HILLCREST BAY WETLAND RESTORATION SITE
(Contract # D04013-2)

MONITORING YEAR 3
2007

Offered By and Monitored By:

Mid-Atlantic Mitigation, LLC
1960 Derita Road
Concord, NC 28027

Designed By:

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Submitted To:

North Carolina Ecosystem Enhancement Program
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1.0 EXECUTIVE SUMMARY/PROJECT ABSTRACT

On behalf of the North Carolina Ecosystem Enhancement Program (NCEEP), Mid-Atlantic Mitigation, LLC (MAM) with technical assistance from Stantec Consulting, Inc. (Stantec) restored a 47-acre ditched and drained clay-based Carolina bay in Hoke County, North Carolina. The Hillcrest Bay Wetland Mitigation Site (Site) is located in the Beaver Creek Watershed of the Cape Fear River Basin (HUC 03030004). Construction of the project began on March 21, 2005 and was completed on April 15, 2005. Additional planting of the site was done in February 2006. The Hillcrest Bay project will restore at least 15 non-riverine wetland mitigation units.

Hillcrest Bay in its preconstruction condition had been ditched and drained for agricultural purposes for at least 40 years. Its most current use was for agricultural (cotton) production. The Site was drained by five connected ditches that eventually flow into Beaver Creek offsite. Scurlock Elementary School sits on the southwestern edge of the bay and a young loblolly pine (*Pinus taeda*) stand borders the Site to the west. Agricultural fields occur north and east of the Site, and residential housing occurs to the south.

The goal of this wetland restoration is to restore the unique natural community associated with the clay based bays of the Sandhill Region of North Carolina. Historically, these clay-based bays differ both in hydrology and vegetation from organic/peat based Carolina bays. Restoration of Hillcrest Bay will improve filtration of nutrients and pollutants from adjacent agricultural fields, parking lots, and roads as well as recharge groundwater and increase base flow in adjacent streams.

In order to restore the Site, drainage ditches were filled using spoil material from the berms located along existing ditches. Clay plugs were used to block flow within existing ditches to interrupt historic drainage patterns and recharge groundwater within the bay. Hydrologic analysis of the site was conducted to ensure success. Data gathered from groundwater monitoring gauges supplemented the results of DRAINMOD, Pierce, and HEC-RAS. The 2-year, 5-year, and 100-year flood elevations were analyzed to examine the potential for hydrologic trespass on property occupied by the elementary school and residents located along the rim of the bay. The 100-year storm event predicted that the elevations of water during these events would have some potential for hydrologic trespass on adjacent residences unless precautions are taken in the design of the restoration. For this reason, two weirs were installed on the north end of the Site to relieve water above the 100-year storm event elevation. Data was also obtained from four reference bays and was used as guidance for the planting plan and assess hydrologic success criteria..

The following table summarizes the construction sequence for the Hillcrest Bay Restoration Site.

Exhibit Table I. Dates of Construction

Event	Date
Begin Construction	March 21, 2005
Ripping and Seeding of Site	March 21, 2005
Filling of Ditches	March 22, 2005 through April 5, 2005
Planting of Interior Portions of Site	March 31, 2005
Installation of Clay Plugs	April 6, 2005 through April 10, 2005
Installation of Weir	April 11, 2005
Planting of Travel Lanes	April 13, 2005
Demobilization	April 15, 2005

The hydrology and vegetation at the Site will be monitored annually for five years (2005-2009). Six $100m^2$ vegetation plots were installed on-site on May 25, 2005. Survivability within these plots will establish the success of the Site. Seven groundwater gauges were installed within Hillcrest Bay, and one in a reference site. The gauges will be used to determine the hydrologic success of the Bay and will be compared to the reference bay's hydroperiod if needed. Monitoring began Fall 2005, however year one failed to achieve success criteria for both vegetation and hydrology, therefore monitoring will be carried out at least one additional year to fall 2010.

The third year monitoring was completed on October 14th, 2006. Groundwater and rain gage data was downloaded, vegetation species were counted within the vegetation plots, and both reference bays, Goose Pond Bay and Antioch Bay, were visited. Throughout the year, gauge data was downloaded and evaluated monthly, as well. Drought conditions had begun to improve in late 2006 and early 2007, however the area and State as a whole have been hit again with severe drought conditions since late spring. The wetland hydrology jurisdictional success criteria (17 consecutive days as noted in the Restoration Plan) has not been met by all gages, but continues to improve. The vegetation installed in the February re-plant shows considerably more success and survival then the initial 2005 planting. To remediate problems experienced during the first year, the mitigation area was re-planted in February 2006, competing herbaceous vegetation was treated with herbicide and several techniques were used to increase survival (tree tubes and tree mats). MAM will analyze the various techniques with regard to increased survival. The most effective techniques will be used if another supplemental planting is required. Because this is a Carolina bay wetland, hydrology will be dependant upon rain events in the area significant enough to recharge ground water resources. As noted above, while jurisdictional hydrology has not been fully achieved it is improving and compares favorably to the hydrology of Goose Pond Bay, our reference bay, as noted below.

Reference bays were examined in conjunction with monitoring of the site. A field visit was made to Goose Pond Bay and Antioch Bay. Hydrology data was downloaded from the gauge that was installed in Goose Pond Bay. MAM personnel augered to a depth of 36" to examine soil moisture in each reference bay. No ground water was identified in the auger hole. Soil was dry and hard at 30" in both reference bays.

Despite the regional drought conditions, the majority of the gages have met jurisdictional hydrology which indicates a positive trend for meeting hydrological success criteria. In fact, the reference bay gage did not meet jurisdictional hydrology while the majority of the Site gages did. Over the next few years the hydrology will be monitored in comparison to the reference bays to determine if the success criteria has been achieved. As the water table slowly recovers from the extended drought over the last several years, we expect continued hydrologic improvements. Additional monitoring years may be required to allow the site to develop jurisdictional hydrology. The Mitigation Plan defined Hydrologic Success as jurisdictional hydrology for 5% of the growing season, which for this area is approximately 219 days beginning March 17th and ending October 12th. Therefore, successful hydrology will be indicated by 11 or more days meeting jurisdiction during that time period. More detailed explanation is discussed in Section 3.2.

2.0 PROJECT BACKGROUND

2.1 LOCATION AND SETTING

The Hillcrest Bay Site is located on a 47-acre parcel owned by Hoke County. The Site is located east of the town of Raeford in Hoke County. The Bay is situated north of SR 1406 (Rockfish Road) and west of SR 1408 (Club Pond Road) on the Raeford 7.5 minute topographic quadrangle (Figures 1 and 2). Scurlock Elementary School is situated along the southwestern property boundary of the site.

The Hillcrest Bay Site lies in the Cape Fear River Basin, US Geologic Survey (USGS) hydrologic unit 03030004, NC Division of Water Quality (NCDWQ) subbasin 03-06-15.

Property ownership was transferred to Hoke County in 2005. Project success is being monitored by Mid-Atlantic Mitigation and the conservation easement is held by the State of North Carolina Property Office.

2.2 STRUCTURE AND OBJECTIVES

The Hillcrest Bay Site has a drainage area of approximately 80 acres (Figure 3). Five ditches were actively draining the Site for agriculture. Two additional ditches were present, but were not well maintained and, consequently, have filled with sediment. The latter are no longer draining the Bay and are now vegetated with mature sweet gum (*Liquidambar styraciflua*), red maple (*Acer rubrum*), and loblolly pine (*Pinus taeda*). Ditches within the bay were approximately four feet in width and four feet in depth. The main collector ditches that flowed north toward Beaver Creek were considerably deeper and wider (six feet wide and 10 feet deep) where they have been dug through the northern rim of the Bay.

The restoration of Hillcrest Bay entailed the filling of the drainage ditches present within the bay to restore the historic hydrology of the site. The restoration of the wetland hydrologic regime will, in turn, support the native plant community endemic to such clay-based bays. Reference bays were used to develop a planting plan that would initiate the restoration of the native plant community.

Land use within the watershed is a mixture of agriculture and low-density residential areas. The entire middle portion of the watershed area is currently, or very recently was, in row crop production. Agriculture comprises nearly 50 percent of the watershed. The remaining 50 percent consists of low-density residential development to the south and northwest (40 percent) and a narrow strip of disturbed, mixed forest located between the agricultural fields and residences to the northwest (10 percent).

The Hillcrest Bay Site lies in the Cape Fear River Basin, US Geologic Survey (USGS) hydrologic unit 03030004, NC Division of Water Quality (NCDWQ) subbasin 03-06-15. The Bay is located in the watershed of Beaver Creek. Beaver Creek flows into Rockfish Creek, which continues on to the Cape Fear River. The creek is listed as 'Class C' waters, indicating waters suitable for secondary recreation (NCDWQ, 2004a), and is not a CWA 303(d) listed waterbody (NCDWQ, 2004b). Visual inspection of water within the ditches revealed the presence of a considerable amount of algae, suggesting that the Site receives some nutrient input from the surrounding residential community, as well as pollutants from agricultural runoff. According to the Hoke County Environmental Health Department, Scurlock Elementary School is on the city sewer system, however, the homes located east of Scurlock Elementary, north of Rockfish Road are on septic systems. Topography around the Site suggests that the septic systems may be draining towards the ditches of the Hillcrest Bay Site.

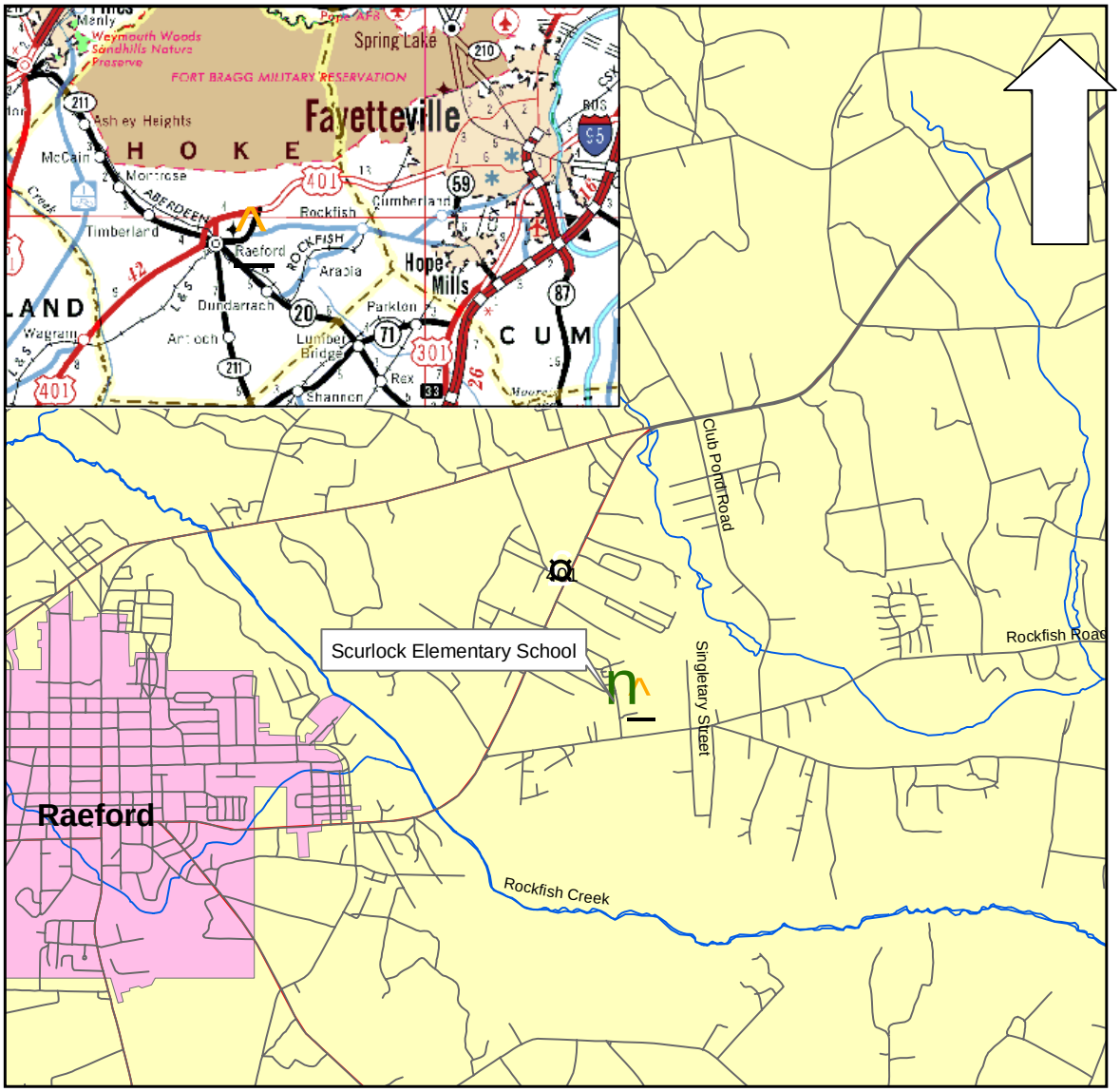
Spring Lake
FORT BRAGG MILITARY RESERVATION
Fayetteville
H O K E
Raeford
Hope Mills
Rockfish
Timberland
Arabia
Parkton
Dundarrach
Lumber Bridge
Rex
Shannon
Wagram
Scurlock Elementary School
Club Pond Road
Singletary Street
Rockfish Road
Raeford
Rockfish Creek
NOT TO SCALE
Legend
Hoke County
Hillcrest Bay
Stantec Consulting
Mid-Atlantic Mitigation, LLC
Ecosystem Enhancement Program
Hillcrest Bay Wetland Restoration
Hoke County, North Carolina
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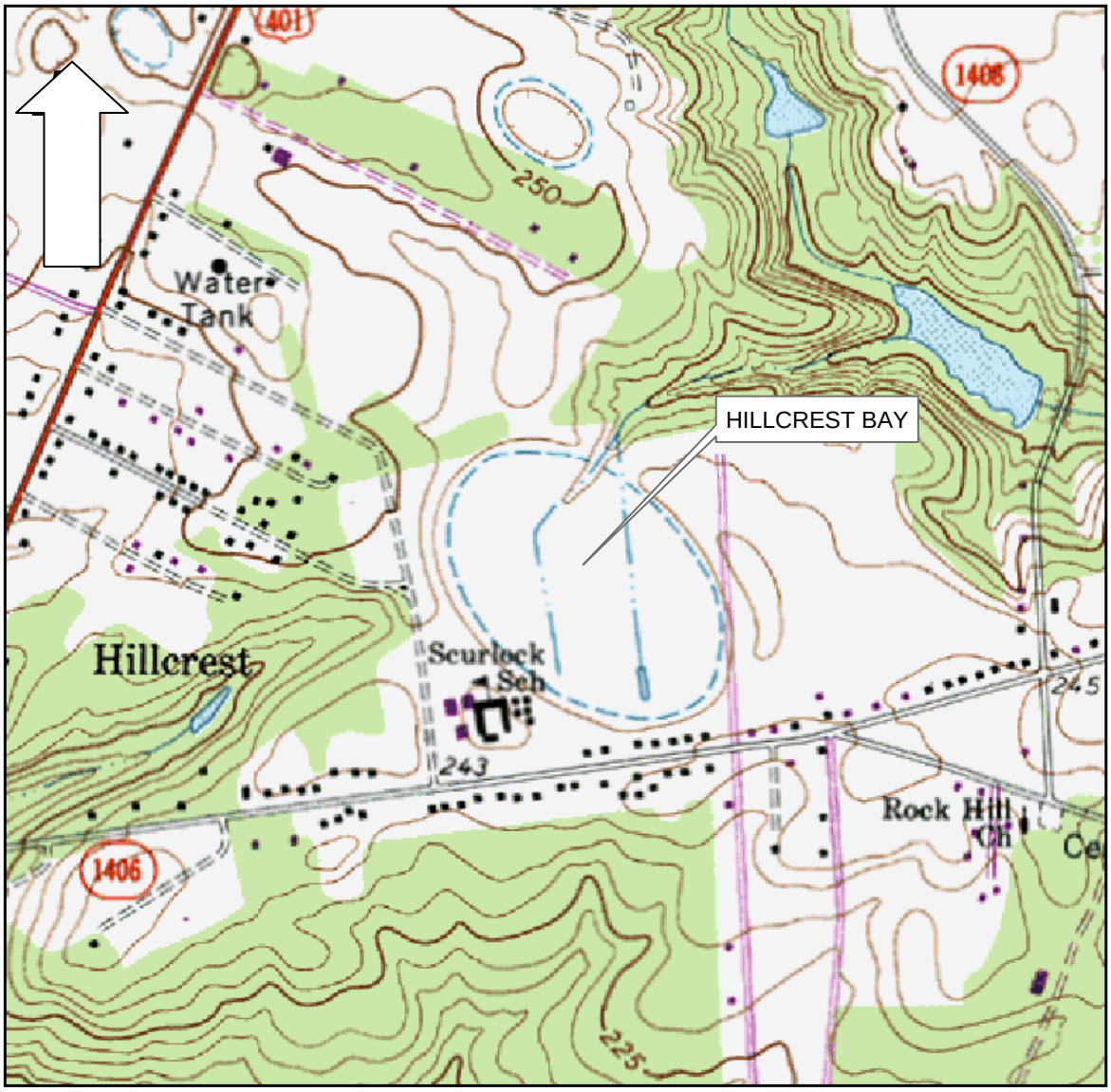
Figure 1. Vicinity Map



Stantec Consulting

Mid-Atlantic Mitigation, LLC

Ecosystem Enhancement Program

Hillcrest Bay Wetland Restoration
Hoke County, North Carolina

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Figure 2. Location Map.

The Cape Fear Basin is characterized by highly urban and industrialized areas around the cities of Greensboro, High Point, Burlington, Chapel Hill, and Durham in the upper part of the watershed and around Fayetteville and Wilmington in the middle and lower part (NCDWQ, 2004c). Water quality in the basin has been affected by the impacts of numerous dischargers and non-point source runoff. There is only one NPDES permitted discharger in the watershed for the Site. The Town of Raeford's Waste Water Treatment Plant is discharging three MGD into Rockfish Creek approximately 1.3 miles downstream of Hillcrest Bay. Even with this discharge, the bioclassification in Rockfish Creek has improved from Good-Fair in 1993 to Good in 2003 (NCDWQ, 2004c).

2.3 PROJECT HISTORY AND BACKGROUND

Exhibit Table II. Project Objectives Table

Segment/Reach ID	Objectives	Linear Feet or Acreage	Comment
Hillcrest Bay	Restoration	15 acres	Bay interior
Buffer	Restoration	32 acres	Bay rim

Exhibit Table III. Project Activity and Reporting History

Activity or Report	Calendar Year of Completion or Planned Completion	Actual Completion Date
Restoration Plan	February 2005	February 2005
Mitigation Plan	June 2005	June 2005
Construction	March 2005	April 2005
Temporary and Permanent S&EC mix applied to entire project area	March 2005	April 2005
Bare Root Plantings	April 2005	April 2005
As-Built report	June 2005	June 2005
Initial – Year 1 monitoring	September 2005	September 2005
Year 2 Monitoring	October 2006	October 2006
Year 3 Monitoring	October 2007	October 2007
Year 4 Monitoring	October 2008	
Year 5 Monitoring	October 2009	
Year 5+ Monitoring	October 2010	

Exhibit Table IV. Project Contact Table	
Project Manager Rich Mogensen	 Mid-Atlantic Mitigation, LLC 1960 Derita Road Concord, North Carolina 28027
Designer Tim Baumgartner	 Stantec Consulting, Inc. 801 Jones Franklin Road, Suite 300 Raleigh, North Carolina 27606
Construction Contractor Michael Granson	 Shamrock Environmental Corporation P.O. Box 14987 Browns Summit, North Carolina 27214
Planting Contractor Dwight McKinney	 Carolina Silvics 908 Indian Trail Road Edenton, North Carolina 27932
Monitoring Performers Christine Cook & Kristy Rodrigue	 Mid-Atlantic Mitigation, LLC 1960 Derita Road Concord, North Carolina 28027

Exhibit Table V. Project Background Table	
Project County	Hoke
Drainage Area	80 Acres
Drainage cover estimate (%)	50% Residential and Commercial
	50% Agricultural
Physiographic Region	Piedmont
Ecoregion	Atlantic Southern Loam Plains
Wetland Type	Clay-based Carolina Bay
Cowardin Classification	PFOE
Dominant soil types	McColl Loam
Reference site ID	Goose Pond Bay
USGS HUC for Project and Reference	Project – 03030004; Reference - 03040203
NCDWQ Sub-basin for Project and Reference	Project 03-06-15;
% of project easement fenced	None

2.4 MONITORING PLAN VIEW

* All coordinates are NAD83 Feet

Exhibit Table VI. Groundwater Gauge Locations		
GAUGE NAME	**NORTHING**	**EASTING**
A1	450647.757	1947265.452
A2	450392.144	1947361.305
A3	450116.862	1947718.567
A4	450358.361	1946842.579
A5	450824.825	1946830.785
A6	451095.286	1946826.596
A7	450567.997	1947649.191
REFERENCE GAUGE	412088.484	1970586.301

Exhibit Table VII. Vegetative Plot Locations			
PLOT NAME	**CORNER**	**NORTHING**	**EASTING**
1	SOUTHWEST	450647.757	1947265.452
	SOUTHEAST	450649.267	1947294.462
	NORTHWEST	450679.136	1947264.119
	NORTHEAST	450679.246	1947297.660
2	SOUTHWEST	450392.144	1947361.305
	SOUTHEAST	450395.209	1947390.554
	NORTHWEST	450420.501	1947357.121
	NORTHEAST	450425.304	1947385.113
3	SOUTHWEST	450116.862	1947718.567
	SOUTHEAST	450120.614	1947744.164
	NORTHWEST	450146.589	1947713.052
	NORTHEAST	450151.292	1947741.291
4	SOUTHWEST	450358.361	1946842.579
	SOUTHEAST	450359.633	1946878.293
	NORTHWEST	450391.017	1946839.244
	NORTHEAST	450390.707	1946868.286
5	SOUTHWEST	450824.825	1946830.785
	SOUTHEAST	450828.675	1946863.150
	NORTHWEST	450855.395	1946829.126
	NORTHEAST	450857.607	1946858.865
6	SOUTHWEST	451095.286	1946826.596
	SOUTHEAST	451097.566	1946854.836
	NORTHWEST	451123.635	1946822.248
	NORTHEAST	451127.353	1946851.780

Exhibit Table VIII. Photo Station Locations		
STATION NUMBER	**NORTHING**	**EASTING**
1	450487.259	1946575.702
2	450918.781	1946501.761
3	451333.583	1946507.378
4	451553.001	1947376.249
5	451370.668	1947379.959
6	450823.779	1948027.547
7	450065.682	1948042.086
8	449930.666	1947534.274

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 VEGETATION ASSESSMENT

3.1.1 Soil Data

Exhibit Table IX. Preliminary Soil Data					
Series	**Max Depth (in.)**	**% Clay on Surface**	**K**	**T**	**OM %**
McColl loam (Mc)	72	10 to 30	0.24	5	1-8
Autryville loamy sand (AuA)	80	0 to 14	0.1	4	0.5-1
Wagram loamy sand (WaB)	72	0 to 14	0.15	5	0.5-2

3.1.2 Vegetative Problem Areas

Exhibit Table X. Vegetative Problem Areas		
Feature/Issue	**Station # / Range**	**Probable Cause**
Invasive Vegetation	Throughout the bay	Scattered sweet gum , large stand around Gage 7
	Bay entrance	Mimosa

Mimosa at Main Entrance to Site

As noted in previous monitoring reports, herbaceous plants are present throughout the Bay and compete with the planted trees and shrubs for resources. Last year the *polygonum* was replaced by other native forbs including dog-fennel (*Eupatorium cpillifolium*), golden rod (*Solidago sp*.) and some brambles (*rubus sp.*). These species are still prevalent in the plots and throughout the site along with daisey fleabane (*Erigeron strigosus*) which was noted as dominant in four of the six plots. Herbaceous plants will continue to be a presence until the trees and shrubs begin to provide shaded canopy cover. Although the herbaceous plants are not helpful, they are not considered invasive and will be addressed each monitoring year as necessary. No herbicide treatments or other forms of weed control were employed in 2007.

3.1.3 Stem Counts

Six vegetation survival plots were established within Zones 1 and 2 of Hillcrest Bay on May 25, 2005. Each plot encompasses $100m^2$ (10m x 10m). Success of the vegetation at Hillcrest Bay will be achieved if 320 stems per acre remain after 3 years. A total of 260 stems per acre must survive after five years. Only those species that were planted within, and are desirable in the Site will be counted. Other volunteers and/or invasive species will be noted, but will not figure into the yearly stem count requirements.

On October 14, 2007, the third year-vegetative monitoring was performed on the established vegetative plots. Planted species that could be identified were noted. Initial totals for Exhibit Table XI were collected during plot counts done after planting in February 2006. A preliminary count was also done in June 2006 and compared well to the February count, but it is obvious that many smaller trees were missed during the June count due to robust herbaceous growth, but were found in the October count. As mentioned above, initial totals in Table XI include only trees and shrubs from the 2006 supplemental planting. All 2005 plants, in the plots, are assumed dead, however live 2005 plants can be seen around the site. Survival percentages are based on 2006 plantings only. Overall, 59 of 100 stems were counted which equals a survival percentage of 59% and the stems per acre averaging 397. This summers drought conditions appear to have taken a toll on the planted trees, as indicated by decreased survival, however the site is still well above the 320 stems per acre goal and supplemental planting will not be considered necessary at this time. Species diversity for all plots and zones averages 5 woody species per plot.

3.1.4 Precipitation and Additional Information

Exhibit Table XII: Average Precipitation Onsite Rain Gage

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Rain fall	3.14	2.19	3.25	3.22	.65	5.33	1.59	1.17	2.45	3.74

The onsite rain gage was compared to two CRONOS gages for quality check purposes, see Rainfall Data in Appendix B. No malfunctions or clogs were noted this year at the onsite raingage, and the onsite data is believed to be accurate. A local CRONOS gage in Red Springs was also used to compare potential differences between rainfall at the project site and rainfall further south in Robeson County near the reference gages.

Exhibit Table XIII Hillcrest Bay Supplemental Planting (02 – 2006)

Zone 1 Plantings			
1030	*Taxodium ascendens*	"Pond Cypress"	bareroot seedling
650	*Cyrilla racemiflora*	" TiTi"	bareroot seedling
323	*Nyssa biflora*	"Swamp Tupelo"	bareroot seedling
350	*Nyssa biflora*	"Swamp Tupelo"	1 gallon
1000	*Pinus serotina*	"Pond Pine"	tubeling
230	*Persea borbonia*	"Redbay"	bareroot seedling
200	*Cephalanthus occidentalis*	"Buttonbush"	1gallon
Zone 2 Plantings			
100	*Lyonia lucida*	"Fetterbush"	tubeling
322	*Nyssa biflora*	"Swamp Tupelo"	bareroot seedling
535	*Aronia arbutifolia*	"Red chokeberry"	1 gallon
415	*Magnolia virginiana*	"SweetBay"	bareroot seedling
169	*Magnolia virginiana*	"SweetBay"	1gallon
30	*Clethra alnifolia*	"Sweetpepper bush"	1 gallon
Zone 3 Plantings			
500	*Quercus laevis*	"Turkey Oak"	bareroot seedling
500	*Quercus marilandica*	"Blackjack Oak"	bareroot seedling
500	*Quercus stellata*	"Post Oak"	bareroot seedling
Total 6,854			

Approximately 10 to 12 acres was planted during the February replant, therefore the site was heavily planted going into this monitoring season.

3.2 WETLAND ASSESSMENT

Site hydrology is meeting jurisdictional criteria on 4 out of 7 gages (gages 1, 2, 5, and 7). Jurisdictional hydrology was defined in the Restoration Plan as 7% of the growing season or 17 consecutive days of groundwater within 12 inches of the surface. Gage 3 continued its same pattern from 2006, rising to within 12 inches for up to 8 days, but falling back below too quickly. A supplemental "check" gage for this gage was installed approximately 20 meters west, closer to the interior of the bay. This gage achieved jurisdictional hydrology prior to the onset of the drought. Gage 4 historically behaves similarly to Gage 3 with jurisdictional periods lasting up to 11 days only to dip again. Gage 6 also shows this dipping pattern, but misses jurisdictional hydrology by only 2 days when a stretch of 15 days is interrupted by 3 days that dip down to -14.3 inches before returning to jurisdictional levels. A "check" gage was also installed for Gage 6 approximately 20 meters south east, closer to the interior of the bay. This gage showed similar data as its counterpart, just missing jurisdictional hydrology by 3 days before the onset of the summer drought conditions. These cycles are obviously precipitation dependent (as noted by rain data graphed above ground water data) and indicate that these areas around gages 3, 4 and 6 are more well drained then the interior areas of the bay. Hydrology of the reference bay (Goose Pond Bay) is still not meeting jurisdictional criteria of 17 consecutive days, even prior to the growing season. Within the growing season, prior to the onset of the drought, only nine consecutive days of jurisdictional hydrology were recorded. The project site actually shows better hydrology than the reference bay. Over the next few years the hydrology will be monitored in comparison to the reference bays to determine if the success criteria has been achieved. Despite monthly site visits and no malfunctions of gages, minimal data was still lost from gages 1, 2, 4, and 5. The longest stretch of missing data is 14 days on Gage 1 and does not include any potentially jurisdictional data points. When gages are found with erroneous readings in the field the sensor is removed from the well and cleaned, once this is done the current status is checked to insure that normal readings are restored. The check gages for gages 3 and 6 were installed with filter sock and sand filters, however it is Gages 3, 6 and 7 which do not show any lost data.

4.0 METHODOLOGY SECTION

Construction and planting of Hillcrest Bay Wetland Restoration Site was completed on April 13, 2005. Mortality of the planted species during the first monitoring year was due primarily to the lack of rain throughout the growing season and a late planting schedule. Competition with weeds left from the prior agricultural operation on the Site also contributed to much of the mortality of the planted species. For the second monitoring year MAM mowed the restoration area in January 2006, replanted parts of Zones 1, 2, and 3, used a combination of tree tubes and tree mats throughout the Site, spot treated with herbicide throughout the site to ensure re-establishment of planted species within the Bay so that the goals of the nonriverine wetland restoration are met. Forested wetland restoration projects typically go through stages of ecological succession prior to achieving all success criteria. It is not uncommon for herbaceous wetland plants to dominate for the first few years after construction. Supplemental plantings will be done if necessary in the future.

Dry conditions identified at the Site since construction were also noted this year although they were not as severe. The reference sites also demonstrated dry conditions, the soils within the bays were inspected to at least 36". No ground water was identified to this depth. Soil within 30" was dry and hard.

4.1 SITE MAINTENANCE

The Mimosa trees at the front entrance of the Site do not appear to be spreading. These trees were cut back and re-grew to approximately the same height. These trees will continue to be trimmed back every year to control their growth and proliferation. MAM will continue to make monthly site visits to assess the needs of the site and minimize lost data. No supplemental plantings are considered necessary at this time.

APPENDIX A

Vegetation Raw Data

Vegetation Plot Photo Log

Permanent Photo Station Photo Log

Exhibit Table XI: Stem Counts for Each Species Arranged by Plot												
	Plots						Initial	Year 1	Year 2	Year 3	Survival	
Species	1	2	3	4	5	6	Totals	Totals	Totals	Totals	%	
Shrubs							(FEB 2006)					
Cephalanthus occidentalis		1	2	1			6	0	16	4	67	
Clethra alnofolia							2	0	0	0	0	
Cyrilla racemiflora			3		1		3	0	4	4	100	
Diospyros viginiana							0	0	0	0	0	
Ilex glabra							0	0	0	0	0	
Lyonia lucida				1			1	0	1	1	100	
Magnolia virginiana							11	1	10	0	0	
Persea borbonia						1	3	0	7	1	33	
Sassafras albidum							0	0	0		0	
Totals	0	1	5	2	1	1	26	1	38	10	38	
Trees												
Aronia arbutiflora	5	1	1	5	4	5	33	0	21	21	64	
Nyssa biflora		1	1	1	1	1	13	0	4	5	38	
Pinus palustris				3			0	0	0	4	0	volunteers
Pinus serotina	1	2		4	5	2	14	0	12	14	100	
Pinus taeda	2						0	0	0	3	0	volunteers
Quercus falcata							0	0	0	0	0	
Quercus laevis							2	0	0	0	0	
Quercus marilandica							0	0	0	0	0	
Quercus stellata							0	0	0	0	0	
Taxodium ascendens	1			3			12	0	8	4	33	
Totals	9	4	2	16	10	8	74	0	45	49	66	
					Overall Totals		100			59	59	
Stems /Acre	364	202	283	728	445	364			559	397		

Plots = 100m2 4046.86 m2 per acre

Total plots = 600m2

$$\frac{59}{600} = \frac{X}{4046.86} = 397.9412$$

Well ID	Well Hydrology Threshold Met?	Mean	Vegetation Plot ID	Vegetation Survival Threshold Met?	Mean
Hill 1	Y	89	Plot 1	N	50
Hill 2	Y		Plot 2	Y	
Hill 3	N		Plot 3	Y	
Hill 3 Alt	Y		Plot 4	Y	
Hill 4	Y		Plot 5	N	
Hill 5	Y		Plot 6	N	
Hill 6	Y				
Hill 6 Alt	Y				
Hill 7	Y				
Goose Pond	N				

Hydrologic Success is set at 11 days between March 17th and October 12th

Well ID	Well Hydrology Threshold Met?	Total days w/ Jurisdictional Hydrology	Percent of Growing Season w/ Jurisdictional Hydrology
Hill 1	Y	48	22
Hill 2	Y	47	21
Hill 3	N	8	3
Hill 3 Alt	Y	16	7
Hill 4	Y	11	5
Hill 5	Y	23	10
Hill 6	Y	15	7
Hill 6 Alt	Y	14	6
Hill 7	Y	16	7
Goose Pond	N	8	3

Veg plot 1

Species	Type	Quantity	
Erigeron strigosus	Herbaceous	Dominant	
Ambrosia artemisiifolia	Herbaceous	Sparse	
Eupatorium capillifolium	Herbaceous	Sparse	
Solidago sp.	Herbaceous	Sparse	
Aronia arbutifolia	Tree	5	
Pinus serotina	Tree	1	
Pinus taeda	Tree	2	volunteer
Liquidambar styraciflua	Tree	6	volunteer/ undesirable?
Taxodium ascendens	Tree	1	

Veg plot 2

Species	Type	Quantity	
Erigeron strigosus	Herbaceous	Dominant	
Solidago L.	Herbaceous	Dominant	
Ambrosia artemisiifolia	Herbaceous	Sparse	
Ipomea purpurea	Vine	Sparse	
Aronia arbutifolia	Shrub	1	
Cephalanthus occidentalis	Shrub	1	
Liquidambar styraciflua	Tree	7	volunteer/ undesirable?
Nyssa biflora	Tree	1	
Pinus serotina	Tree	2	
Salix nigra	Tree	1	volunteer
Malus agustifolia	Tree	1	volunteer/ undesirable?

Veg plot 3

Species	Type	Quantity	
Ambrosia artemisiifolia	Herbaceous	Sparse	
Andropogon virginicus	Herbaceous	Dominant	
Conyza canadensis	Herbaceous	Sparse	
Erigeron strigosus	Herbaceous	Sparse	
Eupatorium capillifolium	Herbaceous	Dominant	
Rubus sp.	Herbaceous	Sparse	
Solidago L.	Herbaceous	Common	
Aronia arbutifolia	Shrub	1	
Cephalanthus occidentalis	Shrub	2	
Cyrilla racemiflora	Shrub	3	
Liquidambar styraciflua	Tree	13	volunteer/ undesirable?
Nyssa biflora	Tree	1	
Platanus occidentalis	Tree	1	volunteer
Malus agustifolia	Tree	3	volunteer/ undesirable?
Prunus serotina	Tree	1	volunteer

Veg plot 4

Species	Type	Quantity	
Ambrosia artemisiifolia	Herbaceous	Sparse	
Eupatorium capillifolium	Herbaceous	Dominant	
Andropogon virginicus	Herbaceous	Common	
Toxicdendron radicans	Herbaceous	Sparse	
Solidago L.	Herbaceous	Common	
Ipomea purpurea	Vine	Sparse	
Aronia arbutifolia	Shrub	5	
Cephalanthus occidentalis	Shrub	1	
Liquidambar styraciflua	Tree	2	volunteer/ undesirable?
Lyonia lucida	Shrub	1	
Malus angustifolia	Tree	2	volunteer/ undesirable?
Nyssa biflora	Tree	1	
Pinus serotina	Tree	4	
Pinus palustris	Tree	3	volunteers
Taxodium ascendens	Tree	3	

Veg plot 5

Species	Type	Quantity	
Ambrosia artemisiifolia	Herbaceous	Sparse	
Eupatorium capillifolium	Herbaceous	Common	
Erigeron strigosus	Herbaceous	Sparse	
Solidago L.	Herbaceous	Common	
Ipomea purpurea	Vine	Sparse	
Lespedeza cuneata	Herbaceous	Sparse	invasive
Aronia arbutifolia	Shrub	4	
Cyrilla racemiflora	Shrub	1	
Liquidambar styraciflua	Tree	2	volunteer/ undesirable?
Nyssa biflora	Tree	1	
Pinus serotina	Tree	5	

Veg plot 6

Species	Type	Quantity	
Andropogon virginicus	Herbaceous	Dominant	
Eupatorium capillifolium	Herbaceous	Common	
Solidago L.	Herbaceous	Common	
Ipomea purpurea	Vine	Sparse	
Aronia arbutifolia	Shrub	5	
Liquidambar styraciflua	Tree	14	volunteer/ undesirable?
Nyssa biflora	Tree	1	
Persea borbonia	Tree	1	
Pinus serotina	Tree	2	

VEGETATION PLOT PHOTO LOG

Veg Plot 1

Veg Plot 2

Veg Plot 3

Veg Plot 4

Veg Plot 5

Veg Plot 6

Photo Point 1

Photo Point 2

Photo Point 3

Photo Point 4

Photo Point 5

Photo Point 6

Photo Point 7

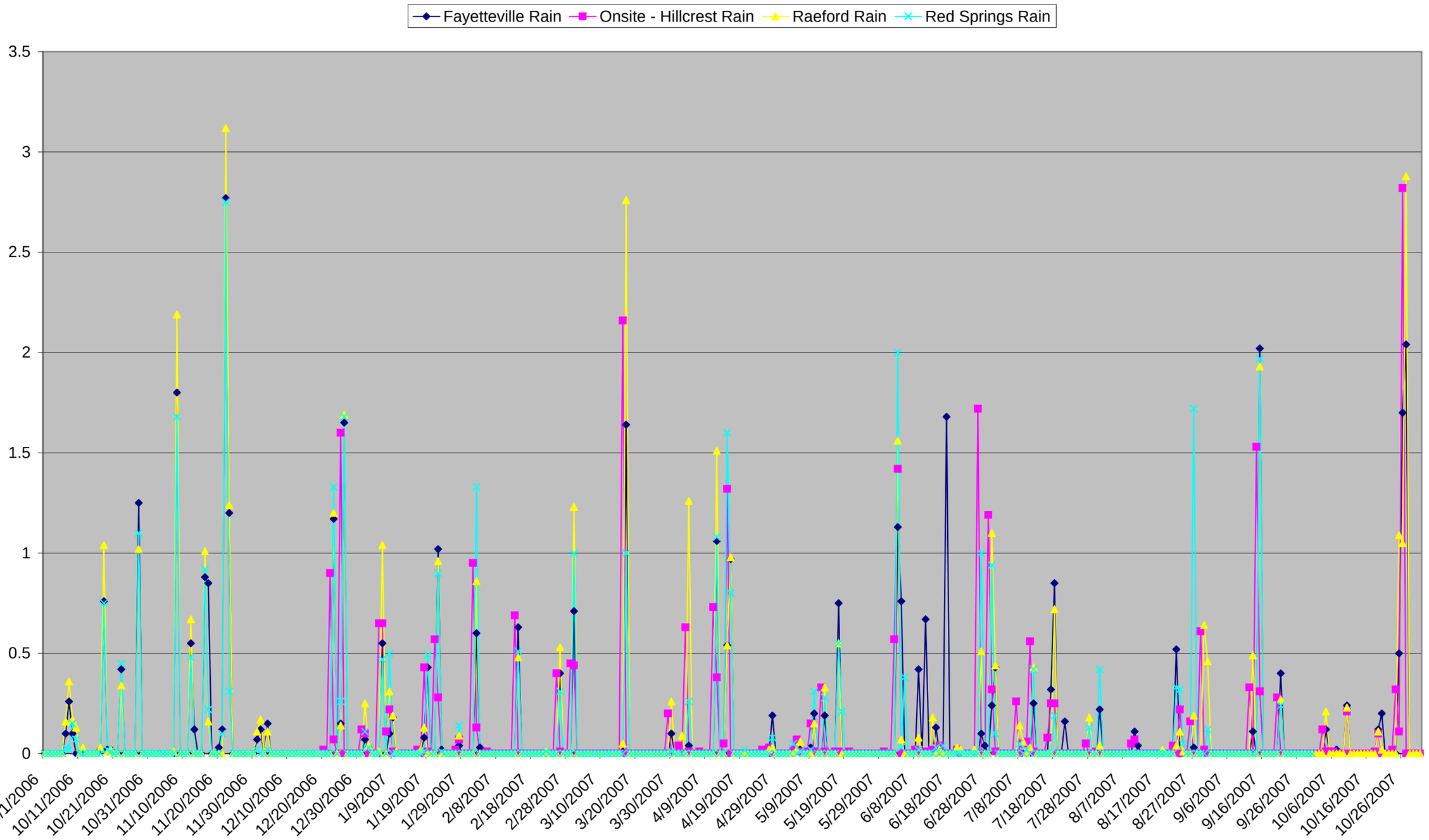
Photo Point 8

Sweet Gum patch around Gage 7

APPENDIX B

Data Tables for Hydrological Data

Reference Bay Test Hole Photo Log


Fayetteville Rain
Onsite - Hillcrest Rain
Raeford Rain
Red Springs Rain
3.5
3
2.5
2
1.5
1
0.5
0
10/1/2006
10/11/2006
10/21/2006
10/31/2006
11/10/2006
11/20/2006
11/30/2006
12/10/2006
12/20/2006
12/30/2006
1/9/2007
1/19/2007
1/29/2007
2/8/2007
2/18/2007
2/28/2007
3/10/2007
3/20/2007
3/30/2007
4/9/2007
4/19/2007
4/29/2007
5/9/2007
5/19/2007
5/29/2007
6/8/2007
6/18/2007
6/28/2007
7/8/2007
7/18/2007
7/28/2007
8/7/2007
8/17/2007
8/27/2007
9/6/2007
9/16/2007
9/26/2007
10/6/2007
10/16/2007
10/26/2007

Date/Time (EST)	Fayetteville Precipitation (in)	Onsite Precipitation (in)	Raeford Precipitation (in)	Red Springs Precipitation (in)
10/1/2006	0		0	0
10/2/2006	0		0	0
10/3/2006	0		0	0
10/4/2006	0		0	0
10/5/2006	0		0	0
10/6/2006	0		0	0
10/7/2006	0.1		0.16	0.03
10/8/2006	0.26		0.36	0.02
10/9/2006	0.1		0.17	0.15
10/10/2006	0		0.13	0.07
10/11/2006	0		0	0
10/12/2006	0		0.03	0
10/13/2006	0		0	0
10/14/2006	0		0	0
10/15/2006	0		0	0
10/16/2006	0		0	0
10/17/2006	0.02		0.03	0
10/18/2006	0.76		1.04	0.75
10/19/2006	0.02		0.01	0.02
10/20/2006	0.02		0.02	0.01
10/21/2006	0		0	0
10/22/2006	0		0	0
10/23/2006	0.42		0.34	0.45
10/24/2006	0		0	0
10/25/2006	0		0	0
10/26/2006	0		0	0
10/27/2006	0		0	0
10/28/2006	1.25		1.02	1.1
10/29/2006	0		0	0
10/30/2006	0		0	0
10/31/2006	0		0	0
11/1/2006	0		0	0
11/2/2006	0		0	0
11/3/2006	0		0	0
11/4/2006	0		0	0
11/5/2006	0		0	0
11/6/2006	0		0	0
11/7/2006	0		0.01	0
11/8/2006	1.8		2.19	1.68
11/9/2006	0		0	0
11/10/2006	0		0	0
11/11/2006	0		0	0
11/12/2006	0.55		0.67	0.48
11/13/2006	0.12		0	0
11/14/2006	0		0	0
11/15/2006	0		0	0
11/16/2006	0.88		1.01	0.92
11/17/2006	0.85		0.16	0.22

11/18/2006	0		0	0
11/19/2006	0		0	0
11/20/2006	0.03		0	0
11/21/2006	0.12		0	0.1
11/22/2006	2.77		3.12	2.75
11/23/2006	1.2		1.24	0.31
11/24/2006	0		0	0
11/25/2006	0		0	0
11/26/2006	0		0	0
11/27/2006	0		0	0
11/28/2006	0		0	0
11/29/2006	0		0	0
11/30/2006	0		0	0
12/1/2006	0.07		0.11	0.02
12/2/2006	0.12		0.17	0
12/3/2006	0		0	0
12/4/2006	0.15		0.11	0.02
12/5/2006	0		0	0
12/6/2006	0		0	0
12/7/2006	0		0	0
12/8/2006	0		0	0
12/9/2006	0		0	0
12/10/2006	0		0	0
12/11/2006	0		0	0
12/12/2006	0		0	0
12/13/2006	0		0	0
12/14/2006	0		0	0
12/15/2006	0		0	0
12/16/2006	0		0	0
12/17/2006	0		0	0
12/18/2006	0		0	0
12/19/2006	0		0	0
12/20/2006	0	0.02	0	0
12/21/2006	0	0	0	0
12/22/2006	0	0.9	0	0
12/23/2006	1.17	0.07	1.2	1.33
12/24/2006	0	0		0
12/25/2006	0.15	1.6	0.14	0.26
12/26/2006	1.65	0	1.69	1.68
12/27/2006	0	0	0	0
12/28/2006	0	0	0	0
12/29/2006	0	0	0	0
12/30/2006	0	0	0	0
12/31/2006	0	0.12	0	0
1/1/2007	0.07	0.1	0.25	0.11
1/2/2007	0.03	0	0.04	0.03
1/3/2007	0	0	0	0
1/4/2007	0	0	0	0
1/5/2007	0	0.65	0.01	0
1/6/2007	0.55	0.65	1.04	0.47

1/7/2007	0	0.11	0	0
1/8/2007	0.1	0.22	0.31	0.5
1/9/2007	0.18	0.01	0.19	0
1/10/2007	0	0	0.01	0
1/11/2007	0	0	0	0
1/12/2007	0	0	0	0
1/13/2007	0	0	0	0
1/14/2007	0	0	0	0
1/15/2007	0	0	0	0
1/16/2007	0	0.02	0	0
1/17/2007	0.01	0	0.02	0
1/18/2007	0.08	0.43	0.13	0.01
1/19/2007	0.43	0.01		0.49
1/20/2007	0	0	0	0
1/21/2007	0	0.57	0	0
1/22/2007	1.02	0.28	0.96	0.9
1/23/2007	0.02	0	0	0.01
1/24/2007	0	0	0	0
1/25/2007	0	0	0	0
1/26/2007	0	0	0	0
1/27/2007	0	0.02	0	0
1/28/2007	0.04	0.07	0.09	0.14
1/29/2007	0	0	0	0
1/30/2007	0	0	0	0
1/31/2007	0	0	0	0
2/1/2007	0	0.95	0	0
2/2/2007	0.6	0.13	0.86	1.33
2/3/2007	0.03	0	0	0
2/4/2007	0	0	0	0
2/5/2007	0	0.01	0	0
2/6/2007	0	0	0	0
2/7/2007	0	0	0	0
2/8/2007	0	0	0	0
2/9/2007	0	0	0	0
2/10/2007	0	0	0	0
2/11/2007	0	0	0	0
2/12/2007	0	0	0	0
2/13/2007	0	0.69	0	0
2/14/2007	0.63	0	0.48	0.51
2/15/2007	0	0	0	0
2/16/2007	0	0	0	0
2/17/2007	0	0	0	0
2/18/2007	0	0	0	0
2/19/2007	0	0	0	0
2/20/2007	0	0	0	0
2/21/2007	0	0	0	0
2/22/2007	0	0	0.01	0.01
2/23/2007	0	0	0	0
2/24/2007	0	0	0	0
2/25/2007	0	0.4	0	0
2/26/2007	0.4	0.01	0.53	0.31

2/27/2007	0	0	0	0
2/28/2007	0	0	0	0
3/1/2007	0	0.45	0	0
3/2/2007	0.71	0.44	1.23	1
3/3/2007	0	0	0	0
3/4/2007	0	0	0	0
3/5/2007	0	0	0	0
3/6/2007	0	0	0	0
3/7/2007	0	0	0	0
3/8/2007	0	0	0	0
3/9/2007	0	0	0	0
3/10/2007	0	0	0	0
3/11/2007	0	0	0	0
3/12/2007	0	0	0	0
3/13/2007	0	0	0	0
3/14/2007	0	0	0	0
3/15/2007	0	0	0	0
3/16/2007	0.01	2.16	0.05	0
3/17/2007	1.64	0	2.76	1
3/18/2007	0	0	0	0
3/19/2007	0	0	0	0
3/20/2007	0	0	0	0
3/21/2007	0	0	0	0
3/22/2007	0	0	0	0
3/23/2007	0	0	0	0
3/24/2007	0	0	0	0
3/25/2007	0	0	0	0
3/26/2007	0	0	0	0
3/27/2007	0	0	0	0
3/28/2007	0	0	0	0
3/29/2007	0	0.2	0	0
3/30/2007	0.1	0	0.26	0.01
3/31/2007	0	0	0	0
4/1/2007	0	0.04	0	0
4/2/2007	0	0	0.09	0
4/3/2007	0	0.63	0	0
4/4/2007	0.04	0.01	1.26	0.26
4/5/2007	0	0	0	0
4/6/2007	0	0	0	0
4/7/2007	0	0.01	0	0
4/8/2007	0	0	0	0
4/9/2007	0	0	0	0
4/10/2007	0	0	0	0
4/11/2007	0	0.73	0	0
4/12/2007	1.06	0.38	1.51	1.08
4/13/2007	0	0	0	0
4/14/2007	0	0.05	0	0
4/15/2007	0.54	1.32	0.54	1.6
4/16/2007	0.97	0	0.98	0.8
4/17/2007	0	0	0	0

4/18/2007	0	0	0	0
4/19/2007	0	0	0	0
4/20/2007	0	0	0	0.02
4/21/2007	0	0	0	0
4/22/2007	0	0	0	0
4/23/2007	0	0	0	0
4/24/2007	0	0	0	0
4/25/2007	0	0.02	0	0
4/26/2007	0	0	0	0
4/27/2007	0	0.03	0.02	0
4/28/2007	0.19	0	0.03	0.08
4/29/2007	0	0	0	0
4/30/2007	0	0	0	0
5/1/2007	0	0	0	0
5/2/2007	0	0	0	0
5/3/2007	0	0	0	0
5/4/2007	0	0.02	0	0.05
5/5/2007	0.02	0.07	0.02	0
5/6/2007	0.02	0.01	0.06	0.01
5/7/2007	0	0	0	0
5/8/2007	0	0.01	0	0
5/9/2007	0.03	0.15	0	0.02
5/10/2007	0.2	0.01	0.15	0.31
5/11/2007	0	0	0	0
5/12/2007	0	0.33	0	0
5/13/2007	0.19	0.01	0.33	0.28
5/14/2007	0	0	0	0
5/15/2007	0	0	0	0
5/16/2007	0	0.01	0	0
5/17/2007	0.75	0.01	0.55	0.55
5/18/2007	0	0	0	0.21
5/19/2007	0	0	0	0
5/20/2007	0	0.01	0	0
5/21/2007	0	0	0	0
5/22/2007	0	0	0	0
5/23/2007	0	0	0	0
5/24/2007	0	0	0	0
5/25/2007	0	0	0	0
5/26/2007	0	0	0	0
5/27/2007	0	0	0	0
5/28/2007	0	0	0	0
5/29/2007	0	0	0	0
5/30/2007	0	0.01	0	0
5/31/2007	0	0	0	0
6/1/2007	0	0	0	0
6/2/2007	0	0.57	0	0
6/3/2007	1.13	1.42	1.56	2
6/4/2007	0.76	0	0.07	0.03
6/5/2007	0	0	0	0.38
6/6/2007	0	0	0	0

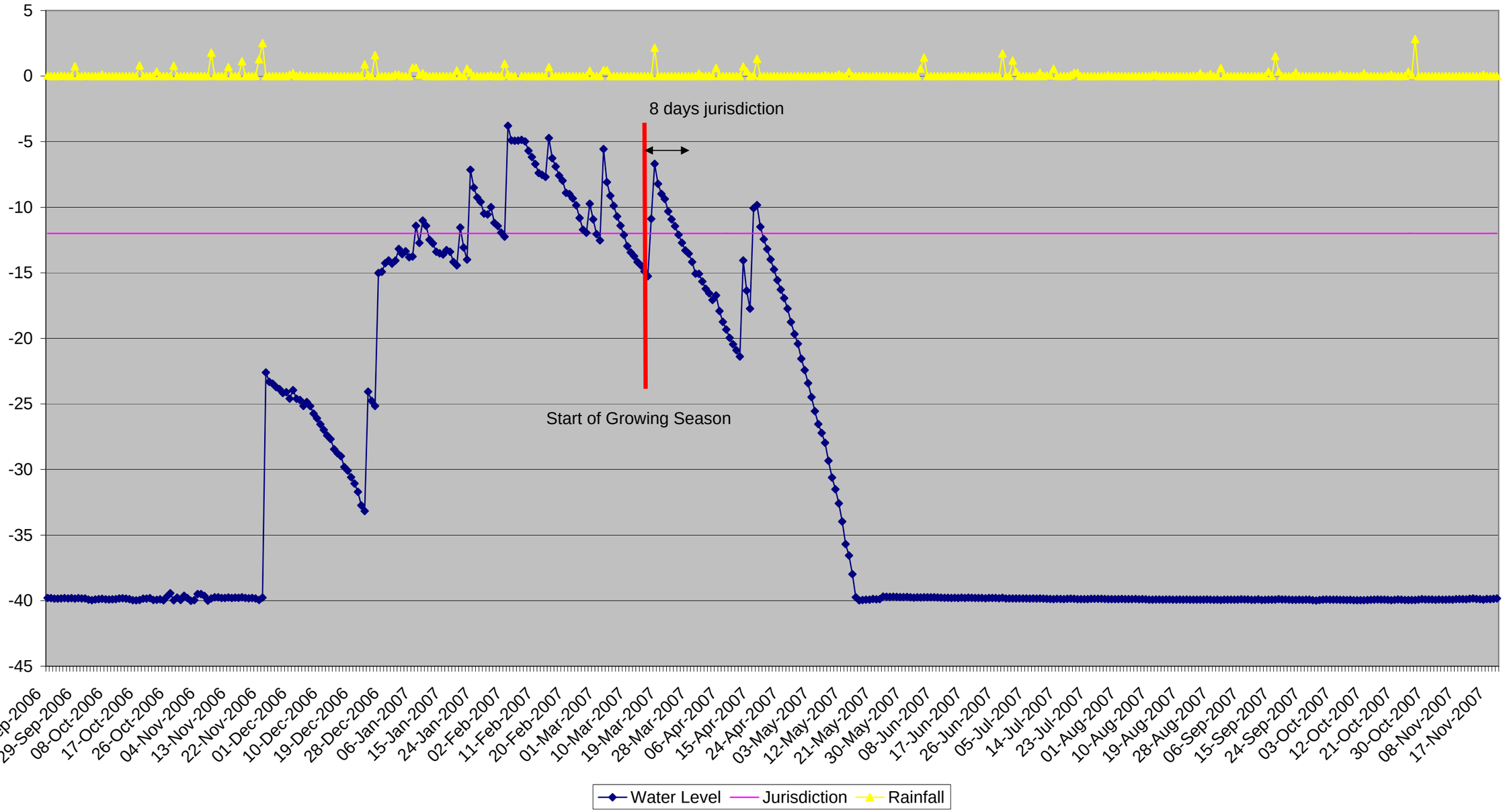
6/7/2007	0	0	0	0
6/8/2007	0	0.02	0	0
6/9/2007	0.42	0	0.08	0.02
6/10/2007	0	0	0	0
6/11/2007	0.67	0.01	0	0
6/12/2007	0	0	0	0
6/13/2007	0	0.02	0.18	0
6/14/2007	0.13	0	0	0.03
6/15/2007	0	0.04	0.02	0
6/16/2007	0	0	0	0.04
6/17/2007	1.68	0	0	0
6/18/2007	0	0	0	0
6/19/2007	0	0	0	0
6/20/2007	0	0.02	0.03	0
6/21/2007	0	0	0.02	0
6/22/2007	0	0	0	0
6/23/2007	0	0	0	0
6/24/2007	0	0	0	0
6/25/2007	0	0	0.02	0
6/26/2007	0	1.72	0	0
6/27/2007	0.1	0	0.51	1
6/28/2007	0.04	0	0	0
6/29/2007	0	1.19	0	0
6/30/2007	0.24	0.32	1.1	0.94
7/1/2007	0.43	0.01	0.44	0.1
7/2/2007	0	0	0	0
7/3/2007	0	0	0	0
7/4/2007	0	0	0	0
7/5/2007	0	0	0	0
7/6/2007	0	0	0	0
7/7/2007	0	0.26	0	0
7/8/2007	0	0	0.14	0.05
7/9/2007	0	0.05	0.06	0
7/10/2007	0	0.06	0	0.02
7/11/2007	0	0.56	0.03	0
7/12/2007	0.25	0.01	0.43	0.42
7/13/2007	0	0	0	0
7/14/2007	0	0	0	0
7/15/2007	0	0	0	0
7/16/2007	0	0.08	0	0
7/17/2007	0.32	0.25	0	0
7/18/2007	0.85	0.25	0.72	0.19
7/19/2007	0	0	0	0
7/20/2007	0	0	0	0
7/21/2007	0.16	0	0	0
7/22/2007	0	0	0	0
7/23/2007	0	0	0	0
7/24/2007	0	0	0	0
7/25/2007	0	0	0	0
7/26/2007	0	0	0	0
7/27/2007	0	0.05	0	0

7/28/2007	0	0	0.18	0.13
7/29/2007	0	0	0	0
7/30/2007	0	0.01	0	0
7/31/2007	0.22	0	0.04	0.42
8/1/2007	0	0	0	0
8/2/2007	0	0	0	0
8/3/2007	0	0	0	0
8/4/2007	0	0	0	0
8/5/2007	0	0	0	0
8/6/2007	0	0	0	0
8/7/2007	0	0	0	0
8/8/2007	0	0	0	0
8/9/2007	0	0.05	0	0
8/10/2007	0.11	0.07	0	0
8/11/2007	0.04	0	0	0
8/12/2007	0	0	0	0
8/13/2007	0	0	0	0
8/14/2007	0	0	0	0
8/15/2007	0	0	0	0
8/16/2007	0	0	0	0
8/17/2007	0	0	0	0
8/18/2007	0	0	0.02	0
8/19/2007	0	0	0	0
8/20/2007	0	0	0	0
8/21/2007	0	0.04	0	0
8/22/2007	0.52	0	0.04	0.33
8/23/2007	0	0.22	0.11	0.32
8/24/2007	0	0	0.01	0.05
8/25/2007	0	0	0	0
8/26/2007	0	0.16	0	0
8/27/2007	0.03	0	0.19	1.72
8/28/2007	0	0	0	0
8/29/2007	0	0.61	0	0
8/30/2007	0	0.02	0.64	0
8/31/2007	0	0	0.46	0.12
9/1/2007	0	0	0	0
9/2/2007	0	0	0	0
9/3/2007	0	0	0	0
9/4/2007	0	0	0	0
9/5/2007	0	0	0	0
9/6/2007	0	0	0	0
9/7/2007	0	0	0	0
9/8/2007	0	0	0	0
9/9/2007	0	0	0	0
9/10/2007	0	0	0	0
9/11/2007	0	0	0	0
9/12/2007	0	0.33	0	0
9/13/2007	0.11	0	0.49	0
9/14/2007	0	1.53	0	0
9/15/2007	2.02	0.31	1.93	1.97

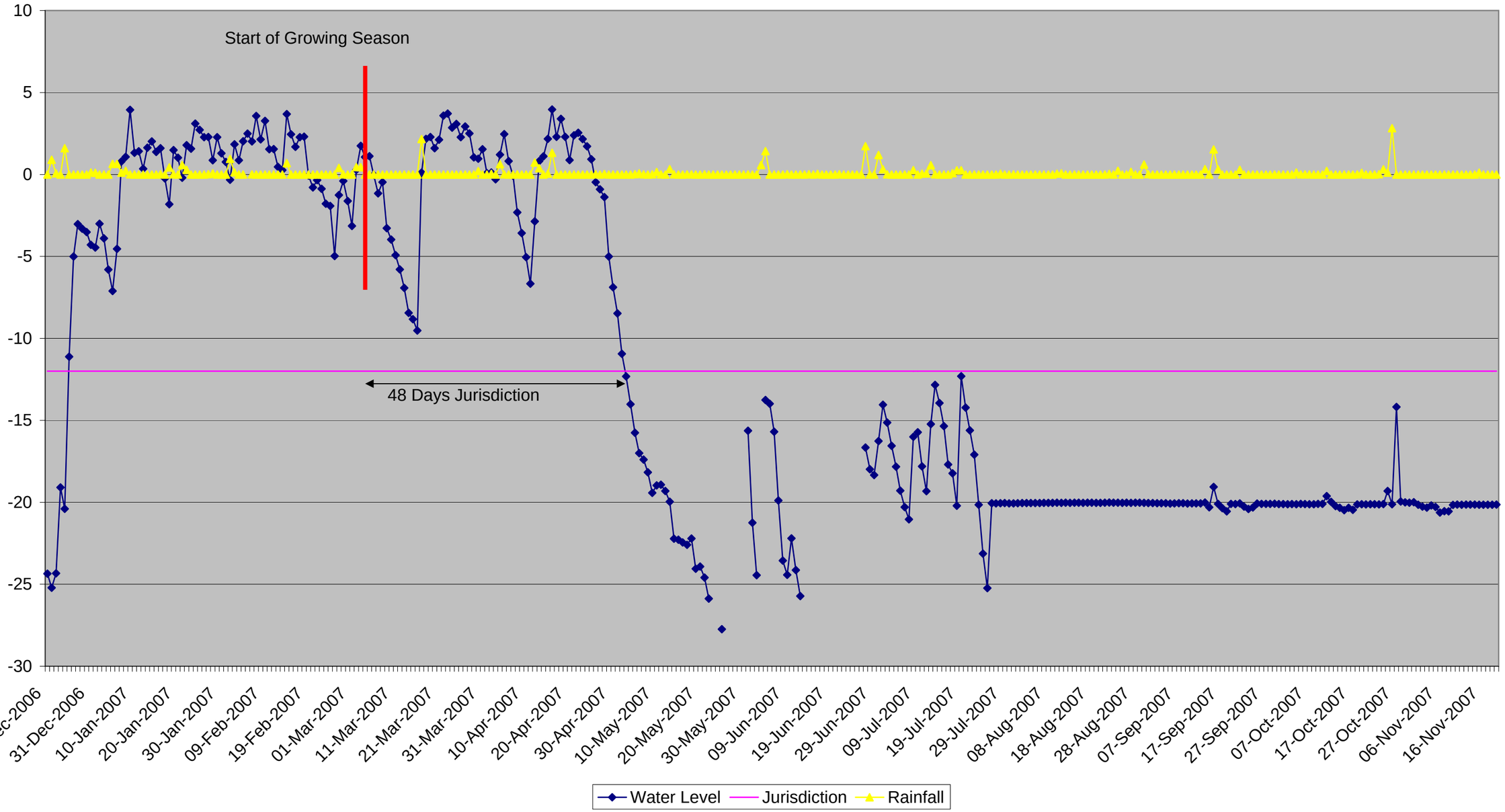
9/16/2007	0	0	0	0
9/17/2007	0	0	0	0
9/18/2007	0	0	0	0
9/19/2007	0	0	0	0
9/20/2007	0	0.28	0	0
9/21/2007	0.4	0	0.27	0.24
9/22/2007	0	0	0	0
9/23/2007	0	0	0	0
9/24/2007	0	0	0	0
9/25/2007	0	0	0	0
9/26/2007	0	0	0	0
9/27/2007	0	0	0	0
9/28/2007	0	0	0	0
9/29/2007	0	0	0	0
9/30/2007	0	0	0	0
10/1/2007	0	0	0	
10/2/2007	0	0	0	
10/3/2007	0	0.12	0	
10/4/2007	0.12	0.01	0.21	
10/5/2007	0	0.01	0	
10/6/2007	0	0.01		
10/7/2007	0.02	0	0	
10/8/2007	0	0	0	
10/9/2007	0	0		
10/10/2007	0.24	0.21	0.23	
10/11/2007	0	0	0	
10/12/2007	0	0	0	
10/13/2007	0	0		
10/14/2007		0	0	
10/15/2007	0	0		
10/16/2007	0	0		
10/17/2007	0	0		
10/18/2007	0	0.01	0	
10/19/2007	0.12	0.1	0.11	
10/20/2007	0.2	0	0.02	
10/21/2007	0	0		
10/22/2007	0	0	0	
10/23/2007	0	0.02	0	
10/24/2007	0	0.32	0	
10/25/2007	0.5	0.11	1.09	
10/26/2007	1.7	2.82	1.05	
10/27/2007	2.04	0	2.88	
10/28/2007	0	0	0	
10/29/2007	0	0	0	
10/30/2007	0	0	0	
10/31/2007	0	0	0	

By Month	Fayetteville Precipitation (in)	Onsite Precipitation (in)	Raeford Precipitation (in)	Red Springs Precipitation (in)
Oct-06	**2.95**	**-**	**3.31**	**2.6**
Nov-06	**8.32**	**-**	**8.4**	**6.46**
Dec-06	**3.31**	**2.71**	**3.42**	**3.31**
Jan-07	**2.53**	**3.14**	**3.05**	**2.66**
Feb-07	**1.66**	**2.19**	**1.88**	**2.16**
Mar-07	**2.46**	**3.25**	**4.3**	**2.01**
Apr-07	**2.8**	**3.22**	**4.43**	**3.84**
May-07	**1.21**	**0.65**	**1.11**	**1.43**
Jun-07	**5.17**	**5.33**	**3.59**	**4.44**
Jul-07	**2.23**	**1.59**	**2.04**	**1.33**
Aug-07	**0.7**	**1.17**	**1.47**	**2.54**
Sep-07	**2.53**	**2.45**	**2.69**	**2.21**
Oct-07	**4.94**	**3.74**	**5.59**	-

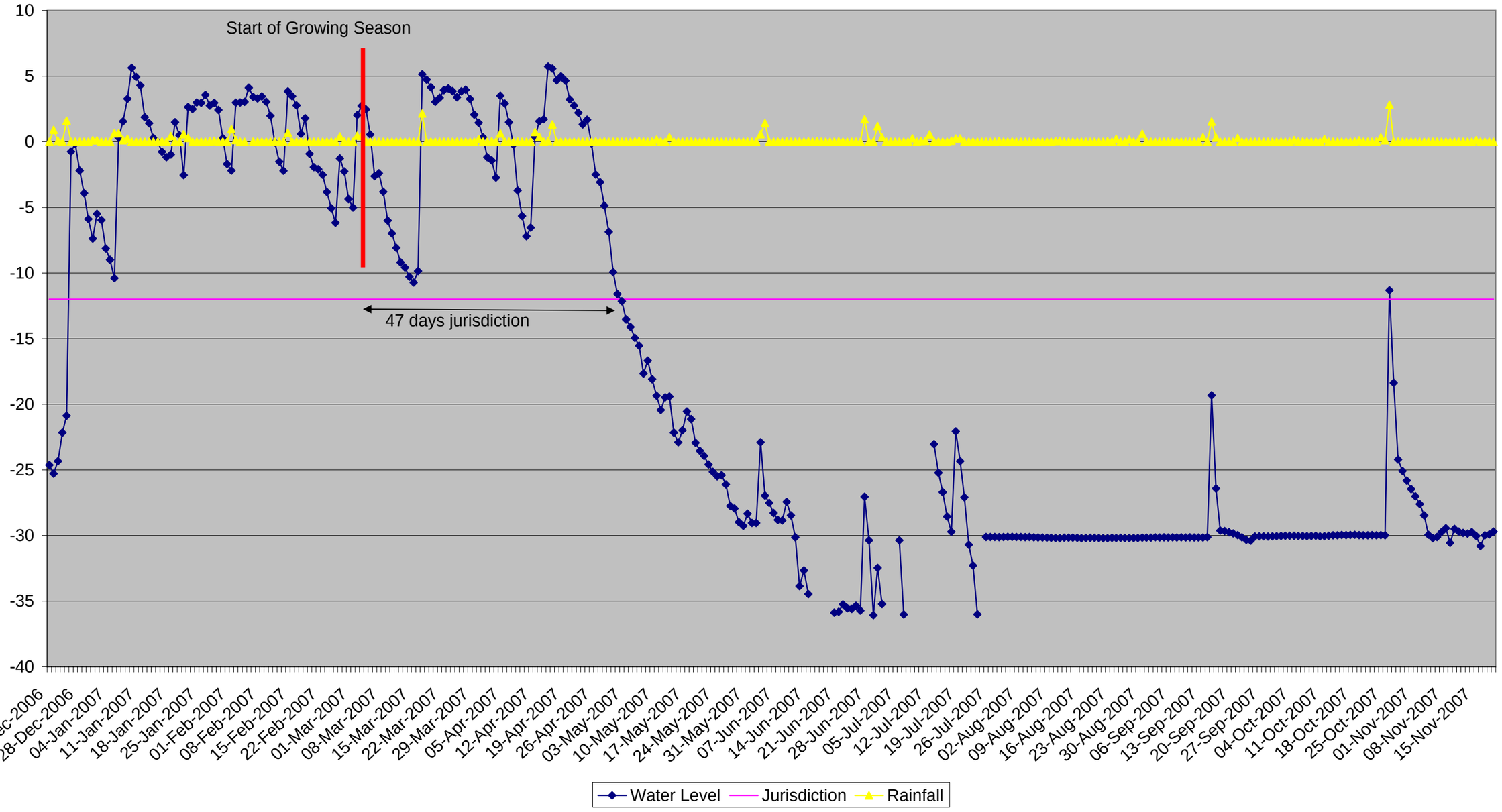
Goose Pond Reference Bay



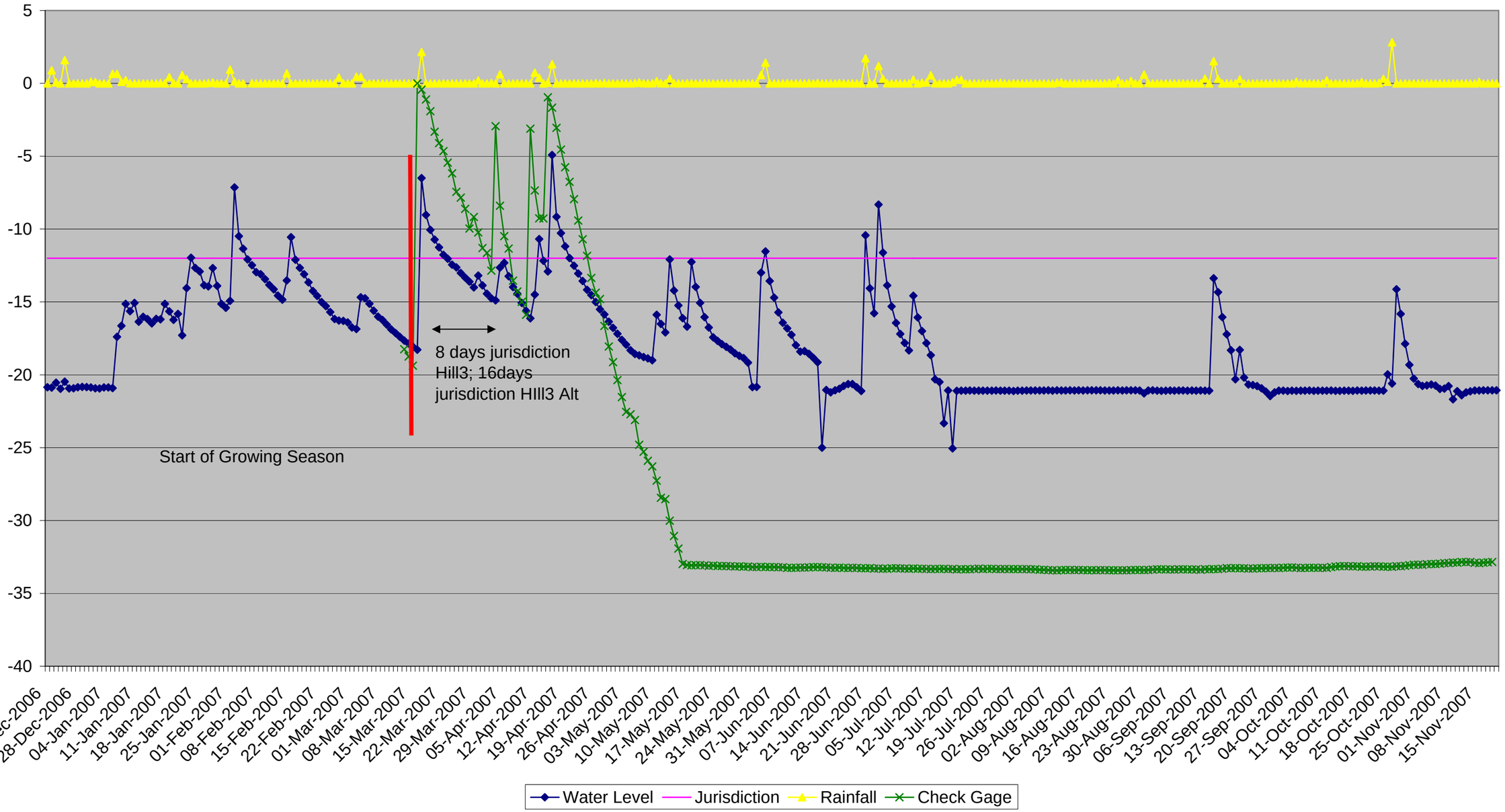
Hillcrest Bay Gage 1



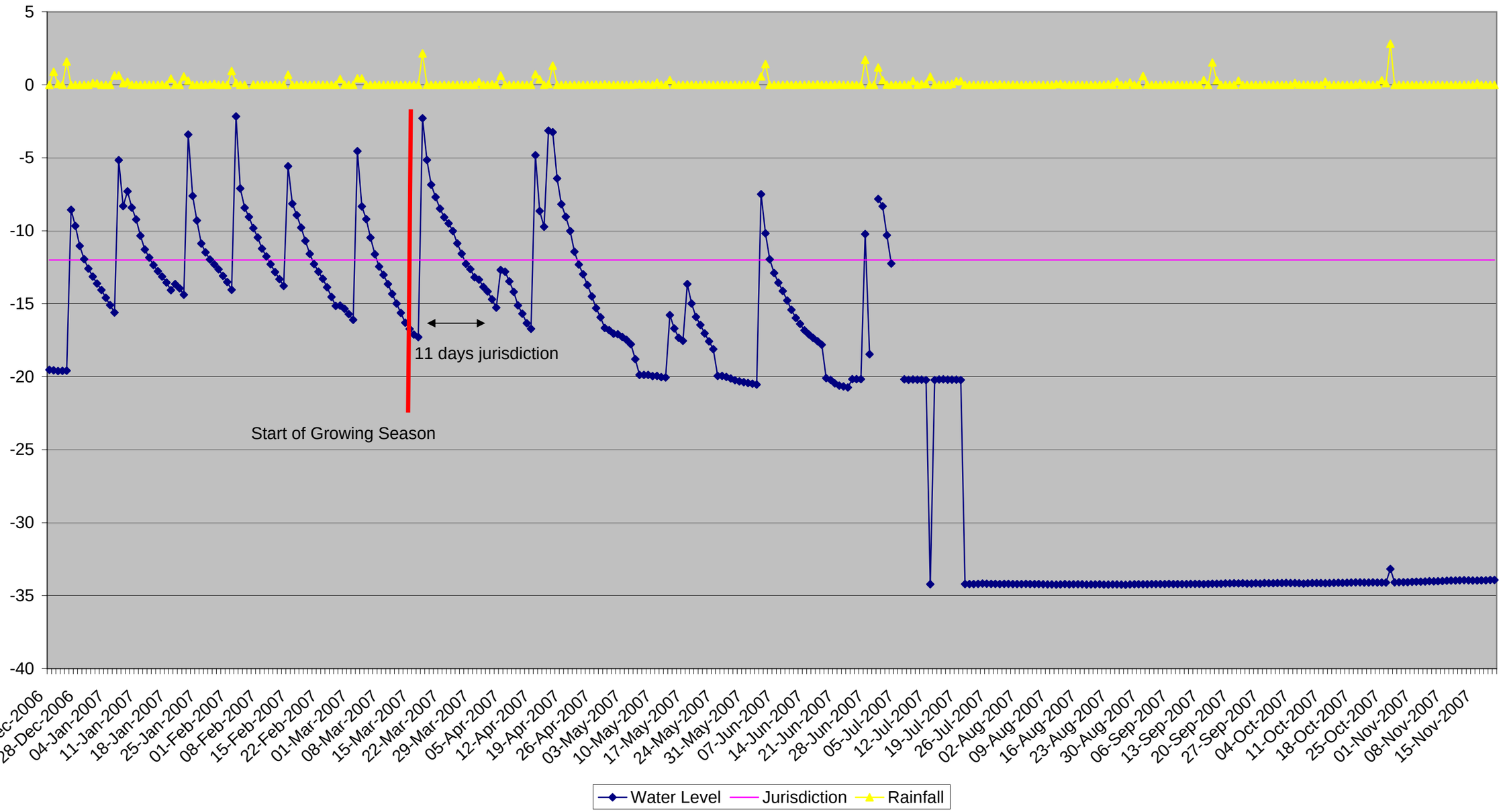
Hillcrest Bay Gage 2



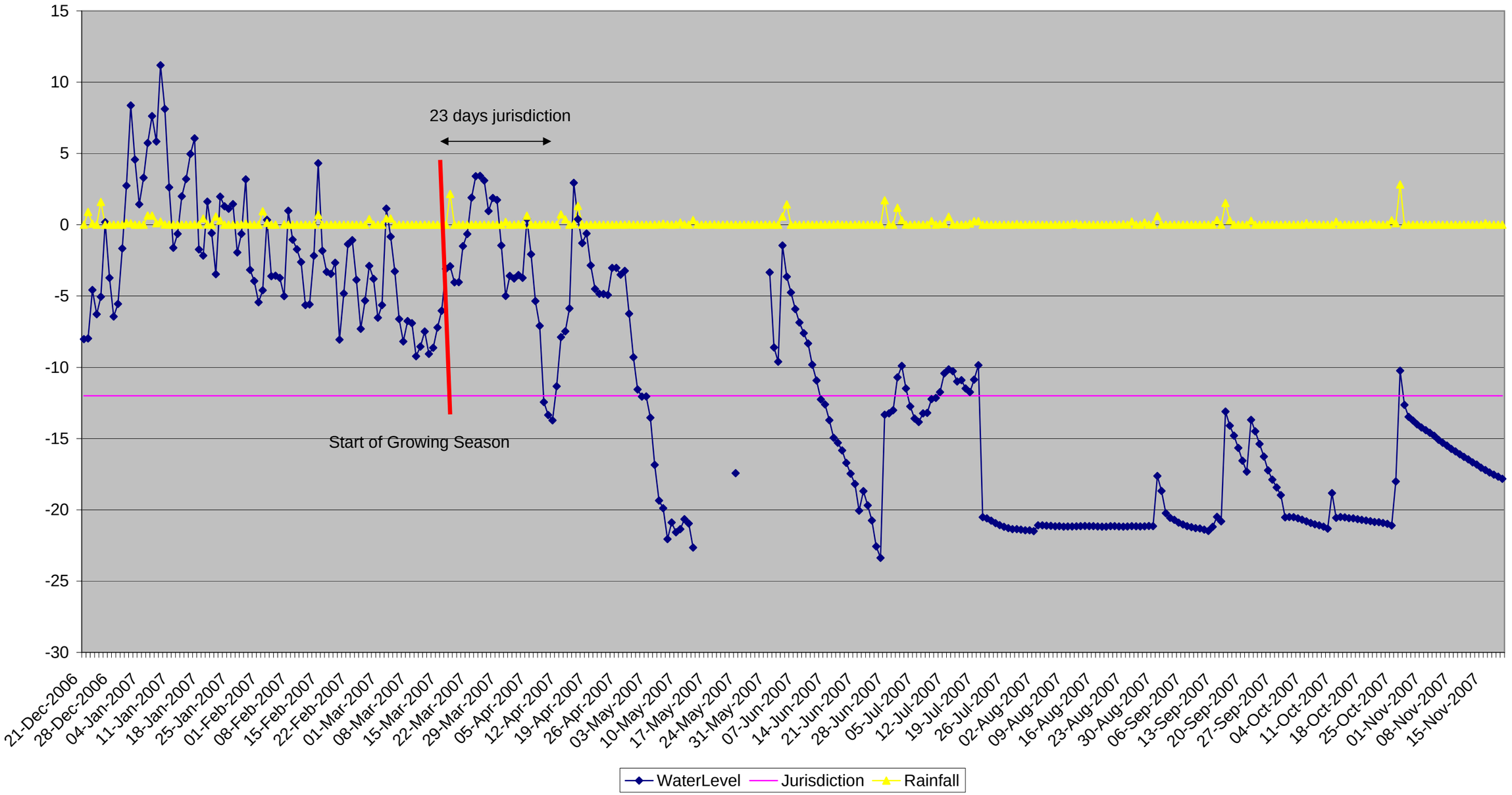
Hillcrest Bay gage 3



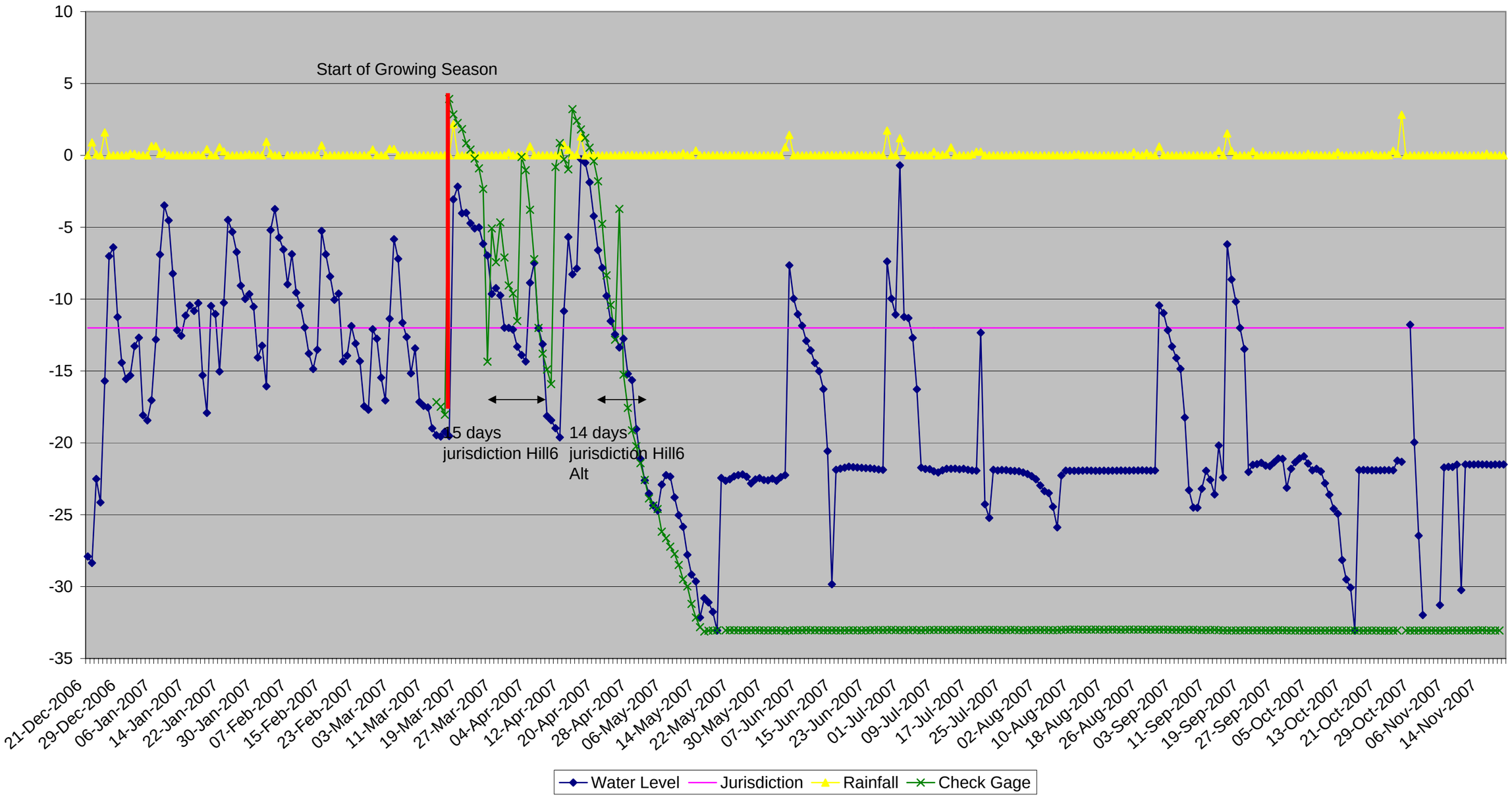
Hillcrest Bay Gage 4



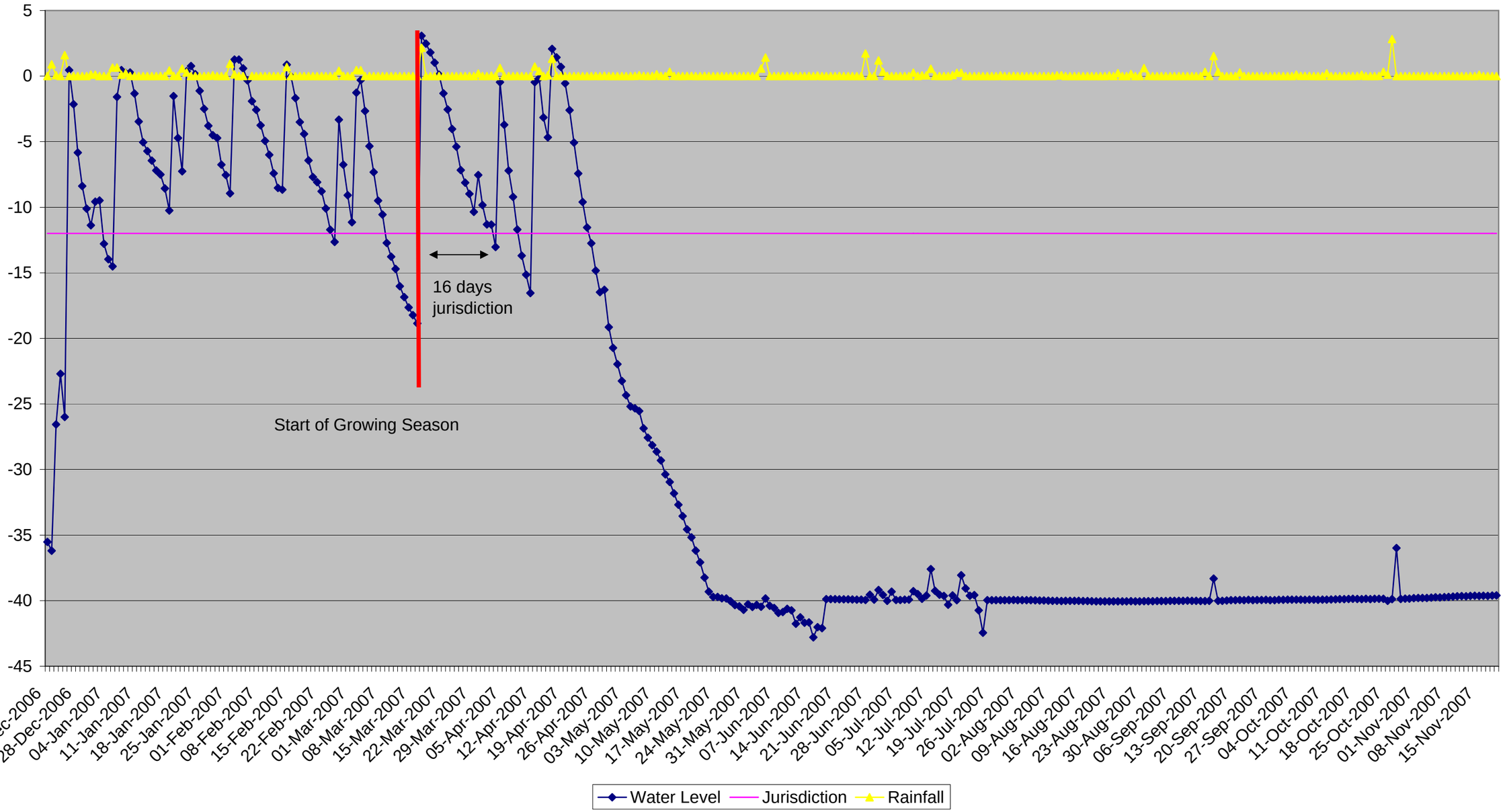
Hillcrest bay Gage 5



Hillcrest Bay Gage 6



Hillcrest Bay Gage 7



Reference Bay Test Hole Photos

Goose Pond Bay Test Hole, approximately 36” deep

Contents of test hole, dry and hard packed

Antioch Bay Test Hole, approximately 30” deep

Contents of test hole, dry and hard packed