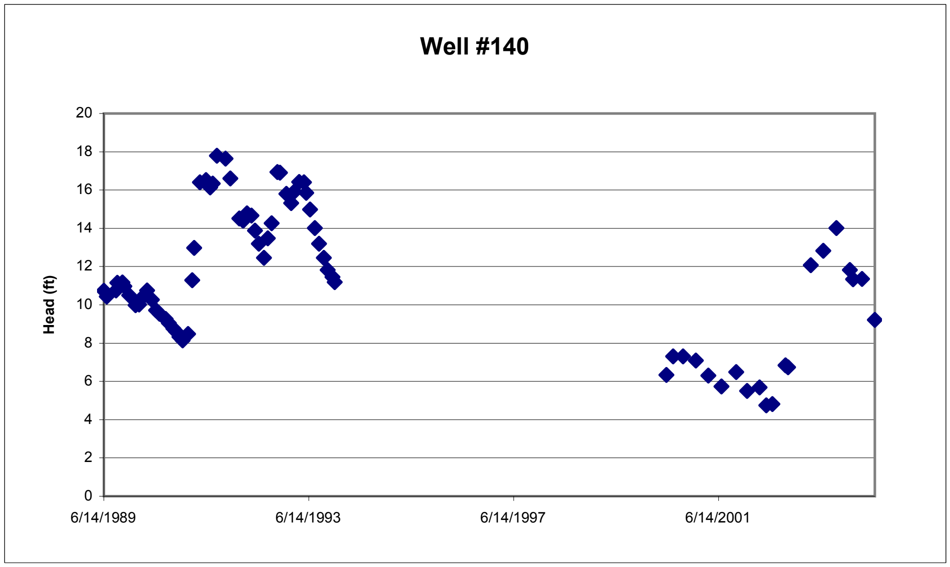

Well #114
Head (ft)
30
25
20
15
10
5
0
1/12/1993
1/12/1996
1/12/1999
1/12/2002

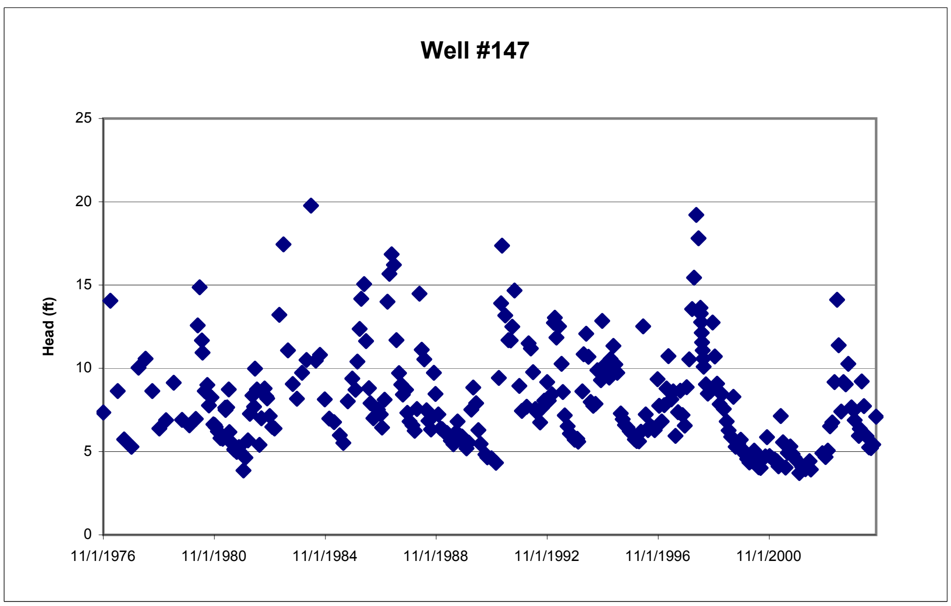

Well #115
Head (ft)
30
25
20
15
10
5
0
11/1/1976
11/1/1980
11/1/1984
11/1/1988
11/1/1992


Well #118
Head (ft)
25
20
15
10
5
0
5/8/1998
5/8/1999
5/8/2000
5/8/2001
5/8/2002
5/8/2003
5/8/2004


Well #120
Head (ft)
18
16
14
12
10
8
6
4
2
0
8/29/1979
2/29/1980
8/29/1980
2/28/1981
8/29/1981
2/28/1982
8/29/1982


Well #125
Head (ft)
16
14
12
10
8
6
4
2
0
Nov-76
May-77
Nov-77
May-78
Nov-78
May-79


Well #140
Head (ft)
20
18
16
14
12
10
8
6
4
2
0
6/14/1989
6/14/1993
6/14/1997
6/14/2001


Well #147
Head (ft)
25
20
15
10
5
0
11/1/1976
11/1/1980
11/1/1984
11/1/1988
11/1/1992
11/1/1996
11/1/2000

Appendix E - Ground \

Well #	Site ID	Date	Head (ft)
9	-121519001	5/21/2002	8.4
		10/3/2002	9.93
		1/28/2004	12.94
12	-121506002	12/12/2001	12.23
		5/25/2002	8.66
		10/3/2002	10.95
		1/28/2004	15.28
14	-121436002	9/30/2003	13.65
		1/28/2004	9.94
16	-121428004	12/17/2003	12.34
		1/28/2004	11.25
17	-121424006	3/5/2002	6.28
		5/28/2002	5.23
		10/3/2002	7.15
		1/28/2004	9.89
18	-121423007	3/5/2002	5.55
		6/5/2002	4.3
		10/3/2002	6.35
		1/28/2004	9.17
19	-121422002	3/6/2002	5.34
		5/21/2002	4.5
		10/3/2002	6.29
		1/28/2004	8.8
22	-121418002	6/22/1982	11.77
		9/27/1982	12.23
		12/6/1982	9.89
23	-121415003	3/6/2002	6.95
		5/21/2002	5.72
		10/3/2002	7.51
		1/28/2004	10.56
24	-121410003	5/28/2002	5.17
		10/3/2002	6.66
		3/27/2003	11.09
		1/28/2004	9.64
25	-121410001	6/22/1982	13.47
		9/27/1982	13.35
		12/6/1982	11.82
		2/28/2002	5.94
		5/28/2002	4.88
		3/27/2003	10.96
26	-121402003	2/28/2002	7.27
		5/21/2002	6.32
		10/3/2002	7.75
		1/28/2004	11.45
29	-121324001	3/7/2002	9.08
		5/16/2002	7.85
		10/3/2002	11.26
		1/28/2004	12.01

Well #	Site ID	Date	Head (ft)
31	-121302011	2/21/2003	3.49
		1/28/2004	4.47
		3/11/2004	6.23
32	-121302010	2/21/2003	5.52
		1/28/2004	4.49
		3/11/2004	6.23
39	-111506010	3/8/2002	5.87
		5/28/2002	5.2
		10/4/2002	6.56
		1/29/2004	11.44
40	-111506001	6/23/1981	10.83
		3/30/1982	9.45
		6/25/1982	13.55
		9/29/1982	14.22
		12/8/1982	14.49
41	-111503011	3/6/2002	11.93
		5/16/2002	10.9
		10/4/2002	12.45
		1/29/2004	18.23
44	-111435007	12/19/2001	9.02
		2/15/2002	8.09
		5/16/2002	7.03
		10/3/2002	8.61
		1/29/2004	12.59
45	-111434010	2/22/2002	8.03
		5/24/2002	6.9
		10/3/2002	8.48
		1/29/2004	12.67
46	-111431006	3/5/2002	3.59
		5/31/2002	2.89
		10/3/2002	4.08
47	-111430015	5/31/2002	1.56
		10/3/2002	2.77
		1/29/2004	4.72
48	-111430014	1/19/2001	3.29
		2/12/2002	2.75
		5/24/2002	2.2
		10/3/2002	3.63
		1/29/2004	4.29
49	-111429006	12/19/2001	3.88
		2/12/2002	3.3
		5/15/2002	2.94
		10/3/2002	4.09
		1/29/2004	5.21
50	-111429005	2/21/2002	4.76
		5/23/2002	3.81
		10/3/2002	5.52
		1/29/2004	7.71

Well #	Site ID	Date	Head (ft)
51	-111428007	2/21/2002	6.11
		5/15/2002	5.37
		10/3/2002	6.81
		1/29/2004	10.13
52	-111426010	12/11/2001	9.4
		2/13/2002	8.31
		5/16/2002	7.37
		10/3/2002	8.6
		1/28/2004	12.8
54	-111425012	4/25/2001	15.69
		12/4/2001	9.78
		3/19/2002	8.26
		5/15/2002	7.48
		10/3/2002	9.07
		5/20/2003	13.3
		1/28/2004	13.41
56	-111423013	4/27/2001	5.51
		12/4/2001	9.23
		3/19/2002	5.84
		5/15/2002	7.14
		10/3/2002	7.78
		5/20/2003	14.04
		1/29/2004	12.82
		4/7/2004	12.87
57	-111421001	3/11/2002	5.88
		5/21/2002	5.05
		10/3/2002	6.64
		1/29/2004	9.93
58	-111417003	3/5/2002	5.54
		5/21/2002	4.91
		10/3/2002	6.36
		1/29/2004	9.62
59	-111415002	3/11/2002	6.01
		5/13/2002	5.6
		10/3/2002	6.7
		1/29/2004	10.27
60	-111414008	2/22/2002	6.6
		5/7/2002	5.65
		10/3/2002	7.34
		1/29/2004	11.32
61	-111413007	2/27/2002	7.56
		5/7/2002	5.76
		10/3/2002	8.38
		1/29/2004	12.84
62	-111410024	2/22/2002	5.43
		5/7/2002	3.17
		10/3/2002	5.76
		1/29/2004	9.49

Well #	Site ID	Date	Head (ft)
63	-111408002	3/11/2002	5.08
		5/7/2002	4.77
		10/3/2002	5.65
		1/29/2004	8.56
65	-111403008	3/6/2002	5.29
		5/7/2002	5.08
		10/4/2002	5.94
		1/29/2004	9.34
66	-111336005	1/28/2004	2.32
		3/11/2004	4.76
67	-111336004	1/28/2004	2.35
		3/11/2004	4.81
		4/30/2004	2.53
68	-111336003	4/29/2002	3.09
		5/29/2002	1.71
		5/30/2002	1.75
		10/3/2002	2.45
		1/28/2004	2.53
69	-111336002	4/29/2002	2.16
		5/29/2002	1.95
		5/30/2002	2.01
		10/3/2002	2.76
		1/28/2004	2.17
70	-111335006	1/28/2004	1.73
73	-111326008	2/15/2000	1.23
		2/27/2002	1.46
		5/29/2002	1.33
		10/3/2002	1.85
75	-111325018	4/29/2002	3.57
		5/29/2002	2.5
		8/28/2002	4.52
		10/3/2002	3.91
		1/28/2004	4.49
77	-111325016	2/15/2001	3.04
		2/27/2001	2.86
		2/12/2002	3.29
		5/29/2002	2.61
78	-111325008	12/13/2000	3.67
		2/15/2001	2.96
		5/29/2002	2.52
		10/3/2002	3.84
		1/28/2004	4.48
80	-111324033	5/15/2002	1.91
81	-111324030	5/23/2002	3
		6/26/2002	2.74

Well #	Site ID	Date	Head (ft)
82	-111324029	4/29/2002	5.61
		5/24/2002	5.65
		7/9/2002	3.94
		8/28/2002	5.03
		10/3/2002	4.54
		1/27/2004	5.78
		1/28/2004	6.7
84	-111324027	4/29/2002	5.73
		5/29/2002	3.87
		8/28/2002	5.95
		10/3/2002	5.17
		1/28/2004	6.09
		3/16/2004	8.98
86	-111312001	4/1/2003	10.25
		1/29/2004	6.93
		4/7/2004	6.7
89	-101528013	3/6/2002	6.44
		5/16/2002	6.04
		10/4/2002	7.17
		1/29/2004	12.11
91	-101435008	12/18/2001	5.87
		2/13/2002	5.33
		5/7/2002	5.02
		10/4/2002	5.77
		1/29/2004	9.54
92	-101435007	12/18/2001	5.83
		2/6/2002	5.41
		5/7/2002	5.6
		10/4/2002	5.94
		1/29/2004	9.9
93	-101433012	12/18/2001	3.32
		5/20/2002	2.77
		10/4/2002	3.68
		1/29/2004	5.35
94	-101432001	3/22/2002	3.88
		4/16/2002	3.7
		5/15/2002	3.13
		10/4/2002	3.83
		1/29/2004	6.53
		4/30/2004	5.99
96	-101429024	4/26/2002	3.04
		5/23/2002	2.46
		6/27/2002	2.58
		10/4/2002	3.27
		1/22/2004	4.5
		1/29/2004	4.32

Well #	Site ID	Date	Head (ft)
98	-101429022	4/26/2002	3.21
		5/22/2002	2.15
		6/27/2002	2.83
		10/4/2002	3.4
		1/22/2004	4.43
		1/29/2004	4.15
99	-101429021	4/26/2002	2.95
		5/22/2002	2.01
		6/27/2002	2.57
		10/4/2002	3.21
		1/26/2004	4.48
		1/29/2004	4.17
104	-101427005	12/18/2001	3.52
		2/13/2002	3.14
		5/14/2002	3.13
		10/4/2002	3.94
		1/29/2004	5.94
105	-101426007	12/18/2001	4.4
		2/13/2002	4.04
		5/6/2002	3.87
		10/4/2002	4.76
106	-101425008	1/31/2001	5.98
		3/19/2002	4.06
		5/7/2002	3.35
		10/4/2002	6.13
		12/10/2002	6.37
		1/29/2004	10.63
		4/1/2004	10.63
107	-101420026	12/6/2001	3.57
		8/2/2002	3.96
		10/14/2002	4.08
		1/29/2004	4.19
110	-101522006	3/14/2002	7.94
		5/17/2002	7.67
		10/4/2002	8.31
		1/28/2004	14.43
112	-101520004	3/14/2002	7.37
		5/17/2002	7.09
		10/4/2002	8.01
		1/28/2004	13.15
117	-101508002	3/29/1982	16.21
		6/30/1982	16.8
		9/29/1982	24.56
		12/7/1982	20.89
		3/14/2002	6.87
		5/17/2002	6
		10/3/2002	7.23
		1/28/2004	14.52

Well #	Site ID	Date	Head (ft)
121	-101421003	3/12/2002	4.26
		5/15/2002	3.21
		10/4/2002	2.83
		1/28/2004	4.35
122	-101416006	3/13/2002	3.99
		5/31/2002	3.28
		10/4/2002	4.55
		1/28/2004	7.04
123	-101414001	3/21/2002	4.47
		5/20/2002	3.76
		10/4/2002	4.93
		1/28/2004	7.84
124	-101413010	3/21/2002	5.34
		5/20/2002	4.78
		10/4/2002	6.02
		1/28/2004	10.07
126	-101410005	3/13/2002	4.28
		5/20/2002	3.61
		10/4/2002	4.93
		1/28/2004	7.68
127	-101408003	3/12/2002	3.73
		5/17/2002	2.89
		10/4/2002	3.73
		1/28/2004	5.21
128	-101406001	3/21/1982	6.06
		6/24/1982	4.57
		9/27/1982	5.22
		12/6/1982	4.33
		7/23/2002	3.58
		10/4/2002	5.08
		1/29/2004	4.14
129	-101401002	3/13/2002	4.76
		5/17/2002	4.31
		10/4/2002	5.55
		1/28/2004	9.19
141	-91520001	9/8/1981	17.69
		3/22/1982	16.42
		6/24/1982	21.15
		9/27/1982	22.66
		12/6/1982	22.99
		3/25/2002	12.85
		5/20/2002	11.96
		10/4/2002	14.14

Well #	Site ID	Date	Head (ft)
142	-91506002	9/21/1981	21.85
		3/22/1982	19.72
		3/21/2002	9.94
		5/28/2002	9.38
		10/4/2002	12.18
		1/28/2004	16.71
145	-91436008	3/25/2002	4.88
		5/20/2002	4.21
		10/4/2002	5.38
		1/28/2004	8.78
146	-91436002	3/22/1982	15.41
		6/30/1982	16.44
		9/27/1982	19.32
		12/6/1982	18.37
148	-91415002	10/1/1981	14.39
		3/22/1982	15.14
		6/24/1982	18.22
		9/27/1982	17.43
		12/6/1982	18.06
		3/21/2002	5.45
		6/5/2002	4.58
		10/4/2002	6.23

Appendix E - Rainfall Data

Figure E-1 Trenton Tower Monthly Rainfall Totals

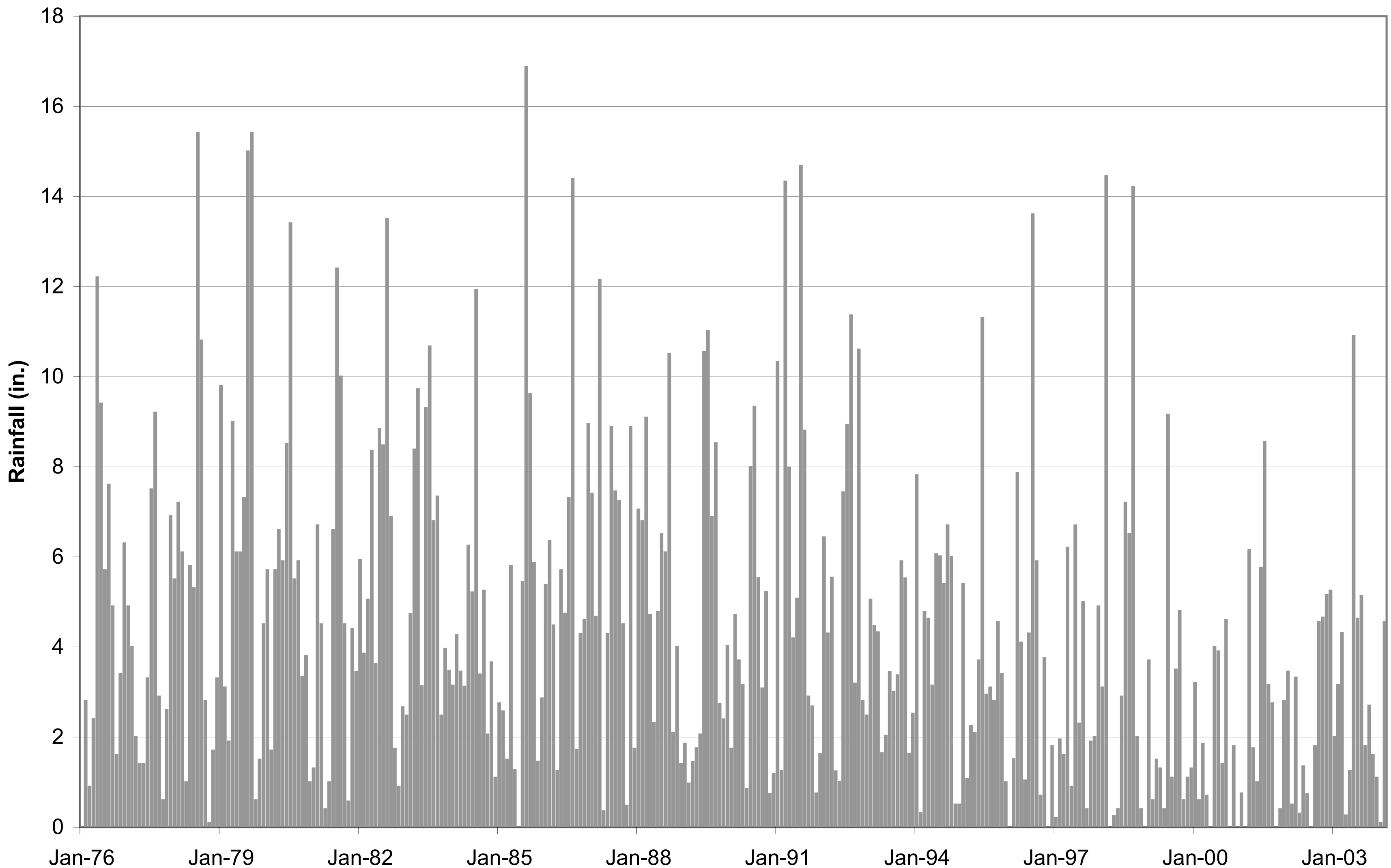


Figure E-2 Fanning Spring Monthly Rainfall Totals

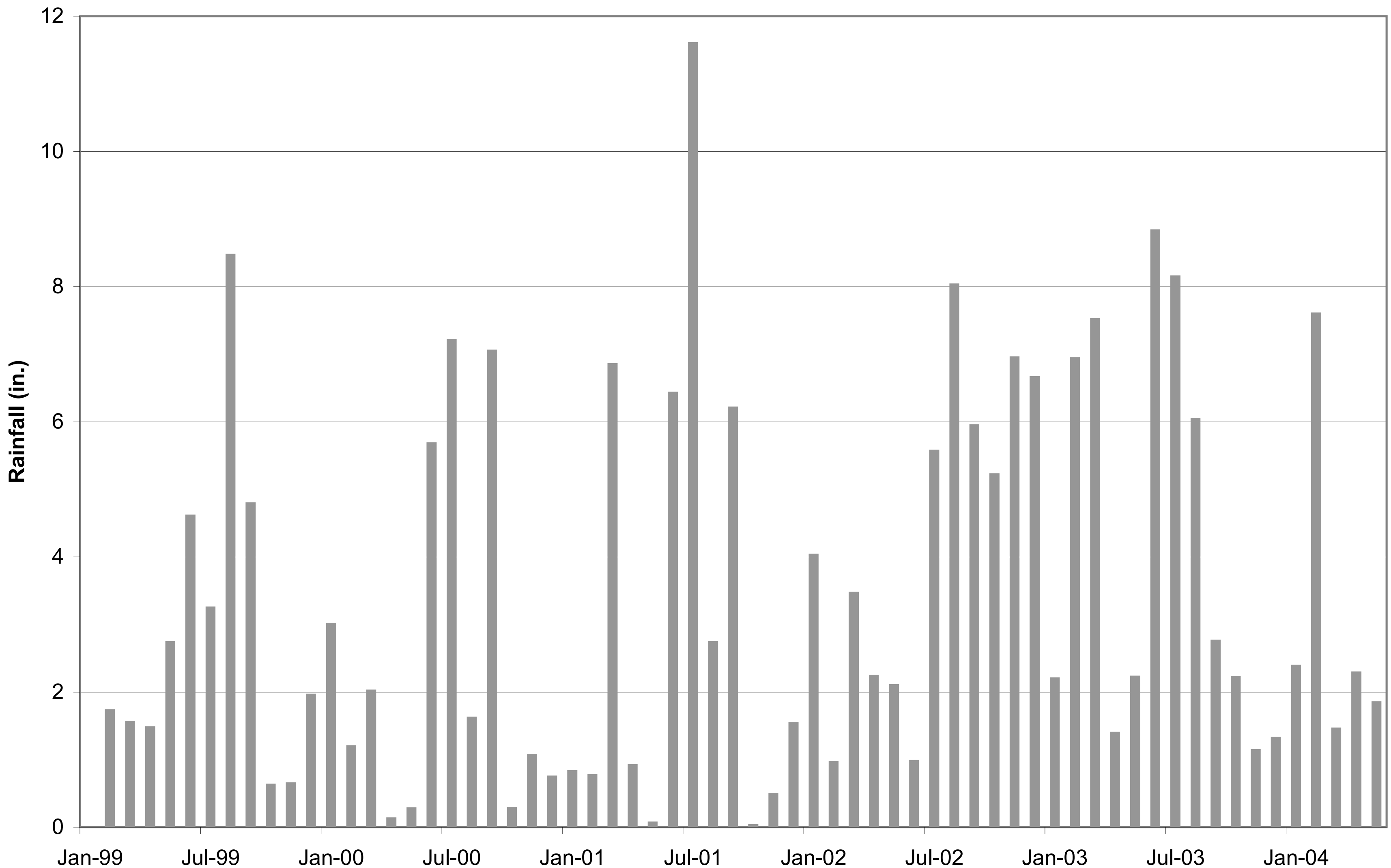
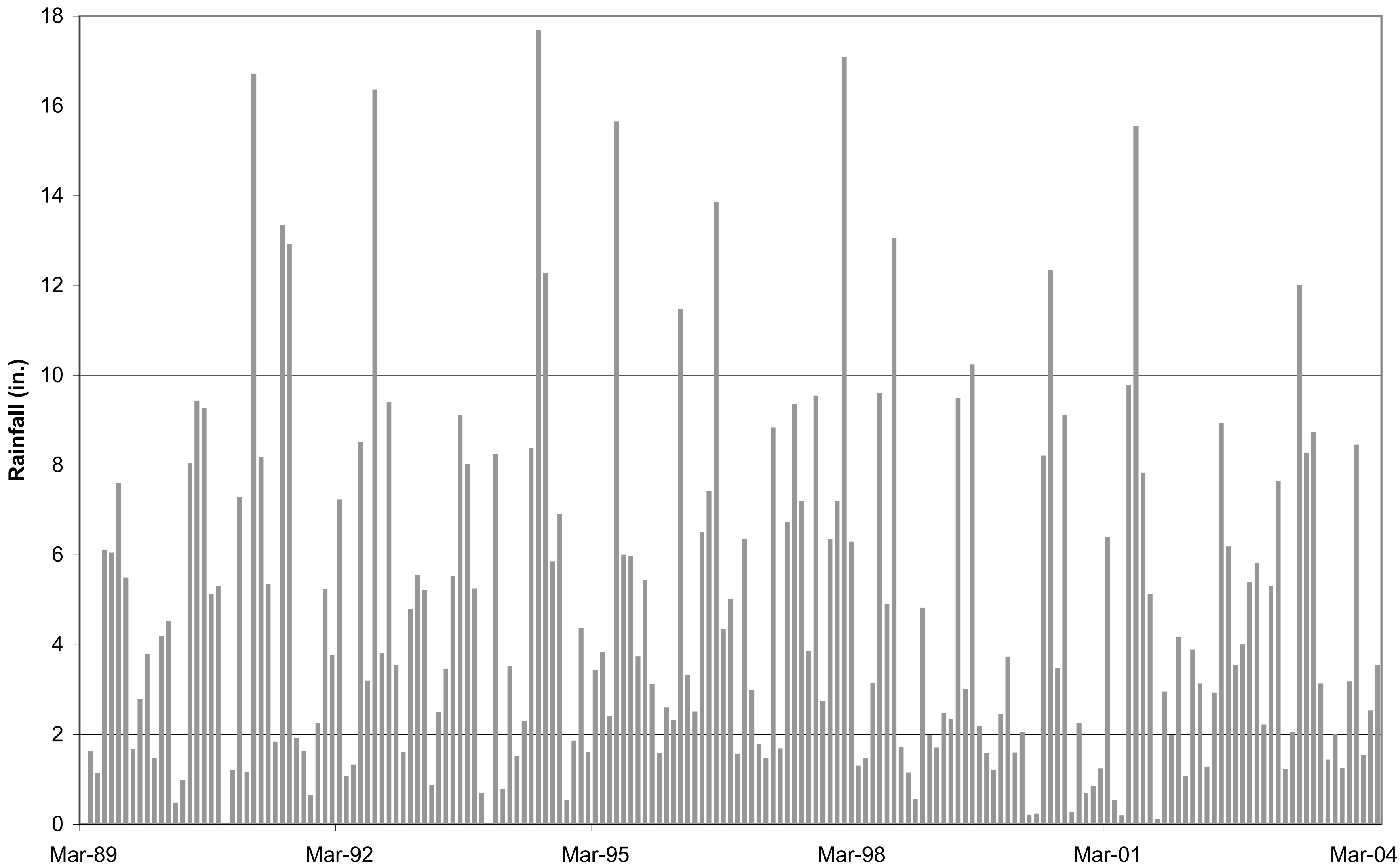


Figure E-3 Manatee Spring Monthly Rainfall Totals



Appendix F – Manatee Springs Thermal Plume Modeling Results

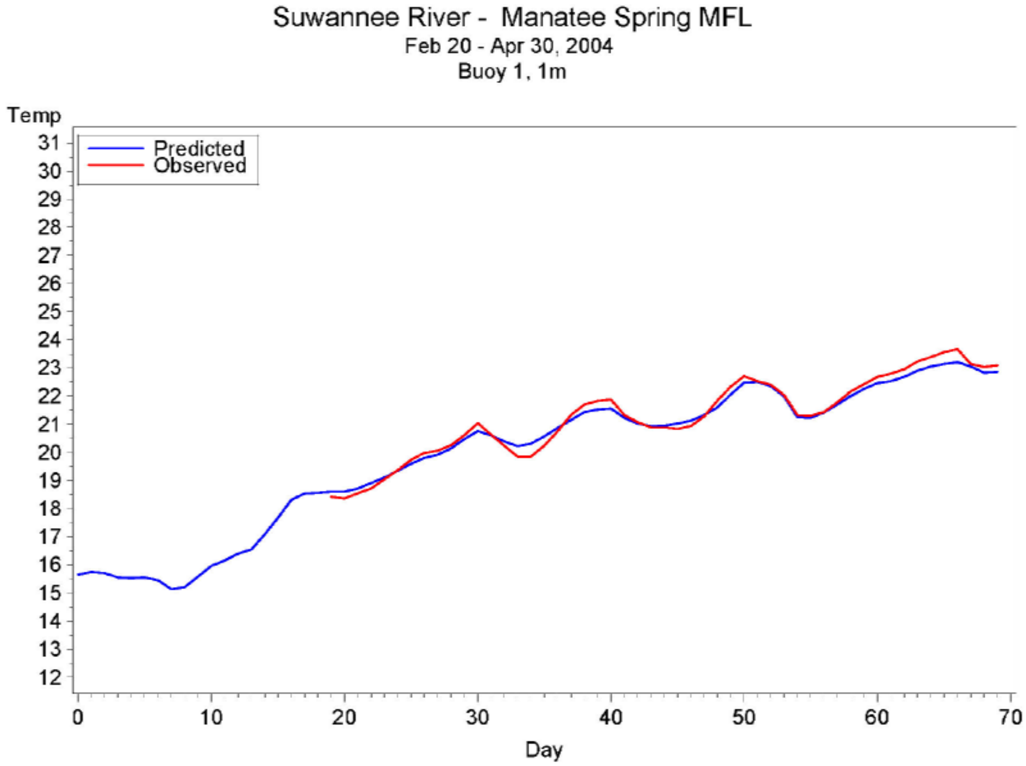


Figure F-1 Daily temperatures, predicted and observed, at Buoy 1, 1m, 2/20/04-4/30/04.

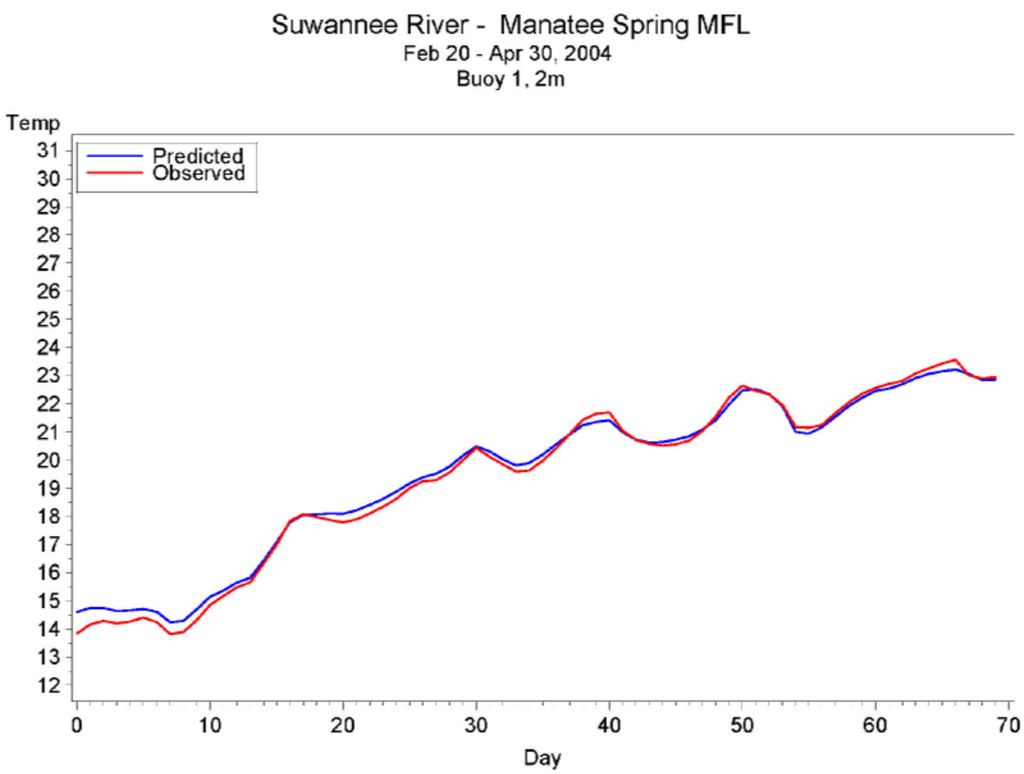


Figure F-2 Daily temperatures, predicted and observed, at Buoy 1, 2 m, 2/20/04-4/30/04.

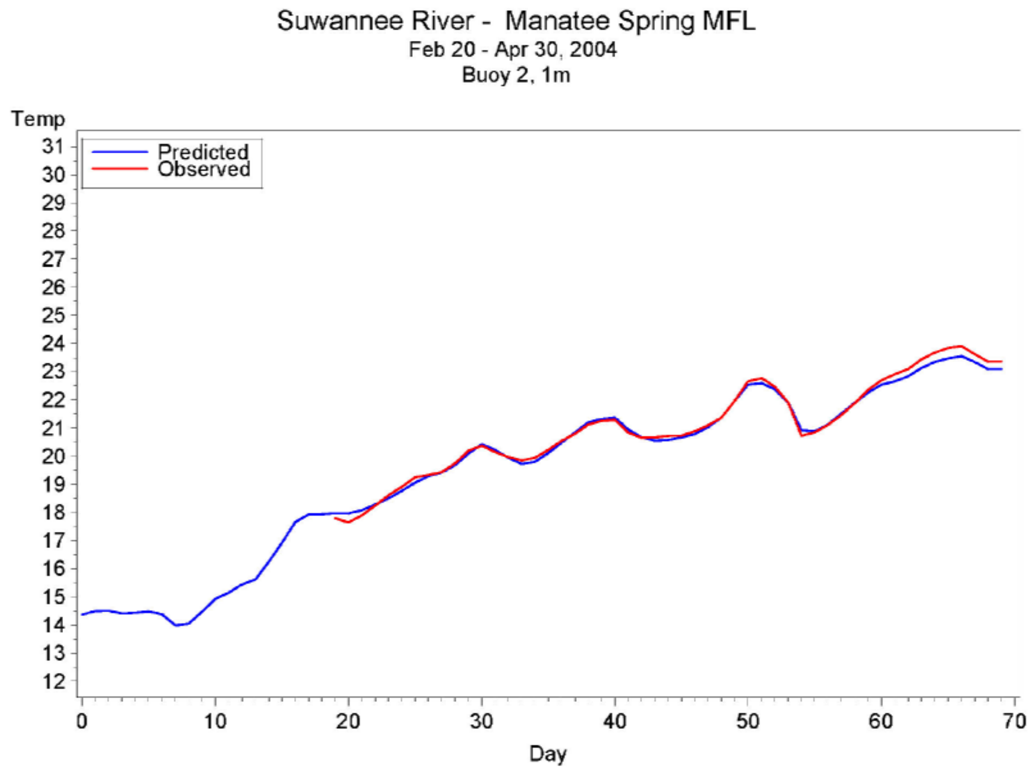


Figure F-3 Daily temperatures, predicted and observed, at Buoy 2, 1 m, 2/20/04-4/30/04.

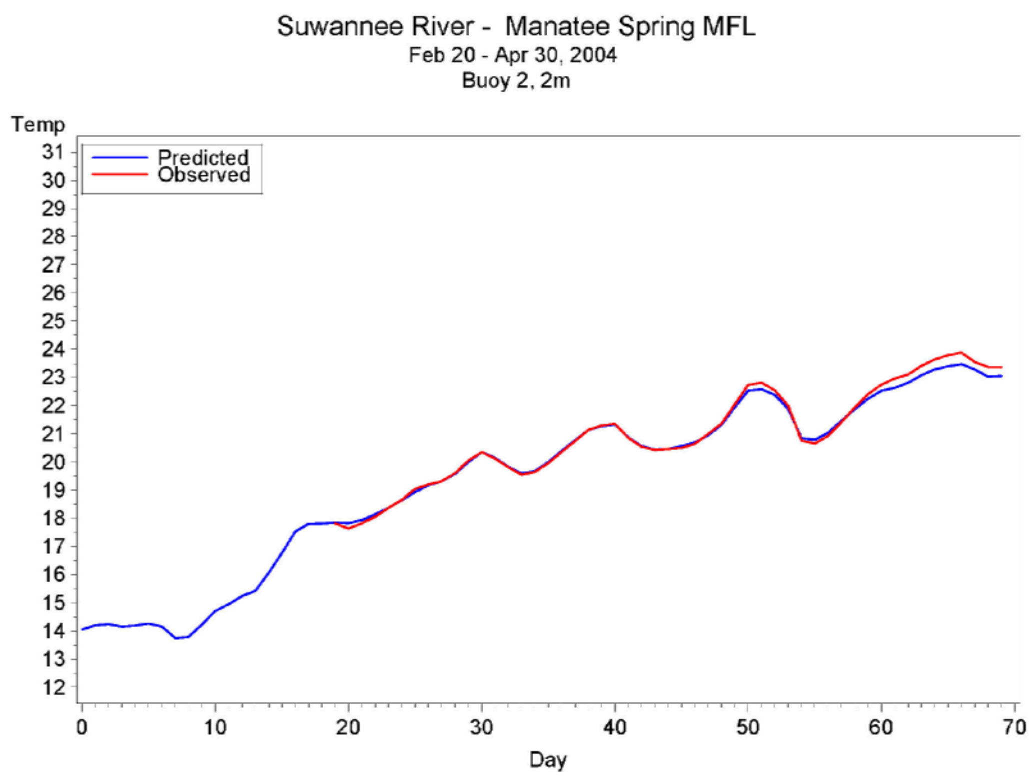


Figure F-4 Daily temperatures, predicted and observed, at Buoy 2, 2 m, 2/20/04-4/30/04.

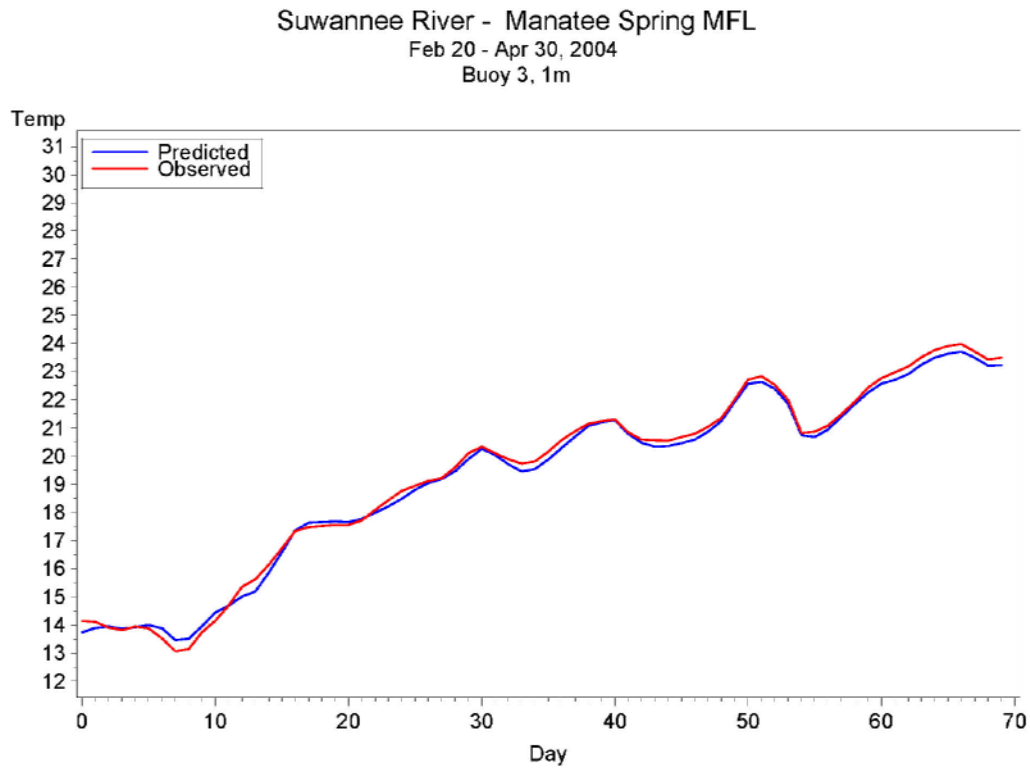


Figure F-5 Daily temperatures, predicted and observed, at Buoy 3, 1 m, 2/20/04-4/30/04.

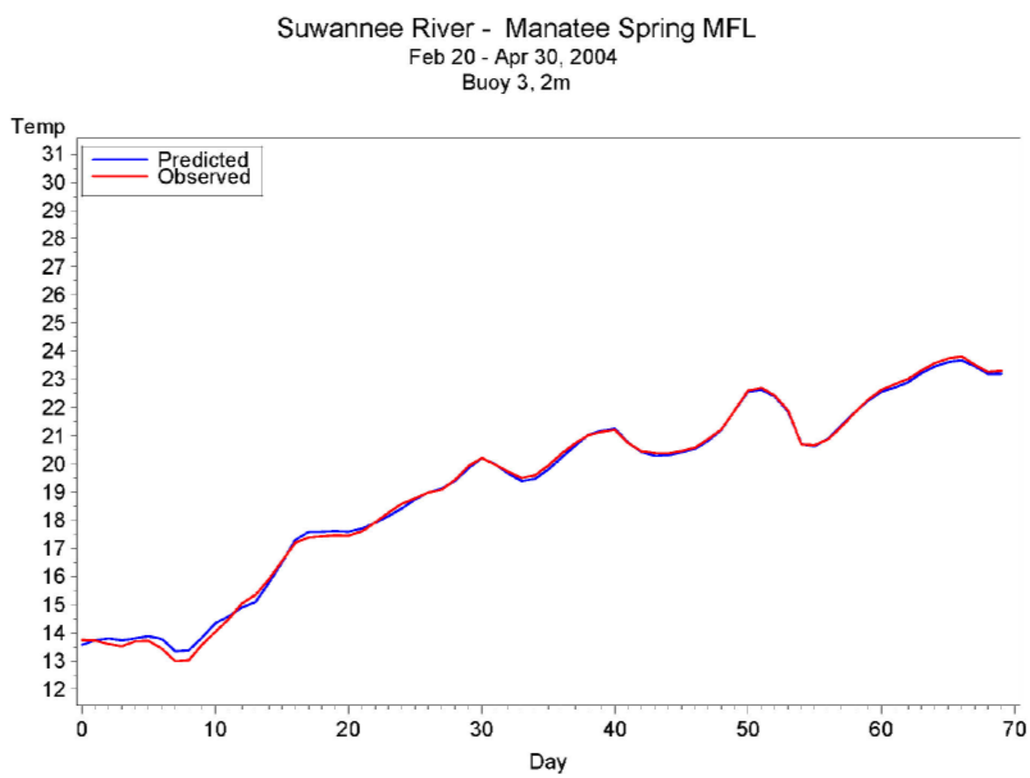


Figure F-6 Daily temperatures, predicted and observed, at Buoy 3, 2 m, 2/20/04-4/30/04.

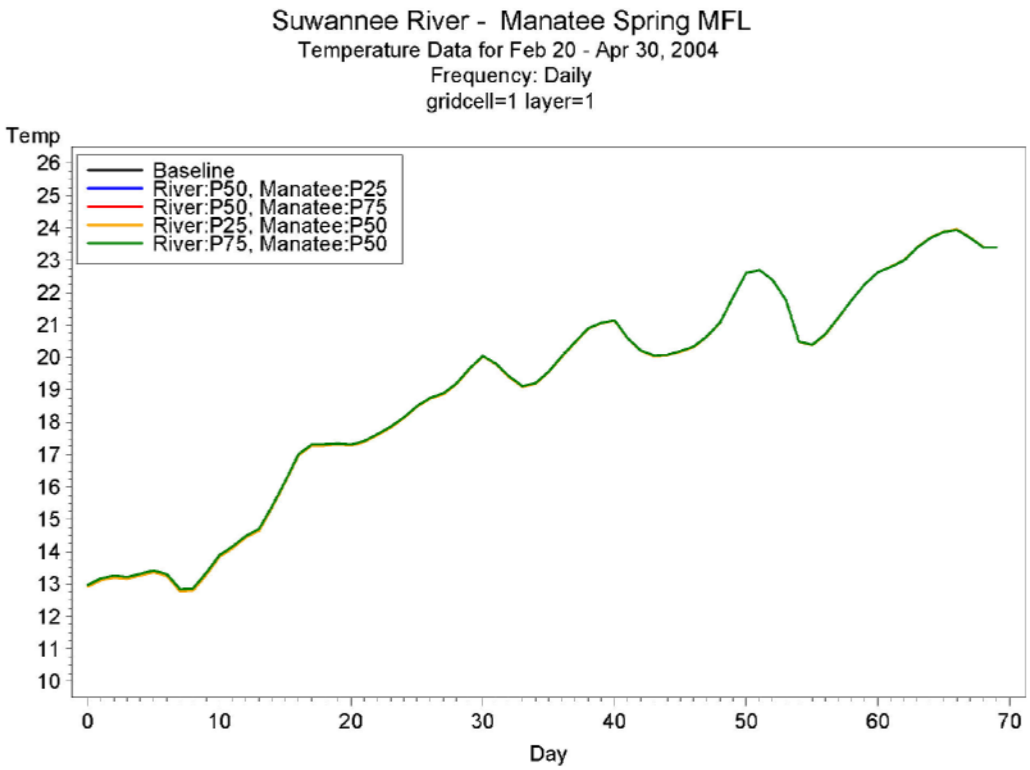


Figure F-7 Predicted daily temperatures, surface grid 1.

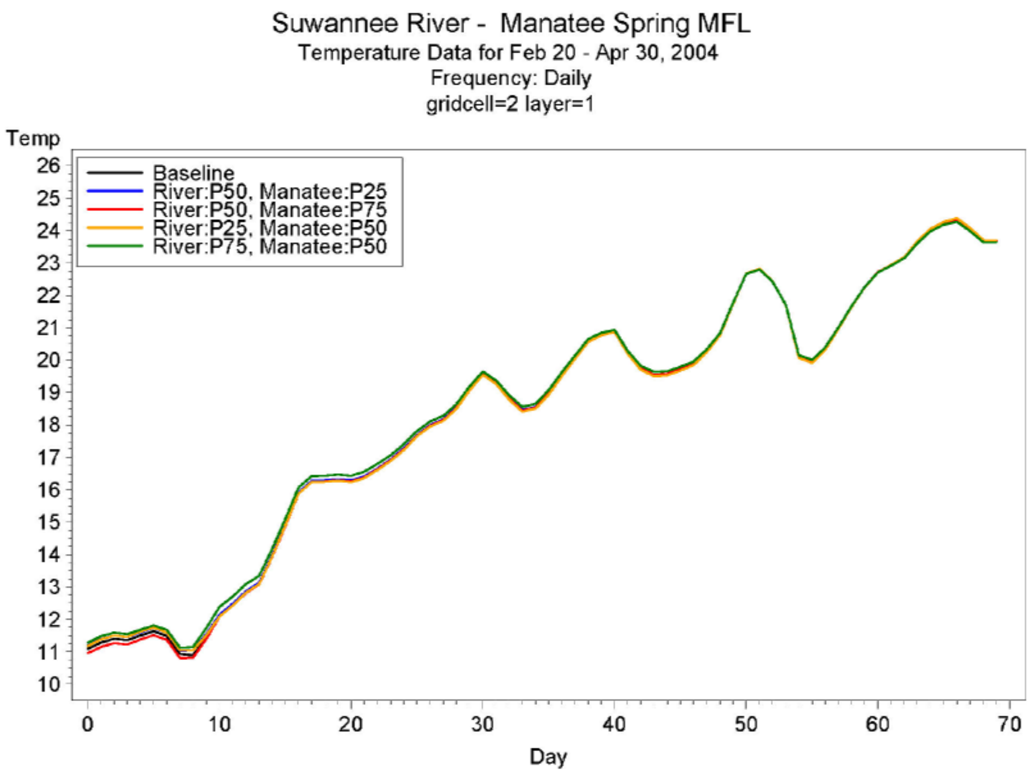


Figure F-8 Predicted daily temperatures, surface grid 2.

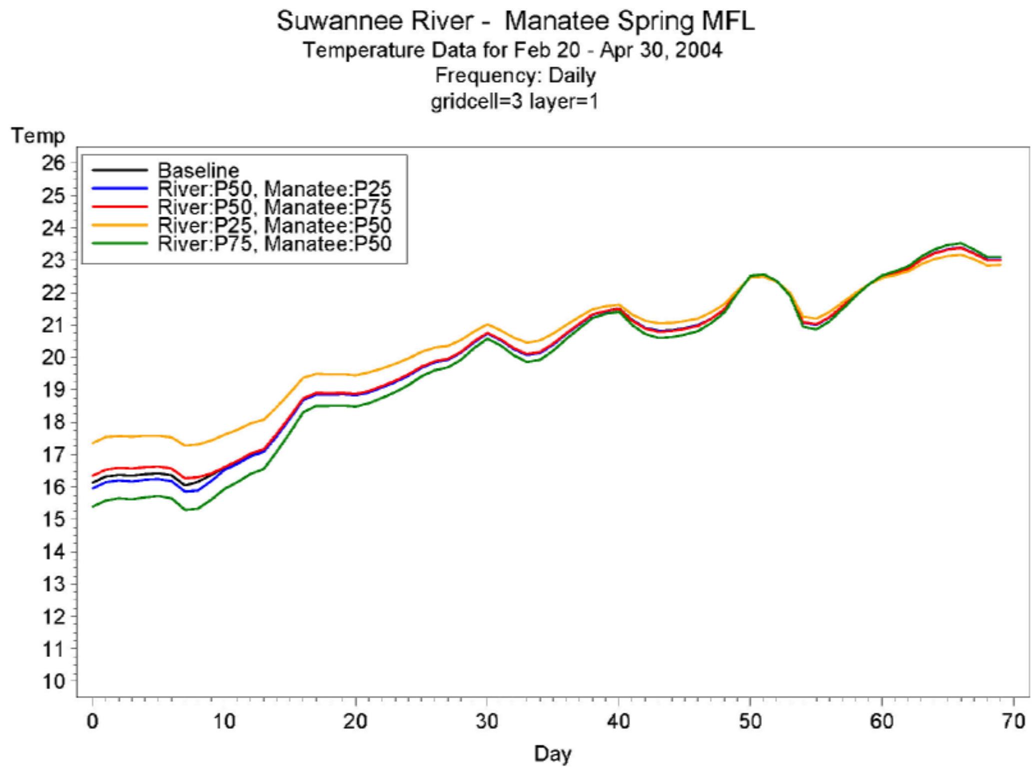


Figure F-9 Predicted daily temperatures, surface grid 3.

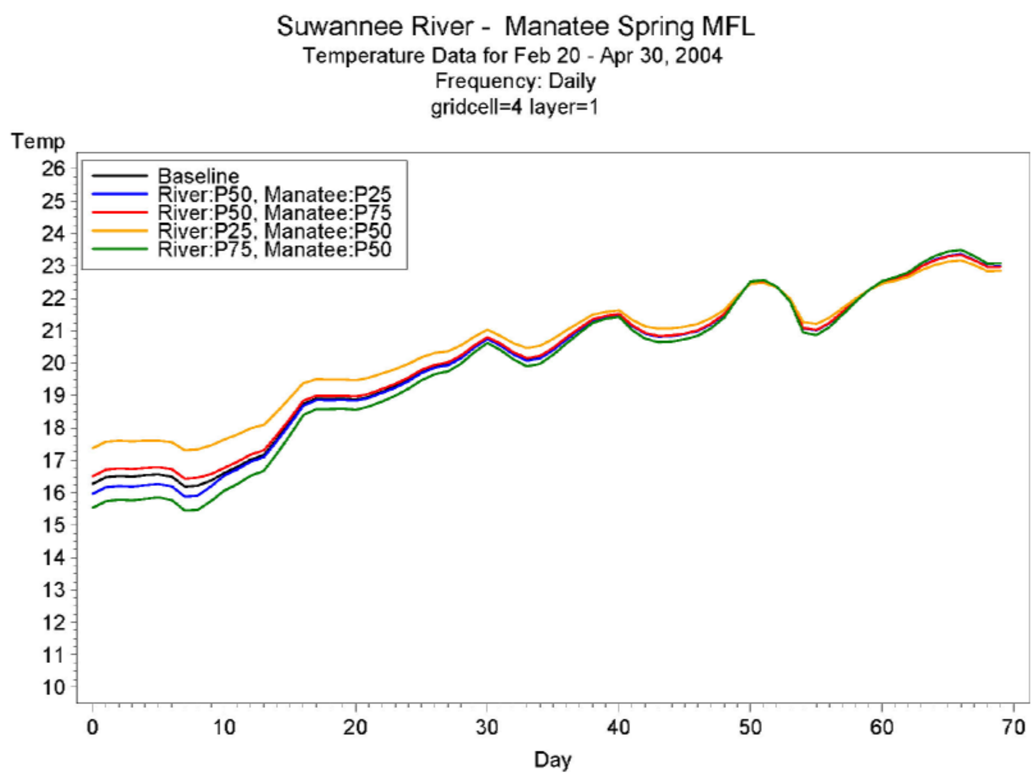


Figure F-10 Predicted daily temperatures, surface grid 4.

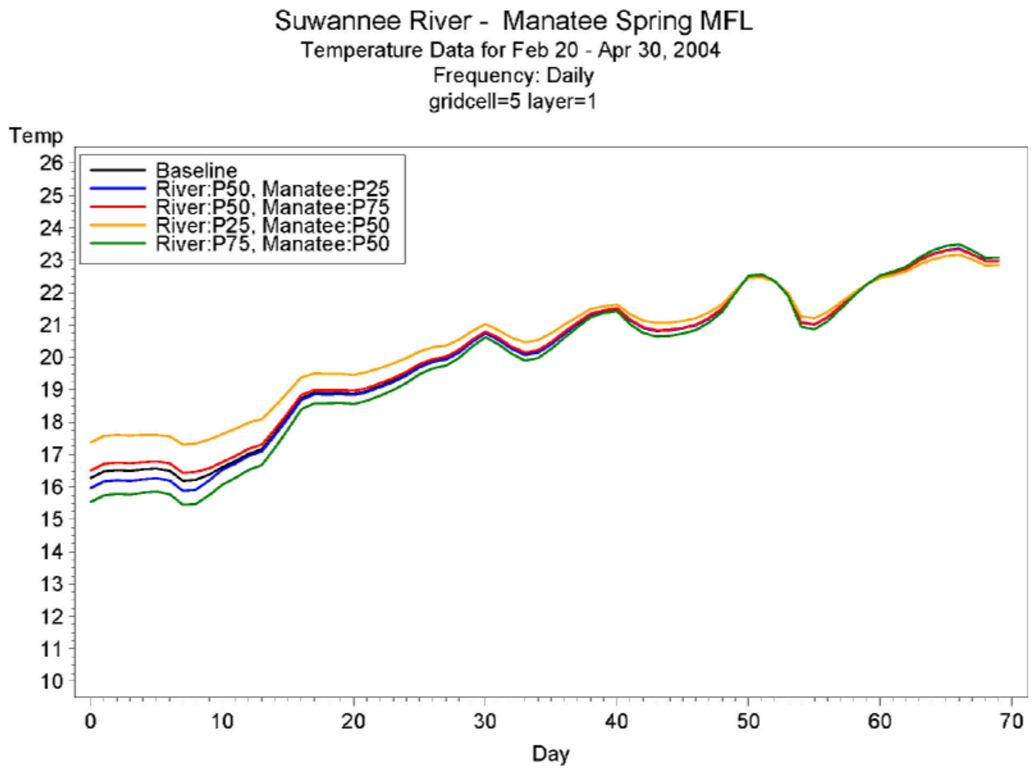


Figure F-11 Predicted daily temperatures, surface grid 5.

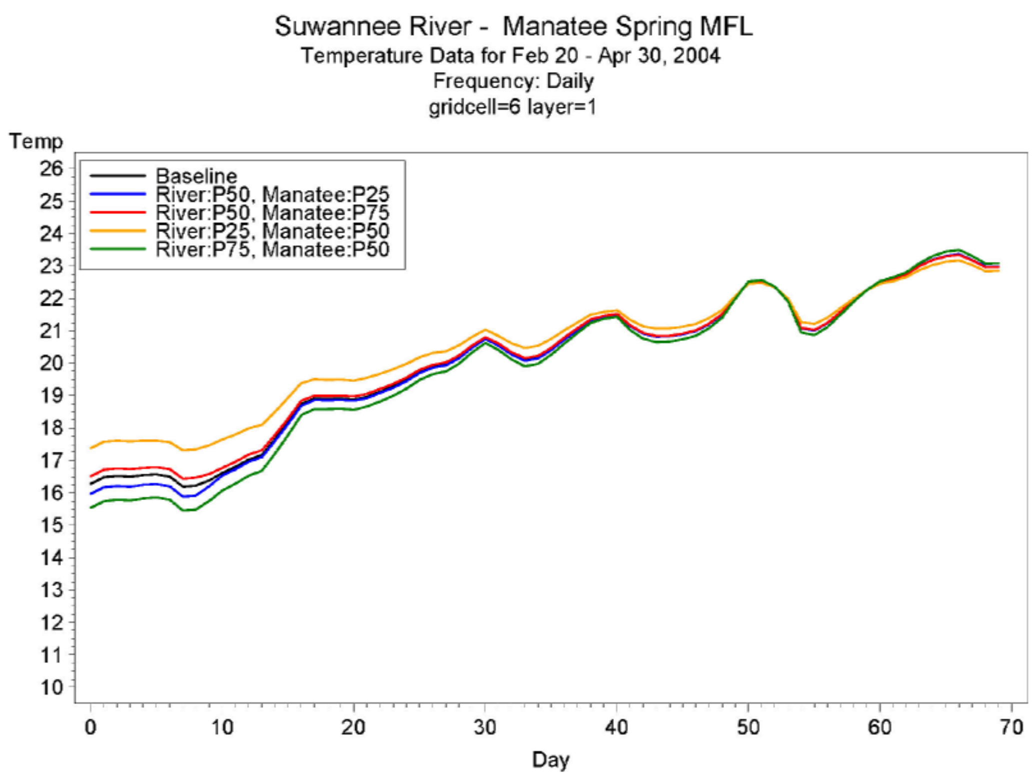


Figure F-12 Predicted daily temperatures, surface grid 6.

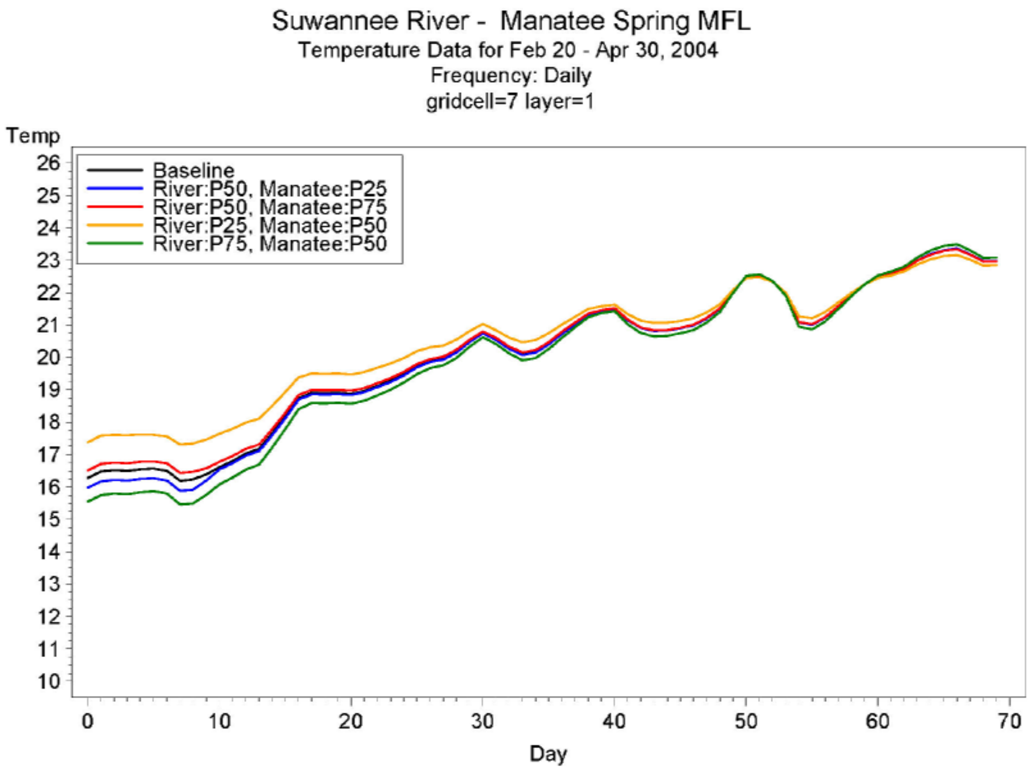


Figure F-13 Predicted daily temperatures, surface grid 7.

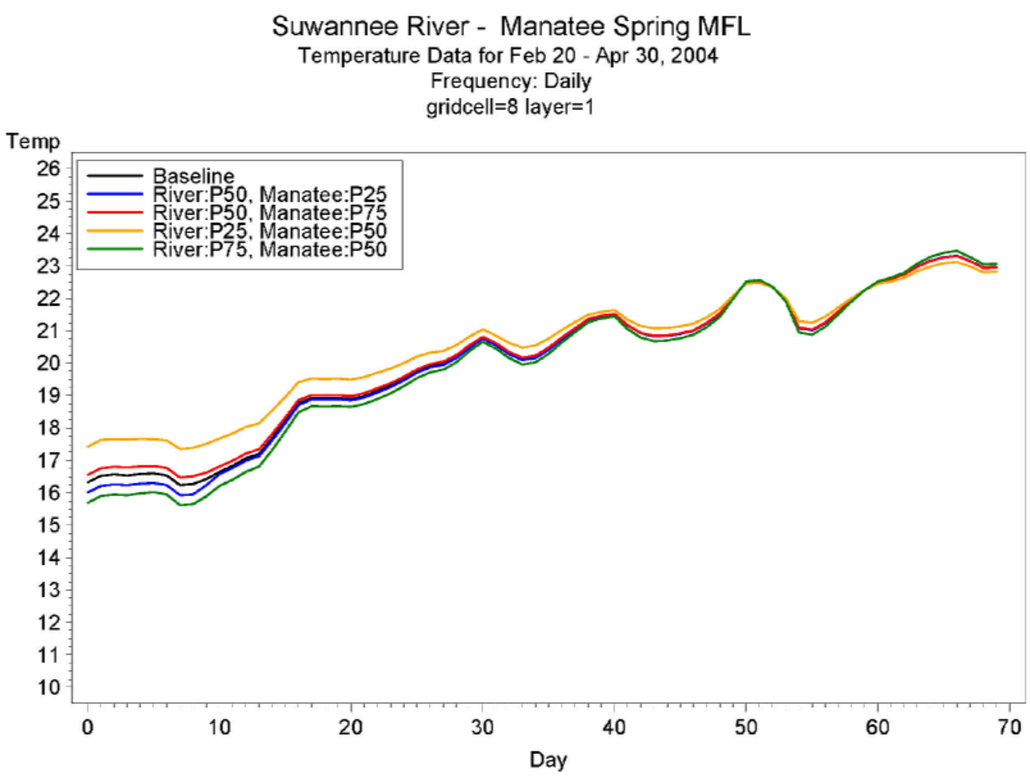


Figure F-14 Predicted daily temperatures, surface grid 8.

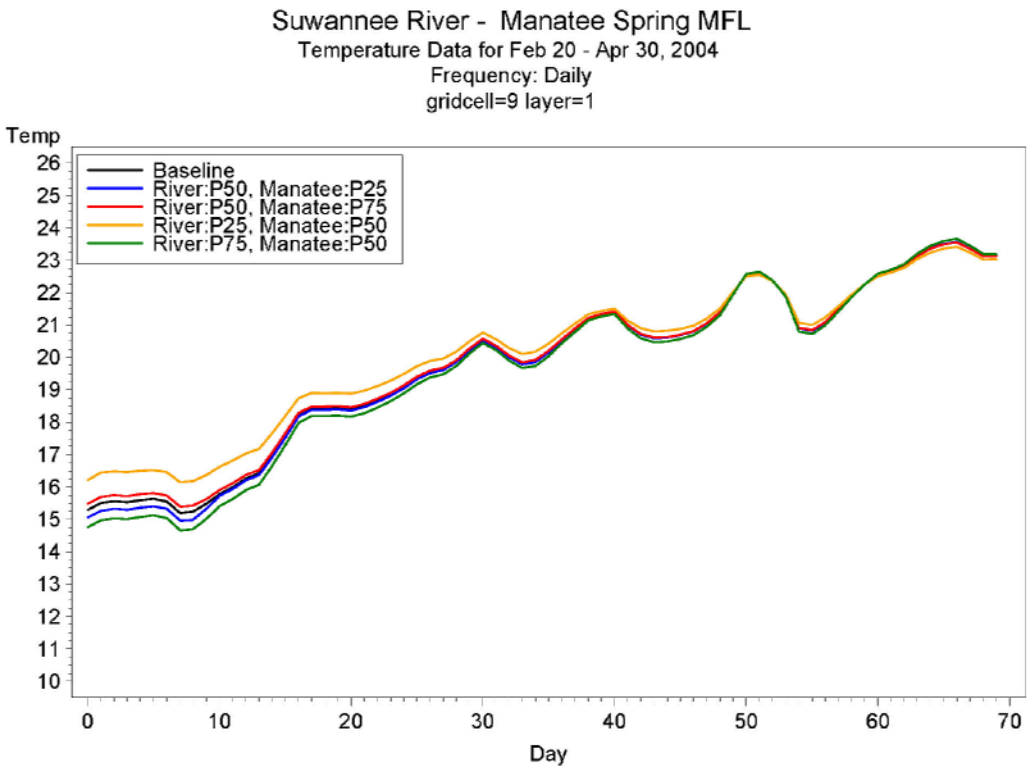


Figure F-15 Predicted daily temperatures, surface grid 9.

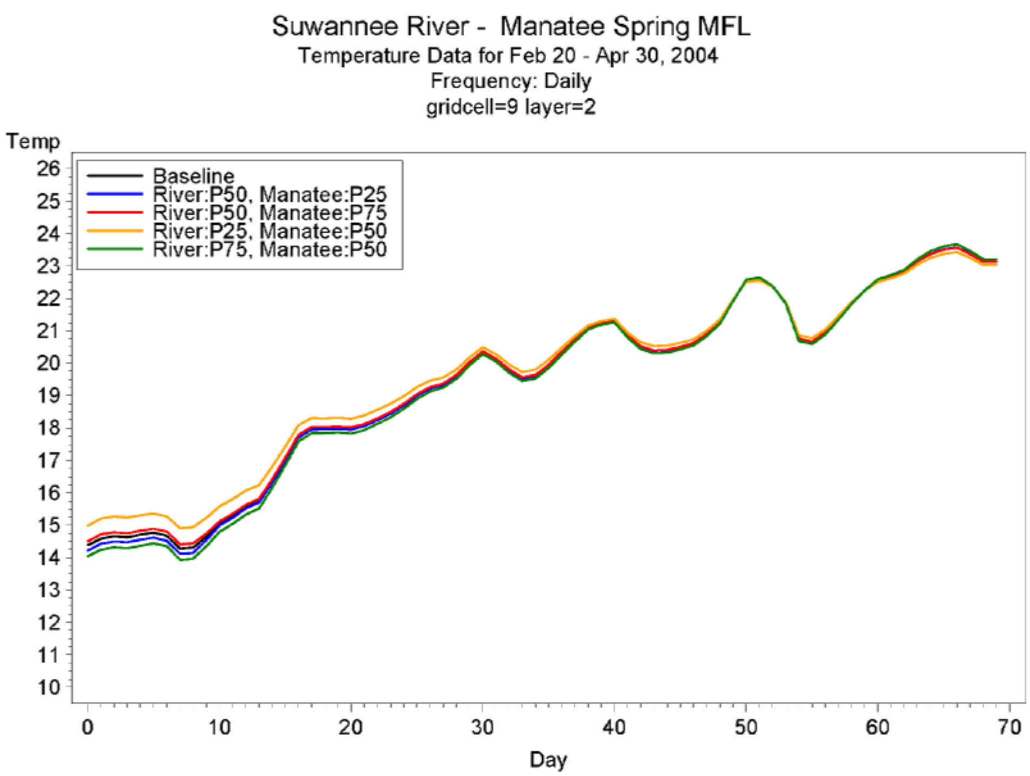


Figure F-16 Predicted daily temperatures, bottom grid 9.

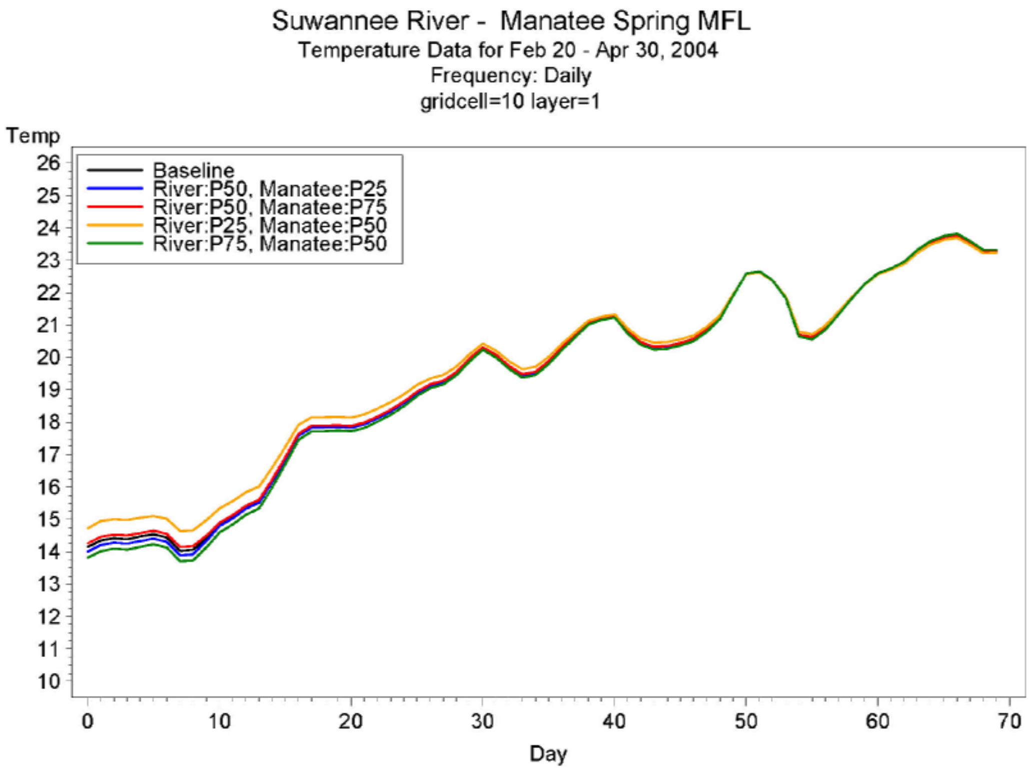


Figure F-17 Predicted daily temperatures, surface grid 10.

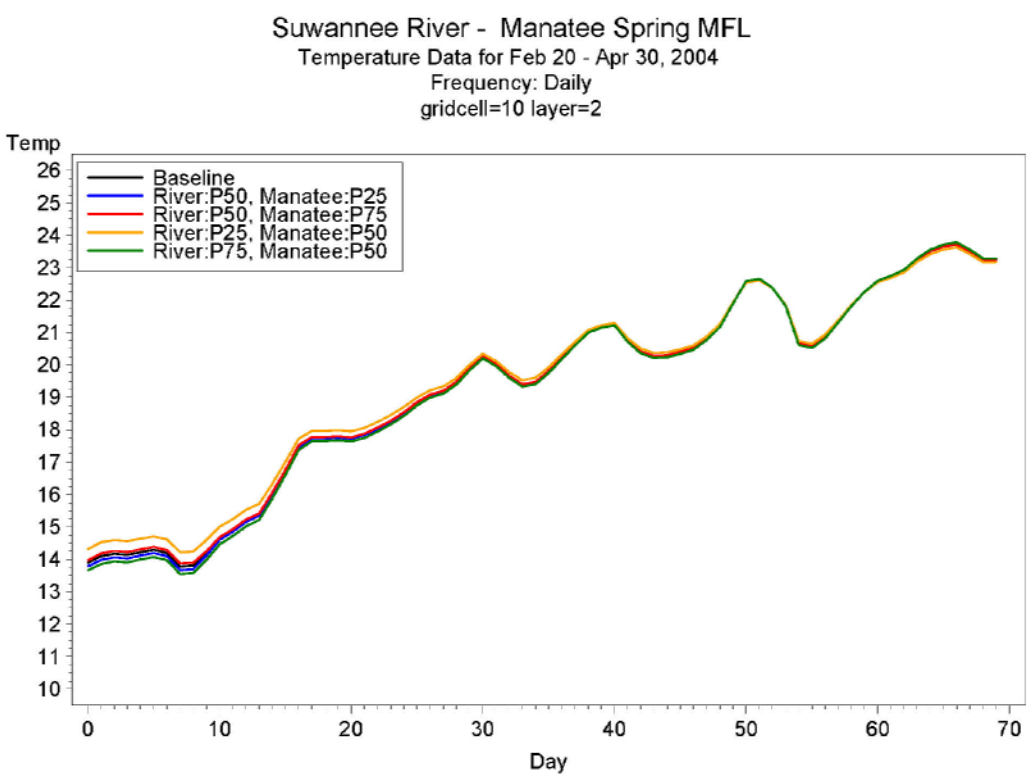


Figure F-18 Predicted daily temperatures, bottom grid 10.

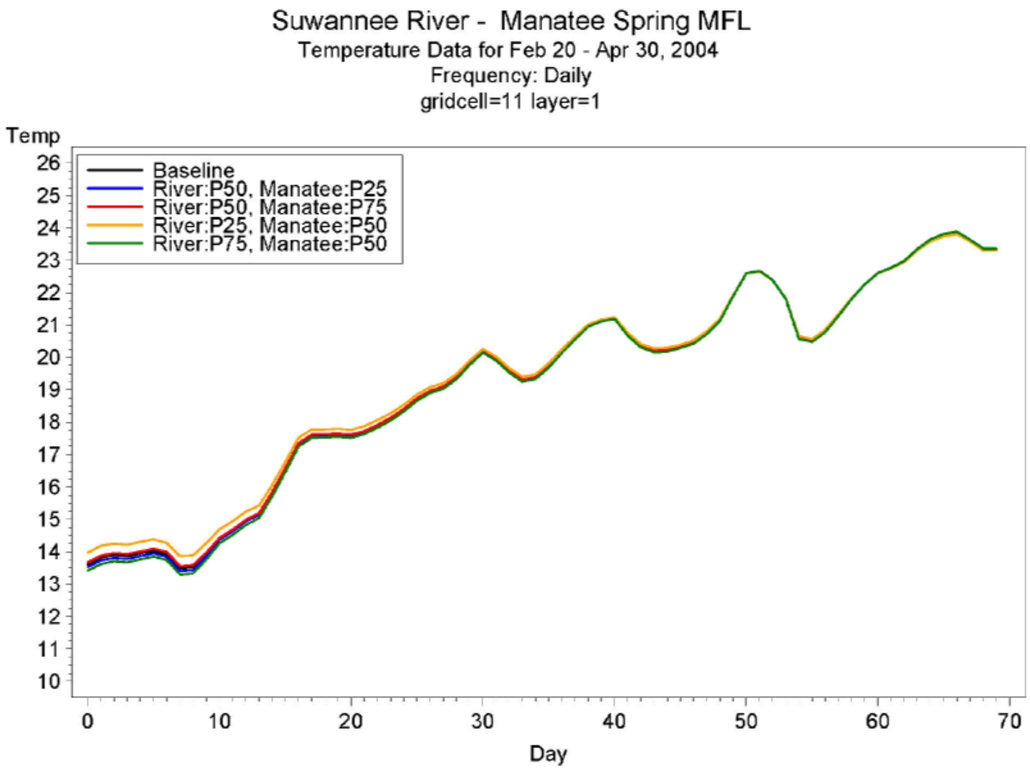


Figure F-19 Predicted daily temperatures, surface grid 11.

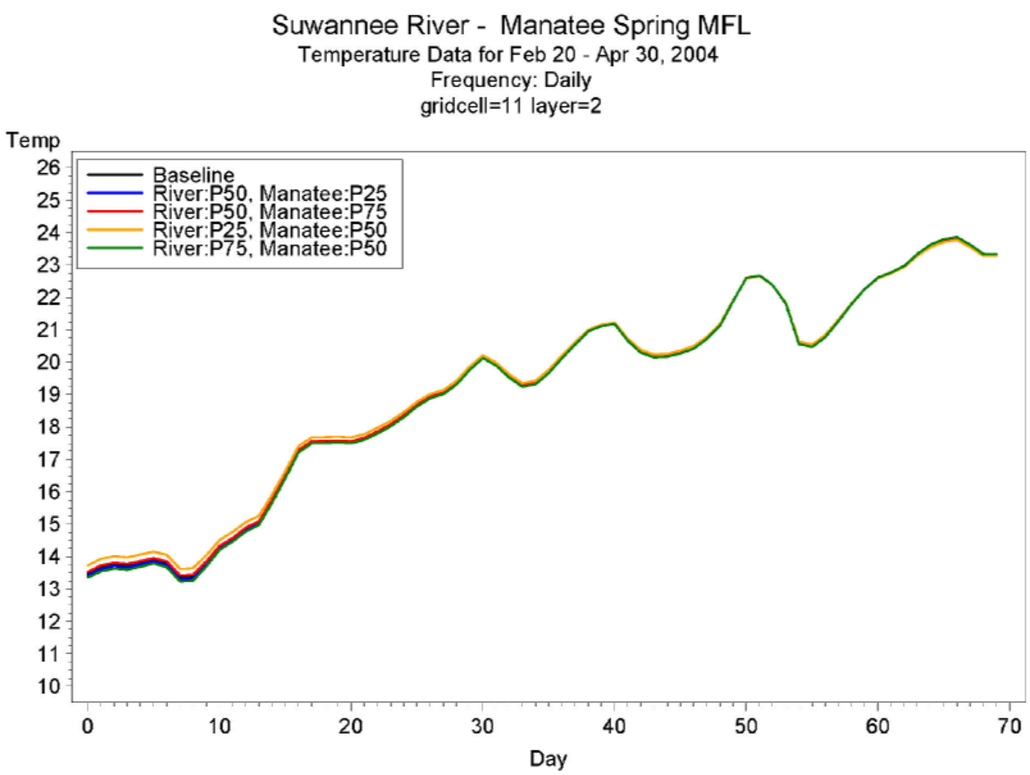


Figure F-20 Predicted daily temperatures, bottom grid 11.

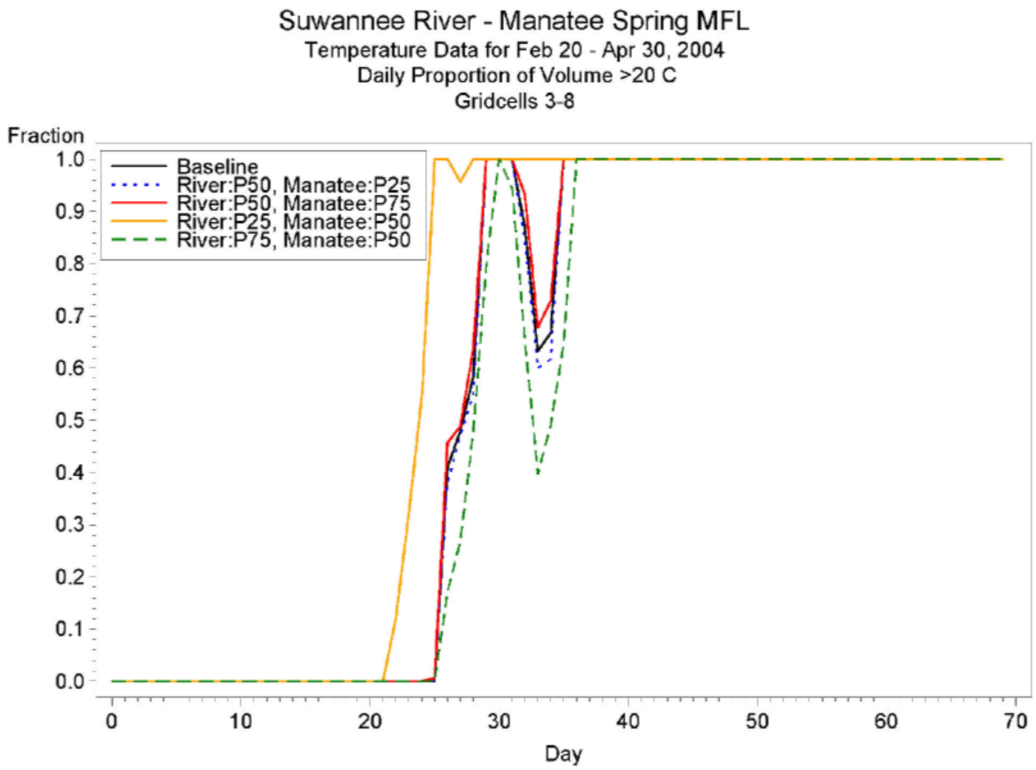
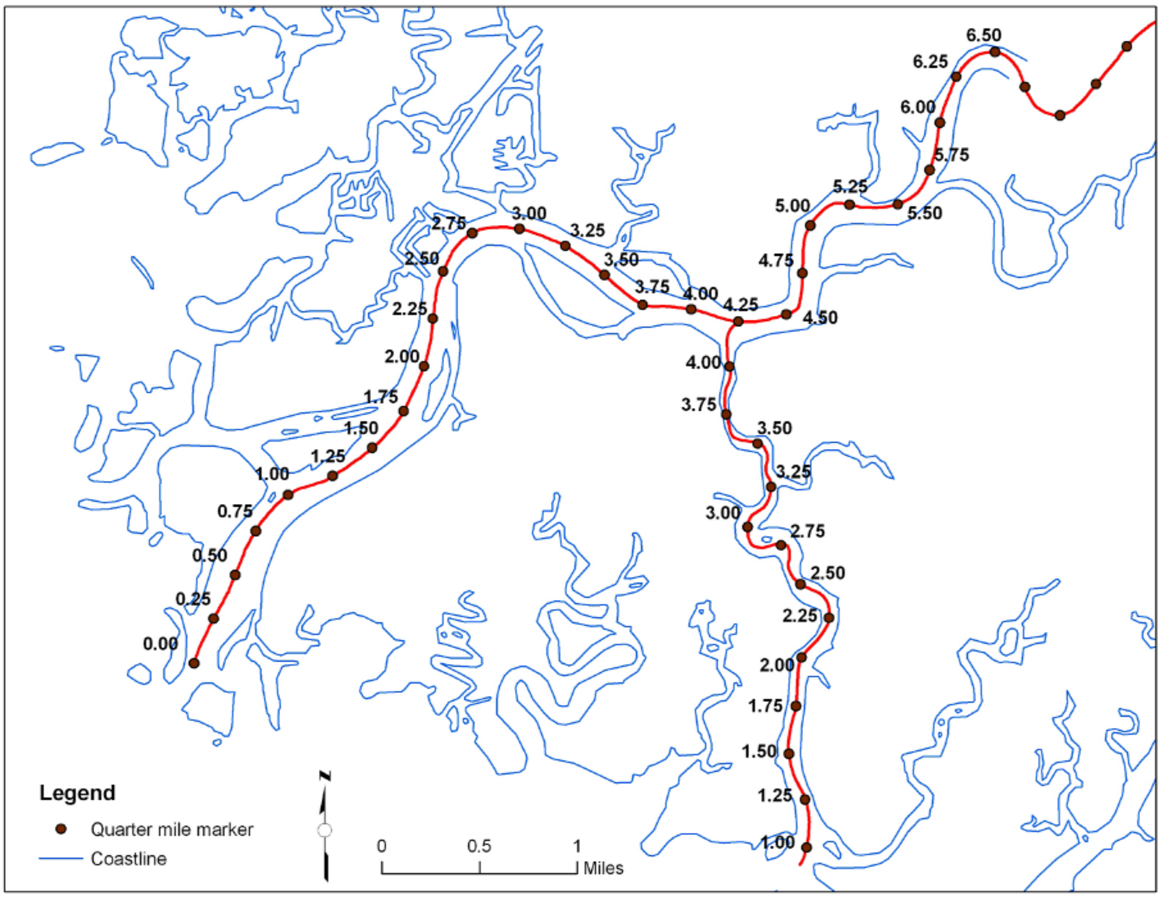


Figure F-21 Predicted daily fraction of volume greater than 20°C for cells 3-8.

Appendix G – Construction of the Lower Suwannee River Mile System



Background

- In studying flow-habitat and flow-salinity relationships, it is crucial to understand the spatial distribution of different riverine habitats. Such a study requires a common river distance system to link current habitat locations with isohaline locations.

Objectives

- To design a river mile system for analyzing the spatial distribution of the lower Suwannee River habitats.

Data Sources

- Centerline coverage as an ARC/INFO export (e00) file from John Good. The original source of this coverage is Jack Grubbs at the USGS and it was created by Augustine Alejandro Sepulveda (personal communication with John Good, 4/11/05).

Methods

- All GIS procedures were performed using ArcMap 9.0, ArcToolbox 9.0, and ArcCatalog 9.0 (packaged as ArcGIS).
- The ARC/INFO export files were converted to coverages using the ArcView Import from Interchange File function under Conversion Tools in ArcCatalog.
- The resulting ARC/INFO coverages were then converted to polyline shapefiles using the Data Export function in ArcMap.
- The splitPLine script was downloaded (http://arcscripts.esri.com/) and modified to split the polyline shapefiles into quarter mile segments. The modification involved setting the cutting distance to quarter mile sections (Figure G-1).
- The East Pass River mile section was constructed such that it had a common river mile marker at the connection point with West Pass (mile 4.25). As a result, the mouth of East Pass has a river mile marker around mile 1.
- Cross lines were constructed by digitizing line sections perpendicular to the centerline at the quarter mile locations (Figure G-2). These sections were used for analyzing the spatial distribution of the different habitats of concern.

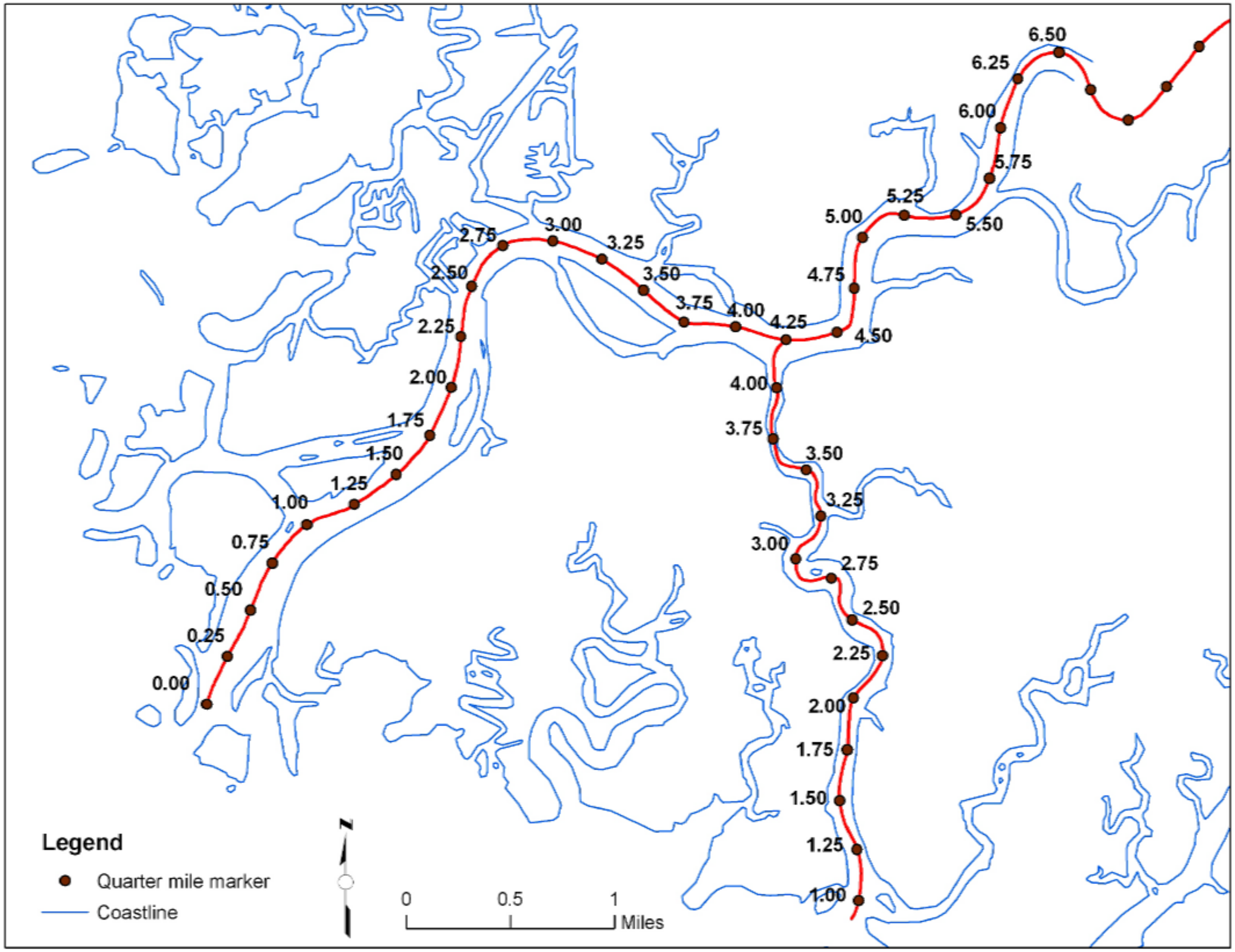


Figure G-1. Centerline and quartermile markers in West Pass, Suwannee River, and East Pass.

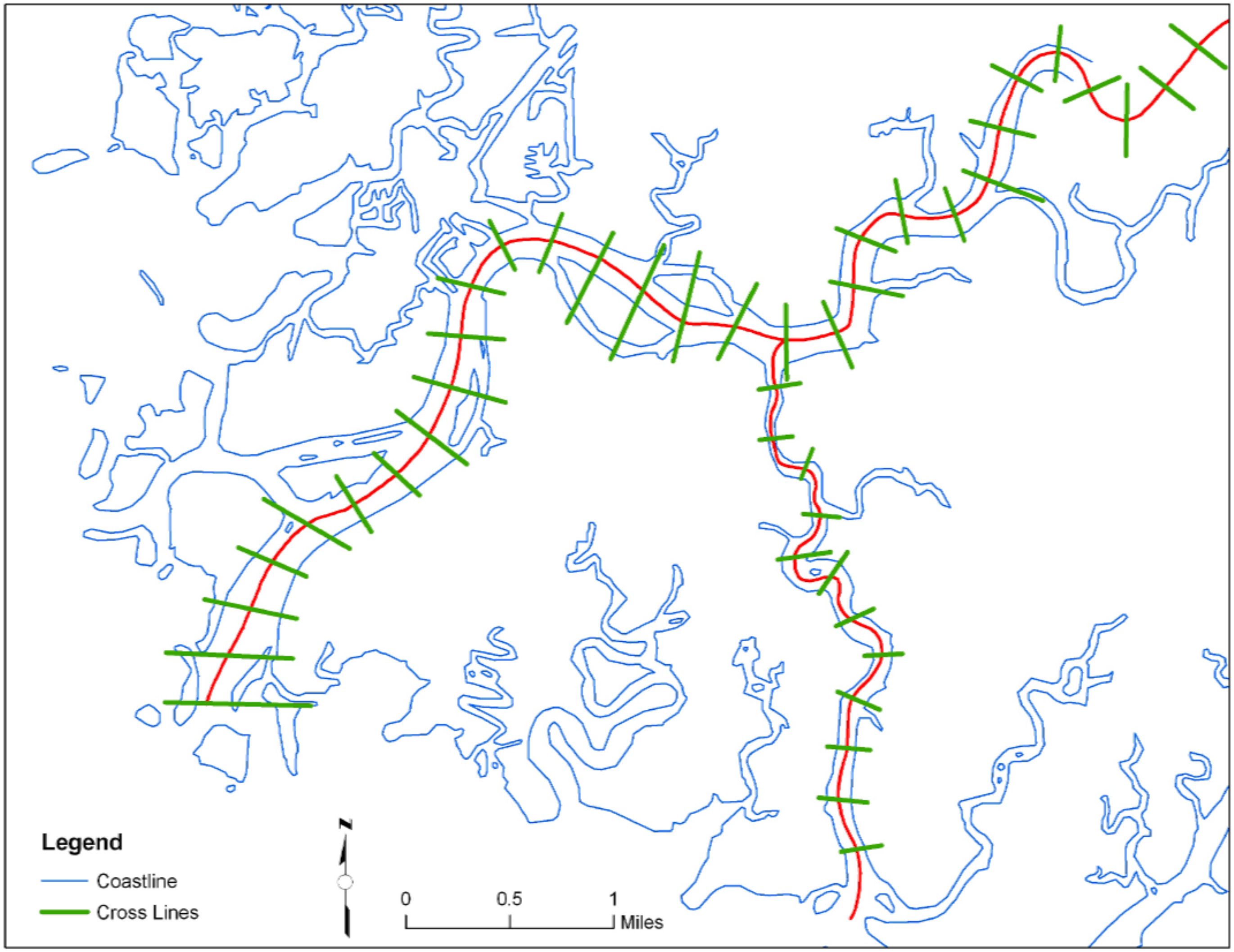
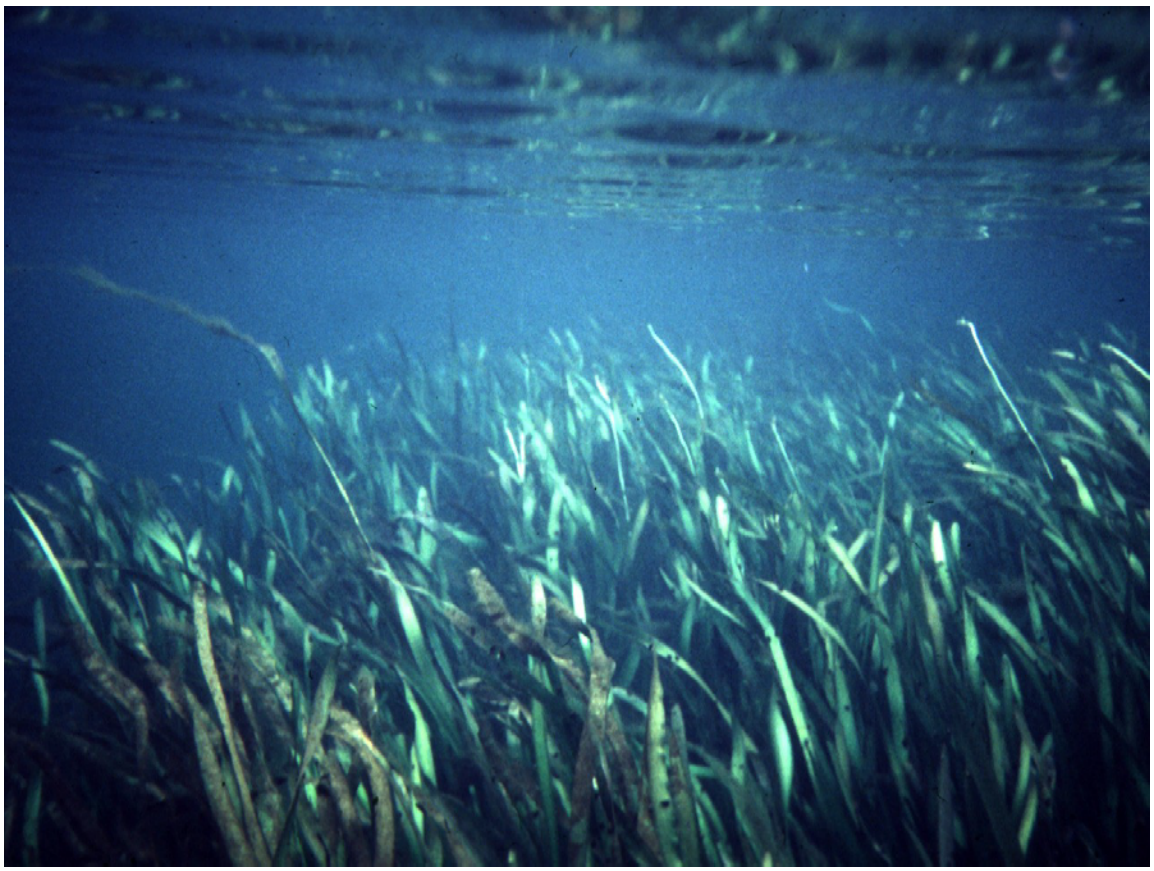


Figure G-2. Cross line sections at quarter mile markers in West Pass, Suwannee River, and East Pass.

Appendix H - Submerged Aquatic Vegetation



Background

- One of the major aquatic habitats in the Lower Suwannee River is beds of low salinity or freshwater submerged aquatic vegetation (SAV) (Figure H-1).
- SAV plays a critical role in terms of providing habitat for invertebrate and fish species, in addition to helping to stabilize sediments and contributing to the total primary productivity in the food web (Rozas and Odum, 1987a;1987b; Mattson and Krummrich, 1995;Thorp et al. 1997).
- The potential for significant harm to SAV habitat is related to changes in salinity, which is a function of flow. Changes in salinity could result in an unacceptable upstream movement of the downstream limit of SAV distribution in the estuary, or the potential for an overall loss of acreage of low salinity SAV habitat.

Objectives

- To evaluate how the relationship between flow and salinity affects the habitat suitability of SAV in the Lower Suwannee River.
- To estimate the risk to SAV habitat based on alterations to the flow regime (flow reductions).

Data Sources

- Daily average discharge data was obtained for the United States Geological Survey (USGS) gage number 02323500 (Suwannee near Wilcox) from 1984-2004.
- Daily lags were created to 15 days, lag averages to 90 days, cumulative flows to 8 days and transformations of flows (e.g. logarithmic, inverse, square root).
- Hydrologic data was also available from the USGS Continuous Recorder Gage WM (Figure H-1) located at river mile 1.82 (Figure H-2).
- Salinity data collected by the FWCC in 1993-1995 was used to develop regression models relating flow at Wilcox to the location of the 9 ppt isohaline.
- SAV habitat data were collected for the SRWMD by Mote Marine Laboratory (Estevez and Sprinkle, 1999; Estevez, 2000; 2002) and by Golder and Associates (2000).

    - The Mote Marine SAV study:
        - Sampling was conducted on a quarterly schedule (4 times) from March 1998 to January 1999. The 16 sites were re-visited in June 2000 and July 2002 during a severe drought.
        - Consisted of 16 sampling sites jointly selected by Mote and SRWMD during a pre-study reconassaince. Placement of sites was systematic, extending from the downstream limit of SAV in East, Alligator, and Wadley Passes up to the confluence with the Gopher River, where salinity never penetrates under ordinary climatic and river flow conditions.
        - The overall goal of the Mote SAV study was to describe the characteristics of SAV where it occurred in the upper estuary and relate to salinity regimes, as opposed to making broader generalizations about SAV in the upper estuary, which would have required a more randomized station distribution.
        - At all 16 sites, SAV characteristics of frequency, cover and abundance by species were measured using 0.25 m^2 quadrats and the non-destructive Braun-Blanquet method. Quadrats were

deployed haphazardly about the grassbed at each site during sampling.

    - Additional SAV data were collected at a subset of six of the 16 study sites. Six (6) quadrats of 0.0625 m^2 area were haphazardly deployed about the grassbed at each site, and all SAV within the quadrat was harvested for determination of dry weight standing crop. In the laboratory, collected plant material was separated by individual plant species and then divided into leaf (above ground) and root (below ground) components by species. This material was air-dried for 24 hours, then further dried at 75-80 degrees C in ovens to obtain dry weight standing crop.

- The Golder SAV study:
    - SAV was mapped by Golder Associates (2000) in late spring and summer of 2000.
    - Mapping was conducted using "in-the-field" technology. A Trimble® AgGPS 132 Global Positioning System unit was linked to a lap-top computer with software which linked the GPS system to ESRI® GIS software.
    - The edges of individual grass beds were delineated in the field by walking the perimeter of each bed with the GPS unit. The hardware and software recorded this polygon on the laptop computer. Various attributes of the grassbed (species composition, dominant species, salinity, etc.) could then be entered into the computer to build the GIS attribute database.
    - Because the mapping effort was conducted during an extreme drought, there were areas known to historically support SAV which were now unvegetated. SRWMD staff located these for Golder Associates field personnel, and areas of unvegetated substrate in depths <3 ft (0.9 m) were delineated during dead low tide to conservatively estimate the amount of "potential" or "historic" SAV habitat.
    - A river mile system was developed and used to help calculate the cumulative acreage of SAV in West Pass, moving from the downstream limit up to the confluence with East Pass.

Isohaline Selection

- Literature supports 9 parts per thousand (ppt) as the threshold value for suitable low salinity SAV habitat in Lower Suwannee River (LSR).
- Salinity data collected by the SRWMD/FWCC in 1993-1995 were used to develop a regression model relating flow at Wilcox to the location of the 9 ppt isohaline.
    - Analyses were restricted to Wadley and West Passes, since the majority of the SAV coverage in the upper estuary is found in West Pass. Salinities are uniformly lower in East Pass, compared to West Pass (Tillis, 2000; Mattson and Krummrich, 1995), so salinity criteria to protect SAV in West Pass should be equally protective in East Pass.
    - Wadley Pass is a historically more saline environment than Alligator Pass; a dynamic area of mixing is created at the confluence as tidally driven and saline water from Wadley Pass mixes with the Suwannee

discharge. Nine ppt is infrequently found in Alligator and East Passes.

Analytical Steps

- A prediction equation was developed for the location of the 9 ppt isohaline in the LSR as a function of flow using regression. The estimation of flow-isohaline location relationships were used to identify the upstream incursion of the 9 ppt isohaline under varying flow conditions (Figures H-3 through H-5).
- River locations associated with 0 to 15 % of the total SAV habitat were identified as risk points (Figure H-6).
- A regression equation was then applied to determine the flow required to keep the 9 ppt isohaline below each of the risk points (Figure H-6).
- Salinity-flow regressions were also developed for the WM continuous recorder in order to provide an independent assessment of the flow required to sustain suitable habitat for SAV.

Validation Using the WM Continuous Recorder

- The USGS Continuous Recorder Gage WM is located at river mile 1.82
- Surface isohaline regression results suggest that 5320 cfs would be required to keep the surface isohaline at the WM continous recorder.
- To validate the isohaline regressions, the flow predicted to keep the 9 ppt isohaline at river mile 1.82 (the location of the WM continuous recorder) was compared using the isohaline regressions to the observed and predicted salinity at the WM continuous recorder (WM salinity /flow regressions).

Validation Analytical Steps

- Hurricane dates were removed from the WM dataset.
- Daily maximum salinity was calculated using the mid-water measurements, which were the most frequent and had the longest period of record (POR) (Figure H-7).
- The salinity-flow relationship was estimated using the WM continuous recorder salinity (Figure H-8).

Inferences Made from Continuous Recorder Regressions

- Daily maximum salinities at the WM continuous recorded gage were highly variable for a given flow. However, despite the large variability, the regression equation predicted the average salinity well with little bias (Figures H-9 through H-11).
- The observed flow for predicted mid-water salinities between 8.5 and 9.5 ppt was averaged, resulting in a flow at Wilcox of 5,353 cfs.
- For observed flows between 5000 cfs and 6000 cfs, the average observed mid-water salinity was 9.18 ppt.
- These values correspond well with isohaline regression estimates of the flow corresponding to a surface isohaline location at the WM on a full moon (5320 cfs).

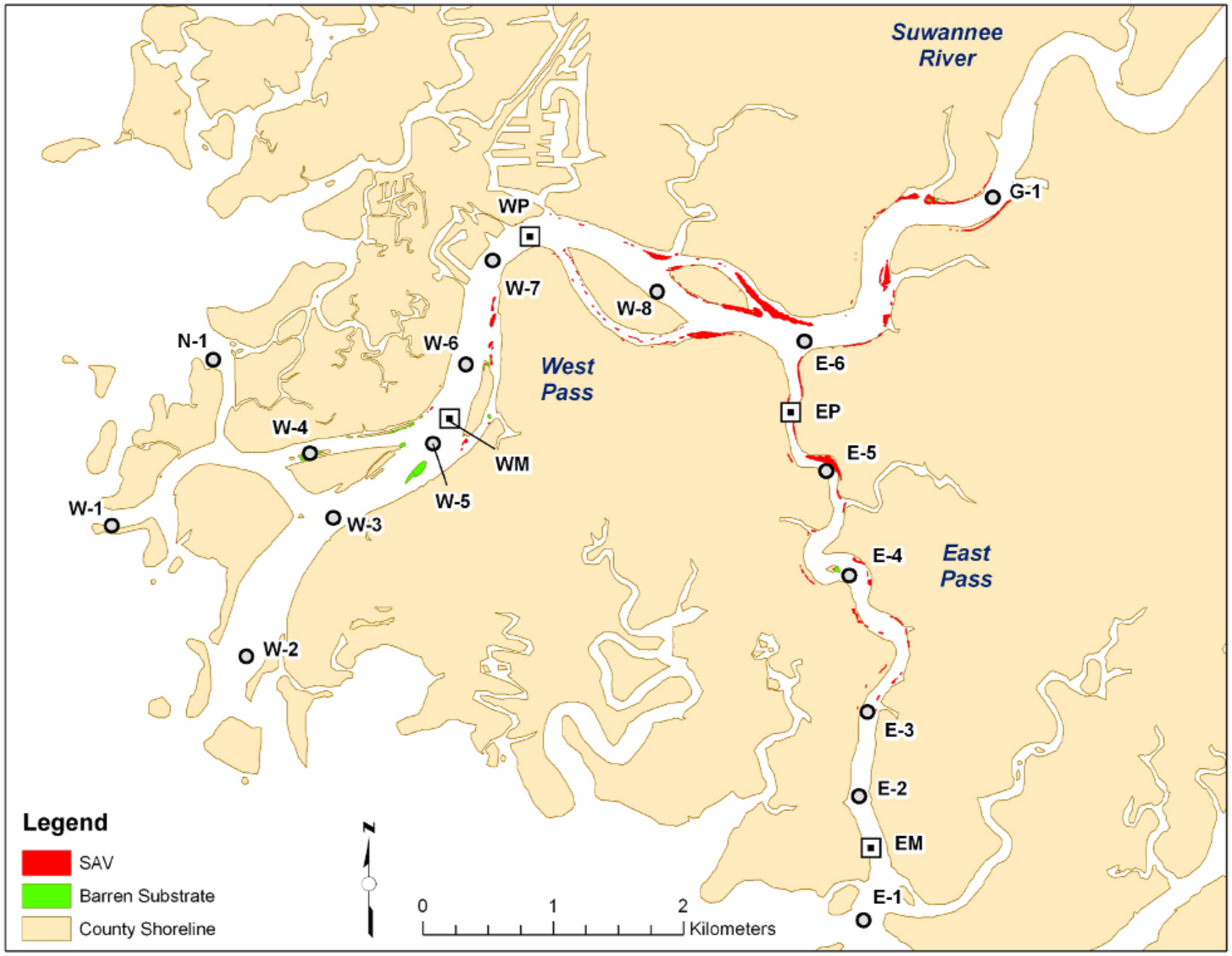


Figure H-1. Distribution of low salinity submerged aquatic vegetation (SAV) and location of continuous recorders in the Lower Suwannee River.

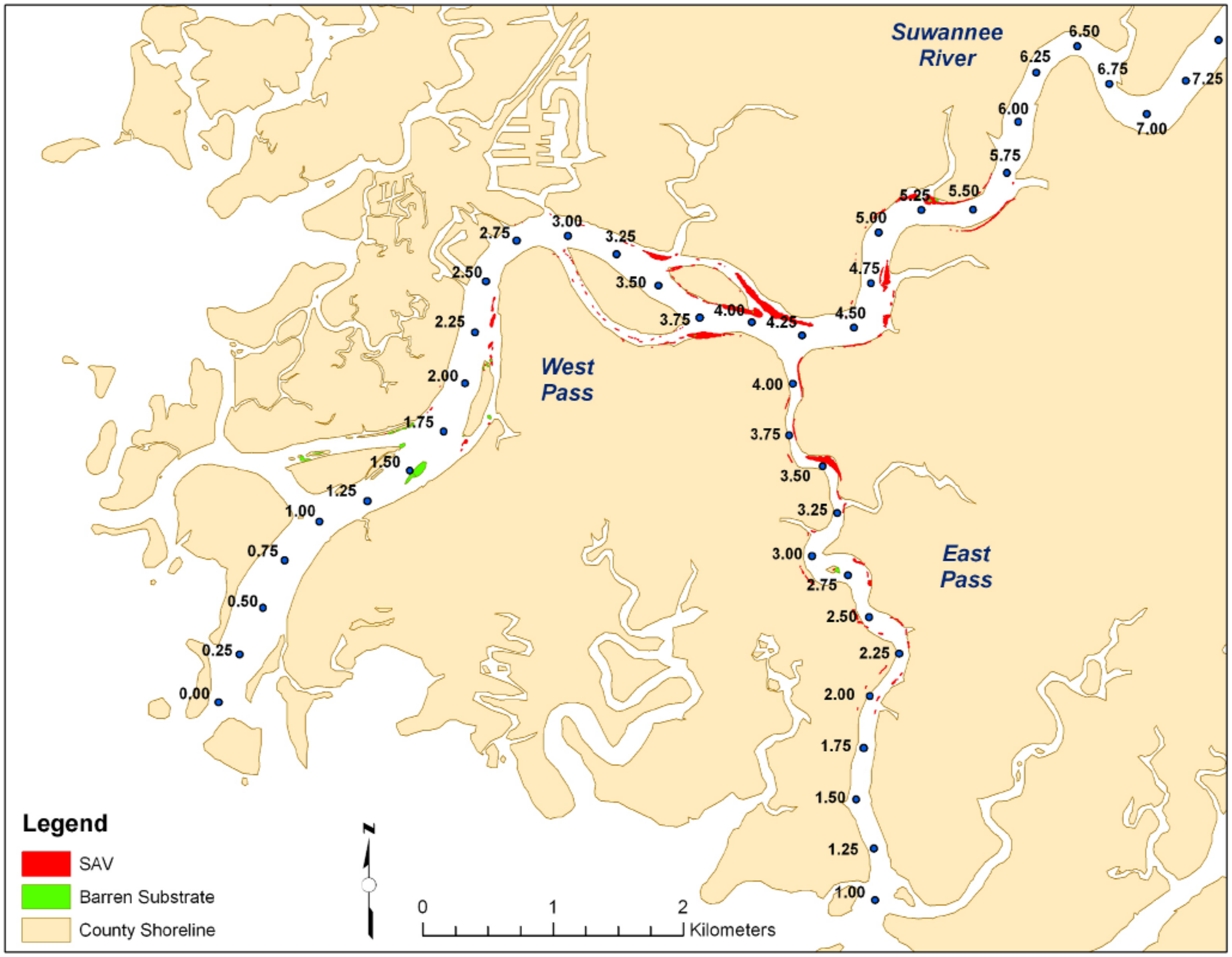


Figure H-2. River mile (rm) system overlaid on the distribution of SAV in the Lower Suwannee River.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	5.29858	5.29858	20.82	0.0008
Error	11	2.79973	0.25452		
Corrected Total	12	8.09831			

Root MSE	0.50450	R-Square	0.6543
Dependent Mean	1.50295	Adj R-Sq	0.6229
Coeff Var	33.56731		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	6.67722	1.14265	5.84	0.0001
Flow**0.4	1	- 0.15740	0.03450	-4.56	0.0008

Figure H-3. Regression details for the 9 ppt surface isohaline developed for Wadley Pass

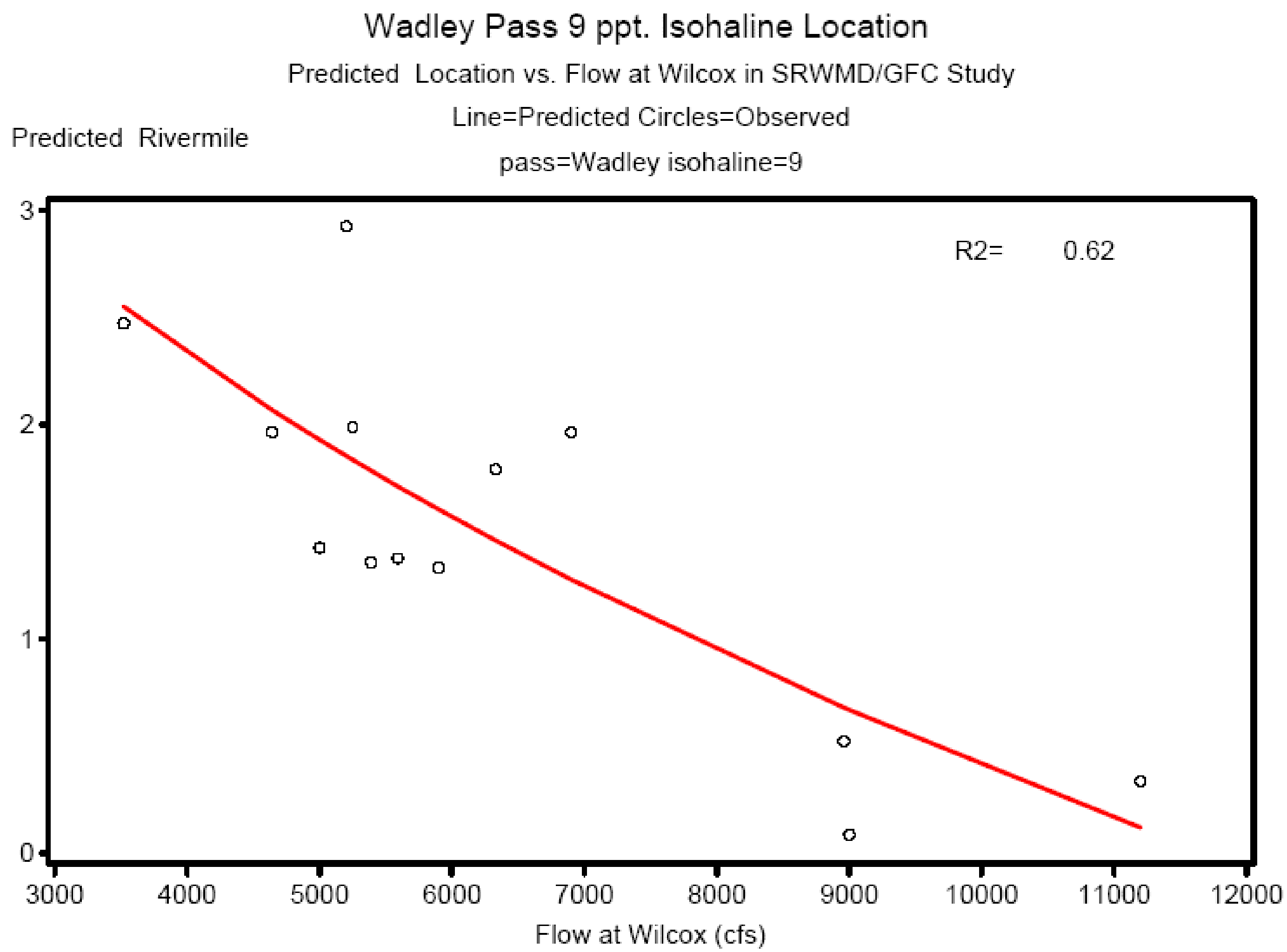


Figure H-4. Regression plots showing the location in river mile of the 9 ppt isohaline as a function of flow.

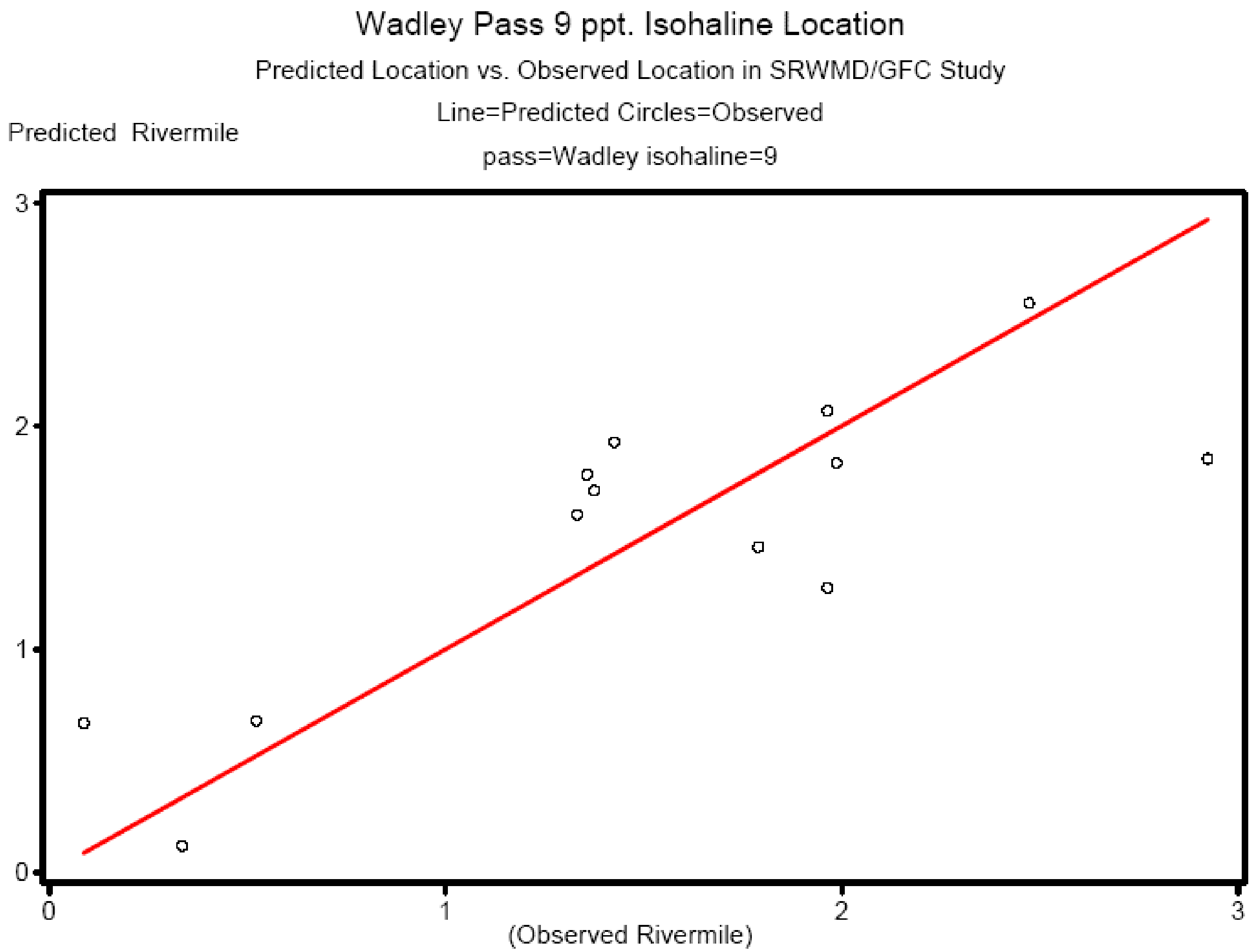


Figure H-5. Relationship between predicted and observed river mile for the 9 ppt isohaline location.

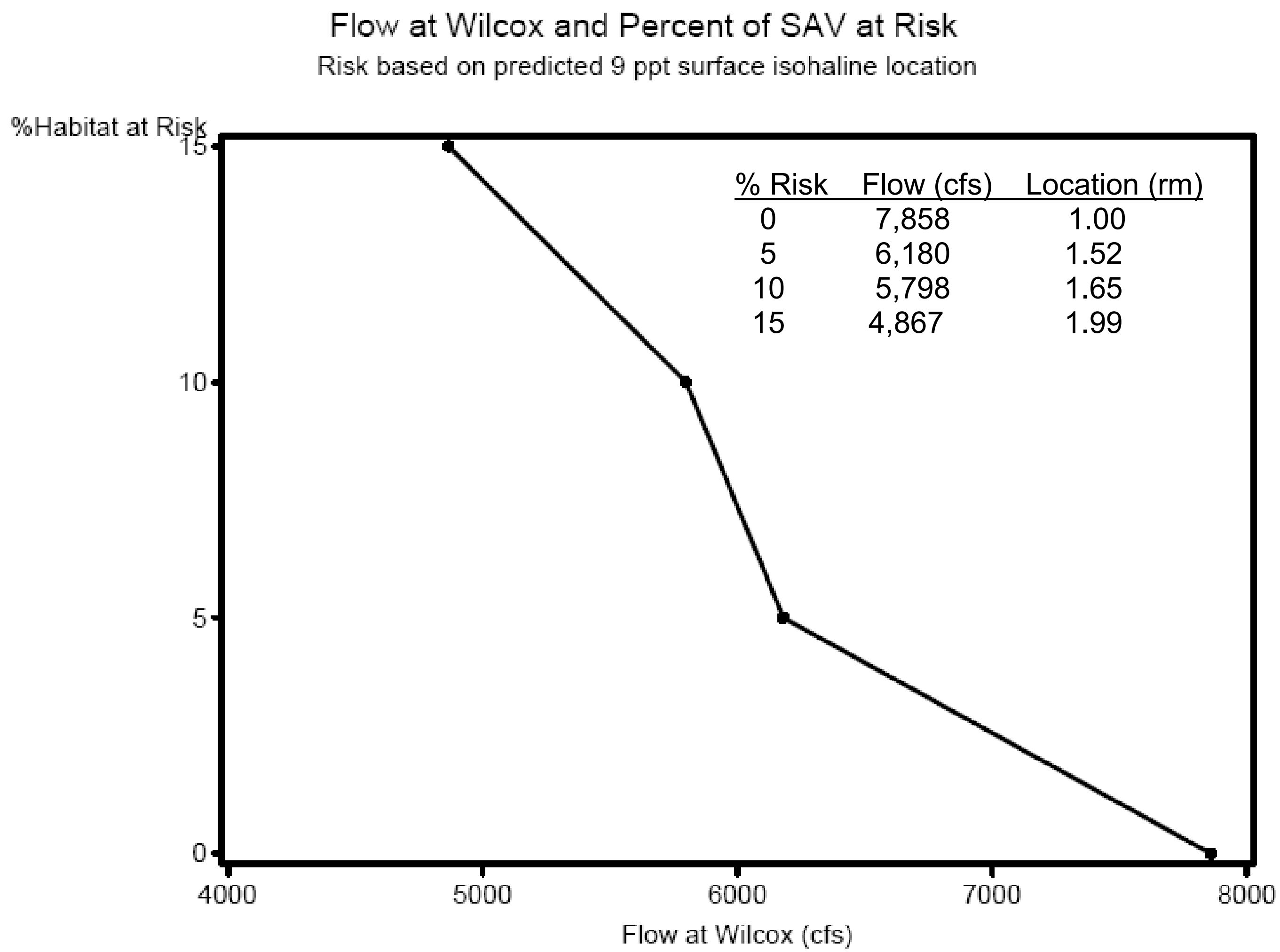


Figure H-6. Relationship between percent of habitat risk for SAV and flow, based on the predicted location of the 9 ppt isohaline.

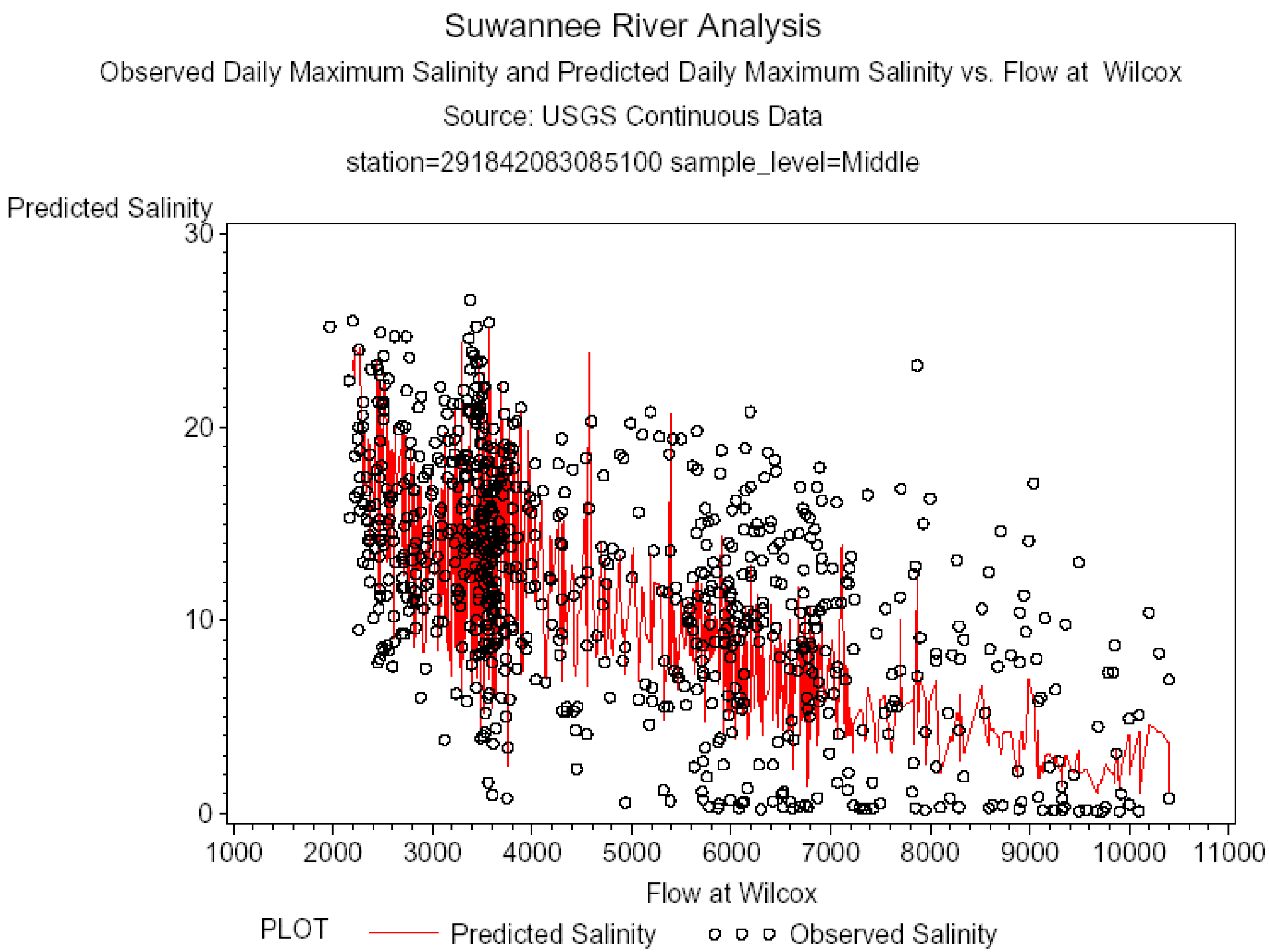


Figure H-7. Predicted and observed daily maximum salinity as a function of flow, based on mid-water column samples.

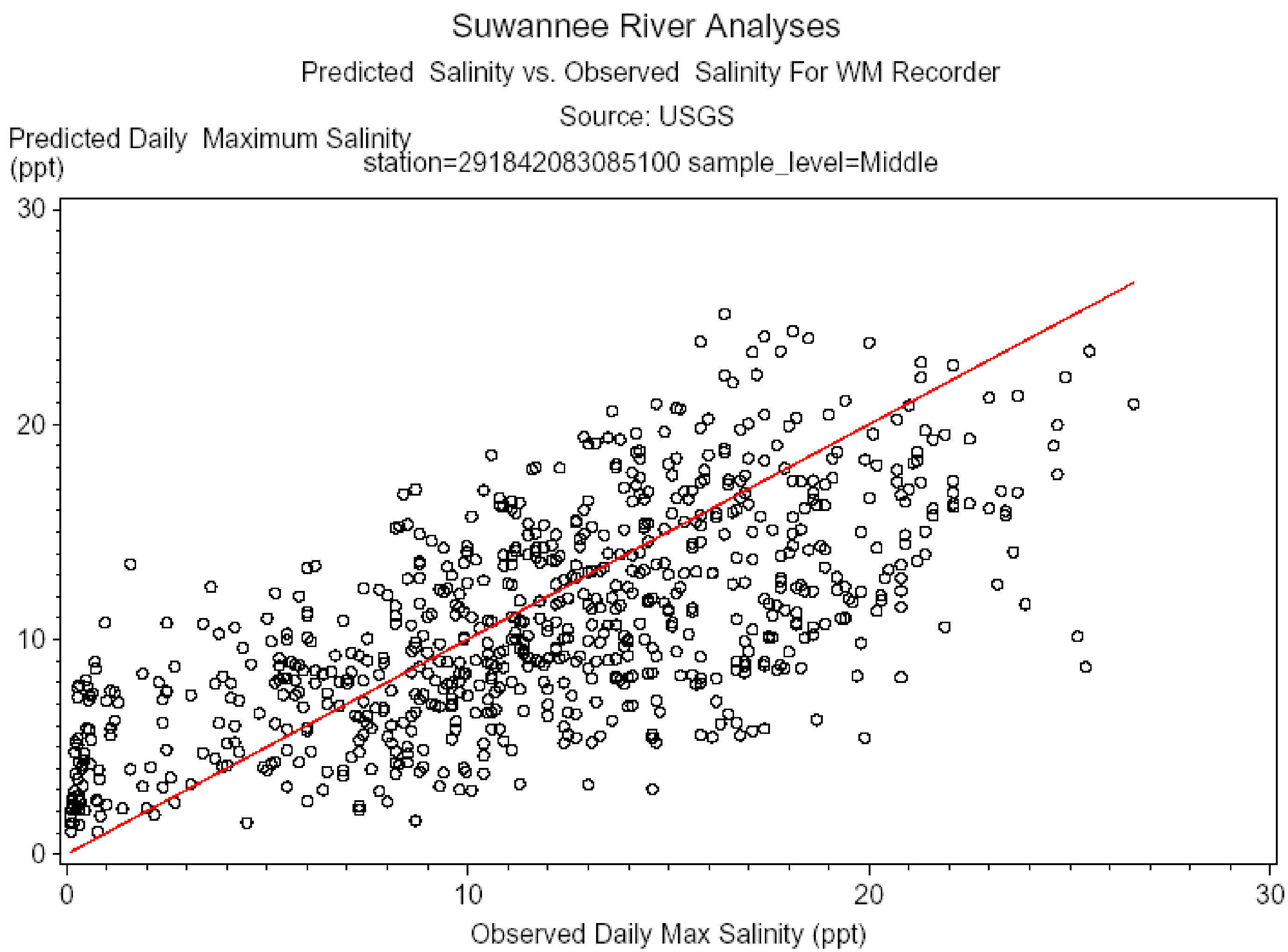


Figure H-8. Relationship between predicted and observed daily maximum salinity from continuous recorder data (WM recorder).

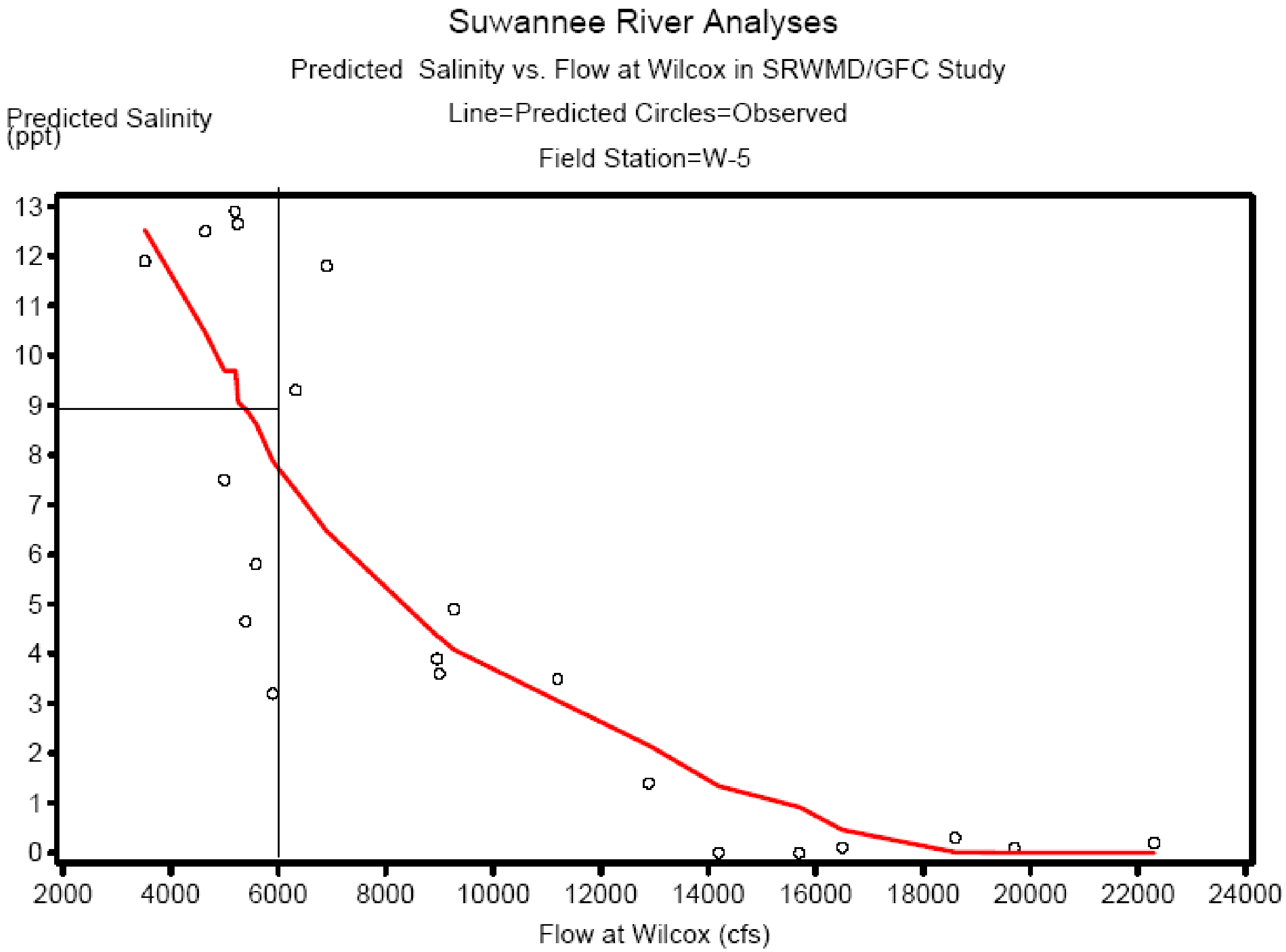


Figure H-9. Regression relationship between predicted salinity and flow for West Pass (fixed station W-5).

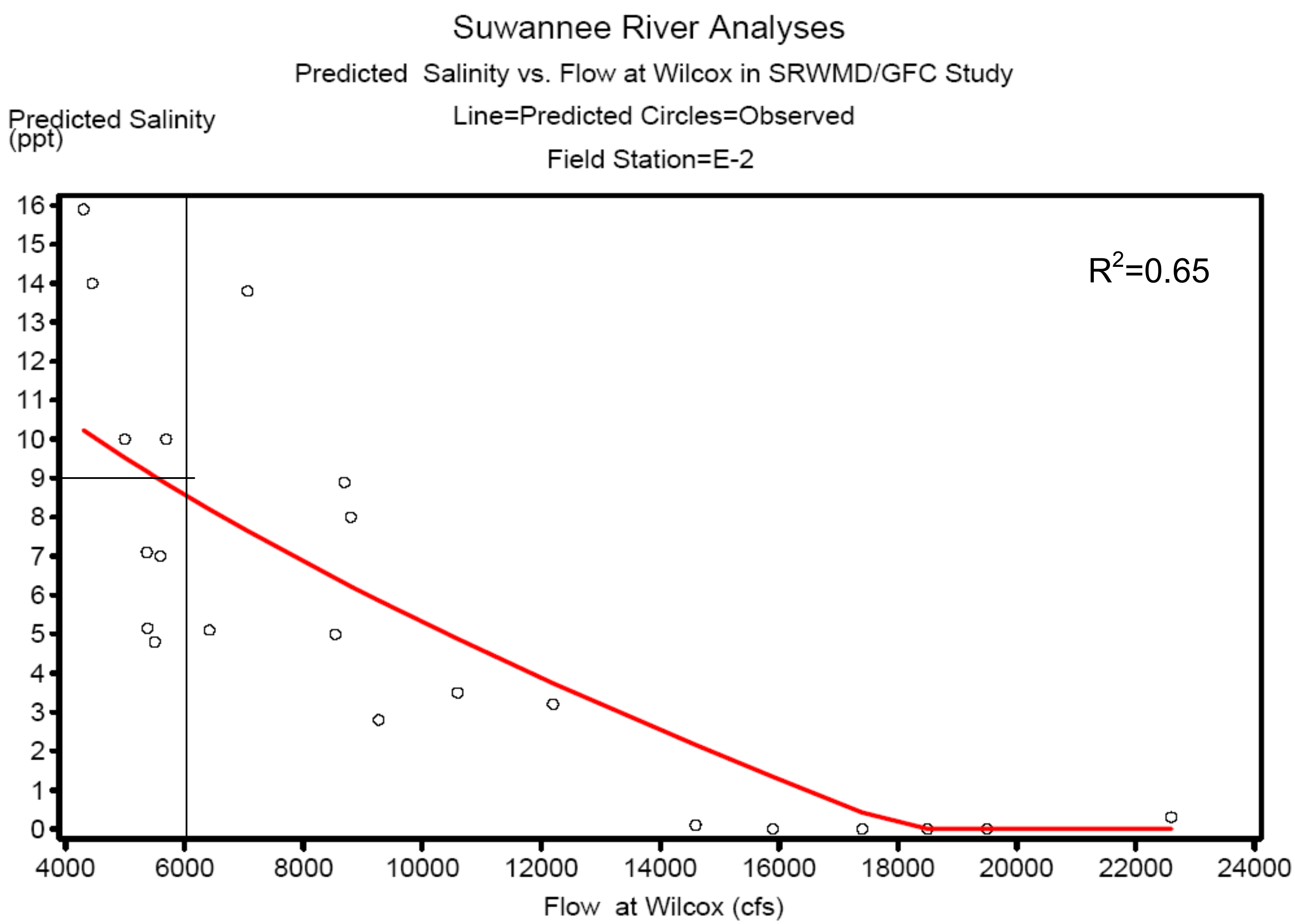


Figure H-10. Regression relationship between predicted salinity and flow for East Pass (fixed station E-2).

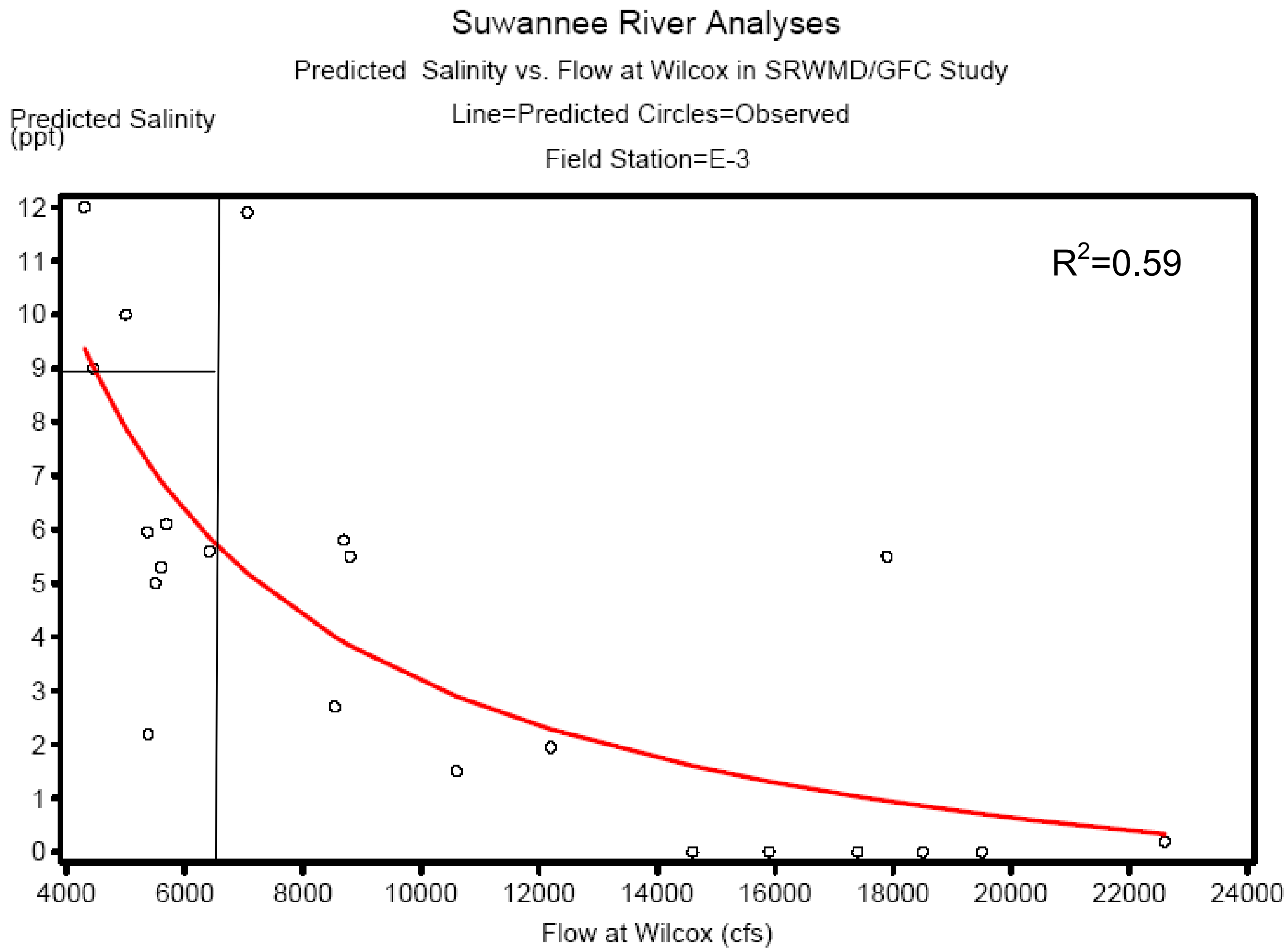


Figure H-11. Regression relationship between predicted salinity and flow for East Pass (fixed station E-3).

References

Estevez, E. D. 2000. Letter report submitted to K. B. Webster describing results of a revisit of SAV sites sampled in 1998-99. Dated September 7, 2000. 29 un-numbered pp.

Estevez, E. D. 2002. Letter report submitted to K. B. Webster describing results of a revisit of SAV sites sampled 1998-99 and 2000. Dated September 11, 2002. 29 un-numbered pp.

Estevez, E. D. and J. Sprinkel. 1999. Dispersion and Abundance of Submerged Aquatic Vegetation in the Tidal Suwannee River, Florida, in relation to Flow, Salinity, and Related Variables. Report submitted to the Suwannee River Water Management District, Live Oak, FL. Mote Marine Laboratory Technical Report No. 648. 48 pp, 2 Tables, 24 Figures, 1 App.

Golder Associates. 2000. Mapping Low-Salinity Submerged Aquatic Vegetation Beds in the Lower Suwannee River. Report submitted to the Suwannee River Water Management District by Golder Associates, Inc., Gainesville, FL. 16 pp, 2 Apps.

Mattson, R. A. and J. T. Krummrich. 1995. Determination of salinity distributions in the upper Suwannee River estuary. Final Report Review Draft. Suwannee River Water Management District, Live Oak, FL. 49 pp., 1 App.

Rozas, L. P. and W. E. Odum. 1987a. Fish and macrocrustacean use of submerged plant beds in tidal freshwater marsh creeks. Marine Ecol. Prog. Series 38: 101-108.

Rozas, L. P. and W. E. Odum. 1987b. The role of submerged aquatic vegetation in influencing the abundance of nekton on contiguous tidal fresh-water marshes. J. Exp. Mar. Biol. Ecol. 114: 289-300.

Thorp, A. G., R. C. Jones, and D. P. Kelso. 1997. A comparison of water-column macroinvertebrate communities in beds of differing submersed aquatic vegetation in the tidal freshwater Potomac River. Estuaries 20(1): 86-95.

Appendix I - Tidal Swamps

Background

- The intertidal areas of the uppermost Suwannee estuary are vegetated with tidal freshwater swamps (Wharton et al., 1982; Clewell et al., 1999; Light et al., 2002) (Figure I-1).
- Tidal freshwater swamps have been identified as the least understood (in terms of quantitative study) coastal wetland ecosystem in the southeastern U.S. (Tiner, 1993; Clewell et al., 1999). Because of this lack of study, these forested wetlands are rarely identified as a distinct wetland community type in Florida west coast rivers, so no data are available to compare the Suwannee to other river systems.
- However, it is probable that the lower Suwannee River supports the most extensive acreage of this wetland type on the Florida gulf coast. Likewise, the habitat values of these swamps have not been studied or quantified. It is known that they provide important nesting habitat for Swallow-tailed kites in the Lower Suwannee Refuge (Sykes et al., 1999). The abundance of fiddler and shore crabs in these swamps suggests they may provide important forage habitat for crab-feeding birds, such as Yellow-crowned night heron and Little green heron, and mammals such as raccoon and mink. The leaf detritus produced in these swamps is likely an important allochthonous food base for the downstream estuarine aquatic communities.
- Light et al. (2002) and Darst et al. (2003) mapped 6,652 acres (2,692 ha) of tidal freshwater swamps in the upper estuary, corresponding to their "Lower Tidal Swamp 1 and Swamp 2" forest types. Most of these are flooded daily by high tides. An additional 2,572 ac (1,041 ha) of Lower Tidal Mixed forest was also mapped. These are flooded during the higher spring tides each month. The "Lower Tidal" reach identified by Light et al. is regarded as the tidal freshwater portion of the Suwannee estuary (after Odum et al., 1984). Dominant trees include bald and/or pond cypress, pumpkin ash, swamp tupelo, cabbage palm, sweet and swamp bay, and red maple (Light et al., 2002; Clewell et al., 1999; Wharton et al., 1982).
- The potential for significant harm to tidal freshwater swamps should be assessed by considering changes in salinity which might cause undesirable shifts in species composition of canopy, sub-canopy, or groundcover plant communities to those of a more saline community type; loss of canopy species from the swamps; encroachment of plants or animals indicative of higher salinity conditions into upstream areas where they have not previously been observed or recorded; the potential for unacceptable upstream movement of the tree line denoting the demarcation between tidal marsh and tidal freshwater swamp; or loss of acreage of tidal swamps or changes in acreage of swamp forest types.

Objectives

- To evaluate how the relationship between flow and salinity affects the habitat suitability of tidal swamps in the Lower Suwannee River.
- To estimate risk to suitable tidal swamp habitat based on alterations to the flow regime (flow reductions).

Data Sources

- Daily average discharge data was obtained for the United States Geological Survey (USGS) gage number 02323500 (Suwannee near Wilcox) from 1984-2004. Daily lags were calculated to 15 days, lag averages to 90 days, cumulative flows to 8 days and transformations of flows (e.g. logarithmic, inverse, square root). Salinities could then be related to various antecedent flows as well as the sample date flows at Wilcox.

- Salinity data collected by the FWCC in 1993-1994 were used to develop regression models relating flow at Wilcox to the location of the 2 ppt isohaline.
- Tidal swamp habitat data were collected by Light et al. (2002).
    - Light et al. (2002) identified a "Lower Tidal" reach of the lower Suwannee study area which for purposes of this report is considered to be the tidal freshwater zone of the upper Suwannee estuary. Six intensive study transects were established in forests of the Lower Tidal reach. The transects were belt transects, with a width of 16.5 feet (5 meters) if over 1,320 feet (400 meters) in length and a width of 33 to 42.9 feet (10 to 13 meters) if less than 1,320 feet long. These judgments were made by the investigators based on their experience in forested wetland sampling in order to obtain a large enough sample of trees to census. Detailed descriptive data on the locations of the transects is provided in Lewis et al. (2002). The locations of the intensive study transects were all on public land and were not made in a completely random fashion. Transects had to be located on public land for two main reasons: so that permanent transects could be established which could be visited reliably in the future (eliminating the possibility that a future landowner on private lands would bar access); public land typically had the best examples of reasonably intact, minimally impacted wetland forest, which would remain so in the future.
    - By distributing the transects at upstream, middle and downstream ends of the Lower Tidal Reach, and by extending transects across a wide range of topographic and soils conditions (from the river bank to upland), as much range of variability as possible was captured. The data from the intensive transects were supplemented with plant community and soils observations at 150 additional observation sites (some systematically selected, some randomly selected). The data from these supplemental sites verified the information derived from the transects, and thus the data from the transects is considered to reasonably describe the range of conditions and forest types found in the upper Suwannee estuary.
    - Land surface elevations along each transect were determined using a surveyor's level and rod. Elevation measurements were made approximately every 16.5 feet (5 meters) and also at locations of topographic breaks, at the edge of standing water, and other "points of interest". Elevations along each transect were tied to a temporary benchmark which was eventually referenced to the National Geodetic Vertical Datum (NGVD) by a licensed professional surveyor. All elevation data were then referred to this datum. Horizontal locations were measured using a portable Precise Lightweight Global Positioning System Receiver with a typical accuracy under tree cover of 19.8 to 49.5 feet (6 to 15 meters) and fiberglass measuring tapes.
    - Hydrologic data in the study area were derived from seven continuous record USGS surface water gage sites as shown in Table 3 in Light et al. (2002). As indicated in Section 3.1.4, most of the flow data used in the floodplain wetland study came from the Branford and Fort White gages. The other five gages were primarily used to supply stage data for construction of rating curves on each transect. Additional water level

measurements were made by tape-down from reference points ("RP's") established at the river bank end of each transect and in selected surface water features (creeks, sloughs, floodplain ponds) on each transect. These were nails driven into trees and marked with a metal tag. Over the course of the study, about 400 separate water level measurements were made at the transects under a wide range of hydrologic conditions.

- Soils data were collected on all intensive study transects to generally characterize soil types associated with the different forest types. The number of borings per transect ranged from 8 to 13 on longer transects and 3 to 6 on shorter transects. Soil profiles were described to a depth of 5 to 6.6 feet (1.5 to 2 meters), typically using a 3 inch bucket auger. Soil profiles were also examined in a few cases with a 1 inch coring tube sampler or a 108 inch muck probe. Soil moisture was also evaluated at all transects and observation sites as dry, saturated, or inundated. Inundation meant the soil was covered with standing water. Saturation was evaluated by firmly squeezing a handful of soil. If free water was squeezed out, the soil was considered saturated. Approximately 600 soil moisture observations were made over a wide range of hydrologic conditions. 21 surface soil samples and 11 subsurface soil samples were collected for salinity analyses, which were conducted by the National Soil Survey Center in Nebraska.
- Vegetation sampling was divided into three strata; canopy, subcanopy, and shrub/groundcover. A canopy plant was defined as a woody plant with a stem diameter at breast height (dbh; 1.4 meters above ground surface) of $\geq$4 inches (10 cm) and a height of 10 feet (3 meters) or taller. Sub-canopy plants were those woody plants with a dbh of 0.8 to < 4 inches (2 to 9.9 cm) and a height $\geq$10 feet (3 meters). Woody plants smaller than this and all herbaceous plants were considered part of the shrub/groundcover layer. The dbh of all canopy and sub-canopy plants was measured on each belt transect using a pair of calipers. Trees with swollen bases or buttressing were measured above the swelling. Estimates of percent cover of groundcover were made as well. Tree species identifications were made in the field concurrent with each dbh measurement. Where necessary to confirm identification, leaves, seeds, branches, etc. were collected for subsequent examination in the laboratory.
- In addition to the field studies, forested wetland communities were mapped using NAPP digital ortho-photo quadrangles taken in 1994. These were false-color infrared images at a scale of 1:40,000. Initially, photo signatures were related to plant communities on the intensive study transects. A decision matrix was developed based on canopy composition to make a determination of a particular forest type (Table 6 in Light et al., 2002). Once the specific signatures of all the forest community types on the photos was confirmed, the remainder of the floodplain was mapped. Classification accuracy of the mapping was determined by visiting 111 randomly-selected verification sites, in conjunction with the decision matrix.
- *Results*. Rating curves were developed for each intensive study transect, relating river stage at the transect to flows at Branford-Fort White. These formed the basis for understanding the hydrology associated with each forest type and for evaluating the impacts of potential flow reductions.

First, rating curves were developed for selected long-term gages using continuous daily values of stage at the gage related to daily flow at Branford-Fort White. Appropriate time-lags were determined and a line fit to aggregated daily values of flow and stage (in increments from 1,000 to 90,000 cfs). Then, the transect ratings were developed by linear interpolation using river mile distances.

- Light et al. (2002) identified four different forest types in the upper estuary; Lower Tidal swamps 1 and 2 (LTsw1 and 2), Lower Tidal mixed forest (LTmix), and Lower Tidal hammock (LTham = hydric hammock). The swamps were flooded daily by high tides, with the mixed forests being flooded several times a month during the spring tides at the full and new moons. Hammocks were occasionally flooded by river flooding. Soils in all lower tidal forest types were primarily continuously saturated mucks, with some sand in the hammocks.
- Light et al. (2002) considered salinity the primary limiting factor influencing the community structure of the lower tidal forests and in setting the downstream limit of the "tree line", where tidal forest grades into tidal marsh. Salinity came from several sources; intrusion of saline water via the river channel at low flows, marine aerosols, and deposition of salt water from storm surges during hurricanes and tropical storms. Maximum salinities in isolated standing water on the Barnett Creek transect ranged from approximately 2 to 5 ppt, but fell to zero during a flood event in 1998. Salinities of up to 2 ppt were measured in isolated standing water on the Sandhill Hammock transect. Subsurface soil conductivities were generally equivalent to or higher than surface soil conductivities (Light et al., 2002).

Isohaline Selection

- Important considerations for development of freshwater inflow criteria which provide for the protection of tidal freshwater swamps included maintaining the tree canopy composition in the Lower Tidal Swamp and Mixed forest types. Some information is available on the salinity tolerances of some of the dominant trees in these swamps.
    - Pezeshki et al. (1987) found that bald cypress seedlings exhibited reduced photosynthetic rates and stomatal conductance at salinities of 2 ppt and higher. Progressively greater reductions in these physiological responses were seen up to 7 ppt. Leaf yellowing (chlorosis) was observed in seedlings in all salinity treatments.
    - Williams et al. (1998) demonstrated that seedlings of elm, Florida maple, and sweetgum exhibited reduced survival at 2 ppt and little or no survival at 4 ppt and higher. Cabbage palm, red cedar, and live oak exhibited reduced survival at 4 ppt and higher (Williams et al., 1998). Based on their work evaluating the effects of sea level rise on coastal wetland forests, Williams et al. (1999) inferred that adult trees were more salt tolerant, based on the existence of "relict" stands in areas of higher salinity, and that dieback of the forests occurred first due to elimination of seedling recruitment.
    - Based on the above, average salinities of high tide waters flooding the swamps should be kept $\leq$2 ppt, with briefer periods of higher salinity tolerable.

- Based on available electroshocking data collected in East Pass by the FWCC, the fish communities in the river channel associated with the distribution of tidal freshwater swamp appear to be dominated by freshwater fish taxa.
- The tree line in East Pass is located near their Station E4. The proposed salinity target of 2 ppt appears to be adequate to maintain the structure and function of these freshwater fish communities in the upper estuary. The fish data indicate that the proposed salinity target would allow for the persistence of a fish community still dominated by freshwater taxa, suggesting that the fauna associated with the swamps should be sustained.

Analytical Steps

- A prediction equation was developed for the location of the 2 ppt isohaline in the LSR as a function of flow using regression. The prediction equation was used to estimate the isohaline location under various flow conditions.
- River locations associated with 0 to 15% of the total cumulative tidal swamp habitat were identified as risk points using GIS.
- The regression equation was applied to solve for the flow required to keep the 2 ppt isohaline at specified risk point locations.

Regression Results

- Regressions were developed by pass in the LSR and relationships tested for differences in intercept and slopes (Figures I-2 through I-4).
- The inverse of flow was the best predictor of isohaline location for the 2 ppt regression (Figures I-2 through I-4).
- No statistical differences were observed in the flow isohaline relationships by pass, allowing a model to be developed for the whole river, irrespective of the different passes of the river.
- The risk to tidal swamp habitat with exposure to salinities above 2 ppt was evaluated based on calculations of the cumulative amount of shoreline lined by tidal swamp. Shoreline length was used instead of total area of tidal swamp coverage due to the large area of swamp located up to 1 mile away from the shore (Figure I-5).
- The highest rate of change in tidal swamp habitat loss was observed for flows less than 6,500 cfs (Figure I-5).

References

Clewell, A. F., R. S. Beaman, C. L. Coultas, and M. E. Lasley. 1999. Suwannee River Tidal Marsh Vegetation and its Response to External Variables and Endogenous Community Processes. Final Report. Report prepared for the Suwannee River Water Management District, Live Oak, FL. 119 pp., 15 Appendices.

Darst, M. R., H. M. Light, L. J. Lewis, and A. Sepulveda. 2003. Forest Types in the Lower Suwannee River Floodplain, Florida. A Report and Interactive Map. U.S. Geological Survey Water-Resources Investigations Report 03-4008. CD-ROM.

Light, H. M., M. R. Darst, L. J. Lewis, and D. A. Howell. 2002. Hydrology, Vegetation, and Soils of Riverine and Tidal Floodplain Forests of the Lower Suwannee River, Florida, and Potential Impacts of Flow Reductions. U. S. Geological Survey Professional Paper 1656A. 124 pp.

Odum, W. E., T. J. Smith, III, J. K. Hoover, and C. C. McIvor. 1984. The ecology of tidal freshwater marshes of the United States east coast: a community profile. U. S. Fish Wildl. Serv. FWS/OBS-83/17. 177 pp. http://cuadra.nwrc.gov/Techrept/83-17.pdf

Pezeshki, S. R., R. D. DeLaune, and W. H. Patrick, Jr. 1987. Response of baldcypress (*Taxodium distichum* L. var. *distichum*) to increases in flooding salinity in Louisiana's Mississippi River deltaic plain. Wetlands 7(1): 1-10.

Sykes, P. W., Jr., C. B. Kepler, K. L. Litzenberger, H. R. Sansing, E. T. R. Lewis, and J. S. Hatfield. 1999. Density and habitat of breeding swallow-tailed kites in the lower Suwannee ecosystem, Florida. J. Field Ornithology 70(3): 321-336.

Tiner, R. W. 1993. Field Guide to Coastal Wetland Plants of the Southeastern United States. Univ. of Massachusetts Press, Amherst, MA. 328 pp.

Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Snipe. 1982. The ecology of bottomland hardwood swamps of the southeast: a community profile. U. S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-81/37. 133 pp. http://cuadra.nwrc.gov/Techrept/81-37.pdf

Williams, K, K. C. Ewel, R. P. Stumpf, F. E. Putz, and T. W. Workman. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida, USA. Ecology 80(6): 2045-2063.

Williams, K., M. V. Meads, and D. A. Sauerbrey. 1998. The roles of seedling salt tolerance and resprouting in forest zonation on the west coast of Florida, USA. Am. J. Bot. 85(12): 1745-1752.

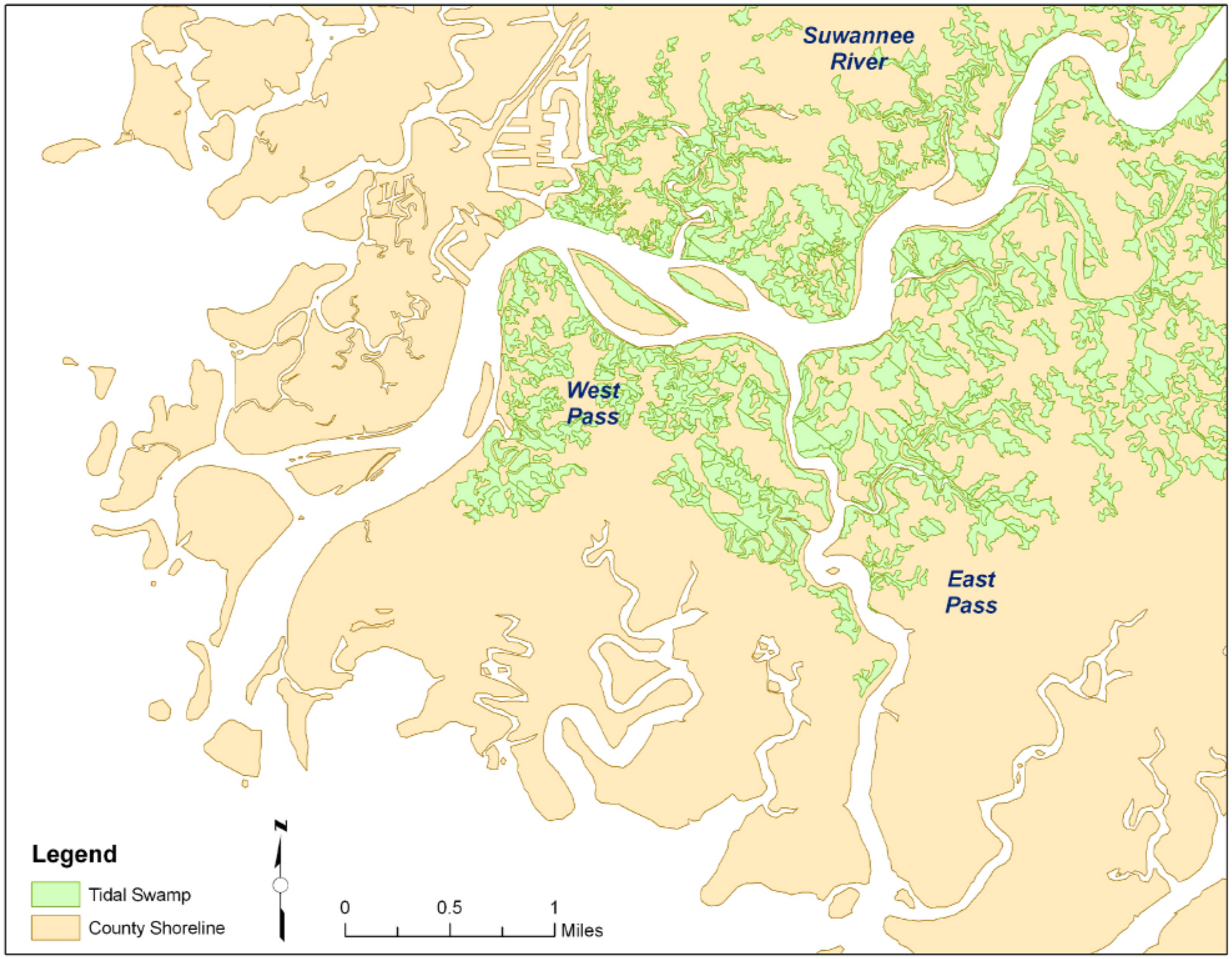


Figure I-1. Distribution of tidal swamp habitat in the Lower Suwannee River.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	23.24038629	23.24038629	44.43	<.0001
Error	29	15.16782692	0.52302851		
Corrected Total	30	38.40821321			

R-Square	Coeff Var	Root MSE	Mean isohaline_rmile
0.605089	25.90111	0.723207	2.792185

Source	DF	Type III SS	Mean Square	F Value	Pr > F
InvFlow	1	23.24038629	23.24038629	44.43	<.0001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.39823	0.381903	1.04	0.3057
InvFlow	14911.54424	2236.987892	6.67	<.0001

Figure I-2. Regression results for the 2 ppt surface isohaline regression developed for the whole river.

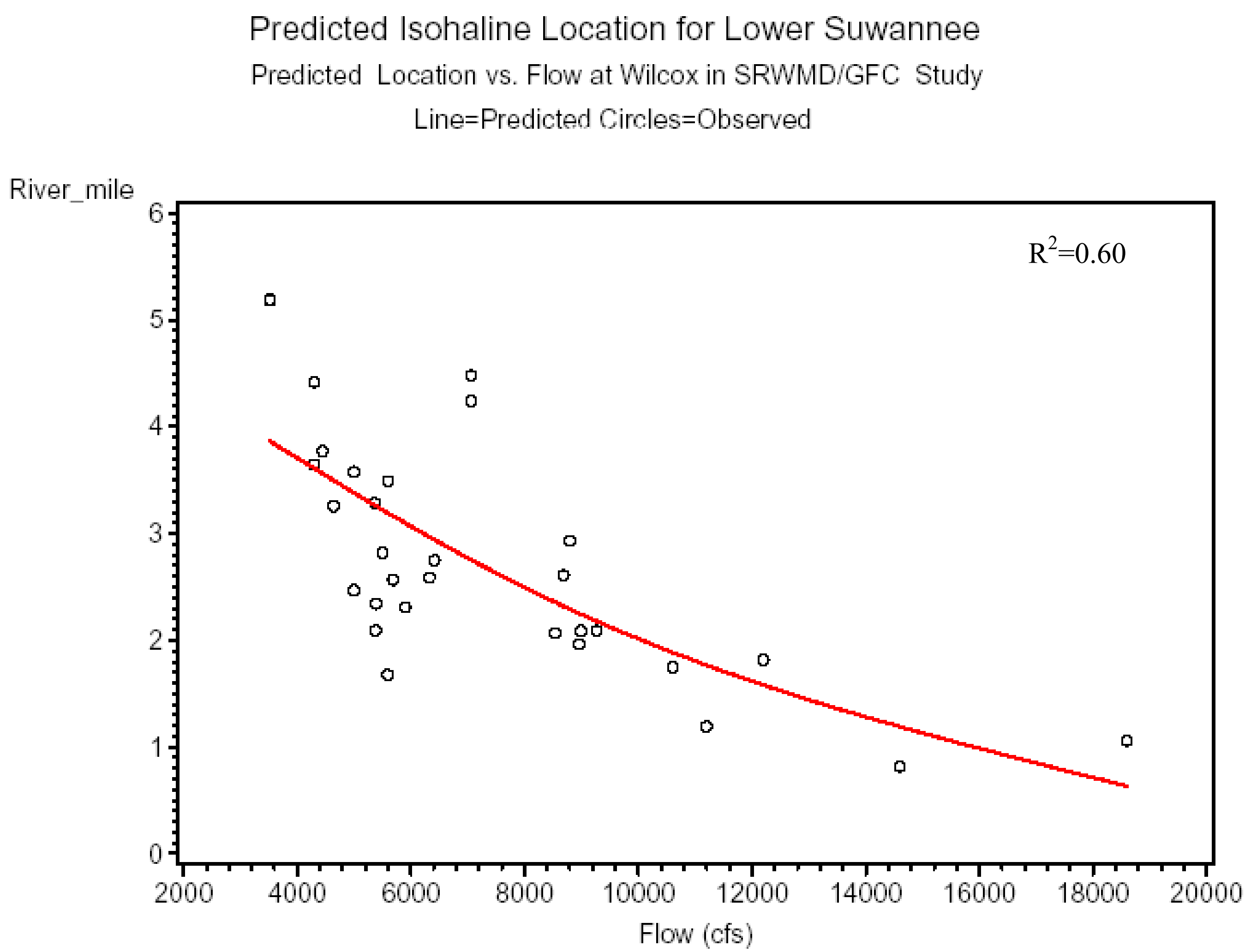


Figure I-3. Regression plot showing the location in river mile of the 2 ppt isohaline as a function of flow.

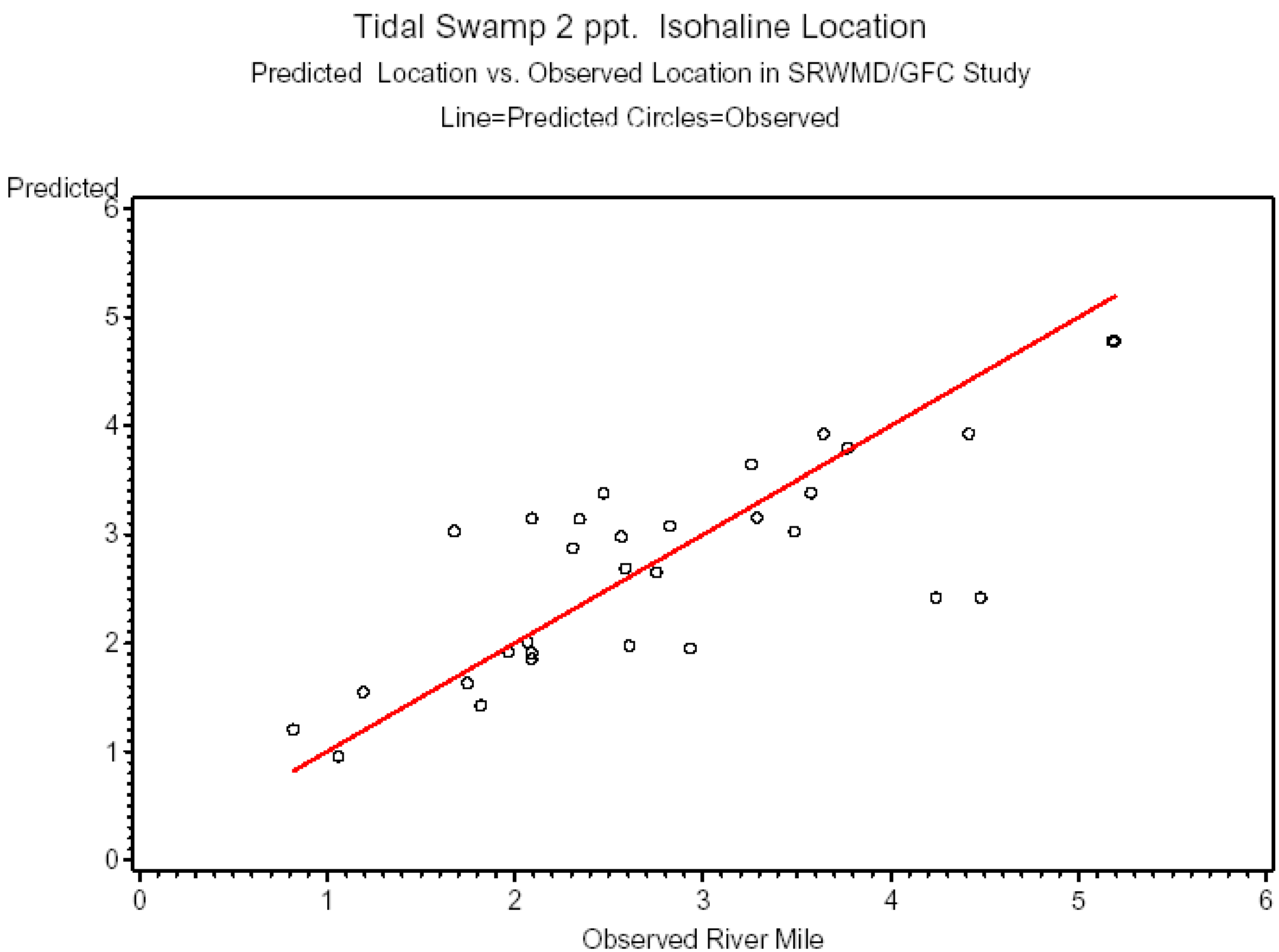


Figure I-4. Relationship between predicted and observed river mile for the 2 ppt isohaline regression

.

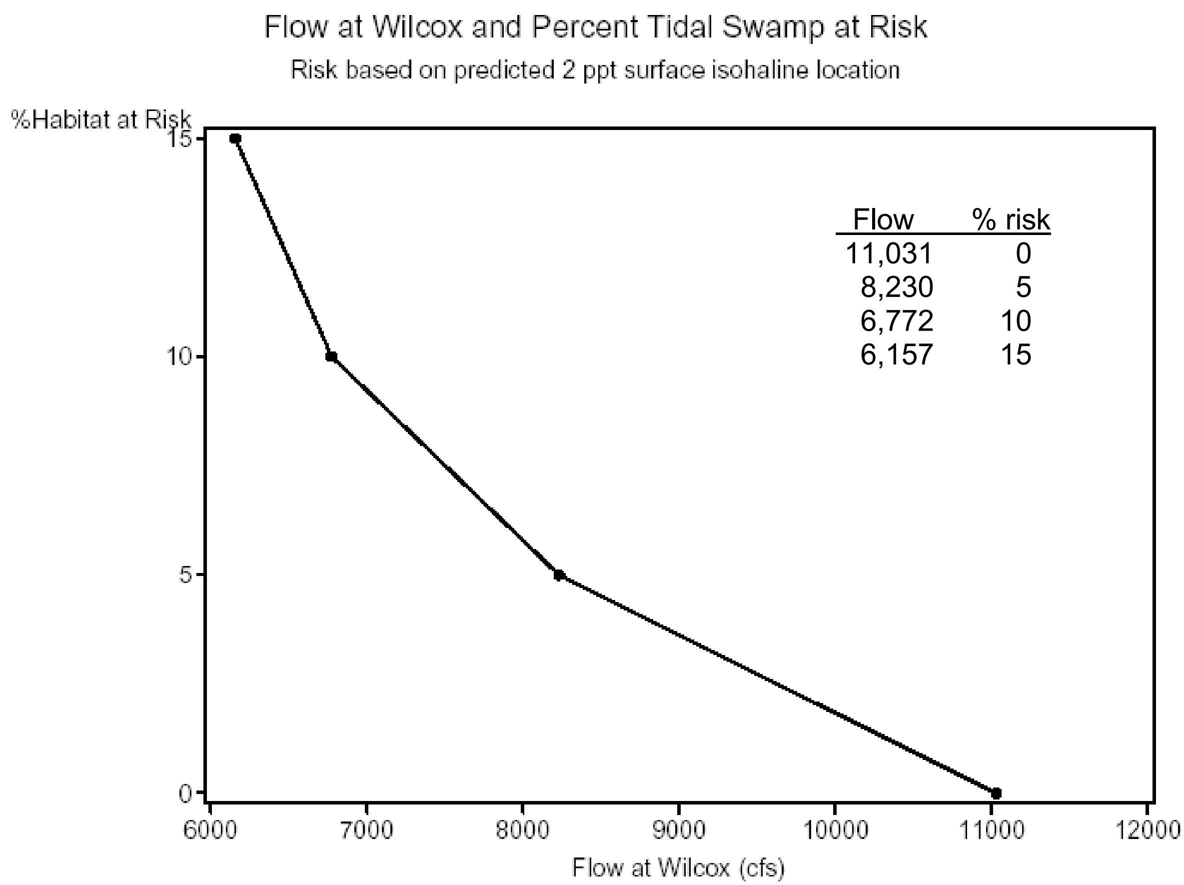
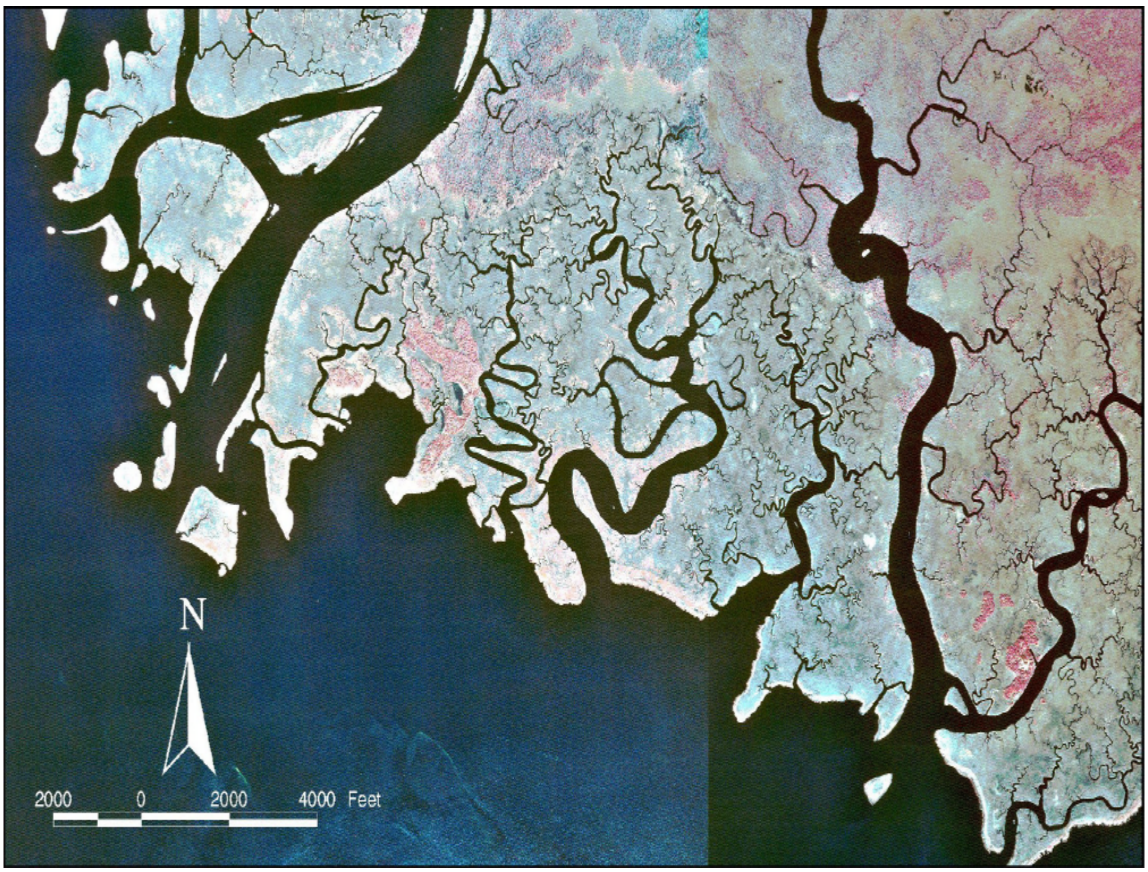


Figure I-5. Relationship between percent of habitat risk for tidal creeks and flow, based on the predicted location of the 2 ppt isohaline.

Appendix J - Tidal Creek



Background

- In addition to the main stem of the river, tidal creeks (Figure J-1) and adjacent marshes provide important habitat for estuarine organisms, including resident and estuarine-dependent fish and invertebrate species (i.e. shrimp, blue crab) (Tsou and Matheson, 2002). Additionally, tidal creeks and marshes provide feeding grounds for wading birds (Montague and Odum, 1997; Montague and Weigert, 1990).
- The potential for significant harm to tidal creek habitat is related to changes in salinity, which is based on the flow and resultant salinity in the river, as well as freshwater run off from the watershed. Changes in salinity could result in alterations to the natural populations of fauna or flora, including changes to diversity, species richness, abundance and productivity. Additionally, harm would occur if exposure occurred which would involved loss of habitat of previously submerged habitats (e.g., SAV or oyster beds).

Objectives

- To evaluate how the relationship between flow and salinity affects tidal creek habitat suitability in the Lower Suwannee River.
- To estimate risk to tidal creek habitat based on alterations to the flow regime (flow reductions).

Data Sources

- Daily average discharge data were obtained for the United States Geological Survey (USGS) gage number 02323500 (Suwannee near Wilcox) from 1984-2004. Daily lag flows were calculated to 15 days, lag averages to 90 days, cumulative flows to 8 days and transformations of flows (e.g., logarithmic, inverse, square root).
- Salinity data collected by the FWCC in 1993-1995 were used to develop regression models relating flow at Wilcox to the location of the 5 ppt isohaline.
- SRWMD created a detailed coverage of tidal creeks on the Hog Island delta and fringing East and West passes up to the Gopher River. The centerline of all tidal creeks on Hog Island and fringing East and West passes was delineated, using 1999 USGS digital ortho-photos. The shorelines of the passes were also delineated and this was overlain with another coverage, segmenting the passes into 0.25 mile increments.
- Juvenile fish data from the FWCC Fisheries Independent Monitoring Program, collected between 1997 and 2003, were used to evaluate and determine a critical salinity for subsequent analysis.

Biologically-Based Salinity Zone Classification

- Tidal creeks are abundant in the Lower Suwannee River (Figure J-1) and many estuarine and estuarine-dependent species (e.g., red drum, mullet, pinfish) are known to recruit to low salinity tidal creek habitats as juveniles.
- Different groups of fish have different salinity tolerances and/or preferences. Within an individual fish species, size classes representing different life history stages may have different salinity requirements.
- Biologically-based salinity zones were established for the Lower Suwannee River using catch data from the Fisheries Independent Monitoring Program and PCA analysis (Figure J-2). Emphasis was placed on identifying the lower salinity

ranges and fish that may have preferences for low salinity habitat (Bulger et al. 1993) .

- A zone consisting of species only captured in fresh water was identified.
- A second zone with salinities from 1 to 5 ppt was also identified. This zone represents an oligohaline group of species that is of special interest with regard to MFL establishment.
- The other groups are representative of more euryhaline and marine species that would likely be highly adaptable to salinity changes in the tidal creeks.
- Analysis of similarity was used to identify fish species contributing to the dissimilarity between the fresh and oligohaline groups.
- These species represented important recreational and commercial species as well as key forage fishes for the top level piscivores; species include spotted seatrout, mullet, blue crab, red drum, flounder, spot, pinfish, largemouth bass, redear sunfish ,and bluegill among others.

Analytical Steps

- A prediction equation was developed for the 5 ppt isohaline regression to represent the tolerance threshold for the oligohaline group of fish (Figures J-3 through J-5)..
- Cumulative tidal creek connections were calculated, based on SRWMD mapping, and converted from a kilometer to a river mile system.
- The river mile associated with various percentages of habitat risk, ranging from 0 to 15 by 5% increments, were applied to the inverted regression equation (Figure J-6). This was done to determine the flows required to keep the 5 ppt surface isohaline at the river mile associated with each increment of habitat risk.

Regression Results

- The 5 ppt surface isohaline regression can be used to predict isohaline location in LSR and can relate the location of the spring tide intrusion of the isohaline to flow in the Suwannee River (Figures J-3 through J-5).
- Establishing the relationship between the 5 ppt isohaline as a function of flow was complicated by the dynamics of the estuarine system near the mouth of each pass. Limited sample size and large variability in location of the isohaline for a given flow condition also played a role in the limitations of the regressions.
- Antecedent flows, specifically the average flow of the week prior to the sample collection date, was incorporated into the analysis to capture some of the variation associated with the effects of previous days flow

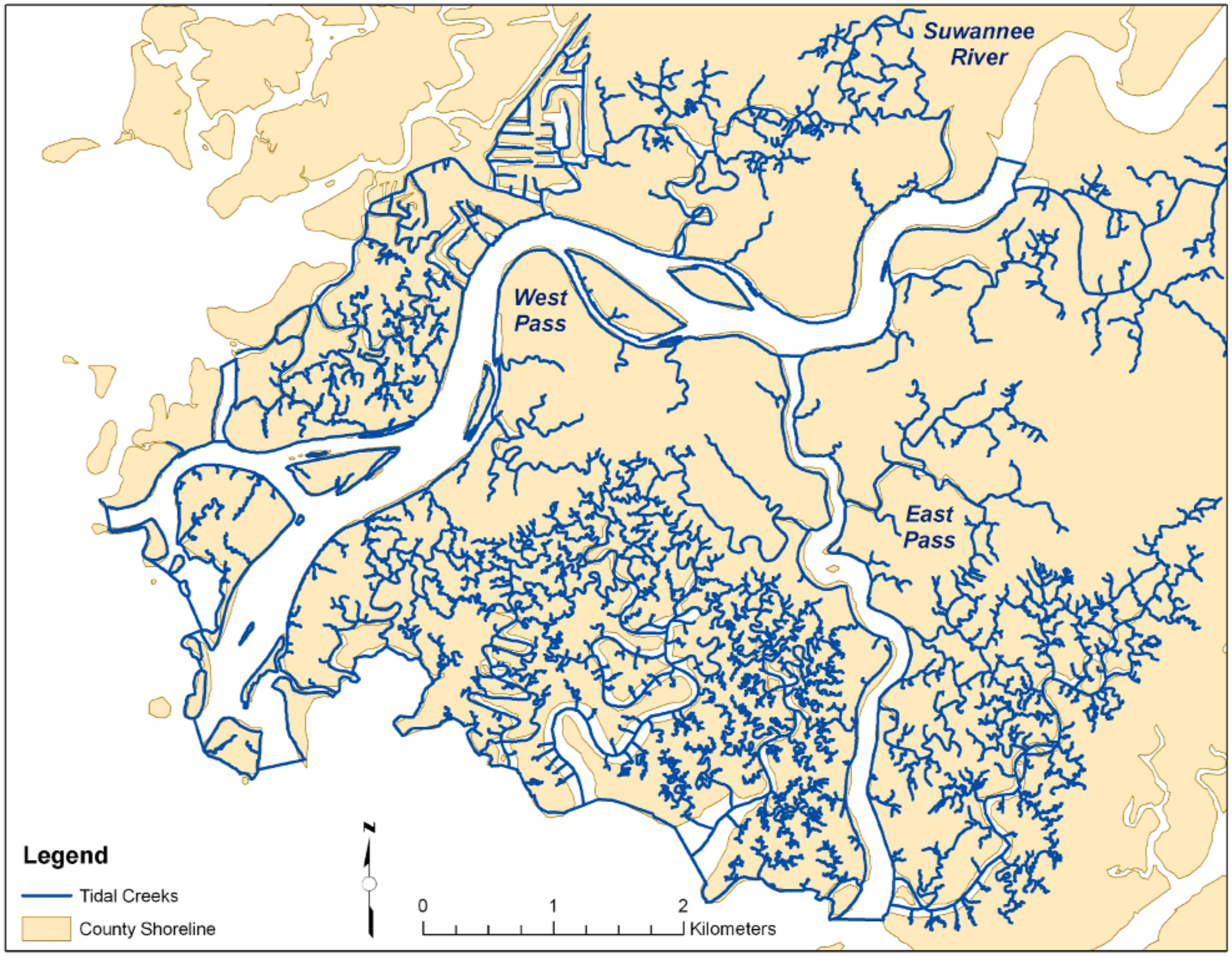


Figure J-1. Network of tidal creek habitat located in the Lower Suwannee River.

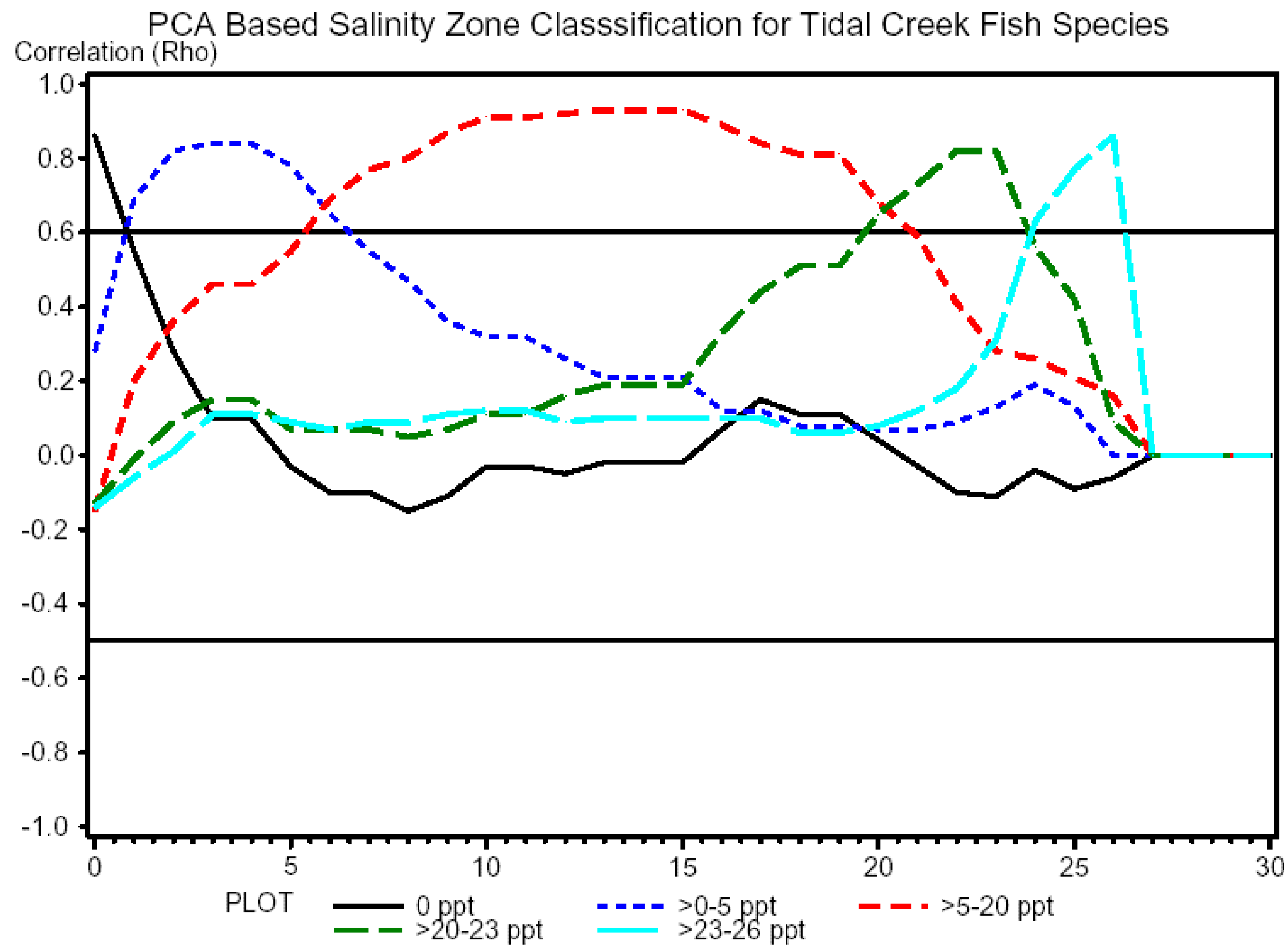


Figure J-2. Salinity zone classification for tidal creek fish species based on results of Principal Components Analysis (PCA).

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	10.74516429	5.37258215	20.63	<.0001
Error	23	5.98850982	0.26036999		
Corrected Total	25	16.73367411			

R-Square	Coeff Var	Root MSE	isohaline_rmile Mean
0.642128	24.37049	0.510265	2.093781

Source	DF	Type III SS	Mean Square	F Value	Pr > F
InvFlow	1	8.72666554	8.72666554	33.52	<.0001
Average 8 days flow	1	3.57460303	3.57460303	13.73	0.0012

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-3.08548	1.027787	-3.00	0.0064
InvFlow	20910.06801	3611.825374	5.79	<.0001
Average 8 days flow	0.00023	0.000062	3.71	0.0012

Figure J-3. Regression results for the 5 ppt surface isohaline regression developed for the whole river.

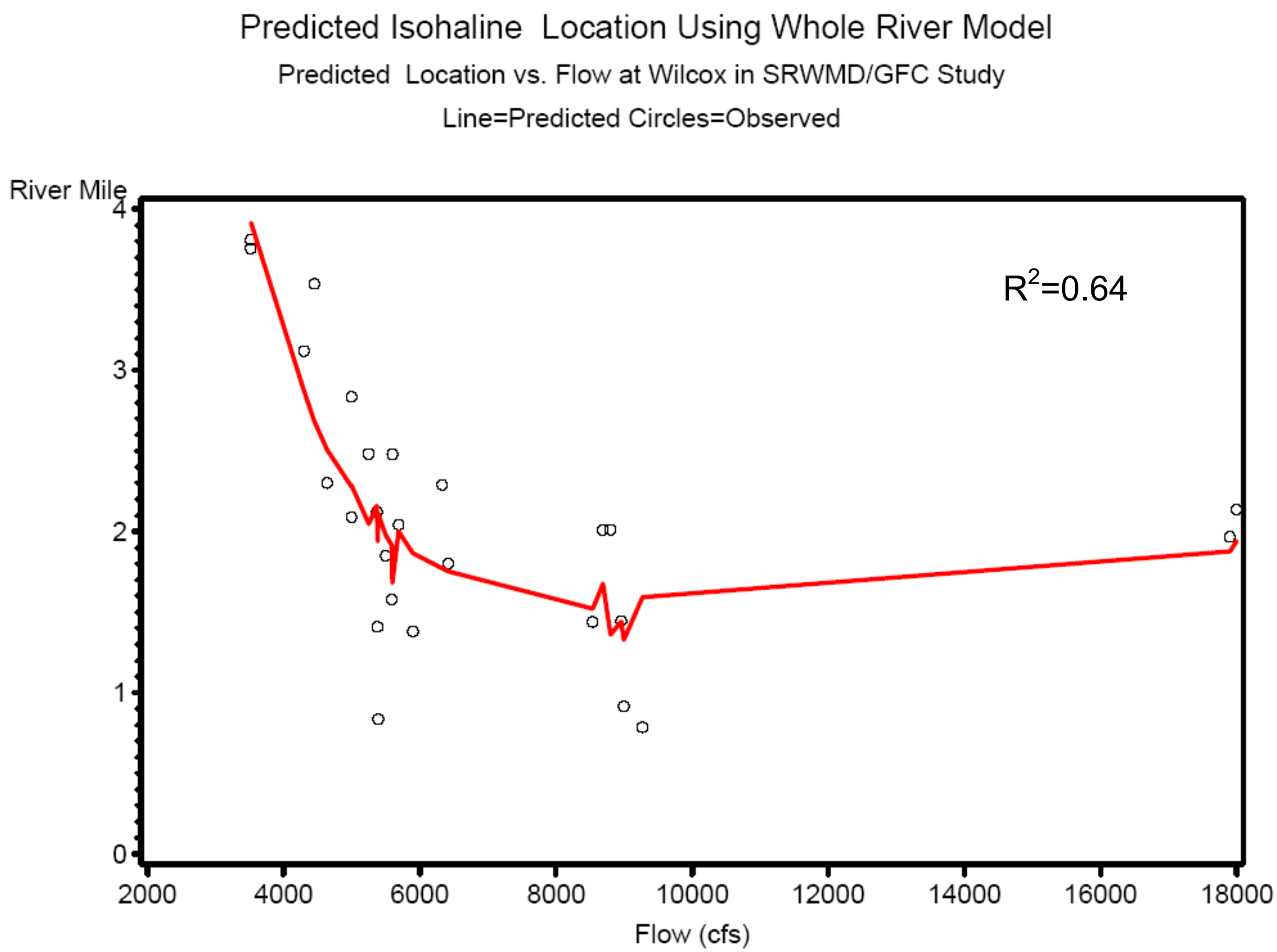


Figure J-4. Regression plot showing the location in river mile of the 5 ppt isohaline as a function of flow.

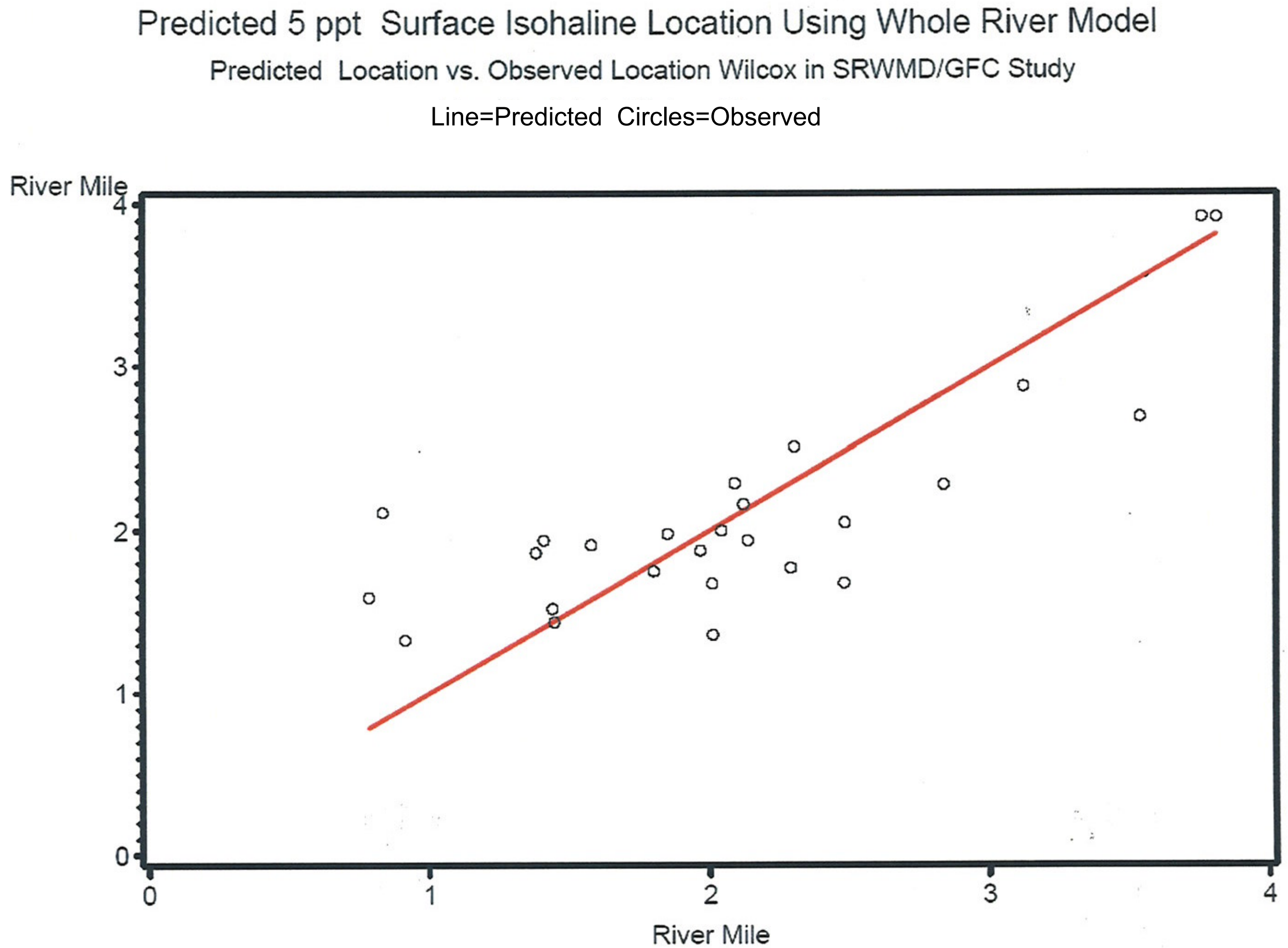


Figure J-5. Relationship between predicted and observed river mile for the 5 ppt isohaline regression.

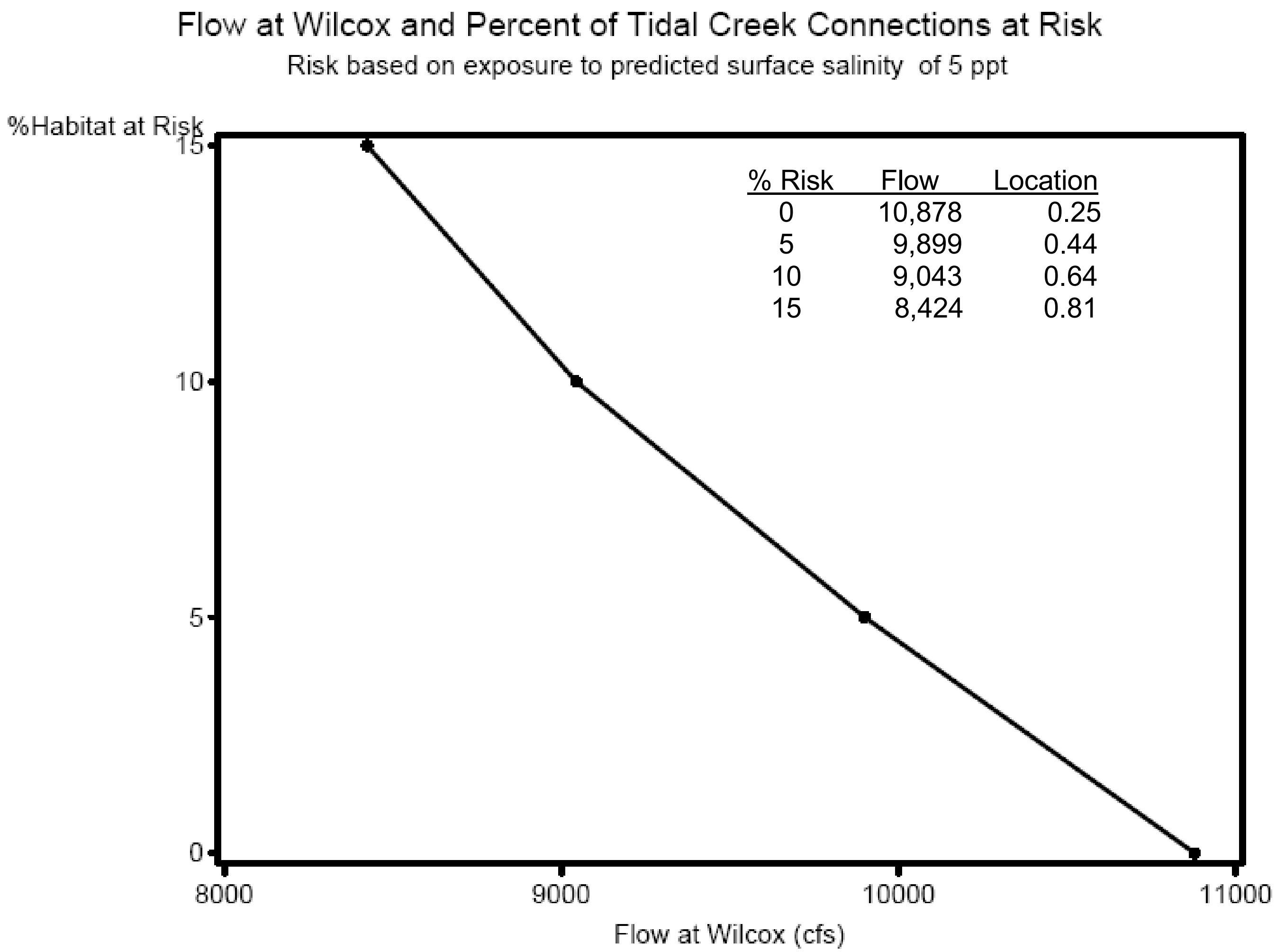


Figure J-6. Relationship between percent of habitat risk for tidal creeks and flow, based on the predicted location of the 5 ppt surface isohaline.

Appendix K - Oysters

Background

- In the Suwannee Sound and in tidal creek areas in the lower river, the principal habitat which provides structure is oyster bars and reefs. These are composed primarily of the eastern oyster (*Crassostrea virginica*), with two species of mussels (*Brachidontes sp.* and/or *Ischadium recurvum*) as secondary member of the reefs.
- Oysters are a harvestable economic resource and based on statistics reported for 2001, the Suwannee River estuary was the second largest oyster producing area in Florida, with Apalachicola Bay being the first most productive (FWC website www.floridaconservation.org).
- In addition to, and perhaps exceeding the economic importance of oysters, is the value of oyster habitat for estuarine invertebrates and fishes (Bahr and Lanier, 1981). Biomass and diversity of crustaceans has been reported to be higher in oyster reef habitat (Glancy 2000) and oyster reefs provide an important food base for recreationally important fish species (Pattillo et al. 1997).
- The potential for significant harm to oyster habitat is related to flow induced changes in salinity which would cause alterations to the natural populations of invertebrates associated with oyster habitat (i.e. species richness, diversity, abundance, productivity, etc.) alterations in oyster reef characteristics (juvenile, subadult, or adult oyster density or cover) due to exposure to high salinities, or the potential loss of acreage of oyster habitat.

Objectives

- To evaluate how the relationship between flow and salinity affects oyster habitat in the Lower Suwannee River.
- To estimate risk to suitable oyster habitat based on alterations to the flow regime (flow reductions).

Data Sources

- Daily average discharge data was obtained for the United States Geological Survey (USGS) gage number 02323500 (Suwannee near Wilcox) from 1984-2004. Daily lags were calculated to 15 days, lag averages to 90 days, cumulative flows to 8 days and transformations of flows (e.g. logarithmic, inverse, square root).
- Salinity data to evaluate oyster habitat characteristics were provided by the FDACS Shellfish Environmental Assessment Section (SEAS).
    - SEAS data consisted of 137 fixed sites (not all sites were used in analysis) throughout the Suwannee Sound that were established in 1989 and data collection efforts are still ongoing (Figure K-1).
    - Salinity data were collected in conjunction with bacteriological monitoring in shellfish harvesting areas.
- Oyster data in the Suwannee River estuary were collected by Baker et al. (2003) with the objective to evaluate characteristics of oyster habitat where it occurred and relate it to salinity.
    - Consideration in sample site selection included distributing sites across a range of salinity regimes, from those near the river mouth exposed to freshwater part of the time to those located far from the freshwater discharge from the river. The 36 sample sites were also distributed across three reef 'strata': inshore bars at tidal creeks, middle reefs (Lone Cabbage and Half Moon), and outer reefs (Suwannee Reef).
    - Study sites were sampled during low tides. Several types of sampling were conducted at each study site. First, the site was divided into high intertidal and

low intertidal strata. This was determined based by inspection in the field at each sampling site; the “break” typically occurring at the reef crest. Locations of sampling quadrats at each site were determined randomly by proceeding in a random direction (right or left) along the tidal stratum for a randomly determined distance from 1-10 meters. Live oyster cover was determined using a minimum of six replicate samples (more if cover was very sparse). Cover was determined using a 1 m^2 grid divided into 100 subsections 10 by 10 cm each in area. Cover was measured by counting the number of subsections lying over live oyster and expressing as a proportion of 100. Oyster density was measured using a 0.25 m^2 quadrat (1 m^2 where live cover/density was very sparse), from which all live oyster was harvested down to dead shell. Live oysters were counted as adult ($\geq$ 76 mm shell length), sub-adult (50 to <76 mm shell length), and juvenile ($\geq$25 to <50 mm shell length). Counts of four major oyster reef associate animals were also made in the oyster density quadrats: the mussels *Brachiodontes* spp. and *Ischadium recurvum*, and the crabs *Eurypanopeus depressus* and *Petrolisthes armatus*.

  - Oyster community parameters were related to salinity using data from the SEAS monitoring program collected 2000-2002 and data from Phlips and Bledsoe (2002) collected in the estuary in 1999-2001. Monthly surface salinity measurements from these studies were incorporated into a GIS coverage of the salinity sampling sites. Surface salinity was used since depths in much of Suwannee Sound are quite shallow and these data reflected the salinities that the oyster reefs were most exposed to (Baker et al., 2003). ArcGrid® was used to generate salinity contours using the field data, and salinity characteristics at each individual oyster study site were estimated from this coverage by interpolation using the inverse distance-weighted method. Mean salinity for the periods 12 months and 24 months prior to the oyster survey was determined for comparison with oyster reef community characteristics.

Isohaline Selection

- Based on the oyster field data from the Suwannee estuary, it will be important to maintain an adequate area of habitat with mean annual salinities of $\leq$20 ppt in order to maintain the existing coverage and health of oyster reefs in the estuary.
- Additionally, literature values support 20 ppt as a threshold value for salinity.
  - Baker et al. (2003) evaluated oyster habitat characteristics in the Suwannee estuary in relation to salinity and relative tidal elevation. They found highest oyster habitat characteristics (% cover, juvenile, sub-adult, and adult density) occurred at mean salinities <20 ppt, for periods 1 year and 2 years prior to their survey (Baker et al., 2003).
  - Burrell (1986) recommended that “moderate salinities (those less than 15 ppt)” be maintained for “a significant period during the year” to exclude most oyster predators and diseases and maintain oyster reef community structure.
  - Stanley and Sellers (1986) indicated that highest oyster abundance in Gulf of Mexico oyster populations occurred between 10-20 ppt.
  - Oyster reefs with highest densities in Apalachicola Bay were found where mean salinities were 20-23 ppt (Livingston et al., 2000). This appeared largely due to exclusion of dominant oyster predators (Livingston et al., 2000).

Analytical steps

- Salinity zones for Suwannee sound were identified by analyzing covariance patterns for stations using Principal Components Analysis (PCA).
- Principal Components Analysis led to the establishment of three salinity zones; River, Inshore Reef and Offshore.
- Salinity-flow regressions were developed to predict the median surface salinities for each of the three regions (offshore, reef, river groups) identified by PCA as a function of flow at Wilcox (Figures K-2 through K-5). To account for tidal influence on the salinity-flow relationship, only samples collected after 1996 were used for the regression analysis.
- Once salinity-flow relationships were established for each of the groups, the long term flow record was used to estimate the change in the probability of an annual average surface salinity of 20 ppt. The long term average flow (10,166 cfs) was used as the baseline probability.
- Risk was estimated as a change between 0 and 15 percent in the exceedance threshold of the 20 ppt criterion for surface salinity (Figures K-6 and K-7). Only the Inshore reef and Offshore zones were evaluated since the River zone median salinities were over 20 ppt less than 10% of the time (Figures K-8 through K-10). The distribution percentiles (e.g., 10%, 50%, 90%) of surface and bottom salinities within each PCA group were identified (Figure K-11, K-12).

Results

- The Inshore Reef group displayed an inflection point in the risk estimates for flow less than 6800 cfs coinciding with a 5% increase in the number of years the average annual salinity would exceed 20 ppt.
- The results of estimating risk for the Offshore group suggested that Offshore salinities were at the 20 ppt threshold approximately 50% of the time based on the study period of record (1997-2003). A 15% change in the probability of annual average exceedance was associated with flows that were still above the long term median flow for Wilcox. Therefore, the use of the 20 ppt threshold for the assessment of risk for the Offshore group appears to be unrealistic.

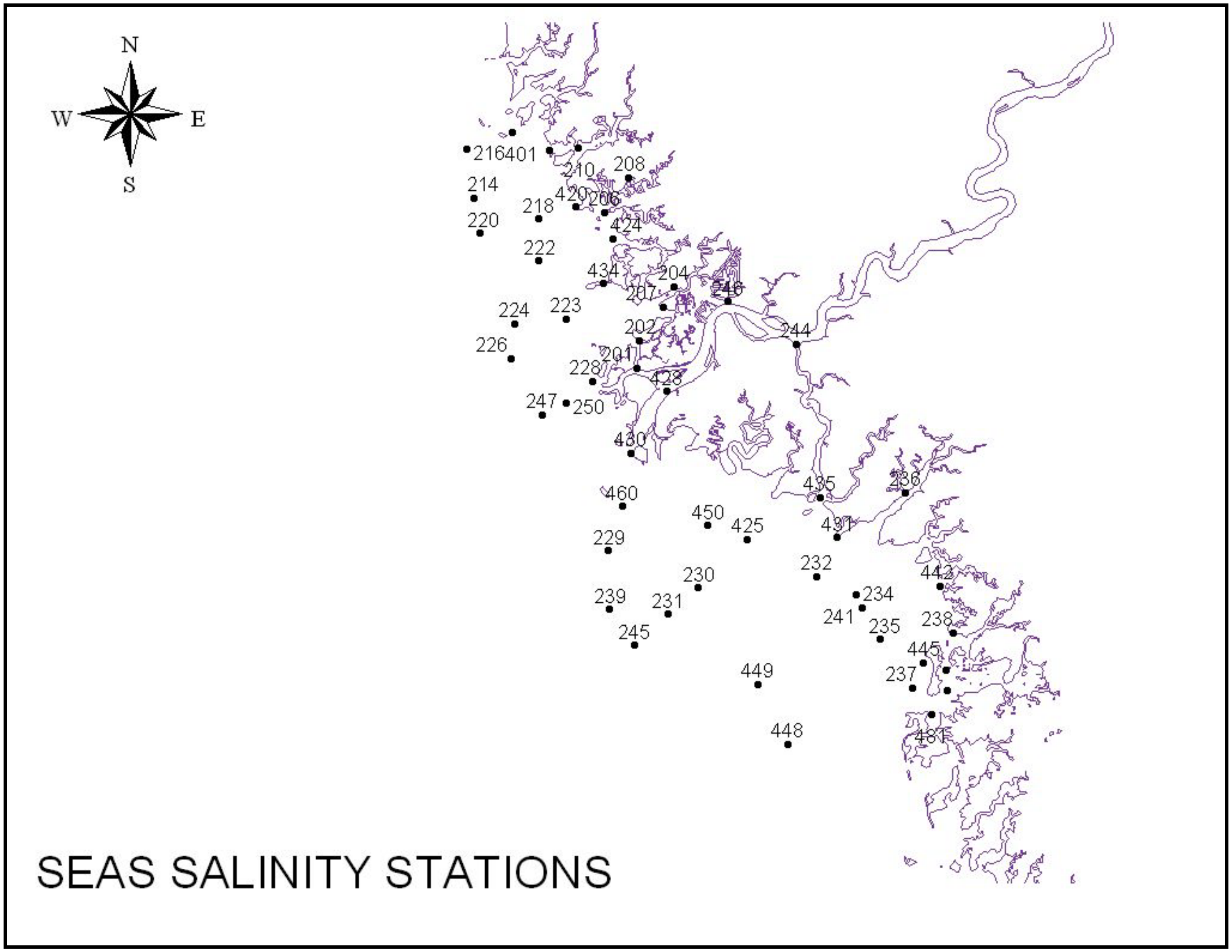


Figure K-1. Distribution of SEAS water quality stations in the Suwannee River Estuary.

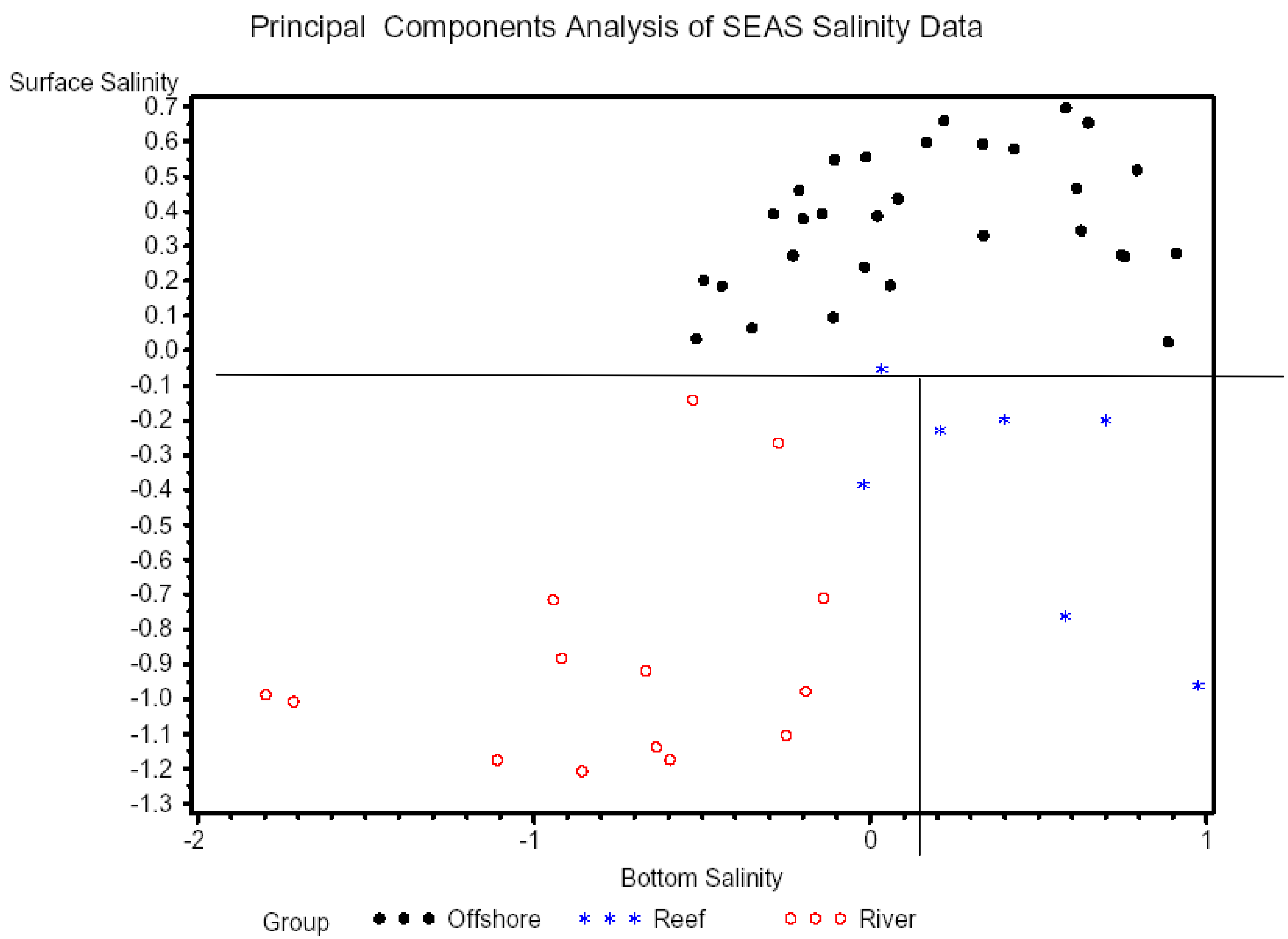


Figure K-2. Results of Principal Components Analysis, showing the separation of offshore, reef and river salinities.

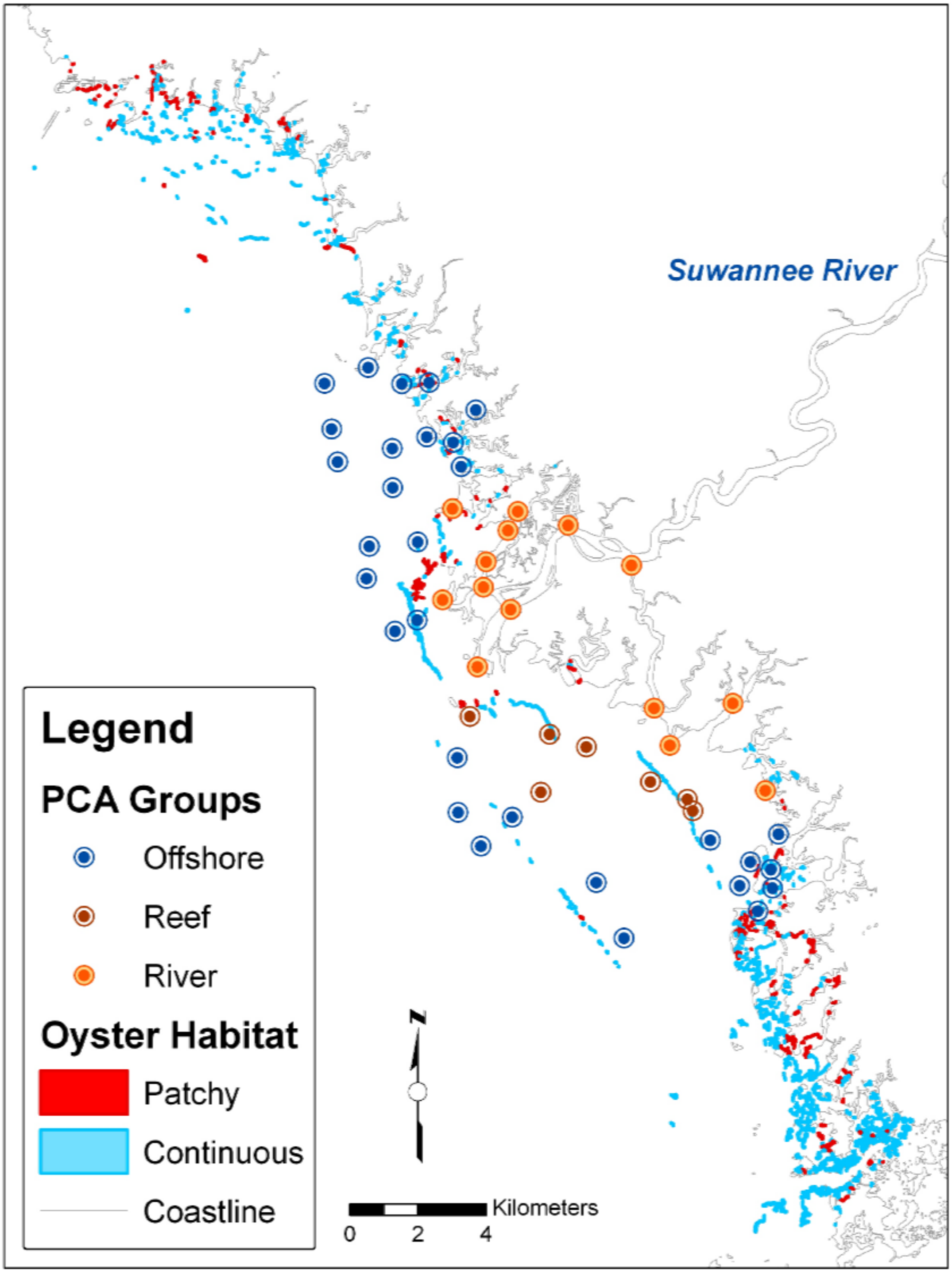
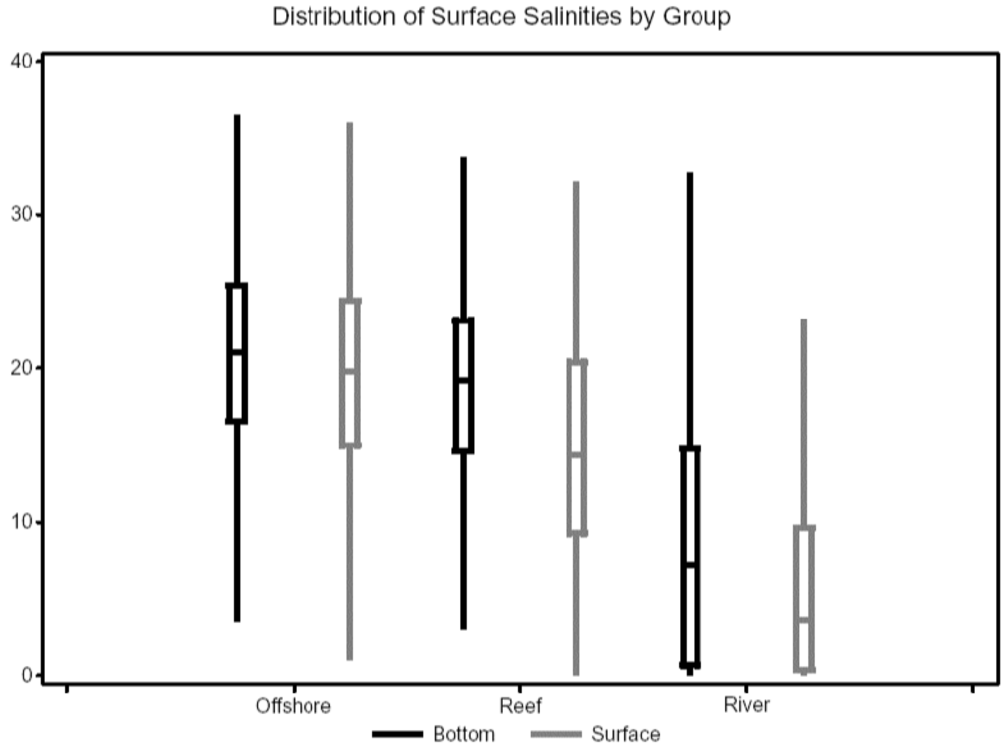


Figure K-3. Distribution of SEAS Water Quality stations, partitioned into offshore, reef and river groups and the distribution of oyster habitat, classified as patchy and continuous.



Distribution statistics for variables used in salinity flow regressions

	Offshore			Reef			River		
Distribution Percentile	Min	Median	Max	Min	Median	Max	Min	Median	Max
Surface Salinity	0	19.8	36.0	0	14.3	32.2	0	3.6	32.8
Bottom Salinity	0	21	36.5	0	19.2	33.8	0	7.25	32.8
Flow at Wilcox	1,970	6,070	43,200	1,970	6,040	43,200	1,970	6,510	43,200
Sample Hour	7	11	16	7	12	15	7	11	15
Tidal Stage (wl/feet mllw)	-1.02	2.32	4.73	-1.02	2.32	4.73	-1.29	2.30	4.52

Figure K-4. Distribution of surface salinities by group.

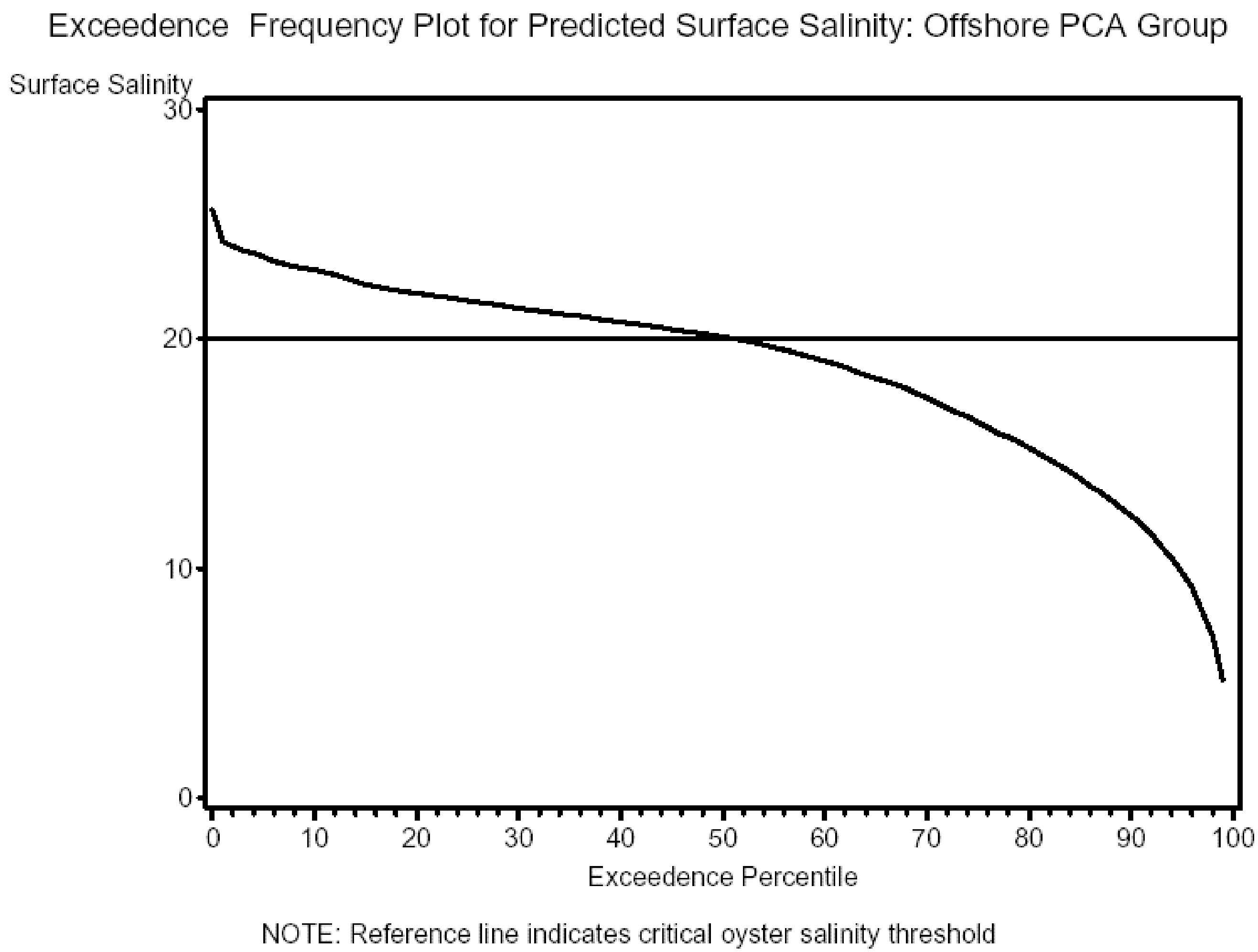


Figure K-5. Exceedance frequency plot for predicted salinity of the offshore group. The reference line at 20 ppt represents the critical salinity threshold for oysters.

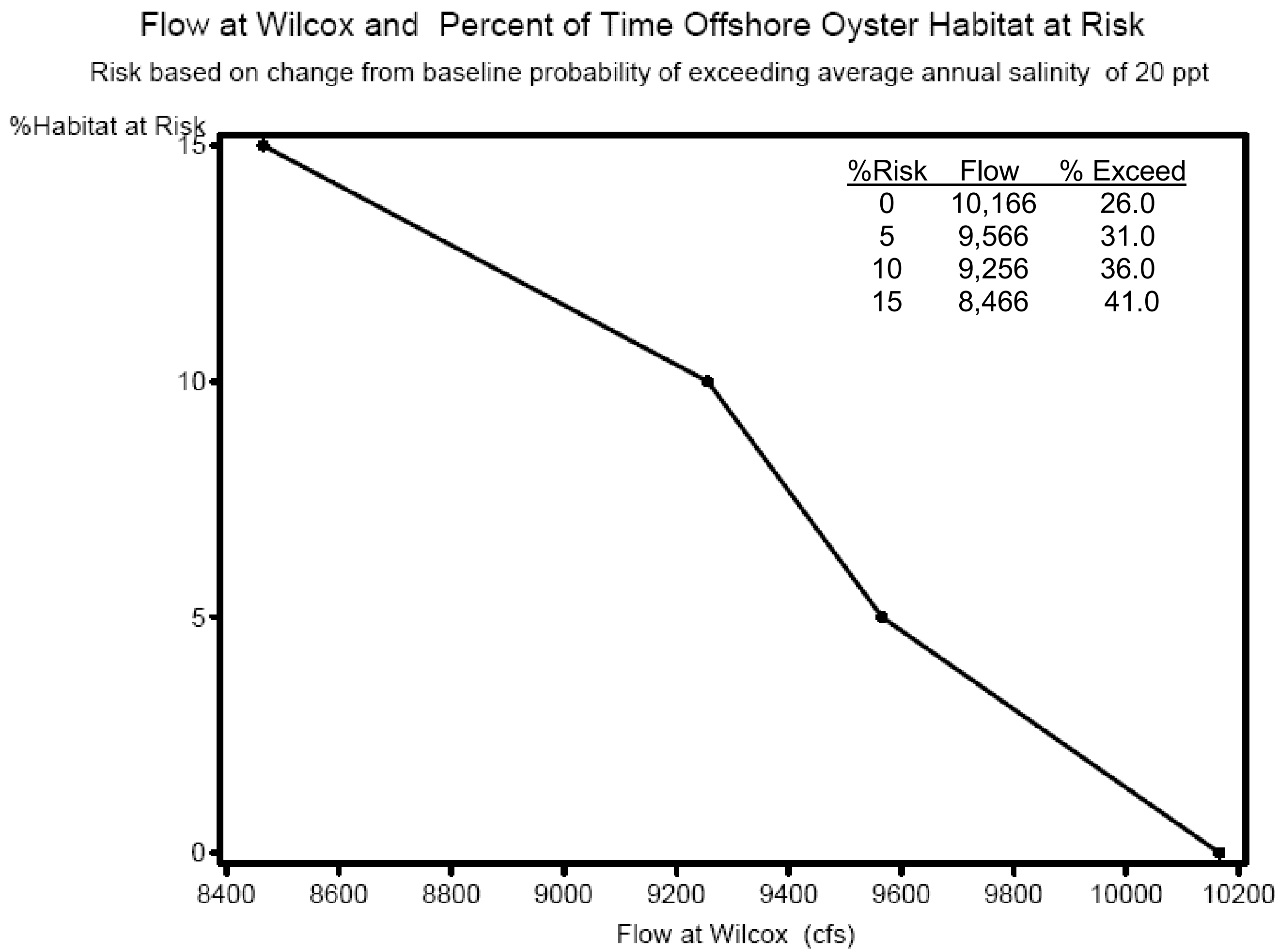


Figure K-6. Relationship between percent of habitat risk for oyster habitat and flow, based on the probability of exceeding the average annual salinity of 20 ppt.

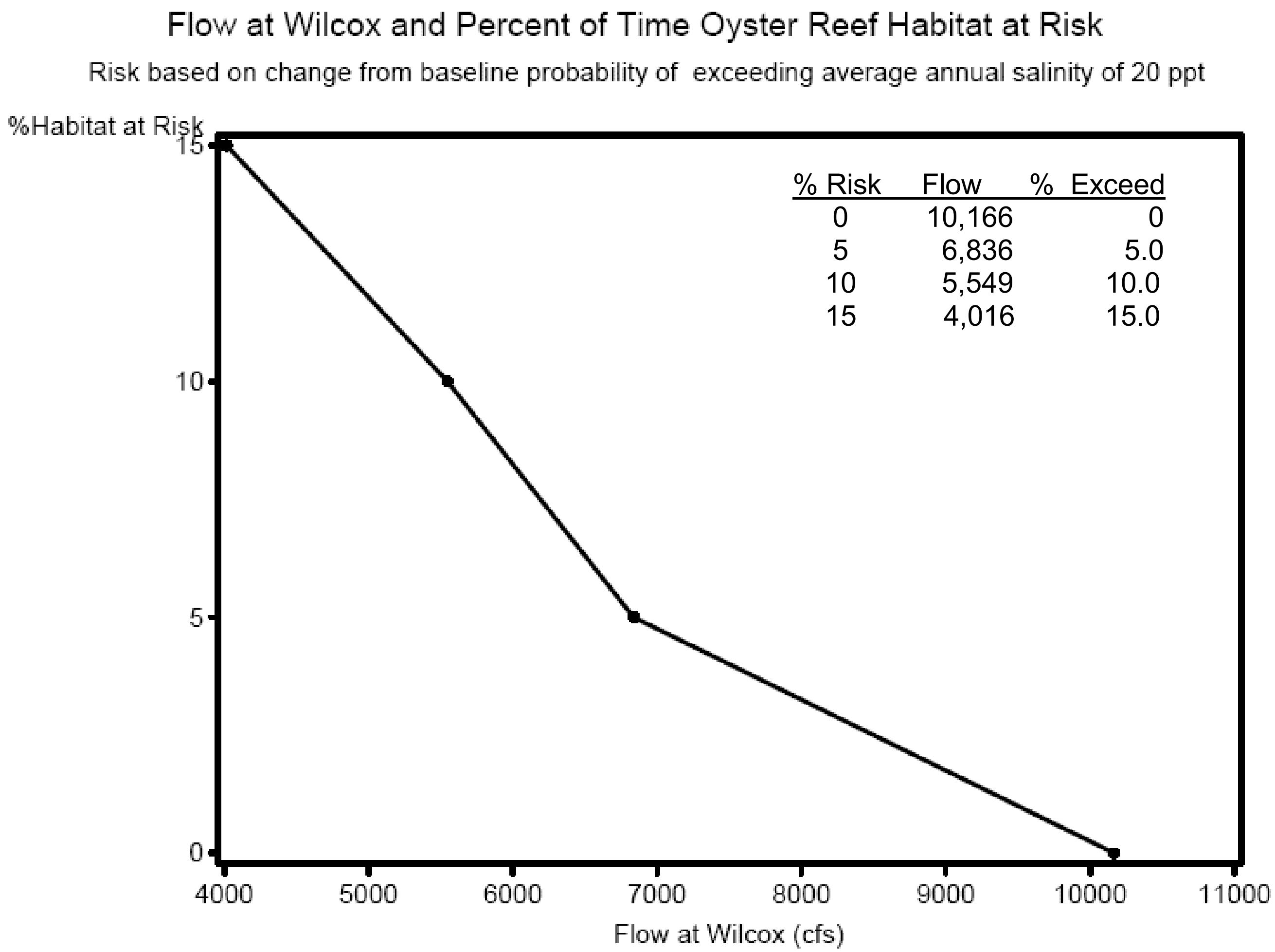


Figure K-7. Relationship between percent of habitat risk for oyster habitat and flow, based on the probability of exceeding the average annual salinity of 20 ppt.

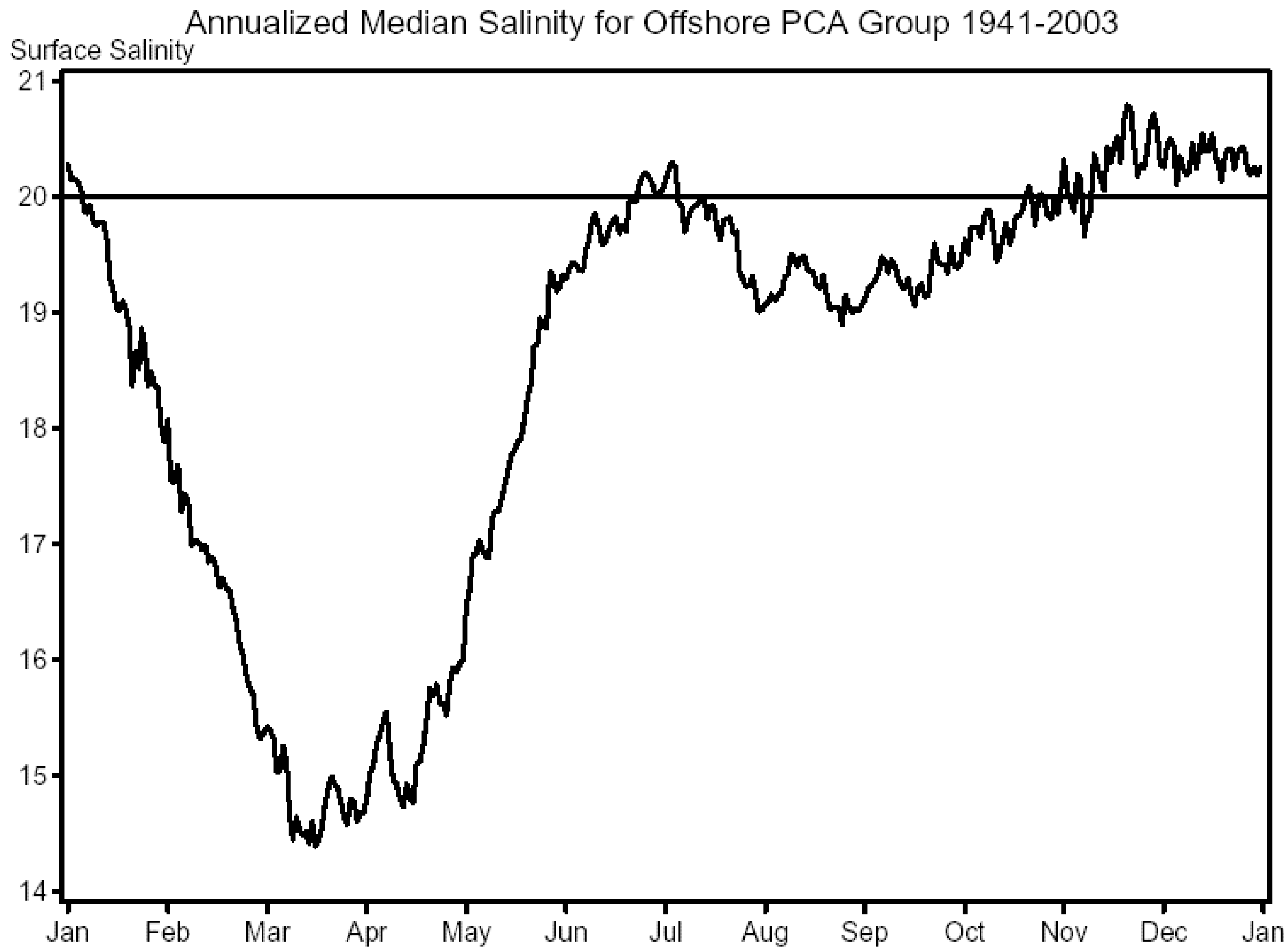


Figure K-8. Annualized median surface salinity for the offshore group.

.

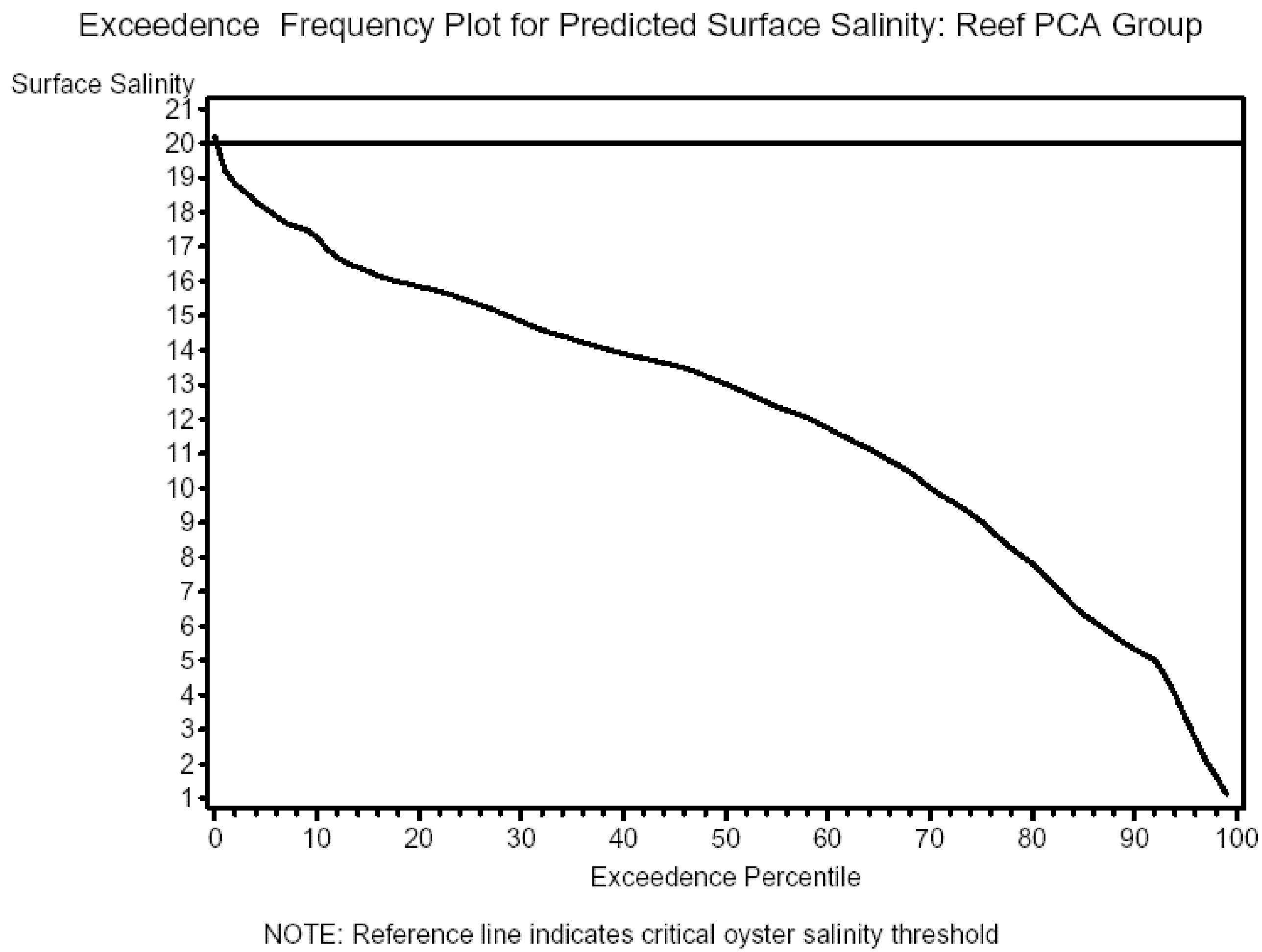


Figure K-9. Exceedance frequency plot for predicted salinity of the Inshore Reef group. The reference line at 20 ppt represents the critical salinity threshold for oysters.

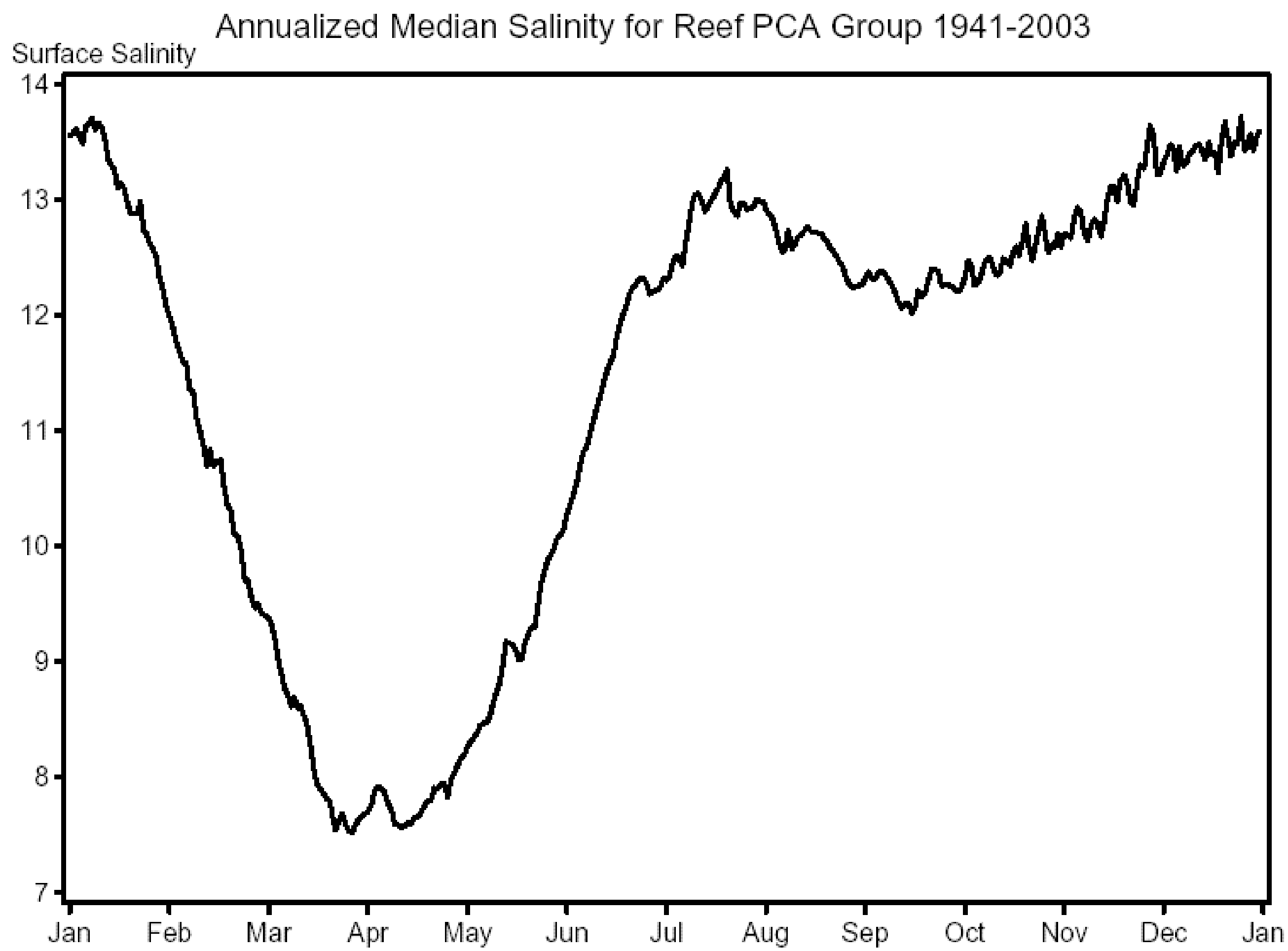


Figure K-10. Annualized median surface salinity for the reef group

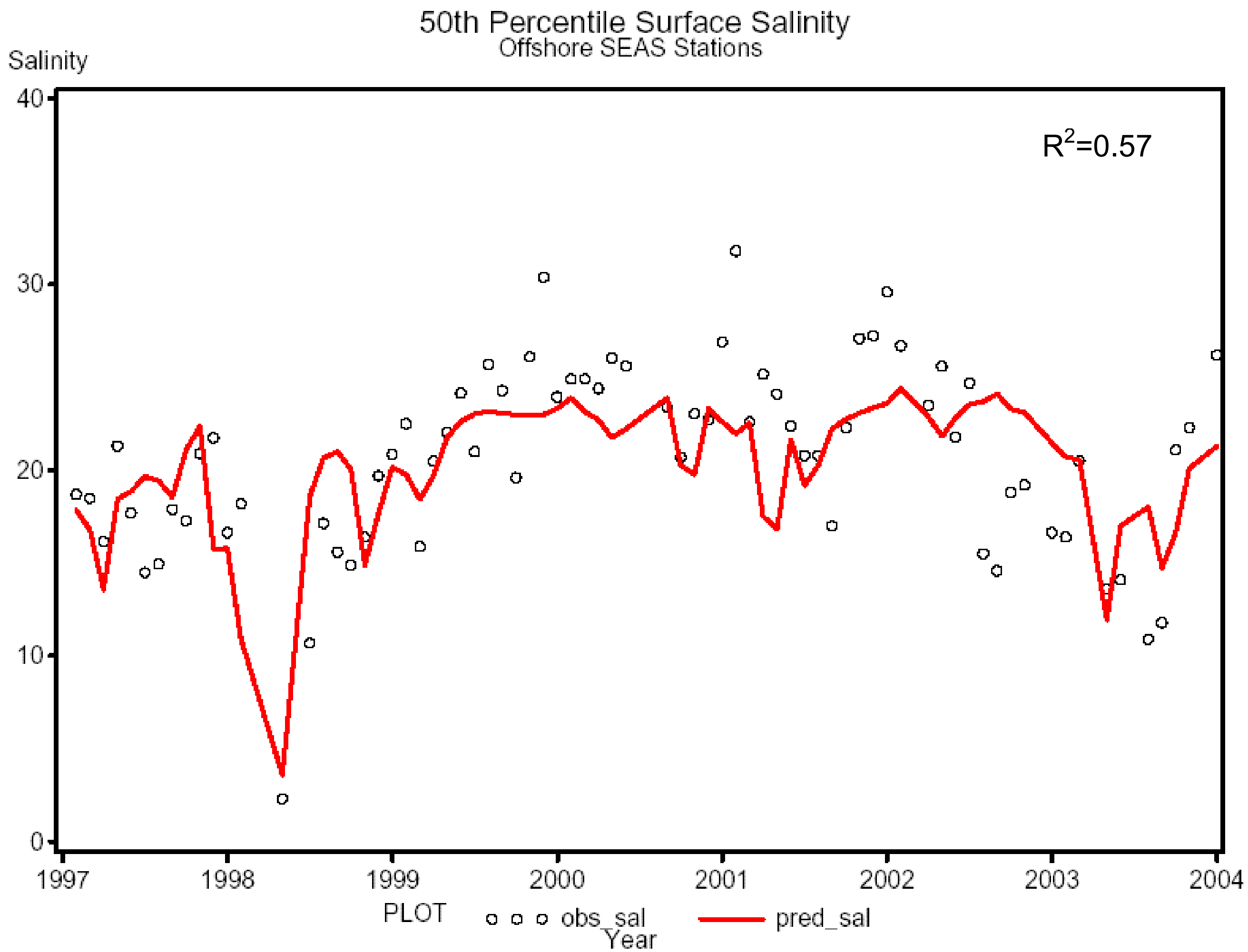


Figure K-11.. Plot showing the 50th percentile of surface salinity in the offshore SEAS stations. Predicted and observed salinity is shown.

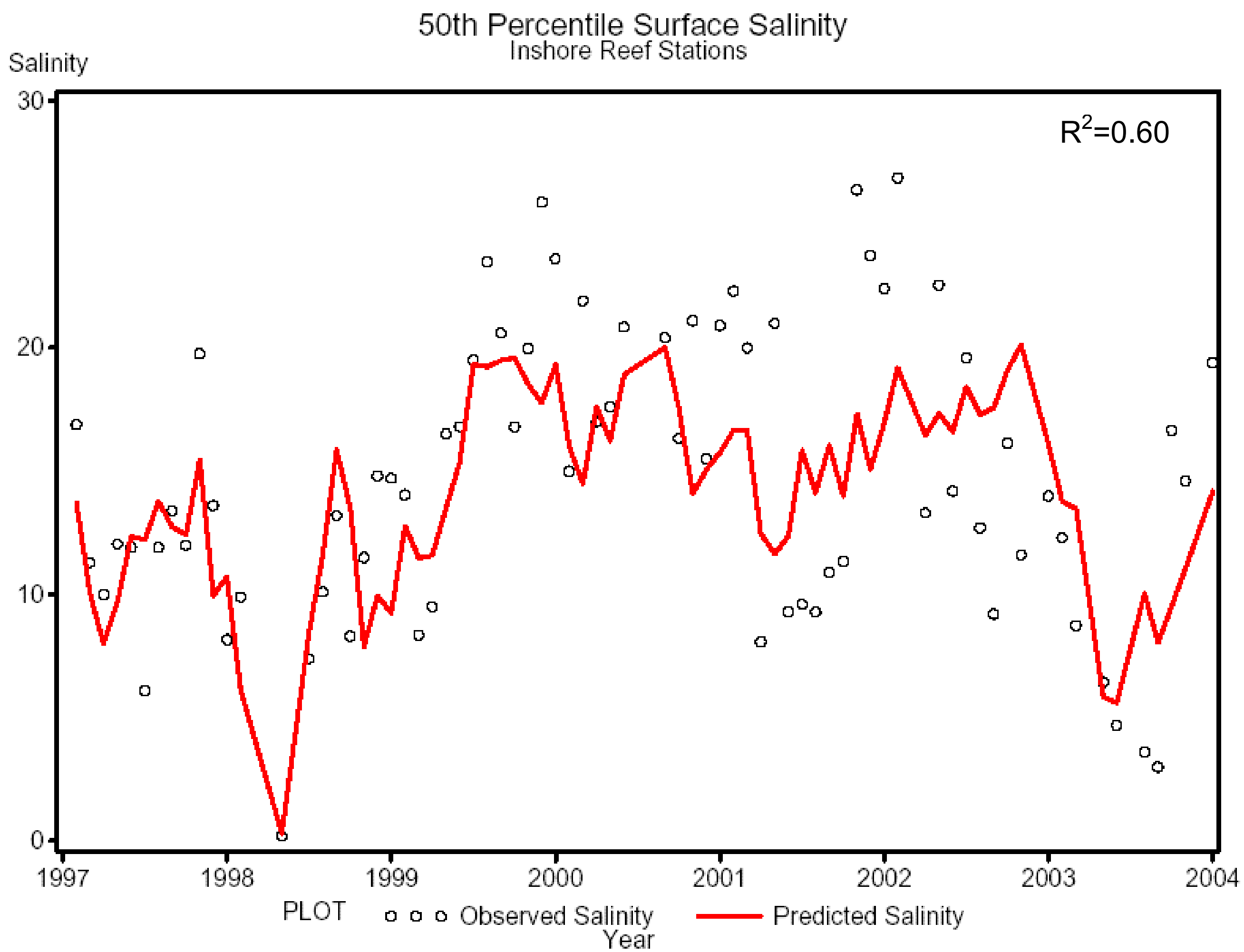


Figure K-12. Plot showing the 50th percentile of surface salinity in the inshore SEAS stations. Predicted and observed salinity is shown

References

Bahr, L. M. and W. P. Lanier. 1981. The ecology of intertidal oyster reefs of the south Atlantic coast: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/15. 105 pp. http://cuadra.nwrc.gov/Techrept/81-15.pdf

Baker, P., D. Bergquist, and S. Baker. 2003. Oyster Reef Assessment in the Suwannee River Estuary. Final Report. Submitted to Suwannee River Water Management District. University of Florida, Dept. of Fisheries and Aquatic Sciences, Gainesville, FL. 29 pp., 2 App.

Burrell, V. G., Jr. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic) - - American oyster. U. S. Fish Wild. Serv. Biol. Report 82(11.57). U. S. Army Corps of Engineers TR EL-82-4. Viii plus 17 pp.

Glancy, T. P. 2000. A Comparison of Seagrass, Oyster Reef, and Salt Marsh Edge as Habitat for Decapod Crustaceans. M.S. Thesis, University of Florida, Gainesville, FL. 59 pp.

Livingston, R. J., F. G. Lewis, G. C. Woodsum, X.-F. Niu, B. Galperin, W. Huang, J. D. Christensen, M. E. Monaco, T. A. Battista, C. J. Klein, R. L. Howell IV., and G. L. Ray. 2000. Modelling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50: 655-672.

Pattillo, M. E., T. E. Czapla, D. M. Nelson, and M. E. Monaco. 1997. Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries. Vol. 2: Species Life History Summaries. ELMR Report No. 11. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 377 pp.

Stanley, J. G. and M. A. Sellers. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) - - American oyster. U. S. Fish Wildl. Serv. Biol. Report 82(11.64). U. S. Army Corps of Engineers TR EL-82-4. Vi plus 25 pp.

References

Bulger, A. J., M. E. Monaco, D. M. Nelson, and M. G. McCormick-Ray. 1993. Biologically-based estuarine salinity zones derived from multivariate analysis. Estuaries 16(2): 311-322.

Montague, C. L. and H. T. Odum. 1997. Setting and functions. Pp. 9-33 IN: C. L. Coultas and Y-P. Hsieh (eds.), Ecology and Management of Tidal Marshes. A Model from the Gulf of Mexico. St. Lucie Press, Delray Beach, FL.

Montague, C. L. and R. G. Wiegert. 1990. Salt marshes. Pp. 481-516 IN: R. L. Myers and J. J. Ewel (eds.), Ecosystems of Florida. Univ. of Central Florida Press, Orlando, FL.

Tsou, T-S. and R. E. Matheson, Jr. 2002 Seasonal changes in the nekton community of the Suwannee River estuary and potential impacts of freshwater withdrawal. Estuaries 25(6B): 1372-1381.

LITERATURE CITED

Literature Cited

Adams, S. M. and C. T. Hackney. 1992. Ecological processes of southeastern United States aquatic ecosystems. Pp. 3-17 IN: C. T. Hackney, S. M. Adams, and W. H. Martin (eds.). Biodiversity of the Southeastern United States. Aquatic Communities. John Wiley & Sons, Inc., New York, NY.

Adicks, V. K. 1998. Relationships of Juvenile and Small Fish Populations to Season and Salinity in Alligator Pass, Suwannee River, Florida. M.S. Thesis. University of Florida, Gainesville, FL. 74 pp.

Alber, M. 2002. A conceptual model of estuarine freshwater inflow manage-ment. Estuaries 25(6B): 1246-1261.

Allan, J. D. 1995. Stream Ecology. Structure and Function of Running Waters. Chapman and Hall, New York, NY. 388 pp.

Allen, J. A., J. L. Chambers, and S. R. Pezeshki. 1997. Effects of salinity on baldcypress seedlings: physiological responses and their relation to salinity tolerance. Wetlands 17: 310-320.

Arnold, J.G. and P.M. Allen. 1999. Automated Methods for Estimating Baseflow and Ground Water Recharge from Streamflow Records. Journal of the American Water Resources Association (JAWRA) Vol. 35, No. 2. Paper No. 98084. pp. 411-421.

Allison, D., M. Groszos, and F. Rupert. 1995. Top of rock of the Florida Aquifer System in the Suwannee River Water Management District. Florida Geological Survey Open File Map Series: No. 84.

Arnold, J.G., P.M. Allen, R. Muttiah, and G. Bernhardt. 1995. Automated Base Flow Separation and Recession Analysis Techniques. Ground Water Vol. 33, No. 6., pp. 1010-1018. November-December 1995.

Bahr, L. M. and W. P. Lanier. 1981. The ecology of intertidal oyster reefs of the south Atlantic coast: a community profile. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C. FWS/OBS-81/15. 105 pp. http://cuadra. nwrc.gov/Techrept/81-15.pdf

Baker, P., D. Bergquist, and S. Baker. 2003. Oyster Reef Assessment in the Suwannee River Estuary. Final Report. Submitted to Suwannee River Water Management District. University of Florida, Dept. of Fisheries and Aquatic Sciences, Gainesville, FL. 29 pp., 2 App.

Bales, J.D. Simulation of Circulation and Salinity Characteristics in the Suwannee River Estuarine System, Florida. U. S. Geological Survey Professional Paper 1656-B, in press.

Bass, D. G., Jr. 1990. Monitoring Florida's riverine fish communities. Florida Scientist 53(1): 1-10.

Bass, D. G., Jr. 1991. Riverine fishes of Florida. Pp. 65-83 IN: R. J. Livingston (ed.), The Rivers of Florida. Ecological Studies Vol. 83. Springer-Verlag, New York, NY.

Bass, D. G. and D. T. Cox. 1985. River habitat and fishery resources of Florida. Pp. 121-187 IN: W. Seaman, Jr. (ed.), Florida Aquatic Habitat and Fishery Resources. Florida Chapter, American Fisheries Society, Kissimmee, FL.

Bass, D. G. and V. G. Hitt. 1973. Sport Fishery Ecology of the Suwannee and Santa Fe Rivers, Florida. Report by Florida Game and Fresh Water Fish Commission, Lake City, Florida. 187 pp.

Bass, G. and V. Guillory. 1979. Community structure and abundance of fishes inhabiting oceanic oyster reefs and spoil islands in the northeastern Gulf of Mexico. Northeast Gulf Science 3(2): 116-121.

Baymont. 2002. Suwannee Estuary 2001 Oyster Mapping Project. Report submitted to the Suwannee River Water Management District by AGRA / Baymont, Inc., Clearwater, FL. 8 pp., 7 Apps.

Beck, M. W., M. Odaya, J. J. Bachant, J. Bergan, B. Keller, R. Martin, R. Mathews, C. Porter, and G. Ramseur. 2000. Identification of Priority Sites for Conservation in the Northern Gulf of Mexico: An Ecoregional Plan. Report prepared for the USEPA Gulf of Mexico Program. The Nature Conservancy, Arlington, VA. 48 pp.

Beck, M. W. Personal communication via email to R. Mattson on 19 January 2001.

Beck, W. M., Jr. 1965. The Streams of Florida. Bulletin of the Florida State Museum, Biological Sciences. Vol. 10, No. 3: 91-126.

Benke, A. C. 1990. A perspective on America's vanishing streams. J. North Amer. Benthological Society 9(1): 77-88.

Benke, A. C., T. C. Van Arsdall, Jr., D. M. Gillespie, and F. K. Parrish. 1984. Invertebrate productivity in a subtropical black-water river: the importance of habitat and life history. Ecological Monographs 54(1): 25-63.

Benke, A. C., R. L. Henry, III, D. M. Gillespie, and R. J. Hunter. 1985. Importance of snag habitat for animal production in southeastern streams. Fisheries 10(5): 8-13.

Berndt, M. P., E. T. Oaksford, M. R. Darst, and R. Marella. 1996. Environmental Setting and Factors that affect Water Quality in the Georgia-Florida Coastal Plain Study Unit. U. S. Geological Survey Water-Resources Investigations Report 95-4268. 46 pp.

Bledsoe, E. L. 1998. Phytoplankton Dynamics and Community Structure in the Suwannee River Estuary, USA. M.S. Thesis. University of Florida, Gainesville, FL. 77 pp.

Bledsoe, E. L. 2003. ____________________________. Ph.D Dissertation. University of Florida, Gainesville, FL.

Bledsoe, E. L. and E. J. Phlips. 2000. Relationships between phytoplankton standing crop and physical, chemical and biological gradients in the Suwannee River and plume region, U.S.A. Estuaries 23(4): 458-473.

Bledsoe, E. L., E. J. Phlips, C. E. Jett, and K. A. Donnelly. 2004. The relationships among phytoplankton biomass, nutrient loading and hydrodynamics in an inner-shelf estuary. Ophelia 58(1): 29-47.

Boesch, D. F. and R. E. Turner. 1984. Dependence of fishery species on salt marshes: the role of food and refuge. Estuaries 7(4A): 460-468.

Brinson, M. M., H. D. Bradshaw, and M. N. Jones. 1985. Transitions in forested wetlands along gradients of salinity and hydroperiod. J. Elisha Mitchell Scientific Soc. 101(2): 76-94.

Brooks, R. A. and K. J. Sulak. 2004. Quantitative Assessment of Benthic Food Resources for Juvenile Gulf Sturgeon, Acipenser oxyrinchus desotoi, in the Suwannee River Estuary, Florida, USA. U. S. Geological Survey Coastal Ecology and Conservation Research Group Investigation Report CEC 2004-02. CD-ROM file.

Browder, J. A. 1991. Watershed management and the importance of freshwater inflow to estuaries. Pp. 7-22 IN: S. F. Treat and P. A. Clark (eds.), Proceedings. Tampa Bay Area Scientific Information Symposium 2. Tampa, Florida.

Brussock P.P., A.V. Brown A.V. and J.C. Dixon, 1985. Channel form and stream ecosystem models. Water Resources Bulletin 21, 859 - 866.

Bulger, A. J., M. E. Monaco, D. M. Nelson, and M. G. McCormick-Ray. 1993. Biologically-based estuarine salinity zones derived from multivariate analysis. Estuaries 16(2): 311-322.

Burrell, V. G., Jr. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Atlantic) - - American oyster. U. S. Fish Wild. Serv. Biol. Report 82(11.57). U. S. Army Corps of Engineers TR EL-82-4. Viii plus 17 pp.

Carr, S. H., F. Tatman, and F. A. Chapman. 1996. Observations on the natural history of the Gulf of Mexico sturgeon (*Acipenser oxyrinchus desotoi* Vladykov 1955) in the Suwannee River, southeastern Unites States. Ecology of Freshwater Fish 5: 169-174.

Ceryak, R. 1977. Alapaha River Basin. SRWMD Information Circular 5, Live Oak, FL. Pp. not numbered.

Ceryak, R., M. S. Knapp and T. Q. Burnson. 1983. The Geology and Water Resources of the Upper Suwannee River Basin, Florida. Florida Department of Natural Resources, Bureau of Geology. Report of Investigation No. 87: 1-165.

Christensen, J. D., M. E. Monaco, and T. A. Lowery. 1997. An index to assess the sensitivity of Gulf of Mexico species to changes in estuarine salinity regimes. Gulf Research Reports 9(4): 219-229.

Clewell, A. F. 1985. Guide to the Vascular Plants of the Florida Panhandle. Florida State University Press, Tallahassee, FL. 605 pp.

Clewell, A. F. 1991. Florida rivers: the vegetational mosaic. Pp. 47-63 IN: R. J. Livingston (ed.), The Rivers of Florida. Ecological Studies Vol. 83. Springer-Verlag, New York, NY.

Clewell, A. F. 2000. Inventory of Tidal Marsh Vegetation along the Suwannee River during Drought in June 2000. Report submitted to the Suwannee River Water Management District by A. F. Clewell, Inc., Quincy, FL. 15 pp. plus 2 pp supplement by C. L. Coultas.

Clewell, A. F., R. S. Beaman, C. L. Coultas, and M. E. Lasley. 1999. Suwannee River Tidal Marsh Vegetation and its Response to External Variables and Endogenous Community Processes. Final Report. Report prepared for the Suwannee River Water Management District, Live Oak, FL. 119 pp., 15 Appendices.

Cole, T.M. and Wells, S.A. 2000. CE-QUAL-W2: A Two-dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.0. Instruction Report EL-00-1, US Army Engineering and Research Development Center, Vicksburg, MS.

Comp, G. S. and W. Seaman, Jr. 1985. Estuarine habitat and fishery resources of Florida. Pp. 337-435 IN: W. Seaman, Jr. (ed.), Florida Aquatic Habitat and Fishery Resources. Florida Chapter, American Fisheries Society, Kissimmee, FL.

Copeland, R.E. 1987 (unpublished m.s.). Water Resources of the Coastal Rivers Basin, Suwannee River Water Management District. Suwannee River Water Management District, Live Oak, FL.

Copeland, R. 2003. Florida Spring Classification System and Spring Glossary. Florida Geological Survey Special Publication No. 52. 18 pp.

Coultas, C. L. 1997. Soils. Pp. 53-75 IN: C. L. Coultas and Y. P. Hsieh (eds.), Ecology and Management of Tidal Marshes. A Model from the Gulf of Mexico. St. Lucie Press, Delray Beach, FL.

Coultas, C. L. and Y. P. Hsieh (eds.). 1997. Ecology and Management of Tidal Marshes. A Model from the Gulf of Mexico. St. Lucie Press, Delray Beach, FL. 355 pp.

Countryman, R. A. and M. T. Stewart, M.T. 1997. Geophysical Delineation of the Position of the Saltwater Interface in the Lower Suwannee River Basin. Final Contract Report for Suwannee River Water Management District, Geology Dept., Univ. of South Florida, Tampa, FL.

Cox, J., R. Kautz, M. MacLaughlin, and T. Gilbert. 1994. Closing the Gaps in Florida's Wildlife Habitat Conservation System. Technical Report. Florida Game and Freshwater Fish Commission Tallahassee, FL. 239 pp.

Crane, J. J. 1986. An Investigation of the Geology, Hydrogeology, and Hydrochemistry of the Lower Suwannee River Basin. Florida Department of Natural Resources, Bureau of Geology. Report of Investigation No. 96: 1-205.

Crance, J. H. and L. S. Ischinger. 1989. Fishery functions and values of forested riparian wetlands. Pp. 14A-9 to 16 IN: F. E. Davis (ed.), Contributed Papers and Abstracts for the Conference on Water: Laws and Management. American Water Resources Association, Bethesda, MD.

Darst, M. R., H. M. Light, and L. J. Lewis. 2002. Ground-cover Vegetation in Wetland Forests of the Lower Suwannee River Floodplain, Florida, and Potential Impacts of Flow Reductions. U. S. Geological Survey Water Resources Investigations Report 02-4027. 46 pp.

Darst, M. R., H. M. Light, L. J. Lewis, and A. Sepulveda. 2003. Forest Types in the Lower Suwannee River Floodplain, Florida. A Report and Interactive Map. U.S. Geological Survey Water-Resources Investigations Report 03-4008. CD-ROM.

Day, J. W., Jr., C. A. S. Hall, W. M. Kemp, and A. Yanez-Arancibia. 1989. Estuarine Ecology. John Wiley and Sons, New York, NY. 558 pp.

Day, J. W., Jr., J. F. Martin, L. Cardoch, and P. H. Templet. 1997. System functioning as a basis for sustainable management of deltaic ecosystem. Coastal Management 25: 115-153.

Doering, P. H., R. H. Chamberlain, K. M. Donohue, and A. D. Steinman. 1999. Effect of salinity on the growth of *Vallisneria americana* Michx. From the Caloosahatchee estuary, Florida. Florida Scientist 62(2): 89-105.

Dolloff, C. A. 1994. Large woody debris – the common denominator for integrated environmental management of forest streams. Pp. 93-108 IN: J. Cairns, Jr., T. V. Crawford, and H. Salwasser (eds.), Implementing Integrated Environmental Management. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Dugger, K. M. and L. H. Fredrickson. 1992. Life History and Habitat Needs of the Wood Duck. Waterfowl Management Handbook. Fish and Wildlife Leaflet 13.1.6. 8 pp.

Durako, M. J., J. A. Browder, W. L. Kruczynski, C. B. Subrahmanyam, and R. E. Turner. 1985. Salt marsh habitat and fishery resources of Florida. Pp. 189-280 IN: W. Seaman, Jr. (ed.), Florida Aquatic Habitat and Fishery Resources. Florida Chapter, American Fisheries Society, Kissimmee, FL.

Dutoit, C. H. 1979. The Carrying Capacity of the Ichetucknee Springs and River. M.S. Thesis. University of Florida, Gainesville, FL. 174 pp.

Elder, J. F. 1985. Nitrogen and phosphorus speciation and flux in a large Florida river wetland system. Water Resources Research 21(5): 724-732.

Estevez, E. D. 1991. A Review of Resource Management Goal Statements for the Apalachicola River and Bay Ecosystem. Report prepared for the Apalachicola Bay Freshwater Inflow Assessment Project. Mote Marine Laboratory, Sarasota, FL. 11 pp.

Estevez, E. D. 2000a. A Review and Application of Literature Concerning Freshwater Flow Management in Riverine Estuaries. Report prepared for the South Florida Water Management District, West Palm Beach, FL. Mote Marine Laboratory Technical Report No. 680. 70 pp.

Estevez, E. D. 2000b. Letter report submitted to K. B. Webster describing results of a revisit of SAV sites sampled in 1998-99. Dated September 7, 2000. 29 un-numbered pp.

Estevez, E. D. 2002. Letter report submitted to K. B. Webster describing results of a revisit of SAV sites sampled 1998-99 and 2000. Dated September 11, 2002. 29 un-numbered pp.

Estevez, E. D. and M. J. Marshall. 1997. A landscape-level method to assess estuarine impacts of freshwater inflow alterations. Pp. 217-236 IN: S. F. Treat (ed.), Proceedings. Tampa Bay Area Scientific Information Symposium 3. Tampa Bay Regional Planning Council, Clearwater, FL.

Estevez, E. D. and J. Sprinkel. 1999. Dispersion and Abundance of Submerged Aquatic Vegetation in the Tidal Suwannee River, Florida, in relation to Flow, Salinity, and Related Variables. Report submitted to the Suwannee River Water Management District, Live Oak, FL. Mote Marine Laboratory Technical Report No. 648. 48 pp, 2 Tables, 24 Figures, 1 App.

Estevez, E. D. and J. Sprinkel. 2000. Dispersion and Abundance of Wood Habitat of the Santa Fe and Lower Suwannee River Systems in Relation to Flow and Flow-Related Variables. Report submitted to the Suwannee River Water Management District, Live Oak, FL. Mote Marine Laboratory Technical Report No. 646. 51 pp, 5 Tables, 20 Figures, 3 Apps.

Estevez, E. D., R. E. Edwards, and D. M. Hayward. 1991. An ecological overview of Tampa Bay's tidal rivers. Pp. 263-277 IN: S. F. Treat and P. A. Clark (eds.), Proceedings. Tampa Bay Scientific Information Symposium 2. Tampa Bay Regional Planning Council, St. Petersburg, FL.

Evans, J. W. and R. H. England. 1995. A Recommended Method to Protect Instream Flows in Georgia. Report by the Georgia Department of Natural Resources Wildlife Resources Division, Social Circle, GA. 52 pp

FDEP. 2000a. Fanning Springs Ecosummary. 10/04/00. Florida Department of Environmental Protection Bureau of Laboratories, Tallahassee, FL. 1 p. http://water.dep.state.fl.us/eswizard/esdata/pdfs/155.pdf.

FDEP. 2000b. Manatee Spring Ecosummary. 10/12/2000. Florida Department of Environmental Protection Bureau of Laboratories, Tallahassee, FL. 1 p.

FDEP. 2001. Manatee Spring Ecosummary. March 2001. Florida Department of Environmental Protection Bureau of Laboratories, Tallahassee, FL. 2 pp. http://water.dep.state.fl.us/eswizard/esdata/pdfs/181.pdf.

FDER. 1985. Limnology of the Suwannee River, Florida. Report by the Biology Section, Division of Environmental Programs, Florida Department of Environmen-tal Regulation. March, 1985. 407 pp.

Ferguson, G. E., Lingham, C. W., Love, S. K., and Vernon, R. O., 1947 Springs of Florida: Florida Geological Survey Bulletin 31, 198 p.

Fernald, E. A. and E. D. Purdum (eds.). 1998. Water Resources Atlas of Florida. Institute of Science and Public Affairs. Florida State University, Tallahassee, FL. 312 pp.

Fisk, D. W. and J. C. Rosenau. 1977. Potentiometric Surface of the Floridan Aquifer in the Suwannee River Water Management District, North Florida, May 1976. U.S. Geological Survey Water Resources Investigation Open File Report 77-1. Map.

Florida Geographic Data Library, 2004. Land-use coverages and metadata accessed via the worldwide web at: http://www.geoplan.ufl.edu/

FNAI and FDNR. 1990. Guide to the Natural Communities of Florida. Florida Natural Areas Inventory, Tallahasee, FL. 111 pp.

Foster, A. M. and J. P. Clugston. 1997. Seasonal migration of gulf sturgeon in the Suwannee River, Florida. Trans. Am. Fish. Soc. 126: 302-308.

Franklin, M. A., G. L. Giese, and P. R. Mixon. 1995. Statistical Summaries of Surface-Water Hydrologic Data Collected in the Suwannee River Water Management District, Florida, 1906-1993. U. S. Geological Survey Open-File Report 94-709. 173 pp.

Franz, R. 2002. Crustacean Surveys in Spring Habitats of Seventeen Florida State Parks. Final Report submitted to the Florida Park Service by Florida Museum of Natural History, Gainesville, FL. 13 pp.

Giese, G. L. and M. A. Franklin. 1996a. Magnitude and Frequency of Floods in the Suwannee River Water Management District, Florida. U. S. Geological Survey Water-Resources Investigations Report 96-4176. 14 pp.

Giese, G. L. and M. A. Franklin. 1996b. Magnitude and Frequency of Low Flows in the Suwannee River Water Management District, Florida. U. S. Geological Survey Water-Resources Investigations Report 96-4308. 62 pp.

Glancy, T. P. 2000. A Comparison of Seagrass, Oyster Reef, and Salt Marsh Edge as Habitat for Decapod Crustaceans. M.S. Thesis, University of Florida, Gainesville, FL. 59 pp.

Golder Associates. 2000. Mapping Low-Salinity Submerged Aquatic Vegetation Beds in the Lower Suwannee River. Report submitted to the Suwannee River Water Management District by Golder Associates, Inc., Gainesville, FL. 16 pp, 2 Apps.

Gosner, K. L. 1978. A Field Guide to the Atlantic Seashore. Peterson Field Guide Series. Houghton Mifflin Co., Boston, MA. 329 pp.

Griffith, G. E., J. M. Omernik, C. M. Rohm, and S. M. Pierson. 1994. Florida Regionalization Project. U.S. Environmental Protection Agency , Environmental Research Laboratory, Corvallis, OR. 83 pp.

Grinnel, R. S., Jr. 1971. Structure and Development of Oyster Reefs on the Suwannee River Delta, Florida. Ph.D Dissertation. State University at New York, Binghampton, N.Y. 186 pp.

Grubbs, J. W. 1998. Recharge Rates to the Upper Floridan Aquifer in the Suwannee River Water Management District, Florida. U. S. Geological Survey Water-Resources Investigations Report 97-4283. 30 pp.

Grubbs, J. W. and C. Crandall. In press. Exchanges of Water Between the Upper Floridan Aquifer and the Lower Suwannee and Lower Santa Fe Rivers, Florida. U. S. Geological Survey Professional Paper 1656C.

Haan, C. T. 1977. Statistical Methods in Hydrology. Iowa State University Press, Ames, IA. 378 pp.

Haller, W. T., D. L. Sutton, and W. C. Barlowe. 1974. Effects of salinity on growth of several aquatic macrophytes. Ecology 55: 891-894.

Ham, L.K. and H.H. Hatzell, 1996. Analysis of nutrients in the surface waters of the Georgia-Florida Coastal Plain study unit, 1970-91. U.S. Geological Survey, WRI 96-4037. 67 pp.

Healy, H. G. 1975. Terraces and shorelines of Florida. U.S. Geological Survey Map Series. No. 71.

Harris, L. D. 1984. Bottomland Hardwoods: Valuable, Vanishing, Vulnerable. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. Informational Bulletin SP-28. 17 pp.

Healy, H. G. 1975. Terraces and shorelines of Florida. U.S. Geological Survey Map Series. No. 71.

Heard, R. W. 1982. Guide to Common Tidal Marsh Invertebrates of the Northeastern Gulf of Mexico. Mississippi-Alabama Sea Grant Consortium Report No. MASGP-79-004. 82 pp.

Heath, R. C. and C. S. Conover. 1981. Hydrologic Almanac of Florida. U. S. Geological Survey Open File Report 81-1107. 239 pp.

Hicks, Stacy D., 1984, et seq. Tide and Current Glossary, NOAA/National Ocean Service. Rockville, MD. See URL http://www.opsd.nos.noaa.gov/tideglos.html

Hill, M. T., W. S. Platts, and R. L. Beschta. 1991. Ecological and geomorpholo-gical concepts for instream and out-of-channel flow requirements. Rivers 2(3): 198-210.

Hirch, R. M. 1982. A comparison of four streamflow record extension techniques. Water Resources Research, 18(4): 1081-1088.

Horlick, R. G. and C. B. Subrahmanyam. 1983. Macroinvertebrate infauna of a salt marsh tidal creek. Northeast Gulf Science 6(2): 79-89.

Hornsby, D, R. A. Mattson, and T. Mirti. 2000. Surfacewater Quality and Biology. 1999 Annual Report. Suwannee River Water Management District Technical Report WR00-04. 148 pp.

Hornsby, D. 2005. Personal communication. Suwannee River Water Management District.

Hornsby, D., and R. Ceryak, 1998. Groundwater Quality Report. Suwannee River Water Management District, Live Oak, Florida, WR99-03.

Howell, D. A. 1999. Floodplain Geomorphology of the Lower Suwannee River, Florida. M. S. Thesis. University of Florida, Gainesville, FL. 82 pp.

Hunt, C.B. 1974. Natural Regions of the United States and Canada. W.H., Freeman and Company, San Francisco, CA. 215 pp.

Hupalo, R. B., C. P. Neubauer, L. W. Keenan, D. A. Clapp, and E. F. Lowe. 1994. Establishment of Minimum Flows and Levels for the Wekiva River System. St. Johns River Water Management District Technical Publication SJ94-1. 86 pp.

Hupp, C. R. and W. R. Osterkamp. 1985. Bottomland vegetation distribution along Passage Creek, Virginia, in relation to fluvial landforms. Ecology 66(3): 670-681.

Hynes, H. B. N. 1970. The Ecology of Running Waters. University of Toronto Press, Toronto, Ontario. 555 pp.

Hynes, H. B. N. 1975. The stream and its valley. Verh. Internat. Verein. Limnol. 19: 1-15.

Instream Flow Council. 2002. Instream Flows for Riverine Resource Steward-ship. Published by the Instream Flow Council, Billings, Montana. 410 pp. Available for order at www.instreamflowcouncil.org.

Jennifer M. Jacobs, J.M., and Dukes, M. 2004. Final Report: Revision of AFSIRS Crop Water Use Simulation Model - AFSIRS Task 13 Climate Database Implementation. Report submitted to St Johns River Water Management District, Palatka, Florida. SJRWMD Contract Number: SE457AA, University of Florida Number: 4910450487112. Compact Disc with data and documentation.

Jacobs, J. and G. Ripo. 2003. (AFDC methodology report).

Jacobs, J.M. and G. Ripo. 2002. Minimum Flows and Levels afor the Lower Suwannee River: Implementation Methodology – Final Report. Report submitted to the Suwannee River Water Management District, Live Oak, Florida. University of Florida Number: 4910450482012.

Jacobs, J.M. and S.R. Satti. 2001. Evaluation of Reference Evapotranspiration Methodologies and AFSIRS Crop Water Use Simulation Model – Final Report. Report submitted to St Johns River Water Management District, Palatka, Florida.

Janicki Environmental, Inc. 2005a. Analysis of Water Quality, Fisheries and Benthic Invertebrate Data to Support Development of Minimum Flows and Levels for the Lower Suwannee River. Report submitted to Suwannee River Water Management District, Live Oak, FL. Pp. variously numbered.

Janicki Environmental, Inc. 2005b. Establishing Salinity-Flow Relationships in Suwannee Sound and Lower Suwannee River. Report submitted to Suwannee River Water Management District, Live Oak, FL. 23 pp.

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5(1): 272-289.

Jowett, I. G. 1997. Instream flow methods: a comparison of approaches. Regulated Rivers: Research & Management 13: 115-127.

Karim, K., M. E. Gubbels, and I. C. Goulter. 1995. Review of determination of instream flow requirements with special application to Australia. Water Resources Bull. 31(6): 1063-1077.

Karst Environmental Services, 1997 (I think this is: Butt, P.L., et al., 1997. Results of the Rose Creek Swallet to Ichetucknee Springs Dye Trace Study, August-September, 1997. Karst Environmental Services, Inc., 5 p.)

Katz, B. G., H. D. Hornsby, J. F. Bohlke, and M. F. Mokray. 1999. Sources and Chronology of Nitrate Contamination in Spring Waters, Suwannee River Basin, Florida. U. S. Geological Survey Water-Resources Investigation Report 99-4252. 54 pp.

Katz, B.G. and H.D. Hornsby, 1998. A Preliminary Assessment of Sources of Nitrate in Springwaters, Suwannee River Basin, Florida. U.S. Geological Survey, Open-File Report 98-69, 38 p.

Kelly, M. 2004. Florida River Flow Patterns and the Atlantic Multidecadal Oscillation. Technical Report. Southwest Florida Water Management District, Brooksville, FL. 80 pp.

Kleiss, B. A., E. E. Morris, J. F. Nix, and J. W. Barko. 1989. Modification of riverine water quality by an adjacent bottomland hardwood wetland. Pp. 429-438 IN: D. W. Fisk (ed.), Wetlands. Concerns and Successes. Symposium Proceedings. American Water Resources Association Technical Publication Series 89-3, Bethesda, Maryland.

Lake, P. S. 2000. Disturbance, patchiness, and diversity in streams. J. North American Benthological Society 19(4): 573-592.

Langtimm, C. A., G. L. Mahon, H. I. Kochman, and S. Butler. 2003. Manatee Habitat Suitability at Manatee Spring, Levy County, Florida. Report by U. S. Geological Survey, Center for Aquatic Resource Studies, Gainesville, FL. 41 pp.

Laughlin, C.P. 1976. Potentiometric Surface Map of the Floridan Aquifer in East Central Florida, May, 1976. U.S. Geological Survey Open File Report 76-813. Map.

Lawrence, F.W., and *S.B. Upchurch*, 1976. Identification of geochemical patterns in ground water by numerical analysis. In E.A. Zaleem (ed.), Advances in Groundwater Hydrology, America Water Resources Association, p. 199-214.

Leadon, C. J. 1979. Environmental Effects of River Flows and Levels in the Suwannee River Subbasin below Wilcox and the Suwannee River Estuary, Florida. Interim Report. Suwannee River Water Management District, Live Oak, FL. 152 pp.

Leitman, H. M., J. E. Sohm, and M. A. Franklin, 1983. Wetland Hydrology and Tree Distribution of the Apalachicola River Flood Plain, Florida. U. S. Geological Survey Water-Supply Paper 2196A. 52 pp.

Leitman, H. M., M. R. Darst, and J. J. Nordhaus. 1991. Fishes in the Flood Plain of the Ochlockonee River, Florida During Flood and Drought Conditions. U. S. Geological Survey Water-Resources Investigation Report 90-4202. 38 pp.

Lewis, L.J., Light, H.M., and Darst, M.R. 2002. Location and description of transects for ecological issues in floodplain forests of the lower Suwannee River, Florida: U.S. Geological Survey Open-File Report 01-410, 84 p.

Light, H. M., M. R. Darst, and J. W. Grubbs. 1998. Aquatic Habitats in Relation to River Flow in the Apalachicola River Floodplain, Florida. U. S. Geological Survey Professional Paper 1594. 77 pp.

Light, H. M., M. R. Darst, L. J. Lewis, and D. A. Howell. 2002. Hydrology, Vegetation, and Soils of Riverine and Tidal Floodplain Forests of the Lower Suwannee River, Florida, and Potential Impacts of Flow Reductions. U. S. Geological Survey Professional Paper 1656A. 124 pp.

Lillie, R. A. 2003. Macroinvertebrate community structure as a predictor of water duration in Wisconsin wetlands. J. American Water Resources Assoc. 39(2): 389-400.

Lindberg, W. J. (ed.). 1997. Florida Big Bend Coastal Research Workshop. Toward a Scientific Basis for Ecosystem Management. Proceedings of the Meeting. May, 1997. Steinhatchee, Florida. Florida Sea Grant Technical Paper 88. University of Florida, Gainesville, FL. 117 pp.

Linsley, R.K., M.A. Kohler, and J.L.H. Paulhus. 1982. Hydrology for Engineers. 3rd Edition. McGraw-Hill Book Company, New York, NY

Livingston, R. J. 1997. Trophic response of estuarine fishes to long-term changes of river runoff. Bulletin of Marine Science 60(3): 984-1004.

Livingston, R. J., F. G. Lewis, G. C. Woodsum, X.-F. Niu, B. Galperin, W. Huang, J. D. Christensen, M. E. Monaco, T. A. Battista, C. J. Klein, R. L. Howell IV., and G. L. Ray. 2000.

Modelling oyster population response to variation in freshwater input. Estuarine, Coastal and Shelf Science 50: 655-672.

Lutgens F.K. and E.J. Tarbuck, 1989. The Atmosphere: An Introduction to Meteorology. 4th edition.

Lynch, J. M. 1984. Suwannee River Preserve design project. Report prepared for the Florida Natural Areas Inventory Program and the Southeast Regional Office of the Nature Conservancy. Vol. 1: vi, 220 pp.

Linsley, R. K., M. A. Kohler, and J. L. H. Paulhus, 1982. Hydrology for Engineers. New York, McGraw-Hill Book Company, 3rd Ed.

Maidment, D. R. (ed.). 1993. Handbook of Hydrology. McGraw-Hill, Inc., New York, NY. Pp. variously numbered.

Marella, R. L. 2004. Water Withdrawals, Use, Discharge, and Trends in Florida, 2000. U.S. Geological Survey Scientific Investigations Rep. 2004-5151. 136 pp.

Maser, C. and J. R. Sedell. 1994. From the Forest to the Sea. The Ecology of Wood in Streams, Rivers, Estuaries and Oceans. St. Lucie Press, Delray Beach, FL. 200 pp.

Mason, W. T., Jr. 1991. A survey of benthic invertebrates in the Suwannee River, Florida. Environmental Monitoring and Assessment 16: 163-187.

Mason, W. T., Jr., R. A. Mattson, and J. H. Epler. 1994. Benthic invertebrates and allied macrofauna in the Suwannee River and Estuary Ecosystem. Florida Scientist 57(4): 141-160.

Master, L. L., S. R. Flack, and B. A. Stein (eds.). 1998. Rivers of Life: Critical Watersheds for Protecting Freshwater Biodiversity. The Nature Conservancy, Arlington, VA. 71 pp. www.conserveonline.org/2000/12/b/en/Rivers.pdf

Mattraw, H. C., Jr. and J. F. Elder. 1984. Nutrient and Detritus Transport in the Apalachicola River, Florida. U. S. Geological Survey Water-Supply Paper 2196C. 62 pp.

Mattson, R. A. 2002a A resource-based framework for establishing freshwater inflow requirements for the Suwannee River estuary. Estuaries 25(6B): 1333-1342.

Mattson, R. A. 2002b. Memorandum submitted to J. C. Good and K. Webster regarding re-visit to tidal marsh transects sampled 1997-98 and 2000. Dated July 9, 2002. 5 pp.

Mattson, R. A. and J. T. Krummrich. 1995. Determination of salinity distributions in the upper Suwannee River estuary. Final Report Review Draft. Suwannee River Water Management District, Live Oak, FL. 49 pp., 1 App.

Mattson, R. A., J. H. Epler, and M. Hein. 1995. Benthic communities in karst, spring-fed streams in north central Florida. J. Kansas Entomological Soc. 68(2) Supplement: 18-41.

McCarron, J. K., K. W. McLeod, and W. H. Conner. 1998. Flood and salinity stress of wetland woody species, buttonbush (*Cephalanthus occidentalis*) and swamp tupelo (*Nyssa sylvatica* var. *biflora*). Wetlands 18(2): 165-175.

McMichael, R. and T-S. Tsou. 2003. Analysis of Fisheries Data in Association with the Development of Minimum Flows and Levels for the Lower Suwannee River/Estuary. Report submitted to the USEPA Gulf of Mexico Program, MS. Project No. MX974080-00-0. 84 pp.

McNulty, J. K., W. N. Lindall, Jr., and J. E. Sykes. 1972. Cooperative Gulf of Mexico Estuarine Inventory and Study, Florida. Phase 1, Area Description. NOAA Technical Report NMFS CIRC-368. 126 pp.

McPherson, B. F. and K. M. Hammett. 1991. Tidal Rivers of Florida. Pp. 31-46 IN: R. J. Livingston (ed.), The Rivers of Florida. Ecological Studies Vol. 83. Springer-Verlag, New York, NY.

Meinzer, O.E., 1927, Large springs in the United States: U.S. Geological Survey Water-Supply Paper 557.

Miller, J. A. 1982. Geology and Configuration of the top of the Tertiary Limestone Aquifer System, Southeastern United States. U.S. Geological Survey Open-File Report 81-1178. Map.

Miller, J.A., 1997. Hydrogeology of Florida. Pp. 69-88 IN: A.F. Randazzo and D.S. Jones (eds.), The Geology of Florida. University Press of Florida, Gainesville, FL.

Miller, K. G. and D. Maurer. 1973. Distribution of the fiddler crabs, *Uca pugnax* and *Uca minax*, in relation to salinity in Delaware rivers. Chesapeake Science 14(3): 219-221.

Mitsch, W. J. and J. G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold, New York, NY. 539 pp.

Montague, C. L. and R. G. Wiegert. 1990. Salt marshes. Pp. 481-516 IN: R. L. Myers and J. J. Ewel (eds.), Ecosystems of Florida. Univ. of Central Florida Press, Orlando, FL.

Montague, C. L. and H. T. Odum. 1997. Setting and functions. Pp. 9-33 IN: C. L. Coultas and Y-P. Hsieh (eds.), Ecology and Management of Tidal Marshes. A Model from the Gulf of Mexico. St. Lucie Press, Delray Beach, FL.

Mote Marine Laboratory. 1986. Oyster Associated Fauna. Vol. 4 in a Series: A Data Collection Program for Selected Coastal Estuaries in Hernando, Citrus and Levy Counties, Florida. Report submitted to Southwest Florida Water Management District, Brooksville, Florida. Pp. not numbered.

NMFS. 1999. Essential Fish Habitat: New Marine Fish Habitat Conservation Mandate for Federal Agencies. National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, FL. Pp. not numbered. http://galveston.ssp. nmfs.gov/efh/EFHprimer2.pdf

Nathan, R.J. and T.A. McMahon. 1990. Evaluation of Automated Techniques for Base Flow and Recession Analysis. Water Resources Research. v. 10, pp. 282-290.

National Research Council. 1986. Ecological Knowledge and Environmental Problem-Solving. Concepts and Case Studies. National Academy Press, Washington, D. C. 388 pp.

Nelson, D. M. (ed.). 1992. Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries. Vol. 1: Data Summaries. ELMR Report Number 10. NOAA/NOS Strategic Environmental Assessments Division, Rockville, MD. 273. pp.

NewFields…2004. Analysis of Blue Spring Discharge Data for Determining Minimum Flows to Protect Manatee Habitat. Prepared for St. Johns River Water Management District.

Noss, R. F., E. T. LaRoe III, and J. M. Scott. 1995. Endangered Ecosystems of the United States: A Preliminary Assessment of Loss and Degradation. Biological Report 28. National Biological Service, Washington, D.C. 73 pp. http://biology.usgs.gov/pubs/ecosys

Notestein, S. K. and T. K. Frazer. 2004. Factors influencing submersed aquatic vegetation of the Ichetucknee River. Abstract for the Conference “Suwannee Rivr Basin and Estuary Integrated Science Workshop.” U.S. Geological Survey Open-File Report 2004-1332. P. 35.

Odum, W. E., T. J. Smith, III, J. K. Hoover, and C. C. McIvor. 1984. The ecology of tidal freshwater marshes of the United States east coast: a community profile. U. S. Fish Wildl. Serv. FWS/OBS-83/17. 177 pp. http://cuadra.nwrc.gov/Techrept/83-17.pdf

Orlando, S. P., Jr., L. P. Rozas, G. H. Ward, and C. J. Klein. 1993. Salinity Characteristics of Gulf of Mexico Estuaries. National Oceanic and Atmospheric Administration, Office of Ocean Resources, Conservation and Assessment, Silver Spring, MD. 209 pp.

Pattillo, M. E., T. E. Czapla, D. M. Nelson, and M. E. Monaco. 1997. Distribution and Abundance of Fishes and Invertebrates in Gulf of Mexico Estuaries. Vol. 2: Species Life History Summaries. ELMR Report No. 11. NOAA/NOS Strategic Environmental Assessments Division, Silver Spring, MD. 377 pp.

PBS&J. 2003a. Synthesis and Bibliography of Hydrologic and Biological Literature to Support Development of Minimum Flows and Levels for the Lower Suwannee River and Estuary. Final Report. Submitted to Suwannee River Water Management District, Live Oak, FL. Pp. variously numbered.

Pezeshki, S. R., R. D. DeLaune, and W. H. Patrick, Jr. 1987. Response of baldcypress (*Taxodium distichum* L. var. *distichum*) to increases in flooding salinity in Louisiana's Mississippi River deltaic plain. Wetlands 7(1): 1-10.

Pezeshki, S. R., R. D. DeLaune, and W. H. Patrick, Jr. 1990. Flooding and saltwater intrusion: potential effects on survival and productivity of wetland forests along the U. S. Gulf coast. Forest Ecology and Management 33/34: 287-301.

Pittman, J. R., H. H. Hatzell, and E. T. Oaksford. 1997. Spring Contributions to Water Quantity and Nitrate Loads in the Suwannee River During Base Flow in July, 1995. U. S. Geological Survey Water-Resources Investigations Report 97-4152. 12 pp.

Planert, M. In press. Simulation of Regional Ground-Water Flow in the Suwannee River Basin, Northern Florida and Southern Georgia. U. S. Geological Survey Water-Resources Investigation Report.

Poff, N. L. and J. D. Allan. 1995. Functional organization of stream fish assemblages in relation to hydrological variability. Ecology 76(2): 606-627.

Poff, N. L. and J. V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. Can. J. Fish. and Aquat. Sci. 46: 1805-1818.

Poff, N. L., J. D. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The natural flow regime. A paradigm for river conservation and restoration. Bioscience 47(11): 769-784.

Puri, H.S. and R. O. Vernon. 1964. Summary of the Geology of Florida and A Guidebook to the Classic Exposures. Florida Geological Survey Special Publication No. 5. 255 pp.

Puri, H.S., J.W. Yon, Jr., and W.R. Oglesby, 1967. Geology of Dixie and Gilchrist Counties, Florida. Florida Geological Survey Bulletin 49.

Raabe, E. A. and R. P. Stumpf. 1996. Monitoring Tidal Marshes of Florida's Big Bend: Regional Variations and Geologic Influences. U. S. Geological Survey Open-File Report 96-35. 9 pp. plus insert map.

Richter, B. D., J. V. Baumgartner, R. Wigington, and D. P. Braun. 1997. How much water does a river need? Freshwater Biology 37: 231-249.

Rogers, S. G., T. E. Targett, and S. B. Van Sant. 1984. Fish-nursery use in Georgia salt-marsh estuaries: the influence of springtime freshwater conditions. Trans. Amer. Fish. Soc. 113: 595-606.

Rosenau, J. C. and P. E. Meadows. 1977. Potentiometric Surface of the Floridan Aquifer in the Northwest Florida Water Management District, May 1976 U.S. Geological Survey Water Resources Investigation Open File Report No. 77-2. Map.

Rozas, L. P. and C. T. Hackney. 1983. The importance of oligohaline estuarine wetland habitats to fisheries resources. Wetlands 3: 77-89.

Rozas, L. P. and W. E. Odum. 1987a. Fish and macrocrustacean use of submerged plant beds in tidal freshwater marsh creeks. Marine Ecol. Prog. Series 38: 101-108.

Rozas, L. P. and W. E. Odum. 1987b. The role of submerged aquatic vegetation in influencing the abundance of nekton on contiguous tidal fresh-water marshes. J. Exp. Mar. Biol. Ecol. 114: 289-300.

Rumenik, R. P. and J. W. Grubbs. 1996. Low-Flow Characteristics of Florida Streams. U. S. Geological Survey Water-Resources Investigations Report 93-4165. 220 pp.

Ryan, E. P. 1956. Observations on the life histories and the distribution of the Xanthidae (mud crabs) of Chesapeake Bay. Amer. Midland Naturalist 56(1): 138-162.

SAS Institute . 1989. SAS Language and Procedures: Usage - Version 6 Edition. SAS Institute Inc., Box 8000, Cary, N.C.

Satti, S.R. and J.M. Jacobs. 2004. A comparison of Florida crop evapotranspiration and consumptive use permitting methods.

Schlosser, I. J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecol. Monographs 52(4): 395-414.

Schlosser, I. J. 1987. The role of predation in age- and size-related habitat use by stream fishes. Ecology 68(3): 651-659.

Schlosser, I. J. 1991. Stream fish ecology: a landscape perspective. BioScience 41(10): 704-712.

Schmidt, W. 1997. Geomorphology and Physiography of Florida. Pp. 1-12 IN: A. F. Randazzo and D. S. Jones (eds.), The Geology of Florida. University Press of Florida, Gainesville, FL.

Scott, T. M., G. H. Means, R. C. Means, and R. P. Meegan. 2002. First Magnitude Springs of Florida. Florida Geological Survey Open File Report No. 85. 138 pp.

Scott, T.M., 1988. The Lithostratigraphy of the Hawthorn Group (Miocene) of Florida. Florida Geological Survey, Bulletin No. 59, 148 p.

Scott, T.M., et al., 2004. Springs of Florida. Florida Geological Survey, Bulletin No. 66, 377 p.

Searcy, J. K. 1959. Flow-Duration Curves. Manual of Hydrology: Part 2. Low-Flow Techniques. Geological Survey Water-Supply Paper 1542-A (1963 Reprint). 33 pp.

Siegel, E. M., R. H. Weisberg, J. C. Donovan, and R. D. Cole. 1996. Physical Factors Affecting Salinity Intrusions in Wetlands: The Suwannee River Estuary. University of South Florida, Department of Marine Science, St. Petersburg, FL. 127 pp.

Smock, L. A. and E. Gilinsky. 1992. Coastal Plain Blackwater Streams. Pp. 271-313 IN: C. T. Hackney, S. M. Adams, and W. H. Martin (eds.), Biodiversity of the Southeastern United States. Aquatic Communities. J. Wiley and Sons, Inc., New York, NY.

Smock, L. A., J. E. Gladden, J. L. Riekenberg, L. C. Smith, and C. R. Black. 1992. Lotic macroinvertebrate production in three dimensions: channel surface, hyporheic, and floodplain environments. Ecology 73(3): 876-886.

Snedaker, S. C., D. P. deSylva, and D. Cottrell. 1977. A Review of the Role of Freshwater in Estuarine Ecosystems. Volume 1: Summary. Southwest Florida Water Management District Planning Report No. 1977-2. 126 pp.

Sniffen, R. P. 1981. Benthic invertebrate production during seasonal inundation of a floodplain swamp. Ph.D. Dissertation. University of North Carolina, Chapel Hill, N.C. 176 pp.

South Florida Water Management District. 2000. Technical Documentation to Support Development of Minimum Flows and Levels for the Caloosahatchee River and Estuary. Draft Report. South Florida Water Management District, West Palm Beach, FL. 80 pp.

South Florida Water Management District. 2002. MFLs for the Northwest Fork of the Loxahatchee River. Appendix A – Results of a Literature Review for the Loxahatchee River and Estuary. Report by the South Florida Water Management District, West Palm Beach, FL. Pp. A-1 to A-29.

SRWMD. 1982. Hydrogeologic Overview. Suwannee River Water Management District. SRWMD Technical Report 82-3. 19 pp.

Suwannee River Water Management District. 2005. Personal communication. Taylor Engineering, 2002

Stalnaker, C. B. 1981. Low flow as a limiting factor in warm-water streams. Pp. 192-199 IN: L. A. Krumholz, C. F. Bryan, G. E. Hall, and G. B. Pardue (eds.), The Warmwater Streams Symposium. American Fisheries Society, Southern Division. Allen Press, Inc., Lawrence, KS.

Stalnaker, C., B. L. Lamb, J. Henriksen, K. Bovee, J. Bartholomew. 1995. The Instream Flow Incremental Methodology. A Primer for IFIM. Biological Report 29. USGS Midcontinent Science Center, Ft. Collins, CO. 45 pp. www.fort.usgs.gov/products/pubs/2422/2422.pdf

Stalnaker, C. Personal Communication. Introduction, Classification and Biologic Methods. Paper presented at a Workshop on Development of Instream Flow Programs in Southeastern States. Mid-year Meeting of the American Fisheries Society, Southern Division. Jacksonville, Florida. 23 February 2001.

Stanley, J. G. and M. A. Sellers. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico) - - American oyster. U. S. Fish Wildl. Serv. Biol. Report 82(11.64). U. S. Army Corps of Engineers TR EL-82-4. Vi plus 25 pp.

Stewart, J.W., and L.R. Mills, 1984. Hydrogeology of the Sulphur Springs Area, Tampa, Florida. U.S. Geological Survey Water-Resources Investigations Report 83-4085.

Stringfield, V.T. 1966. Artesian Water in Tertiary Limestone in the Southeastern States. U.S. Geologic Survey Professional Paper 517. 226 pp.

Sulak, K. J., M. Randall, and J. Clugston. 2001. Critical spawning habitat, early life history requirements, and other life history and population aspects of the Gulf Sturgeon in the Suwannee River. Results of research conducted 1995-2000. Report submitted to the Nongame Wildlife Program, Florida Fish and Wildlife Conservation Commission, Tallahassee, FL. 105 pp.

SWFWMD. 2002. Upper Peace River. An Analysis of Minimum Flows and Levels. Draft Report by the Southwest Florida Water Management District, Brooksville, FL. Pp. variously numbered.

Sykes, P. W., Jr., C. B. Kepler, K. L. Litzenberger, H. R. Sansing, E. T. R. Lewis, and J. S. Hatfield. 1999. Density and habitat of breeding swallow-tailed kites in the lower Suwannee ecosystem, Florida. J. Field Ornithology 70(3): 321-336.

Taylor Engineering, Inc. 2002. HEC-RAS Update for the Aucilla River and Suwannee River System. Report submitted to the Suwannee River Water Management District, Live Oak, Florida. SRWMD Contract #01/02-216

Thorp, A. G., R. C. Jones, and D. P. Kelso. 1997. A comparison of water-column macroinvertebrate communities in beds of differing submersed aquatic vegetation in the tidal freshwater Potomac River. Estuaries 20(1): 86-95.

Tillis, G. M. 2000. Flow and Salinity Characteristics of the Upper Suwannee River Estuary. U. S. Geological Survey Water-Resources Investigations Report 99-4268. 40 pp.

Tiner, R. W. 1993. Field Guide to Coastal Wetland Plants of the Southeastern United States. Univ. of Massachusetts Press, Amherst, MA. 328 pp.

Tootle, G. A. and T. C. Piechota. 2004. Suwannee River long range streamflow forecasts based on seasonal climate predictors. J. American Water Resources Assoc. 40(2): 523-532.

Tsou, T-S. and R. E. Matheson, Jr. 2002 Seasonal changes in the nekton community of the Suwannee River estuary and potential impacts of freshwater withdrawal. Estuaries 25(6B): 1372-1381.

Twilley, R. R. and J. W. Barko. 1990. The growth of submersed macrophytes under experimental light and salinity conditions. Estuaries 13(3): 311-321.

Upchurch, S.B. 1990. Quality of Ground Water in the Suwannee River Water Management District: Results of the First Sampling of the Background Water-Quality Network. Unpublished contract report submitted to the Suwannee River Water Management District, March 28, 1990.

Upchurch, S.B., and K.M. Champion, 2003a . Geostatistical Analysis of Water-Level and Water-Quality Data for the Manatee-Fanning Springshed. SDII Global Corporation. Tampa, Florida.

Upchurch, S.B., and K.M. Champion, 2003b. Delineation of Spring-Water Source Areas in the Ichetucknee Springshed. SDII Global Corporation. Tampa, Florida.

Upchurch, S.B., and K.M. Champion, 2004. Interim Spring Basin Management Plans for Five First-Magnitude Springs in North-Central Florida. SDII Global Corporation. Tampa, Florida.

Upchurch, S.B., D. Hornsby, R. Ceryak, and W. Zwanka, 2001. A Strategy for the Characterization of First Magnitude Springs. Suwannee River Water Management District, Live Oak, FL, WR01/02-01.

Upchurch, S.B., 2002. Hydrogeochemistry of a Karst Escarpment. In J.B. Martin, C.M. Wicks, and I.D. Sasowsky (eds.), Hydrogeology and Biology of Post-Paleozoic Carbonate Aquifers. Charles Town, WV, Karst Waters Institute, Special Publication 7, pp. 73-75.

Upchurch, S.B., 1992. Quality of Waters in Florida's Aquifers. In G.L. Maddox, J.M. Lloyd, T.M. Scott, S.B. Upchurch, and R. Copeland (eds.), Florida Ground Water Quality Monitoring Program -- Volume 2, Background Hydrogeochemistry, Florida Geological Survey, Special Publication No. 34, Ch. IV, pp. 12-52, 64-84,90-347.

Upchurch, S.B., K.M. Champion, and J.C. Schneider, 2005. Ground Water Chemistry and Origin of Water Discharging from Manatee and Fanning Springs, Levy and Gilchrist Counties, Florida. Live Oak, Florida, Suwannee River Water Management District, 41 p.

U.S. Census Bureau, 2002. State and County Quick Facts. Accessed via the worldwide web at: http://quickfacts.census.gov/qfd/states/12/12023.html.

U. S. Dept of Agriculture (USDA). 1977. Northeast Gulf River Basins. Florida, Alabama and Georgia. Co-operative Survey. Volume 1 and Appendix to Vol. 1. Report produced by the U.S.D.A. Soil Conservation Service in co-operation with the Fla. Dept. of Environmental Regulation and the Alabama Development Office. Vol. 1: 236 pp.; App. to Vol. 1: 107 pp.

USGS. 2001. Water Resources Data. Florida. Water Year 2000. Volume 4. Northwest Florida. U. S. Geological Survey Water-Data Report FL-00-4. 222 pp.

Van Wagner, C.E. 1968. The line intercept method in forest fuel sampling. Forest Science 14:20-26.

Vince, S. W., S. R. Humphrey, and R. W. Simons. 1989. The ecology of hydric hammocks: a community profile. U.S. Fish Wildl. Serv. Biol. Report 85(7.26). 81 pp. http://cuadra.nwrc.gov/Techrept/85-7-26.pdf

Vogel, R. M. and N. M. Fennessey. 1994. Flow duration curves. I. New interpretation and confidence intervals. J. Water Res. Planning and Manage-ment 120(4): 485-504.

Vogel, R. M. and N. M. Fennessey. 1995. Flow duration curves II: a review of applications in water resources planning. Water Res. Bull. 31(6): 1029-1039.

Wallace, J. B. and A.C. Benke, 1984. Quantification of wood habitat in subtropical Coastal Plain streams. Canadian Journal of Fisheries and Aquatic Sciences 41: 1643-1652.

Walsh, S. J. 2001. Freshwater macrofauna of Florida karst habitats. Pp. 78-88 IN: Kuniansky, E. L. (ed.), Karst Interest Group Proceedings. St. Petersburg, FL. February 13-16, 2001. U. S. Geological Survey Water-Resources Investigations Report 01-4011.211 pp.

Walsh, S. J. and J. D. Williams. 2003. Inventory of Fishes and Mussels in Springs and Spring Effluents of North-Central Florida State Parks. Final Report. U.S. Geological Survey Center for Aquatic Resources, Gainesville, FL. 97 pp.

Ward, J. V. 1989. The four-dimensional nature of lotic ecosystems. J. North American Benthological Soc. 8(1): 2-8.

Warm-Water Task Force. 2004 (Draft). Recommendations for Future Manatee Warm-Water Habitat. Report prepared under the auspices of the Florida Manatee Recovery/Implementation Team. Review Draft dated December 27, 2004. 26 pp.

Weinstein, M. P. 1979. Shallow marsh habitats as primary nurseries for fishes and shellfish, Cape Fear River, North Carolina. Fish. Bulletin 77(2): 339-357.

Wharton, C. H., W. M. Kitchens, E. C. Pendleton, and T. W. Snipe. 1982. The ecology of bottomland hardwood swamps of the southeast: a community profile. U. S. Fish and Wildlife Service, Biological Services Program, Washington, D.C. FWS/OBS-81/37. 133 pp. http://cuadra.nwrc.gov/Techrept/81-37.pdf

Wharton, C. H., H. T. Odum, K. Ewel, M. Duever, A. Lugo, R. Boyt, J. Bartholomew, and E. DeBellevue. 1976. Forested Wetlands of Florida – their Management and Use. Final Report to the Florida Division of State Planning. University of Florida, Center for Wetlands, Gainesville, FL. 421 pp.

White, William A., 1970. The Geomorphology of the Florida Peninsula. Florida Geological Survey, Bulletin No. 51, 164 p.

Williams, K, K. C. Ewel, R. P. Stumpf, F. E. Putz, and T. W. Workman. 1999. Sea-level rise and coastal forest retreat on the west coast of Florida, USA. Ecology 80(6): 2045-2063.

Williams, K., M. V. Meads, and D. A. Sauerbrey. 1998. The roles of seedling salt tolerance and resprouting in forest zonation on the west coast of Florida, USA. Am. J. Bot. 85(12): 1745-1752.

Wolfe, S. H. and L. E. Wolfe. 1985. The Ecology of the Suwannee River Estuary. An Analysis of Ecological Data from the Suwannee River Water Management District Study of the Suwannee River Estuary 1982-1983. Technical Report. Florida Department of Environmental Regulation, Tallahassee, FL. 118 pp.

Woodruff, A. 1993. Florida Springs Chemical Classification and Aquatic Biological Communities. M.S. Thesis. University of Florida, Gainesville, FL. 117 pp.

Wright, E. E. 1995. Sedimentation and Stratigraphy of the Suwannee River Marsh Coastline. Ph.D Dissertation. University of South Florida, St. Petersburg, FL.254 pp.