Data Reduction and Analysis of Hydrologic Data for Selected Tree Islands (3AN1, 3AS3, and 3BS1)

SFWMD Purchase Order 4500026695

Prepared for:

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1 EXECUTIVE SUMMARY

Tree islands are tear-shaped topographic features in the relatively flat, low-lying landscape of southern Florida. Tree islands are only slightly (a few feet) elevated above the surrounding wetland, but are an important habitat for plants and animals. Tree islands are sensitive to changes in their hydrologic conditions; hence, a better understanding of the factors affecting the hydrology of tree islands is needed in the efforts to protect and restore the Everglades.

In 2000, South Florida Water Management District began monitoring meteorological data and groundwater and surface-water levels at selected tree islands as part of a 5-year, multidisciplinary study conducted in cooperation with the Florida Fish and Wildlife Conservation Commission, the Florida Center for Environmental Studies, the U.S. Geological Survey, and several universities. The three selected tree islands—3AN1, 3AS3, and 3BS1—are all located in Water Conservation Area 3. A total of four well pairs were installed at each of the three tree islands. Well pairs, consisting of a shallow piezometer (depths from 4.1 to 15 ft below land surface) and a deep groundwater well (depths from 25 – 49.6 ft below land surface), were installed just northwest, northeast, and south of each island. A well pair also was installed within each island. A stilling well was installed at one well pair at each of the three islands to monitor surface-water stage. A meteorological station also was established at tree island 3AS3.

This two-volume report summarizes the results of a data-analysis project conducted in 2008 by staff at Adamski Geological Consulting, LLC. The project consisted of three components, the first of which was to assess the quality assurance of the site information and time-series data. The second component included analysis of seasonal fluctuations in groundwater and surface-water levels, and determination of factors affecting water levels. Finally, the third component was an analysis of the vertical and horizontal flow of groundwater at each of the tree islands. Results of component 1 are published in volume 1, and results of components 2 and 3 are published in volume 2.

The site and time-series data from the 23 wells, 3 stilling wells, and 1 meteorological station were reviewed for quality assurance. The location, depth, and construction information were thoroughly reviewed during this project and during two previous groundwater quality-assurance projects conducted in 2006 and 2007. In general, the site information for the wells appeared to be accurate; however, new ground-elevation surveys of the three tree islands were conducted in 2007 (Keith and Schnars, 2007). As a result, the reference elevations (elevation of the measuring point at the top of the well casing) and land-surface elevations were revised for 25 of the 26 stations.

The time-series data (groundwater level, surface-water stage, and selected meteorological data) were reviewed for accuracy according to SFWMD protocols. All analyses were conducted using daily values. The objective of this part of the project was to produce sets of preferred time-series data for use by SFWMD scientists and engineers, consultants, and the general public. The review included analyzing the data for outliers,

anomalies, and missing values. Overall, the time-series data were valid and accurately represented water levels at the sites. However, the groundwater and surface-water data from the three tree islands were corrected based on the new reference elevations.

The water-level and meteorological data from the tree islands were analyzed for seasonal fluctuations and factors affecting water levels. Water-level data from the monitor wells also were analyzed to assess horizontal and vertical flow of groundwater. These analyses were primarily conducted using daily averages of the incremental data.

Groundwater and surface-water levels exhibited seasonal and temporal fluctuations related to meteorological conditions. Water levels in the wells and stilling wells generally reached minimum values toward the end of the dry season, around May of each year, and peaked in late September or October at the end of the wet season. Groundwater and surface-water levels were statistically higher at the end of the wet season compared to water levels at the end of the dry season. Evapotranspiration and photosynthetic radiation also affected groundwater and surface-water levels at the tree islands. In general, water levels in wells and stilling wells declined as evapotranspiration and photosynthetic radiation increased.

The abundant rainfall in southern Florida results in the areas around the islands, and even the islands themselves, to be periodically or frequently inundated. Water-level data indicate the areas surrounding 3AS3 were inundated 85 to 100 percent of time during the period of record, while the island itself was inundated up to 24 percent of the time. The island at 3AN1 was inundated nearly 18 percent of the time, but the island at 3BS1 was never inundated, possibly from the higher topographic relief at that island.

At any one time, the difference in water levels between well pairs installed at the same island was small, usually less than a tenth of a foot. The difference in water levels between the shallow piezometer and deep well in the same well pair was equally small. Small differences in water levels indicate a flat water table with low gradients, and result from the high hydraulic conductivity of the aquifer.

Groundwater flow at each island varied over time, and generally was higher at 3AN1 than at the other two islands. The direction of horizontal groundwater flow varied widely during the period of record, possibly from changing gradients with seasonal fluctuations in water levels. However, water levels indicated mounding of groundwater under all three islands. Mounding indicates that groundwater is flowing laterally away from each island to the areas underlying the surrounding wetland. In contrast, water levels during May 2007 indicate a depression formed in the groundwater underlying the island 3AN1.

Differences between water levels in the deep wells and water levels in the adjacent piezometers or stilling wells indicated the direction of vertical groundwater flow. Vertical groundwater flow was upward 60 to 70 percent of the time in the areas surrounding 3AN1. Groundwater flow also was upward 84 to 90 percent of the time in areas north of 3AS3; however, vertical groundwater was downward 47 and 56 percent of the time underlying the island and areas just south at 3AS3. Vertical groundwater flow was downward at 56 to 76 percent of the time in and around 3BS1.

Groundwater withdrawals and operation of nearby canals could be affecting the hydrology of the tree islands. Surface-water levels at the three tree islands strongly correlated with water levels at several of the structures on nearby canals.

In summary, the hydrology of the tree islands is complex, with considerable interaction between groundwater and surface. Mounding of groundwater indicates local lateral flow is away from the islands to areas underlying the surrounding wetlands, with direction of regional flow varying over time and with seasonal conditions. Groundwater generally flows downward at the islands and discharges in areas underlying the wetlands.

Additional analysis of the water-level data is recommended to further quantify meteorological and other factors affecting vertical and horizontal groundwater flow. These analyses can be coupled with existing water-quality data collected from the wells to better understand flow paths in the groundwater underlying the three tree islands.

Data Reduction and Analysis of Hydrologic Data for Selected Tree Islands (3AN1, 3AS3, and 3BS1)
Volume 1—Quality-Assurance Assessment
SFWMD Purchase Order 4500026695

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Volume 1 of 2

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1 INTRODUCTION

Tree islands are topographically elevated, typically tear-shaped features with their long axis oriented parallel to surface-water flow. The islands consist of tall trees, shrubs, and saw grass, and "provide habitat for a wide variety of terrestrial plants and animals" (Bevier and Krupa, 2001). Tree islands, which are very sensitive to changes in hydrologic conditions and extreme wet and dry periods, are considered indicators of the overall ecological health of the Everglades system. Hence, information collected from tree islands will be crucial to better understanding the hydrologic conditions in the Everglades.

In 2000, South Florida Water Management District began monitoring meteorological data and groundwater and surface-water levels at selected tree islands as part of a 5-year, multidisciplinary study conducted in cooperation with the Florida Fish and Wildlife Conservation Commission, the Florida Center for Environmental Studies, the U.S. Geological Survey, and several universities. The three selected tree islands—3AN1, 3AS3, and 3BS1—are all located in Water Conservation Area 3 (fig. 1). Reports have documented the construction of wells and stilling wells at the tree islands (Bevier and Krupa, 2001) and summarized the results of a preliminary assessment of groundwater-surface-water interactions (Krupa and Gefvert, 2006; Steve Krupa, SFWMD, written commun., 2008). However, a compilation report is needed to assess the quality of the data collected, and to analyze factors affecting groundwater levels and flow. This two-volume report summarizes the results of a quality-assurance and data-analysis project conducted on site information and time-series data collected from May 2000 through June 2008.

1.1 Objectives

The objective of this contract (Purchase Order 4500026695) is to obtain professional consulting services for quality assurance and analysis of hydrometeorological data at three tree island sites (3AN1, 3AS3, and 3BS1) in the Everglades (fig. 1). The objectives of the project are as follows:

1. Generate sets of high-quality site information and time-series data collected from monitoring stations at 3AN1, 3AS3, and 3BS1
2. Analyze seasonal, meteorological, and other factors that affect groundwater and surface-water levels at the three tree islands
3. Determine horizontal and vertical groundwater flow at the three tree islands

Volume 1 of this report contains the summary of the quality-assurance review and revisions of the data (objective 1). Volume 2 contains an analysis of the factors affecting surface-water and ground-water levels at the three tree islands (objectives 2 and 3).

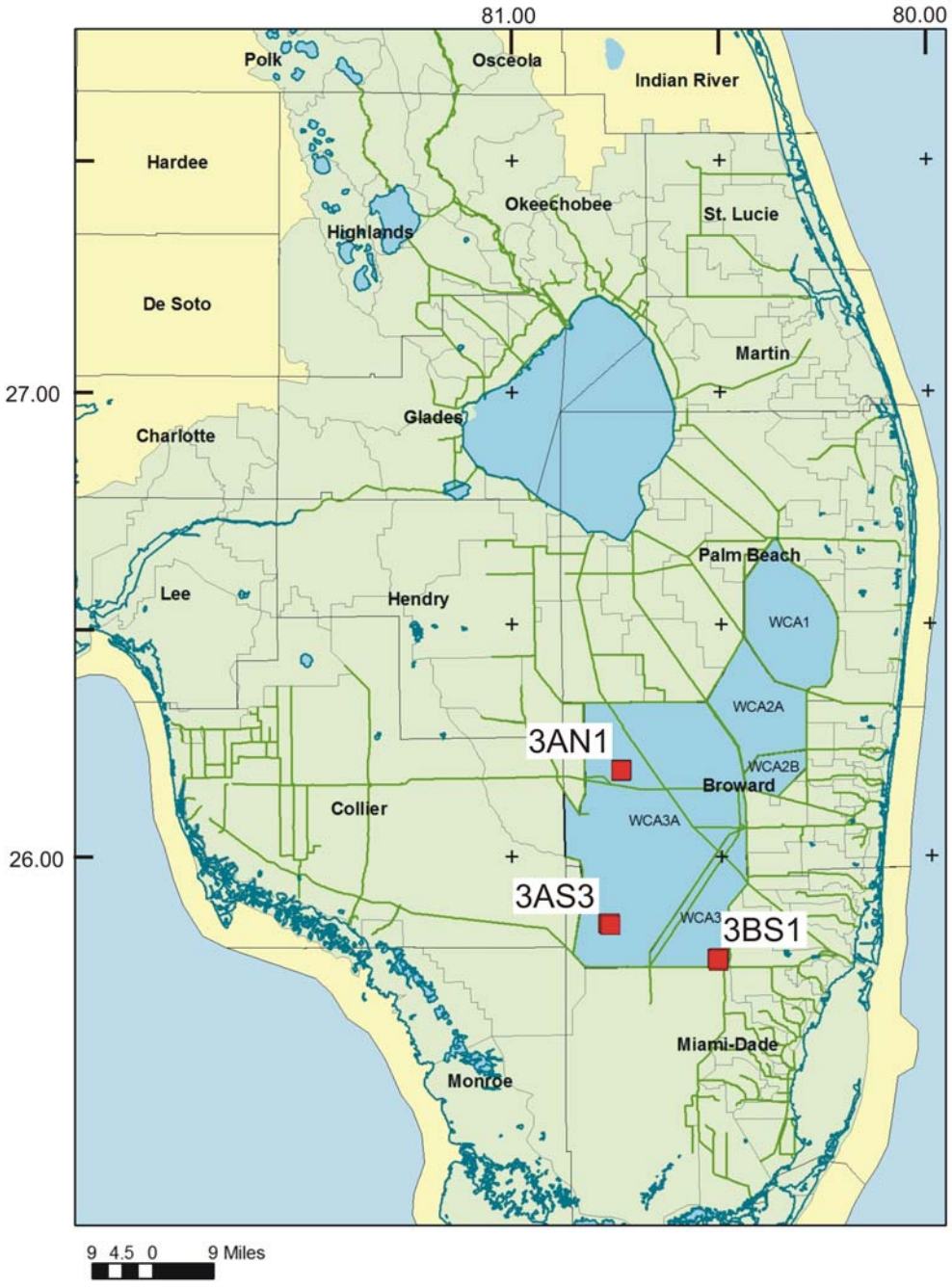


Figure 1 Location of the three tree islands

1.2 Scope of Work

The overall scope of work for the project is to conduct quality assurance/quality control assessment of site information (Meta data) and time-series data for 23 wells and 3 stilling wells used to monitor ground-water levels and surface-water stage. The hydrologic conditions, seasonal fluctuations, and factors affecting ground- and surface-water levels also were analyzed. The work was conducted off-site by staff at Adamski Geological Consulting, LLC (AGC). The project includes the following components:

Component 1 Quality assurance and quality control analysis were conducted on Meta data (site information) and time-series data collected at the three tree islands. The site location, construction information, and time-series data through December 31, 2006, were previously reviewed as part of a 2-year project for Taiye Sangoyomi, PE (SFWMD). However, a new survey of the stations was conducted in September 2007, which resulted in slight adjustments to the reference and land-surface elevations at most of the stations. Time-series data collected at the stations were adjusted using correction factors to account for the new reference elevations. In addition, data from the three stilling wells and meteorological station had not been previously reviewed, but were extensively analyzed as part of this project. All QA/QC analysis closely followed methods outlined in standard operating procedures (SOPs) of the SFWMD (Sangoyomi and others, 2005; Sangoyomi and others, 2006; Sangoyomi and Lambright, 2006).

Component 2 The seasonal fluctuations in ground-water level and surface-water stage at the three islands were identified. The dates on which maximum and minimum water levels occurred were documented for analysis in component 3. Data were analyzed for the effects of weather and operation of structures on fluctuations of ground-water levels and stage.

Component 3 The vertical and horizontal movement of water at the three tree islands was mapped and analyzed. The maps and analysis were done using extreme data (periods of water level minimums and maximums) and average data. The results were documented in this report.

The purpose of this report is to summarize work conducted by AGC on the project and document the results. During this period, Meta and time-series data from 23 monitoring wells, 3 surface-water stations, and 1 meteorological station (henceforth, known as target stations) were reviewed and revised for quality assurance and quality control. The revised data are submitted with this report for approval and uploading into DBHYDRO.

1.3 Data Sources

The Meta and time-series data for all 27 stations were collected by SFWMD and stored in the DBHYDRO database. The data from the 27 target stations used for analysis during this project were downloaded directly from DBHYDRO (Table 1).

Station number from SOW	*Station name*	*Source DBKEY*	*Agency*	*Strata (feet)*	*MOD1 DBKEY*
1	3AN1W1_GP	OH532	WMD	14.5	UD202
2	3AN1W1_GW	OH531	WMD	32.9	UD201
3	3AN1W1_H	OH538	WMD	0	
4	3AN1W2_GP	OH534	WMD	15	UD200
5	3AN1W2_GW	OH533	WMD	49.6	UD199
6	3AN1W3_GP	OH536	WMD	14.5	UD204
7	3AN1W3_GW	OH535	WMD	31.7	UD205
8	3AN1W4_GP	OH537	WMD	4.1	UD203
9	3AS3W1_GP	PT035	WMD	8.7	UD311
10	3AS3W1_GW	M6884	WMD	26.4	UD300
11	3AS3W1_H	M6883	WMD	0	
12	3AS3W2_GP	PT036	WMD	8.5	UD361
13	3AS3W2_GW	M6885	WMD	25	UD360
14	3AS3W3_GP	PT037	WMD	8.5	UD312
15	3AS3W3_GW	M6887	WMD	28.6	UD301
16	3AS3W4_GP	PT038	WMD	10.7	UD313
17	3AS3W4_GW	M6886	WMD	30	UD299
18	3BS1W1_GP	PT039	WMD	15	UD307
19	3BS1W1_GW	M6890	WMD	34	UD295
20	3BS1W1_H	M6889	WMD	0	
21	3BS1W2_GP	PT040	WMD	13.5	UD308
22	3BS1W2_GW	M6891	WMD	30	UD296
23	3BS1W3_GP	PT041	WMD	15	UD309
24	3BS1W3_GW	M6892	WMD	28.5	UD298
25	3BS1W4_GP	PT042	WMD	14	UD310
26	3BS1W4_GW	M6893	WMD	34	UD297
27	3AS3W3_R	M6888	WMD		
28	3AS3WX	LA373	WMD		
29	3AS3WX	LA374	WMD		
30	3AS3WX	LA372	WMD		
31	3AS3WX	LA364	WMD		

Table 1 Site information for target wells, stilling wells, and weather station. [WMD, South Florida Water Management District]

The time-series data from nearby weather stations also were downloaded from DBHYDRO. A discussion of the results in provided in the following Results and Discussion section.

2 METHODS

2.1 Data Acquisition

Meta data and time-series data for the 27 stations were downloaded from DBHYDRO. Other site information, such as reference and land-surface elevations and well depths, were previously obtained and (or) verified from survey reports and recorder registration worksheets.

2.2 Procedures for Verification of Well Location and Elevation

Accurate site information, particularly locations and reference elevations (defined as the elevation of the measuring point, usually the top of the casing or platform, in feet above mean sea level), is critical in conducting quality-assurance procedures on monitoring wells. Quality-assurance procedures include comparison of time-series data from the target well with data from nearby rain gages and other active monitoring wells. An incorrect reference elevation for a target well will lead to an erroneous set of time-series data upon which the reference elevation is based. In addition, accurate site information is important in maintaining the integrity of the database. Much of the assessment of site information was conducted as part of the previously noted QA/QC analysis for these stations. The methods used in this analysis included AGC staff becoming familiar with the stations, plotting the stations using GIS to verify the county and geographic location of the sites, and viewing photographs of the wells to verify information such as the casing height. In addition, staff from AGC spoke with personnel at SFWMD to resolve any discrepancies.

The reference and land-surface elevations were revised using the new information from surveys conducted in September 2007 (Keith and Schnars, PA, 2007). The difference between the old and new elevations was calculated for each station to determine the correction factor to be applied to the time-series data. For example, the original reference elevation for well 3BS1W1_GP was 12.13 ft above mean sea level, whereas the new reference elevation was determined to be 12.21 ft above mean sea level (NGVD 29). The difference between the two elevations is 0.08 ft, the correction factor added to the time-series data.

2.3 Procedures for QA/QC of Water-Level Data

After well locations were verified, quality assurance was conducted on time-series data from each well using the methods described in SFWMD SOPs (Sangoyomi and others, 2005; Sangoyomi and others, 2006; Sangoyomi and Lambright, 2006). These methods are summarized as follows:

1. Time-series data from the target station were plotted in order to identify and document anomalies, outliers, and gaps in the record. Gaps, or periods of missing

data, are easily identified. Anomalies are shifts in the values that might or might not represent valid hydrologic data. Anomalies could also be periods of flat or suspiciously linear data. Outliers are extreme values that are significantly greater than or less than a specified range within which most of the data occur. Anomalies and outliers might represent valid hydrologic conditions such as a drought or excessive rainfall. However, anomalies and outliers that are inconsistent with data from nearby wells and rain gages could indicate errors in the time-series data.

2. Summary statistics (minimum, mean, median, maximum, and standard deviation) were determined for each set of time-series data prior to revision (Appendix A).

3. Box plots of time-series data were generated in order to quantitatively identify outliers. Box plots consist of a box with one end (lower quartile, Q1) representing the 25^{th} percentile, and the opposite end (upper quartile, Q3) representing the 75^{th} percentile of the time-series data (fig. 2). A line is drawn near the middle of the box to represent the median of the data. The distance between the lower and upper quartiles is the inter quartile range (IQR). An outlier is defined as any data point greater than the upper fence (upper quartile plus 1.5*IQR), or any data point less than the lower fence (lower quartile minus 1.5*IQR).

4. Time-series data were plotted with data from nearby monitoring stations and rain gages in order to evaluate anomalies and outliers. For example, heavy rains could explain a sudden increase in water levels in the target well. Trends in nearby wells also were used to document and verify that anomalies in the time-series data of the target wells represented valid hydrologic conditions.

5. Anomalies and outliers that did not appear to represent valid hydrologic conditions were deleted from the record. The values were coded as an “M” for missing.

6. Gaps in data can either be tagged as an “M” or an “N”. An “M” indicates the data are missing, possibly as a result of equipment failure or some other technical problem. During the previous QA/QC analysis, missing values were estimated using interpolation (gaps of 7 or less days) or regression analysis with data from nearby wells. However, the time-series data from the two sites needed to be significantly correlated (R^2>0.70) in order to use regression analysis. No attempt was made to estimate missing data tagged with an “M” that was collected after December 31, 2006.

7. Gaps in the time-series data tagged with an “N” indicate that the data are not yet available. Personnel at SFWMD were contacted to determine if data were available for processing. If data were not available, the gaps were processed using the same techniques as gaps tagged with an “M”.

8. The data were revised, based on the analysis of anomalies, outliers, and gaps. Summary statistics were determined for the revised time-series data (Appendix A). Revisions, particularly the addition of the correction factors, caused the summary

statistics to change. Final hydrographs (Appendix A) of the revised data were reviewed to verify that the data were valid.

Revised time-series data are submitted with this report for approval and uploading into DBHYDRO.

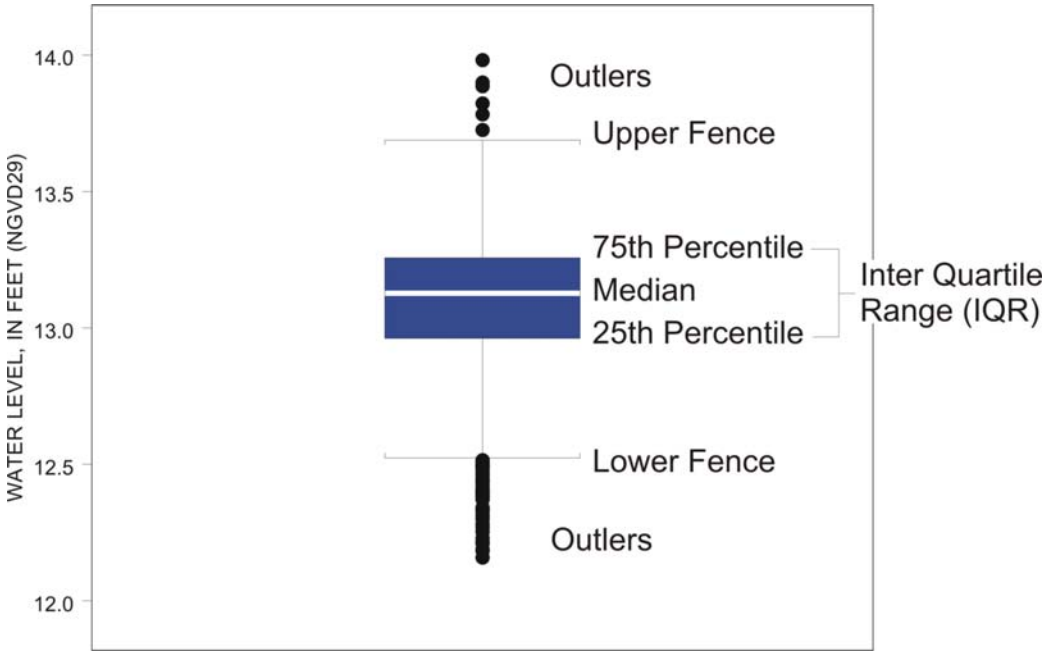


Figure 2 Sample box plot showing lower (Q1) and upper (Q3) quartiles, inter quartile range, and outliers.

Well depths (strata variable in DBHYDRO) are listed as feet below land surface (bls), unless otherwise noted. Water-level data, and reference and land-surface elevations are listed as feet above mean sea level, and are based on the National Geodetic Vertical Datum of 1929 (NGVD29). Horizontal locations are based on North American Datum of 1983 (NAD83) and Florida State Plane coordinates.

3 BACKGROUND

In 2000, South Florida Water Management District began monitoring the ground-water and surface-water interactions at selected tree islands as part of a 5-year, multidisciplinary study conducted in cooperation with the Florida Fish and Wildlife Conservation Commission, the Florida Center for Environmental Studies, the U.S. Geological Survey, and several universities. The three selected tree islands—3AN1, 3AS3, and 3BS1—are all located in Water Conservation Area 3 (fig. 1).

Monitoring is conducted at sets of dual-zone monitor wells installed at each of the tree islands. Dual-zone wells were installed northwest, northeast, and south of each tree island, with a final set of wells located within the tree island. The resulting four sets of

wells at each island are identified as W1, W2, W3, and W4, respectively. With one exception, each dual-zone site contains a shallow (depths range from 4.1 to 15 ft) ¾-inch diameter piezometer and a deeper (depths range from 26.4 to 49.6 ft) 2-inch diameter well installed in the same borehole; 3AN1W4 consists of just the shallow piezometer. A detailed description of well construction and data-collection activities is provided in Bevier and Krupa (2001).

In addition, each W1 site also has an adjacent stilling well to monitor surface-water stage data. Finally, a weather station for monitoring air temperature, barometric pressure, evapotranspiration, humidity, and wind speed was installed at 3AS3. A preliminary assessment of water-level and water-quality data from the tree islands is discussed in Krupa and Gefvert (2006).

4 QUALITY ASSURANCE ANALYSIS

The site information and time-series data from 26 stations were reviewed and analyzed according to SFWMD quality-assurance protocols. The following discussion includes analysis conducted for this project as well as a brief summary of the work done as part of the 2-year QA/QC project.

The station name used for storing the wells in DBHYDRO often refers to both the shallow piezometer and the deeper well at the same site. For example, the station name 3AS3W1_G is used for both the 8.7-ft deep piezometer and the 26.4-ft deep well. For this report, the station names were slightly modified for clarity by adding a P or a W at the end to distinguish the piezometer (3AS3W1_GP) from the well (3AS3W1_GW), respectively. The station name in DBHYDRO is included in the following tables for consistency.

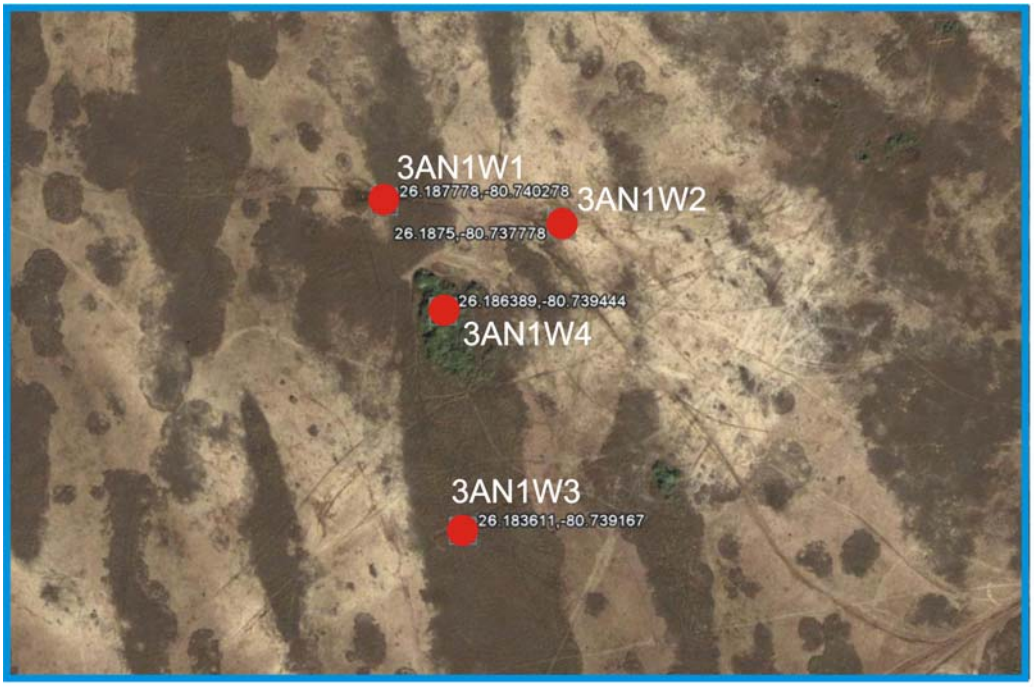


Figure 3 Location of target stations at Tree Island Site 3AN1.

Figure 4 Location of target stations at Tree Island 3AS3.

Figure 5 Location of target stations at Tree Island 3BS1.

4.1 Station 1: 3AN1W1_GP

3AN1W1_GP is a 14.5-ft deep well located in Broward County (figs. 1 and 3). 3AN1W1_G is one of two wells at the site (3AN1W1), which also includes a 32.9-ft deep well 3AN1W1_GW and a surface-water station 3AN1W1_H.

4.1.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W1_GP	3AN1W1_GP
Station (DBHYDRO)	3AN1W1_G	3AN1W1_G
Source DBKEY	OH532	OH532
MOD1 DBKEY	UD202	UD202
Latitude (NAD83)	26 11 16	26 11 16
Longitude (NAD83)	80 44 25	80 44 25
FL State Planar X Coordinate	741311	741311
FL State Planar Y Coordinate	674056	674056
Land-surface elevation (feet NGVD29) (dm_location)	10.219	10.219
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.22	10.22
Land (rock)-surface elevation (feet) (2007 survey)	9.9	9.9
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	17.407	17.39
Strata (feet bls) (DBHYDRO)	14.5	14.5
Recorder	CR10	CR10

Table 2 Site information obtained for Station 1: 3AN1W1_GP

Analysis: The reference elevation determined from the 2007 survey is 0.017 ft less than the elevation listed on the recorder registration. The difference between the reference and land-surface elevations indicates the casing extends about 7.2 ft above land surface. A photograph of the site (below) confirms the casing height. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. Inundation is consistent with the location of the site in wetlands in WCA3.

Station 3AN1W1

Overall, the site information is consistent, and appears to be accurate. No other revisions were required.

4.1.2 Data analysis and revision

The period of record analyzed for well 3AN1W1_GP extends from July 18, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,175 observations with 36 outliers and 204 missing values, all of which were estimated as part of the previous QA/QC project. The summary statistics for this well are provided in table 3.

Problem: The time-series data from well 3AN1W1_GP contain 36 outliers.

Analysis: The outliers, which are less than the lower fence, all occurred in spring 2007 at the end of the dry season. These outliers are consistent with declines in water levels in nearby wells drilled to similar depths (Appendix A), and, therefore, probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The 2007 survey indicates the reference elevation is 0.017 ft lower than initially determined.

Analysis: The correction factor of 0.017 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W1_GP closely coincide with peaks and declines in water-level data from nearby wells (3AN1W2_GP, 3AN1W3_GP, and 3AN1W4_GP) drilled to a similar depth (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3ANIW1_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than subtracting the correction factor of 0.017 ft from the time-series data.

Statistic	Original series	Revised series
Minimum (feet NGVD29)	8.692	8.675
Mean (feet NGVD29)	11.020	11.007
Median (feet NGVD29)	10.887	10.887
Maximum (feet NGVD29)	12.582	12.565
Standard deviation	0.706	0.681
Variance	0.498	0.463
Outliers	36	43
Missing values	204	0

Table 3 Summary statistics of original time-series data for Station 1: 3AN1W1_GP

4.2 Station 2: 3AN1W1_GW

3AN1W1_GW is a 32.9-ft deep well located in Broward County (figs. 1 and 3). 3AN1W1_GW is one of two wells at the site (3AN1W1), which also includes a 14.5-ft deep well 3AN1W1_GP and a surface-water station 3AN1W1_H.

4.2.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W1_GW	3AN1W1_GW
Station (DBHYDRO)	3AN1W1_G	3AN1W1_G
Source DBKEY	OH531	OH531
MOD1 DBKEY	UD201	UD201
Latitude (NAD83)	26 11 16	26 11 16
Longitude (NAD83)	80 44 25	80 44 25
FL State Planar X Coordinate	741311	741311
FL State Planar Y Coordinate	674056	674056
Land-surface elevation (feet NGVD29) (dm_location)	10.22	10.22
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.2	10.2
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	9.9	9.9
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	17.417	17.40
Strata (feet bls) (DBHYDRO)	32.9	32.9
Recorder	CR10	CR10

Table 4 Site information obtained for Station 2: 3AN1W1_GW

Analysis: The reference elevation determined from the 2007 survey is 0.017 ft less than the elevation on the recorder registration. The difference between the reference and land-surface elevations indicates the casing extends 7.2 ft above land surface. In a photograph of the site (see station 1: 3AN1W1_GP), the top of the casing appears to be

elevated above land surface, probably to allow access during high water. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. Inundation is consistent with a location in WCA3.

Overall, the site information is consistent, and appears to be accurate. No other revisions were required.

4.2.2 Data analysis and revision

The period of record analyzed for well 3AN1W1_GW extends from July 18, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,175 observations with 43 outliers and 174 missing values, all of which were estimated as part of the previous QA/QC project. The summary statistics for this well are provided in table 5.

Problem: The time-series data from well 3AN1W1_GW contain 43 outliers, all of which were less than the lower fence.

Analysis: Outliers primarily in spring 2007 at the end of the dry, probably as water levels declined from sparse rainfall. The outliers coincide with declines in nearby wells drilled to similar depths. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The 2007 survey indicates the reference elevation is 0.017 ft lower than initially determined.

Analysis: The correction factor of 0.017 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W1_GW generally coincide with peaks and declines in water-level data from nearby wells (3AN1W2_GW, 3AN1W3_GW, and 3AS3W1_GW) drilled to a similar depth (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AN1W1_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than subtracting the correction factor from the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.716	8.699
Mean (feet NGVD29)	11.017	11.021
Median (feet NGVD29)	10.897	10.918
Maximum (feet NGVD29)	12.665	12.648
Standard deviation	0.717	0.697
Variance	0.515	0.486
Outliers	43	44
Missing values	174	0

Table 5 Summary statistics of time-series data for Station 2: 3AN1W1_GW

4.3 Station 3: 3AN1W1_H

3AN1W1_H is a stilling well located in Broward County (figs. 1 and 3). 3AN1W1_H is located at the same site as 3AN1W1_GP and 3AN1W1_GW.

4.3.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W1_H	3AN1W1_H
Station (DBHYDRO)	3AN1W1	3AN1W1
Source DBKEY	OH538	OH538
Latitude (NAD83)	26 11 16	26 11 16
Longitude (NAD83)	80 44 25	80 44 25
FL State Planar X Coordinate	741311	741311
FL State Planar Y Coordinate	674056	674056
Land-surface elevation (feet NGVD29) (dm_location)	10.05	10.05
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.2	10.2
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	9.9	9.9
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	18.655	18.64
Strata (feet bls) (DBHYDRO)	0	0
Recorder	CR10	CR10

Table 6 Site information obtained for Station 3: 3AN1W1_H

Analysis: The reference elevation determined from the 2007 survey is 0.15 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 8.4 ft above land surface. A photograph of

the site (see Station 1: 3AN1W1_GP) confirms the casing height. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time, as would be expected for a surface-water station.

4.3.2 Data analysis and revision

The period of record analyzed for well 3AN1W1_H extends from July 18, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,175 observations with 8 outliers and 91 missing values. The summary statistics for this well are provided in table 7.

Problem: The time-series data from well 3AN1W1_H contain 8 outliers.

Analysis: The data from this station closely coincide with data from the other two stilling wells (3AS3W1_H and 3BS1W1_H) and to the water levels in the adjacent piezometer 3AN1W1_GP. The outliers probably are valid data that accurately represent conditions at the site.

Problem: The time-series data from stilling well 3AN1W1_H contain 91 missing values, all of which are coded as M.

Analysis: Missing values occurred from August 14 – November 12, 2002 and possibly result from equipment problems. The missing values were not estimated as part of this project.

Problem: The time-series data from stilling well 3AN1W1_H contain anomalous periods of flat data.

Analysis: The anomalous data occurred during periods of water level declines, in May 2006 and in March, April, and May 2007. These periods of flat data are inconsistent with the water level in nearby well 3AN1W1_GP, which continued to decline during the same time. During each period, the water level in 3AN1W1_H declined to slightly less than 9.8 ft above mean sea level. The recorder registration indicates the elevation of the bottom of the stilling well is 9.535 ft above mean sea level, so the anomalous data probably result from the water level declining below the pressure transducer. The anomalous data also occurred during periods when the water level declined below land-surface elevations (fig. 6). The anomalous data were tagged with a less than sign (<) in DBKEY OH538, and deleted and tagged with an M in the preferred MOD1 DBKEY.

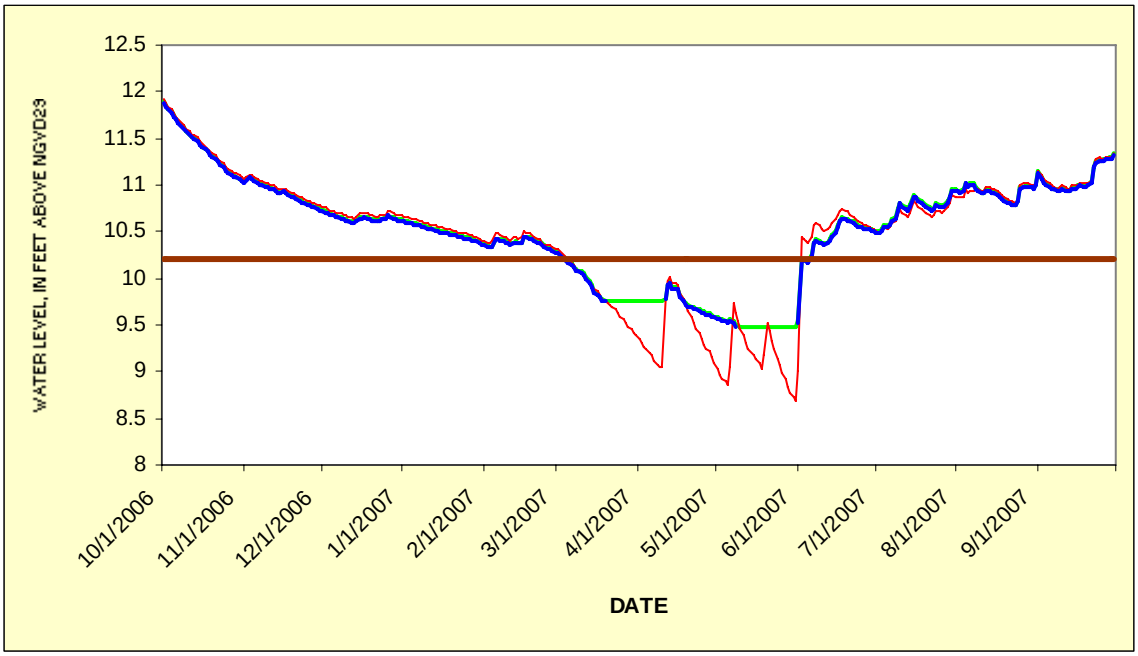


Figure 6 Water-level data from the target station (blue) show two periods of anomalously flat hydrographs (green), which are inconsistent with data from nearby well 3AN1W1_GP (red). The anomalous data were deleted, and tagged with M in the preferred data set. The horizontal brown line represents the land-surface elevation.

Problem: The 2007 survey indicates the reference elevation is 0.015 ft less than the initial reference elevation.

Analysis: The correction factor of 0.015 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W1_H generally coincide with peaks and declines in water-level data from nearby stations (3AN1W1_GP, 3AS3W1_H, and 3BS1W1_H) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AN1W1_H probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than removing the anomalous data and subtracting the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	9.473	9.487
Mean (feet NGVD29)	11.026	11.054
Median (feet NGVD29)	10.894	10.899
Maximum (feet NGVD29)	12.647	12.632
Standard deviation	0.671	0.635
Variance	0.450	0.403
Outliers	8	0
Missing values	91	152

Table 7 Summary statistics of original time-series data for Station 3: 3AN1W1_H

4.4 Station 4: 3AN1W2_GP

3AN1W2_GP is a 15-ft deep well located in Broward (figs. 1 and 3). 3AN1W2_GP is one of two wells at the site (3AN1W2), which also includes a 49.6-ft deep well (3AN1W2_GW).

4.4.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W2_GP	3AN1W2_GP
Station (DBHYDRO)	3AN1W2_GW2	3AN1W2_GW2
Source DBKEY	OH534	OH534
MOD1 DBKEY	UD200	UD200
Latitude (NAD83)	26 11 15	26 11 15
Longitude (NAD83)	80 44 16	80 44 16
FL State Planar X Coordinate	742162	742162
FL State Planar Y Coordinate	673965	673965
Land-surface elevation (feet NGVD29) (dm_location)	10.05	10.05
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.1	10.1
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	9.4	9.4
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	18.281	18.27
Strata (feet bls) (DBHYDRO)	15	15
Recorder	CR10	CR10

Table 8 Site information obtained for Station 4: 3AN1W2_GP

Analysis: The reference elevation determined from the 2007 survey is 0.011 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 8.2 ft above land surface. A photograph of

the site (see below) confirms the casing height. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the site is surrounded by water, which is not unexpected for stations located in wetlands of WCA3.

Station 3AN1W2

Overall, the site information is consistent, and appears to be accurate. No other revisions were required.

4.4.2 Data analysis and revision

The period of record analyzed for well 3AN1W2_GP extends from July 17, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,176 observations with 47 outliers and no missing values. The summary statistics for this well are provided in table 9.

Problem: The time-series data from well 3AN1W2_GP contain 47 outliers, all of which occurred in spring 2007.

Analysis: All of the outliers were less than the lower fence, and coincide with similar declines in water levels in nearby wells that occurred at the end of the dry season. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The reference elevation from the 2007 survey is 0.011 ft less than the initial reference elevation.

Analysis: A correction factor of 0.011 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W2_GP coincide with peaks and declines in water-level data from nearby wells (3AN1W1_GP, 3AN1W3_GP, and 3AN1W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AN1W2_GP appear to be valid data that accurately

represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.572	8.561
Mean (feet NGVD29)	11.018	11.007
Median (feet NGVD29)	10.918	10.908
Maximum (feet NGVD29)	12.571	12.560
Standard deviation	0.712	0.712
Variance	0.506	0.506
Outliers	47	47
Missing values	0	0

Table 9 Summary statistics of time-series data for Station 4: 3AN1W2_GP

4.5 Station 5: 3AN1W2_GW

3AN1W2_GW is a 49.6-ft deep well located in Broward (figs. 1 and 3). 3AN1W2_GW is one of two wells at the site (3AN1W2), which also includes a 15-ft deep well (3AN1W2_GP).

4.5.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W2_GW	3AN1W2_GW
Station (DBHYDRO)	3AN1W2_GW1	3AN1W2_GW1
Source DBKEY	OH533	OH533
MOD1 DBKEY	UD199	UD199
Latitude (NAD83)	26 11 15	26 11 15
Longitude (NAD83)	80 44 16	80 44 16
FL State Planar X Coordinate	742162	742162
FL State Planar Y Coordinate	673965	673965
Land-surface elevation (feet NGVD29) (dm_location)	10.05	10.05
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.1	10.1
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	9.4	9.4
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	18.291	18.28
Strata (feet bls) (DBHYDRO)	49.6	49.6
Recorder	CR10	CR10

Table 10 Site information obtained for Station 5: 3AN1W2_GW

Analysis: The reference elevation from the 2007 survey is 0.011 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 8.2 ft above land surface. A photograph of the site (see station 4: 3AN1W2_GP) confirms the casing height. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the site is surrounded by water.

Overall, the site information is consistent, and appears to be accurate. No other revisions were required.

4.5.2 Data analysis and revision

The period of record analyzed for well 3AN1W2_GW extends from July 17, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,176 observations with 47 outliers and no missing values. The summary statistics for this well are provided in table 11.

Problem: The time-series data from well 3AN1W2_GW contain 47 outliers, all of which occurred in spring 2007.

Analysis: All of the outliers were less than the lower fence, and coincide with similar declines in water levels in nearby wells that occurred at the end of the dry season. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The reference elevation from the 2007 survey is 0.011 ft less than the initial reference elevation.

Analysis: A correction factor of 0.011 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W2_GW coincide with peaks and declines in water-level data from nearby wells (3AN1W1_GW, 3AN1W3_GW, and 3AS3W1_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AN1W2_GW appear to be valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.651	8.640
Mean (feet NGVD29)	11.046	11.035
Median (feet NGVD29)	10.936	10.925
Maximum (feet NGVD29)	12.679	12.668
Standard deviation	0.704	0.704
Variance	0.495	0.495
Outliers	47	47
Missing values	0	0

Table 11 Summary statistics of time-series data for Station 5: 3AN1W2_GW

4.6 Station 6: 3AN1W3_GP

3AN1W3_GP is a 14.5-ft deep well located in Broward County (figs. 1 and 3). 3AN1W3_GP is one of two wells at the site (3AN1W3), which also includes 3AN1W3_GW.

4.6.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W3_GP	3AN1W3_GP
Station (DBHYDRO)	3AN1W3_GW2	3AN1W3_GW2
Source DBKEY	OH536	OH536
MOD1 DBKEY	UD204	UD204
Latitude (NAD83)	26 11 01	26 11 01
Longitude (NAD83)	80 44 21	80 44 21
FL State Planar X Coordinate	741735	741735
FL State Planar Y Coordinate	672543	672543
Land-surface elevation (feet NGVD29) (dm_location)	10.58	10.58
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.5	10.5
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	9.3	9.3
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	18.273	18.23
Strata (feet bls) (DBHYDRO)	14.5	14.5
Recorder	CR10	CR10

Table 12 Site information obtained for Station 6: 3AN1W3_GP

Analysis: The reference elevation from the 2007 survey is 0.043 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends 7.7 ft above land surface. In a photograph of the site (below), the well casing appears to extend several feet above land surface. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water about half of the time. Inundation of the site is not unexpected for stations located in wetlands in WCA3.

3AN1W3 site

Overall, the site information is consistent, and appears to be accurate. No other revisions were required.

4.6.2 Data analysis and revision

The period of record analyzed for well 3AN1W3_GP extends from July 18, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,175 observations with 33 outliers and no missing values. The summary statistics for this well are provided in table 13.

Problem: The time-series data from well 3AN1W3_GP contain 33 outliers, all of which occurred in spring 2007.

Analysis: All of the outliers were less than the lower fence, and coincide with similar declines in water levels in nearby wells that occurred at the end of the dry season. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The reference elevation from the 2007 survey is 0.043 ft less than the initial reference elevation.

Analysis: A correction factor of 0.043 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W3_GP coincide with peaks and declines in water-level data from nearby wells (3AN1W1_GP, 3AN1W2_GP, and 3AN1W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AN1W3_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.628	8.585
Mean (feet NGVD29)	10.967	10.924
Median (feet NGVD29)	10.848	10.805
Maximum (feet NGVD29)	12.585	12.542
Standard deviation	0.724	0.724
Variance	0.524	0.524
Outliers	33	33
Missing values	0	0

Table 13 Summary statistics of time-series data for Station 6: 3AN1W3_GP

4.7 Station 10: 2AN1W3_GW

3AN1W3_GW is a 31.7-ft deep well located in Broward County (figs. 1 and 3). 3AN13_GW is one of two wells at the site (3AN1W3), which also includes 3AN1W3_GP.

4.7.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W3_GW	3AN1W3_GW
Station (DBHYDRO)	3AN1W3_GW1	3AN1W3_GW1
Source DBKEY	OH535	OH535
MOD1 DBKEY	UD205	UD205
Latitude (NAD83)	26 11 01	26 11 01
Longitude (NAD83)	80 44 21	80 44 21
FL State Planar X Coordinate	741735	741735
FL State Planar Y Coordinate	672543	672543
Land-surface elevation (feet NGVD29) (dm_location)	10.58	10.58
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.5	10.5
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	9.3	9.3
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	18.285	18.25
Strata (feet bls) (DBHYDRO)	31.7	31.7
Recorder	CR10	CR10

Table 14 Site information obtained for Station 7: 3AN1W3_GW

Analysis: The reference elevation from the 2007 survey is 0.035 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 7.8 ft above land surface. In a photograph of the site

(see Station 6: 3AN1W3_GP), the top of the casing appears to be elevated above land surface, probably to allow access during high water. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. Overall, the site information is consistent, and appears to be accurate. No other revisions were required.

4.7.2 Data analysis and revision

The period of record analyzed for well 3AN1W3_GW extends from July 18, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,175 observations with 28 outliers and no missing values. The summary statistics for this well are provided in table 15.

Problem: he time-series data from well 3AN1W3_GW contain 28 outliers, all of which occurred in spring 2007.

Analysis: All of the outliers were less than the lower fence, and coincide with similar declines in water levels in nearby wells that occurred at the end of the dry season. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The reference elevation from the 2007 survey is 0.035 ft less than the initial reference elevation.

Analysis: A correction factor of 0.035 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W3_GW coincide with peaks and declines in water-level data from nearby wells (3AN1W1_GW, 3AN1W2_GW, and 3AS3W1_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AN1W3_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.595	8.560
Mean (feet NGVD29)	11.017	10.982
Median (feet NGVD29)	10.904	10.869
Maximum (feet NGVD29)	12.641	12.606
Standard deviation	0.740	0.740
Variance	0.547	0.547
Outliers	28	28
Missing values	0	0

Table 15 Summary statistics of time-series data for Station 7: 3AN1W3_GW

4.8 Station 8: 3AN1W4_GP

3AN1W4_GP is a 4.1-ft deep well located in Broward (figs. 1 and 3). 3AN1W4_GP is the only well at the site (3AN1W4).

4.8.1 Site and data description

Variable	Original value	Revised value
Station	3AN1W4_GP	3AN1W4_GP
Station (DBHYDRO)	3AN1W4_GW2	3AN1W4_GW2
Source DBKEY	OH537	OH537
MOD1 DBKEY	UD203	UD203
Latitude (NAD83)	26 11 11	26 11 11
Longitude (NAD83)	80 44 22	80 44 22
FL State Planar X Coordinate	741616	741616
FL State Planar Y Coordinate	673551	673551
Land-surface elevation (feet NGVD29) (dm_location)	10.61	10.61
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	11.8	11.8
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	10.8	10.8
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	16.212	16.19
Strata (feet bls) (DBHYDRO)	4.1	4.1
Recorder	CR10	CR10

Table 16 Site information obtained for Station 8: 3AN1W4_GP

Analysis: The reference elevation from the 2007 is 0.022 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends 4.4 ft above land surface, which is consistent with the casing shown in the photograph (below). The maximum water level is higher than the land-surface elevation, indicating that the land is periodically inundated with water. The well is within the tree island; hence, rare or occasional inundation is not unexpected.

3AN1W4_GW2

Overall, the site information is consistent, and appears to be accurate. No other revisions were necessary.

4.8.2 Data analysis and revision

The period of record analyzed for well 3AN1W4_GP extends from July 18, 2002 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,175 observations with 31 outliers and 179 missing values, all of which were estimated as part of the previous QA/QC project. The summary statistics for this well are provided in table 17.

Problem: The time-series data from well 3AN1W4_GP contain 31 outliers, all but one of which occurred in spring 2007.

Analysis: All of the outliers were less than the lower fence, and coincide with similar declines in water levels in nearby wells that occurred at the end of the dry season. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The reference elevation from the 2007 survey is 0.022 ft less than the initial reference elevation.

Analysis: A correction factor of 0.022 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AN1W4_GP coincide with peaks and declines in water-level data from nearby wells (3AN1W1_GP, 3AN1W2_GP, and 3AN1W3_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AN1W4_GP probably are valid data that

accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.573	8.551
Mean (feet NGVD29)	11.054	11.052
Median (feet NGVD29)	10.945	10.955
Maximum (feet NGVD29)	12.593	12.571
Standard deviation	0.704	0.686
Variance	0.495	0.471
Outliers	31	34
Missing values	179	0

Table 17 Summary statistics of time-series data for Station 8: 3AN1W4_GP

4.9 Station 9: 3AS3W1_GP

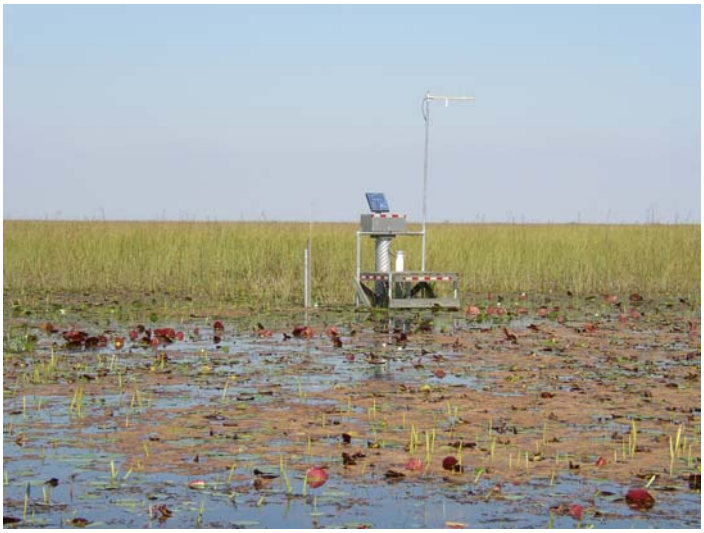
3AS3W1_GP is an 8.7-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W1_GP is one of three stations at the site (3AS3W1), which also includes well 3AS3W1_GW and stilling well 3AS3W1_H.

4.9.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W1_GP	3AS3W1_GP
Station (DBHYDRO)	3AS3W1_G	3AS3W1_G
Source DBKEY	PT035	PT035
MOD1 DBKEY	UD311	UD311
Latitude (NAD83)	25 51 26	25 51 26
Longitude (NAD83)	80 46 17	80 46 17
FL State Planar X Coordinate	731346.66	731346.66
FL State Planar Y Coordinate	553896.56	553896.56
Land-surface elevation (feet NGVD29) (dm_location)	7.33	7.33
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.4	8.4
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	4.6	4.6
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	14.50	14.50
Strata (feet bls) (DBHYDRO)	8.7	8.7
Recorder	CR10	CR10

Table 18 Site information obtained for Station 9: 3AS3W1_GP

Analysis: The reference elevation from the 2007 survey is identical to the initial reference elevation. No correction factor was needed. The difference between the reference and land-surface elevations indicates the casing extends 6.1 ft above land surface, which is consistent with the well casing showin in a photograph of the site (below). The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the well surrounded by water, which is not unexpected for sites located in wetlands of WCA3. The site information for the target well is consistent, and appears to be accurate. No revisions were required.



Site 3AS3W1

4.9.2 Data analysis and revision

The period of record analyzed for well 3AS3W1_GP extends from July 29, 2003 through June 30, 2008 (Appendix A). The time-series data from that period contain 1,799 observations with no outliers and no missing values. The summary statistics for this well are provided in table 19.

Summary: The peaks and declines in water-level data from well 3AS3W1_GP coincide with peaks and declines in water-level data from nearby wells (3AS3W2_GP, 3AS3W3_GP, and 3AS3W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AS3W1_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.309	8.309
Mean (feet NGVD29)	9.724	9.724
Median (feet NGVD29)	9.623	9.623
Maximum (feet NGVD29)	11.232	11.232
Standard deviation	0.726	0.726
Variance	0.527	0.527
Outliers	0	0
Missing values	0	0

Table 19 Summary statistics of time-series data for Station 9: 3AS3W1_GP

4.10 Station 10: 3AS3W1_GW

3AS3W1_GP is a 26.4-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W1_GW is one of three stations at the site (3AS3W1), which also includes well 3AS3W1_GP and stilling well 3AS3W1_H.

4.10.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W1_GW	3AS3W1_GW
Station (DBHYDRO)	3AS3W1_G	3AS3W1_G
Source DBKEY	M6884	M6884
MOD1 DBKEY	UD300	UD300
Latitude (NAD83)	25 51 26	25 51 26
Longitude (NAD83)	80 46 17	80 46 17
FL State Planar X Coordinate	731346.66	731346.66
FL State Planar Y Coordinate	553896.56	553896.56
Land-surface elevation (feet NGVD29) (dm_location)	7.33	7.33
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.4	8.4
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	4.6	4.6
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	14.49	14.48
Strata (feet bls) (DBHYDRO)	26.4	26.4
Recorder	CR10	CR10

Table 20 Site information obtained for Station 10: 3AS3W1_GW

Analysis: The reference elevation from the 2007 survey is 0.01 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 6.1 ft above land surface, which is consistent with the well casing shown in a photograph of the site (see station 9: 3AS3W1_GP). The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the well surrounded by water. The site information is consistent, and appears to be accurate. No revisions were required.

4.10.2 Data analysis and revision

The period of record analyzed for well 3AS3W1_GW extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,975 observations with no outliers and no missing values. The summary statistics for this well are provided in table 21.

Problem: The reference elevation from the 2007 survey is 0.01 ft less than the initial reference elevation.

Analysis: A correction factor of 0.01 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from well 3AS3W1_GW coincide with peaks and declines in water-level data from nearby wells (3AS3W2_GW, 3AS3W3_GW, and 3AS3W4_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AS3W1_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.097	8.087
Mean (feet NGVD29)	9.695	9.685
Median (feet NGVD29)	9.669	9.659
Maximum (feet NGVD29)	11.283	11.273
Standard deviation	0.694	0.694
Variance	0.482	0.482
Outliers	0	0
Missing values	0	0

Table 21 Summary statistics of time-series data for Station 10: 3AS3W1_GW

4.11 Station 11: 3AS3W1_H

3AS3W1_H is a stilling well located in Miami-Dade County (figs. 1 and 3). 3AS3W1_H is one of three stations at the site (3AS3W1), which also includes wells 3AS3W1_GP and 3AS3W1_GW.

4.11.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W1_H	3AS3W1_H
Station (DBHYDRO)	3AS3W1_H	3AS3W1_H
Source DBKEY	M6883	M6883
MOD1 DBKEY		
Latitude (NAD83)	25 51 26	25 51 26
Longitude (NAD83)	80 46 17	80 46 17
FL State Planar X Coordinate	731346.66	731346.66
FL State Planar Y Coordinate	553896.56	553896.56
Land-surface elevation (feet NGVD29) (dm_location)	7.33	7.33
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.4	8.4
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	4.6	4.6
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	16.18	16.15
Strata (feet bls) (DBHYDRO)	0	0
Recorder	CR10	CR10

Table 22 Site information obtained for Station 11: 3AS3W1_H

Analysis: The reference elevation from the 2007 survey is 0.03 ft less than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 7.75 ft above land surface. In a photograph of the site (see station 9: 3AS3W1_GP), the top of the casing appears to be elevated above land surface, probably to allow access during high water. The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the well surrounded by water. The site information is consistent, and appears to be accurate. No revisions were required.

4.11.2 Data analysis and revision

The period of record analyzed for station 3AS3W1_H extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,975 observations with no outliers and no missing values. The summary statistics for this station are provided in table 23.

Problem: The reference elevation from the 2007 survey is 0.03 ft less than the initial reference elevation.

Analysis: A correction factor of 0.03 ft was subtracted from the time-series data.

Summary: The peaks and declines in water-level data from station 3AS3W1_H coincide with peaks and declines in water-level data from nearby wells (3AN1W1_H, 3AS3W1_GW, and 3BS1W1_H) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AS3W1_H probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.065	8.035
Mean (feet NGVD29)	9.676	9.646
Median (feet NGVD29)	9.659	9.629
Maximum (feet NGVD29)	11.246	11.216
Standard deviation	0.704	0.704
Variance	0.495	0.495
Outliers	0	0
Missing values	0	0

Table 23 Summary statistics of time-series data for Station 11: 3AS3W1_H

4.12 Station 12: 3AS3W2_GP

3AS3W2_GP is an 8.5-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W2_GP is the one of two wells at the site (3AS3W2), which also includes 3AS3W2_GW.

4.12.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W2_GP	3AS3W2_GP
Station (DBHYDRO)	3AS3W2_G	3AS3W2_G
Source DBKEY	PT036	PT036
MOD1 DBKEY	UD361	UD361
Latitude (NAD83)	25 51 26	25 51 26
Longitude (NAD83)	80 46 04	80 46 04
FL State Planar X Coordinate	732508	732508
FL State Planar Y Coordinate	553815	553815
Land-surface elevation (feet NGVD29) (dm_location)	7.97	7.97
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.1	8.1
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	4.8	4.8
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	15.990	16.00
Strata (feet bls) (DBHYDRO)	8.5	8.5
Recorder	CR10	CR10

Table 24 Site information obtained for Station 12: 3AS3W2_GP

Analysis: The reference elevation from the 2007 survey is 0.01 ft higher than the initial reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 8.0 ft above land surface, which is consistent with the casing height shown in a photograph (below). The minimum water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the well surrounded by water, which is common in wetlands in WCA3. The site information is consistent, and appears to be accurate. No revisions were required.

3AS3W2_G

4.12.2 Data analysis and revision

The period of record analyzed for well 3AS3W2_GP extends from July 30, 2003 through June 30, 2008 (Appendix A). The time-series data from that period contain 1,798 observations with no outliers and 86 missing values. The summary statistics for this well are provided in table 25.

Problem: The time-series data from well 3AS3W2_GP contain 86 missing values coded as M.

Analysis: Thirty-six of the missing values occurred in 2003 and nine occurred from December 23 – 31, 2006. These missing value were estimated using regression analysis as part of the previous QA/QC project. Missing values also occurred from January 1 through February 10, 2007, but have not been estimated. The missing values probably are related to equipment issues, as the tree island sites are in remote locations.

Problem: The reference elevation from the 2007 survey is 0.01 ft higher than the initial reference elevation.

Analysis: A correction factor of 0.01 ft was added from the time-series data.

Summary: The peaks and declines in water-level data from well 3AS3W2_GP coincide with peaks and declines in water-level data from nearby wells (3AS3W1_GP, 3AS3W3_GP, and 3AS3W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AS3W2_GP probably are valid data that accurately represent hydrologic conditions at the site. No other revisions were required, other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.235	8.245
Mean (feet NGVD29)	9.668	9.701
Median (feet NGVD29)	9.552	9.592
Maximum (feet NGVD29)	11.240	11.287
Standard deviation	0.734	0.744
Variance	0.539	0.554
Outliers	0	0
Missing values	86	41

Table 25 Summary statistics of time-series data for Station 12: 3AS3W2_GP

4.13 Station 13: 3AS3W2_GW

3AS3W2_GW is a 25-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W2_GW is the one of two wells at the site (3AS3W2), which also includes an 8.5-ft deep well 3AS3W2_GP.

4.13.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W2_GW	3AS3W2_GW
Station (DBHYDRO)	3AS3W2_G	3AS3W2_G
Source DBKEY	M6885	M6885
MOD1 DBKEY	UD360	UD360
Latitude (NAD83)	25 51 26	25 51 26
Longitude (NAD83)	80 46 04	80 46 04
FL State Planar X Coordinate	732508	732508
FL State Planar Y Coordinate	553815	553815
Land-surface elevation (feet NGVD29) (dm_location)	7.97	7.97
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.1	8.1
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	4.8	4.8
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	15.975	16.01
Strata (feet bls) (DBHYDRO)	25	25
Recorder	CR10	CR10

Table 26 Site information obtained for Station 13: 3AS3W2_GW

Analysis: The reference elevation from the 2007 survey is 0.035 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 8.0 ft above land surface, which is

consistent with the casing height shown in a photograph of the site (see station 12: 3AS3W2_GP). The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. The photograph also shows the well surrounded by water, which is not unexpected for sites located in wetlands in WCA3. The site information is consistent, and appears to be accurate. No revisions were required.

4.13.2 Data analysis and revision

The period of record analyzed for well 3AS3W2_GW extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data from that period contain 2,975 observations with no outliers and 26 missing values, which were estimated as part of the previous QA/QC project. The summary statistics for this well are provided in table 27.

Problem: The reference elevation from the 2007 survey is 0.035 ft higher than the initial reference elevation.

Analysis: A correction factor of 0.035 ft was added from the time-series data.

Summary: The peaks and declines in water-level data from well 3AS3W2_GW coincide with peaks and declines in water-level data from nearby wells (3AS3W1_GW, 3AS3W3_GW, and 3AS3W4_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. Therefore, the time-series data from well 3AS3W2_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.051	8.086
Mean (feet NGVD29)	9.639	9.686
Median (feet NGVD29)	9.639	9.684
Maximum (feet NGVD29)	11.224	11.259
Standard deviation	0.693	0.701
Variance	0.480	0.491
Outliers	0	0
Missing values	26	0

Table 27 Summary statistics of time-series data for Station 13: 3AS3W2_GW

4.14 Station 14: 3AS3W3_GP

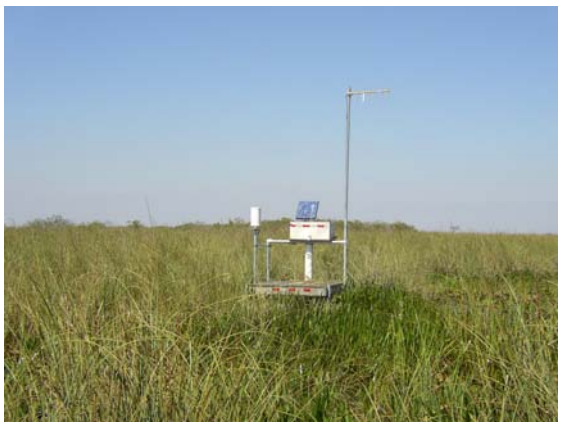
3AS3W3_G is an 8.5-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W3_GP is one of two wells at the site (3AS3W3), which also includes 3AS3W3_GW.

4.14.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W3_GP	3AS3W3_GP
Station (DBHYDRO)	3AS3W3_G	3AS3W3_G
Source DBKEY	PT037	PT037
MOD1 DBKEY	UD312	UD312
Latitude (NAD83)	25 51 12	25 51 12
Longitude (NAD83)	80 46 09	80 46 09
FL State Planar X Coordinate	732097.39	732097.39
FL State Planar Y Coordinate	552418.02	552418.02
Land-surface elevation (feet NGVD29) (dm_location)	7.9	7.9
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.9	8.9
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	3.3	3.3
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	16.13	16.20
Strata (feet bls) (DBHYDRO)	8.5	8.5
Recorder	CR10	CR10

Table 28 Site information obtained for Station 16: 3AS3W3_G

Analysis: The reference elevation from the 2007 survey is 0.07 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends 7.3 ft above land surface, which is consistent with the casing height shown in a photograph of the site (below). The median water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. Inundation of the site is not unexpected due to its location in wetlands in WCA3. The site information is consistent, and appears to be accurate. No revisions were required.



Site 3AS3W3_G

4.14.2 Data analysis and revision

The period of record analyzed for well 3AS3W3_GP extends from July 31, 2003 through June 30, 2008 (Appendix A). The time-series data from that period contain 1,797 observations with no outliers and 50 missing values, 9 of which were estimated as part of the previous QA/QC project. The summary statistics for this well are provided in table 29.

Problem: The time-series data from well 3AS3W3_GP contain 41 missing values coded as M.

Analysis: Missing values occurred from January 1 through February 10, 2007, and probably result from equipment issues. The missing values were not estimated as part of this project.

Problem: The new reference elevation from the 2007 survey is 0.07 ft higher than the original reference elevation.

Analysis: A correction factor of 0.07 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3AS3W3_GP coincide with peaks and declines in water-level data from nearby wells (3AS3W1_GP, 3AS3W2_GP, and 3AS3W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AS3W3_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.138	8.208
Mean (feet NGVD29)	9.662	9.733
Median (feet NGVD29)	9.557	9.637
Maximum (feet NGVD29)	11.193	11.263
Standard deviation	0.741	0.739
Variance	0.549	0.546
Outliers	0	0
Missing values	50	41

Table 29 Summary statistics of time-series data for Station 14: 3AS3W3_GP

4.15 Station 15: 3AS3W3_GW

3AS3W3_GW is a 28.6-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W3_GW is one of two wells at the site (3AS3W3), which also includes 3AS3W3_GP.

4.15.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W3_GW	3AS3W3_GW
Station (DBHYDRO)	3AS3W3_G	3AS3W3_G
Source DBKEY	M6887	M6887
MOD1 DBKEY	UD301	UD301
Latitude (NAD83)	25 51 12	25 51 12
Longitude (NAD83)	80 46 09	80 46 09
FL State Planar X Coordinate	732097.39	732097.39
FL State Planar Y Coordinate	552418.02	552418.02
Land-surface elevation (feet NGVD29) (dm_location)	7.9	7.9
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.9	8.9
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	3.3	3.3
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	16.14	16.21
Strata (feet bls) (DBHYDRO)	28.6	28.6
Recorder	CR10	CR10

Table 30 Site information obtained for Station 15: 3AS3W3_GW

Analysis: The reference elevation from the 2007 survey is 0.07 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends 8.2 ft above land surface, which is consistent with the casing height shown in a photograph of the site (see station 16: 3AS3W3_G). The

minimum water level is higher than the land-surface elevation, indicating that the land is inundated with water most of the time. Inundation is not unexpected as the site is located in wetlands in WCA3. The site information is consistent, and appears to be accurate. No revisions were required.

4.15.2 Data analysis and revision

The period of record analyzed for well 3AS3W3_GW extends from May 9, 2000 to June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with no outliers and 50 missing values, of which 9 were estimated as part of the previous QA/QC project. The summary statistics for well 3AS3W3_GW are provided in table 31.

Problem: The time-series data from well 3AS3W3_GW contain 41 missing values coded as M.

Analysis: Missing values occurred from January 1 through February 10, 2007, and probably result from equipment issues. The missing values were not estimated as part of this project.

Problem: The new reference elevation from the 2007 survey is 0.07 ft higher than the original reference elevation.

Analysis: A correction factor of 0.07 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3AS3W3_GW coincide with peaks and declines in water-level data from nearby wells (3AS3W1_GW, 3AS3W2_GW, and 3AS3W4_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AS3W3_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.007	8.077
Mean (feet NGVD29)	9.615	9.686
Median (feet NGVD29)	9.601	9.672
Maximum (feet NGVD29)	11.196	11.266
Standard deviation	0.705	0.704
Variance	0.497	0.495
Outliers	0	0
Missing values	50	41

Table 31 Summary statistics of time-series data for Station 15: 3AS3W3_GW

4.16 Station 16: 3AS3W4_GP

3AS3W4_G is a 10.7-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W4_GP is one of two wells at the site (3AS3W4), which also includes 3AS3W4_GW.

4.16.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W4_GP	3AS3W4_GP
Station (DBHYDRO)	3AS3W4_G	3AS3W4_G
Source DBKEY	PT038	PT038
MOD1 DBKEY	UD313	UD313
Latitude (NAD83)	25 51 24	25 51 24
Longitude (NAD83)	80 46 10	80 46 10
FL State Planar X Coordinate	731945.46	731945.46
FL State Planar Y Coordinate	553625.92	553625.92
Land-surface elevation (feet NGVD29) (dm_location)	11.74	11.74
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.3	10.3
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	6.2	6.2
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	15.682	15.75
Strata (feet bls) (DBHYDRO)	10.7	10.7
Recorder	CR10	CR10

Table 32 Site information obtained for Station 16: 3AS3W4_GP

Analysis: The reference elevation from the 2007 survey is 0.068 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 5.5 ft above land surface, which is consistent with the photograph below.

The maximum water level in the well is higher than the land-surface elevation, indicating the site is periodically inundated with water. Occasional inundation is not unexpected for site located on tree islands. A walkway was installed next to the well (see photograph), probably to allow access to the site during high water. No revisions were necessary.

Site 3AS3W4_G

4.16.2 Data analysis and revision

The period of record analyzed for well 3AS3W4_GP extends from July 30, 2003 through June 30, 2008 (Appendix A). The time-series data for that period contain 1,798 observations with no outliers and 43 missing values, of which 2 were estimated as part of the previous QA/QC project. The summary statistics for well 3AS3W4_GP are provided in table 33.

Problem: The time-series data from well 3AS3W4_GP contain 41 missing values coded as M.

Analysis: Missing values occurred from January 1 through February 10, 2007, and probably result from equipment issues. The missing values were not estimated as part of this project.

Problem: The new reference elevation from the 2007 survey is 0.068 ft higher than the original reference elevation.

Analysis: A correction factor of 0.068 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3AS3W4_GP coincide with peaks and declines in water-level data from nearby wells (3AS3W1_GP,

3AS3W2_GP, and 3AS3W3_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AS3W4_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	8.169	8.237
Mean (feet NGVD29)	9.679	9.747
Median (feet NGVD29)	9.614	9.682
Maximum (feet NGVD29)	11.155	11.223
Standard deviation	0.735	0.735
Variance	0.540	0.540
Outliers	0	0
Missing values	43	41

Table 33 Summary statistics of time-series data for Station 16: 3AS3W4_GP

4.17 Station 17: 3AS3W4_GW

3AS3W4_GW is a 30-ft deep well located in Miami-Dade County (figs. 1 and 4). 3AS3W4_GW is one of two wells at the site (3AS3W4), which also includes well 3AS3W4_GP.

4.17.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W4_GW	3AS3W4_GW
Station (DBHYDRO)	3AS3W4_G	3AS3W4_G
DBKEY	M6886	M6886
MOD1 DBKEY	UD299	UD299
Latitude (NAD83)	25 51 24	25 51 24
Longitude (NAD83)	80 46 10	80 46 10
FL State Planar X Coordinate	731945.46	731945.46
FL State Planar Y Coordinate	553625.92	553625.92
Land-surface elevation (feet NGVD29) (dm_location)	11.74	11.74
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.3	10.3
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	6.2	6.2
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	15.682	15.75
Strata (feet bls) (DBHYDRO)	30	30
Recorder	CR10	CR10

Table 34 Site information obtained for Station 17: 3AS3W4_GW

Analysis: The reference elevation from the 2007 survey is 0.068 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 5.5 ft above land surface, which is consistent with a photograph (see Station 16: 3AS3W4_GP).

The maximum water level in the well is higher than the land-surface elevation, indicating the site is periodically inundated with water. A walkway was installed next to the well (see photograph), probably to allow access to the site during high water. No revisions were necessary.

4.17.2 Data analysis and revision

The period of record analyzed for well 3AS3W4_GW extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with no outliers and 58 missing values, all of which were estimated as part

of the previous QA/QC project. The summary statistics for well 3AS3W4_GW are provided in table 35.

Problem: The new reference elevation from the 2007 survey is 0.068 ft higher than the original reference elevation.

Analysis: A correction factor of 0.068 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3AS3W4_GW coincide with peaks and declines in water-level data from nearby wells (3AS3W1_GW, 3AS3W2_GW, and 3AS3W3_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3AS3W4_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	7.998	8.066
Mean (feet NGVD29)	9.629	9.707
Median (feet NGVD29)	9.591	9.685
Maximum (feet NGVD29)	11.210	11.278
Standard deviation	0.699	0.696
Variance	0.489	0.484
Outliers	0	0
Missing values	58	0

Table 35 Summary statistics of time-series data for Station 17: 3AS3W4_GW

4.18 Station 18: 3BS1W1_GP

3BS1W1_G is a 15-ft deep well located in Miami-Dade County (figs. 1 and 5). 3BS1W1_GP is one of three stations at the site (3BS1W1), which also includes 3BS1W1_GW and 3BS1W1_H.

4.18.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W1_GP	3BS1W1_GP
Station (DBHYDRO)	3BS1W1_G	3BS1W1_G
DBKEY	PT039	PT039
MOD1 DBKEY	UD307	UD307
Latitude (NAD83)	25 46 49	25 46 49
Longitude (NAD83)	80 30 41	80 30 41
FL State Planar X Coordinate	816927.98	816927.98
FL State Planar Y Coordinate	526166.98	526166.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	5.4	5.4
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	2.8	2.8
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	12.13	12.21
Strata (feet bls) (DBHYDRO)	15	15
Recorder	CR10	CR10

Table 36 Site information obtained for Station 18: 3BS1W1_GP

Analysis: The reference elevation from the 2007 survey is 0.08 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 6.8 ft above land surface. A photograph (below) confirms the casing height. The median water level in the well is higher than the land-surface elevation, indicating that the site is inundated most of the time. The photograph shows the site is surrounded by water, which is not unexpected for a location in the wetlands of WCA3. Overall, the site information for the station was accurate, and no revisions were necessary.

3BS1W1_G

4.18.2 Data analysis and revision

The period of record analyzed for well 3BS1W1_GP extends from July 19, 2003 through June 30, 2008 (Appendix A). The time-series data for that period contain 1,809 observations with no outliers and no missing values. The summary statistics for well 3BS1W1_GP are provided in table 37.

Problem: The new reference elevation from the 2007 survey is 0.08 ft higher than the original reference elevation.

Analysis: A correction factor of 0.08 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W1_GP coincide with peaks and declines in water-level data from nearby wells (3BS1W2_GP, 3BS1W3_GP, and 3BS1W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W1_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	4.611	4.691
Mean (feet NGVD29)	6.562	6.642
Median (feet NGVD29)	6.638	6.718
Maximum (feet NGVD29)	8.327	8.407
Standard deviation	0.875	0.875
Variance	0.765	0.765
Outliers	0	0
Missing values	0	0

Table 37 Summary statistics of time-series data for Station 18: 3BS1W1_GP

4.19 Station 19: 3BS1W1_GW

3BS1W1_GW is a 34-ft deep well located in Miami-Dade County (figs. 1 and 5). 3BS1W1_GW is one of three stations at the site (3BS1W1), which also includes 3BS1W1_GP and 3BS1W1_H.

4.19.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W1_GW	3BS1W1_GW
Station (DBHYDRO)	3BS1W1_G	3BS1W1_G
Source DBKEY	M6890	M6890
MOD1 DBKEY	UD295	UD295
Latitude (NAD83)	25 46 49	25 46 49
Longitude (NAD83)	80 30 41	80 30 41
FL State Planar X Coordinate	816927.98	816927.98
FL State Planar Y Coordinate	526166.98	526166.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	5.4	5.4
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	2.8	2.8
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	12.15	12.22
Strata (feet bls) (DBHYDRO)	34	34
Recorder	CR10	CR10

Table 38 Site information obtained for Station 19: 3BS1W1_GW

Analysis: The reference elevation from the 2007 survey is 0.07 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 6.8 ft above land surface. A photograph (see station 18: 3BS1W1_GP) confirms the casing height. The median water level in the well

is higher than the land-surface elevation, which is consistent with its location with WCA3. The photograph shows the site is surrounded by water. Overall, the site information for the well is accurate. No revisions were necessary.

4.19.2 Data analysis and revision

The period of record analyzed for well 3BS1W1_GW extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with 2 outliers and no missing values. The summary statistics for well 3BS1W1_GW are provided in table 39.

Problem: The time-series data from well 3BS1W1_GW contain 2 outliers, all of which are less than the lower fence.

Analysis: The outliers occurred in May 2001, after a period of low rainfall. These lower outliers also coincide with declines in water levels in nearby wells drilled to similar depths. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The new reference elevation from the 2007 survey is 0.07 ft higher than the original reference elevation.

Analysis: A correction factor of 0.07 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W1_GW coincide with peaks and declines in water-level data from nearby wells (3BS1W2_GW, 3BS1W3_GW, and 3BS1W4_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W1_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	3.987	4.057
Mean (feet NGVD29)	6.572	6.642
Median (feet NGVD29)	6.635	6.705
Maximum (feet NGVD29)	8.314	8.384
Standard deviation	0.873	0.873
Variance	0.762	0.762
Outliers	2	2
Missing values	0	0

Table 39 Summary statistics of time-series data for Station 19: 3BS1W1_GW

4.20 Station 20: 3BS1W1_H

3BS1W1_H is a stilling well to monitor surface-water stage (figs. 1 and 5). 3BS1W1_H is one of three stations at the site (3BS1W1), which also includes 3BS1W1_GP and 3BS1W1_GW.

4.20.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W1_H	3BS1W1_H
Station (DBHYDRO)	3BS1W1_H	3BS1W1_H
Source DBKEY	M6889	M6889
MOD1 DBKEY		
Latitude (NAD83)	25 46 49	25 46 49
Longitude (NAD83)	80 30 41	80 30 41
FL State Planar X Coordinate	816927.98	816927.98
FL State Planar Y Coordinate	526166.98	526166.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	5.4	5.4
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	2.8	2.8
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	14.00	14.05
Strata (feet bls) (DBHYDRO)	0	0
Recorder	CR10	CR10

Table 40 Site information obtained for Station 20: 3BS1W1_H

Analysis: The reference elevation from the 2007 survey is 0.05 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 8.6 ft above land surface. A photograph (see station 18: 3BS1W1_GP) confirms the casing height. The minimum water level in the

well is less than the land-surface elevation, indicating that the site is periodically dry. However, the elevation of the well bottom is 4.1 ft above mean sea level (from recorder registration), so water-level data were accurately recorded even during periods when the land surface was dry. Overall, the site information for the well is accurate. No revisions were necessary.

4.20.2 Data analysis and revision

The period of record analyzed for station 3BS1W1_H extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with no outliers and no missing values. The summary statistics for station 3BS1W1_H are provided in table 41.

Problem: The new reference elevation from the 2007 survey is 0.05 ft higher than the original reference elevation.

Analysis: A correction factor of 0.05 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from station 3BS1W1_H coincide with peaks and declines in water-level data from nearby stations (3BS1W1_GW, 2AN1W1_H, and 3AS3W1_H) (Appendix A). In addition, water levels in the target station decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W1_H probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	4.270	4.320
Mean (feet NGVD29)	6.612	6.662
Median (feet NGVD29)	6.664	6.714
Maximum (feet NGVD29)	8.475	8.525
Standard deviation	0.898	0.898
Variance	0.807	0.807
Outliers	0	0
Missing values	0	0

Table 41 Summary statistics of time-series data for Station 20: 3BS1W1_H

4.21 Station 21: 3BS1W2_GP

3BS1W2_GP is a 13.5-ft deep well located in Miami-Dade County (figs. 1 and 5). 3BS1W2_GP is one of two wells at the site (3BS1W2), which also includes 3BS1W2_GW.

4.21.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W2_GP	3BS1W2_GP
Station (DBHYDRO)	3BS1W2_G	3BS1W2_G
DBKEY	PT040	PT040
MOD1 DBKEY	UD308	UD308
Latitude (NAD83)	25 46 50	25 46 50
Longitude (NAD83)	80 30 25	80 30 25
FL State Planar X Coordinate	818360.43	818360.43
FL State Planar Y Coordinate	526241.98	526241.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	5.5	5.5
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	3.1	3.1
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	13.40	13.49
Strata (feet bls) (DBHYDRO)	13.5	13.5
Recorder	CR10	CR10

Table 42 Site information obtained for Station 21: 3BS1W2_GP

Analysis: The reference elevation from the 2007 survey is 0.09 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends 8 ft above land surface. A photograph (below) confirms the casing height.

The median water level in the well is higher than the land-surface elevation, indicating that the site is inundated most of the time. The photograph shows the site is surrounded by water, which is consistent for a location in WCA3. Overall, the site information for the well is consistent and appears to be accurate. No revisions were necessary.

Site 3BS1W2_G

4.21.2 Data analysis and revision

The period of record analyzed for well 3BS1W2_GP extends from July 23, 2003 through June 30, 2008 (Appendix A). The time-series data for that period contain 1,805 observations with no outliers and 70 missing values, all of which were estimated as part of the previous QA/QC project. The summary statistics for well 3BS1W2_GP are provided in table 43.

Problem: The new reference elevation from the 2007 survey is 0.09 ft higher than the original reference elevation.

Analysis: A correction factor of 0.09 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W2_GP coincide with peaks and declines in water-level data from nearby wells (3BS1W1_GP, 3BS1W3_GP, and 3BS1W4_G) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W2_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	4.520	4.610
Mean (feet NGVD29)	6.491	6.614
Median (feet NGVD29)	6.569	6.718
Maximum (feet NGVD29)	8.295	8.385
Standard deviation	0.899	0.898
Variance	0.808	0.806
Outliers	0	0
Missing values	70	0

Table 43 Summary statistics of time-series data for Station 21: 3BS1W2_GP

4.22 Station 22: 3BS1W2_GW

3BS1W2_GW is a 30-ft deep well located in Miami-Dade County (figs. 1 and 5). 3BS1W2_GW is one of two wells at the site (3BS1W2), which also includes 3BS1W2_GP.

4.22.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W2_GW	3BS1W2_GW
Station (DBHYDRO)	3BS1W2_G	3BS1W2_G
Source DBKEY	M6891	M6891
MOD1 DBKEY	UD296	UD296
Latitude (NAD83)	25 46 50	25 46 50
Longitude (NAD83)	80 30 26	80 30 26
FL State Planar X Coordinate	818360.43	818360.43
FL State Planar Y Coordinate	526241.98	526241.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	5.5	5.5
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	3.1	3.1
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	13.40	13.49
Strata (feet bls) (DBHYDRO)	30	30
Recorder	CR10	CR10

Table 44 Site information obtained for Station 22: 3BS1W2_GW

Analysis: The reference elevation from the 2007 survey is 0.09 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends 8 ft above land surface. A photograph (see station 21: 3BS1W2_GP) confirms the casing height.

The median water level in the well is higher than the land-surface elevation, indicating that the site is inundated most of the time. The photograph shows the site is surrounded by water, which is consistent with a location in WCA3. Overall, the site information for the well is consistent and appears to be accurate. No revisions were necessary.

4.22.2 Data analysis and revision

The period of record analyzed for well 3BS1W2_GW extends from May 1, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,983 observations with no outliers and no missing values. The summary statistics for well 3BS1W2_GW are provided in table 45.

Problem: The new reference elevation from the 2007 survey is 0.09 ft higher than the original reference elevation.

Analysis: A correction factor of 0.09 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W2_G coincide with peaks and declines in water-level data from nearby wells (3BS1W1_G, 3BS1W3_G, and 3BS1W4_G) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W2_G probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	3.922	4.012
Mean (feet NGVD29)	6.507	6.597
Median (feet NGVD29)	6.589	6.679
Maximum (feet NGVD29)	8.302	8.392
Standard deviation	0.905	0.905
Variance	0.820	0.820
Outliers	0	0
Missing values	0	0

Table 45 Summary statistics of time-series data for Station 22: 3BS1W2_GW

4.23 Station 23: 3BS1W3_GP

3BS1W3_GP is a 15-ft deep well located in Miami-Dade County (figs. 1 and 5). 3BS1W3_GP is one of two wells at the site (3BS1W3), which also includes 3BS1W3_GW.

4.23.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W3_GP	3BS1W3_GP
Station (DBHYDRO)	3BS1W3_G	3BS1W3_G
Source DBKEY	PT041	PT041
MOD1 DBKEY	UD309	UD309
Latitude (NAD83)	25 46 27	25 46 27
Longitude (NAD83)	80 30 34	80 30 34
FL State Planar X Coordinate	817560.13	817560.13
FL State Planar Y Coordinate	523914.98	523914.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	6.2	6.2
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	2.2	2.2
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	13.35	13.45
Strata (feet bls) (DBHYDRO)	15	15
Recorder	CR10	CR10

Table 46 Site information obtained for Station 23: 3BS1W3_GP

Analysis: The reference elevation from the 2007 survey is 0.10 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 7.25 ft above land surface. A photograph (below) confirms the casing height.

The median water level in the well is higher than the land-surface elevation, indicating that the site is inundated most of the time. The photograph shows the site is surrounded by water, which is consistent with a location in WCA3. The site information is consistent, and probably is correct. Overall, the site information from the well is consistent, and probably is accurate. No revisions were necessary.

3BS1W3_G

4.23.2 Data analysis and revision

The period of record analyzed for well 3BS1W3_GP extends from July 23, 2003 through June 30, 2008 (Appendix A). The time-series data for that period contain 1,805 observations with no outliers and 36 missing values. The summary statistics for well 3BS1W3_GP are provided in table 47.

Problem: The time-series data from well 3BS1W3_GP contain 36 missing values, all of which were coded as M.

Analysis: Missing values occurred from January 10 through February 9, 2007, and from June 26 – 30, 2008. The missing values probably resulted from equipment issues. None of the missing values were estimated as part of this project.

Problem: The new reference elevation from the 2007 survey is 0.10 ft higher than the original reference elevation.

Analysis: A correction factor of 0.10 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W3_GP coincide with peaks and declines in water-level data from nearby wells (3BS1W1_GP, 3BS1W2_GP, and 3BS1W4_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W3_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required, other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	4.484	4.584
Mean (feet NGVD29)	6.533	6.633
Median (feet NGVD29)	6.646	6.746
Maximum (feet NGVD29)	8.241	8.341
Standard deviation	0.929	0.929
Variance	0.862	0.862
Outliers	0	0
Missing values	36	36

Table 47 Summary statistics of time-series data for Station 23: 3BS1W3_GP

4.24 Station 24: 3BS1W3_GW

3BS1W3_GW is a 28.5-ft deep well located in Miami-Dade County (figs. 1 and 5). 3BS1W3_GW is one of two wells at the site (3BS1W3), which also includes 3BS1W3_GW.

4.24.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W3_GW	3BS1W3_GW
Station (DBHYDRO)	3BS1W3_G	3BS1W3_G
DBKEY	M6892	M6892
MOD1 DBKEY	UD298	UD298
Latitude (NAD83)	25 46 27	25 46 27
Longitude (NAD83)	80 30 34	80 30 34
FL State Planar X Coordinate	817560.13	817560.13
FL State Planar Y Coordinate	523914.98	523914.98
Land-surface elevation (feet NGVD29) (dm_location)	4.45	4.45
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	6.2	6.2
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	2.2	2.2
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	13.35	13.45
Strata (feet bls) (DBHYDRO)	28.5	28.5
Recorder	CR10	CR10

Table 48 Site information obtained for Station 24: 3BS1W3_GW

Analysis: The reference elevation from the 2007 survey is 0.10 ft higher than the original reference elevation. The difference between the reference and land-surface elevations indicates the casing extends about 7.25 ft above land surface. A photograph (see Station 23: 3BS1W3_GP) confirms the casing height.

The median water level in the well is higher than the land-surface elevation, indicating that the site is inundated most of the time. The photograph shows the site is surrounded by water. The site information is consistent, and probably is correct. Overall, the site information from the well is consistent, and probably is accurate. No revisions were necessary.

4.24.2 Data analysis and revision

The period of record analyzed for well 3BS1W3_GW extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with 1 outlier and 31 missing values. The summary statistics for well 3BS1W3_GW are provided in table 49.

Problem: The time-series data from well 3BS1W3_GW contain 1 outlier.

Analysis: The outlier, which is less than the lower fence, occurred in May 2001 at the end of the dry season. The outlier coincides with similar declines in water levels in nearby wells, such as 3BS1W2_GW, and, therefore, probably is a valid data point.

Problem: The time-series data from well 3BS1W3_GP contain 31 missing values, all of which are coded as M.

Analysis: Missing values occurred from January 10 through February 9, 2007. 3BS1W3_GP also was missing values during these same dates, so the missing values probably resulted from equipment issues. None of the missing values were estimated as part of this project.

Problem: The new reference elevation from the 2007 survey is 0.10 ft higher than the original reference elevation.

Analysis: A correction factor of 0.10 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W3_GW coincide with peaks and declines in water-level data from nearby wells (3BS1W1_GW, 3BS1W2_GW, and 3BS1W4_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W3_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required other than applying the correction factor.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	3.957	4.057
Mean (feet NGVD29)	6.518	6.618
Median (feet NGVD29)	6.612	6.712
Maximum (feet NGVD29)	8.318	8.418
Standard deviation	0.899	0.899
Variance	0.808	0.808
Outliers	1	1
Missing values	31	31

Table 49 Summary statistics of time-series data for Station 24: 3BS1W3_GW

4.25 Station 25: 3BS1W4_GP

3BS1W4_GP is a 14-ft deep well located in Miami-Dade County (figs. 1 and 5).3BS1W4_GP is one of two wells at the site (3BS1W4), which also includes 3BS1W4_GW.

4.25.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W4_GP	3BS1W4_GP
Station (DBHYDRO)	3BS1W4_G	3BS1W4_G
Source DBKEY	PT042	PT042
MOD1 DBKEY	UD310	UD310
Latitude (NAD83)	25 46 44	25 46 44
Longitude (NAD83)	80 30 35	80 30 35
FL State Planar X Coordinate	817461.52	817461.52
FL State Planar Y Coordinate	525677.48	525677.48
Land-surface elevation (feet NGVD29) (dm_location)	9.9	9.9
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.1	10.1
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	8.9	8.9
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	13.73	13.84
Strata (feet bls) (DBHYDRO)	14	14
Recorder	CR10	CR10

Table 50 Site information obtained for Station 25: 3BS1W4_GP

Analysis: The reference elevation from the 2007 survey is 0.11 ft higher than the original survey. The difference between the reference and land-surface elevations indicates the casing extends about 3.7 ft above land surface. A photograph (below) confirms the casing height. The maximum was level is less than the land-surface

elevation, indicating that the site is rarely inundated with water. Rare or occasional inundation is consistent with its location on a tree island. Overall, the site information for the well is consistent, and probably is accurate. No revisions were necessary.

Site 3BS1W4_G

4.25.2 Data analysis and revision

The period of record analyzed for well 3BS1W4_GP extends from July 25, 2003 through June 30, 2008 (Appendix A). The time-series data for that period contain 1,803 observations with no outliers and 30 missing values, all of which were estimated as part of the previous QA/QC project. The summary statistics for well 3BS1W4_GP are provided in table 51.

Problem: The new reference elevation from the 2007 survey is 0.11 ft higher than the original reference elevation.

Analysis: A correction factor of 0.11 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W4_GP coincide with peaks and declines in water-level data from nearby wells (3BS1W1_GP, 3BS1W2_GP, and 3BS1W3_GP) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W4_GP probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	4.596	4.706
Mean (feet NGVD29)	6.562	6.694
Median (feet NGVD29)	6.634	6.767
Maximum (feet NGVD29)	8.458	8.568
Standard deviation	0.916	0.924
Variance	0.838	0.854
Outliers	0	0
Missing values	30	0

Table 51 Summary statistics of time-series data for Station 25: 3BS1W4_GP

4.26 Station 26: 3BS1W4_GW

3BS1W4_GW is a 34-ft deep well located in Miami-Dade County (figs. 1 and 5).3BS1W4_GW is one of two wells at the site (3BS1W4), which also includes 3BS1W4_GP.

4.26.1 Site and data description

Variable	Original value	Revised value
Station	3BS1W4_GW	3BS1W4_GW
Station (DBHYDRO)	3BS1W4_G	3BS1W4_G
Source DBKEY	M6893	M6893
MOD1 DBKEY	UD297	UD297
Latitude (NAD83)	25 46 44	25 46 44
Longitude (NAD83)	80 30 35	80 30 35
FL State Planar X Coordinate	817461.52	817461.52
FL State Planar Y Coordinate	525677.48	525677.48
Land-surface elevation (feet NGVD29) (dm_location)	9.9	9.9
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	10.1	10.1
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	8.9	8.9
Reference elevation (feet NGVD29) (recorder registration and 2007 survey)	13.725	13.84
Strata (feet bls) (DBHYDRO)	34	34
Recorder	CR10	CR10

Table 52 Site information obtained for Station 26: 3BS1W4_GW

Analysis: The reference elevation from the 2007 survey is 0.095 ft higher than the original survey. The difference between the reference and land-surface elevations indicates the casing extends about 3.7 ft above land surface. A photograph (see Station 26: 3BS1W4_GP) confirms the casing height. The maximum was level is less than the

land-surface elevation, indicating that the site is rarely inundated with water. Occasional or rare inundation is consistent with the well's location on a tree island. Overall, the site information for the well is consistent, and probably is accurate. No revisions were necessary.

4.26.2 Data analysis and revision

The period of record analyzed for well 3BS1W4_GW extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with 3 outliers and 51 missing values, all of which were estimated as part of the previous QA/QC project. The summary statistics for well 3BS1W4_GW are provided in table 53.

Problem: The time-series data from well 3BS1W4_GW contain 3 outliers, all of which were less than the lower fence.

Analysis: The outliers occurred in May 2001, at the end of the dry season, and closely coincide with similar declines in nearby wells, such as 3BS1W1_GW. The outliers probably are valid data that accurately represent hydrologic conditions at the site.

Problem: The new reference elevation from the 2007 survey is 0.095 ft higher than the original reference elevation.

Analysis: A correction factor of 0.095 ft was added to the time-series data from this station.

Summary: The peaks and declines in water-level data from well 3BS1W4_GW coincide with peaks and declines in water-level data from nearby wells (3BS1W1_GW, 3BS1W2_GW, and 3BS1W3_GW) drilled to similar depths (Appendix A). In addition, water levels in the target well decline as expected during periods of low rainfall, and increase as expected during periods of excessive rainfall recorded by nearby rain gages. The time-series data from well 3BS1W4_GW probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required other than applying the correction factor to the time-series data.

Statistics	Original series	Revised series
Minimum (feet NGVD29)	3.995	4.090
Mean (feet NGVD29)	6.550	6.663
Median (feet NGVD29)	6.633	6.741
Maximum (feet NGVD29)	8.299	8.394
Standard deviation	0.874	0.877
Variance	0.764	0.770
Outliers	3	3
Missing values	51	0

Table 53 Summary statistics of time-series data for Station 26: 3BS1W4_GW

4.27 Station 27: 3AS3W3_R

3AS3W3_R is a rain station located at the same location as well 3AS3W3_GP and 3AS3W3_GW (figs. 1 and 4). The site information for this station is consistent with the site information for the two wells, and, therefore, probably is correct.

4.27.1 Site and data description

Variable	Original value	Revised value
Station	3AS3W3_R	3AS3W3_R
Station (DBHYDRO)	3AS3W3_R	3AS3W3_R
Source DBKEY	M6888	M6888
MOD1 DBKEY		
Latitude (NAD83)	25 51 12	25 51 12
Longitude (NAD83)	80 46 09	80 46 09
FL State Planar X Coordinate	732097.391	732097.391
FL State Planar Y Coordinate	552418.016	552418.016
Land (muck)-surface elevation (feet NGVD29) (2007 survey)	8.9	8.9
Land (rock)-surface elevation (feet NGVD29) (2007 survey)	3.3	3.3
Recorder	CR10	CR10

Table 54 Site information obtained for Station 27: 3AS3W3_R

4.27.2 Data analysis and revision

The period of record analyzed for station 3AS3W3_R extends from May 9, 2000 through June 30, 2008 (Appendix A). The time-series data for that period contain 2,975 observations with 587 outliers and 100 missing values. The summary statistics for station 3AS3W3_R are provided in table 55.

Problem: The time-series data contain 587 outliers.

Analysis: The median value for the time-series data is 0, which indicates that no precipitation occurred during at least half the period of record. Therefore, days with even

slight precipitation (greater than 0.07 inch) are statistical outliers, but valid data. Daily precipitation of 1 inch or more occurred on 112 days. These excessive rainfalls were recorded at one to three nearby stations (3A-SW_R, S12D_R, and S140W) on 82 (73 percent) of those days, indicating that the data from 3AS3W3_R closely coincide with nearby stations.

Problem: The time-series data from station 3AS3W3_R contain 100 missing values.

Analysis: Missing values occurred from October 4 – 30, 2000, July 26 and 27, 2001, July 2 – 13, 2002, June 20 – 22 and July 5 and 6, 2004, September 10 – 14, 2004, and December 23, 2006 through February 9, 2007. These gaps probably result from equipment issues. Wells 3AS3W3_GP and 3AS3W3_GW also were missing values from December 23, 2006 through February 9, 2007, which could indicate a problem with the data logger or power source. None of the missing values were estimated as part of this project.

Summary: The precipitation recorded at 3AS3W3_R coincides with precipitation data from nearby wells (3A-SW_R, S12D_R, and S140W), particularly with excessive rainfall of 1 inch or more (Appendix A). In addition, periods of low rainfall also coincide with dry periods recorded at nearby stations. The time-series data from 3AS3W3_R probably are valid data that accurately represent hydrologic conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (inches)	0.000	0.000
Mean (inches)	0.131	0.131
Median (inches)	0.000	0.000
Maximum (inches)	3.720	3.720
Standard deviation	0.389	0.389
Variance	0.151	0.151
Outliers	587	587
Missing values	100	100

Table 55 Summary statistics of time-series data for Station 27: 3AS3W3_R

4.28 Station 28: 3AS3WX

3AS3WX is a weather station operated at the 3AS3 Tree Island (figs. 1 and 4). Data collected there include minimum, maximum, and means for air temperature, barometric pressure, evapotranspiration potential (ETP), humidity, solar radiation, rainfall, and wind speed and wind gusts. Most of the data collection began in April 2000, with the exception of rainfall, which began on October 1, 2007. A preferred data set exists for the ETP data, which does not need to be reviewed as part of this project. However, none of the other weather data have been previously submitted to extensive QA/QC. For this project, the mean daily values of air temperature, barometric pressure, humidity, and wind speed were reviewed for quality control. The rainfall data from this station were not reviewed because of the brief period of record and the availability of data from 3AS3W3_R.

4.28.1 Site and data description

Variable	Original value	Revised value
Station	3AS3WX	3AS3WX
Latitude (NAD83)	25 51 06	25 51 06
Longitude (NAD83)	80 45 59	80 45 59
FL State Planar X Coordinate	733034.259	733034.259
FL State Planar Y Coordinate	551868.573	551868.573
Air Temperature DBKEY	LA373	LA373
Barometric pressure DBKEY	LA374	LA374
ETP DBKEY (PREF)	OH515	OH515
Humidity DBKEY	LA372	LA372
Photosynthetic radiation DBKEY	LA368	LA368
Wind Speed DBKEY	LA364	LA364
Recorder	CR10	CR10

Table 56 Site information obtained for Station 28: 3AS3WX

Analysis: The site information is consistent with other stations at 3AS3. Therefore, the location of the weather station probably is correct, and no revisions are necessary.

4.28.2 Air Temperature (LA373)

The period of record analyzed for air temperature from station 3AS3WX extends from April 4, 2000 through June 30, 2008 (Appendix A). The time-series data contain 3,010 observations with 58 outliers and 523 missing values. All four sets of time-series data contain large periods of missing values extending from October 25, 2005 through March 4, 2007. A shorter period of missing values also occurred from October 5 – 31, 2000 in all four DBKEYs. The missing values were not estimated as part of this project. The summary statistics for air temperature from station 3AS3WX are provided in table 57.

Problem: The air-temperature data from 3AS3WX contain 58 outliers, all of which are less than the lower fence.

Analysis: The outliers generally occurred from late December through early February of each year of record. These outliers are consistent with low air temperature values recorded at two nearby stations. For example, the minimum air temperature from 3AS3WX of 7.25 degrees Celsius (^{o} C) was recorded on January 24, 2003. The two nearby stations S140W and S331W recorded 6.08 and 8.18^{o} C on that same date. Therefore, the outliers probably are valid data that accurately represent conditions at the site.

Summary: The peaks and declines in air-temperature data from 3AS3WX closely coincide with peaks and declines in air-temperature data from nearby stations (S140W and S331W) (Appendix A). In addition, the data indicate the air temperatures peak in summer and decline in late fall and early winter as expected. The air temperature data

from 3AS3WX appear to be valid data that accurately represent conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (^{o}C)	7.250	7.250
Mean (^{o}C)	23.885	23.885
Median (^{o}C)	24.649	24.649
Maximum (^{o}C)	30.051	30.051
Standard deviation	3.966	3.966
Variance	15.731	15.731
Outliers	58	58
Missing values	523	523

Table 57 Summary statistics for air-temperature data from Station 28: 3AS3WX

4.28.3 Barometric Pressure (LA374)

The period of record analyzed for barometric (air) pressure from station 3AS3WX extends from April 4, 2000 through June 30, 2008 (Appendix A). The time-series data contain 3,010 observations with 50 outliers and 523 missing values. As with air temperature, missing values occurred from October 25, 2005 through March 4, 2007, and from October 5 – 31, 2000. The missing values were not estimated as part of this project. The summary statistics for barometric pressure from station 3AS3WX are provided in table 58.

Problem: The barometric-pressure data from 3AS3WX contain 50 outliers.

Analysis: A total of 25 outliers were less than the lower fence of 756.12 and 25 outliers exceeded the upper fence of 769.5 millimeters (mm). The lower and upper outliers coincide with low and high values recorded by two nearby stations. For example, the maximum value of 773.77 mm occurred on January 3, 2008. Data from stations S140W and S331W also show barometric pressures exceeded 773 mm on that date. The minimum value of 747.83 recorded on October 24, 2005 coincides with values of 746.54 and 746.04 mm, respectively, at stations S140W and S331W. In addition, these low barometric pressures coincide with heavy rainfalls that occurred on that date. 3AS3W3_R, 3A-SW_R, and S140W recorded rainfalls of 1.86, 2.72, and 4.98 inches of rain, respectively, on October 24, 2005. Barometric pressures less than 750 mm also occurred on September 5 and 26, 2004. Precipitation on those two dates also exceeded 1 inch at one or more rain stations. The outliers probably are valid data that accurately represent conditions at the site.

Summary: The peaks and declines in barometric-pressure data from 3AS3WX closely coincide with peaks and declines in barometric-pressure data from nearby stations (S140W and S331W) (Appendix A). In addition, low barometric pressures coincide with heavy rainfalls. The barometric-pressure data from 3AS3WX appear to be valid data that accurately represent conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (mm)	747.833	747.833
Mean (mm)	762.794	762.794
Median (mm)	762.766	762.766
Maximum (mm)	773.770	773.770
Standard deviation	2.713	2.713
Variance	7.361	7.361
Outliers	50	50
Missing values	523	523

Table 58 Summary statistics for barometric-pressure data from Station 28: 3AS3WX

4.28.4 Humidity (LA372)

The period of record analyzed for humidity from station 3AS3WX extends from April 4, 2000 through June 30, 2008 (Appendix A). The time-series data contain 3,010 observations with 39 outliers and 528 missing values. As with air temperature, missing values occurred from October 25, 2005 through March 4, 2007, and from October 5 – 31, 2000. The missing values were not estimated as part of this project. The summary statistics for humidity from station 3AS3WX are provided in table 59.

Problem: The humidity data from 3AS3WX contain 39 outliers.

Analysis: A total of 31 outliers were less than the lower fence of 60.26 percent and 8 outliers exceeded the upper fence of 94.41 percent. The lower and upper outliers coincide with low and high values recorded by two nearby stations. For example, the maximum value of 95.45 percent occurred on April 14, 2000. Data from stations S140W and S331W also show humidity exceeded 95 percent on that date. The minimum value of 48.84 recorded on January 2, 2008 coincides with values of 46.29 and 49.07 percent, respectively, at stations S140W and S331W. The outliers probably are valid data that accurately represent conditions at the site.

Summary: The peaks and declines in humidity data from 3AS3WX closely coincide with peaks and declines in humidity data from nearby stations (S140W and S331W) (Appendix A). The humidity data from 3AS3WX appear to be valid data that accurately represent conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (percent)	48.842	48.842
Mean (percent)	76.210	76.210
Median (percent)	76.415	76.415
Maximum (percent)	95.465	95.465
Standard deviation	6.249	6.249
Variance	39.051	39.051
Outliers	39	39
Missing values	528	528

Table 59 Summary statistics for humidity data from Station 28: 3AS3WX

4.28.5 Wind Speed (LA364)

The period of record analyzed for wind speed from station 3AS3WX extends from April 4, 2000 through June 30, 2008 (Appendix A). The time-series data contain 3,010 observations with 53 outliers and 529 missing values. As with air temperature, missing values occurred from October 25, 2005 through March 4, 2007, and from October 5 – 31, 2000. The missing values were not estimated as part of this project. The summary statistics for wind speed from station 3AS3WX are provided in table 60.

Problem: The wind-speed data from 3AS3WX contain 53 outliers, all of which exceeded the upper fence of 14.9 miles per hour (mph).

Analysis: The wind-speed data from 3AS3WX is strongly correlated to data from nearby sites such as S331W (R^2=0.80; fig. 7). However, the wind speed is consistently higher at 3AS3WX compared to wind speed at S331W. The difference probably results different equipment or different conditions at the two sites. The outliers probably are valid data that accurately represent conditions at the site.

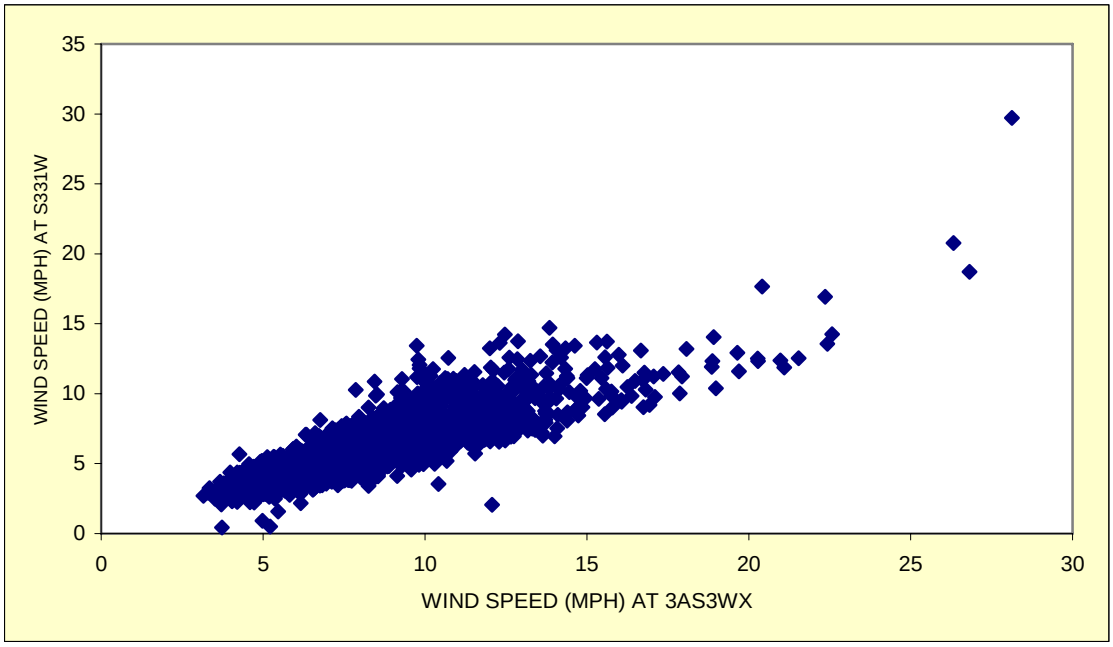


Figure 7 Wind speed at target station 3AS3WX plotted against wind speed from nearby station S331W.

Summary: The wind-speed data from 3AS3WX strongly correlated with wind-speed data from nearby stations (S140W and S331W) (Appendix A). The wind-speed data from 3AS3WX appear to be valid data that accurately represent conditions at the site. No revisions were required.

Statistics	Original series	Revised series
Minimum (mph)	3.151	3.151
Mean (mph)	7.939	7.939
Median (mph)	7.451	7.451
Maximum (mph)	28.128	28.128
Standard deviation	2.843	2.843
Variance	8.082	8.082
Outliers	53	53
Missing values	529	529

Table 60 Summary statistics for wind-speed data from Station 28: 3AS3WX

5 SUMMARY

Tree islands are tear-shaped topographic features in the relatively flat, low-lying landscape of southern Florida. Tree islands are only slightly (a few feet) elevated above the surrounding wetland, but are an important habitat for plants and animals. Tree islands are sensitive to changes in their hydrologic conditions; hence, a better understanding of the factors affecting the hydrology of tree islands is needed in the efforts to protect and restore the Everglades.

In 2000, the South Florida Water Management (SFWMD) began monitoring groundwater and surface-water levels, respectively, at three tree islands (designated 3AN1, 3AS3, and 3BS1) in Water Conservation Area 3 to better understand the unique hydrologic and ecologic conditions of the sites. A total of four well pairs were installed at each of the three tree islands. Well pairs, consisting of a shallow piezometer (depths from 4.1 to 15 ft below land surface) and a deep groundwater well (depths from 25 – 49.6 ft below land surface), were installed just northwest, northeast, and south of each island. A well pair also was installed within each island. A stilling well was installed at one well pair at each of the three islands to monitor surface-water stage. A meteorological station also was established at tree island 3AS3.

This two-volume report summarizes the results of a data-analysis project conducted in 2008 by staff at Adamski Geological Consulting, LLC. The project consisted of three components, the first of which was to assess the quality assurance of the site information and time-series data. The second component included analysis of seasonal fluctuations in groundwater and surface-water levels, and determination of factors affecting water levels. Finally, the third component was an analysis of the vertical and horizontal flow of groundwater at each of the tree islands. Results of component 1 are published in volume 1 (this report), and results of components 2 and 3 are published in volume 2.

The site and time-series data from the 23 wells, 3 stilling wells, and 1 meteorological station were reviewed for quality assurance. The location, depth, and construction information were thoroughly reviewed during this project and during two previous groundwater quality-assurance projects conducted in 2006 and 2007. In general, the site information for the wells appeared to be accurate; however, new ground-elevation surveys of the three tree islands were conducted in 2007 (Keith and Schnars, 2007). As a result, the reference elevations (elevation of the measuring point at the top of the well casing) and land-surface elevations were revised for 25 of the 26 stations.

The time-series data (groundwater level, surface-water stage, and selected meteorological data) were reviewed for accuracy according to SFWMD protocols. All analyses were conducted using daily values. The objective of this part of the project was to produce sets of preferred time-series data for use by SFWMD scientists and engineers, consultants, and the general public. The review included analyzing the data for outliers, anomalies, and missing values.

The groundwater and surface-water data from each station at 3AN1 contained up to 47 outliers. However, the local minimum and maximum values were consistent with precipitation data and water-level data from nearby wells drilled to similar depths. The data, therefore, were considered accurate. The time-series data from three wells and the stilling well at 3AN1 were missing up to 204 values, most of which were estimated as part of the previous quality-assurance projects. Data from the stilling well were not previously reviewed, and missing data were not estimated. In addition, the time-series data from the stilling well had 61 anomalous data values that resulted from surface-water levels declining below the bottom of the well. The anomalous data were deleted from the preferred set of time-series data and coded as M.

The time-series data from wells and the stilling well at 3AS3 contained no outliers or anomalous data; however, data from six wells contained missing values. The number of missing values per station ranged from 26 to 86, with up to 41 values estimated as part of the previous quality-assurance projects.

The time-series data from the wells and still well at 3BS1 contained 0 – 3 outliers, all of which were consistent with precipitation data and water-level data from nearby stations. The time-series data from five of the wells contained missing values. The number of missing values per stations ranged from 30 to 70. Missing values from three of the wells were estimated as part of the previous quality-assurance projects. None of the time-series data from stations at 3BS1 contained anomalous data.

Finally, the groundwater and surface-water data from the three tree islands were corrected based on the new reference elevations. A correction factor was determined by subtracting the new reference elevation from the old reference elevation. The correction factor was then applied to the time-series data in the new preferred data sets.

Selected meteorological data [air temperature, barometric pressure, humidity, precipitation (rainfall), and wind speed] also were briefly reviewed for accuracy. As with the groundwater and surface-water level data, all analyses were conducted using daily values. The meteorological data generally were accurate and consistent with expected seasonal fluctuations. The rainfall data also were relatively consistent with rainfall data from nearby stations. However, the number of missing values was large. Rainfall data were missing 100 values, whereas air temperature, barometric pressure, humidity, and wind speed were each missing more than 520 values. None of the missing values were estimated as part of this project.

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Data Reduction and Analysis of Hydrologic Data for Selected Tree Islands (3AN1, 3AS3, and 3BS1) Volume 2—Water-Level Data Analysis

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1 INTRODUCTION

Tree islands are topographically elevated, typically tear-shaped features with their long axis oriented parallel to surface-water flow. The islands consist of tall trees, shrubs, and saw grass, and "provide habitat for a wide variety of terrestrial plants and animals" (Bevier and Krupa, 2001). Tree islands, which are very sensitive to changes in hydrologic conditions and extreme wet and dry periods, are considered indicators of the overall ecological health of the Everglades system. Hence, information collected from tree islands will be crucial to better understanding the hydrologic conditions in the Everglades.

In 2000, South Florida Water Management District began monitoring meteorological data and groundwater and surface-water levels at selected tree islands as part of a 5-year, multidisciplinary study conducted in cooperation with the Florida Fish and Wildlife Conservation Commission, the Florida Center for Environmental Studies, the U.S. Geological Survey, and several universities. The three selected tree islands—3AN1, 3AS3, and 3BS1—are all located in Water Conservation Area 3 (fig. 1). Previous reports have documented the construction of wells and stilling wells at the tree islands (Bevier and Krupa, 2001) and summarized the results of a preliminary assessment of groundwater-surface-water interactions (Krupa and Gefvert, 2006; Steve Krupa, SFWMD, written commun., 2008). However, a compilation report is needed to assess the quality of the data collected, and to analyze factors affecting groundwater levels and flow. This two-volume report summarizes the results of a quality-assurance and data-analysis project conducted on site information and time-series data collected from May 2000 through June 2008.

1.1 Objectives

The objective of this contract (Purchase Order 4500026695) is to obtain professional consulting services for quality assurance and analysis of hydrometeorological data at three tree island sites (3AN1, 3AS3, and 3BS1) in the Everglades (fig. 1). The objectives of the project are as follows:

1. Generate sets of high-quality site information and time-series data collected from monitoring stations at 3AN1, 3AS3, and 3BS1
2. Analyze seasonal, meteorological, and other factors that affect groundwater and surface-water levels at the three tree islands
3. Determine horizontal and vertical groundwater flow at the three tree islands

Volume 1 of this report contains the summary of the quality-assurance review and revisions of the data (objective 1). Volume 2 contains an analysis of the factors affecting surface-water and ground-water levels at the three tree islands (objectives 2 and 3).

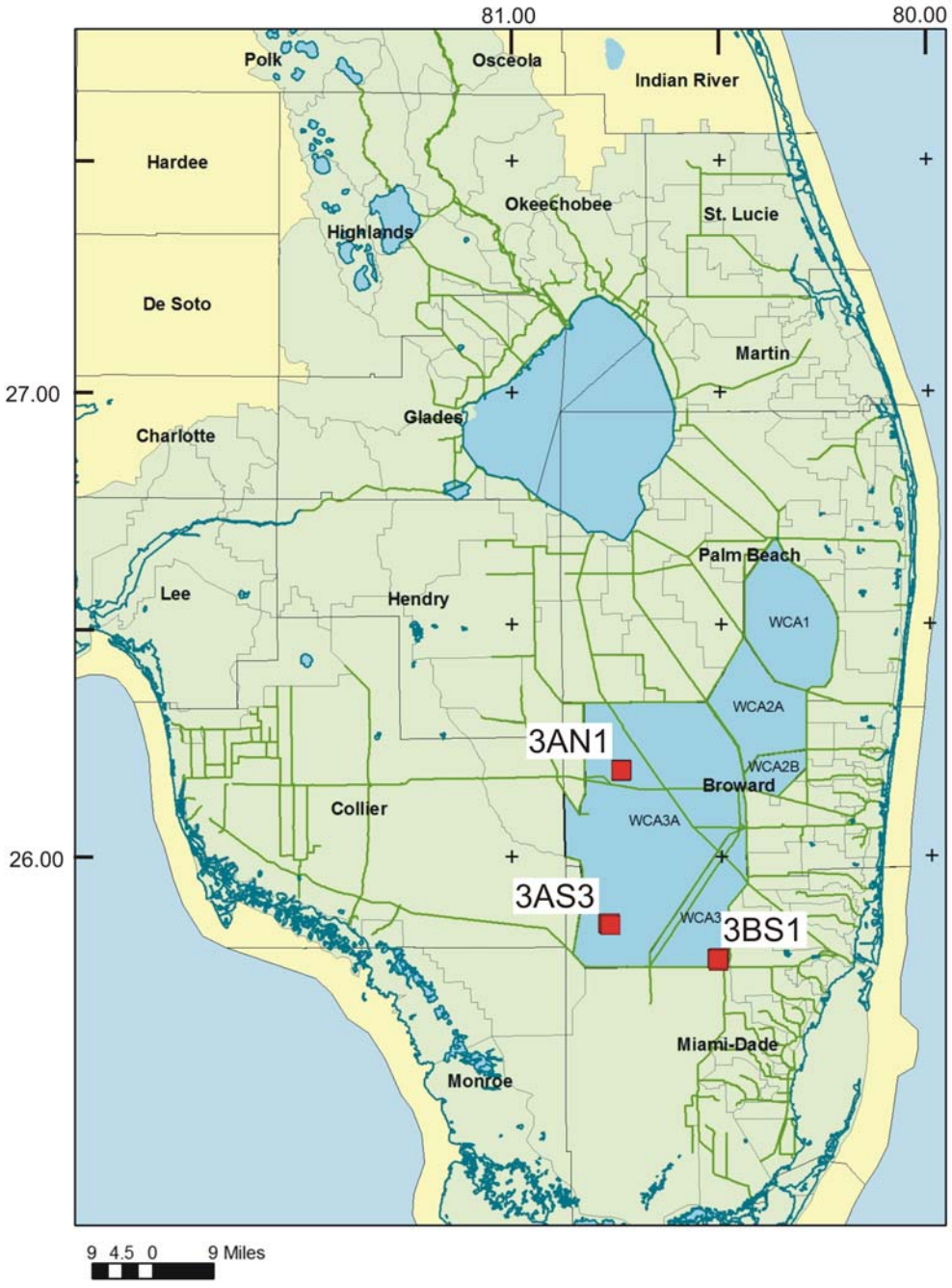

Figure 1 Location of the three tree islands

1.2 Scope of Work

The overall scope of work for the project is to conduct quality assurance/quality control assessment of site information and time-series data for 23 wells, 3 stilling wells, and 1 weather station used to monitor ground-water levels, surface-water stage, and various meteorological data. The hydrologic conditions, seasonal fluctuations, and factors affecting ground- and surface-water levels also were analyzed. The work was conducted off-site by staff at Adamski Geological Consulting, LLC (AGC). The project includes the following components:

Component 1 Quality-assurance and quality-control analyses were conducted on site information and time-series data collected at the three tree islands. The site location, construction information, and time-series data through December 31, 2006, were previously reviewed as part of a 2-year project for Taiye Sangoyomi, PE (SFWMD). However, a new survey of the stations was conducted in September 2007, which resulted in slight adjustments to the reference and land-surface elevations at most of the stations. Time-series data collected at the stations were adjusted using correction factors to account for the new reference elevations. In addition, data from the three stilling wells and meteorological station had not been previously reviewed, but were extensively analyzed as part of this project. All QA/QC analysis closely followed methods outlined in standard operating procedures (SOPs) of the SFWMD (Sangoyomi and others, 2005; Sangoyomi and others, 2006; Sangoyomi and Lambright, 2006).

Component 2 The seasonal fluctuations in ground-water level and surface-water stage at the three islands were identified. The dates on which maximum and minimum water levels occurred were documented for analysis in component 3. Data were analyzed for the effects of weather and operation of structures on fluctuations of ground-water levels and stage.

Component 3 The vertical and horizontal movement of water at the three tree islands was mapped and analyzed. The maps and analysis were done using extreme data (periods of water level minimums and maximums) and average data. The results were documented in this report.

The purpose of this report is to summarize work conducted by AGC on the project and document the results. During this period, site information and time-series data from 23 monitoring wells, 3 surface-water stations, and 1 meteorological station (henceforth, known as target stations) were reviewed and revised for quality assurance and quality control. The revised data are submitted with volume 1 of this report for approval and uploading into DBHYDRO. The purpose of this report also is to summarize results of statistical and other analyses conducted on the time-series data to determine groundwater flow and factors affecting groundwater and surface water levels.

1.3 Data Sources

The site information and time-series data for all 27 stations were collected by SFWMD and stored in the DBHYDRO database. The data from the target stations used for analysis during this project were downloaded directly from DBHYDRO (Table 1).

Station number from SOW	*Station name*	*Source DBKEY*	*Agency*	*Strata (feet)*	*MOD1 DBKEY*
1	3AN1W1_GP	OH532	WMD	14.5	UD202
2	3AN1W1_GW	OH531	WMD	32.9	UD201
3	3AN1W1_H	OH538	WMD	0	
4	3AN1W2_GP	OH534	WMD	15	UD200
5	3AN1W2_GW	OH533	WMD	49.6	UD199
6	3AN1W3_GP	OH536	WMD	14.5	UD204
7	3AN1W3_GW	OH535	WMD	31.7	UD205
8	3AN1W4_GP	OH537	WMD	4.1	UD203
9	3AS3W1_GP	PT035	WMD	8.7	UD311
10	3AS3W1_GW	M6884	WMD	26.4	UD300
11	3AS3W1_H	M6883	WMD	0	
12	3AS3W2_GP	PT036	WMD	8.5	UD361
13	3AS3W2_GW	M6885	WMD	25	UD360
14	3AS3W3_GP	PT037	WMD	8.5	UD312
15	3AS3W3_GW	M6887	WMD	28.6	UD301
16	3AS3W4_GP	PT038	WMD	10.7	UD313
17	3AS3W4_GW	M6886	WMD	30	UD299
18	3BS1W1_GP	PT039	WMD	15	UD307
19	3BS1W1_GW	M6890	WMD	34	UD295
20	3BS1W1_H	M6889	WMD	0	
21	3BS1W2_GP	PT040	WMD	13.5	UD308
22	3BS1W2_GW	M6891	WMD	30	UD296
23	3BS1W3_GP	PT041	WMD	15	UD309
24	3BS1W3_GW	M6892	WMD	28.5	UD298
25	3BS1W4_GP	PT042	WMD	14	UD310
26	3BS1W4_GW	M6893	WMD	34	UD297
27	3AS3W3_R	M6888	WMD		
28	3AS3WX	LA373	WMD		
29	3AS3WX	LA374	WMD		
30	3AS3WX	LA372	WMD		
31	3AS3WX	LA364	WMD		

Table 1 Site information for target wells, stilling wells, and weather station. [WMD, South Florida Water Management District]

2 METHODS

In late 1999, SFWMD began drilling and installing monitor wells at selected tree islands. Four sets of dual-zone monitor wells were installed at each of the tree islands for continual monitoring of groundwater levels. Dual-zone wells were installed northwest, northeast, and south of each tree island, with a final set of wells located within the tree island. The resulting four sets of wells at each island are identified as W1, W2, W3, and W4, respectively (figs. 2 through 4). With one exception (3AN1W4), each dual-zone site contains a shallow (depths range from 4.1 to 15 ft) ¾-inch diameter piezometer and a deeper (depths range from 26.4 to 49.6 ft) 2-inch diameter well installed in the same borehole. A detailed description of well construction and data-collection activities is provided in Bevier and Krupa (2001).

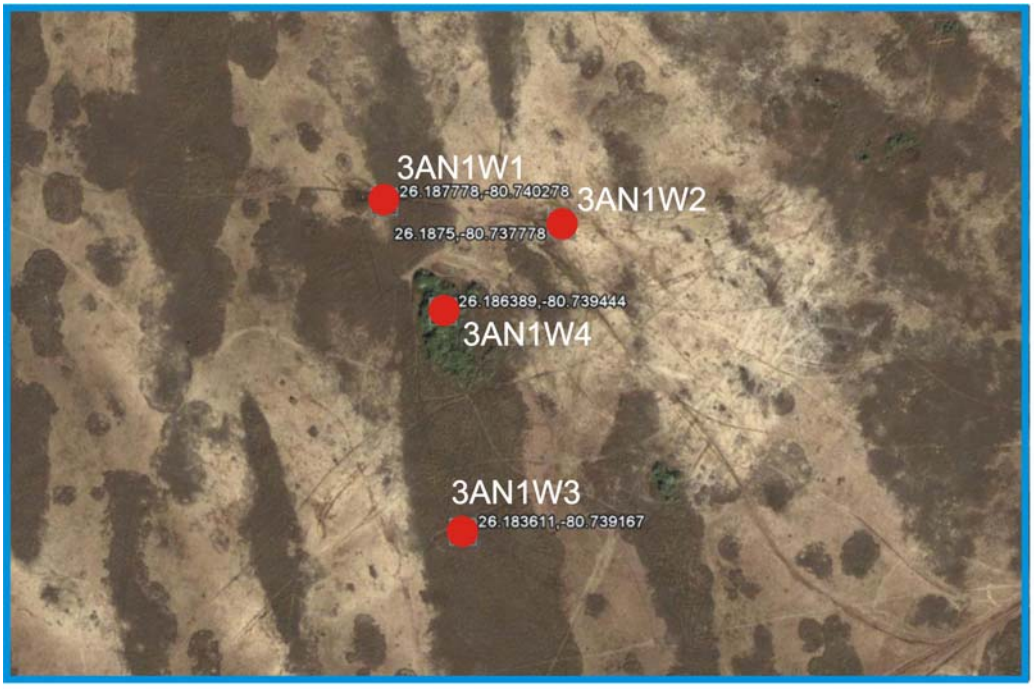

Figure 2 Location of target stations at Tree Island Site 3AN1.

Figure 3 Location of target stations at Tree Island 3AS3.

Figure 4 Location of target stations at Tree Island 3BS1.

In addition, W1 sites at each tree island also have an adjacent stilling well to monitor surface-water stage. Finally, a weather station for monitoring air temperature, barometric pressure, evapotranspiration, humidity, solar radiation, and wind speed was installed at 3AS3. A preliminary assessment of water-level and water-quality data from the tree islands is discussed in Krupa and Gefvert (2006). An in-depth quality-assurance assessment of the site and time-series data is discussed in volume 1 of this report.

Time-series (water level) data were collected continually (15-min increments) at all wells and stilling wells using pressure transducers and data loggers. The data analyzed as part of this project were daily averages of the incremental data. All of the stations were recently surveyed to accurately determine the elevation of the land surface, top of rock, and top of well casing at each site (Keith and Schnars, PA, 2007). Correction factors were applied to the daily-average data to account for elevation changes from the 2007 surveys.

Location coordinates, well depth, and time-series data for the 27 stations were downloaded from DBHYDRO. Other site information, such as reference and land-surface elevations and well depths, were previously obtained and (or) verified from survey reports and recorder registration worksheets.

The site information and time-series data were analyzed for quality assurance according to SFWMD protocols (Sangoyomi and others, 2005; Sangoyomi and others, 2006; Sangoyomi and Lambright, 2006). Volume 1 of this report contains a description of the methods as well as the results of that analysis.

Statistical methods, such as descriptive statistics and correlations, were used to describe the distribution of the time-series data, and determine relations among the variables. The non-parametric Wilcoxon rank-sum also was used to statistically analyze for differences between median values of two groups. An existing regression model (Cindy Bevier, SFWMD, written commun., 2008) was used to analyze the direction and flow of groundwater at the three tree islands. The model was run with and without data from the wells on the islands (W4 sites), but results from both analyses were similar. In general, the results discussed in this report are from the model run without the W4 wells. Results of the analyses were illustrated using hydrographs, scatter plots, and box plots. An example box plot is shown in figure 2.

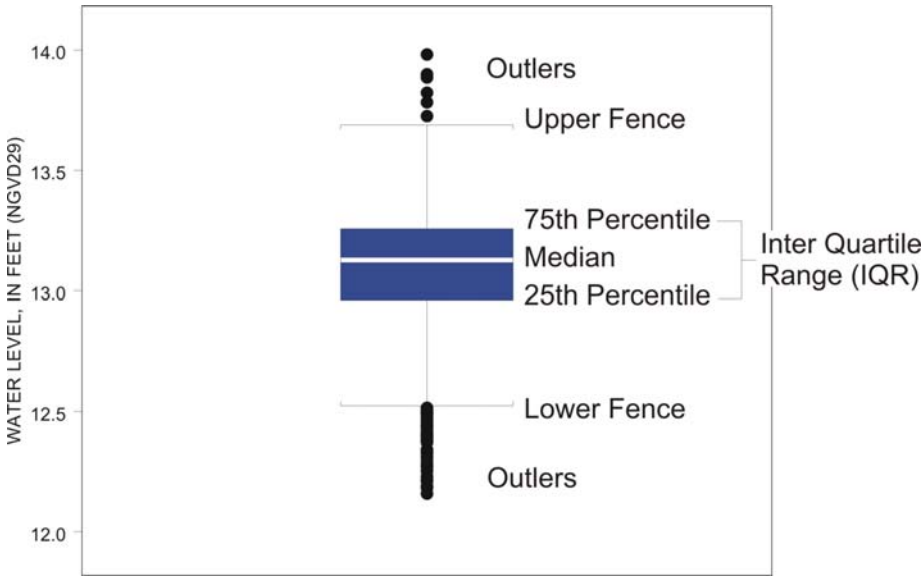

Figure 5 Sample box plot showing lower (Q1) and upper (Q3) quartiles, inter quartile range, and outliers.

Horizontal and vertical groundwater flow was analyzed using a series of maps and cross sections for each tree island. Six water-level maps were generated for each of the three tree islands (appendix) to illustrate horizontal groundwater flow during two dry periods, two wet periods, and two periods with average conditions. Average conditions for analysis were determined by selecting dates on which the water level in the deep well at the W1 site (for example, 3AS3W1_GW) was equal to the median value for that well. Cross sections were generated to show vertical and horizontal groundwater flow during one dry season and one wet season for each well. Vertical groundwater flow over time also was determined by subtracting the value of water level in the deep well from the water level in the adjacent piezometer or stilling well on the same date. A positive value indicates downward migration or recharge of groundwater, whereas a negative value indicates upward migration or discharge of groundwater.

Well depths (Strata variable in DBHYDRO) are listed as feet below land surface (bls), unless otherwise noted. Water-level data, and reference and land-surface elevations are listed as feet above mean sea level, and are based on the National Geodetic Vertical Datum of 1929 (NGVD29). Horizontal locations are based on North American Datum of 1983 (NAD83) and Florida State Plane coordinates.

3 ENVIRONMENTAL AND HYDROGEOLOGIC SETTING

Southern Florida is a topographically flat region, with land-surface elevations ranging from near sea level to a few tens of feet above sea level. Land-surface elevations at the three island sites range from 5.4 ft above NGVD29 at 3BS1W1 to 11.8 ft above NGVD29 at 3AN1W4 (table 2). The islands themselves are only slightly elevated above

the surrounding land. Topographic relief—the difference between maximum and minimum elevations—at each island ranges from 1.7 ft at 3AN1 to 4.7 ft at 3BS1.

As noted earlier, tree islands are topographically elevated, typically tear-shaped features located within wetland systems of southern Florida (figs. 1 through 4). The tree islands generally are oriented their long axis parallel to surface-water flow (Bevier and Krupa, 2001). Tree islands, which are very sensitive to changes in hydrologic conditions and extreme wet and dry periods, are considered indicators of the overall ecological health of the Everglades system.

The islands coincide with, and possibly result from, structural highs in the underlying limestone. Table 2 shows the elevation of the top of the limestone at the four well sites at each of the three tree islands. A layer of organic matter (muck, soil, and leaf litter), ranging from 0.3 to 5.6 ft thick (table 2), overlies the limestone.

Well Site	Land-surface elevation (top of muck; ft above NGVD29)	Elevation of top of limestone rock (ft above NGVD29)	Thickness of organic matter (ft)
3AN1W1	10.2	9.9	0.3
3AN1W2	10.1	9.4	0.8
3AN1W3	10.5	9.3	1.2
3AN1W4	11.8	10.8	1.0
3AS3W1	8.4	4.6	3.8
3AS3W2	8.1	4.8	3.3
3AS3W3	8.9	3.3	5.6
3AS3W4	10.3	6.2	4.1
3BS1W1	5.4	2.8	2.6
3BS1W2	5.5	3.1	2.4
3BS1W3	6.2	2.2	4.0
3BS1W4	10.1	8.9	1.2

Table 2 Land-surface and top of rock elevations at the 12 well sites (based on survey data from Keith and Schnars, PA, 2007). Well sites on each island are highlighted in yellow.

Climate in southern Florida is subtropical with hot, humid summers and mild winters. Meteorological data from 3AS3 indicate that air temperatures ranged from 7.3 to 30.0 degrees Celsius (^{o} C) during the period of record, with a median value of 24.6 ^{o} C. Rainfall accumulations in the wet season (June – September) can be up to 36 inches, and as much as 3.7 inches was recorded in a single day. As a result of the intense rainfall,

humidity values recorded at 3AS3 ranged from 48.8 to 95 percent, with a median value of 76.4 percent.

The high rates of rainfall have resulted in abundant surface-water and wetland resources surrounding the numerous tree islands (figs. 2 – 4). Photographs indicate that natural stream channels generally are absent, and most surface-water flow is overland sheet flow. The wetlands and surface water also interact with the underlying carbonate aquifer. Even during much of the dry season (October – May), the wetland surrounding the islands remains inundated, possibly as a result of groundwater discharge. Table 3 shows the percentage of time the water level in each well was higher than land-surface elevation, indicating the site is inundated with water. Tree islands 3AN1 and 3AS3 also are periodically inundated during the wet season.

Well	Land-surface elevation (in feet above NGVD29)	Percentage of time water level exceeded land-surface elevation
3AN1W1_GP	10.2	92.6
3AN1W1_GW	10.2	92.8
3AN1W1_H	10.2	95.4
3AN1W2_GP	10.1	93.3
3AN1W2_GW	10.1	94
3AN1W3_GP	10.5	74.7
3AN1W3_GW	10.5	76.8
3AN1W4_GP	11.8	17.9
3AS3W1_GP	8.4	99.7
3AS3W1_GW	8.4	99.2
3AS3W1_H	8.4	98.5
3AS3W2_GP	8.1	100
3AS3W2_GW	8.1	100
3AS3W3_GP	8.9	85.9
3AS3W3_GW	8.9	84.9
3AS3W4_GP	10.3	23.4
3AS3W4_GW	10.3	20.0
3BS1W1_GP	5.4	89.7
3BS1W1_GW	5.4	89.4
3BS1W1_H	5.4	88.8
3BS1W2_GP	5.5	85.4
3BS1W2_GW	5.5	84.7
3BS1W3_GP	6.2	65.8
3BS1W3_GW	6.2	69.9
3BS1W4_GP	10.1	0
3BS1W4_GW	10.1	0

Table 3 Percentage of time water levels in each well were higher than land-surface elevations. Wells on each island are highlighted in yellow.

Beginning in the 1910s, canals and associated structures (gates, culverts, and pump stations) have been constructed in southern Florida for the purpose of water management (Bevier and Krupa, 2001). The installation and operation of these structures has significantly modified the hydrology of southern Florida, and likely affects the water levels and flow of groundwater in and around the tree islands. An analysis of potential effects is part of this project, and discussed in section 5.2.

4 SEASONAL FLUCTUATIONS

4.1 Meteorological Data

Most of the meteorological data show seasonal fluctuations. Air temperature recorded at 3AS3WX generally decreases during the winter, and increases during the spring and summer months (Volume 1 Appendix). Potential evapotranspiration, which is related to solar and photosynthetic radiation, is least around the time of the winter solstice and greatest around the start of summer (fig. 6). Evapotranspiration (ET) can be a large component of an area's water balance. ET rates from nine sites in the Everglades ranged from 42.4 to 57.4 inches per year (German, 2000). High rates of solar radiation and evapotranspiration likely contribute to groundwater and surface-water level declines during periods of low rainfall. Barometric pressure and humidity (Volume 1 Appendix) also have cyclic patterns related to seasons as well as storm systems that affect the area.

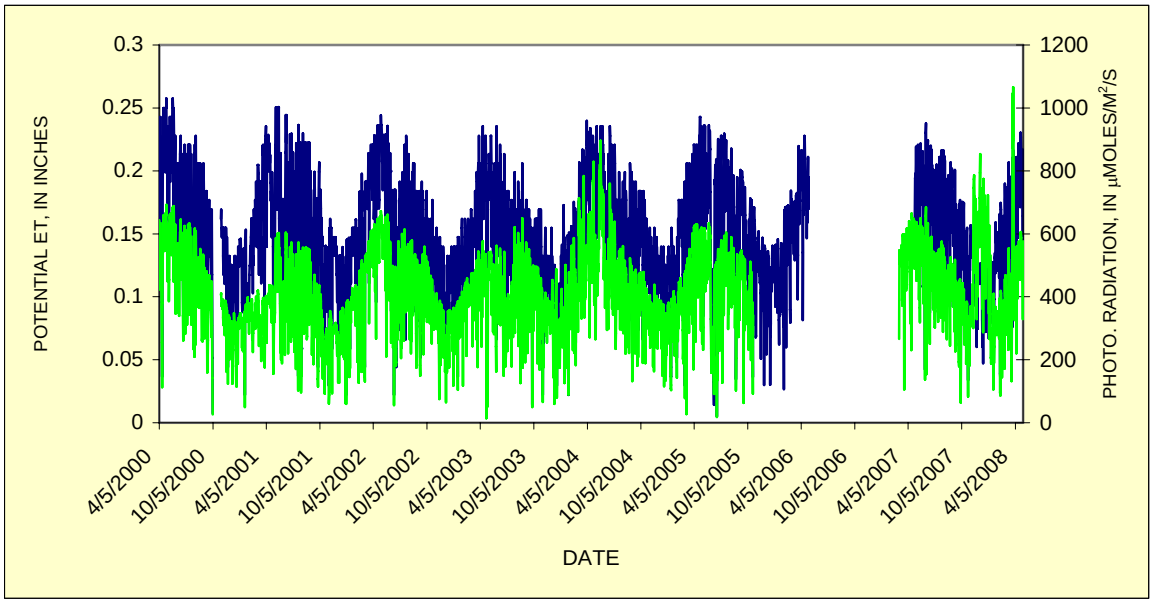

Figure 6 Seasonal fluctuations in potential evapotranspiration (blue) and photosynthetic radiation (green) recorded at station 3AS3WX.

Along with ET, the seasonal fluctuations of rainfall have a large impact on groundwater and surface-water levels at the tree islands. In general, southern Florida has two seasons with respect to rainfall—a wet season that extends from June through September of each year, followed by a dry season from October through May. Data collected from June 1, 2000 through May 31, 2008 at station 3AS3W3_R indicate that the cumulative rainfall during the 4-month wet season ranged from 17.0 (2002) to 36.2 inches (2005) with a media of 30.4 inches. In contrast, rainfall during the dry season was significantly less during the same period of record, ranging from 10.2 (2007) to 25.2 inches (2003) with a median of 16.1 inches. The dry season that ended in May 2007 is missing 49 values, so the actual rainfall during that season could be greater than 10.2

inches. Figure 7 shows the cumulative rainfall during each wet and dry season at 3AS3W3_R.

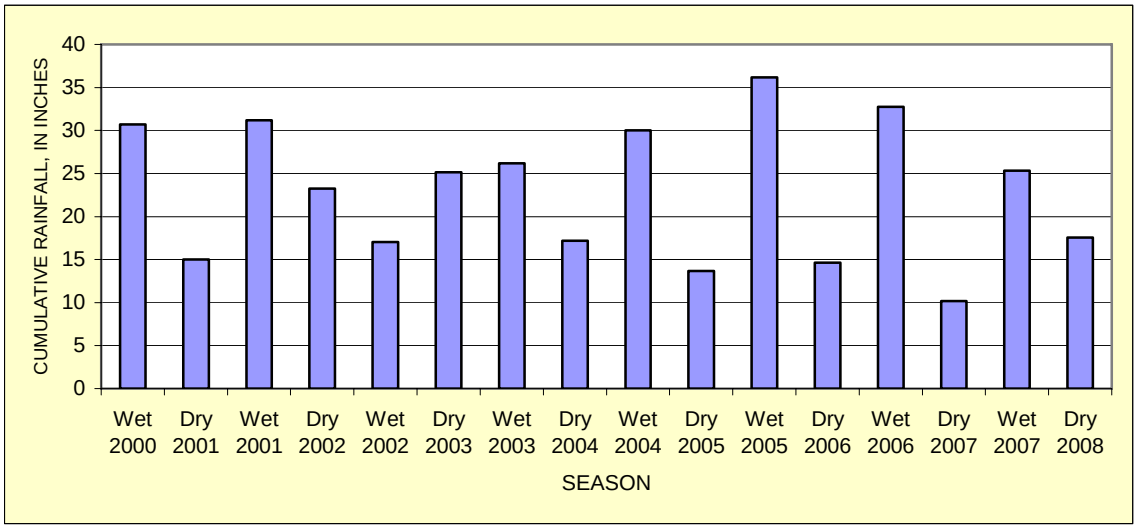

Figure 7 Cumulative rainfalls during each annual wet and dry season at station 3AS3W3_R.

The source of rainfall often differs between the wet and dry seasons. Dry season rainfall usually is associated with weather fronts as air masses with different temperatures and pressures interact. Wet season rainfall results primarily from isolated summer storms together with less frequent tropical storms and periodic hurricanes. The isolated storms generally result in large variations in rainfall between different rain stations across the region.

4.2 Water-Level Data

Surface-water stage and groundwater levels also show significant seasonal fluctuations. Water levels generally increase during the wet season, and decline during the dry season, which imparts a sinusoidal pattern to the hydrograph over periods greater than one year (see hydrographs in Volume 1 Appendix). A preliminary analysis of these seasonal fluctuations was conducted by Krupa and Gefvert (2006). The fluctuations, along with the occurrence of minimum and maximum water levels, at each tree island are also discussed below.

For brevity, the discussion below focuses primarily on the sites with stilling wells in order to assess surface water and ground water fluctuations, but the fluctuations in water levels in other wells are similar due to the strong correlation among all the wells at each tree island. For example, the water level in well 3AN1W1_GP (depth = 14.5 ft) is strongly correlated to the water level in well 3AN1W2_GW (depth = 49.6 ft) (fig. 8; R^2=0.99).

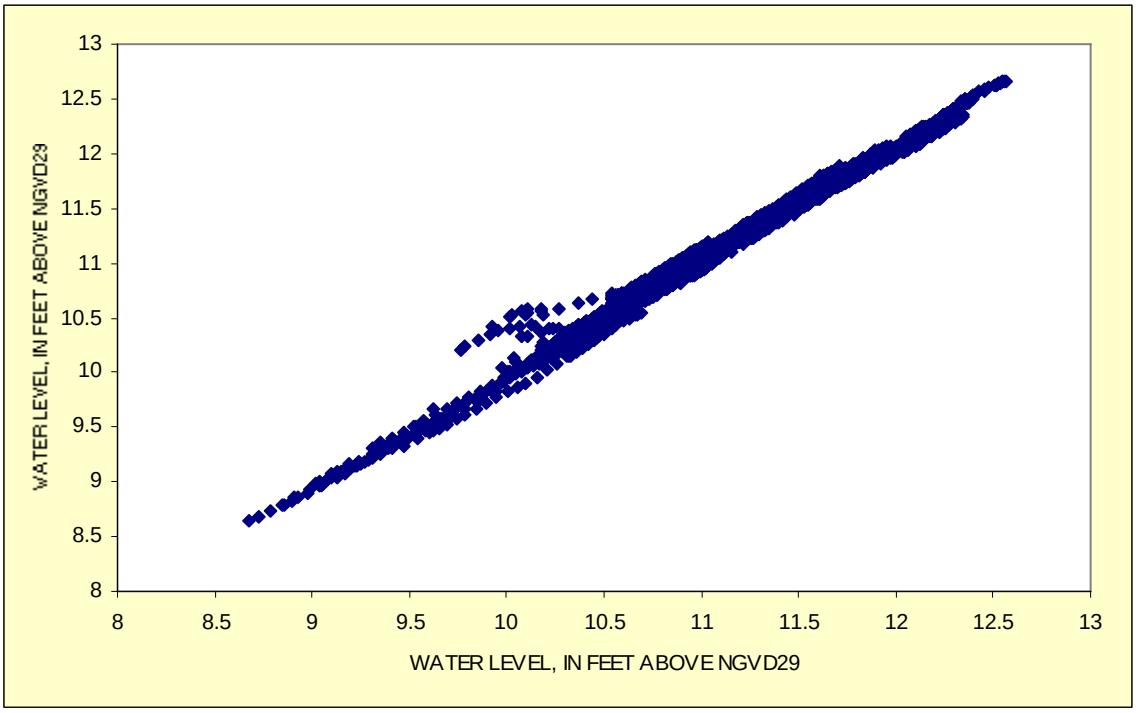

Figure 8 Water level in well piezometer 3AN1W2_GW (Y axis) is plotted against water level in piezometer 3AN1W1_GP (R^2=0.99).

4.2.1 3AN1

Surface-water stage and groundwater levels in the stations at 3AN1 generally decline through the dry season and increase during the wet season. Water levels in the wells and the stilling well generally are at their lowest level (annual minimum) in mid to late May, although in 2005, the annual minimum water levels occurred on March 2 and 3 (Appendix A). Water levels in the wells and stilling wells peak each year (annual maximum) in late September to early October. In 2005, the annual maximum water levels occurred on July 11, and were consistently elevated through mid November.

The minimum water levels during the entire period of record occurred on May 31, 2007 (fig. 9; Appendix A), which coincides with the low rainfall during the 2007 dry season. In March and May 2007, water level in the stilling well declined below the pressure transducer, and possibly below the bottom of the well, which resulted in anomalous data (see Volume 1 Sect. 4.3 Station 3: 3AN1W1_H).

Figure 9 Water levels in wells 3AN1W1_GP (blue) and 3AN1W1_GW (green) and stilling well 3AN1W1_H (red) from October 1, 2006 through September 30, 2007. The horizontal brown line represents land-surface elevation at the station.

The maximum water levels for the entire period of record occurred on July 11, 2005 (fig. 10; Appendix A), which coincides with the excessive rainfall during the wet season of 2005. The maximum water level on that date was 12.648 ft above mean sea level in well 3AN1W1_GW. Water levels in the associated piezometer and stilling well were slightly lower at 12.565 and 12.632 ft above mean sea level, respectively. These water levels indicate that vertical flow on this date was extremely complex. The water level in the stilling well was higher than the level in the piezometer, indicating downward flow as might be expected toward the end of the wet season. However, the water level in the deep well is higher than the levels in either the piezometer or the stilling well, which indicates an overall upward flow of groundwater. The water levels in all three stations were continually higher than 12 ft above mean sea level through November 15.

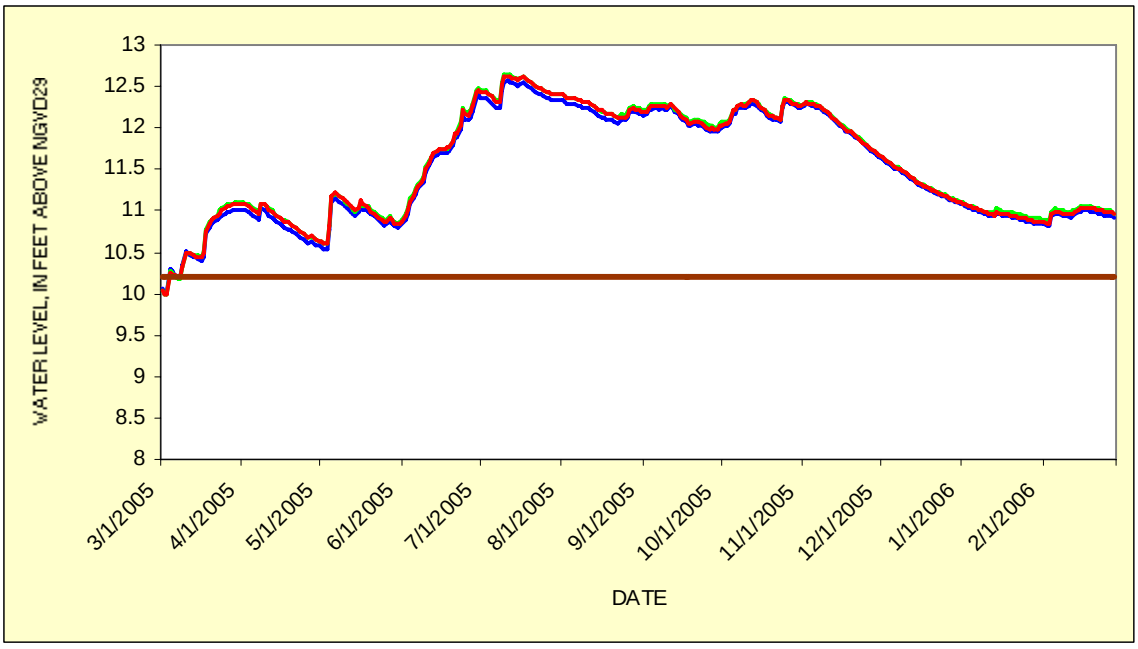

Figure 10 Water levels in wells 3AN1W1_GP (blue) and 3AN1W1_GW (green) and stilling well 3AN1W1_H (red) from March 1, 2005 through February 28, 2006. The horizontal brown line represents land-surface elevation at the station.

4.2.2 3AS3

As with 3AN1, surface-water stage and groundwater levels in the stations at 3AS3 generally decline throughout the dry season and increase during the wet season. Water levels in the wells and the stilling well generally are at their lowest in mid to late May, although annual minimum water levels occurred as early as April 25 in 2003, and as late as June 14 in 2004 (Appendix A). Water levels in the wells and stilling well peak each year in late September to early October. In 2005, the annual maximum water level occurred on September 2, and in 2001 and 2007, the annual maximum water levels occurred in early November.

The minimum water levels (entire period) in three of the wells and the stilling well at 3AS3 occurred on May 22, 2001 (fig. 11). The minimum water level in 3AS3W2_GW occurred on May 31, 2007. Minimum water levels in the piezometers also occurred on May 31, 2007; however, data-collection activities did not begin for those stations until July 2003.

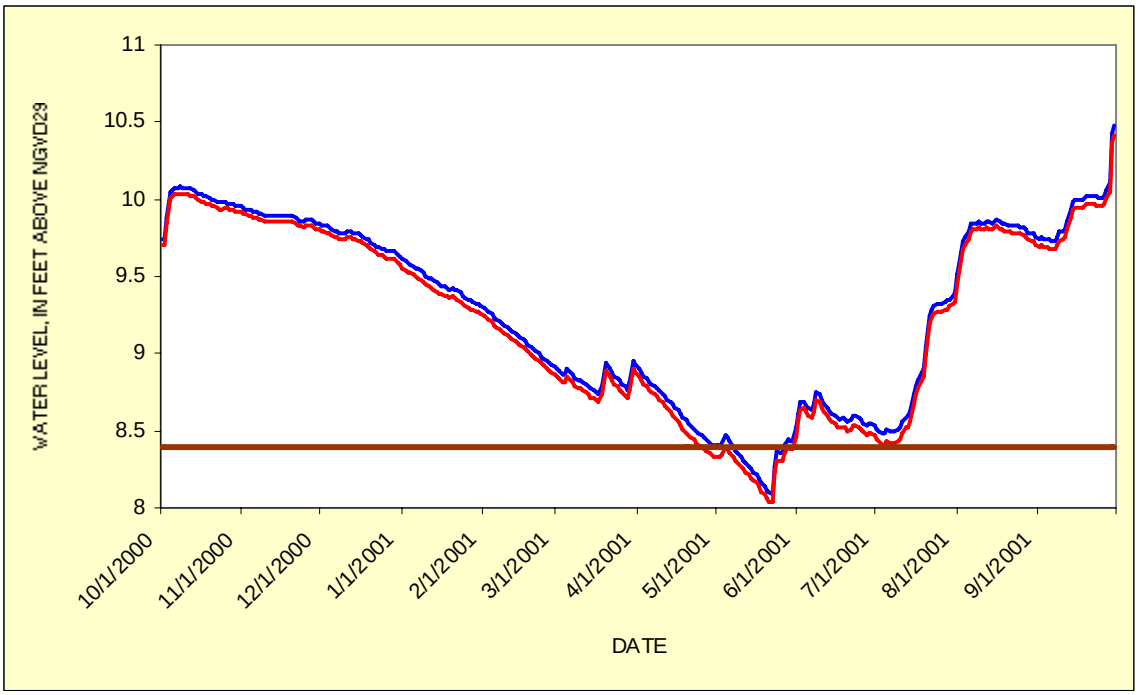

Figure 11 Water levels in well 3AS3W1_GW (blue) and stilling well 3AS3W1_H (red) from October 1, 2000 through September 30, 2001. The horizontal brown line represents land-surface elevation at the site.

The maximum water levels in the stilling well and all but one of the deep wells occurred on September 2, 2005 (fig. 12; Appendix A). The maximum water level in piezometer 3AS3W2_GP occurred on September 30, 2003. The water level in 3AS3W1_GW on September 2, 2005 was 11.273 ft above mean sea level. Water levels in the associated piezometer and stilling well on that same date were slightly lower at 11.232 and 11.216 ft above mean sea level, respectively. Water levels at the end of the wet season in 2005 were continually higher in the deep well than levels in either the piezometer or stilling well; therefore, vertical groundwater flow appears to be upward, even at the end of the wet season

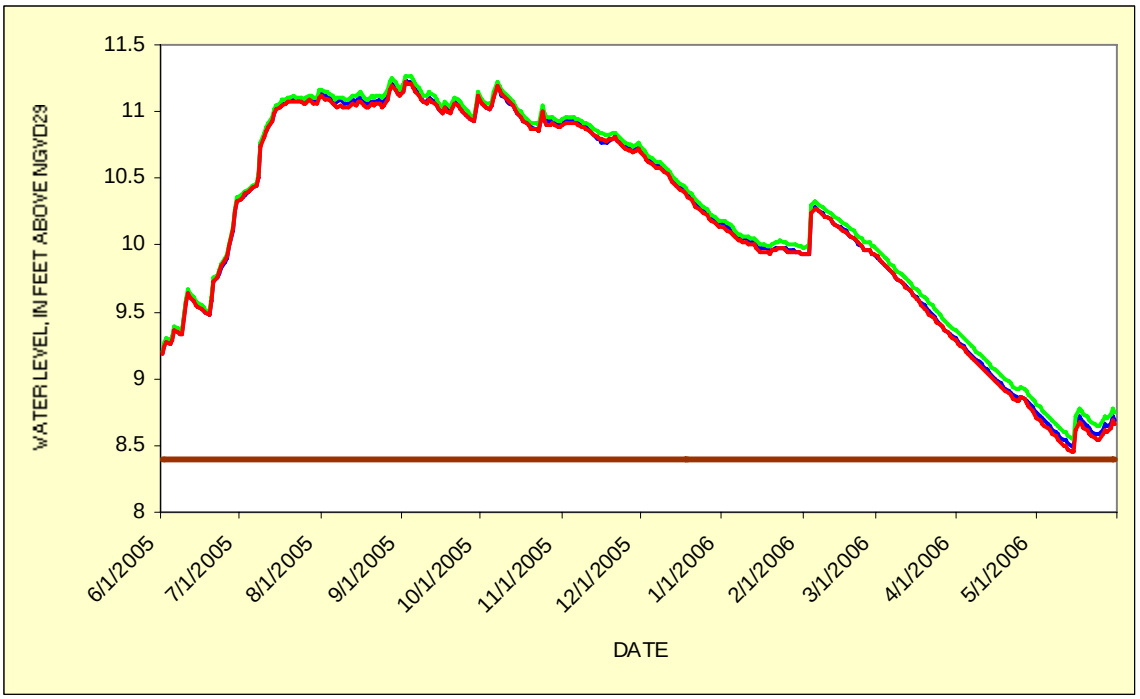

Figure 12 Water levels in wells 3AS3W1_GP (blue) and 3AS3W1_GW (green) and stilling well 3AS3W1_H (red) from June 1, 2005 through May 31, 2006. The horizontal brown line represents land-surface elevation at the site.

4.2.3 3BS1

As with 3AN1 and 3AS3, surface-water stage and groundwater levels in the stations at 3BS1 generally decline through the dry season and increase during the wet season. Water levels in the wells and the stilling well generally are at their lowest in mid to late May, although annual minimum water levels occurred as early as March 3 in 2005, and as late as July 2 in 2004 (Appendix A). Water levels in the wells and stilling well reach their annual maximum each year in late September to early October, although peak water levels occurred on November 12, 2006 in piezometer 3BS1W3_GP.

The minimum water levels (entire period) in the four deep wells and the stilling well occurred on May 21 and 22, 2001 (fig. 13), which coincides with the minimum water levels in the deep wells and stilling well at 3AS3. The minimum water levels in the piezometers occurred on May 31, 2007 (Appendix A); however, data-collection activities did not begin until July 2003.

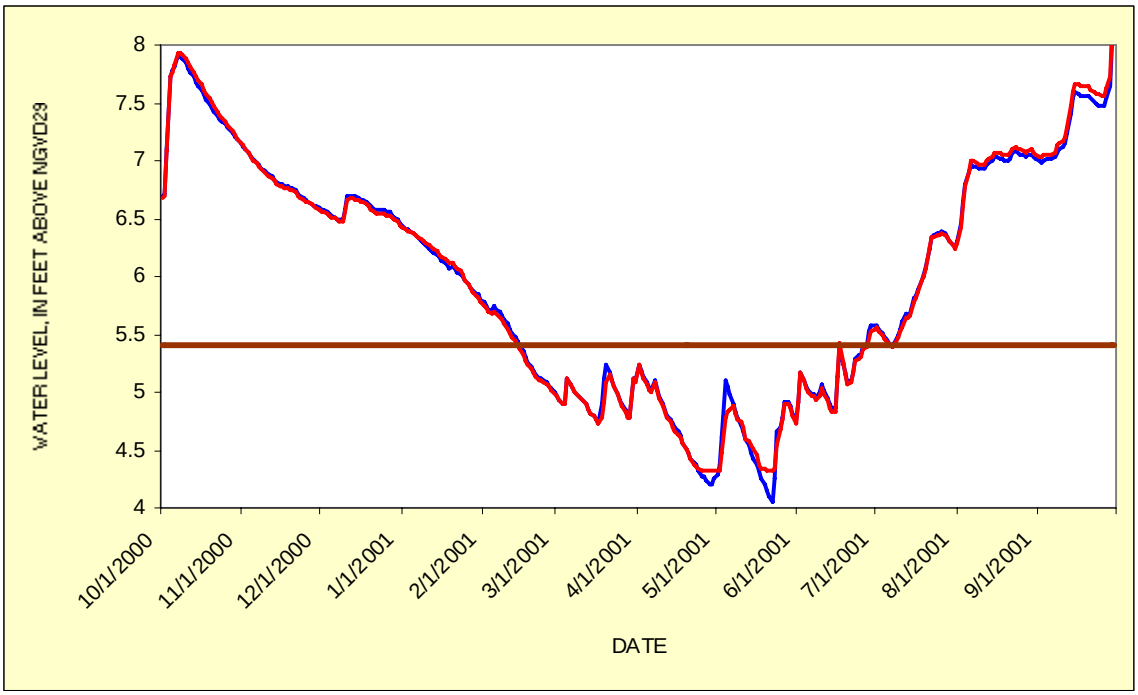

Figure 13 Water levels in well 3BS1W1_GW (blue) and stilling well 3BS1W1_H (red) from October 1, 2000 through September 30, 2001. The horizontal brown line represents land-surface elevation at the site.

The maximum water levels in the four deep wells and stilling well occurred on October 25, 2001 (fig. 14; Appendix A). The water level in the stilling well (8.525 ft above NGVD29) was higher than the water level in the adjacent deep well (8.384 ft), indicating subsurface water flow was downward. The maximum water level in three of the four piezometers occurred on September 12, 2005. On that date, the water level in the stilling well (8.457 ft above NGVD29) was higher than the levels in either the adjacent piezometer (8.407 ft above NGVD29) or deep well (8.35 ft). Hence, vertical flow of water appears to have been downward.

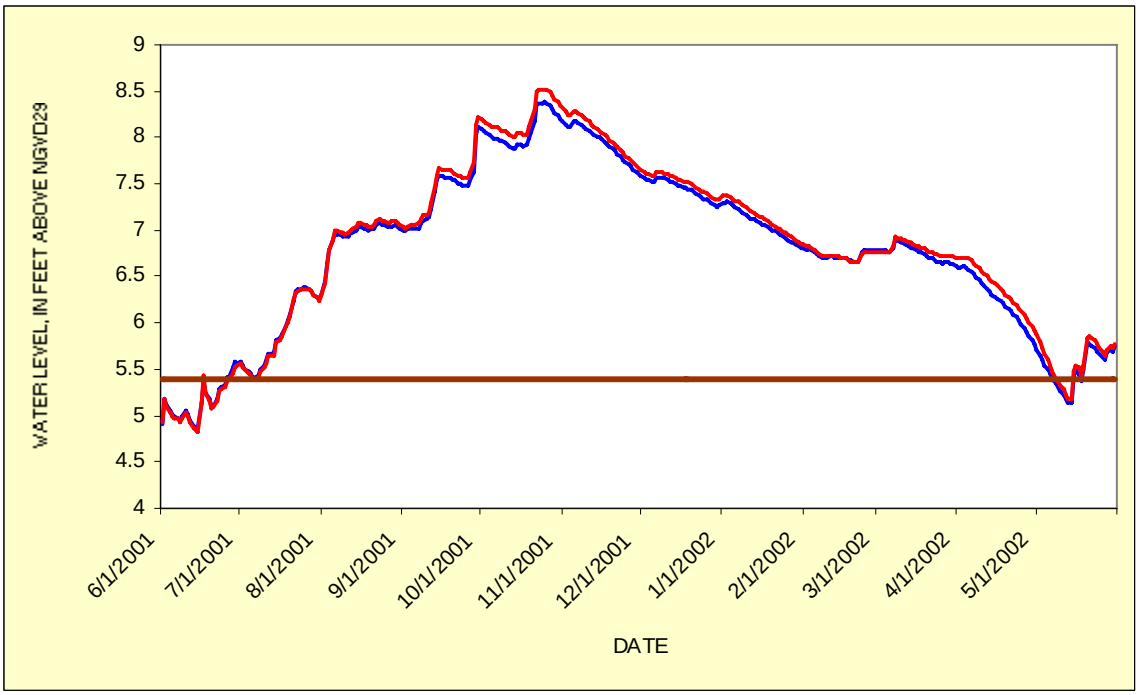

Figure 14 Water levels in wells 3BS1W1_GW (blue) and stilling well 3BS1W1_H (red) from June 1, 2001 through May 31, 2002. The horizontal brown line represents land-surface elevation at the site.

5 FACTORS AFFECTING WATER LEVELS

5.1 Meteorological Conditions

Groundwater and surface-water levels at the three tree islands appear to be strongly related to rainfall at the sites. Water levels in the wells and stilling wells increase during the wet season and decline during the dry season (fig. 15). This relation occurs regardless of the well depth.

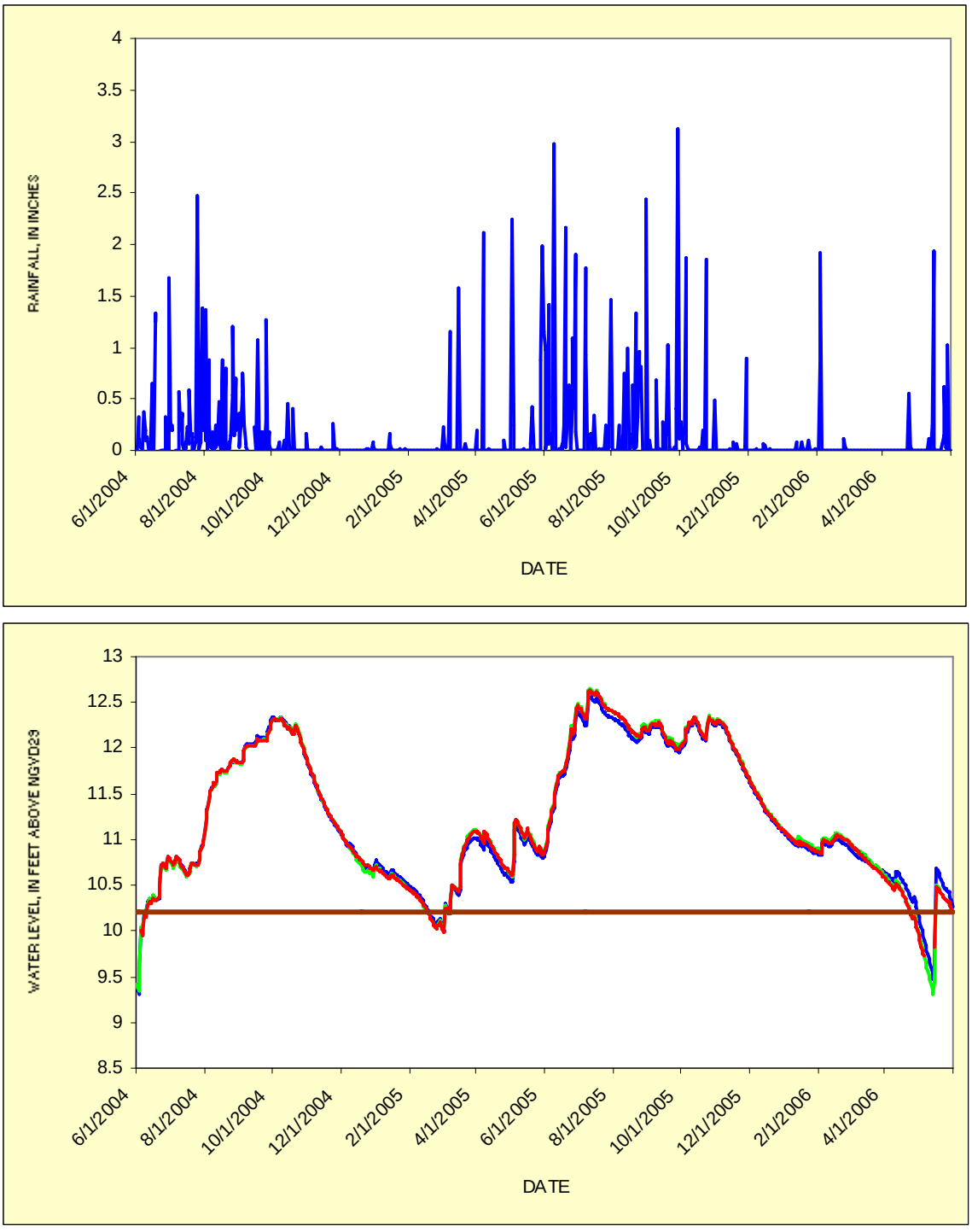

Figure 15 Response of water levels in stations 3AN1W1_H (red), 3AN1W1_GP (blue) and 3AN1W1_GW (green) to rainfall during 2004 and 2005 wet seasons. The horizontal brown line in the bottom graph represents land-surface elevation at the site.

Results from the Wilcoxon rank-sum test indicate that groundwater and surface-water levels were statistically higher at the end of each wet season compared to water levels at the end of each dry season (fig. 16; $p<0.01$). In addition, groundwater and surface-water levels were positively correlated ($R^2=0.78$) to cumulative rainfall at the end of each wet and dry season (fig. 17). In other words, higher accumulated rainfalls during the season resulted in higher water levels in each station.

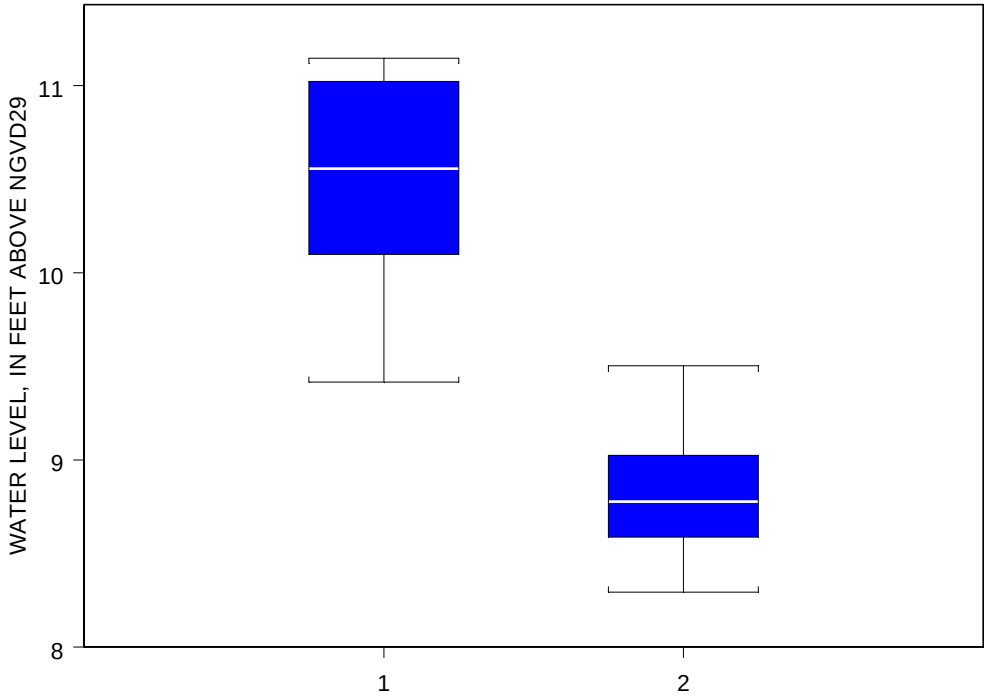

Figure 16 Groundwater levels in well 3AS3W1_GW are significantly higher ($p<0.01$) at the end of each wet season (1) compared to groundwater levels in the same well at the end of each dry season (2).

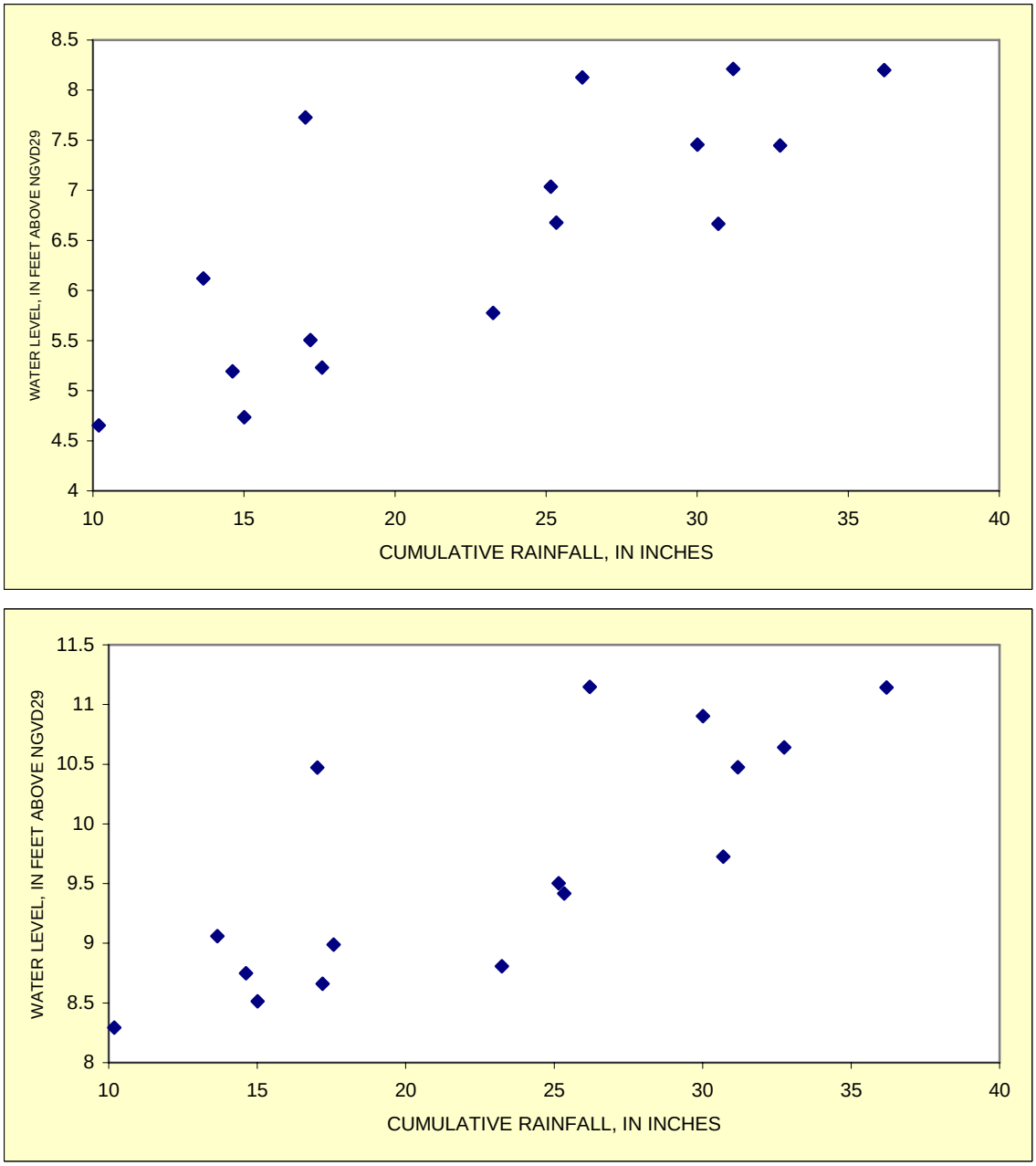

Figure 17 Water level in stations 3BS1W1_H (top) and 3AS3W1_GW plotted against cumulative rainfall (3AS3W3_R) after each wet season and each dry season.

Groundwater and surface-water levels also increased sharply after each individual storm or rainfall. Figure 18 shows that groundwater and surface-water levels at 3AS3W1 increased about 0.4 ft after the 3.7-in rainfall recorded at 3AS3W3_R on February 13, 2008. Groundwater and surface-water levels also increased after smaller rainfalls occurred on March 8 and 22, 2008.

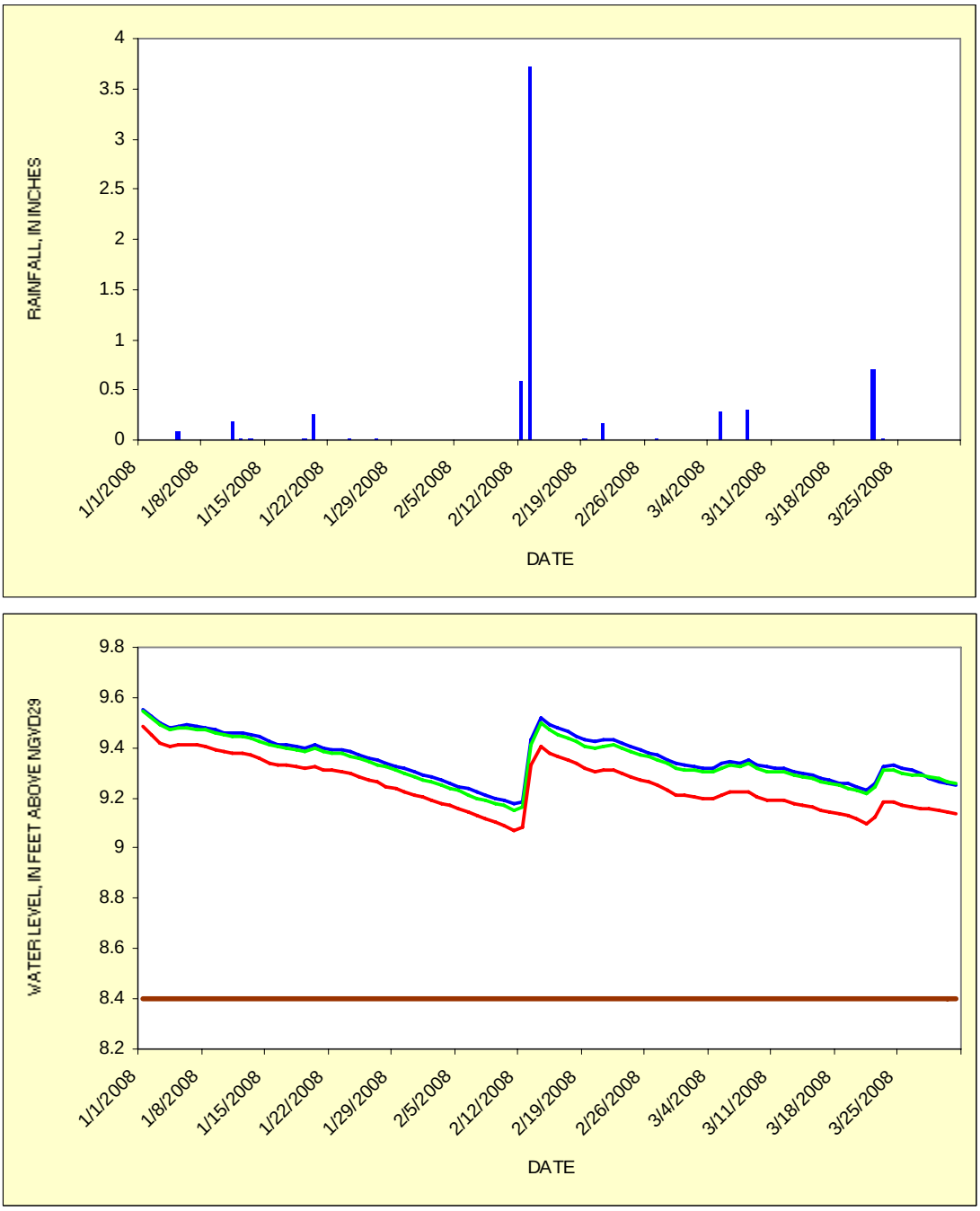

Figure 18 Response of water levels in stations 3AS3W1_GP (blue), 3AS3W1_GW (green), and 3AS3W1_H (red) to rainfalls recorded at 3AS3W3_R (top). The horizontal brown line represents land-surface elevation at the site.

The increase in groundwater and surface-water levels for each well at 3AS3 also is significantly correlated to the amount of each individual rainfall recorded at 3AS3W3_R

(fig. 19; table 4). The correlation between water levels and rainfall was weaker for stations at 3AN1 and 3BS1, possibly because many of the storms recorded at 3AS3W3_R were localized, and data from that station are not necessarily accurate for rainfalls at the other two tree islands.

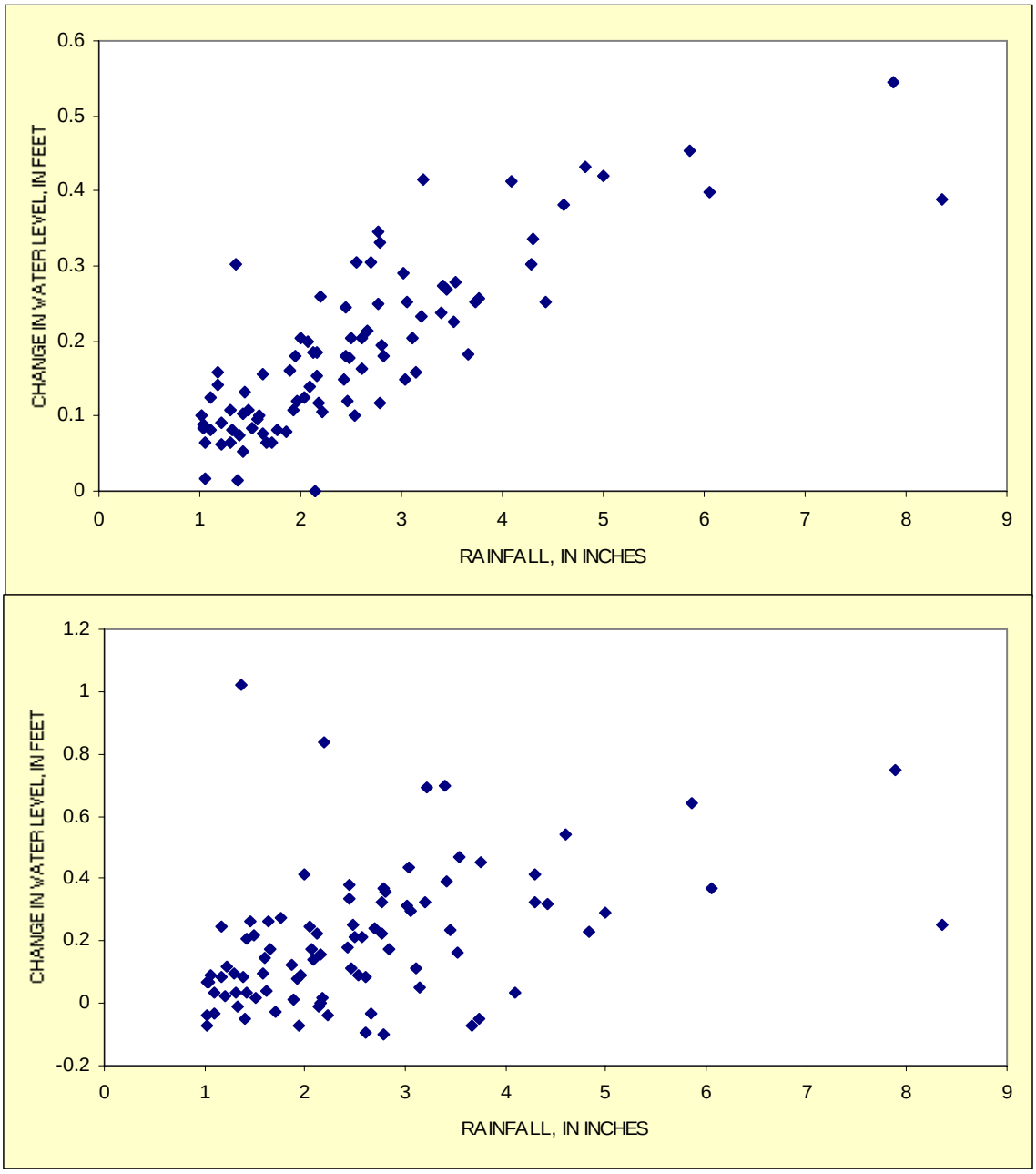

Figure 19 The change in water level in stations 3AS3W3_GW (top; R^2=0.87) and 3BS1W1_H (R^2=0.52) plotted against rainfall from individual storms recorded at 3AS3W3_R.

Station	Number of Samples	Correlation Factor (R^2)
3AN1W1_GP	62	0.30
3AN1W1_GW	62	0.29
3AN1W1_H	62	0.12
3AS3W3_GP	55	0.86
3AS3W3_GW	89	0.87
3AS3W1_H	89	0.87
3BS1W1_GP	55	0.54
3BS1W1_GW	89	0.53
3BS1W1_H	89	0.52

Table 4 Results of correlation analyses between increases in water level and amount of rainfall from individual storms recorded at 3AS3W3_R.

Surface- and groundwater levels generally are inversely related to photosynthetic radiation and potential evapotranspiration (ETP). Groundwater and surface-water levels decline as photosynthetic radiation and evapotranspiration increase (fig. 20). Evapotranspiration is related to solar radiation (itself a function of cloud cover and length of daylight), air temperature, humidity, precipitation, and wind speed. As a result, potential evapotranspiration shows not only large seasonal variations, but also daily and other short-term variations from storms and other factors. Hence, although the general relation between water levels and ETP is apparent, statistical correlation is difficult due to these large short-term fluctuations (fig. 21).

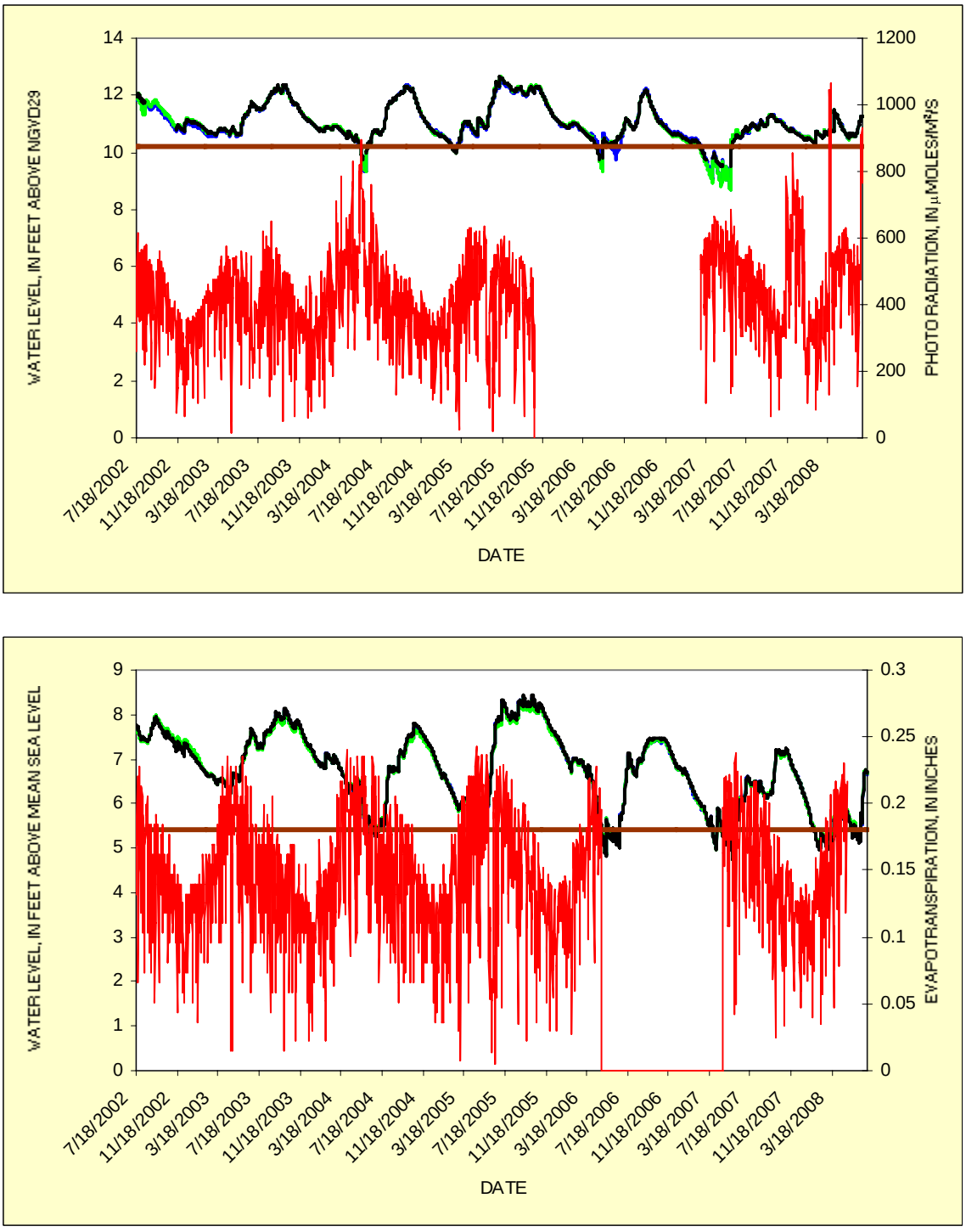

Figure 20 Water levels in the shallow piezometers (blue), deep wells (green) and stilling wells (black) at sites 3AN1W1 (top) and 3BS1W1 (bottom) plotted with photosynthetic radiation (top, red) and potential evapotranspiration (bottom, red) recorded at 3AS3WX. The horizontal brown line on each graph represents land-surface elevation at the sites.

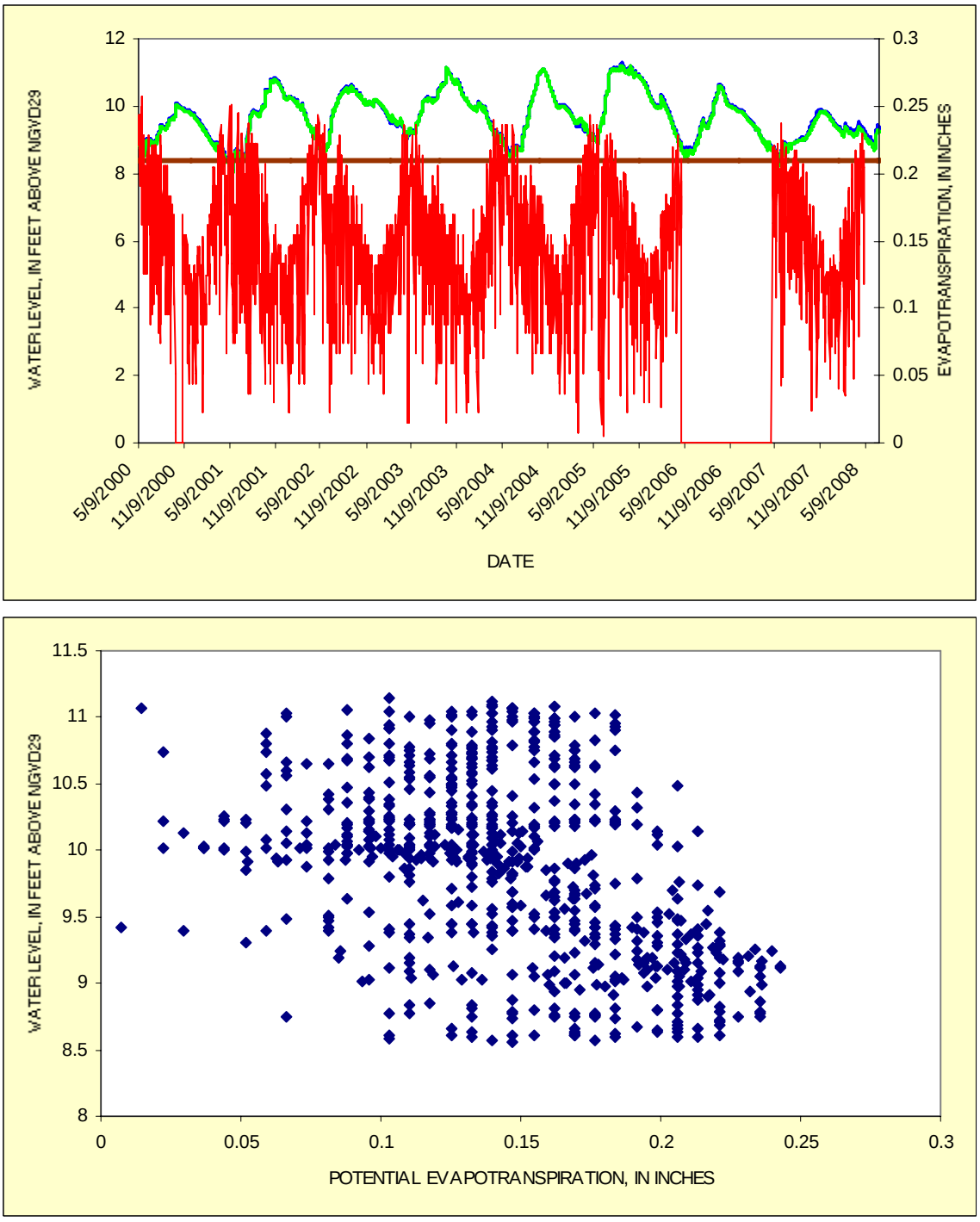

Figure 21 Water levels in stations 3AS3W1_GW (blue) and 3AS3W1_H (green) are plotted with potential evapotranspiration (red) over time (top). Water levels in well 3AS3W3_GW are plotted against potential evapotranspiration (correlation coefficient = -0.43).

The effects of photosynthetic radiation and evapotranspiration on water levels are even more apparent on plots of shorter duration (figs. 22 and 23). In particular, the peak in photosynthetic radiation that occurs each mid day coincides with a slight (0.01 ft) daily decline in groundwater and surface-water levels at 3AS3W1 (fig. 23). This trend continues even after the water levels decline below land-surface elevation, probably as a result of water uptake by plant roots. Water levels in wells show a similar daily decline when plotted with sap flow in plants, which, like photosynthetic radiation, peaks during the middle of each day (Steve Krupa, SFWMD, written commun., 2008).

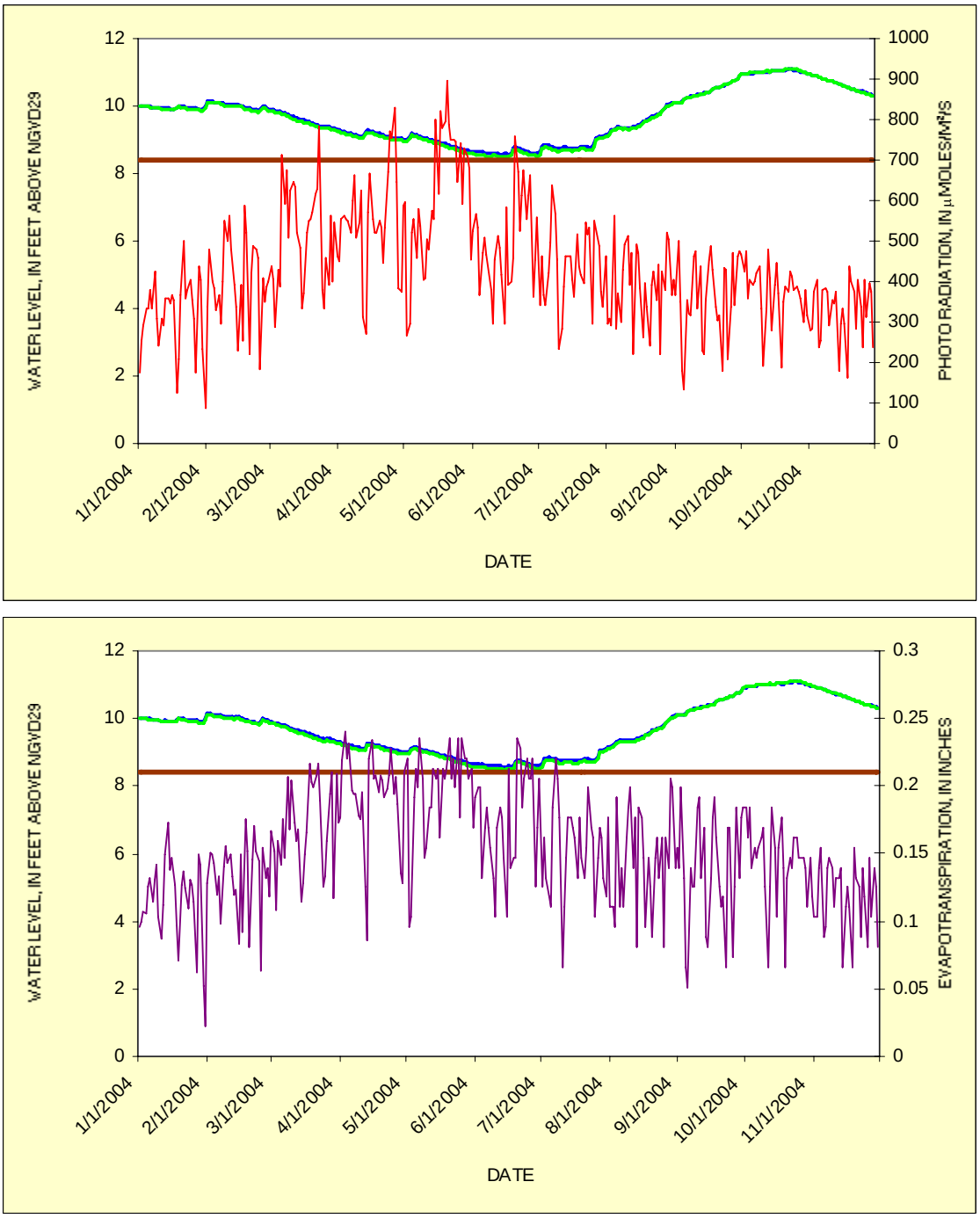

Figure 22 Water levels in stilling well 3AS3W1_H (green) and deep well 3AS3W1_GW (blue) decline as photosynthetic radiation (top, red) and evapotranspiration (bottom, dark blue) increase. The horizontal brown line represents the land-surface elevation at 3AS3W1.

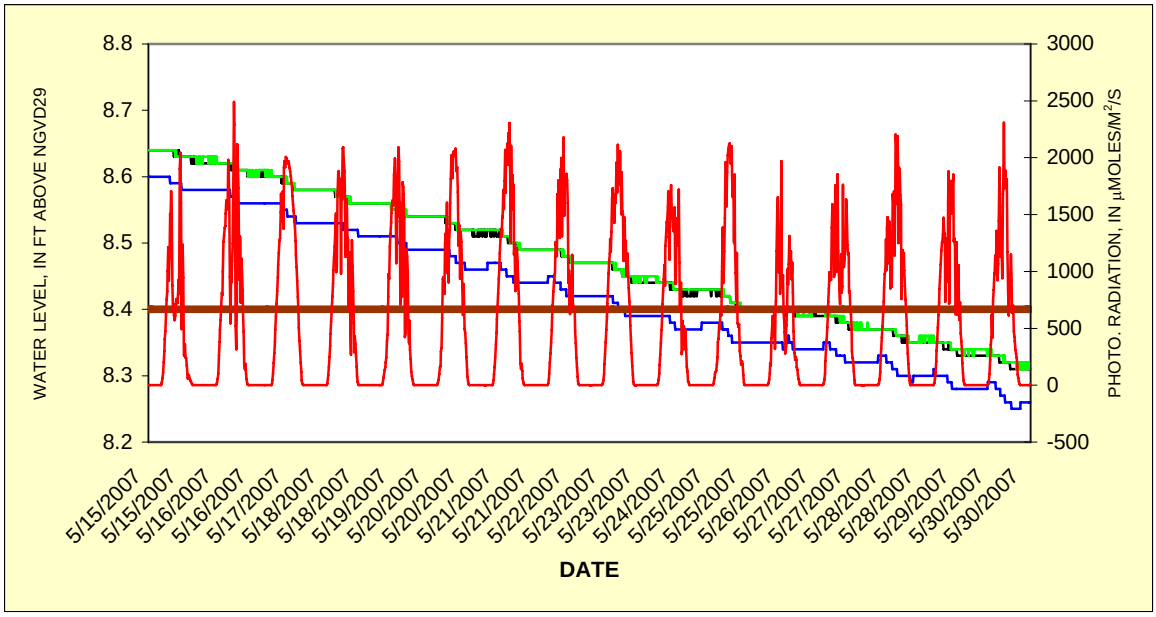

Figure 23 Water levels in wells 3AS3W1_GP (black) and 3AS3W1_GW (green) and stilling well 3AS3W1_H (blue) decline in response to maximum daily peaks in photosynthetic radiation (red). The horizontal brown line represents land-surface elevation at site 3AS3W1.

Other meteorological factors, such as barometric pressure and humidity, have cyclic patterns, but do not appear to affect groundwater or surface-water levels at the tree islands. Air temperature exhibits seasonal patterns, which weakly mimic groundwater and surface-water levels (fig. 24). However, this relation is rather indirect, as wet-season storms, which increase water levels, are a product of warm temperatures in the summer months.

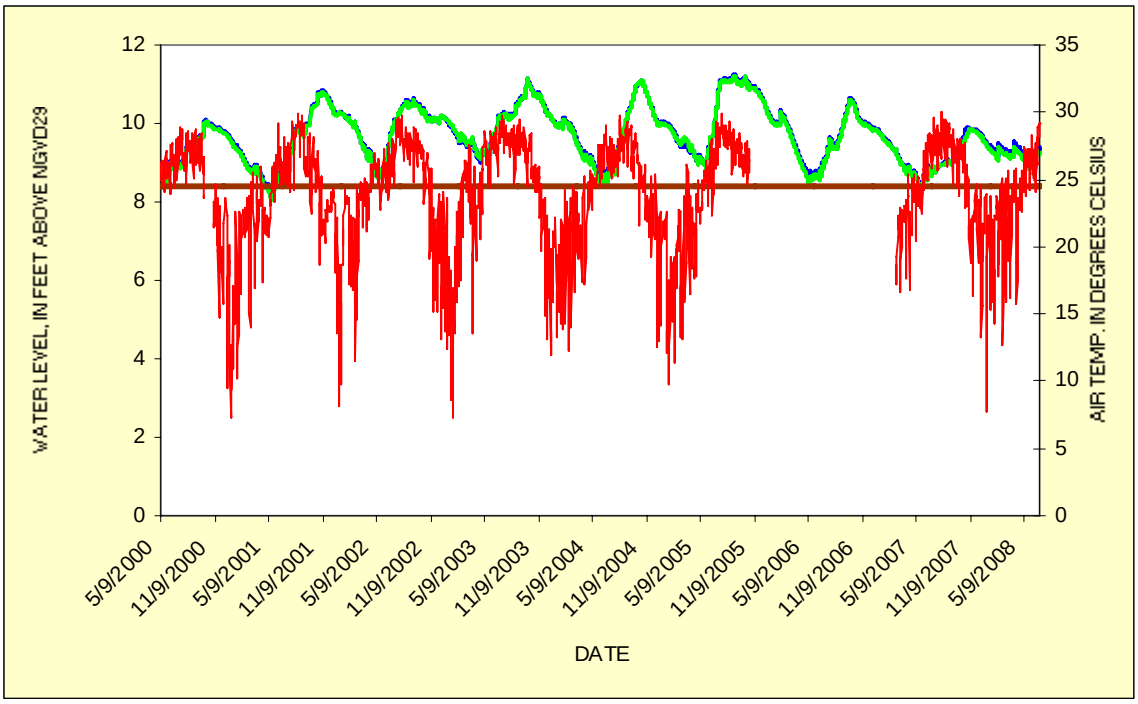

Figure 24 Water levels in stations 3AS3W1_GW (blue) and 3AS3W1_H (green) are plotted with air temperature (red) recorded at 3AS3WX. Water levels are in feet above mean sea level; air temperatures are in degrees Celsius. The horizontal brown line represents land-surface elevation at 3AS3W1.

5.2 Operation of Structures

Groundwater and surface-water levels at the three tree islands appear to fluctuate according to natural processes. Water levels increase as a result of precipitation, and decline smoothly during dry periods as a result of evapotranspiration. However, a number of structures that control flow are present in canals near the three tree islands. The relation of stage at these structures was compared to surface-water and groundwater levels to determine if operation of the structures affects the hydrology of the tree islands.

5.2.1 3AN1

Groundwater and surface-water levels were compared to stage data from structure S339 to determine the effects on island hydrology. Structure S339 is a spillway on the C-123 Canal just east-northeast of Tree Island 3AN1 (fig. 25). The canal trends northwest to southeast. Daily mean stage is monitored on both the headwater (upstream) and tailwater (downstream) sides of the spillway. Water levels in stations 3AN1W1_GW and 3AN1W1_H closely coincide with stage on the tailwater side of S339, but are less correlated to stage on the headwater side (figs. 26 and 27). Stage data from the headwater side contains sharp peaks, which probably result from excessive rainfalls. The magnitude of these peaks is diminished on the tailwater side of S339 (fig. 26). The strong correlation between water levels at 3AN1 and stage on the tailwater side of S339 indicates that

operation of this structure or other nearby structures could be affecting the hydrology at the tree island. The correlation appears to weaken when water levels in 3AN1W1_H decline below land-surface elevation at the site (fig. 27).

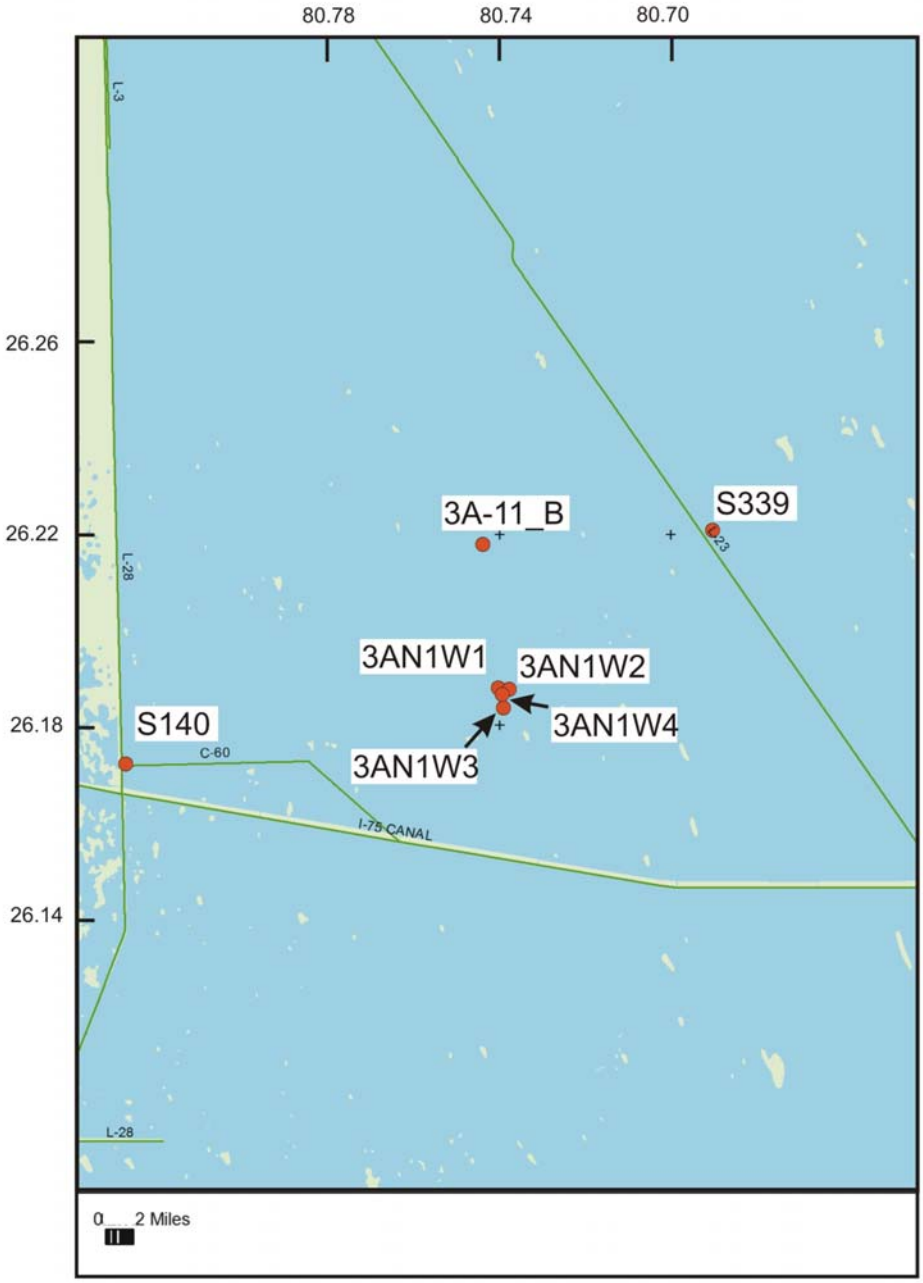

Figure 25 Location of selected surface-water stations in relation to sites at tree island 3AN1.

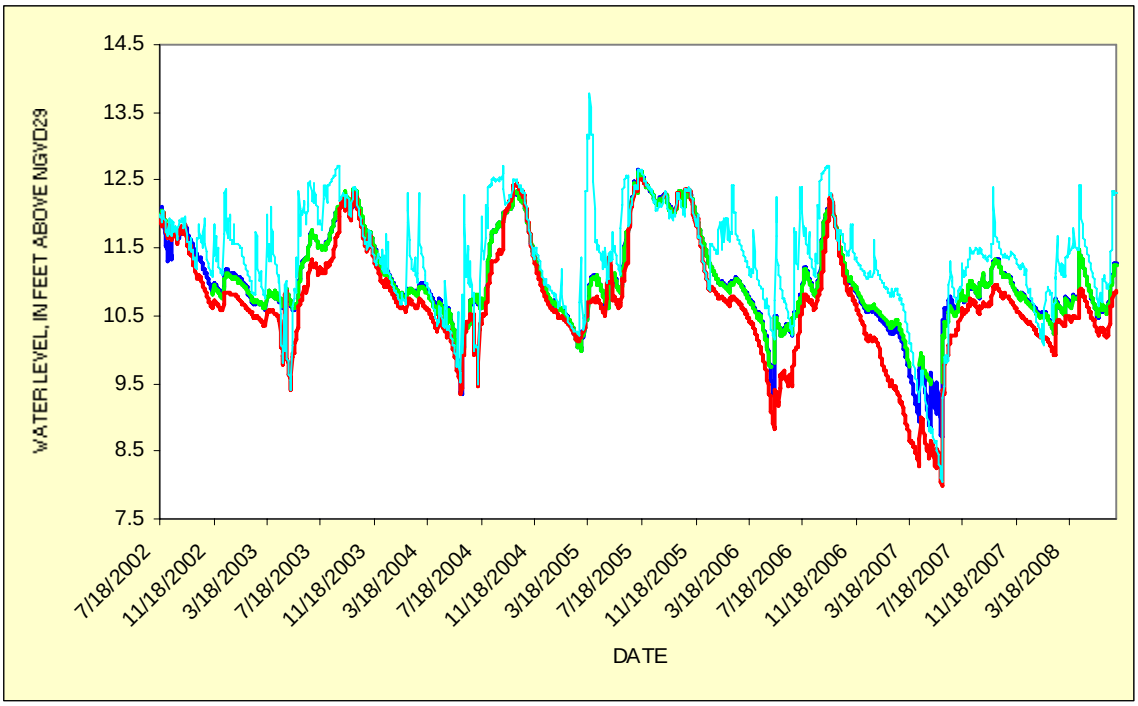

Figure 26 Water levels in stations 3AN1W1_H (green) and 3AN1W1_GW (blue) are plotted with stage from the headwater (cyan) and tailwater (red) side of structure S339 on the C-123 Canal.

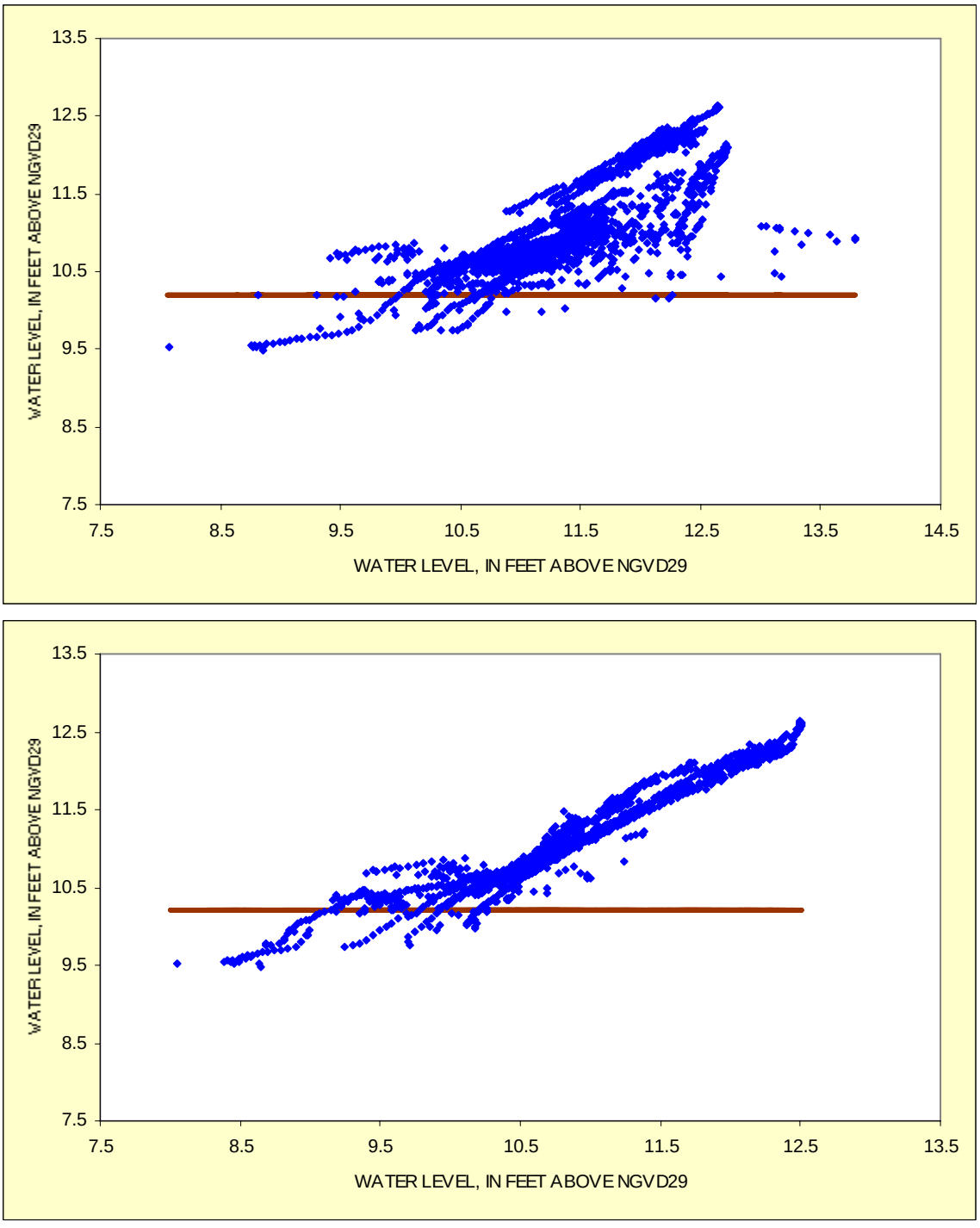

Figure 27 Water level in stilling well 3AN1W1_H (Y axis) is plotted against stage at the headwater (top; correlation coefficient = 0.79) and tailwater (bottom; correlation coefficient = 0.96) side of structure S339 on the C-123 Canal. The horizontal brown line represents land-surface elevation at well 3AN1W1_H.

5.2.2 3AS3

A number of structures are present near tree island 3AS3 (fig. 28), of which culvert S-343A south-southwest of the tree island at the junction of levees L-28 and L-29, and spillways S12A and S12B on L-29, south of the tree island, were selected. The groundwater and surface-water levels at 3AS3 closely coincide with stage on the headwater side of each structure, but are less correlated with stage of the tailwater sides of the structures (figs. 29 and 30).

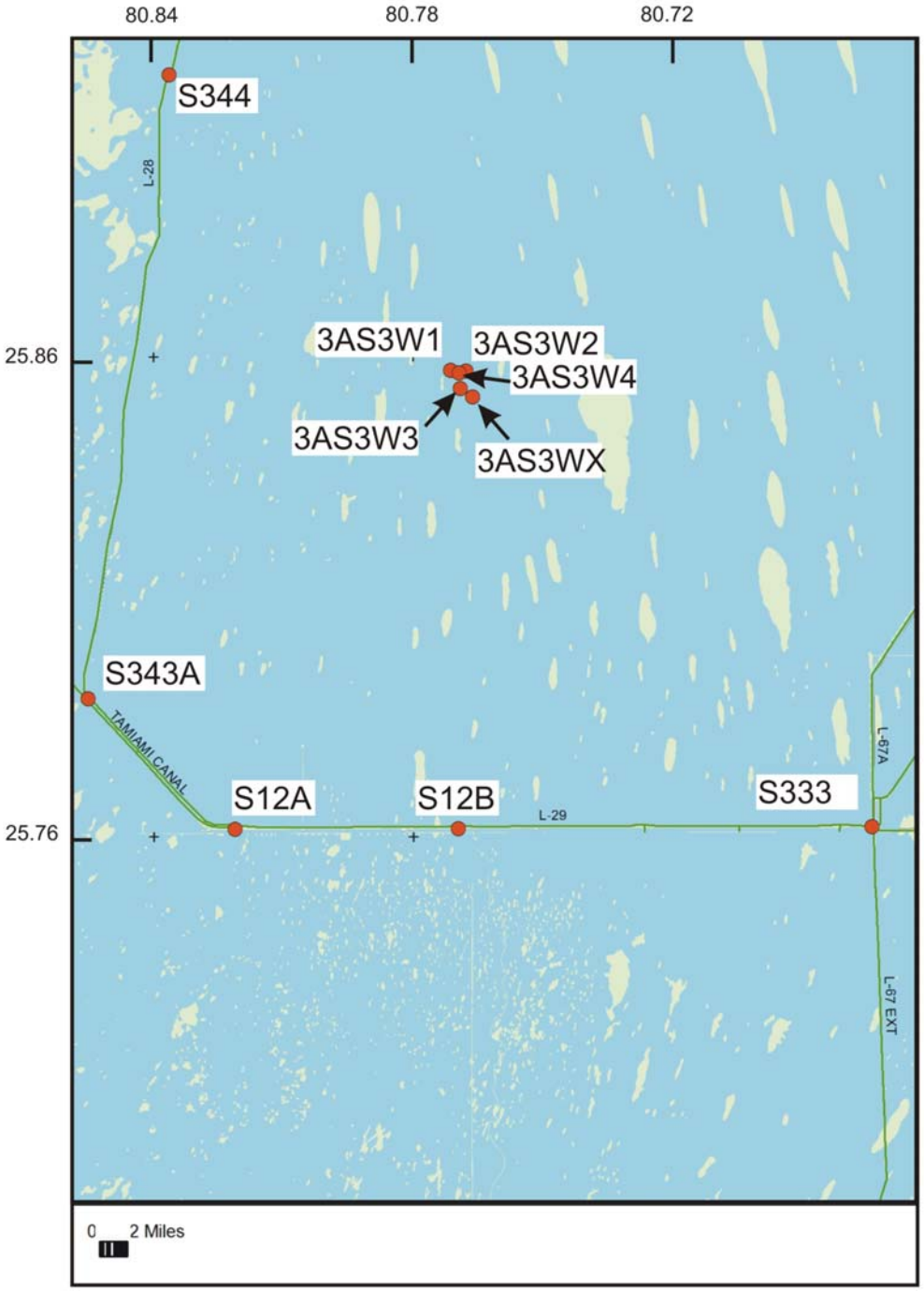

Figure 28 Location of selected surface-water stations in relation to sites at tree island 3AS3.

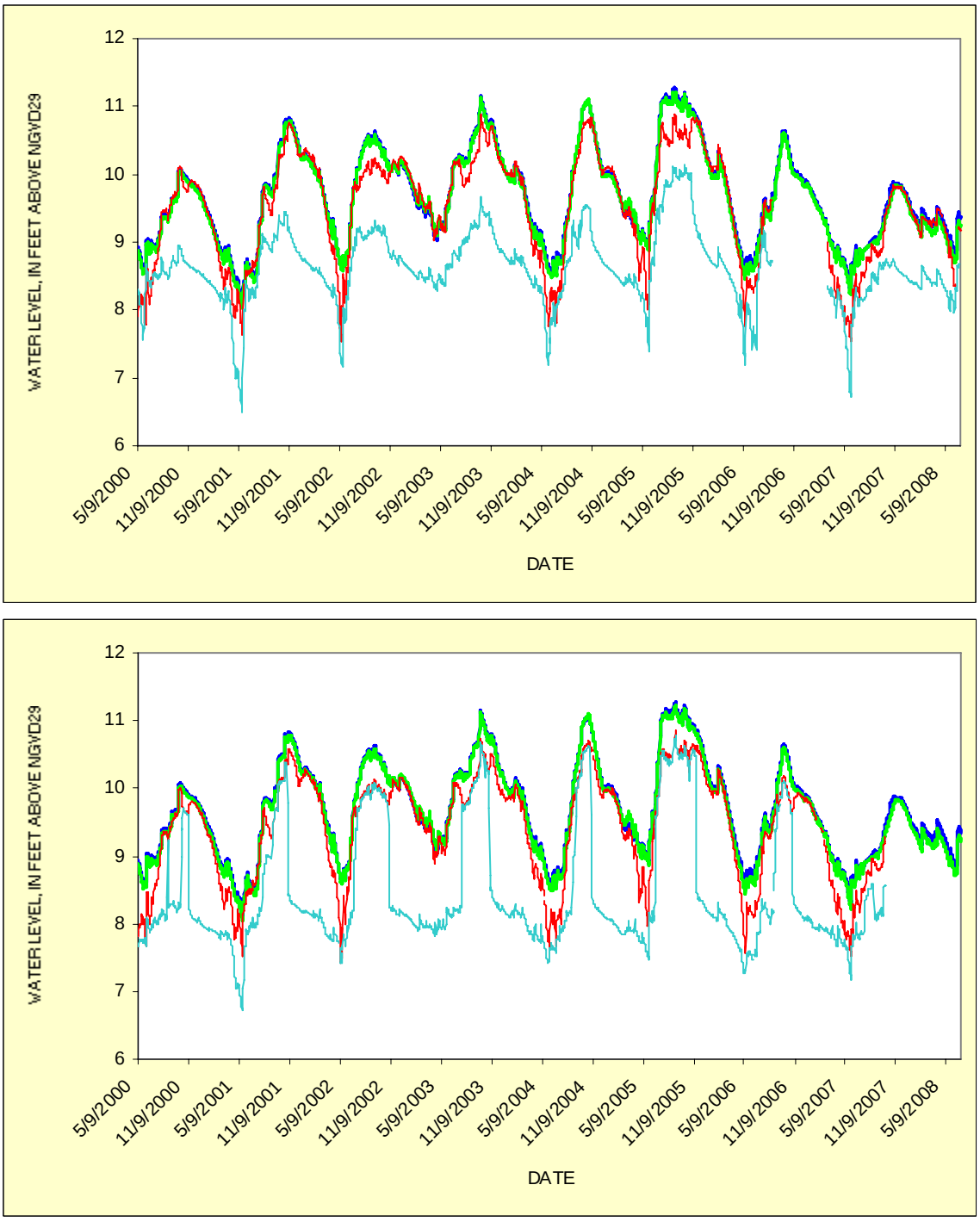

Figure 29 Water levels in station 3AS3W1_GW (green) and 3AS3W1_H (blue) plotted with stage at the headwater (red) and tailwater (cyan) sides of structures S-343A (top) and S12 (bottom).

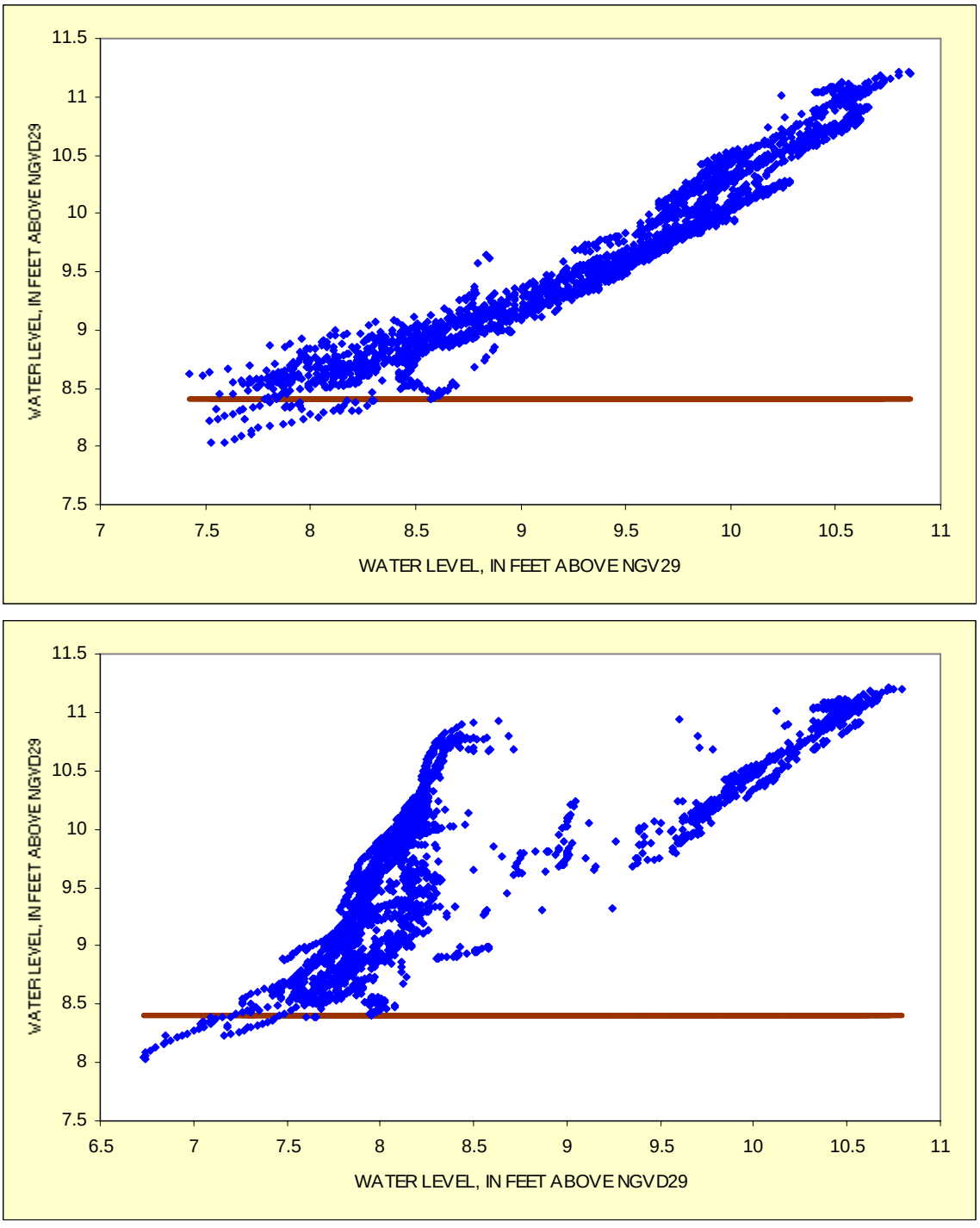

Figure 30 Water level in stilling well 3AS3W1_H (Y axis) is plotted against stage at the headwater side of spillway S12B (top; correlation coefficient = 0.96) and tailwater side of spillway S12A (bottom; correlation coefficient = 0.77). The horizontal brown lines represent land-surface elevation at 3AS3W1_H.

The stage data from the tailwater side of spillway S12A has a bimodal distribution, with one set of data representing relatively low stage levels and a second set of data representing relatively high levels. Changes from low-level to high-level stage are abrupt, and generally coincide with peaks in stage at 3AS3W1_H (fig. 29). These abrupt peaks in tailwater stage probably result from water being released from WCA3 into the canal. Declines from high-level to low-level stage are equally abrupt, and could result from the closing of gates and preventing water from entering the canal. As a result, the hydrology at 3AS3 is affected by the operation of structures, which maintain groundwater and surface-water levels within a certain range of values.

5.2.3 3BS1

Surface-water stage and groundwater levels in the stations at 3BS1 coincide with stage data at nearby spillway S334 (fig. 31), which is located just southeast of the tree island on the Tamiami Canal; however, water levels at 3BS1 correlate less well to tailwater stage at the same spillway (figs. 32 and 33). In general, the stage in the tailwater side of the spillway stays relatively constant except during very dry periods, at which time the gate on the spillway is probably closed and presumably not affecting the water levels at the tree island. Occasional peaks in the tailwater stage are abrupt, and could result from releasing water from WCA3 into the canal. Overall, the effect of the spillway on the hydrology of 3BS1 is difficult to assess; however, the close proximity of the structure indicates that the hydrology of 3BS1 probably is greatly affected by their operation.

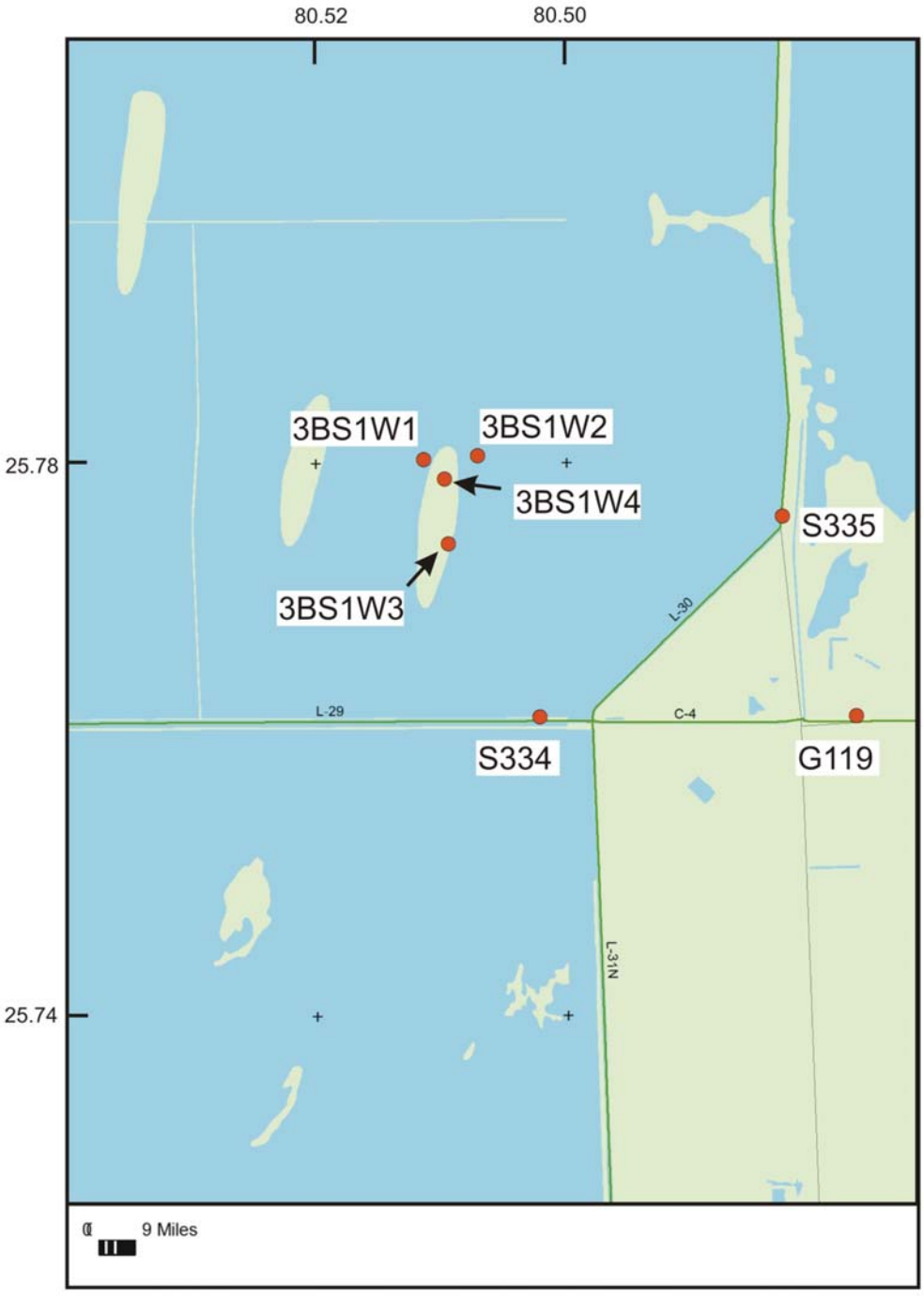

Figure 31 Location of selected surface-water stations in relation to sites at tree island 3BS1.

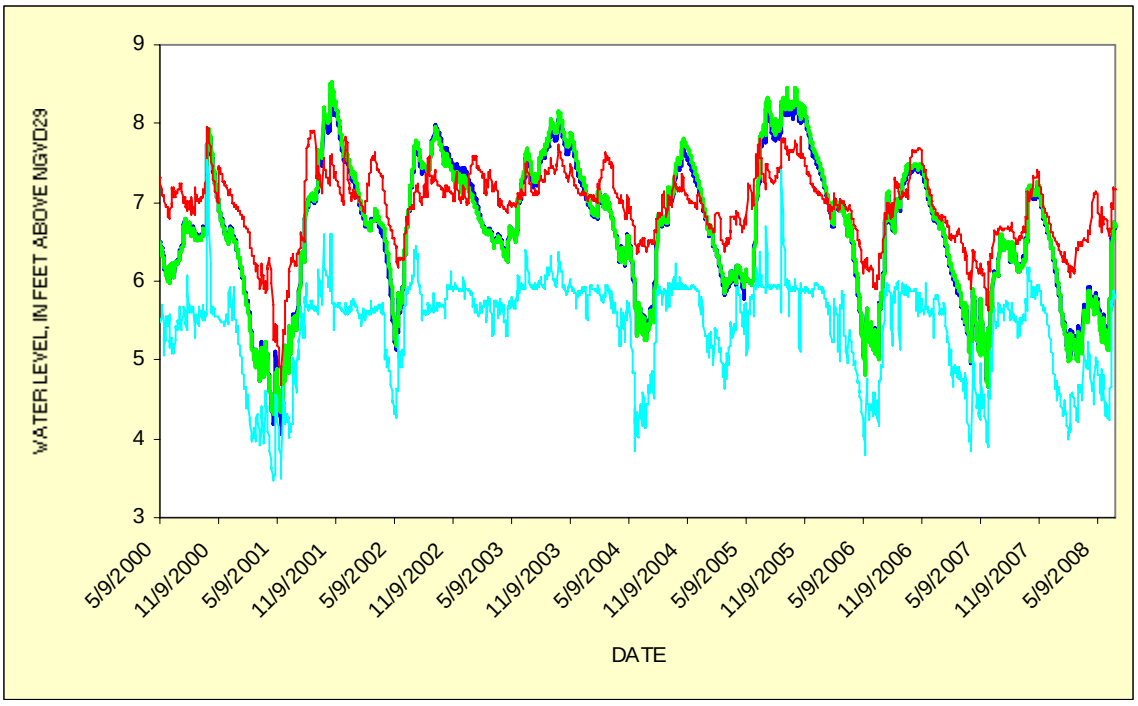

Figure 32 Water levels in station 3BS1W1_GW (green) and 3BS1W1_H (blue) plotted with stage at the headwater (red) and tailwater (cyan) sides of spillway S334 on the Tamiami Canal.

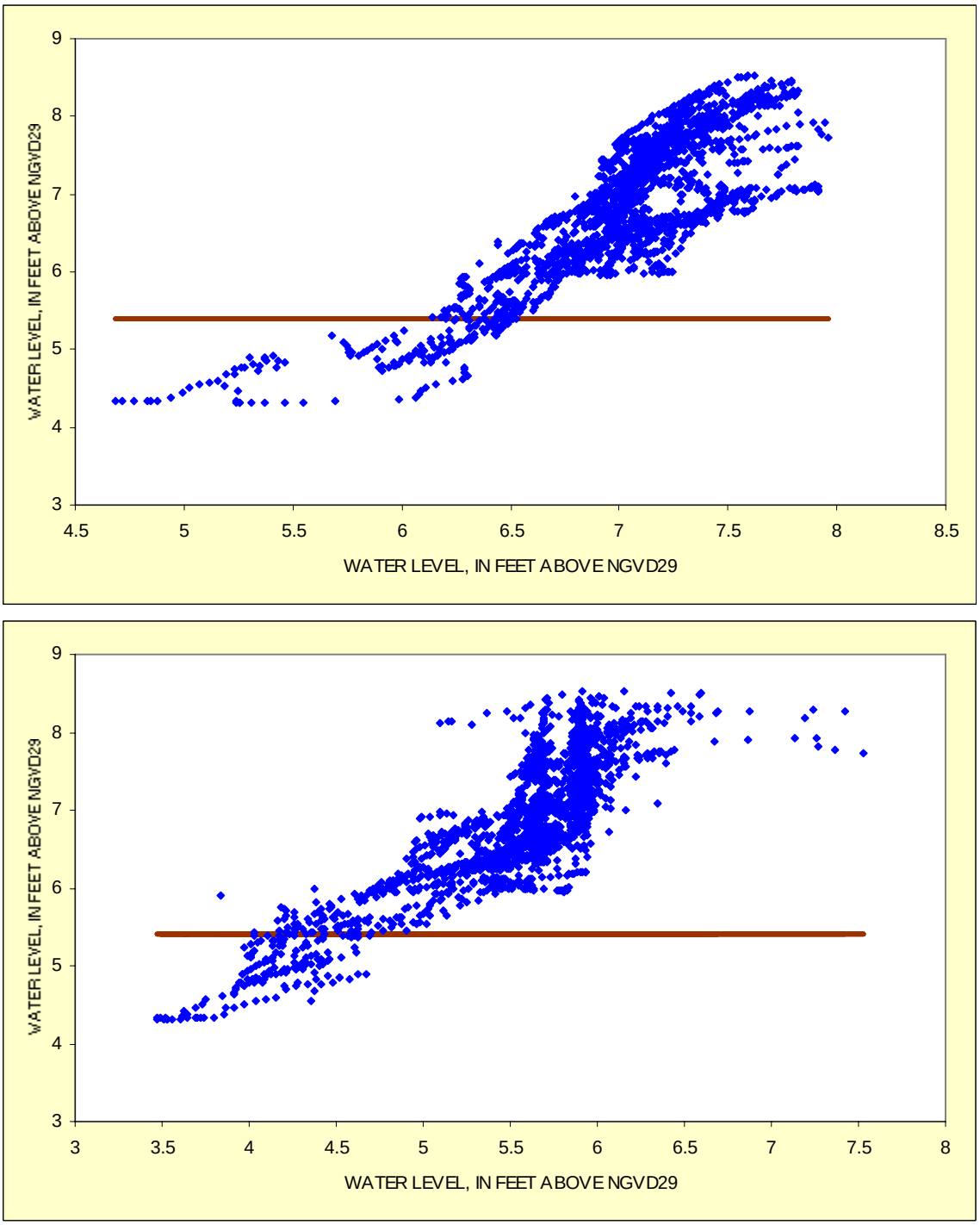

Figure 33 Water level in stilling well 3BS1W1_H (Y axis) is plotted against stage at the headwater side (top; correlation coefficient = 0.85) and tailwater side of spillway S334 (bottom; correlation coefficient = 0.88). The horizontal brown lines represent land-surface elevation at station 3BS1W1_H.

6 GROUNDWATER FLOW

The vertical and horizontal flow of groundwater at each of the tree islands was analyzed using the daily-values data. Maps and cross sections were constructed to show the potentiometric surfaces during extreme conditions and during average conditions. These results indicate that groundwater flow at the islands is complex, with groundwater flow at each island varying temporally and spatially. In general, water levels in the wells and piezometers at each tree island differ only a few hundreds or a few tenths of a foot on the same date. These small differences indicate rather flat a water table and potentiometric surface, which probably result from the flat topography and high hydraulic conductivities. Bevier and Krupa (2001) reported hydraulic conductivities at 3AS3 ranged from 0.58 to 103.6 feet per day (ft/d) in the piezometers and 1.5 to 16.08 ft/d in the deep wells. Hydraulic conductivities at 3BS1 ranged from 30.82 to 184 ft/d in the deep wells (Bevier and Krupa, 2001). Similarly, the small differences between water levels in piezometers and adjacent deep wells indicate good hydraulic connection between the vertical zones in the aquifer.

6.1 3AN1

The regression model results show that groundwater flow at 3AN1 varies from 0.009 to 1.855 ft/d, with a median of 0.184 ft/d (table 5). The direction of flow ranges from 0.2 to 180 degrees from north, with a median of 48 degrees. However, the direction provided by the model is actually the orientation or trend of the flow, without regard to true direction. In other words, a value of 90 degrees from north can indicate flow either from west to east or east to west.

Statistics	Flow (feet per day)	Direction (degrees from true north)
Minimum	0.009	0.2
Mean	0.233	64
Median	0.184	48
Maximum	1.855	180
Standard Deviation	0.181	54.3
Variance	0.033	2,945

Table 5 Summary statistics for groundwater flow and direction at tree island 3AN1

Groundwater flow at 3AN1 generally increases as water levels decline, possibly as a result of increasing gradients (figs. 34). However, groundwater flow fluctuated erratically at the beginning of the period of record for unknown reasons.

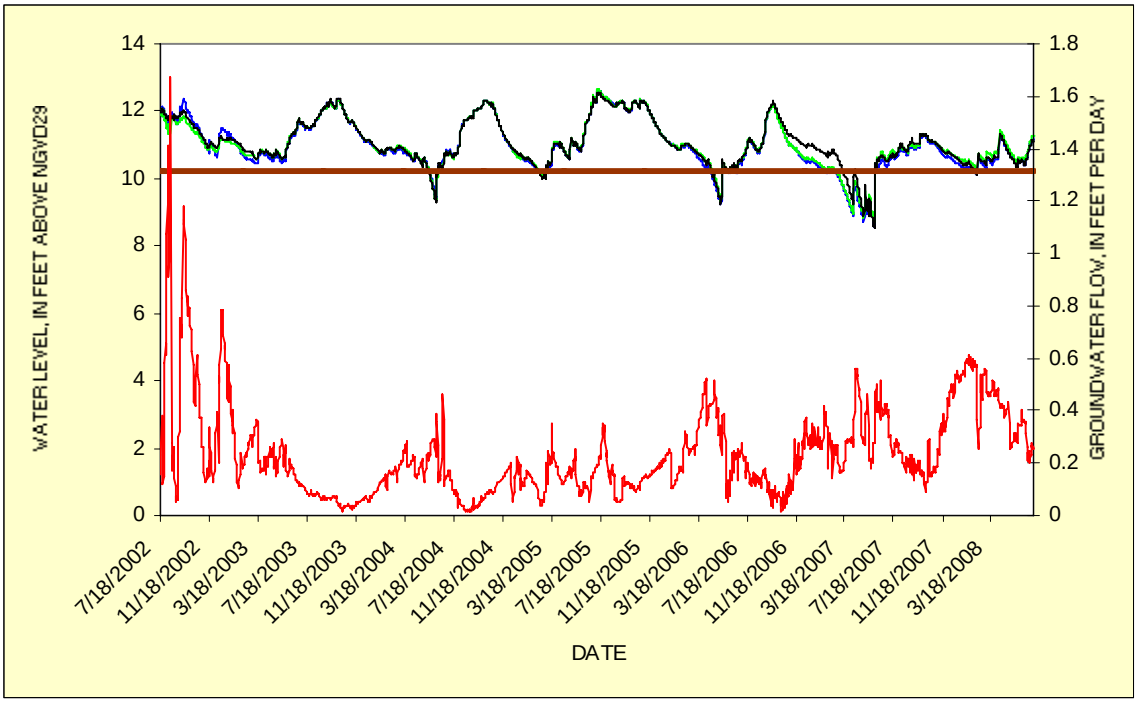

Figure 34 Groundwater flow (red) is plotted with water-level data from wells 3AN1W1_GW (green), 3AN1W3_GW (blue) and 3AN1W4_GP (black). The horizontal brown line represents land-surface elevation at site 3AN1W1.

The direction of vertical groundwater flow was qualitatively determined at three well sites by subtracting the water level in the deep well from the water level in the stilling well (3AN1W1) or the piezometer at each site. A positive value indicates downward migration or recharge, and a negative value indicates upward migration or discharge. A small (1 – 2) percent of the time the value was 0, indicating minimal vertical flow. Table 6 shows the percentage of time during the period of record that groundwater at each well pair is either flowing downward or upward. The results indicate that 60 – 70 percent of the time, groundwater is discharging at sites 3AN1W1, 3AN1W2, and 3AN1W3. Site 3AN1W4, which only has a shallow piezometer, could not be analyzed. The direction of groundwater flow does not fluctuate seasonally or appear to be related to water levels (fig. 35).

Well Site	Percentage of time vertical flow is upward	Percentage of time vertical flow is downward
3AN1W1	61	37
3AN1W2	72	27
3AN1W3	73	26

Table 6 Vertical groundwater flow at tree island 3AN1

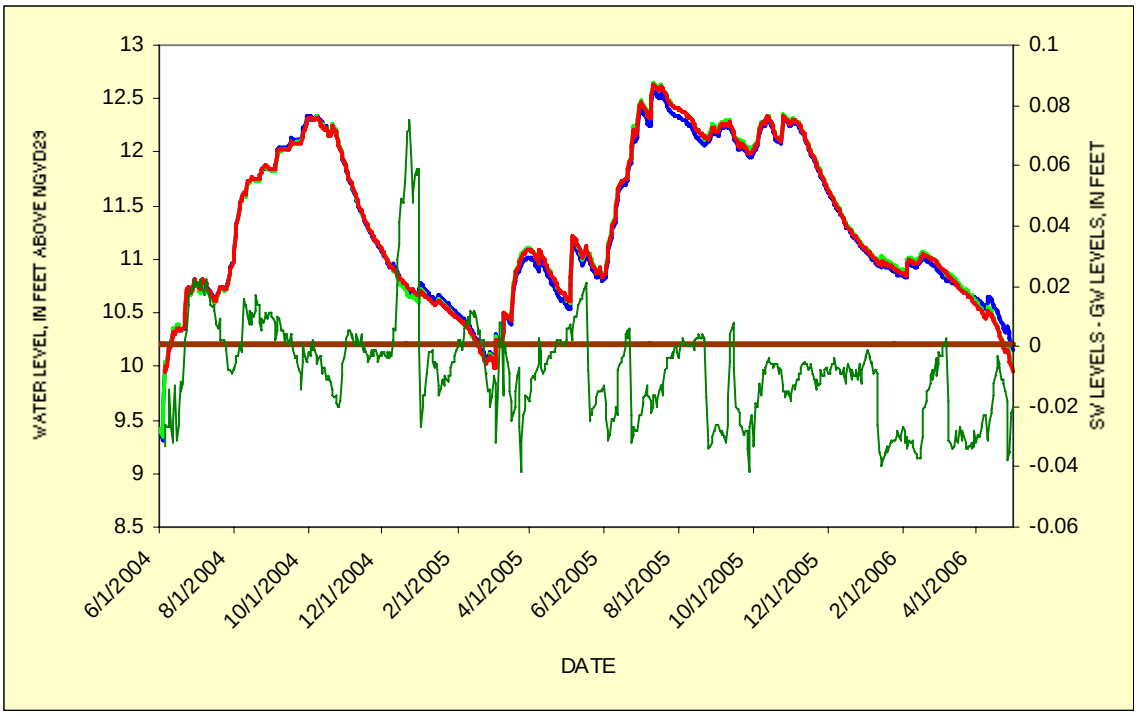

Figure 35 The difference between surface-water and groundwater levels (dark green) is plotted with water levels in stations 3AN1W1_GP (blue), 3AN1W1_GW (green), and 3AN1W1_H (red). The horizontal brown line represents land-surface elevation at 3AN1W1.

The configuration of the water table in the aquifer changes over time with seasonal fluctuations in water levels in the wells. For example, levels in the wells in October 2004 (annual maximum) show mounding of ground water under the tree island (fig. 36). Cross sections indicate that water levels were relatively high and even the tree island was inundated (fig. 37, top). Water levels in the piezometers indicate the water table slopes to the south. Furthermore, the water level in the shallow piezometer was higher than the level in the deep well at 3AN1W1, indicating vertical flow was downward. However, flow conditions were reversed at 3AN1W3, south of the tree island, where water level in the deep well was higher than the level in the shallow piezometer. In other words, groundwater appears to be recharging north of the tree island at 3AN1W1, flowing south of the island, and then discharging at 3ANW3.

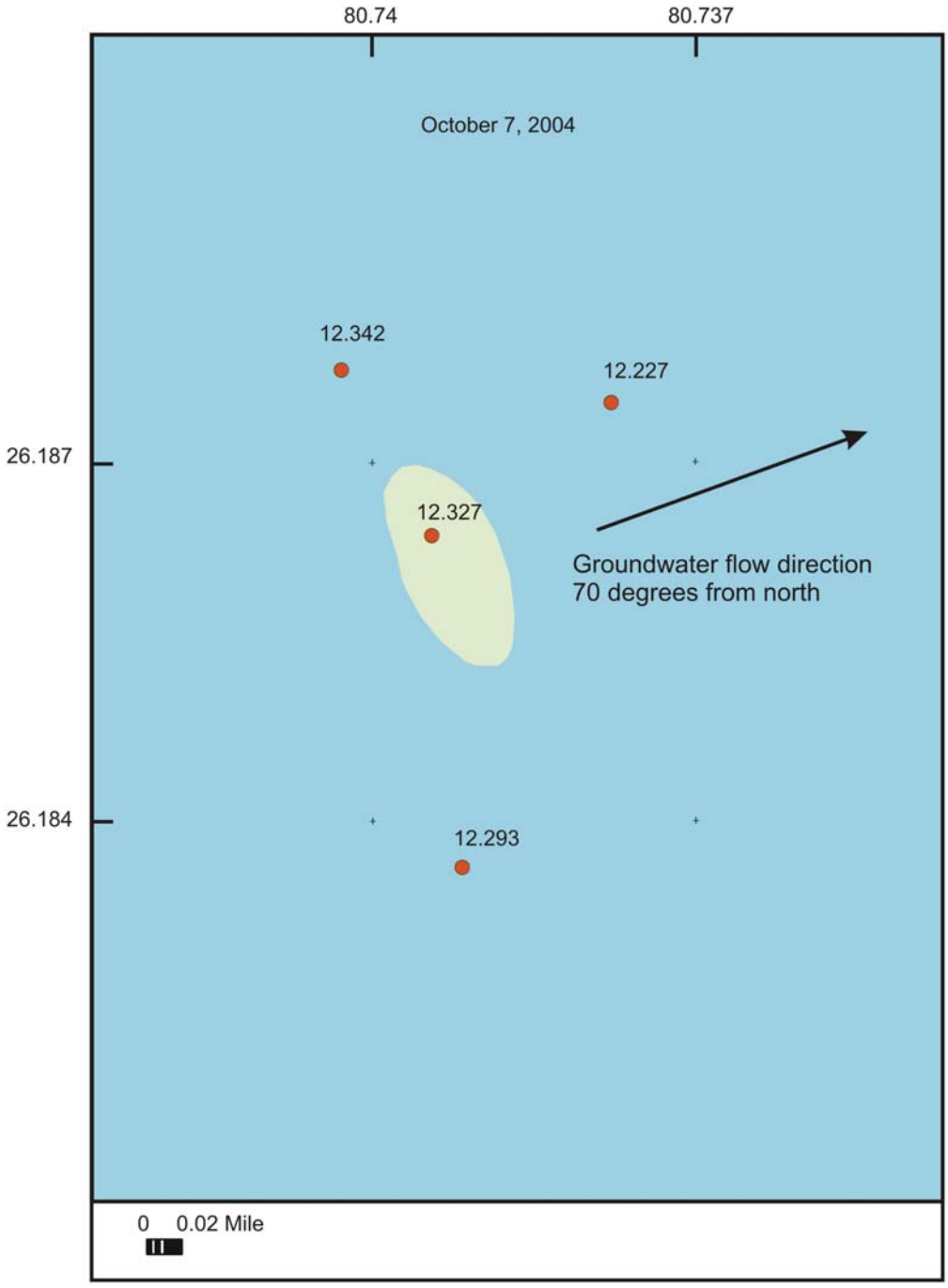

Figure 36 Water levels in shallow piezometers in and around 3AN1 on October 7, 2004. Direction of flow is based on regression model.

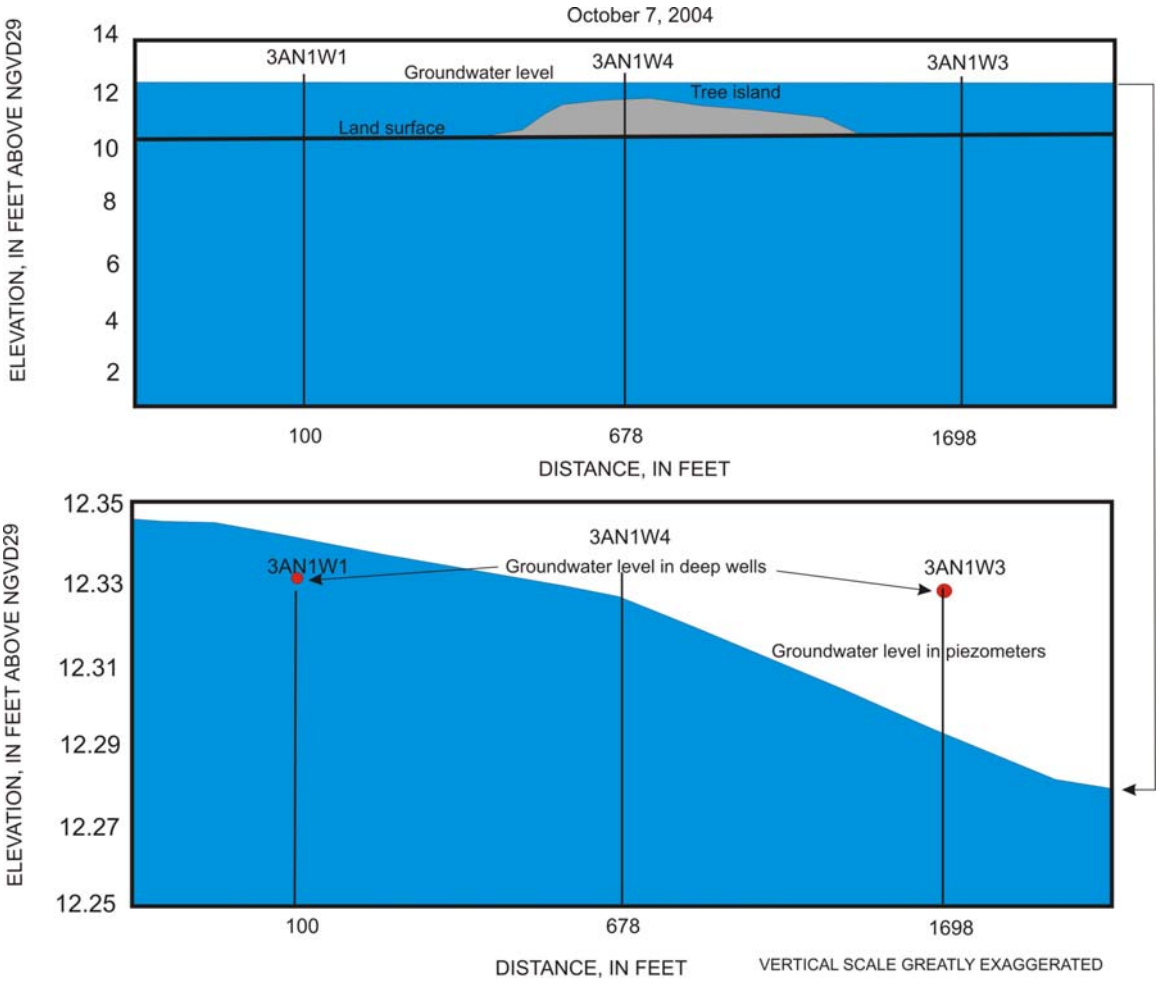

Figure 37 Cross sections showing the configuration of the water table and water levels in deep wells at 3AN1 on October 7, 2004. Water levels beyond the wells were estimated using extrapolation.

Water levels in the wells during May 2007 (annual minimum) indicate a depression of ground water under the tree island (fig. 38). During this time, water levels in the wells were nearly 2 ft below land surface (fig. 39, top). Water levels in the piezometers indicate a depression in the water table beneath the tree island (fig. 39, bottom). The deeper roots from the trees could be causing higher evapotranspiration rates at the island, and subsequently a more rapid lowering of the groundwater. As a result, local groundwater flow appears to be toward the island, with overall groundwater flow to the southeast.

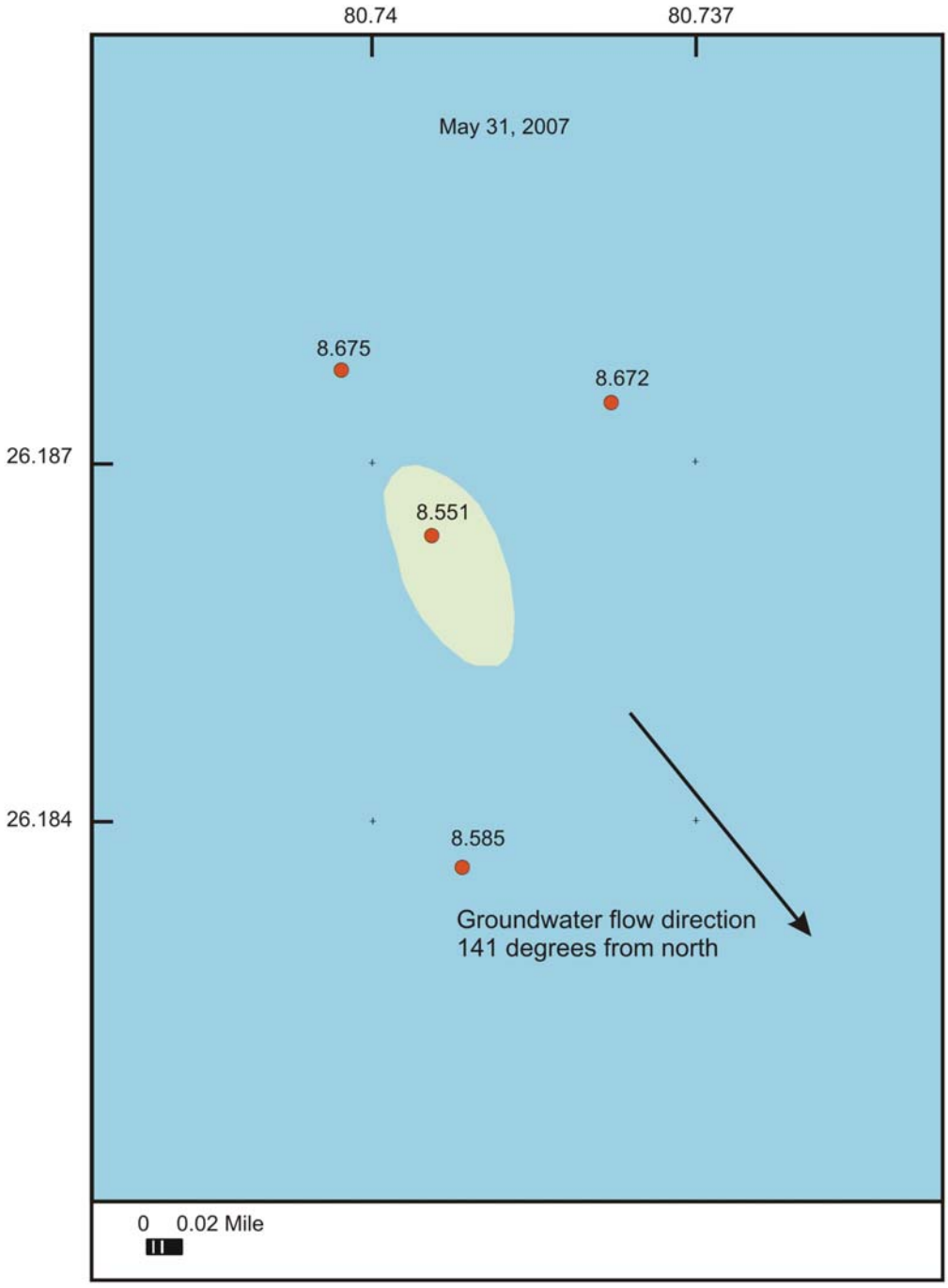

Figure 38 Water levels in shallow piezometers in and around 3AN1 on May 31, 2007. Direction of flow is based on regression model.

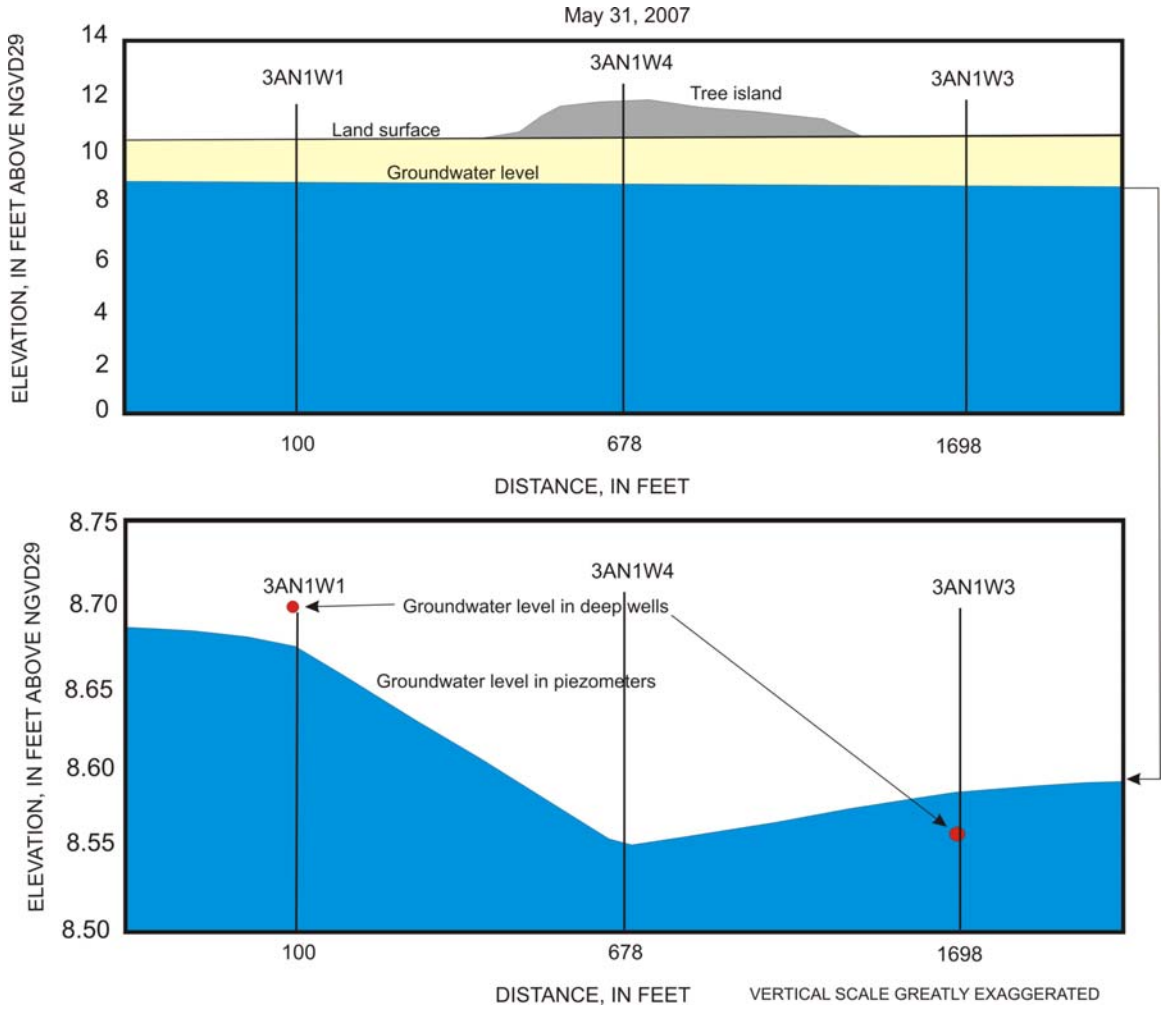

Figure 39 Cross sections showing the configuration of the water table and water levels in deep wells at 3AN1 on May 31, 2007. Water levels beyond the wells were estimated using extrapolation.

The groundwater depression under the tree island in May 2007 could be a unique situation caused by the low rainfall and extreme dry conditions that existed in early 2007. A map of water levels in June 2004 indicates mounding of groundwater under the island, similar to October 2004 (Appendix B). In general, the water level in the piezometer at 3AN1W4 is consistently higher than the water levels in 2 to 3 of the other piezometers around the tree island (Appendix B). The higher groundwater levels under the island indicate that water is flowing horizontally away from the island to the surrounding areas. Vertical movement of groundwater appears to fluctuate over time, with areas surrounding the tree island alternately serving both as places of groundwater recharge and groundwater discharge. Overall, the groundwater hydrology is complex, with numerous flow paths and changing directions.

6.2 3AS3

The regression model results show that groundwater flow at 3AS3 varies from 0.002 to 0.777 ft/d, with a median of 0.082 ft/d (table 7). These flow values are significantly less than the flow at 3AN1, which had a median value of 0.184 ft/d. The direction of flow ranges from 0.1 to 180 degrees from north, with a median of 94 degrees (east-west).

Statistics	Flow (feet per day)	Direction (degrees from true north)
Minimum	0.002	0.1
Mean	0.106	94
Median	0.082	94
Maximum	0.777	180
Standard Deviation	0.084	44.6
Variance	0.007	1,997

Table 7 Summary statistics for groundwater flow and direction at tree island 3AS3

Groundwater flow at 3AS3 fluctuates over time, but does not appear to be related to seasons or changes in water levels in the wells (figs. 40). The maximum flow occurred on February 16, 2007, shortly after a gap in the data that lasted from January 1 – February 10, 2007. The high flow rates do not coincide with extremes in rainfall or other environmental factors. The high flow rates, which extend from February 11 to about mid March, could be anomalies, but the water-level data upon which the flow is based appear valid.

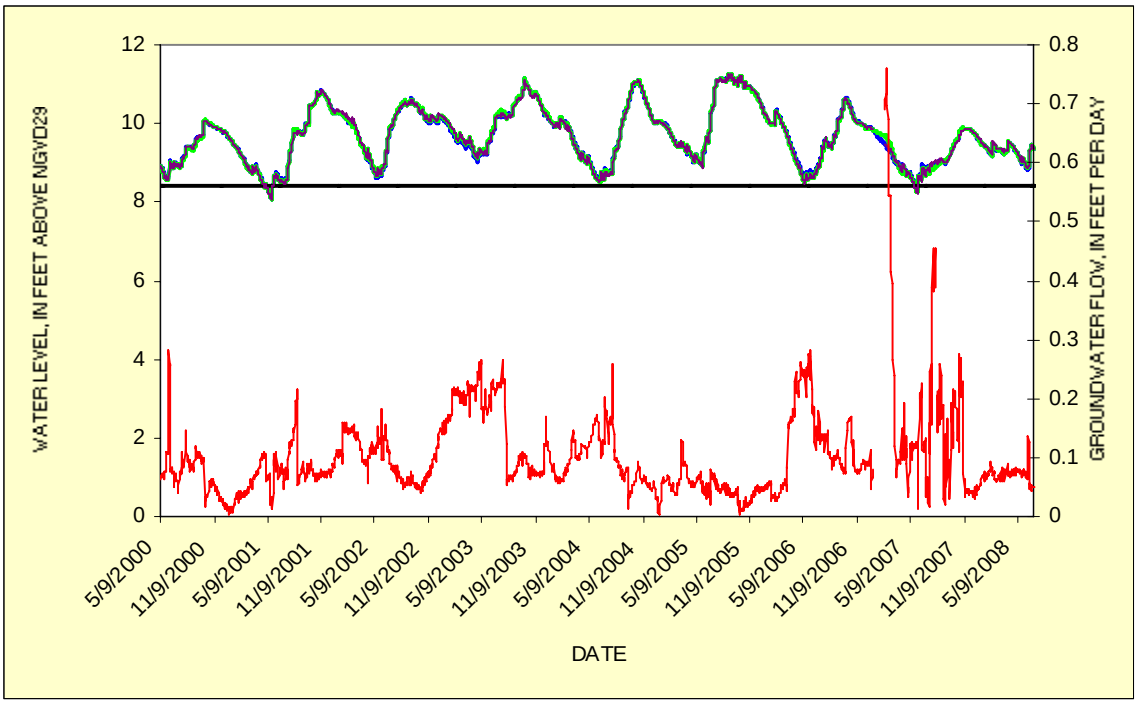

Figure 40 Groundwater flow (red) is plotted with water-level data from wells 3AS3W1_GW (blue), 3AS3W2_GW (green) and 3AS3W3_GW (black). The horizontal brown line represents land-surface elevation at site 3AS3W1.

The direction of vertical groundwater flow was determined at all four well sites by subtracting the water level in the deep well from the water level in the stilling well (3AS3W1) or the piezometer at each site. A positive value indicates downward migration or groundwater recharge, and a negative value indicates upward migration or groundwater discharge. A small (1 – 3) percent of the time the value was 0, indicating no vertical flow. Table 8 shows the percentage of time during the period of record that groundwater at each well pair is either flowing downward or upward. About 80 - 90 percent of the time, groundwater is discharging at sites north of the tree island (3AS3W1 and 3AS3W2). Groundwater underlying the tree island (site 3AS3W4) and south of the island (3AS3W3) alternates between flowing upward (discharging) and flowing downward (recharging). The direction of groundwater flow does not fluctuate seasonally or appear to be related to water levels in the wells (fig. 41). The difference between surface-water and groundwater levels at 3AS3W1 is consistently negative, indicating groundwater discharge. The maximum value of 0.172 occurred on March 22, 2005, and could be related to a rainfall of 1.58 inches that occurred on March 17. Additional analysis of the data is needed to determine the factors affecting the vertical movement of groundwater.

Well Site	Percentage of time vertical flow is upward	Percentage of time vertical flow is downward
3AS3W1	90	10
3AS3W2	84	15
3AS3W3	50	47
3AS3W4	42	56

Table 8 Vertical groundwater flow at tree island 3AS3

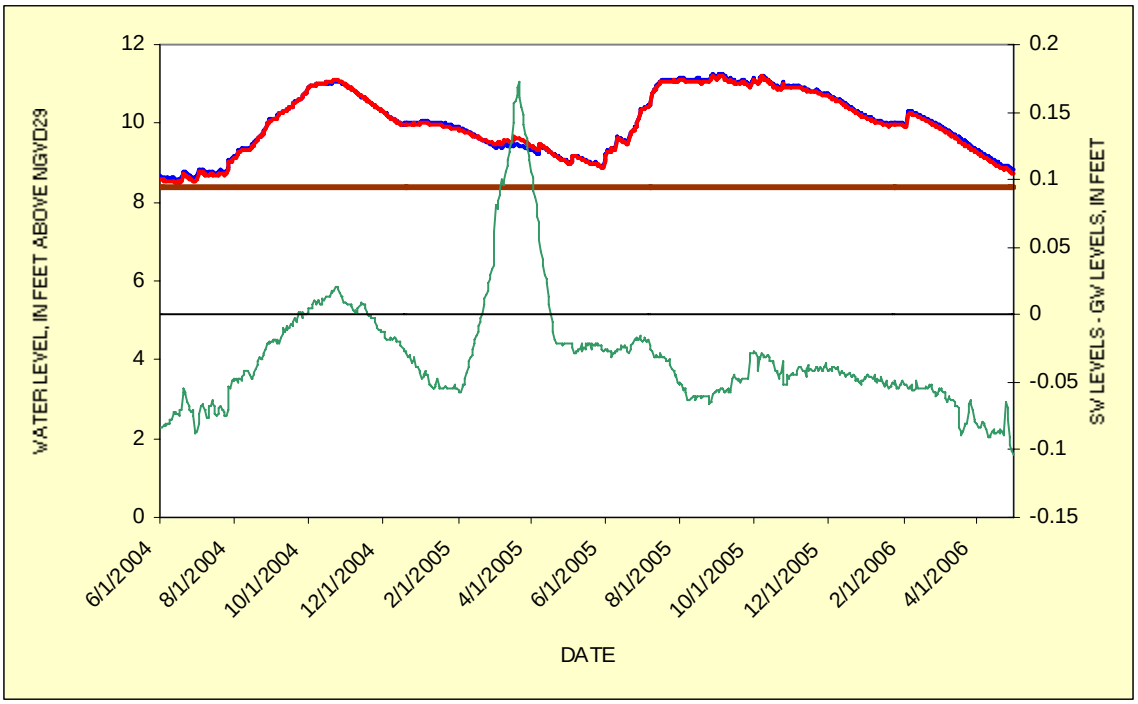

Figure 41 The difference between surface-water and groundwater levels (dark green) is plotted with water levels in stations 3AS3W1_GW (blue) and 3AS3W1_H (red). The thick horizontal brown line represents land-surface elevation at 3AS3W1.

As with 3AN1, the configuration of the water table at 3AS3 changes over time with seasonal fluctuations in water levels in the wells. Water levels in the wells in October 2004 (annual maximum) indicate a similar mounding of groundwater under the tree island (fig. 42). Cross sections indicate that water levels were relatively high and even the tree island was inundated (fig. 43, top). Water levels in the piezometers indicate the water table has an overall slope to the north. Unlike 3AN1, water levels in the four piezometers at 3AS3 are higher than water levels in their adjacent deep wells on this date, indicating vertical flow was downward and groundwater was recharging throughout the entire area.

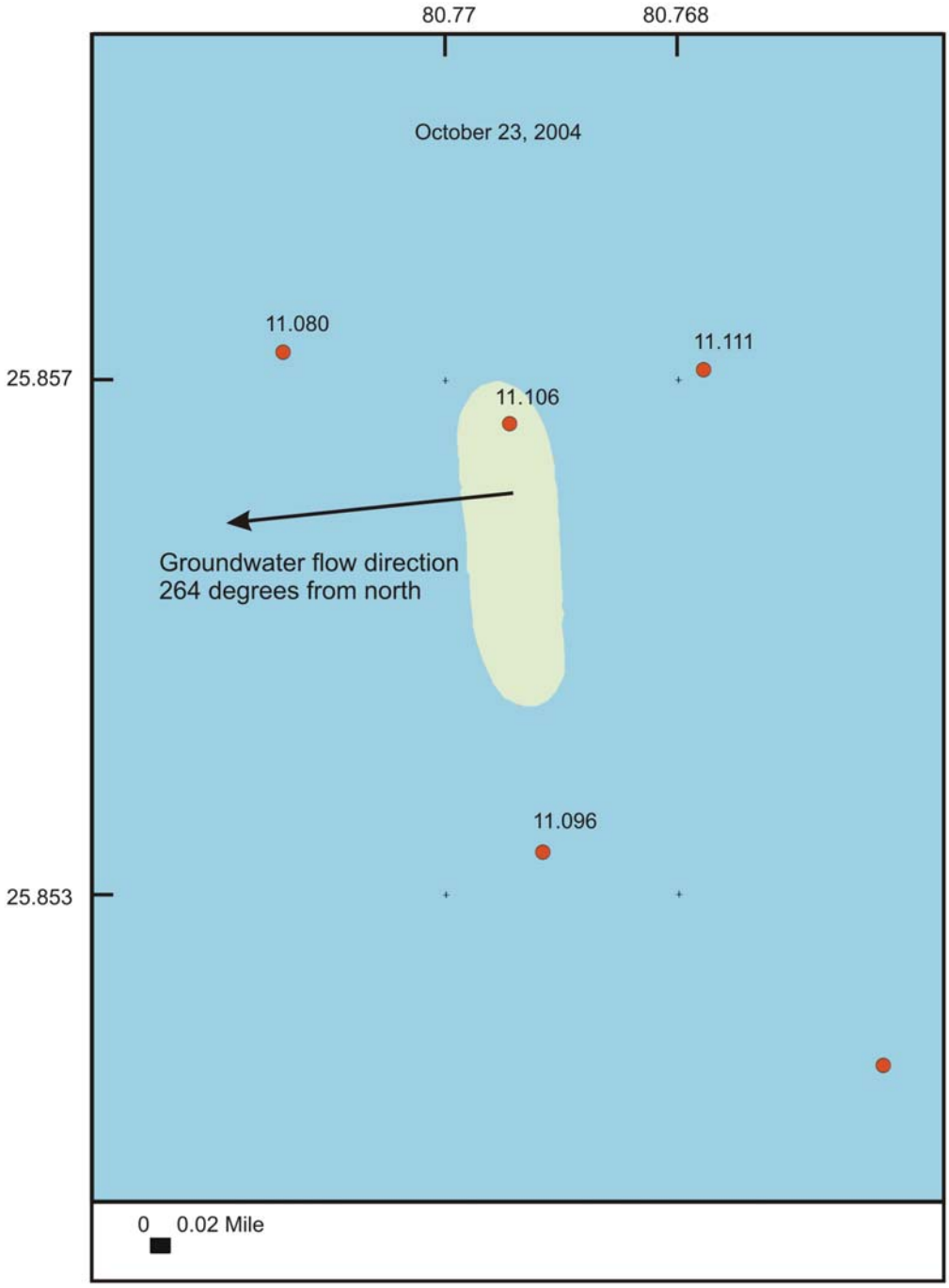

Figure 42 Water levels in deep wells in and around 3AS3 on October 23, 2004. Direction of flow is based on regression model.

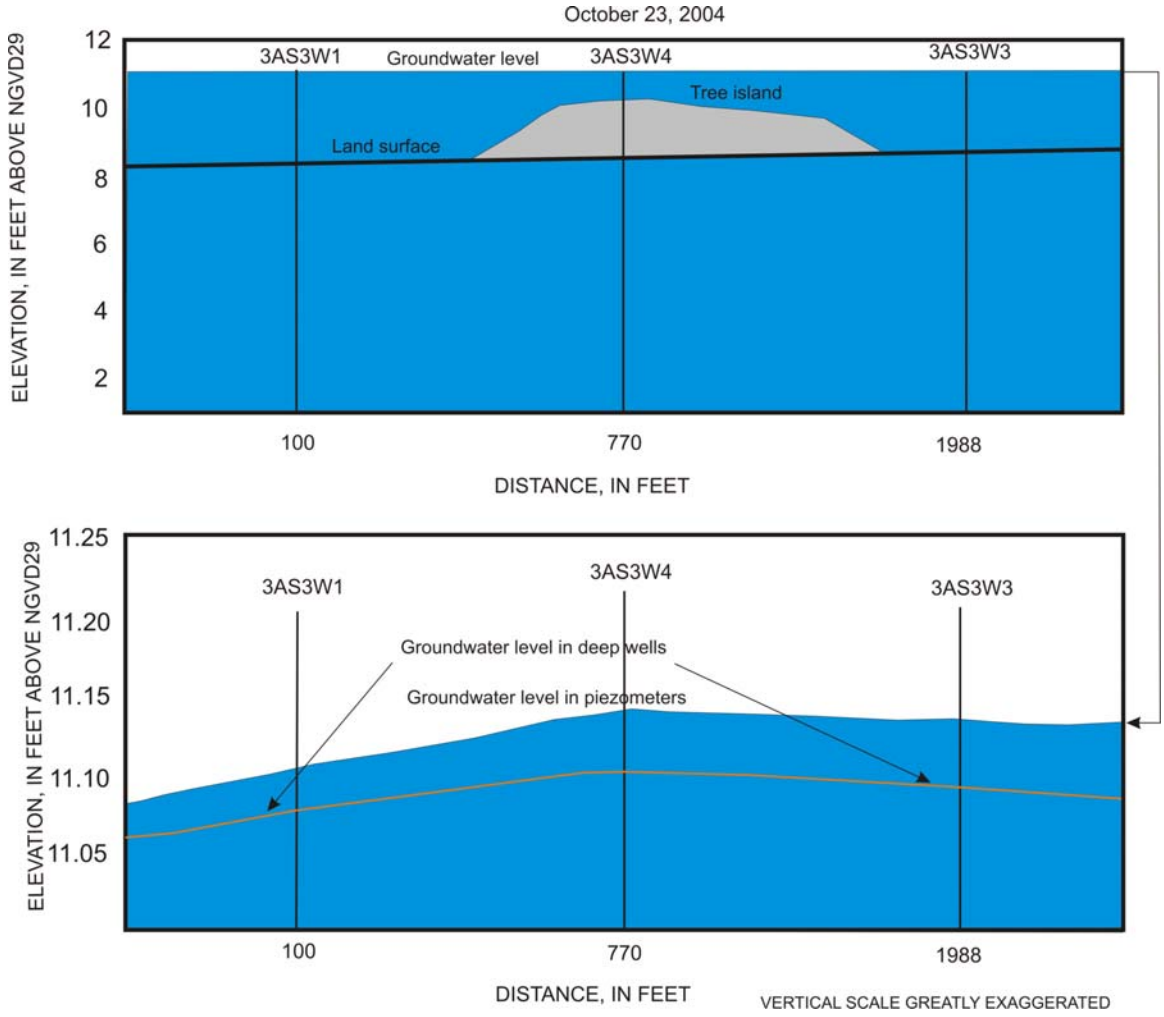

Figure 43 Cross sections showing the configuration of the water table and water levels in deep wells at 3AS3 on October 23, 2004.

Water levels in the deep wells during May 2007 (annual minimum) show a slope in the potentiometric surface to the south-southeast (fig. 44). Water levels in the wells at all four locations were below land surface, ranging from 0.2 ft below land surface at 3AS3W1 to 0.7 ft below land surface at 3AS3W3 (fig. 45, top). Unlike 3AN1, water levels in the piezometers do not indicate a depression in the water table beneath the tree island; however, the gradient in the water table is steeper north of the tree island compared to the gradient south of the tree island (fig. 45, bottom). The deep roots from the trees at the island, and subsequent high rates of evapotranspiration, or other hydrogeologic factors could be causing the change in gradient under the tree island. In addition, water levels are higher in the piezometer compared to the water level in the adjacent deep well at 3AS3W1, indicating downward migration of groundwater. In contrast, water level in the deep well at 3AS3W3 is higher than the level in the adjacent piezometer, indicating groundwater is upwelling into more shallow zones. In summary,

the water levels in the wells and piezometers around 3AS3 indicate a localized groundwater flow system, with groundwater migrating downward north of the tree island, then flowing south, and ultimately migrating upward to shallow zones near 3AS3W3. Additional analysis is needed to determine the factors affecting these small spatial changes in the water table.

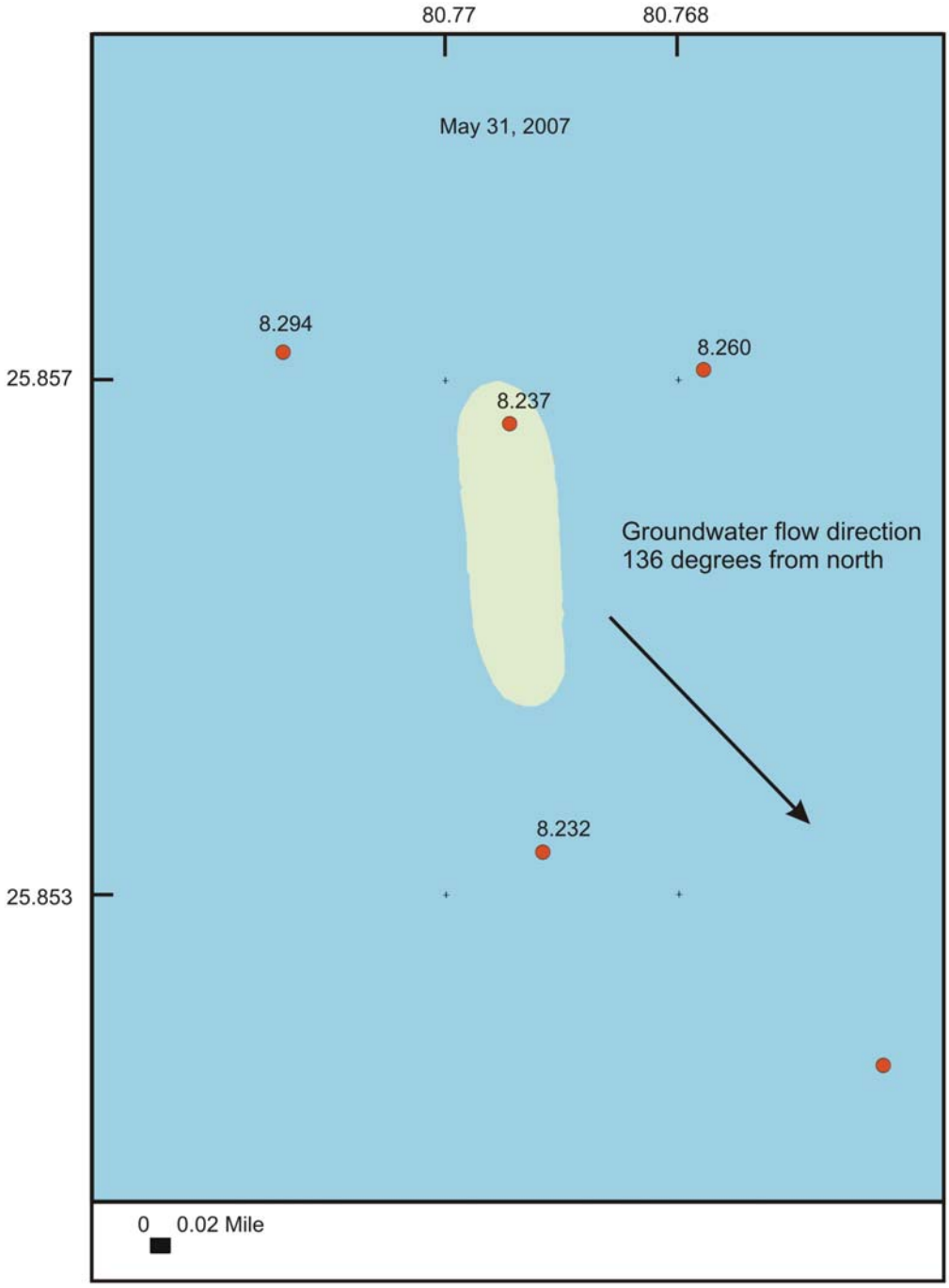

Figure 44 Water levels in deep wells in and around 3AS3 on May 31, 2007. Direction of flow is based on regression model.

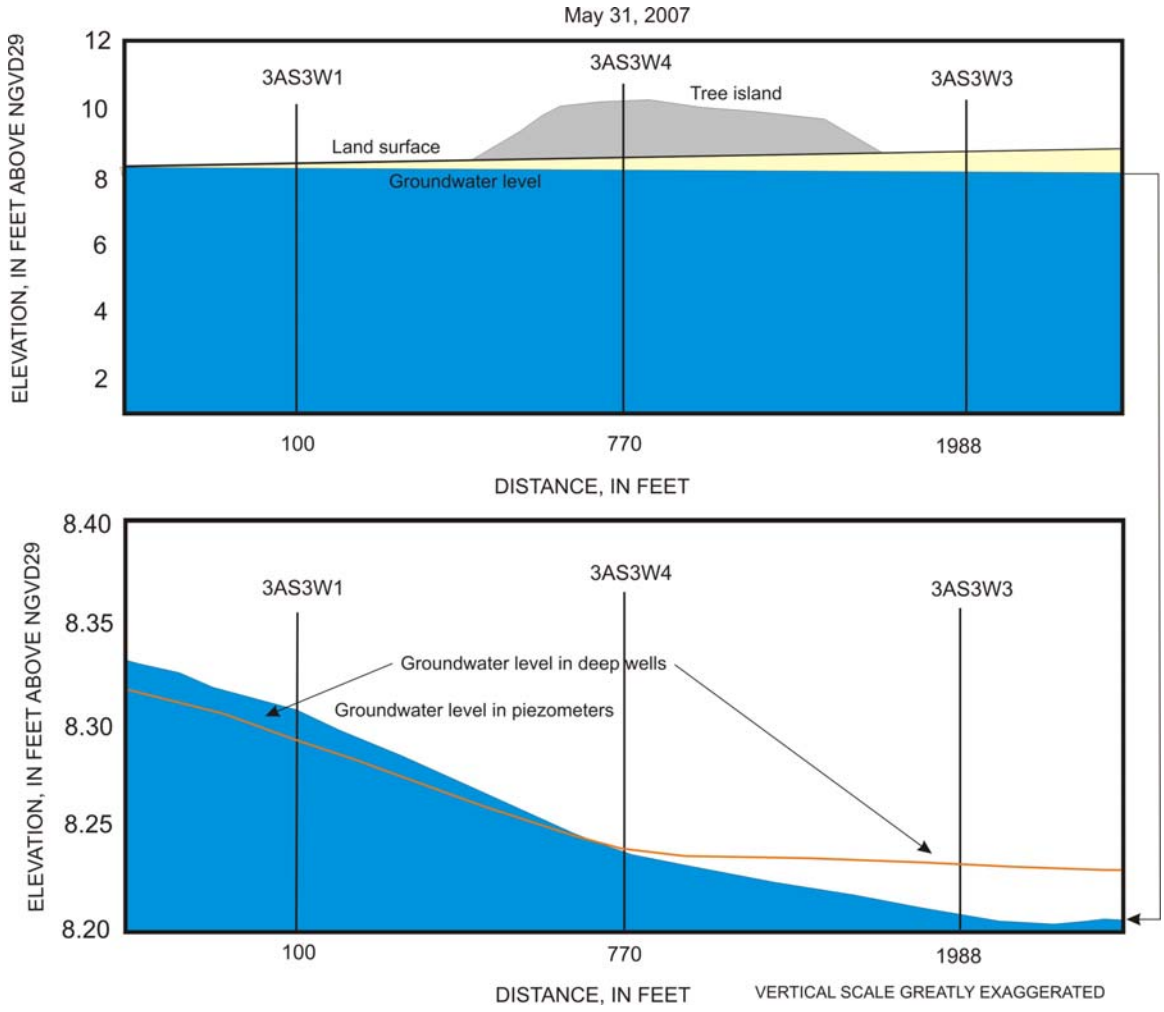

Figure 45 Cross sections showing the configuration of the water table and water levels in deep wells at 3AS3 on May 31, 2007. Water levels beyond the wells were estimated using extrapolation.

With the exception of May 31, 2007, water levels in the piezometer and deep well at 3AS3W4 generally are higher than the water levels in most of the other piezometers and wells around the tree island (Appendix B). The higher groundwater levels under the island indicate that water is flowing horizontally away from the island to the surrounding areas. Vertical movement of groundwater appears to fluctuate over time, with areas north of the tree island serving primarily as places of groundwater recharge, and areas south of the island serving both as places of groundwater recharge and groundwater discharge. As with 3AN1, the groundwater hydrology at 3AS3 is complex, with numerous flow paths and changing directions.

6.3 3BS1

The regression model results show that groundwater flow at 3BS1 varies from less than 0.001 to 1.684 ft/d, with a median of 0.096 ft/d (table 9). The range of flow values is comparable to the flow at 3AN1. However, the median value at 3BS1 is closer to the median value of flow at 3AS3, which was 0.082 ft/d. The direction of flow ranges from 79 to 109 degrees from north, with a median of 90 degrees (east-west). In other words, most of the flow is oriented in an east-west direction. The results for flow direction were similar regardless of whether the water levels at the island (well site 3BS1W4) were included in the model or not.

Statistics	Flow (feet per day)	Direction (degrees from true north)
Minimum	<0.001	79
Mean	0.132	90
Median	0.096	90
Maximum	1.684	109
Standard Deviation	0.154	1.748
Variance	0.024	3.055

Table 9 Summary statistics for groundwater flow and direction at tree island 3BS1

Groundwater flow at 3BS1 fluctuates over time, but only roughly corresponds to seasons or changes in water levels in the wells (figs. 46). Higher flow rates generally occur during declines in groundwater levels, possibly as a result of increases in gradients. As with 3AS3, the maximum flow occurred in February 2007, shortly after a gap in the data that lasted from January 1 – February 10, 2007. The high flow rates do not coincide with extremes in rainfall or other environmental factors. The high flow rates, which extend from February 11 to about mid March, could be anomalies, but the water-level data upon which the flow is based appear valid. The similarity with the peak in flow rate at 3AS3 (see fig. 40) could indicate these data are valid. More analysis, perhaps using incremental data over shorter time periods, is needed to determine the factors affecting temporal variations in flow rates.

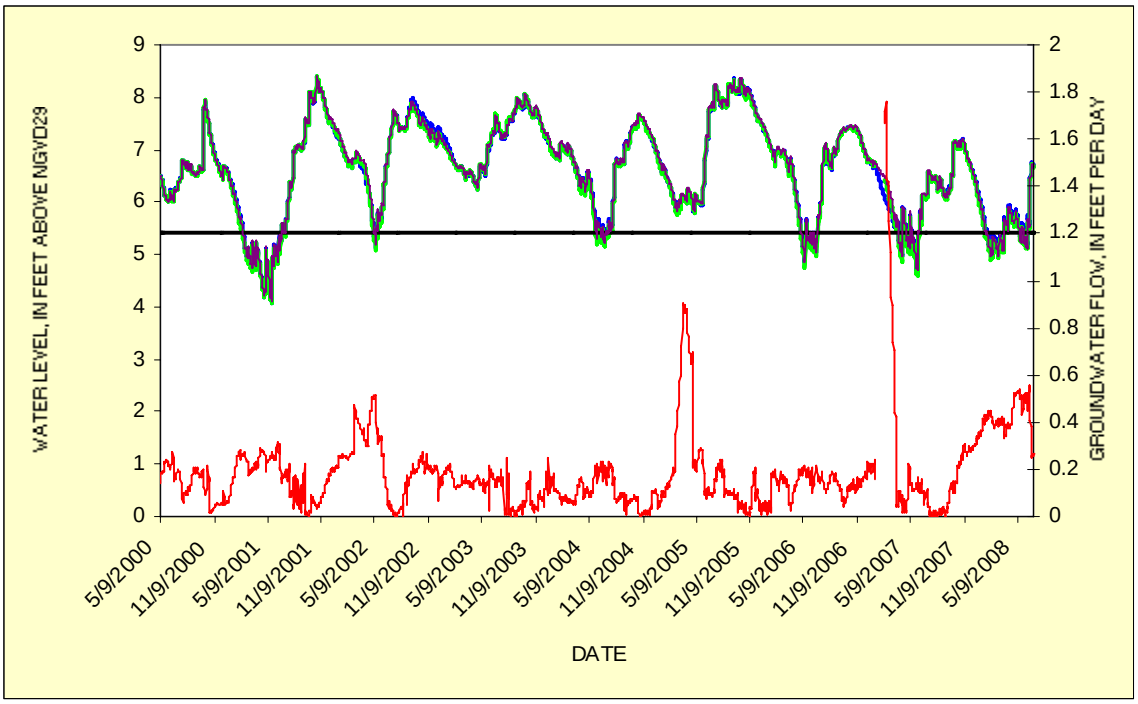

Figure 46 Groundwater flow (red) is plotted with water-level data from wells 3BS1W1_GW (blue), 3BS1W3_GW (green) and 3BS1W4_GW (black). The horizontal brown line represents land-surface elevation at site 3BS1W1.

The direction of vertical groundwater flow was determined at all four well sites by subtracting the water level in the deep well from the water level in the stilling well (3BS1W1) or the piezometer at each site. A positive value indicates downward migration or groundwater recharge, and a negative value indicates upward migration or groundwater discharge. As with the other two tree islands, a small (1 – 2) percent of the time the value was 0, indicating no vertical flow. The results indicate that most of the time (56 – 76 percent), groundwater is flowing downward at all four well sites at 3BS1 (table 10). The downward flow of groundwater occurs throughout the year, but the difference between surface-water (or shallow groundwater) levels and water levels in the deep wells increases as the water levels in the wells increase (fig. 47). Upward movement of groundwater only seems to occur at the end of the dry season, during periods of annual water-level minima.

Well Site	Percentage of time vertical flow is upward	Percentage of time vertical flow is downward
3BS1W1	37	62
3BS1W2	22	76
3BS1W3	42	56
3BS1W4	36	63

Table 10 Vertical groundwater flow at tree island 3BS1

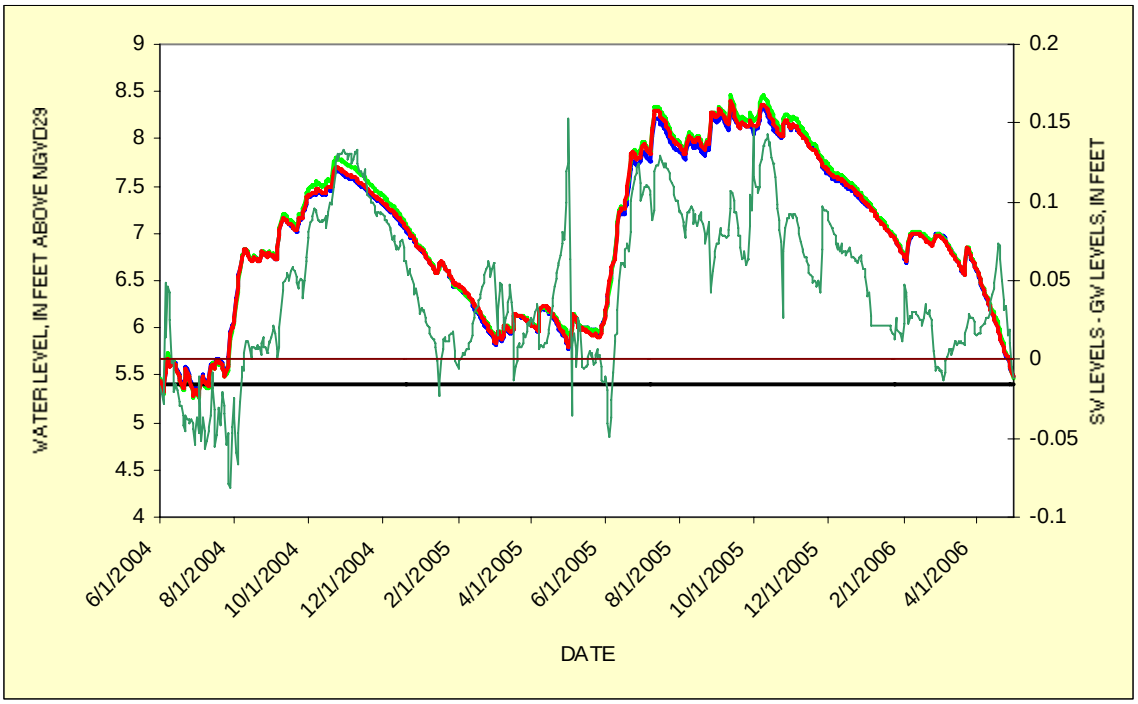

Figure 47 The difference between surface-water and groundwater levels (dark green) is plotted with water levels in stations 3BS1W1_GP (red), 3BS1W1_GW (blue) and 3BS1W1_H (green). The thick horizontal brown line represents land-surface elevation at 3BS1W1.

As with the other two tree islands, the configuration of the water table at 3BS1 changes over time with seasonal fluctuations in water levels in the wells. Water levels in the wells in October 2004 (annual maximum) indicate mounding of groundwater under the tree island (fig. 48), with the water level in the well at the island (3BS1W4) being higher than the water levels in any of the other three deep wells. Cross sections indicate that water levels were relatively high, inundating most of the land around the island. However, unlike the other two islands on this date, the tree island at 3BS1 was not

inundated (fig. 49, top). The topographic relief is higher at 3BS1 than at either of 3AN1 or 3AS3 (table 2), which could explain the lack of inundation. In addition, 3BS1 is in close proximity to the urban areas of Miami-Dade County (fig. 1). Groundwater withdrawals by the cities could result in the overall downward migration of groundwater (table 10) and a decline in groundwater levels. Water levels in the piezometers indicate the water table has an overall slope to the north. Similar to 3AS3, water levels in the four piezometers at 3BS1 are higher than water levels in their adjacent deep wells on this date, indicating vertical flow was downward and groundwater was recharging throughout the entire area.

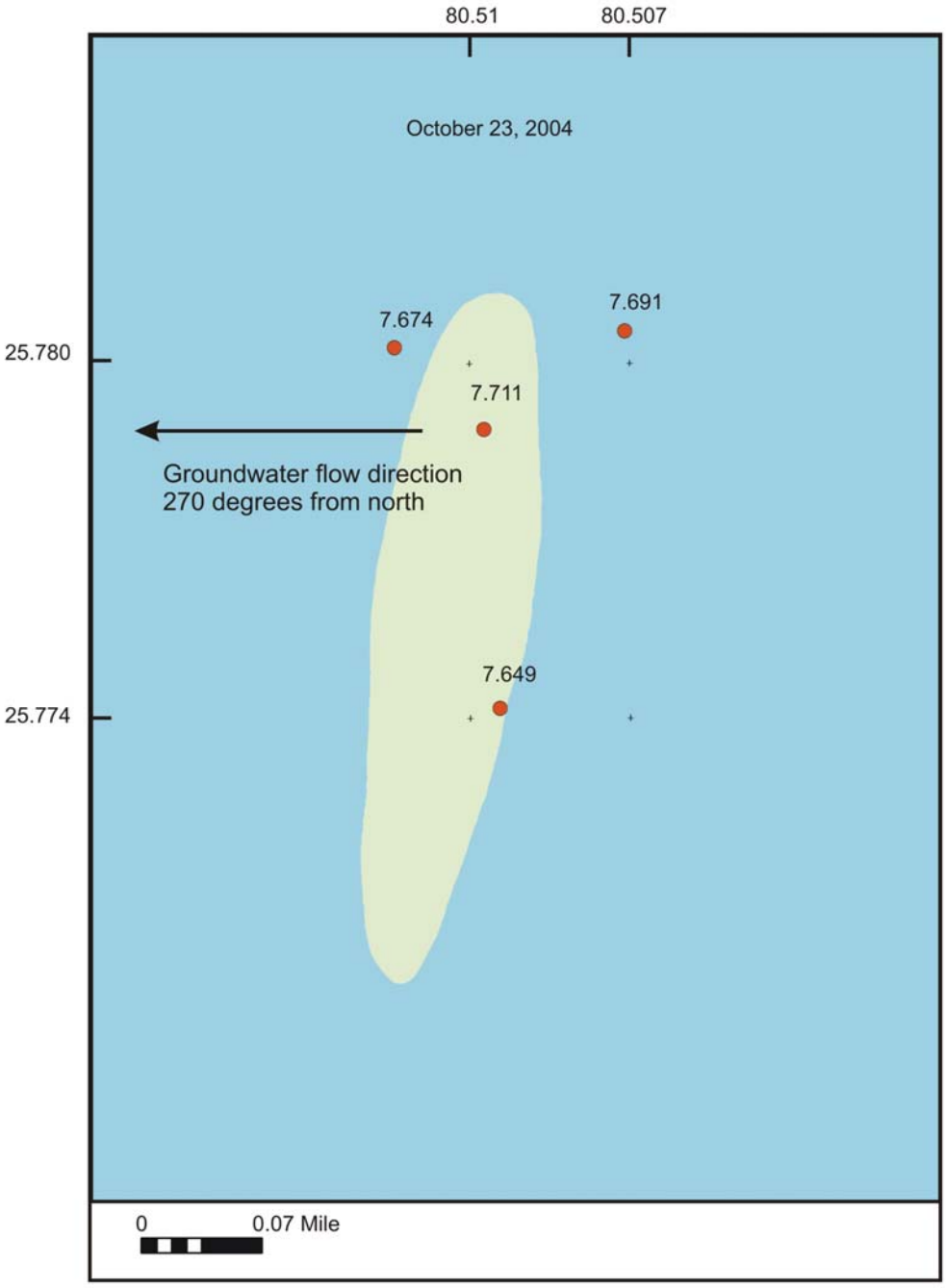

Figure 48 Water levels in deep wells in and around 3BS1 on October 23, 2004. Orientation of flow from the regression model was 90 degrees from north, but the direction of flow was estimated to be from east-west (270 degrees).

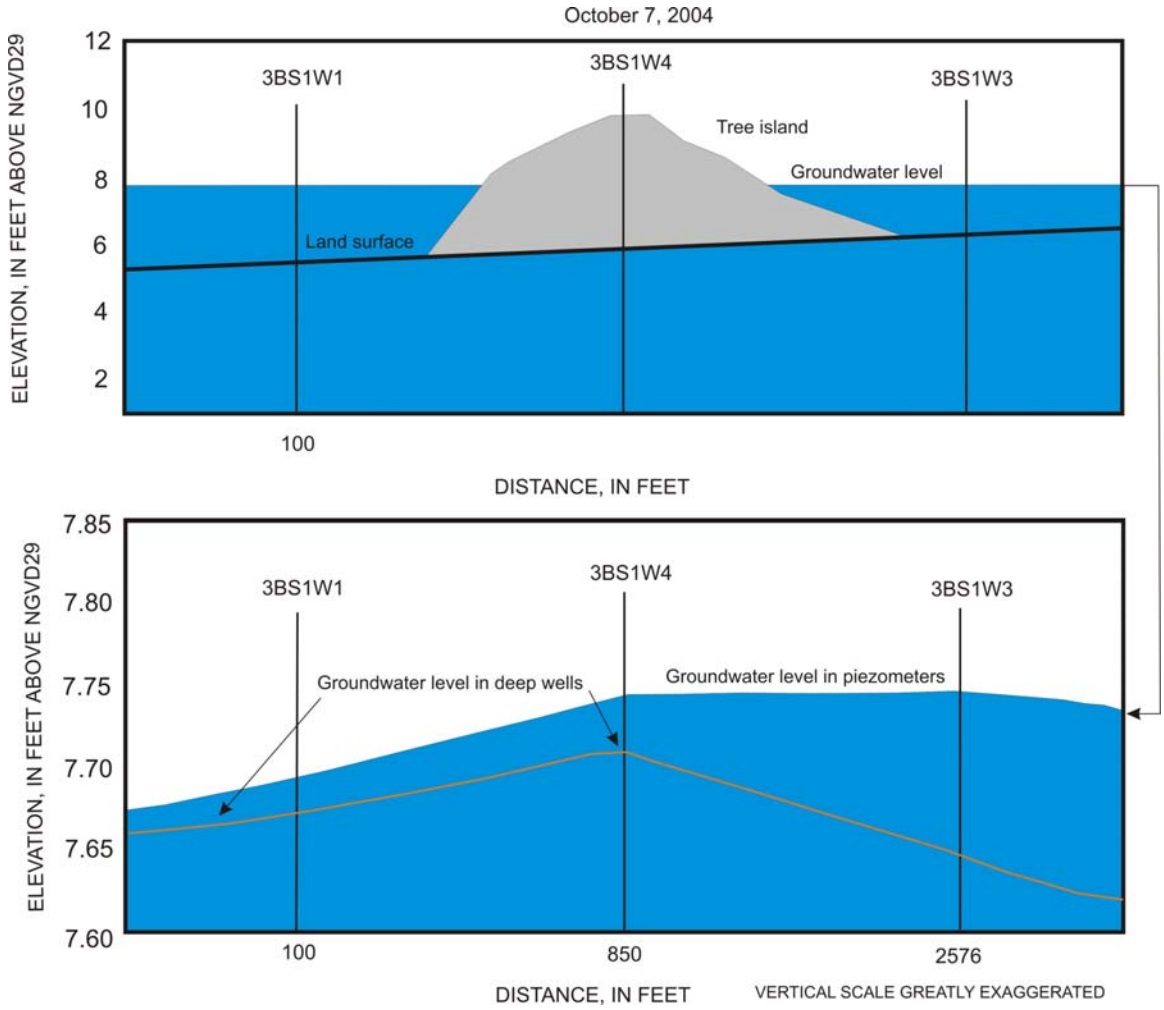

Figure 49 Cross sections showing the configuration of the water table and water levels in deep wells at 3BS1 on October 23, 2004.

Water levels in the deep wells during May 2007 (annual minimum) also show a mound in the potentiometric surface under the tree island (fig. 50). Water levels in the wells at all four locations were below land surface, ranging from 0.7 ft below land surface at 3BS1W1 to 1.6 ft below land surface at 3BS1W3 (fig. 51, top). The water level at 3BS1W4 was 5.41 ft below land surface. Water levels in both the piezometers and deep wells indicate a mounding of groundwater under the tree island (fig. 51, bottom), which is in contrast to the depression in the water table under 3AN1 on the same date. The water levels in the piezometers and deep wells also indicate that vertical groundwater flow is downward at sites 3BS1W1 and 3BS1W4, but is upward at 3BS1W3.

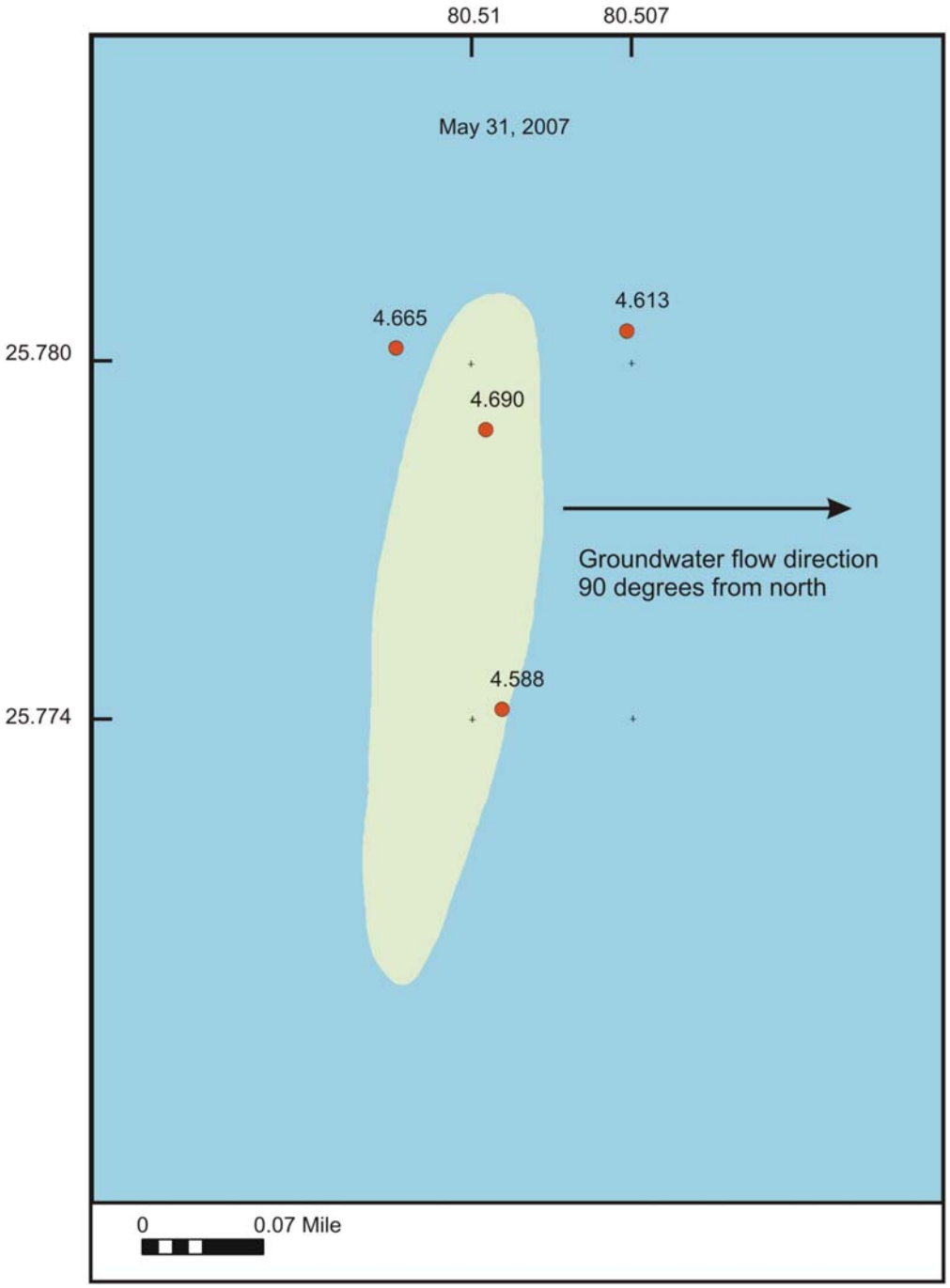

Figure 50 Water levels in deep wells in and around 3BS1 on May 31, 2007. Direction of flow is based on regression model.

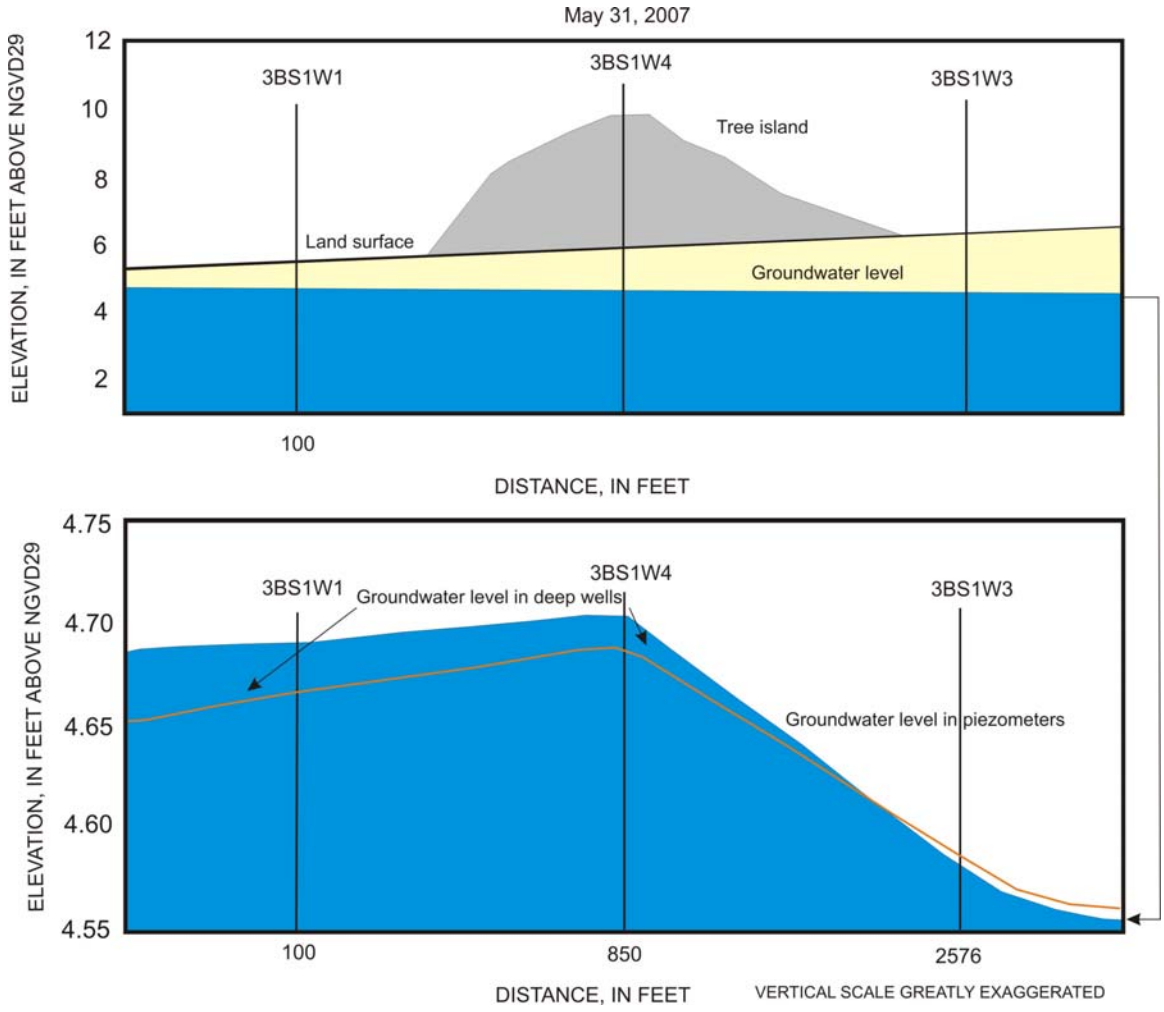

Figure 51 Cross sections showing the configuration of the water table and water levels in deep wells at 3BS1 on May 31, 2007. Water levels beyond the wells were estimated using extrapolation.

In summary, water levels in the piezometers and deep wells at and around 3BS1 indicate a persistent mounding of groundwater underneath the tree island itself (Appendix B). This mounding is inconsistent with the constant 90 degree direction of flow determined by the regression model. Even when the water levels at 3BS1W4 are disregarded, the groundwater flow at 3BS1 appears to range from southeast to southwest (figs. 48 and 50; Appendix B). Vertical groundwater movement is primarily downward, possibly a result of groundwater withdrawals from nearby urban areas in Miami-Dade County. Additional study is needed to verify actual groundwater flow directions and correlations between groundwater levels and withdrawals.

7 RECOMMENDATIONS

The results of this project, which was limited in scope to the daily-value data, provided an overview of the hydrology of the tree islands. However, additional analyses could be conducted on the extensive incremental and daily-value data to obtain an even more detailed understanding of the factors affecting the complex flow systems underlying the tree islands. Recommended analyses could include, but are not limited to, the following:

- Modify the regression model code to provide true direction of flow
- Determine the frequency of flow direction changes, and environmental or anthropogenic factors that affect flow direction
- Run the regression model with water-level data from nearby surface-water stations or monitor wells to determine direction and quantity of flow for larger areas
- Use incremental water-level and meteorological data to better quantify the effects of rainfall, evapotranspiration, and photosynthetic radiation on water levels
- Use incremental data to better understand factors and conditions affecting the vertical movement of groundwater
- Investigate the effect of groundwater withdrawals on the hydrology of 3BS1
- Couple the water-level and water-quality data from the stations to provide insight into the local flow systems underlying the islands

Geochemical modeling also could be used to help determine sources of inorganic constituents and chemical reactions along flow paths. These proposed investigations could be conducted as a single large project or as multiple smaller projects over time, to best satisfy SFWMD needs.

8 SUMMARY

Tree islands are tear-shaped topographic features in the relatively flat, low-lying landscape of southern Florida. Tree islands are only slightly (a few feet) elevated above the surrounding wetland, but are an important habitat for plants and animals. Tree islands are sensitive to changes in their hydrologic conditions; hence, a better understanding of the factors affecting the hydrology of tree islands is needed in the efforts to protect and restore the Everglades.

In 2000, the South Florida Water Management (SFWMD) began monitoring groundwater and surface-water levels, respectively, at three tree islands (designated 3AN1, 3AS3, and 3BS1) in Water Conservation Area 3 to better understand the unique hydrologic and ecologic conditions of the sites. A series of dual-zone monitor wells were installed at each of the three tree islands. Well pairs, which consisted of a shallow piezometer (depths from 4.1 to 15 ft below land surface) and a deep groundwater well (depths from 25 – 49.6 ft below land surface), were installed just northwest (W1), northeast (W2), and south of each island (W3). A well pair (W4) also was installed within each island. A stilling well was installed adjacent to the W1 well pair at each of the three islands to monitor surface-water stage. Water-level data were collected at 15-minute increments from the wells and stilling wells using pressure transducers and data loggers. A meteorological station also was established at 3AS3.

The water-level and meteorological data from the tree islands were analyzed for seasonal fluctuations and factors affecting water levels. Water-level data from the monitor wells also were analyzed to assess horizontal and vertical flow of groundwater. These analyses were primarily conducted using daily averages of the incremental data.

Meteorological data varied according to season, as was expected. Maximum air temperatures occurred in late August and September, and minimum air temperatures occurred in January and early February. Photosynthetic radiation and evapotranspiration peaked in May and June, and reached minimum values in late November and December.

Southern Florida generally has two seasons with respect to rainfall—a wet season that occurs from June through September and a dry season that lasts from October through May. During the period of record, data collected from the meteorological station at 3AS3 indicated cumulative rainfall during the wet season ranged from 17 to 36 inches, whereas cumulative rainfall during the dry season ranged from 10 to 25 inches.

Groundwater and surface-water levels also exhibit seasonal and temporal fluctuations related to meteorological conditions. Water levels in the wells and stilling wells generally reached minimum values toward the end of the dry season, around May of each year, and peaked in late September or October at the end of the wet season. Groundwater and surface-water levels were statistically higher at the end of the wet season compared to water levels at the end of the dry season. Furthermore, the amount of increase in groundwater and surface-water levels after a rain storm was positively correlated to the amount of rainfall during the storm.

The abundant rainfall in southern Florida results in the areas around the islands, and even the islands themselves, to be periodically or frequently inundated. For example, water-level data indicate the areas surrounding 3AS3 were inundated 85 to 100 percent of time during the period of record, while the island itself was inundated up to 24 percent of the time. The island at 3AN1 was inundated nearly 18 percent of the time, but the island at 3BS1 was never inundated, possibly from the higher topographic relief at that island.

Evapotranspiration and photosynthetic radiation also affected groundwater and surface-water levels at the tree islands. In general, water levels in wells and stilling wells declined as evapotranspiration and photosynthetic radiation increased. Analysis of incremental data indicated daily declines in water levels in wells at 3AS3 coincided with peaks in photosynthetic radiation that occurred during the middle of each day.

At any one time, the difference in water levels between well pairs installed at the same island was small, usually less than a tenth of a foot. The difference in water levels between the shallow piezometer and deep well in the same well pair was equally small. Small differences in water levels indicate a flat water table with low gradients, and result from the high hydraulic conductivity of the aquifer.

Results of regression analysis indicate groundwater flow at each island varied over time, and generally was higher at 3AN1 than at the other two islands. Groundwater flow at 3AN1 ranged from 0.009 to 1.855 feet per day (ft/d), with a median of 0.184 ft/d, whereas groundwater flow at 3AS3 ranged from 0.002 to 0.777 ft/d, with a median of 0.082 ft/d. Groundwater flow at 3BS1 ranged from less than 0.001 to 1.684 ft/d, with a median of 0.096 ft/d.

The direction of horizontal groundwater flow varied widely during the period of record, possibly from changing gradients with seasonal fluctuations in water levels. However, water levels indicated mounding of groundwater under all three islands. Mounding indicates that groundwater is flowing laterally away from each island to the areas underlying the surrounding wetland.

In contrast, water levels during May 2007 indicate a depression formed in the groundwater underlying the island 3AN1. This depression appears to be a unique situation caused in part by the low rainfall and excessive dry conditions in early 2007. Evapotranspiration by deep-rooted trees on the island could have contributed to the formation of the groundwater depression. Horizontal groundwater movement would have been toward the depression during this time. Additional study is needed to determine if the depression occurred at other times or if similar depressions ever formed under the other two islands.

Differences between water levels in the deep wells and water levels in the adjacent piezometers or stilling wells indicated the direction of vertical groundwater flow. Vertical groundwater flow was upward 60 to 70 percent of the time in the areas surrounding 3AN1. Groundwater flow also was upward 84 to 90 percent of the time in areas north of 3AS3; however, vertical groundwater was downward 47 and 56 percent of the time underlying the island and areas just south at 3AS3. Vertical groundwater flow was

downward at 56 to 76 percent of the time in and around 3BS1. Groundwater withdrawal from nearby urban areas in Miami-Dade County could be affecting vertical groundwater flow at 3BS1.

Nearby canals also could be affecting the hydrology of the tree islands. Surface-water levels at the three tree islands strongly correlated with water levels at several of the structures on nearby canals. Water levels in the stilling wells at 3AN1, 3AS3, and 3BS1 correlate to stage at S339_T (tailwater), 12B_H (headwater), and S334_T (tailwater), respectively. Further study is needed to document this effect.

In summary, the hydrology of the tree islands is complex, with considerable interaction between groundwater and surface. Mounding of groundwater indicates local lateral flow is away from the islands to areas underlying the surrounding wetlands, with direction of regional flow varying over time and with seasonal conditions. At 3AN1 and 3AS3, groundwater generally flows downward at the island and discharges in areas underlying the wetlands. Groundwater flow is primarily downward underlying areas in and around 3BS1. The downward movement of groundwater at 3BS1 could be related to groundwater withdrawals at nearby urban areas.

Additional analysis of the water-level data is recommended to further quantify meteorological and other factors affecting vertical and horizontal groundwater flow. These analyses can be coupled with existing water-quality data collected from the wells to better understand flow paths in the groundwater underlying the three tree islands.

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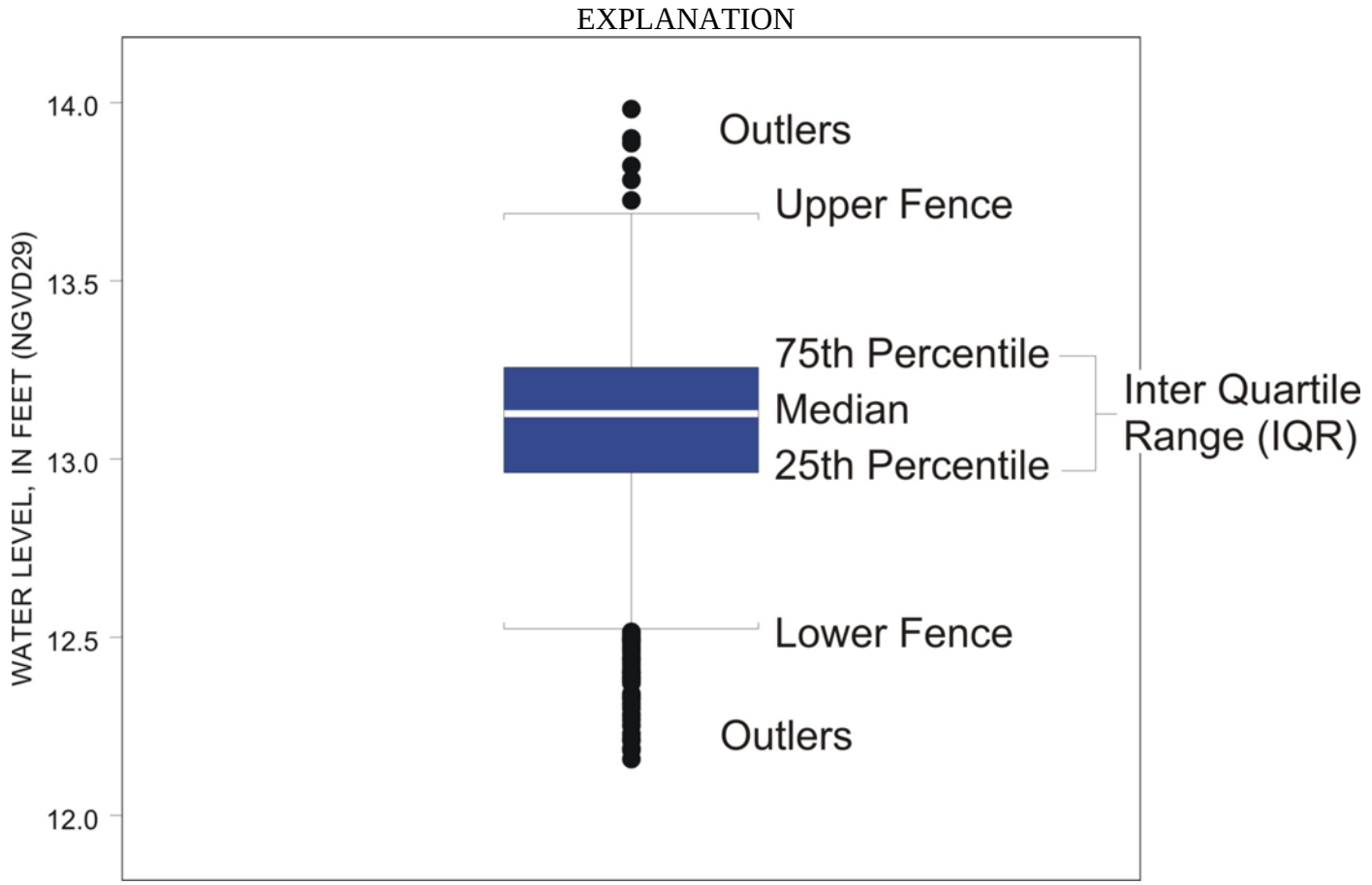
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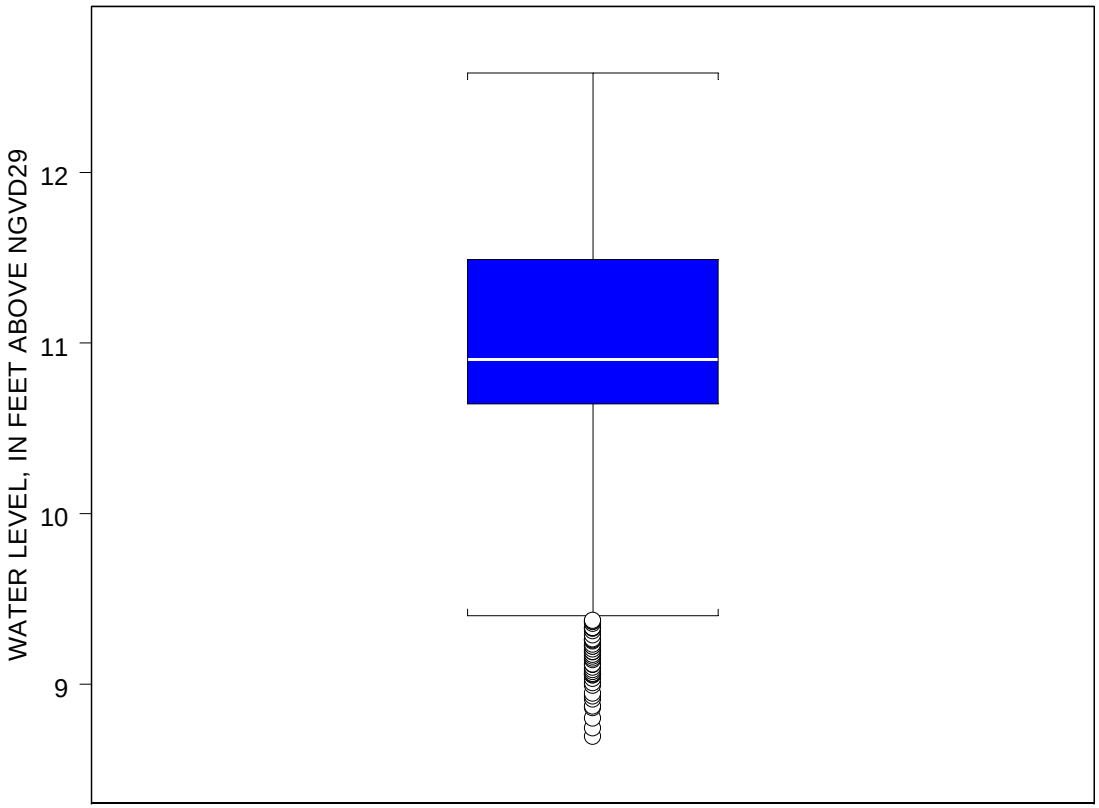

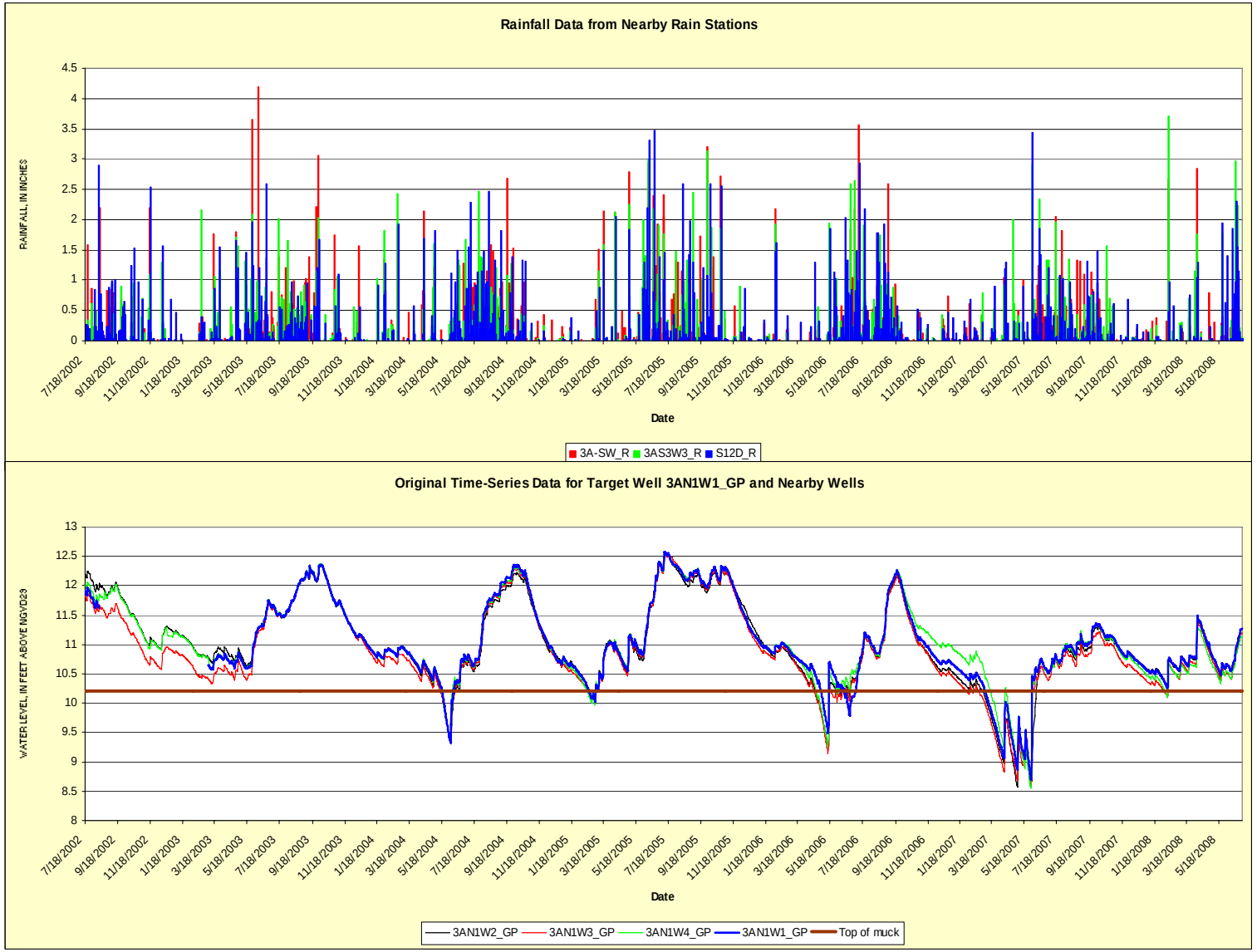
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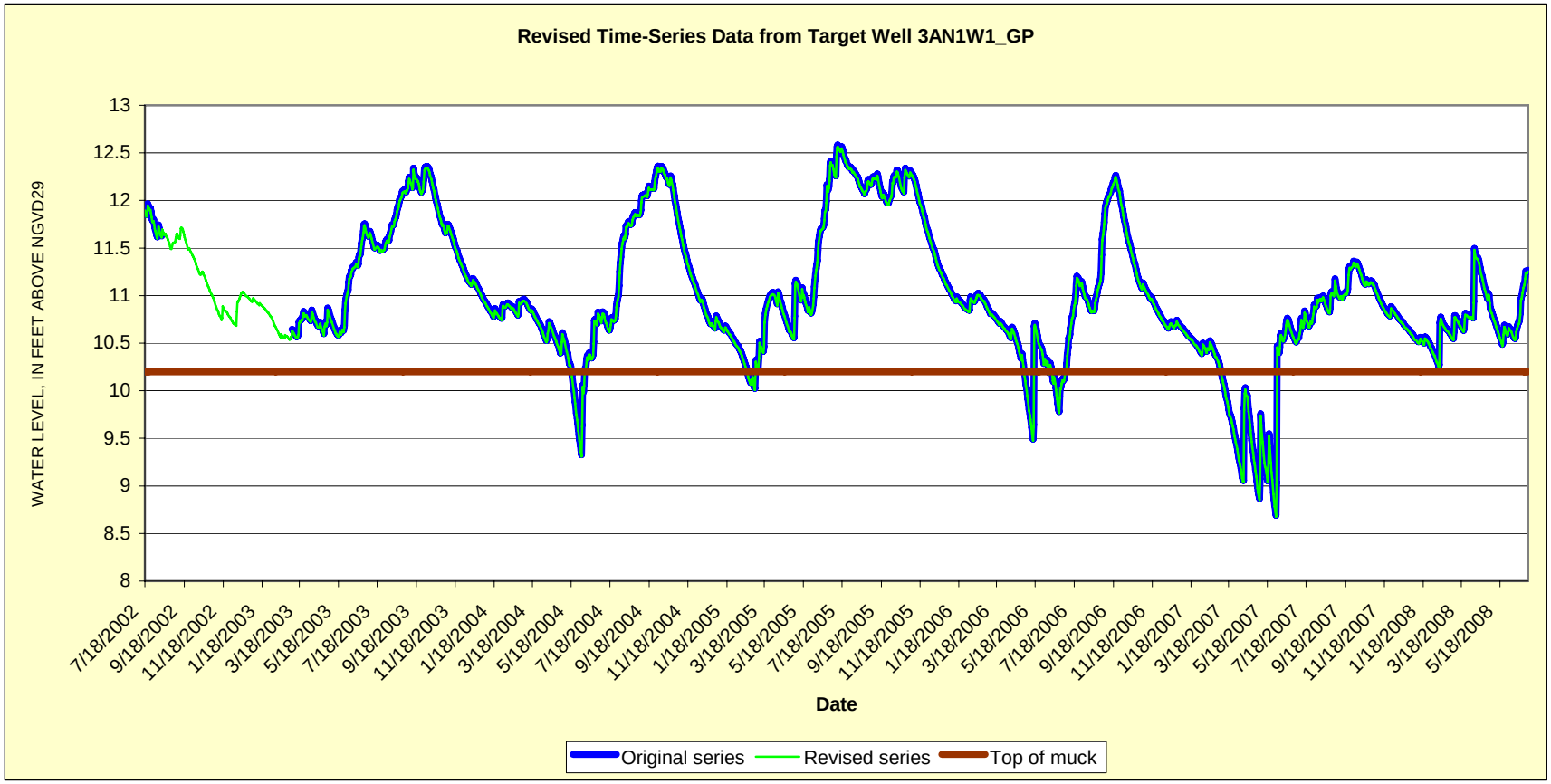
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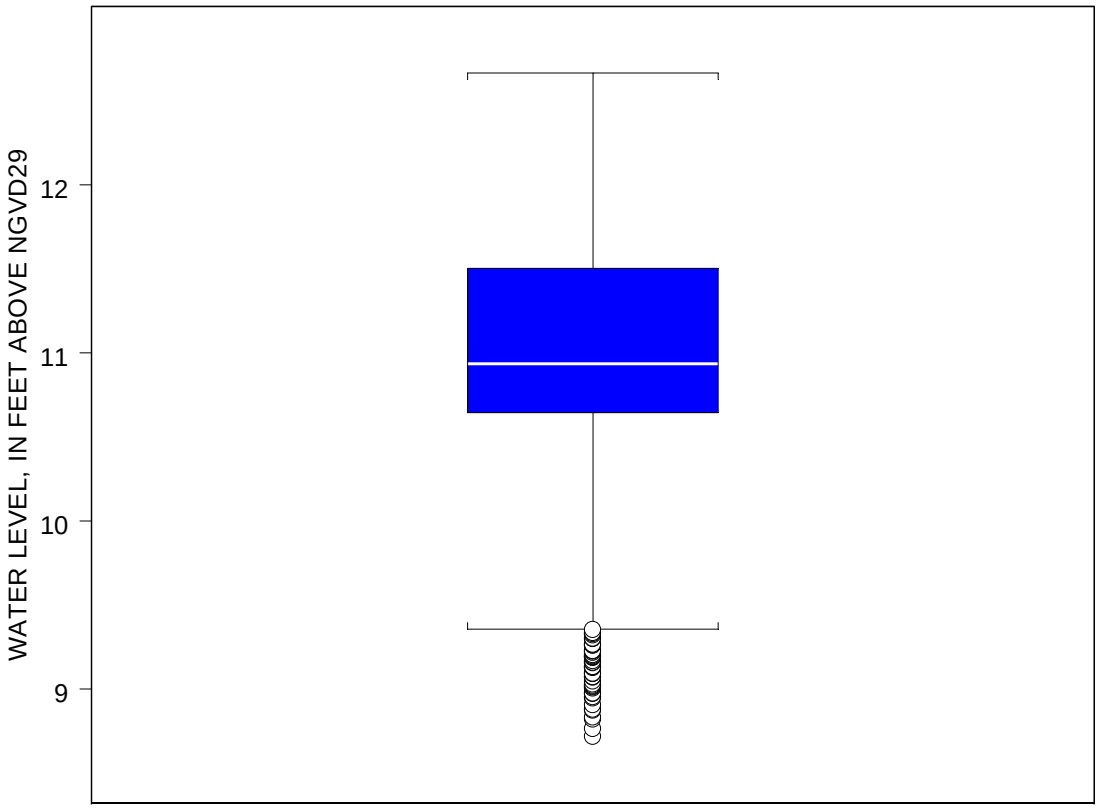

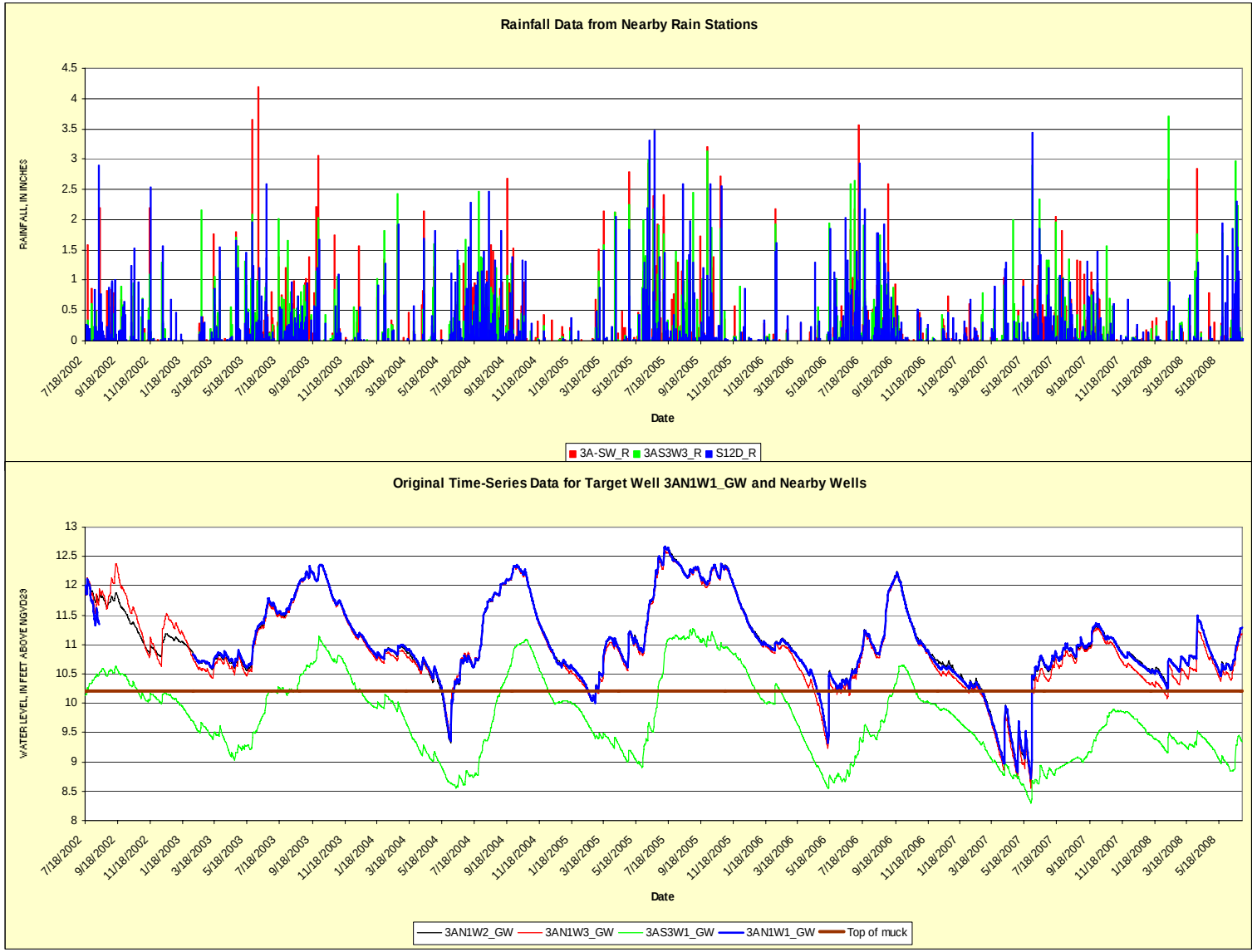
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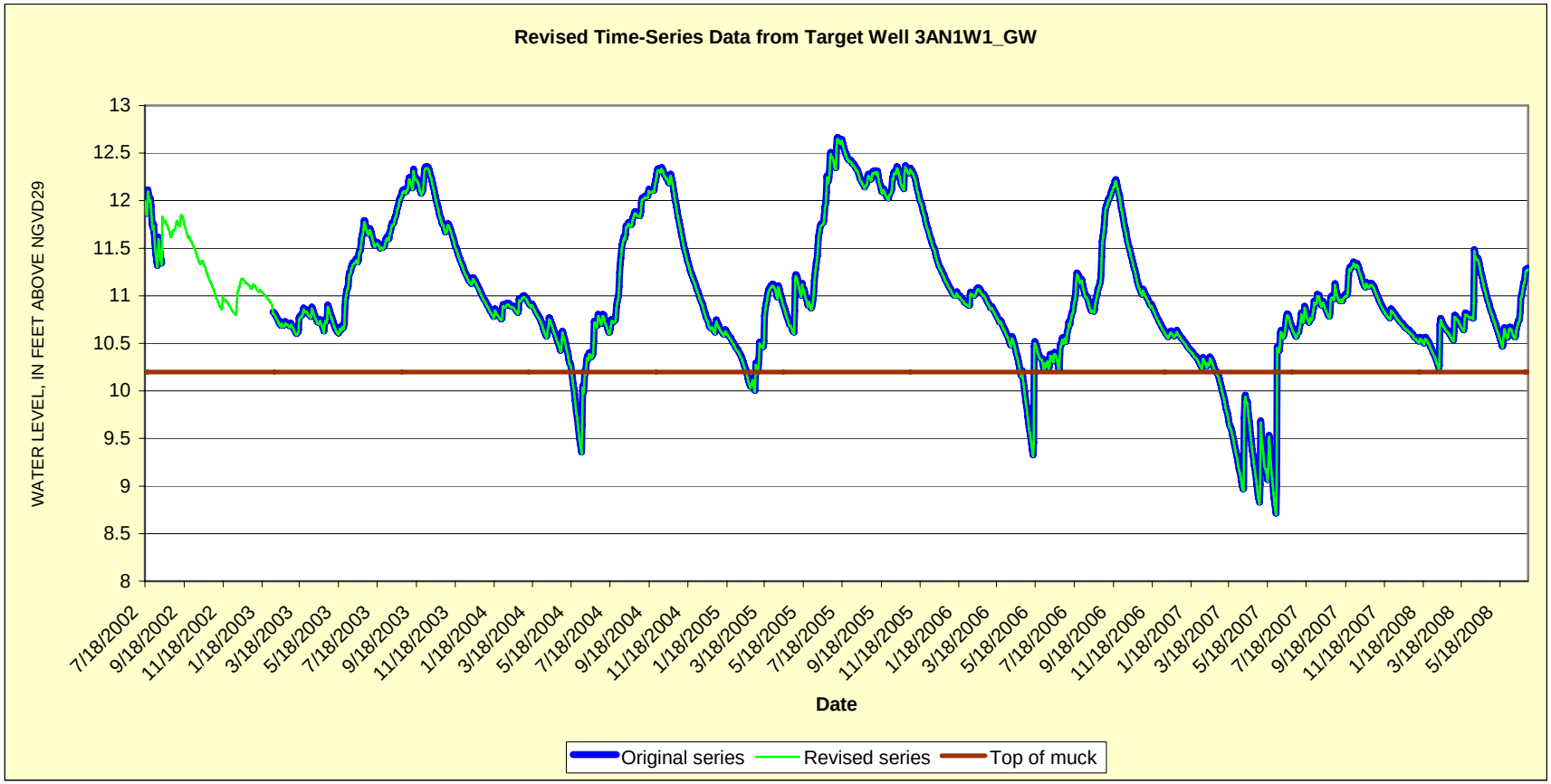
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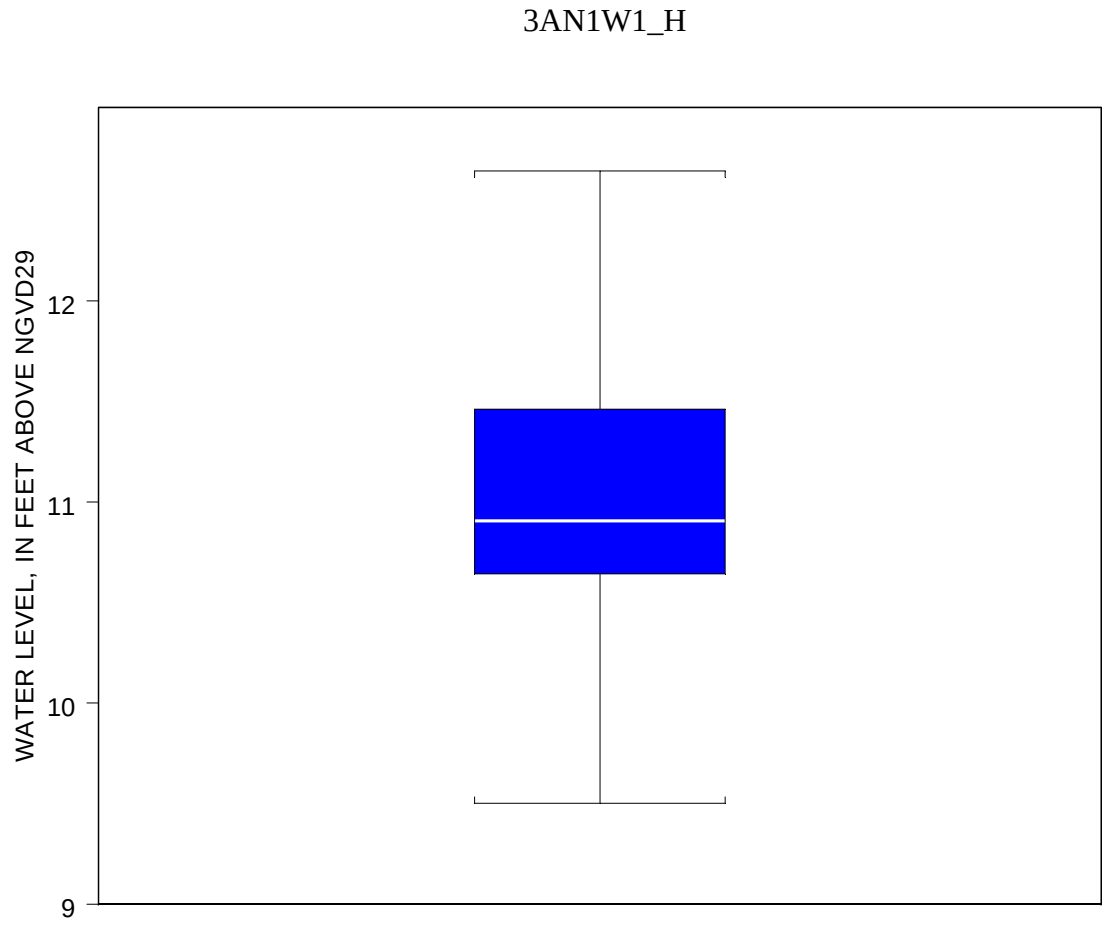
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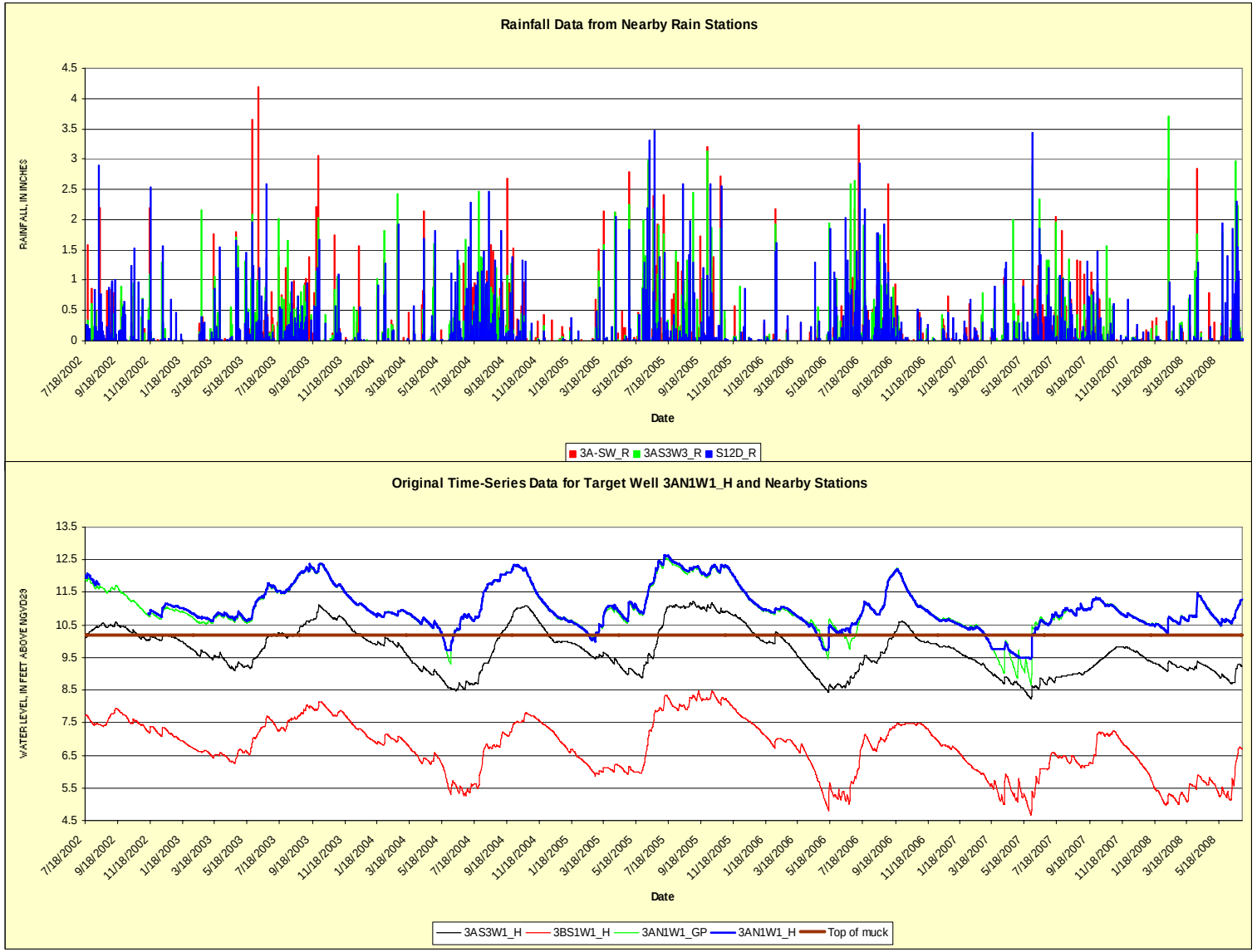
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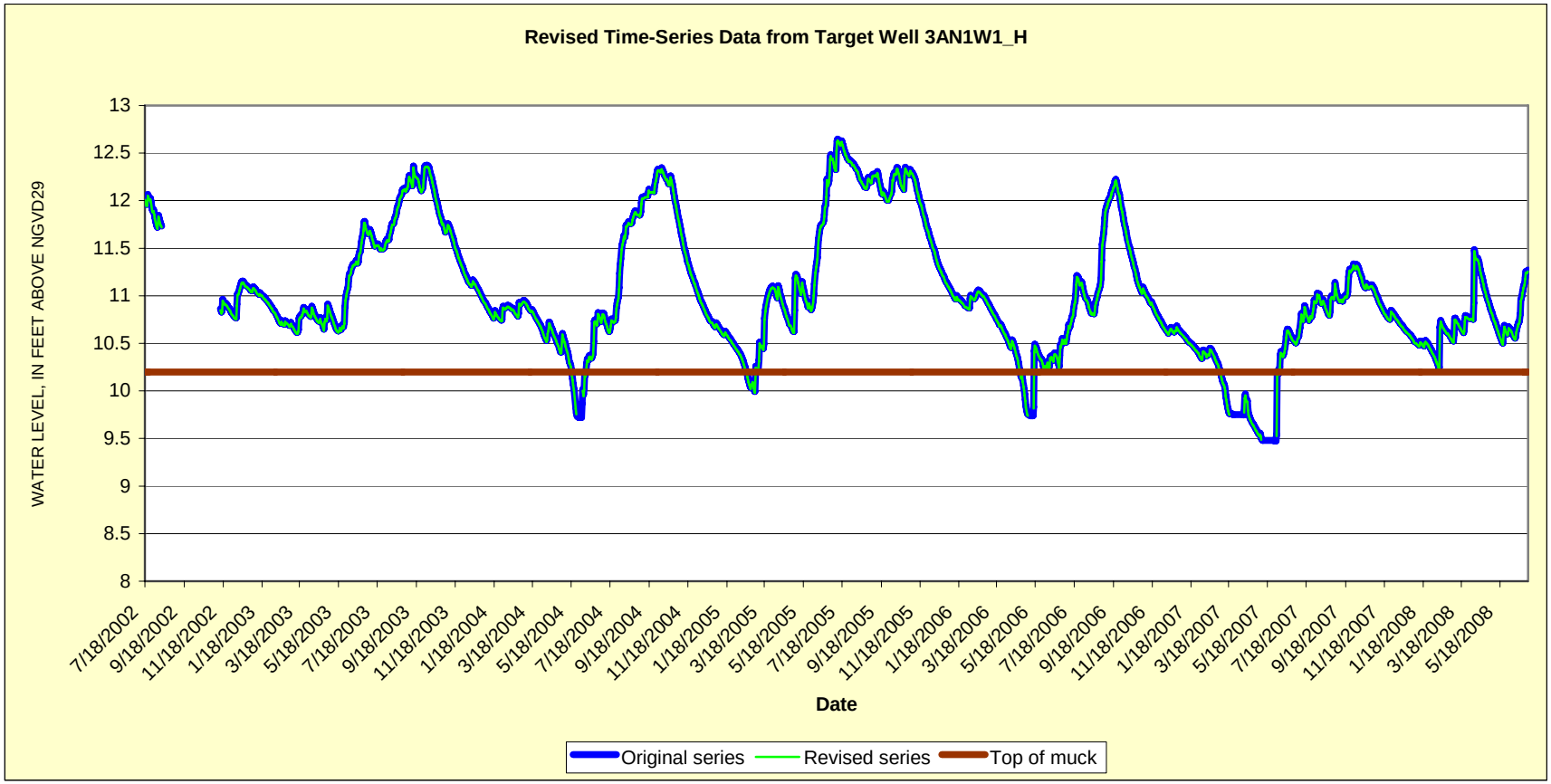
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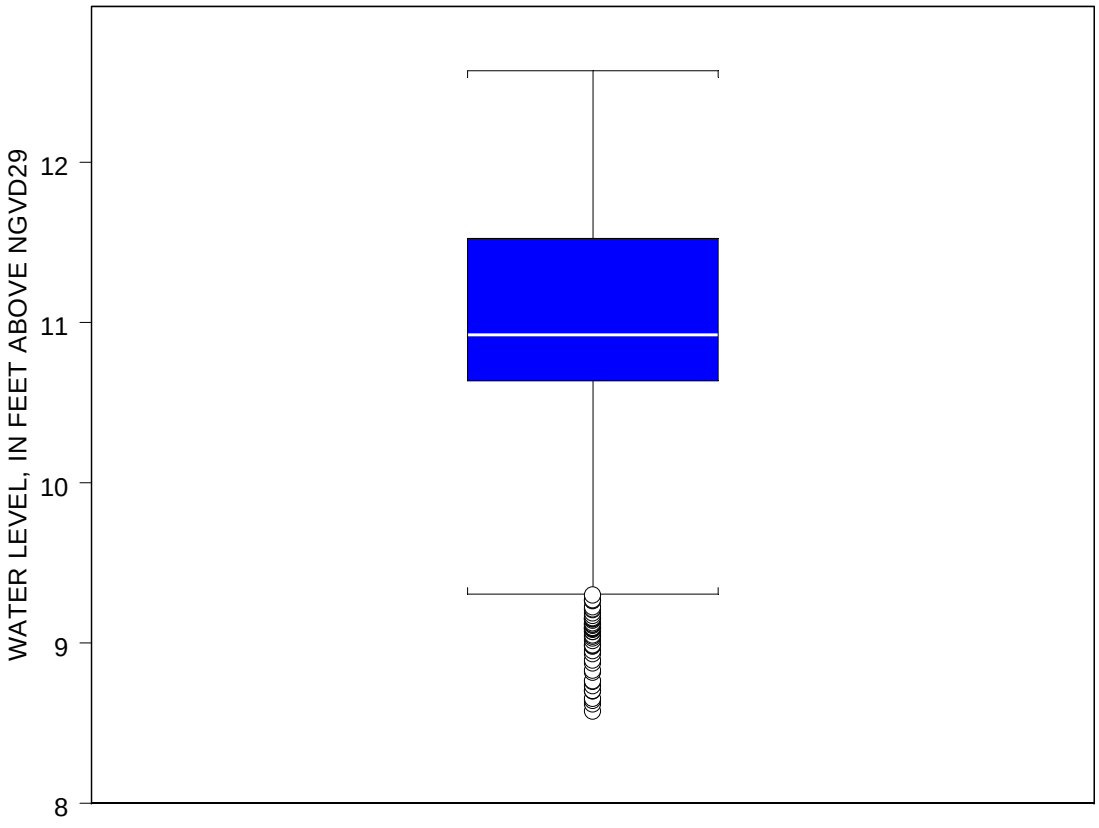

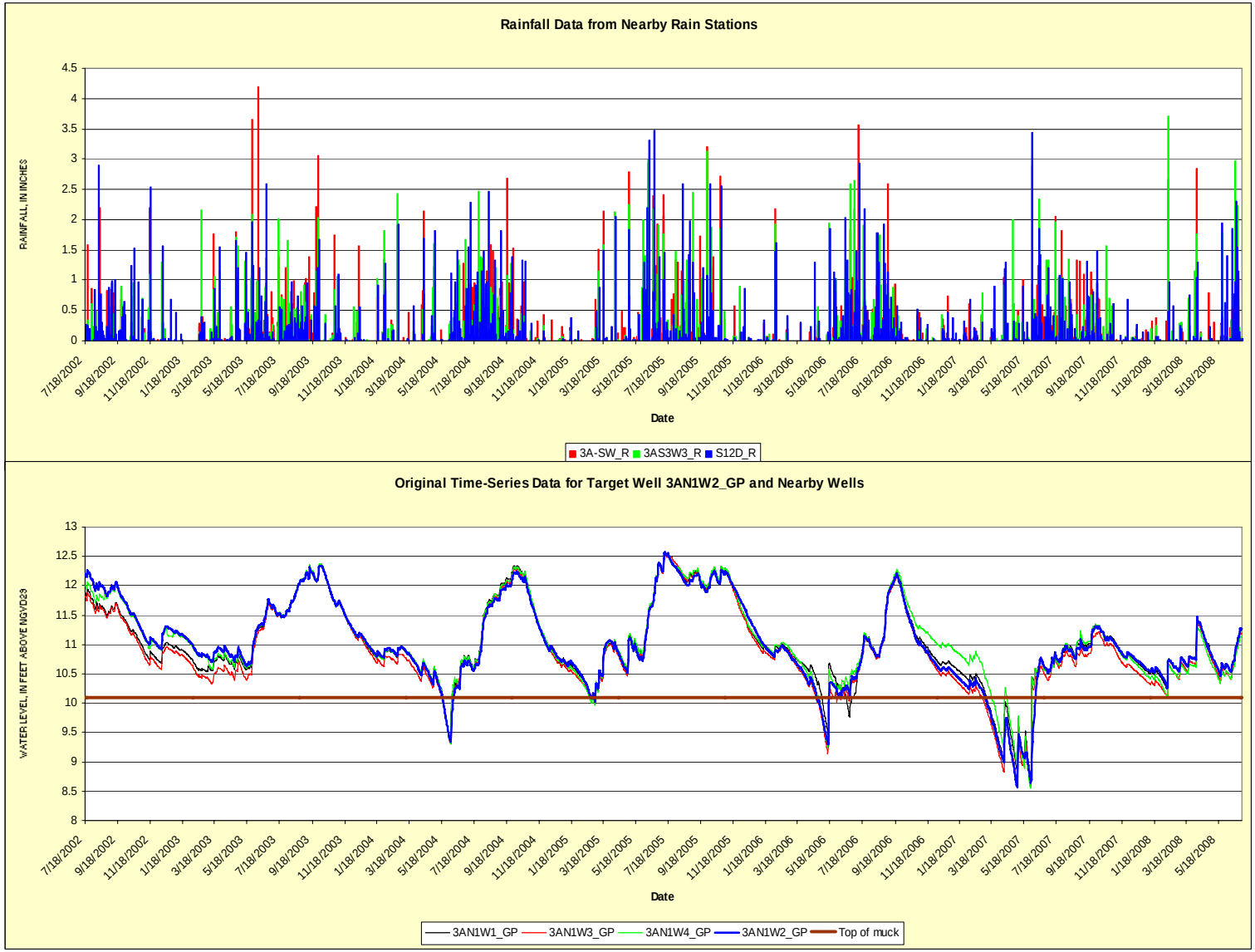
Rainfall Data from Nearby Rain Stations
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WATER LEVEL, IN FEET ABOVE NGVD29
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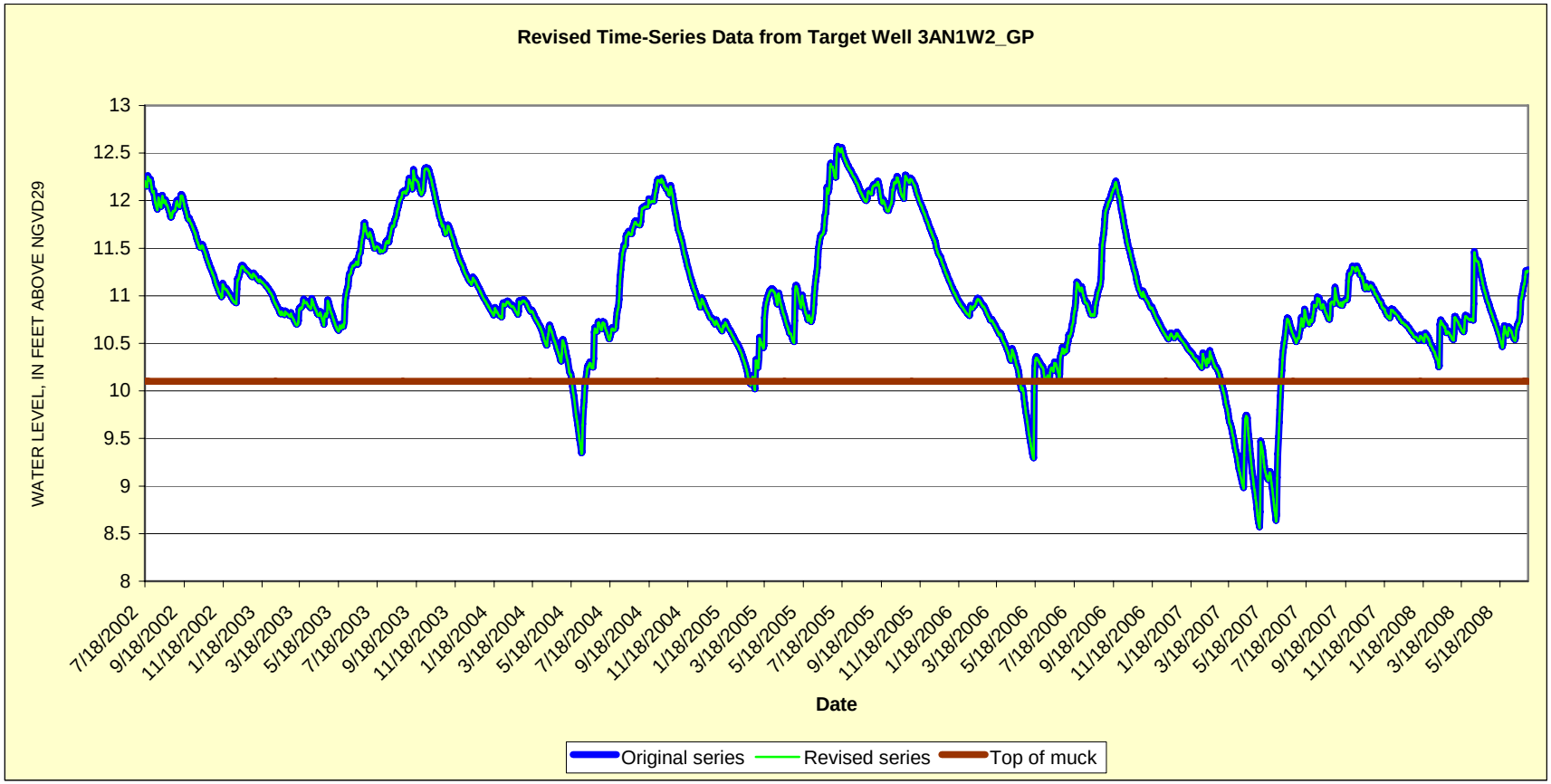
Revised Time-Series Data from Target Well 3AN1W2_GP
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Original series
Revised series
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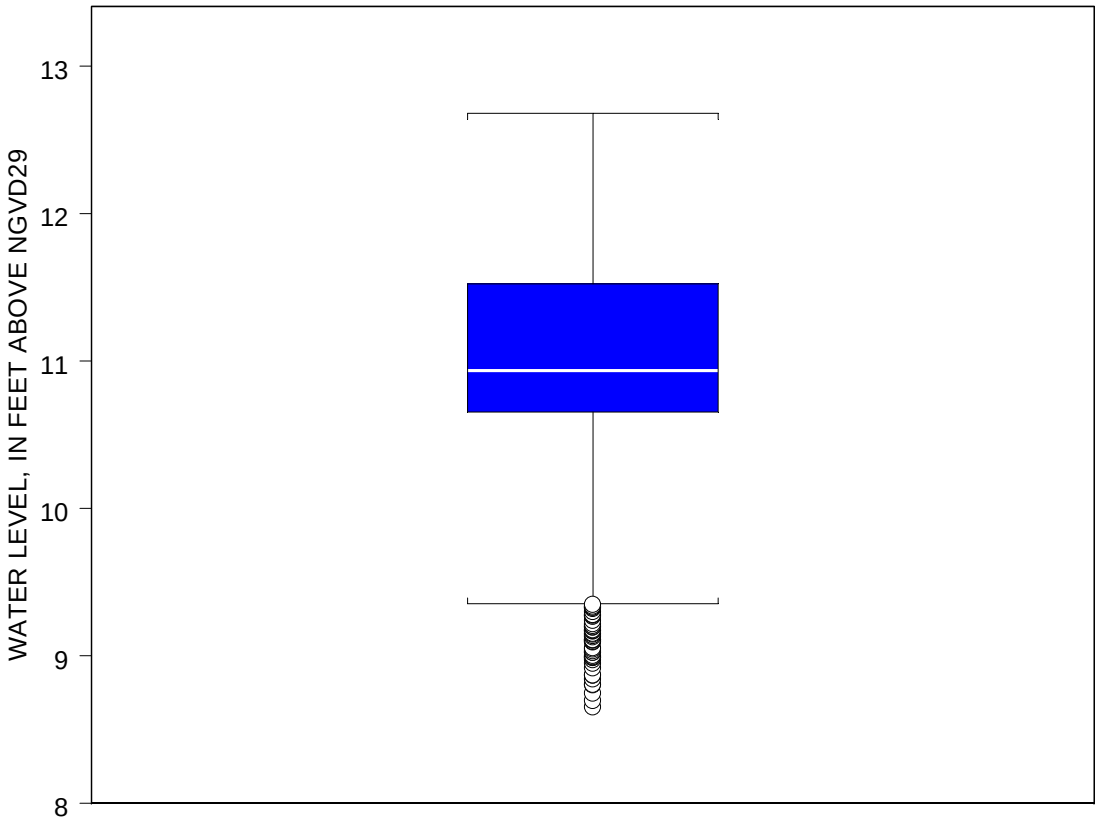

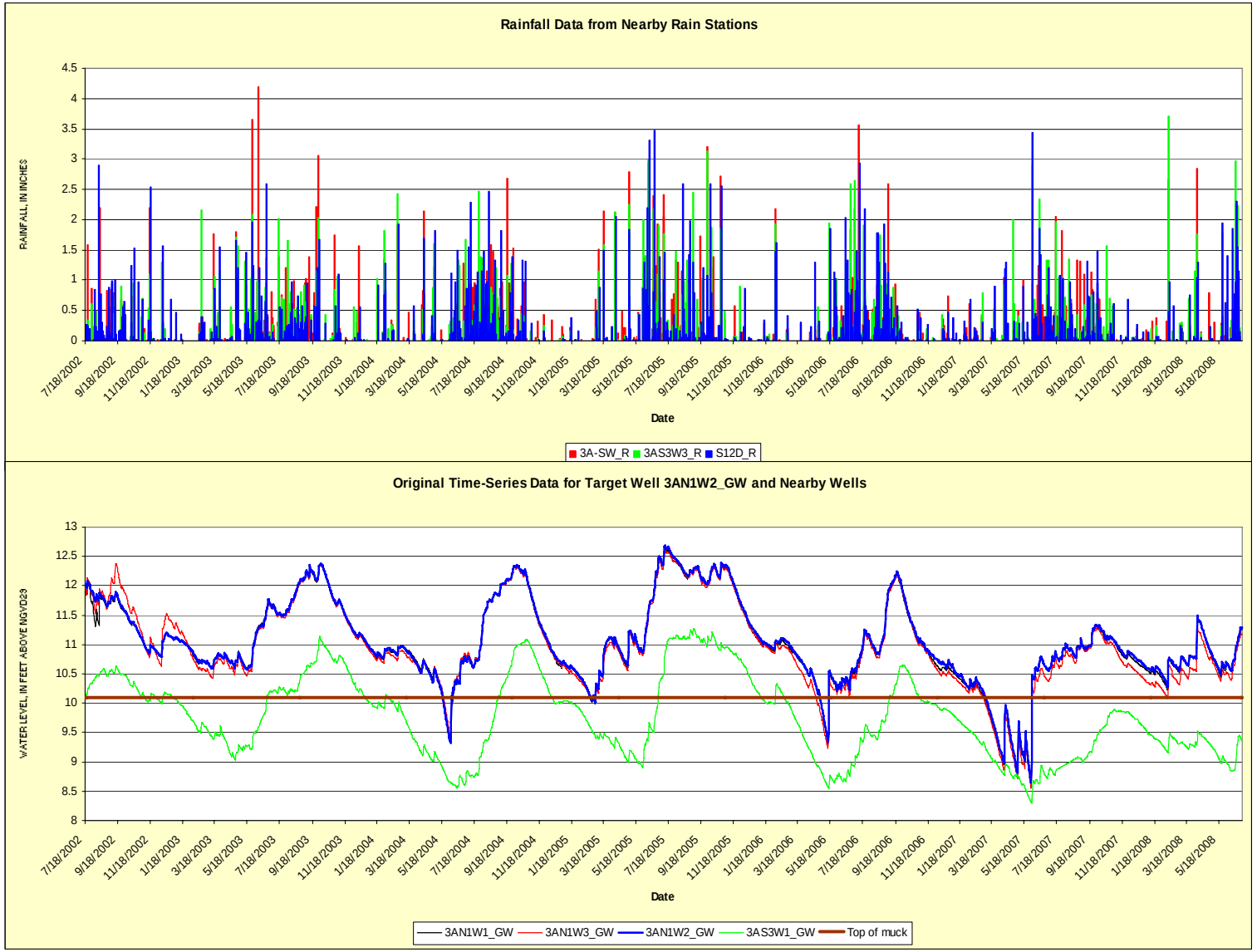
Rainfall Data from Nearby Rain Stations
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Original Time-Series Data for Target Well 3AN1W2_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
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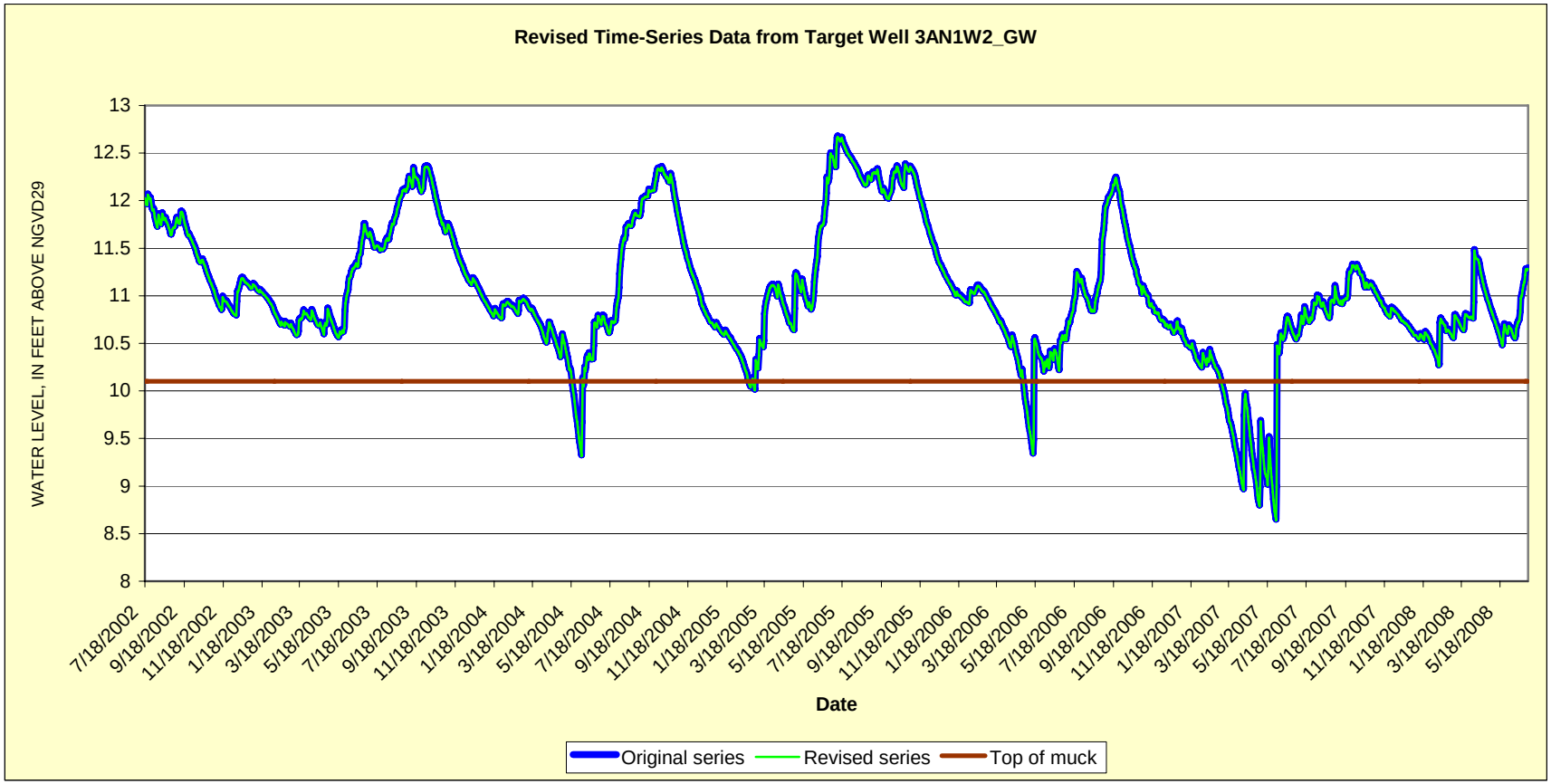
Revised Time-Series Data from Target Well 3AN1W2_GW
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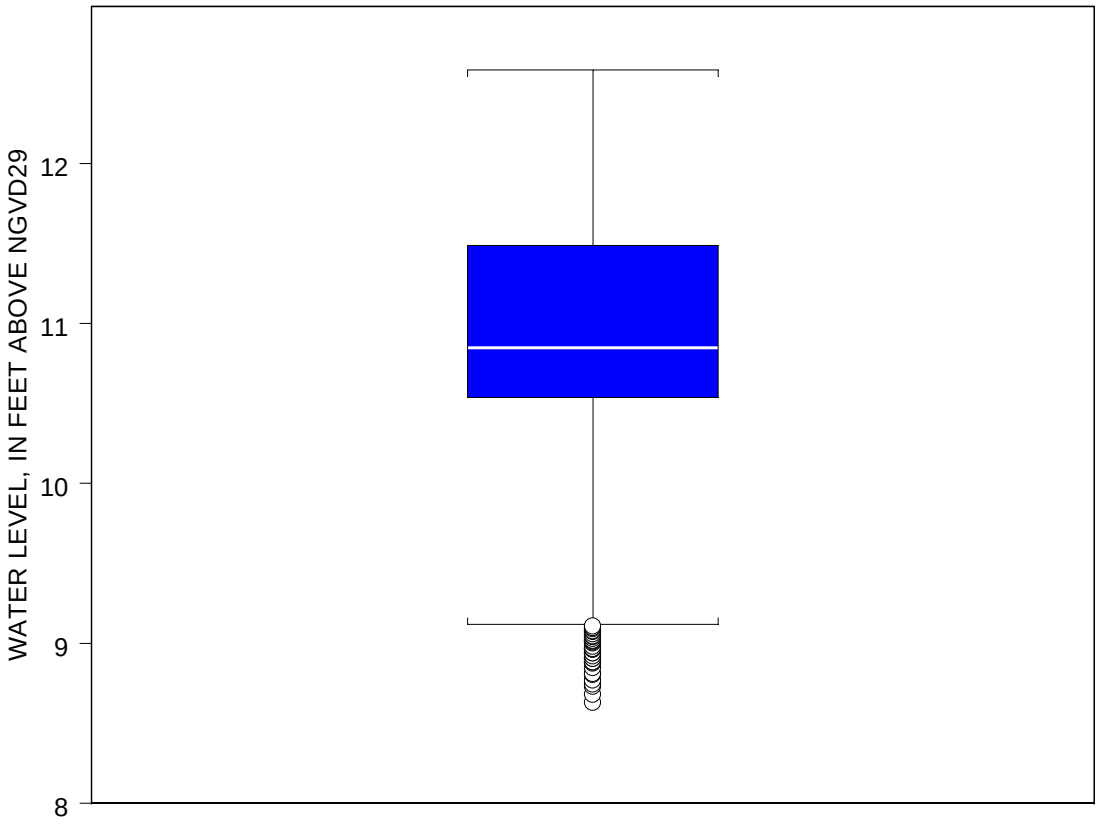

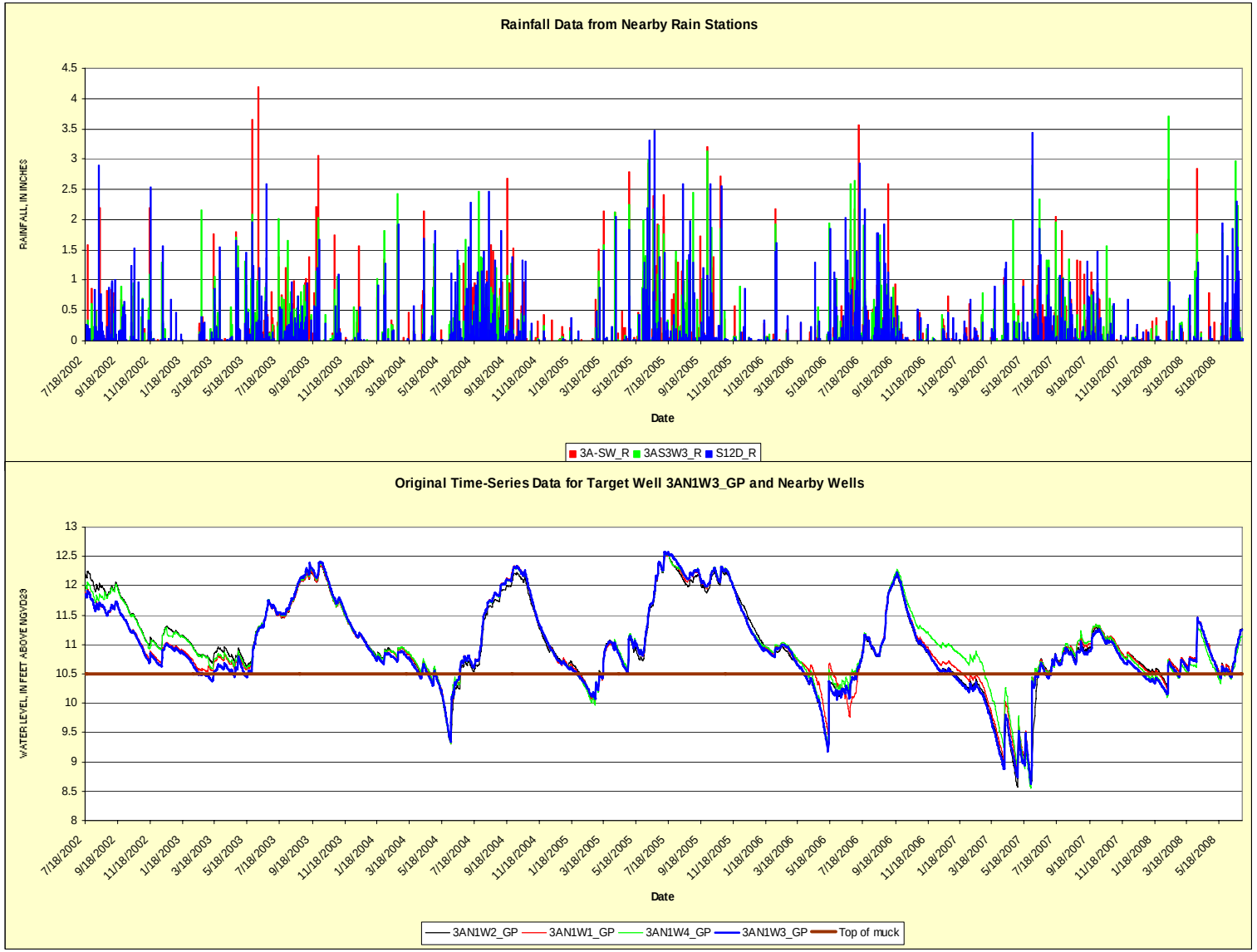
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Date
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S12D_R
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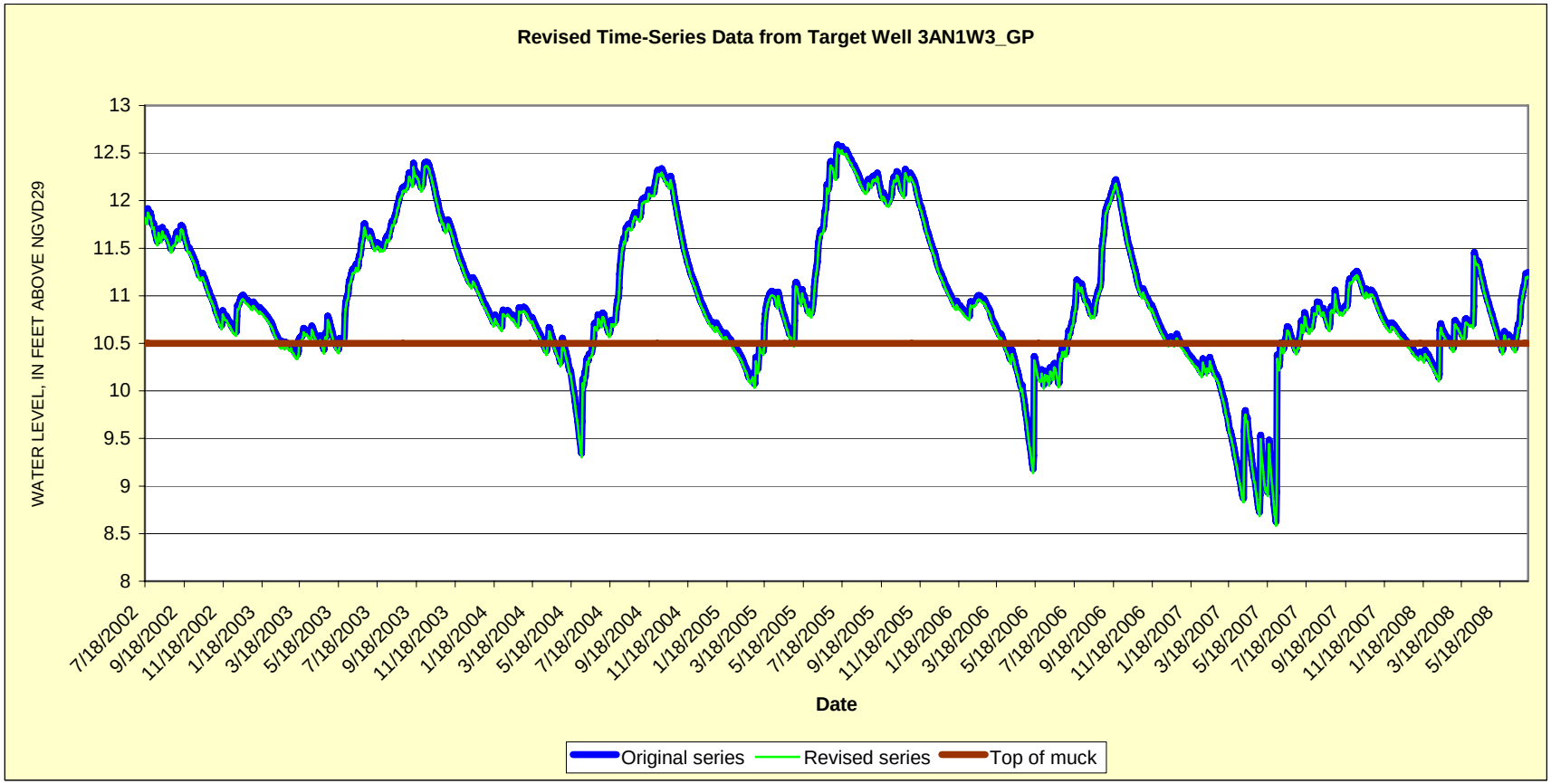
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Revised series
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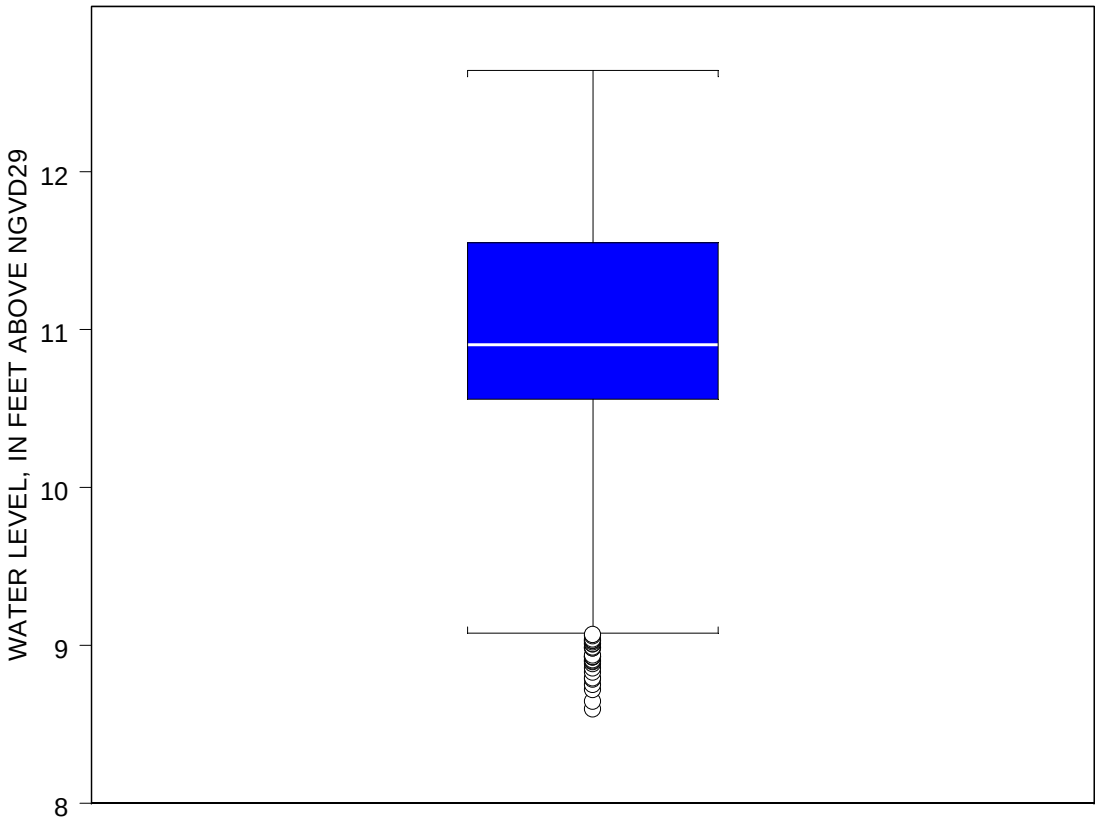

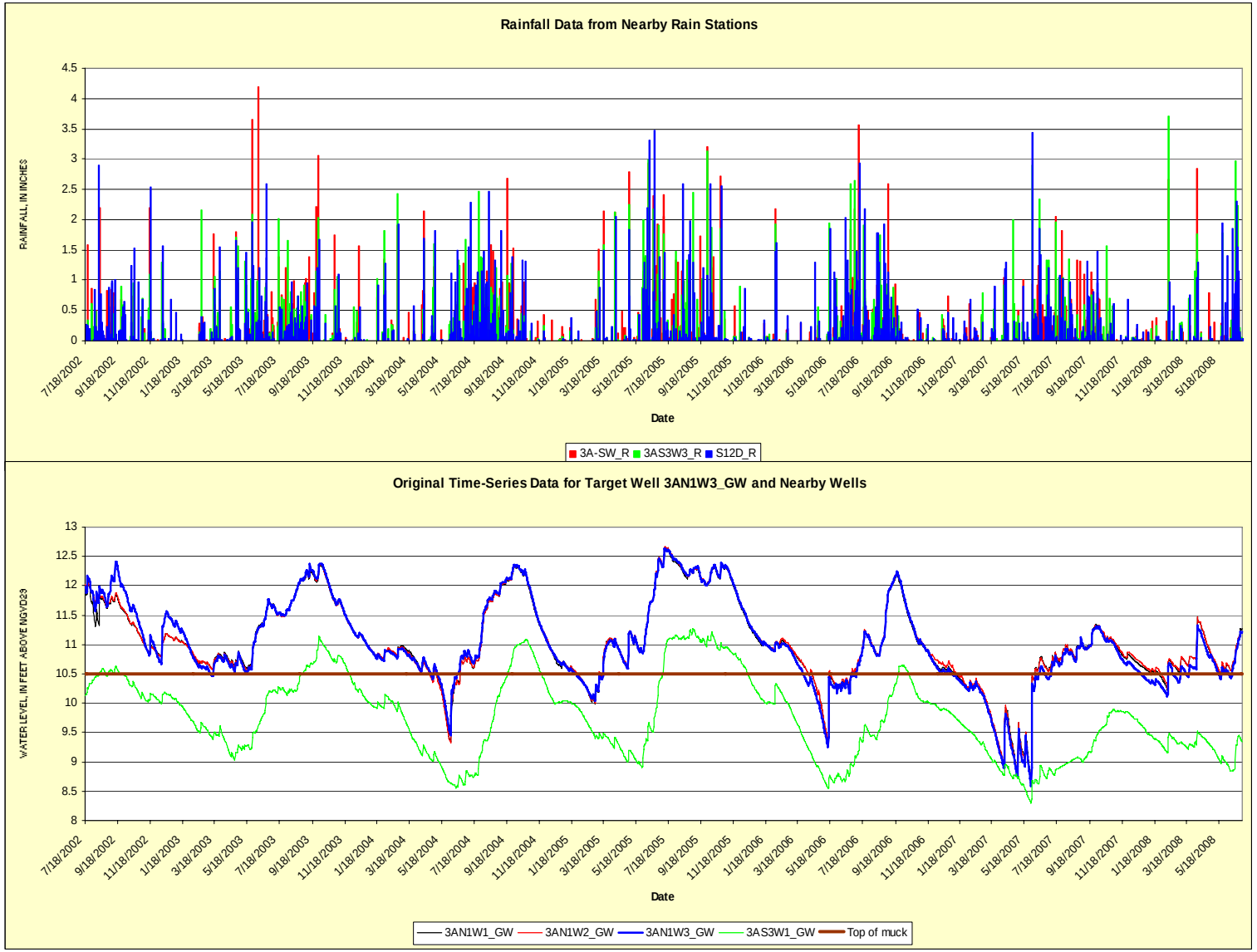
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Date
3A-SW_R
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S12D_R
Original Time-Series Data for Target Well 3AN1W3_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
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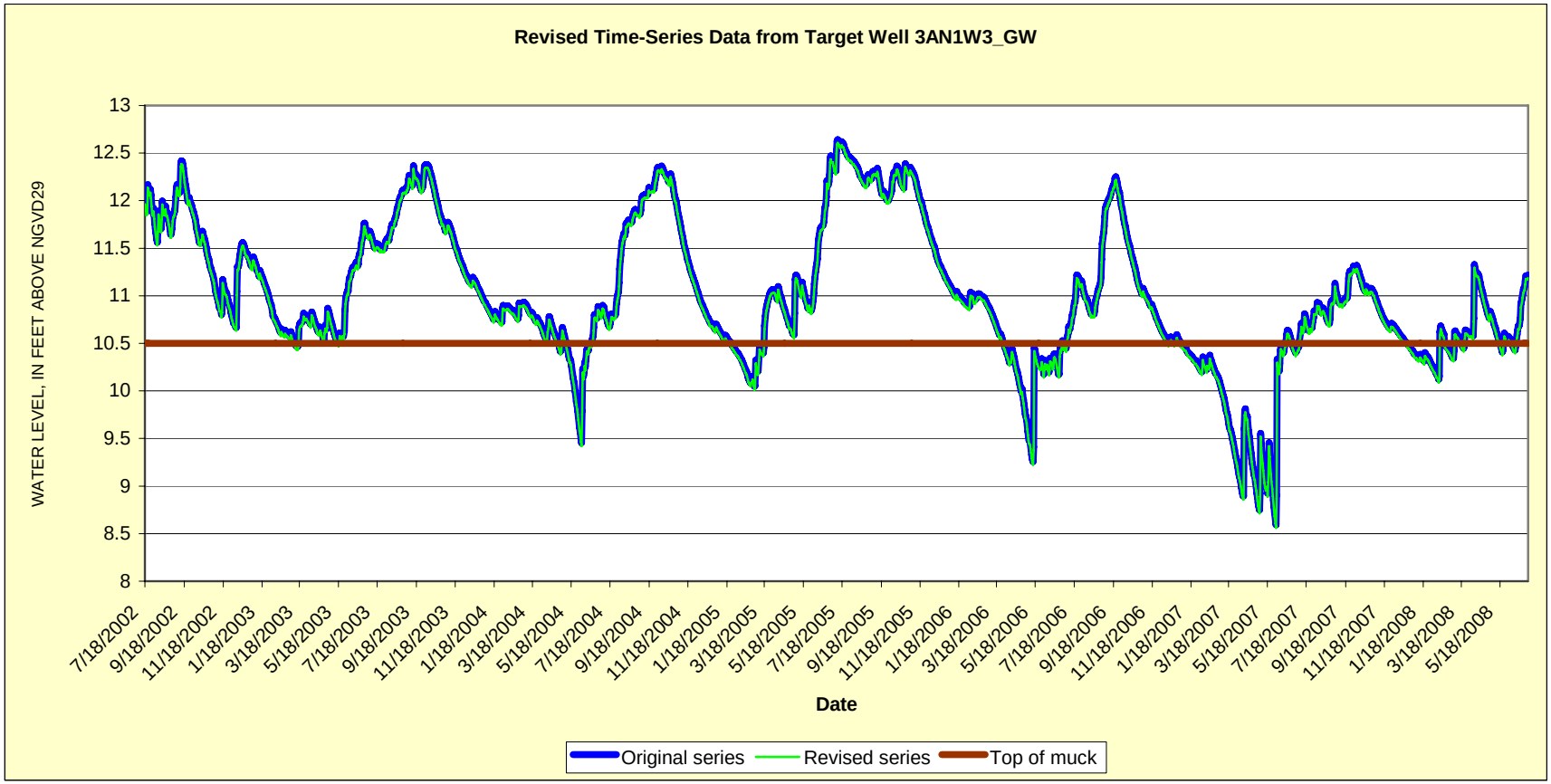
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Revised series
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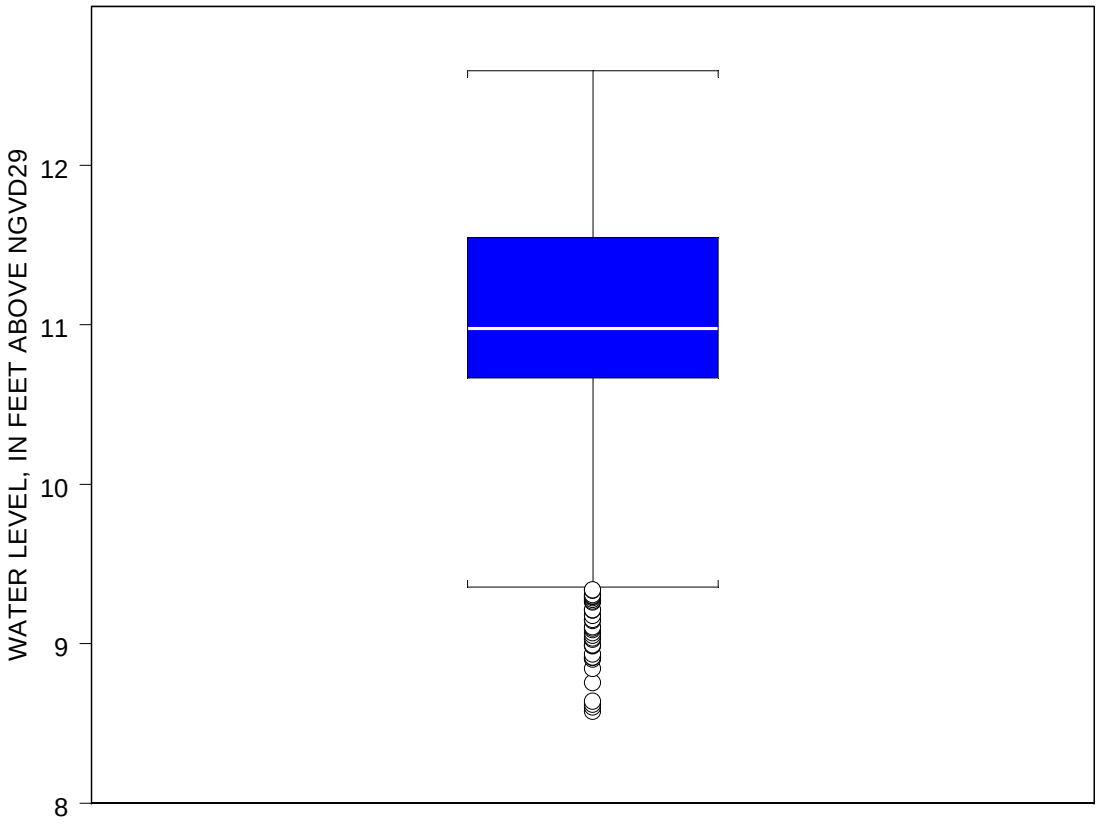

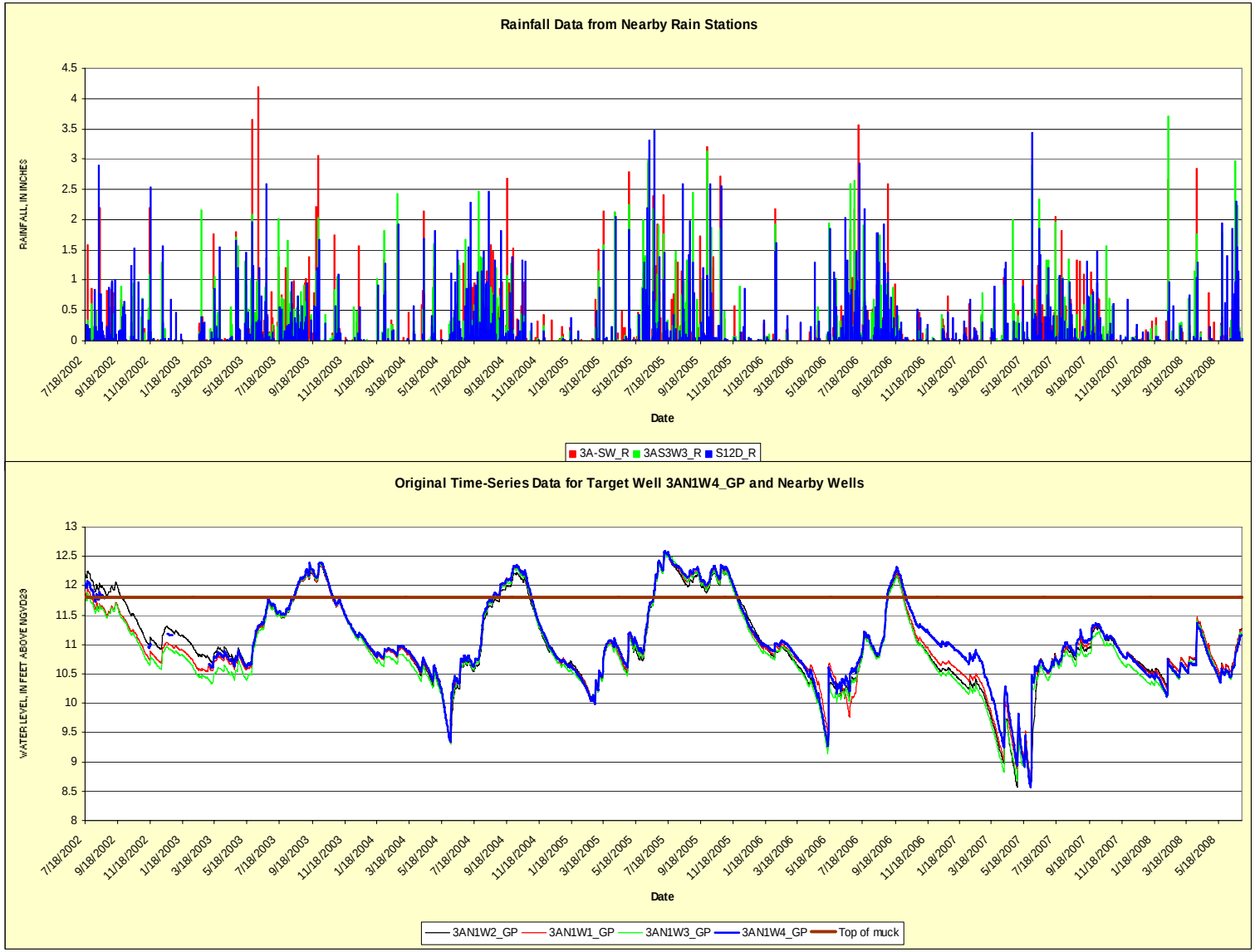
Rainfall Data from Nearby Rain Stations
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S12D_R
Original Time-Series Data for Target Well 3AN1W4_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
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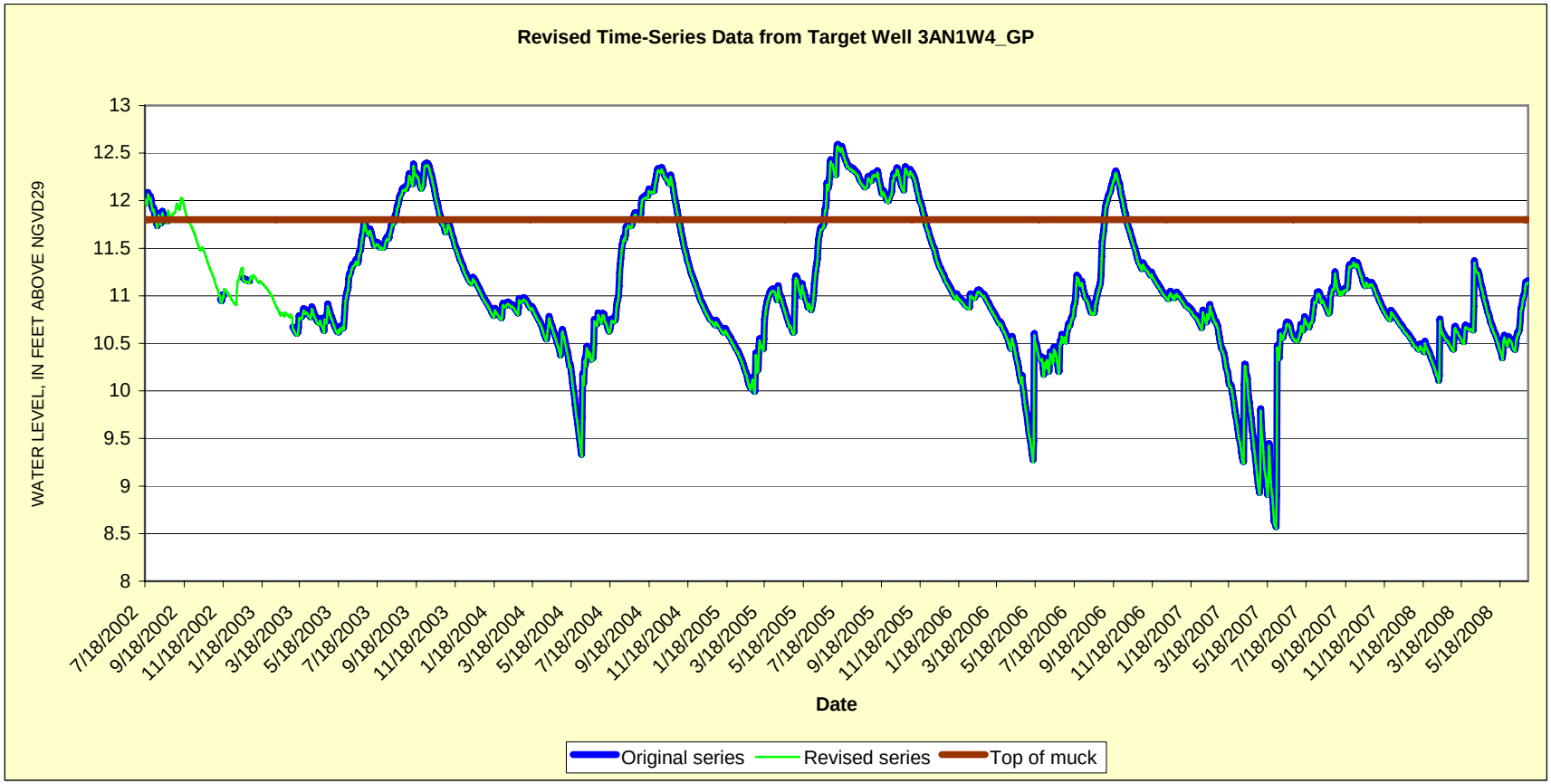
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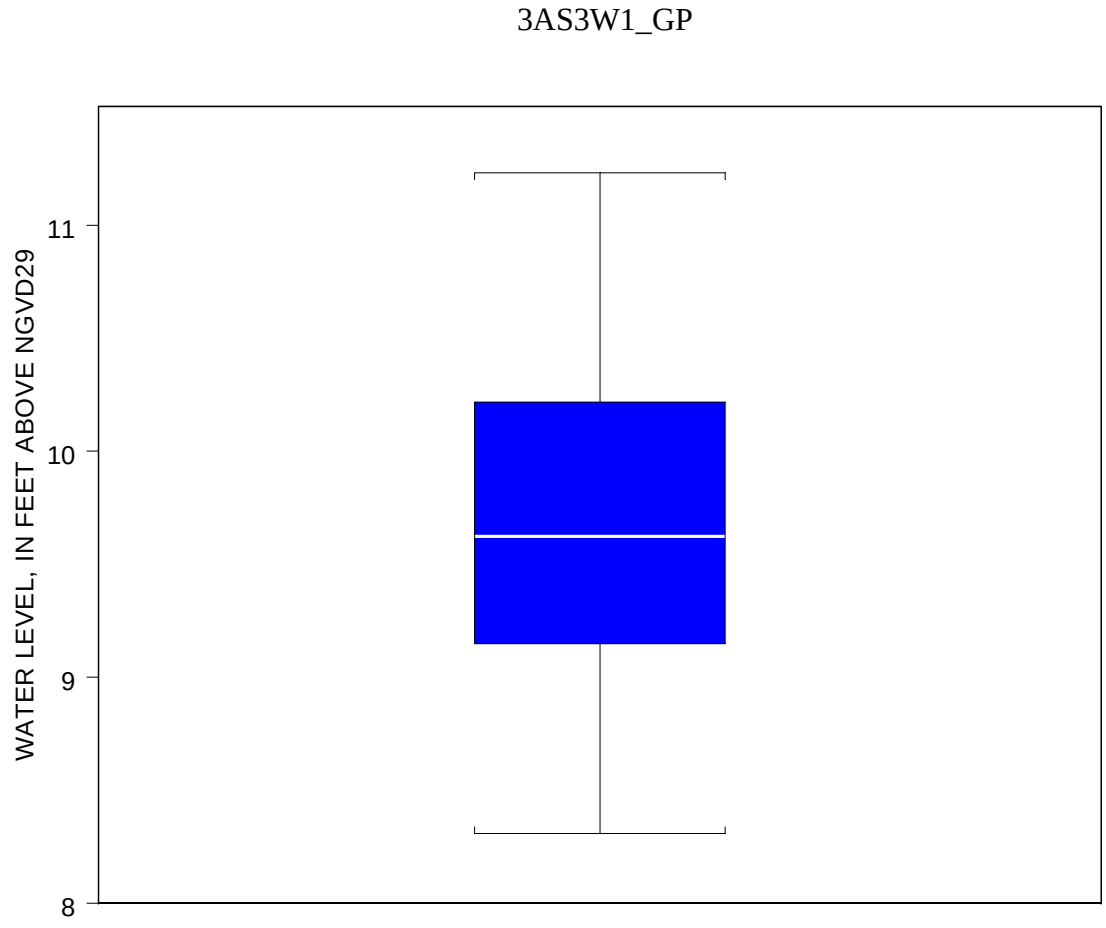
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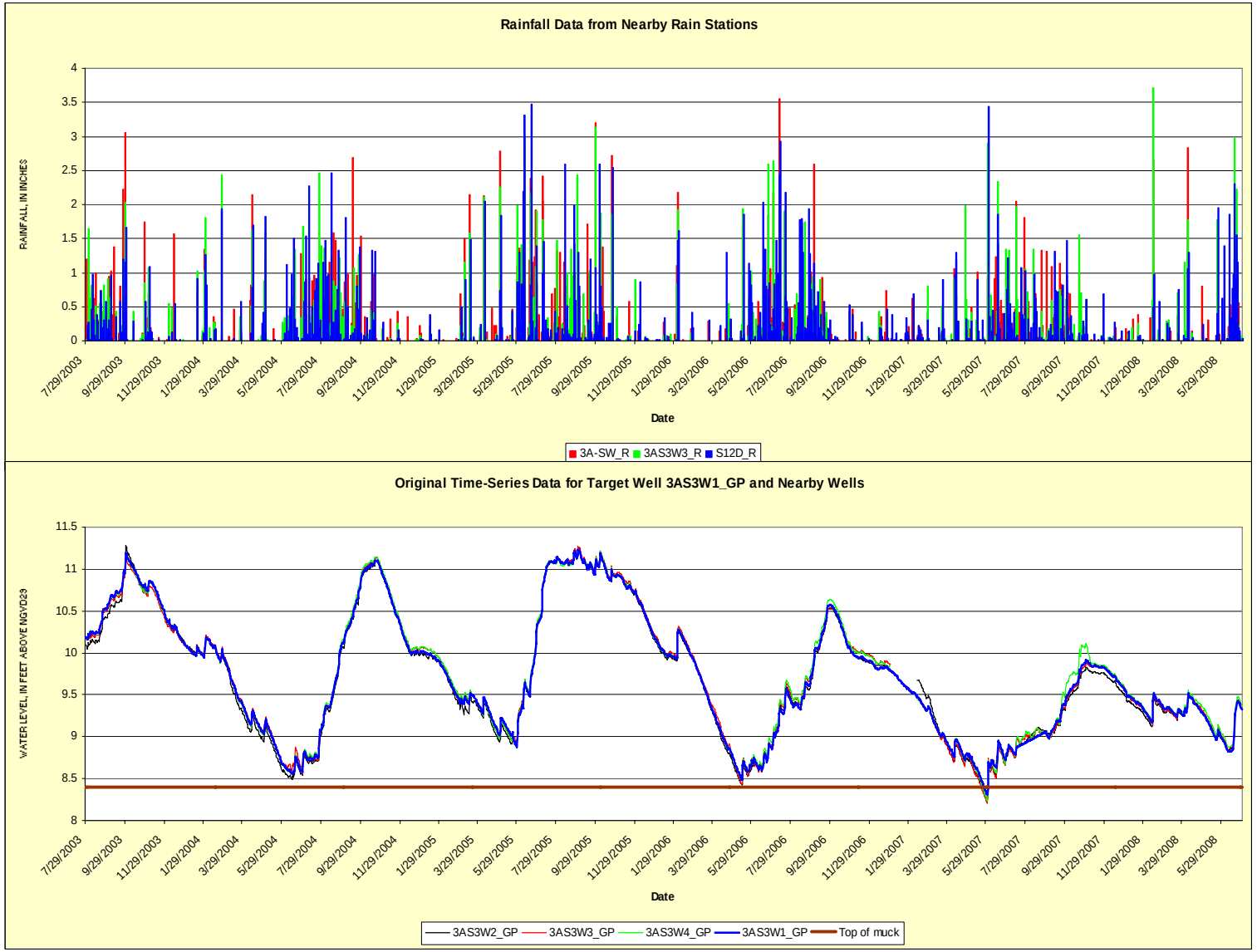
Rainfall Data from Nearby Rain Stations
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Date
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3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3AS3W1_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
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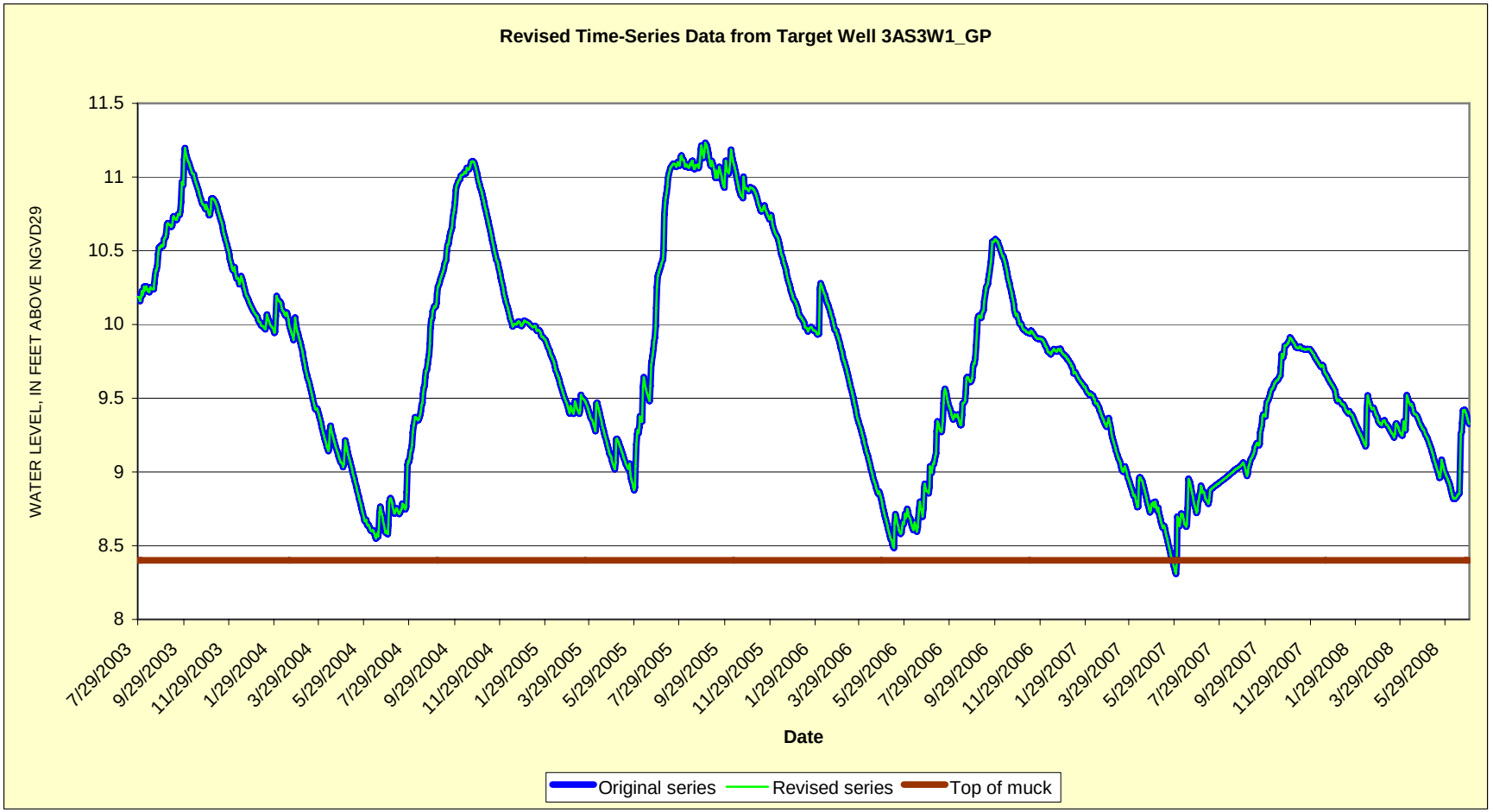
Revised Time-Series Data from Target Well 3AS3W1_GP
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Revised series
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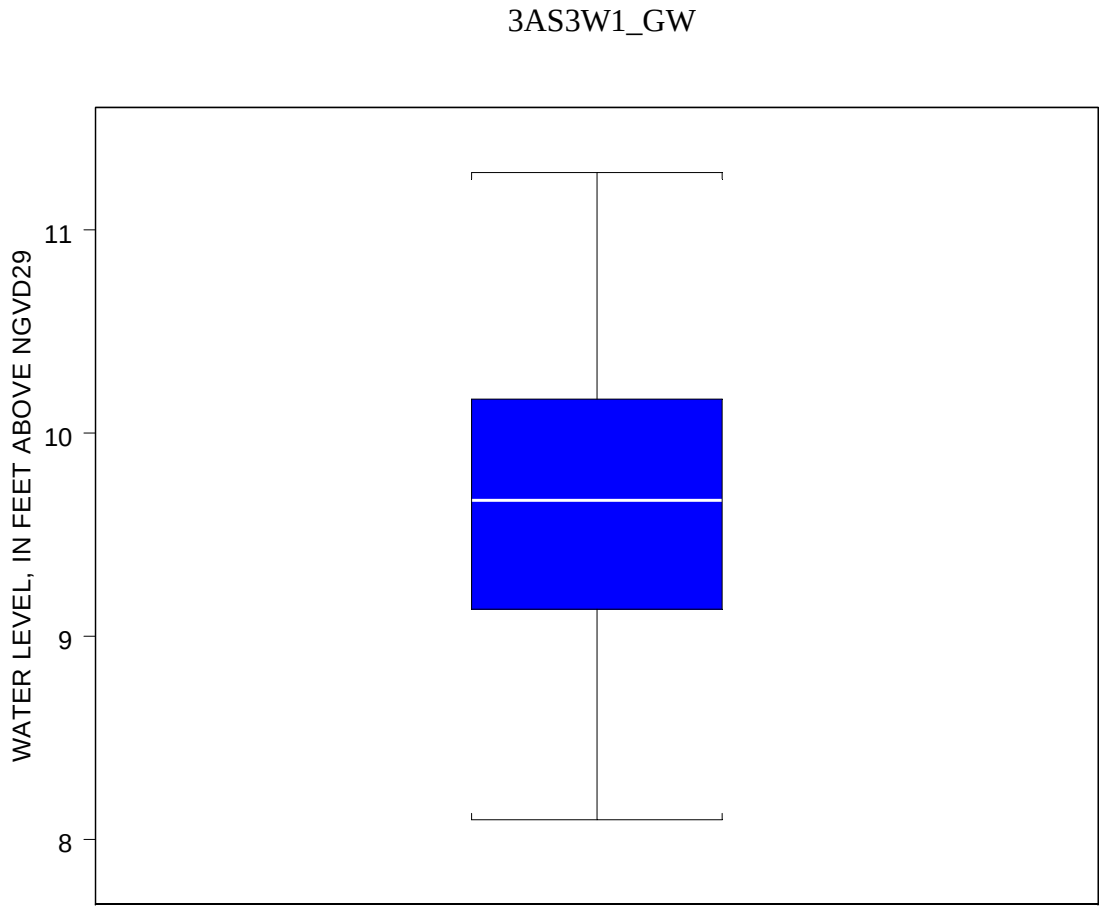
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WATER LEVEL, IN FEET ABOVE NGVD29
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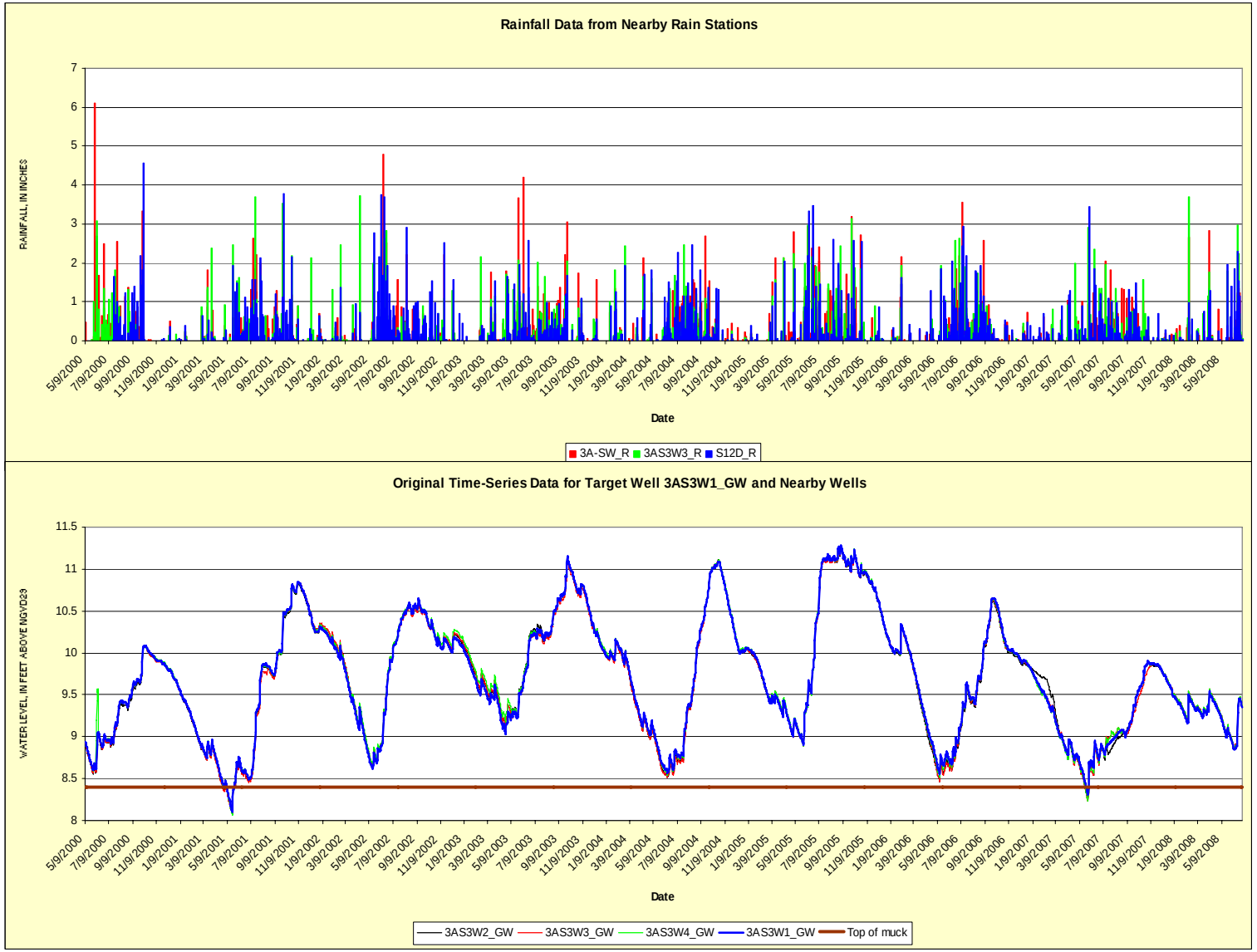
Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
Date
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S12D_R
Original Time-Series Data for Target Well 3AS3W1_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
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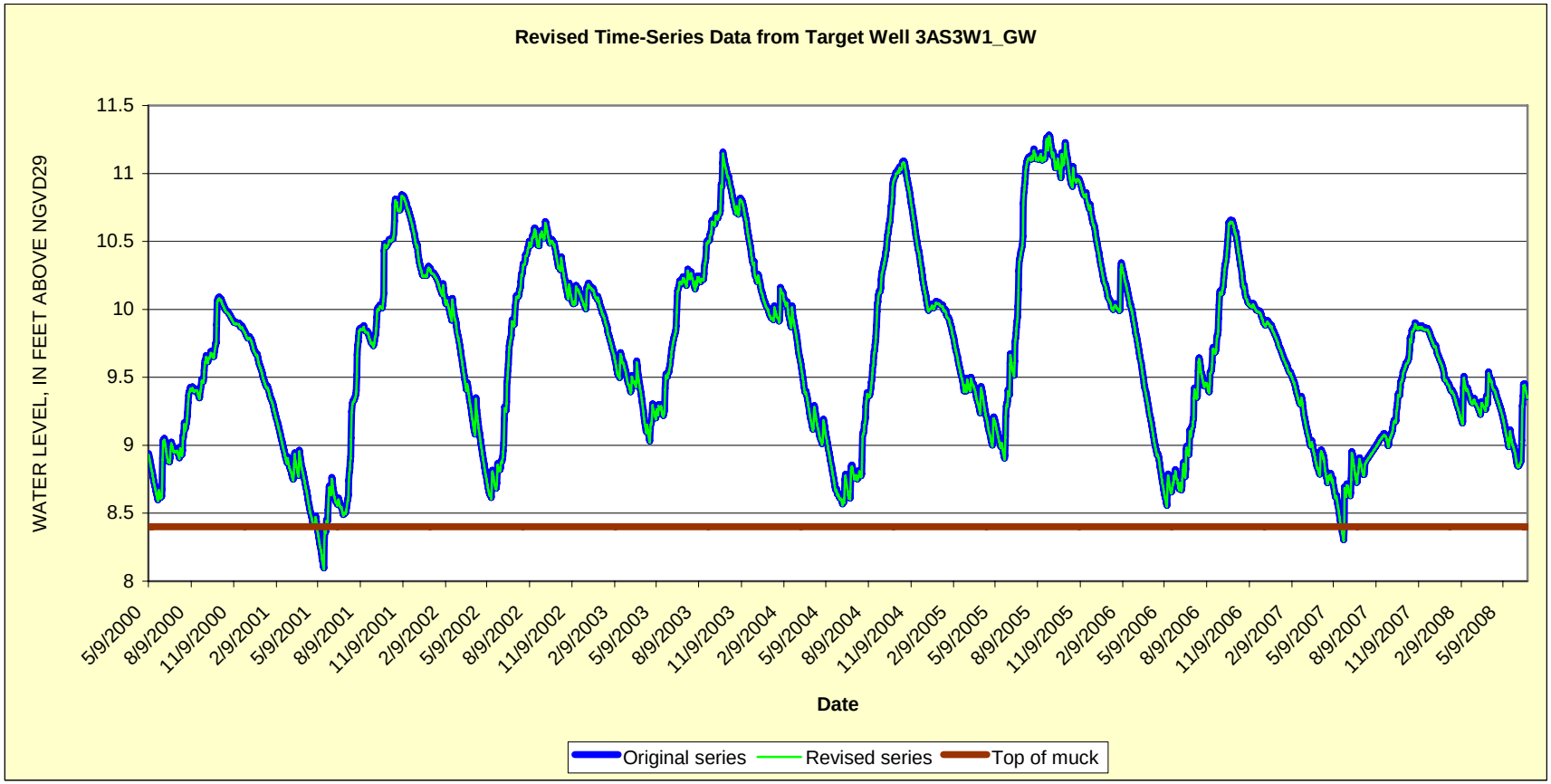
Revised Time-Series Data from Target Well 3AS3W1_GW
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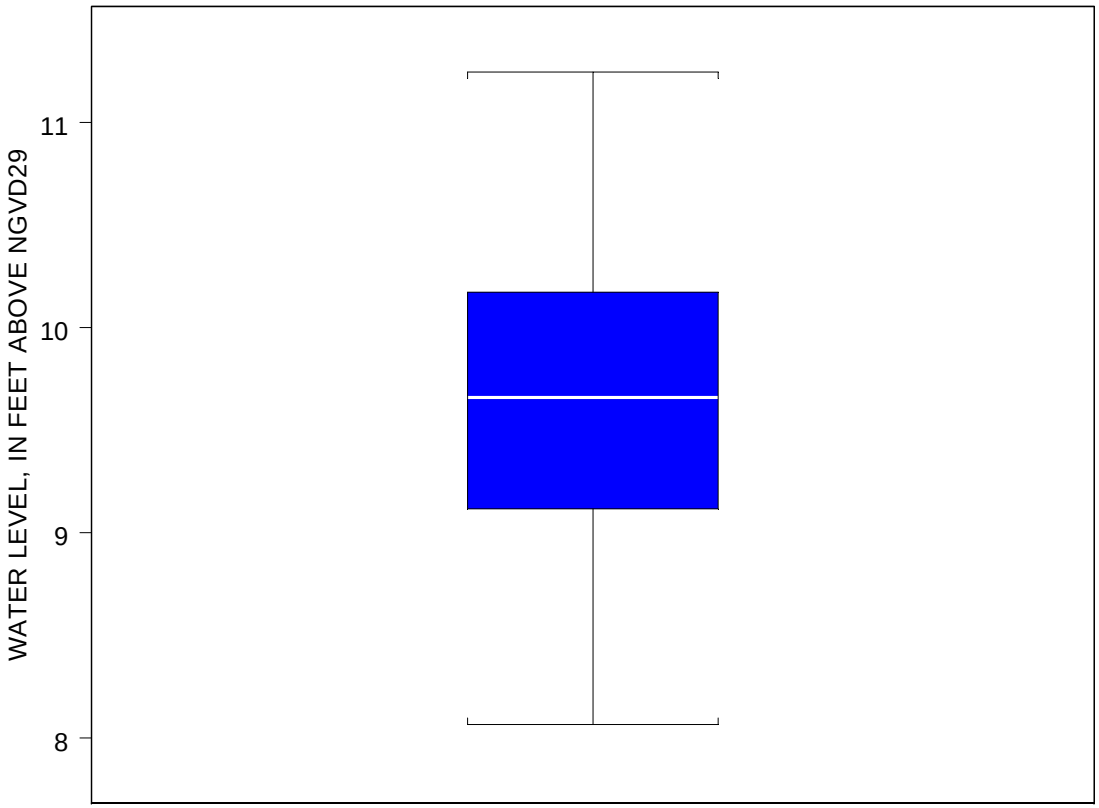
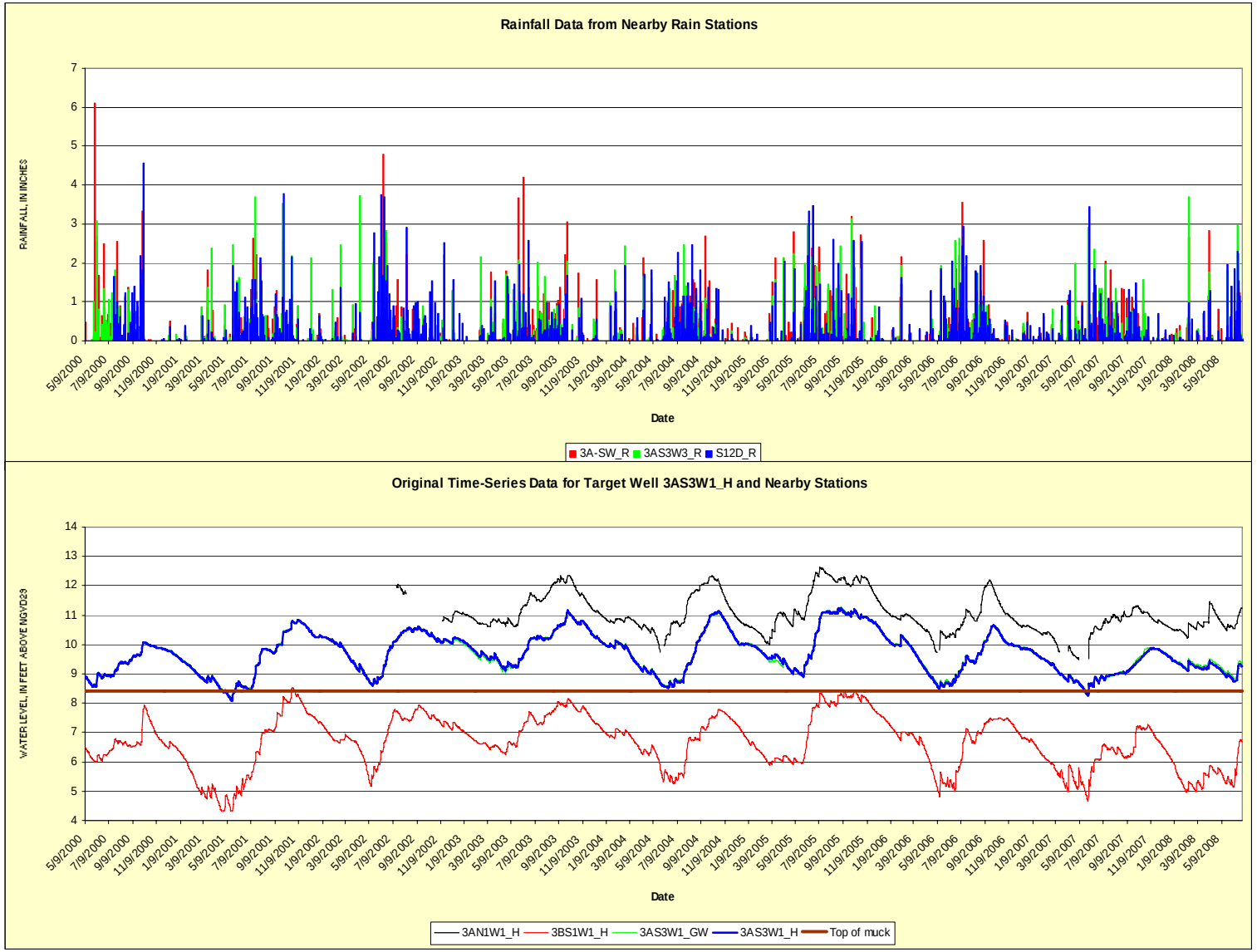
Original series
Revised series
Top of muck

3AS3W1_H

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WATER LEVEL, IN FEET ABOVE NGVD29
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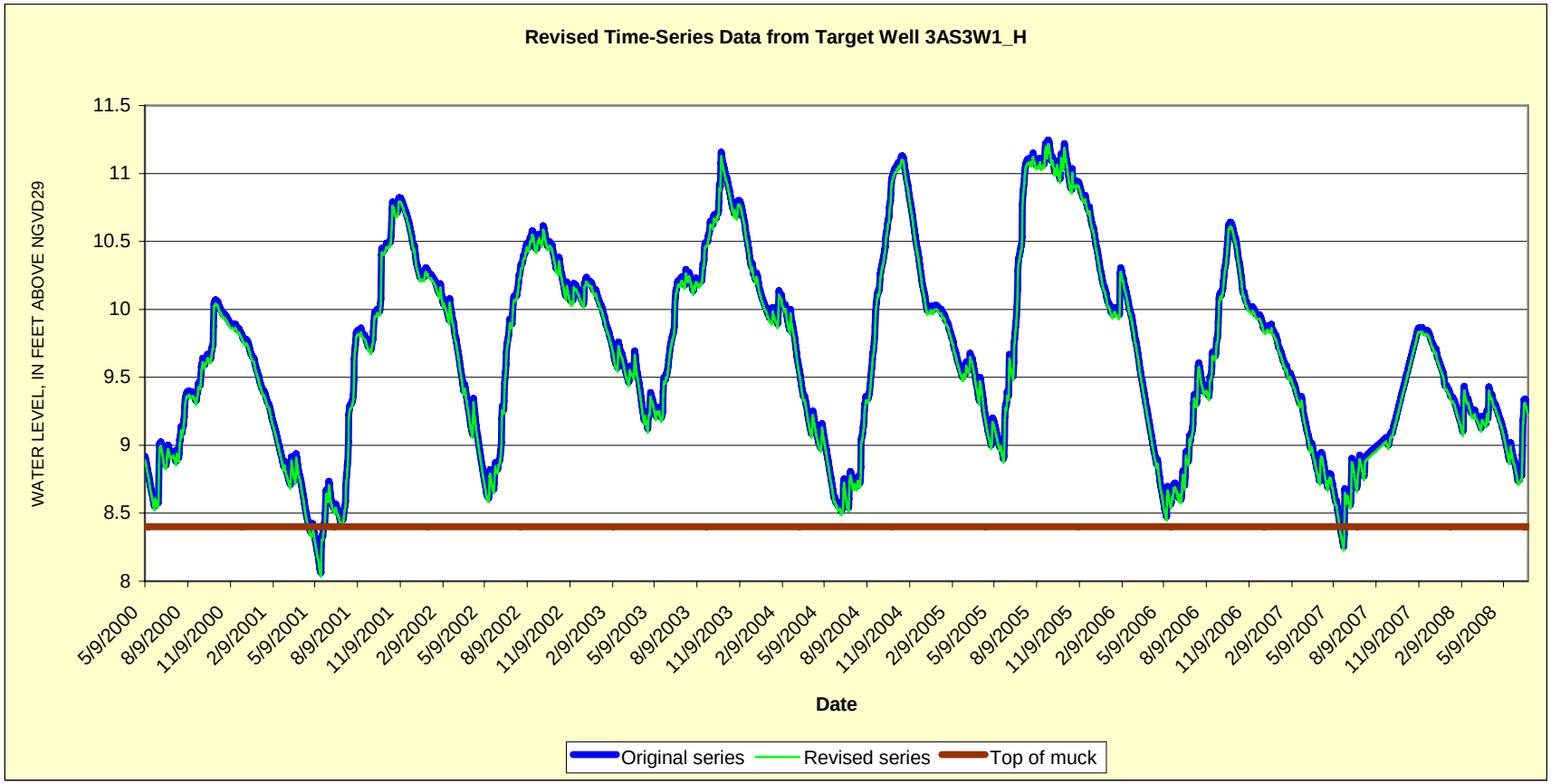
Revised Time-Series Data from Target Well 3AS3W1_H
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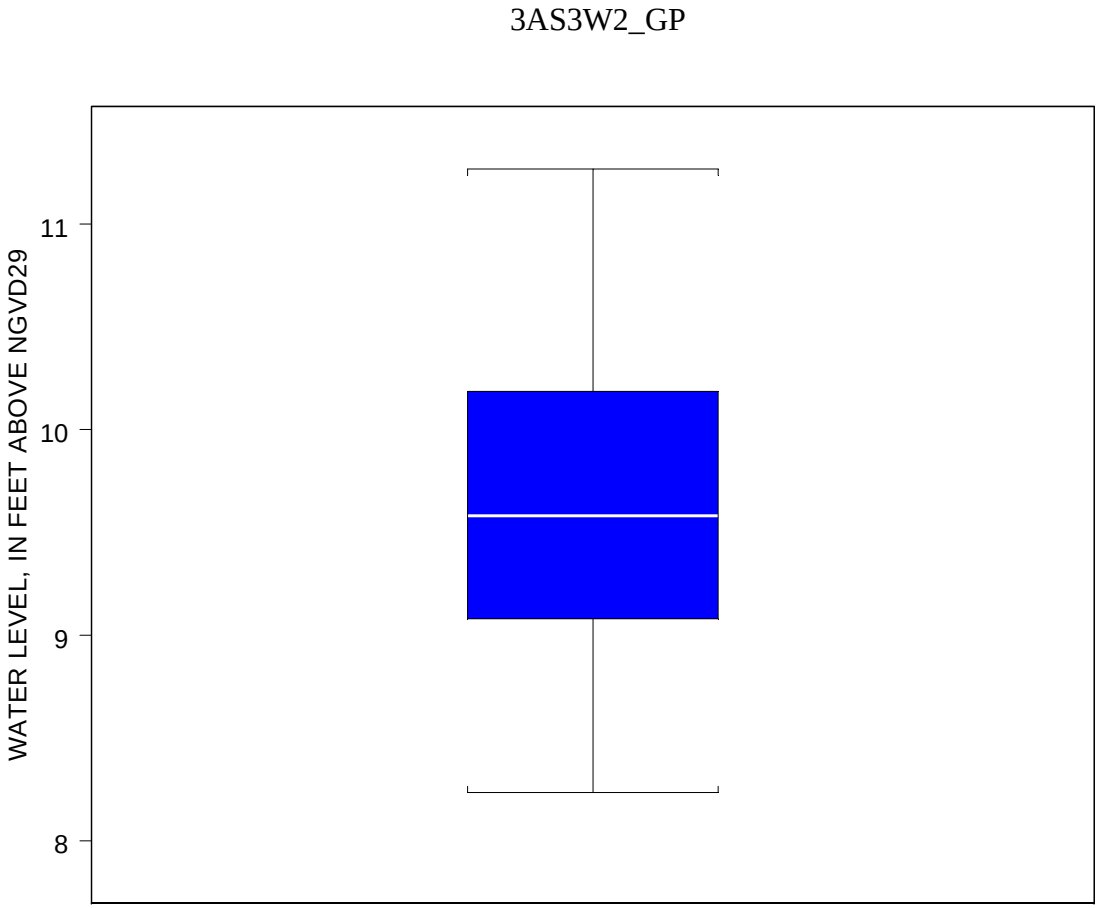
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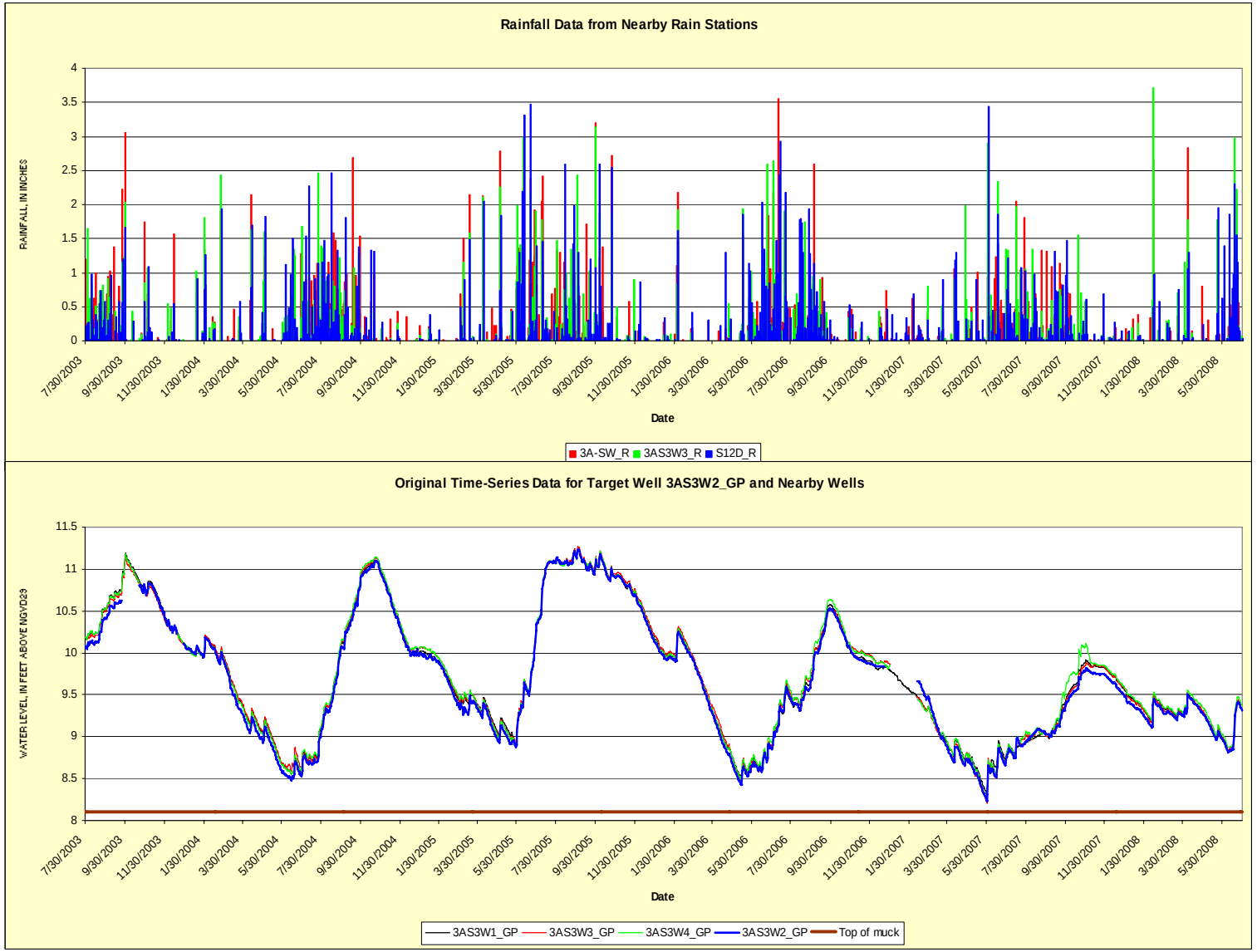
Rainfall Data from Nearby Rain Stations
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S12D_R
Original Time-Series Data for Target Well 3AS3W2_GP and Nearby Wells
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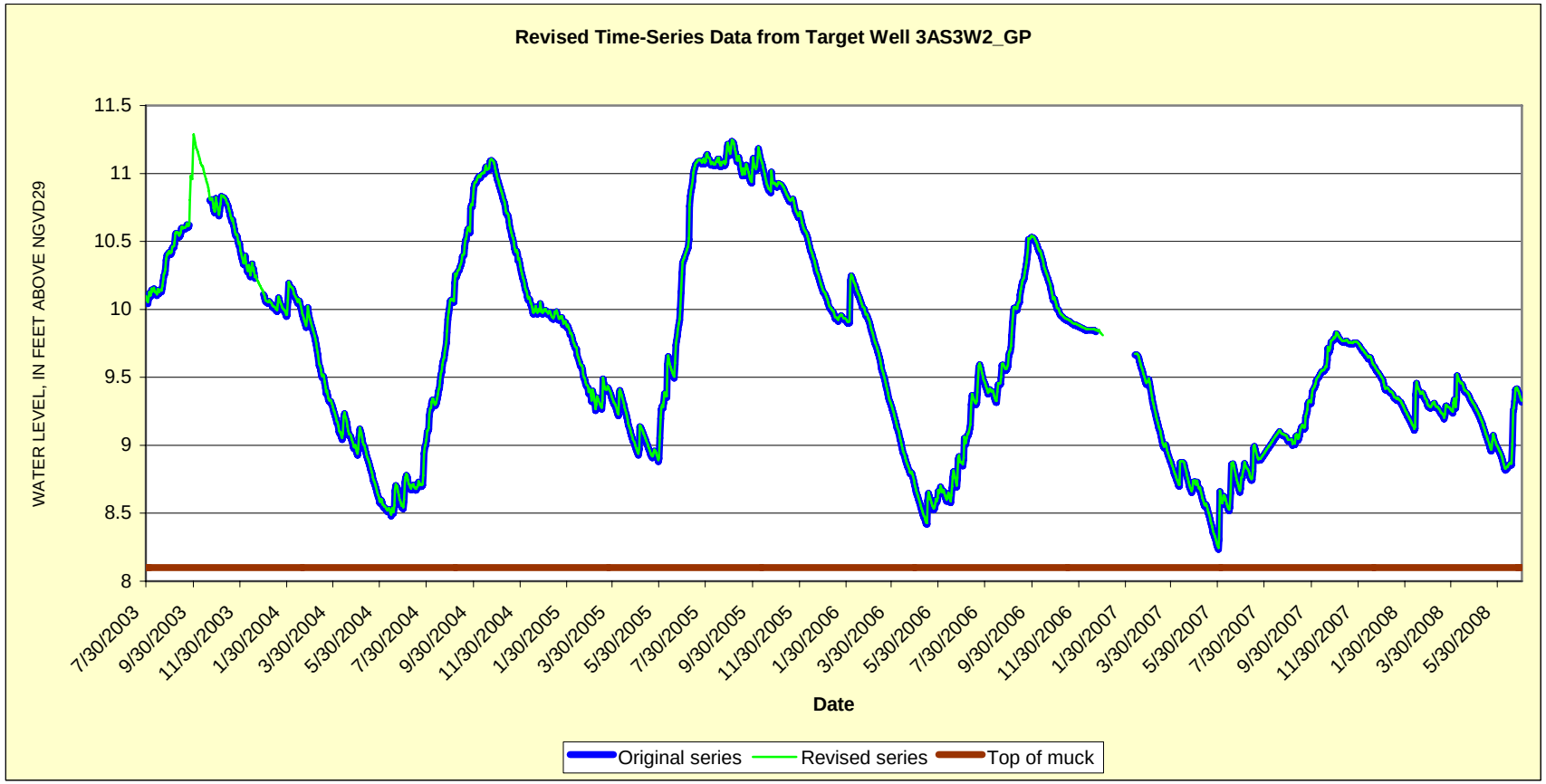
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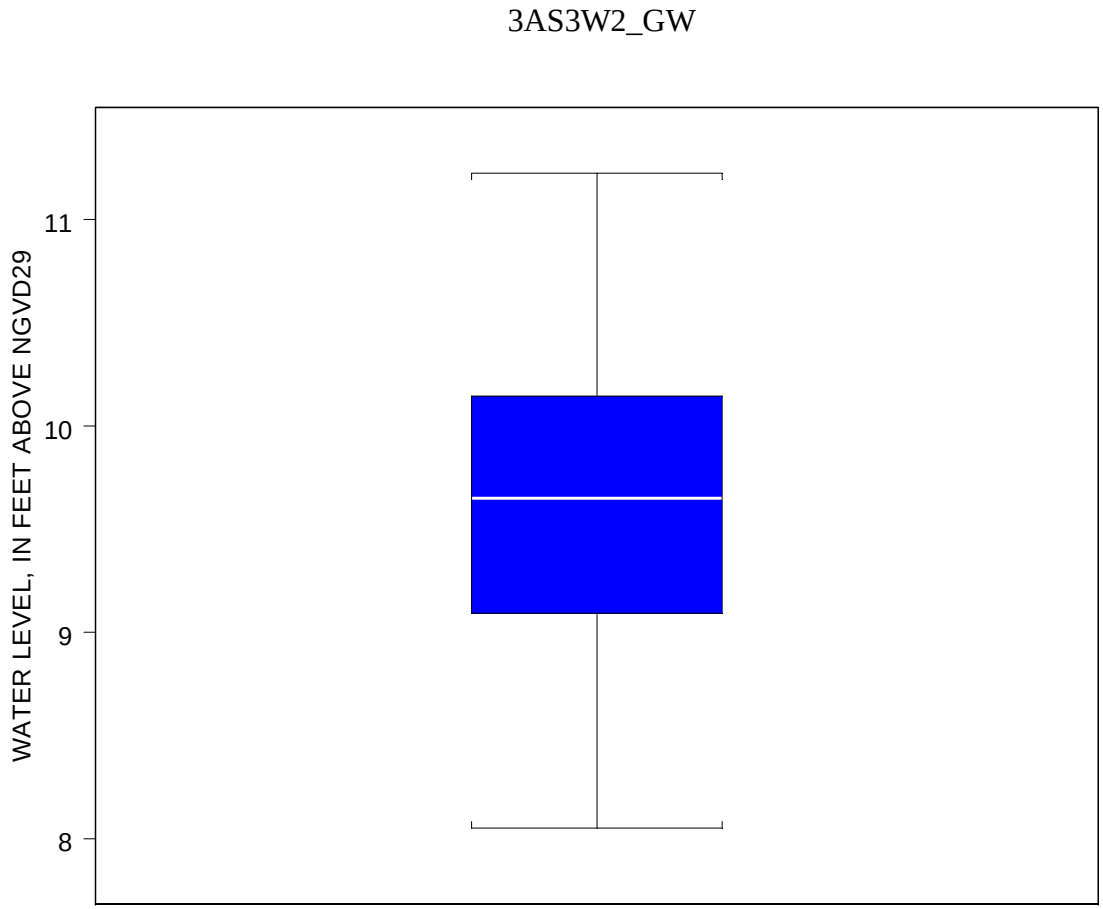
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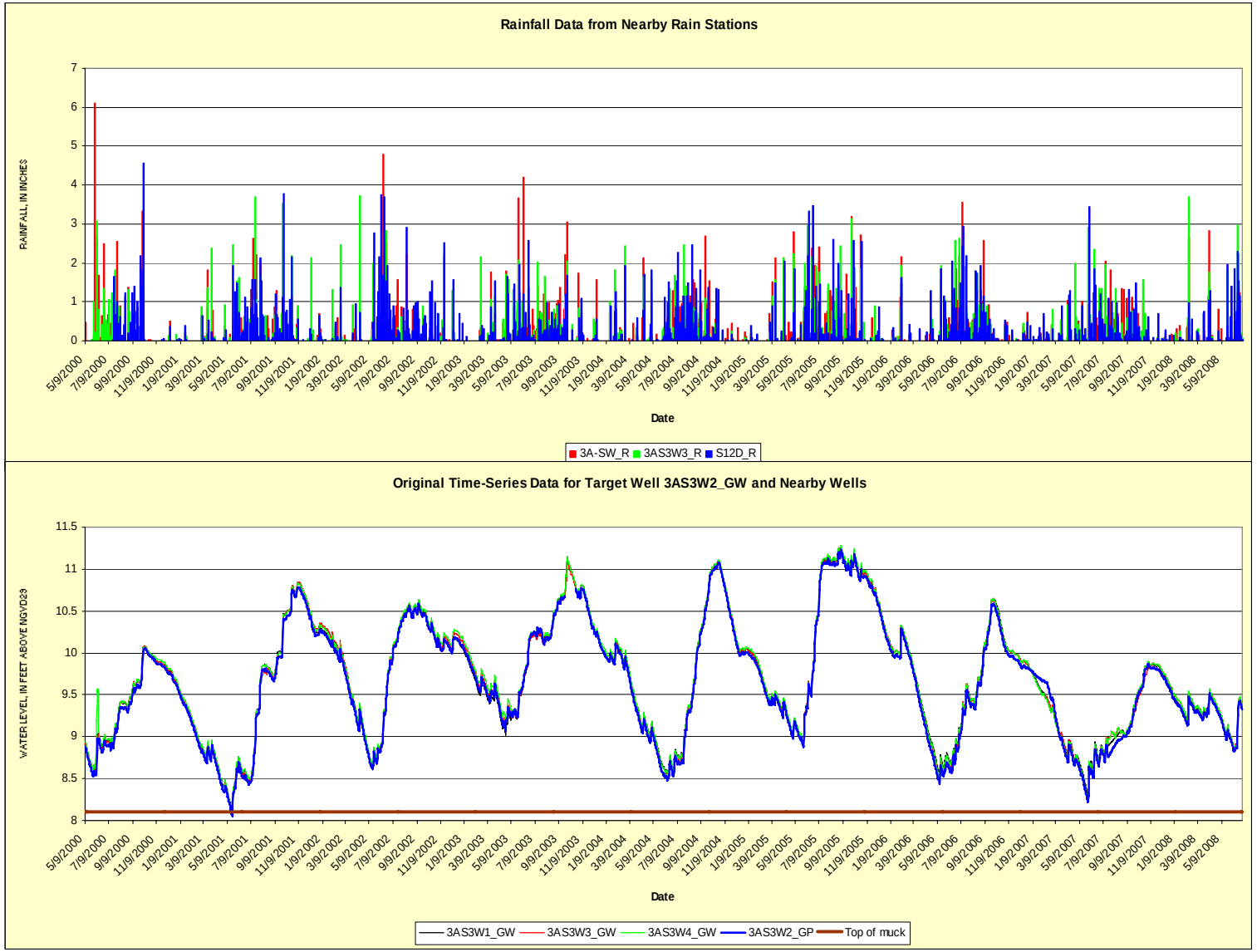
Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
Date
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S12D_R
Original Time-Series Data for Target Well 3AS3W2_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
Date
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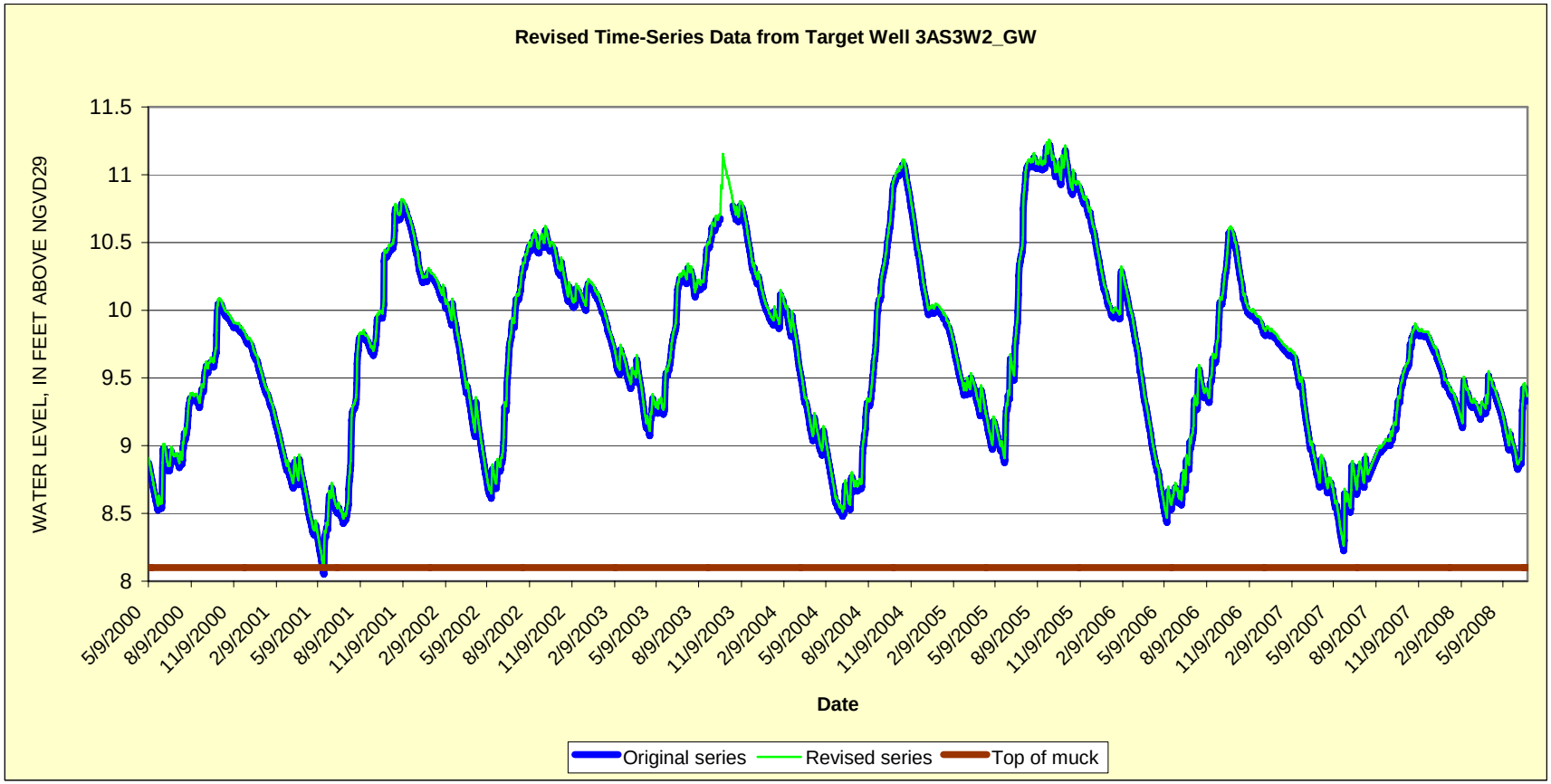
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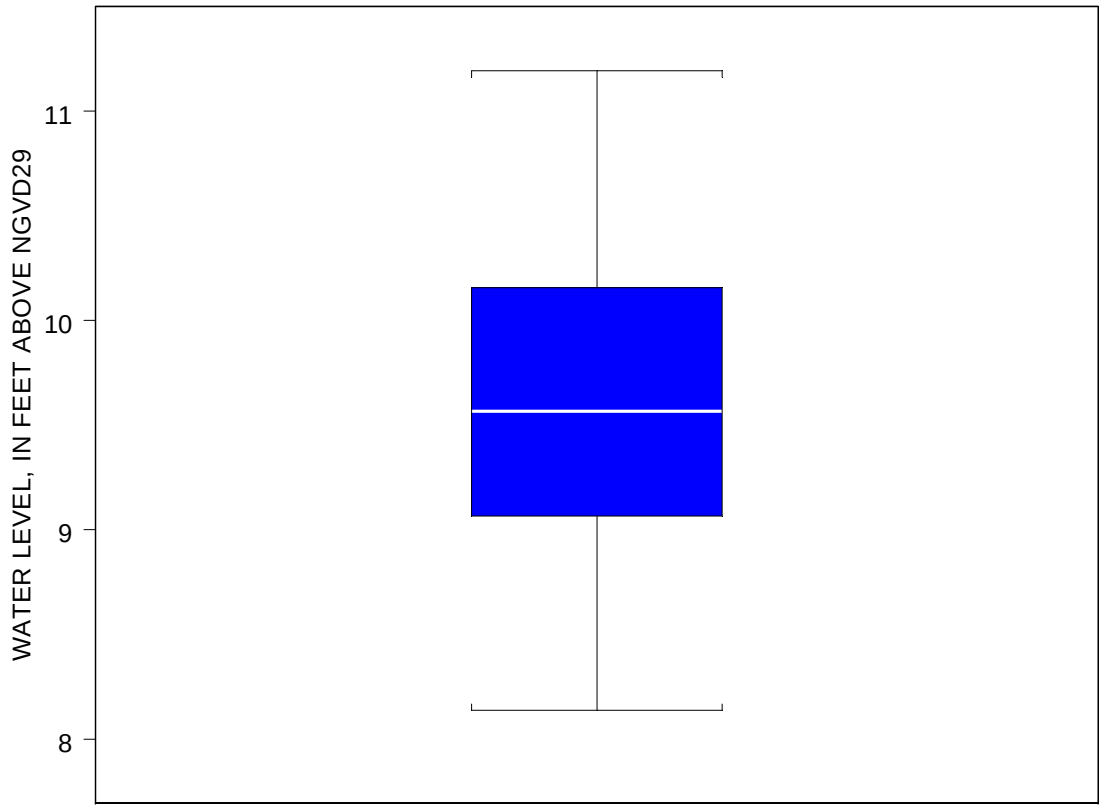
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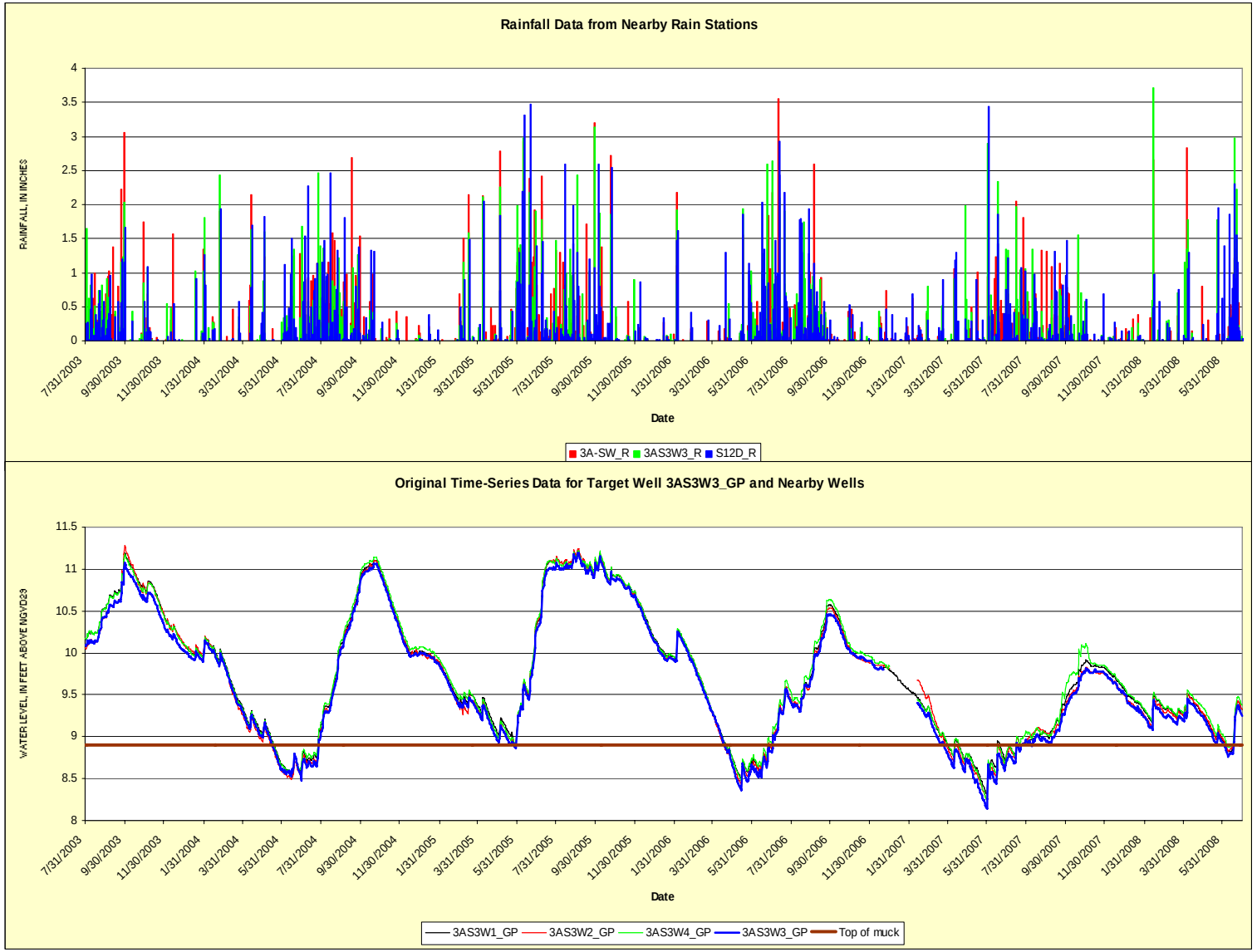
Rainfall Data from Nearby Rain Stations
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S12D_R
Original Time-Series Data for Target Well 3AS3W3_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
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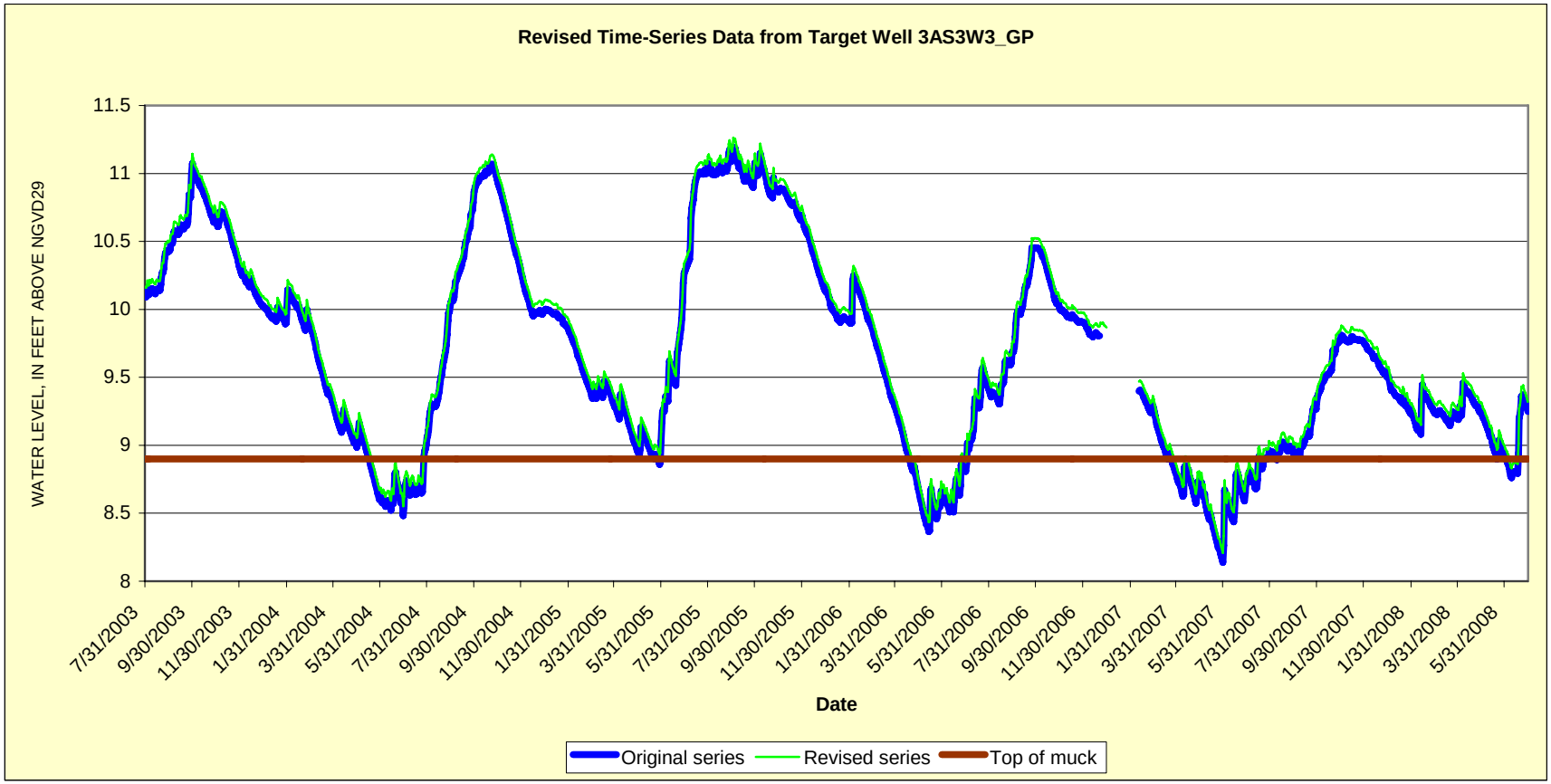
Revised Time-Series Data from Target Well 3AS3W3_GP
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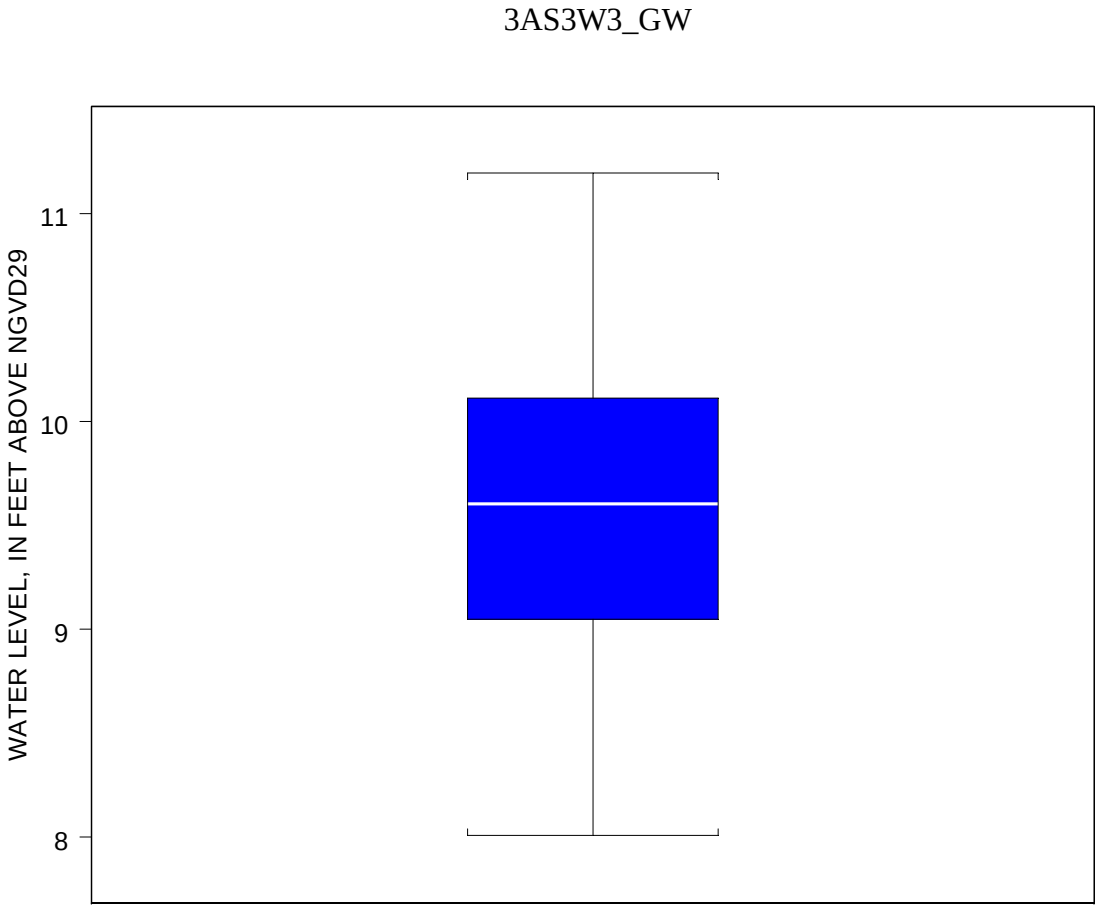
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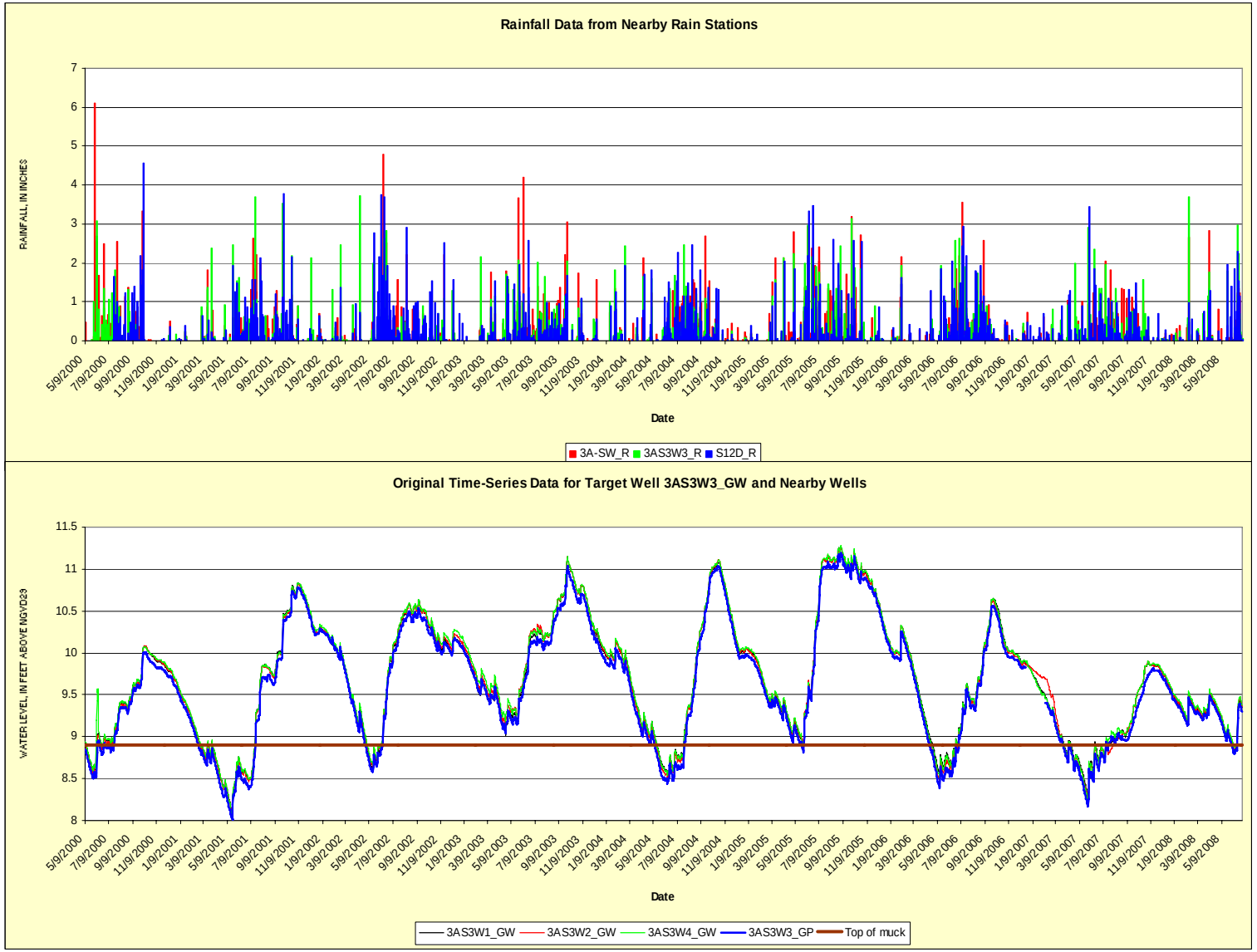
Rainfall Data from Nearby Rain Stations
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Original Time-Series Data for Target Well 3AS3W3_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
Date
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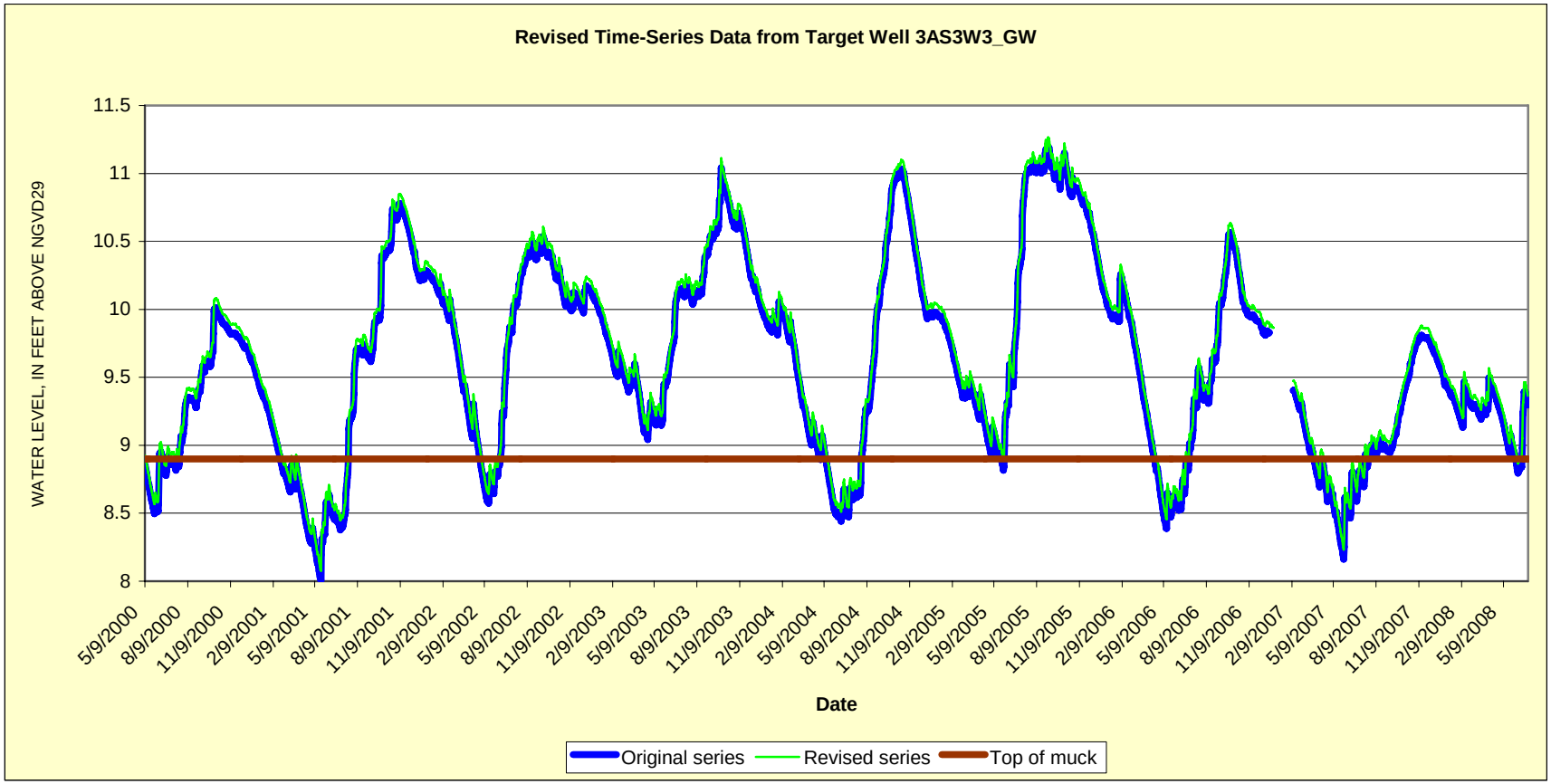
Revised Time-Series Data from Target Well 3AS3W3_GW
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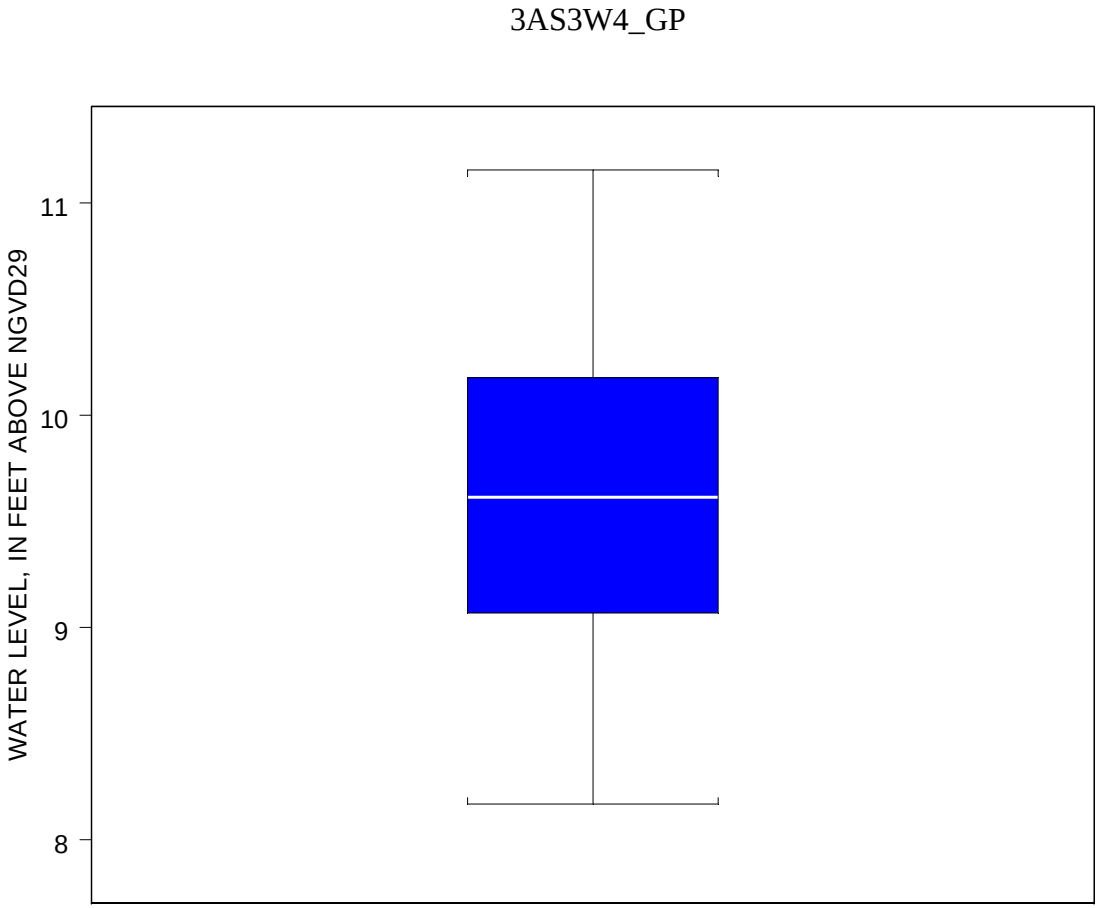
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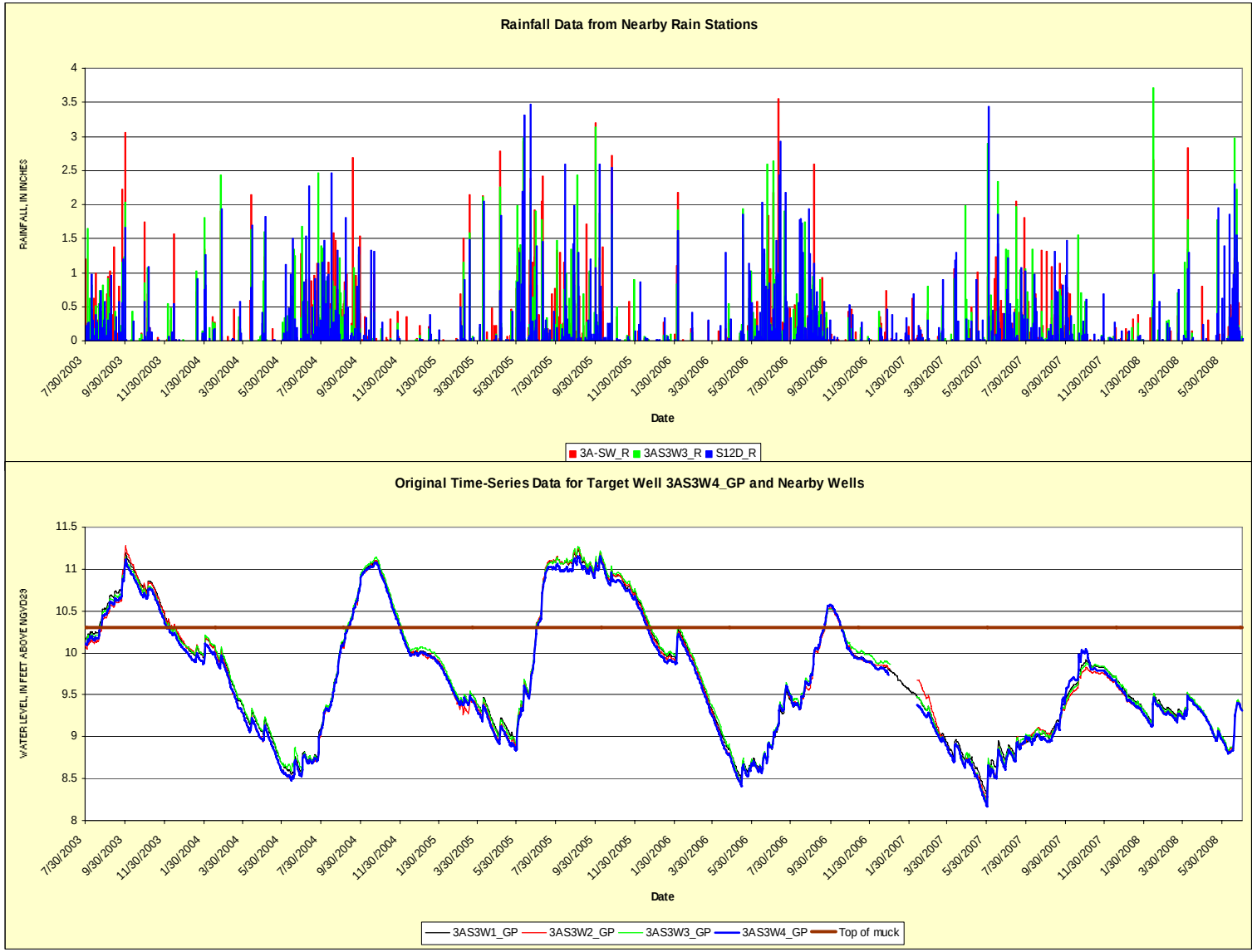
Rainfall Data from Nearby Rain Stations
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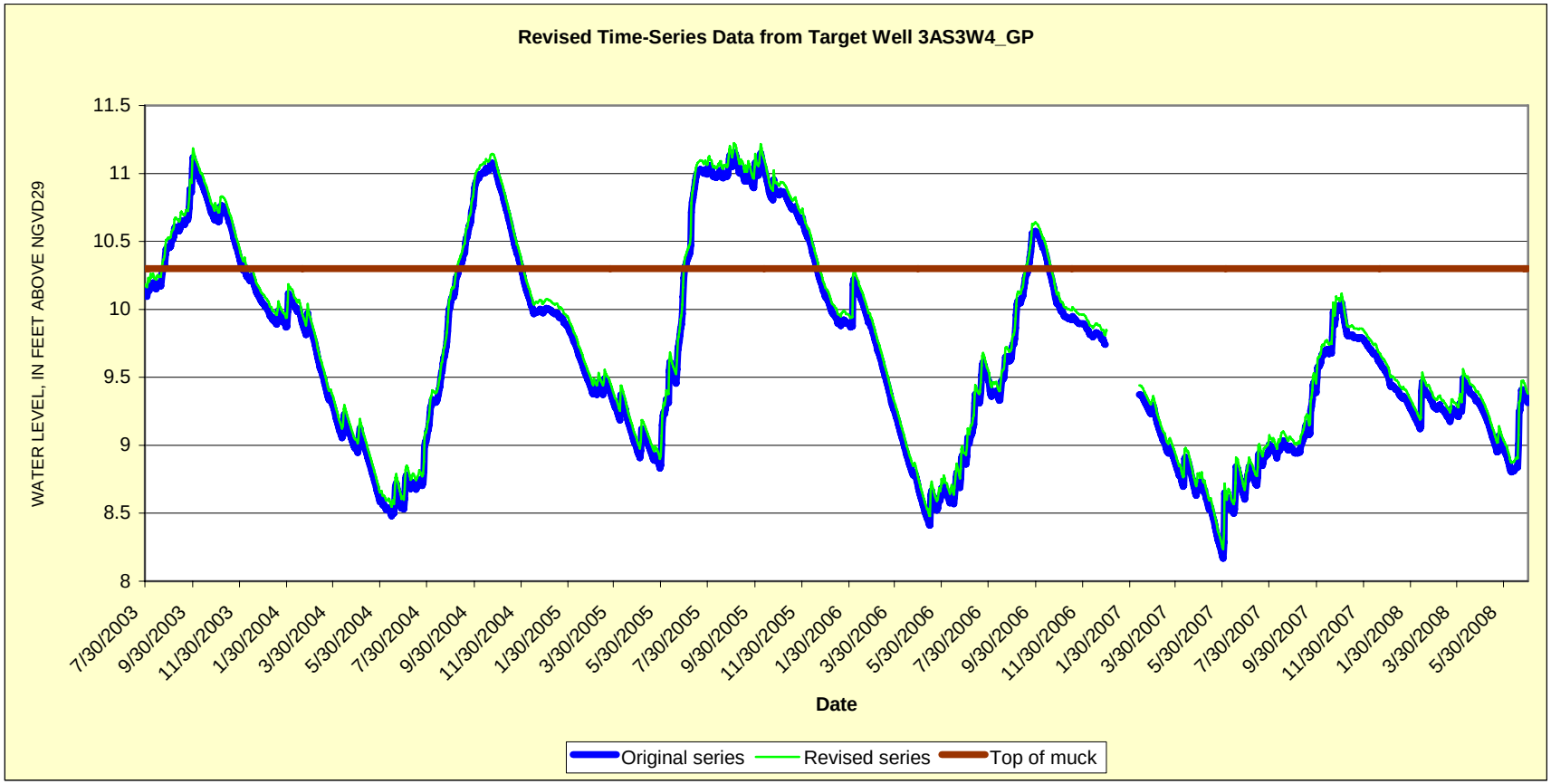
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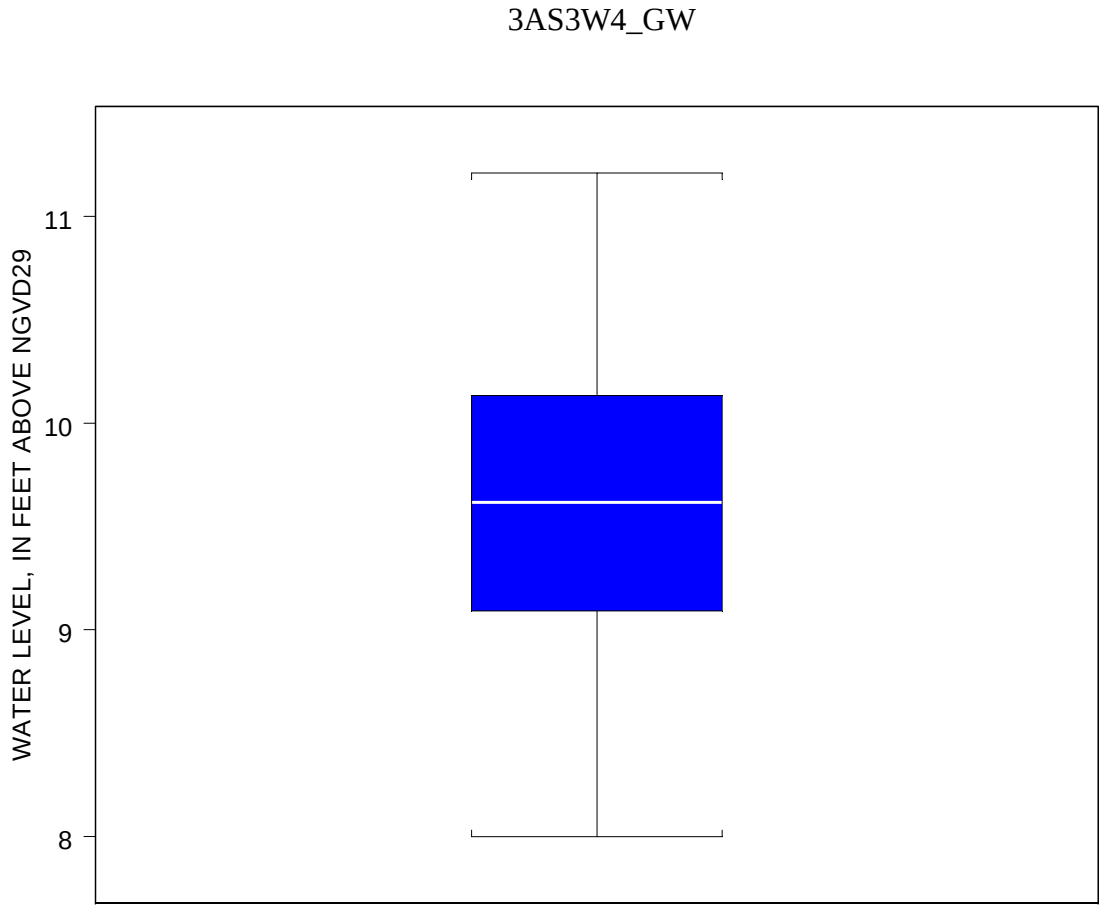
5/30/2008
Date
Original series
Revised series
Top of muck


3AS3W4_GW
WATER LEVEL, IN FEET ABOVE NGVD29
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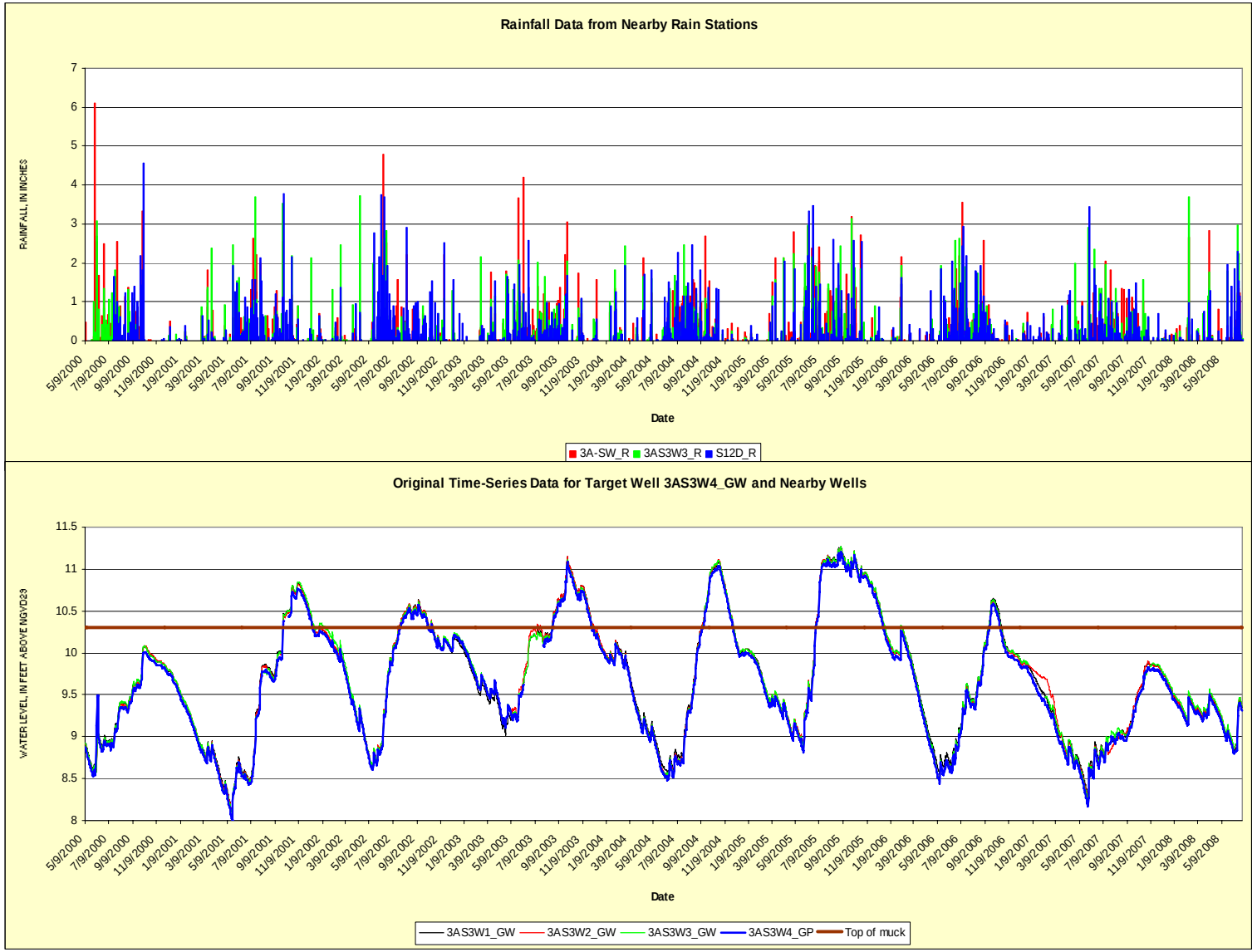
Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
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3/9/2008
5/9/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3AS3W4_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
8
8.5
9
9.5
10
10.5
11
11.5
5/9/2000
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1/9/2008
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5/9/2008
Date
3AS3W1_GW
3AS3W2_GW
3AS3W3_GW
3AS3W4_GP
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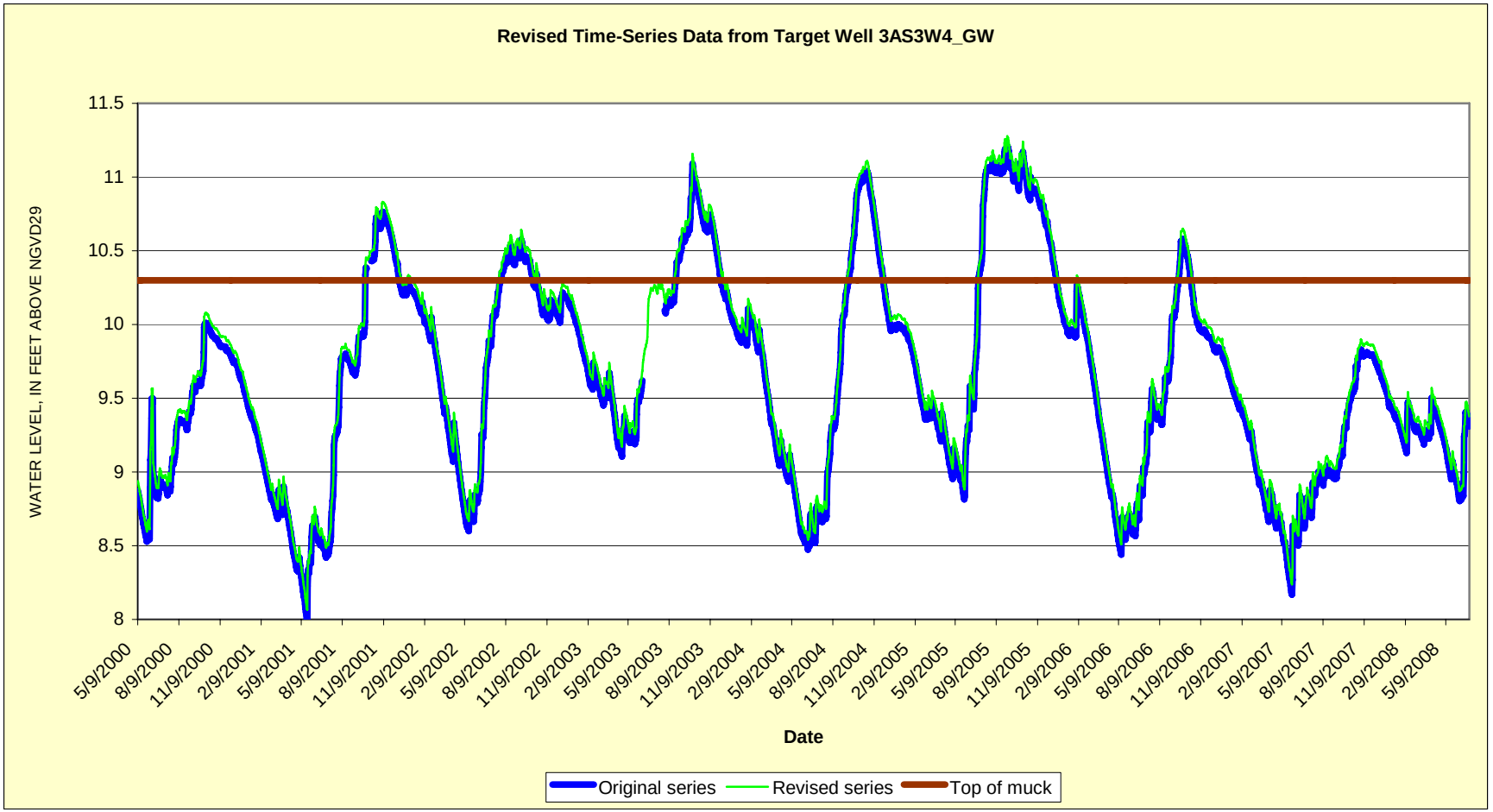
Revised Time-Series Data from Target Well 3AS3W4_GW
WATER LEVEL, IN FEET ABOVE NGVD29
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8.5
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2/9/2002
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5/9/2006
8/9/2006
11/9/2006
2/9/2007
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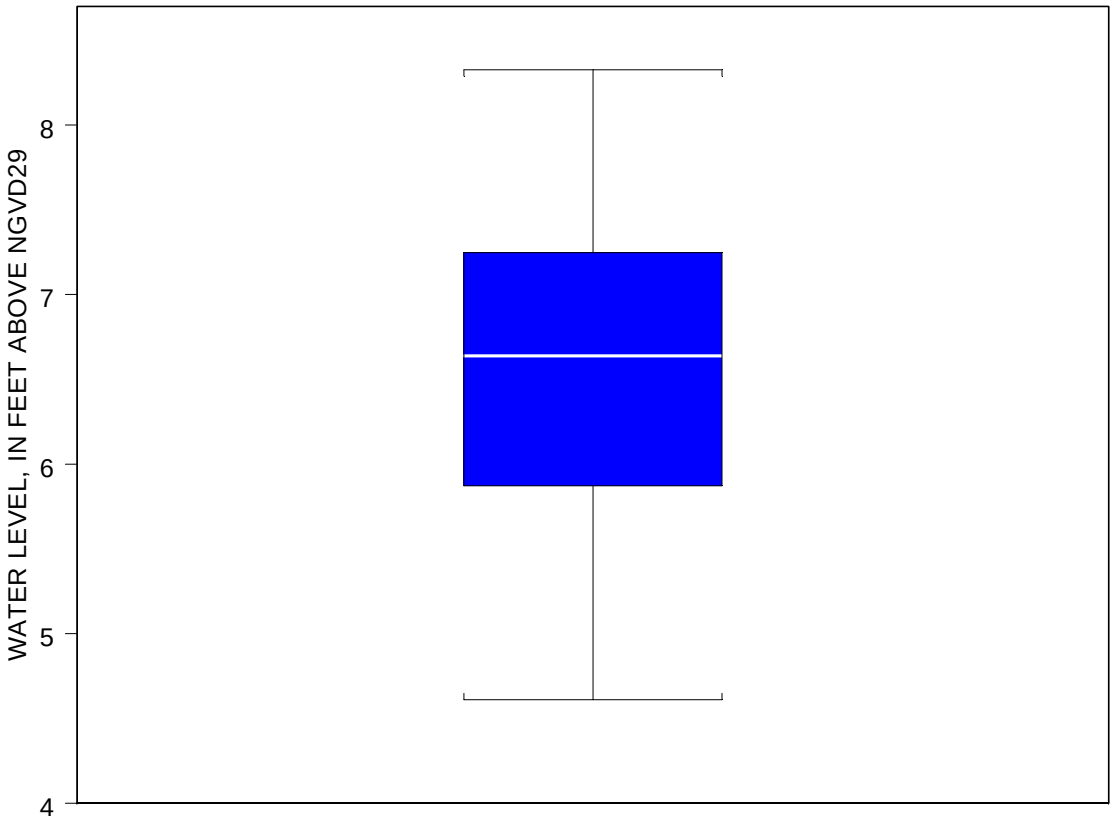
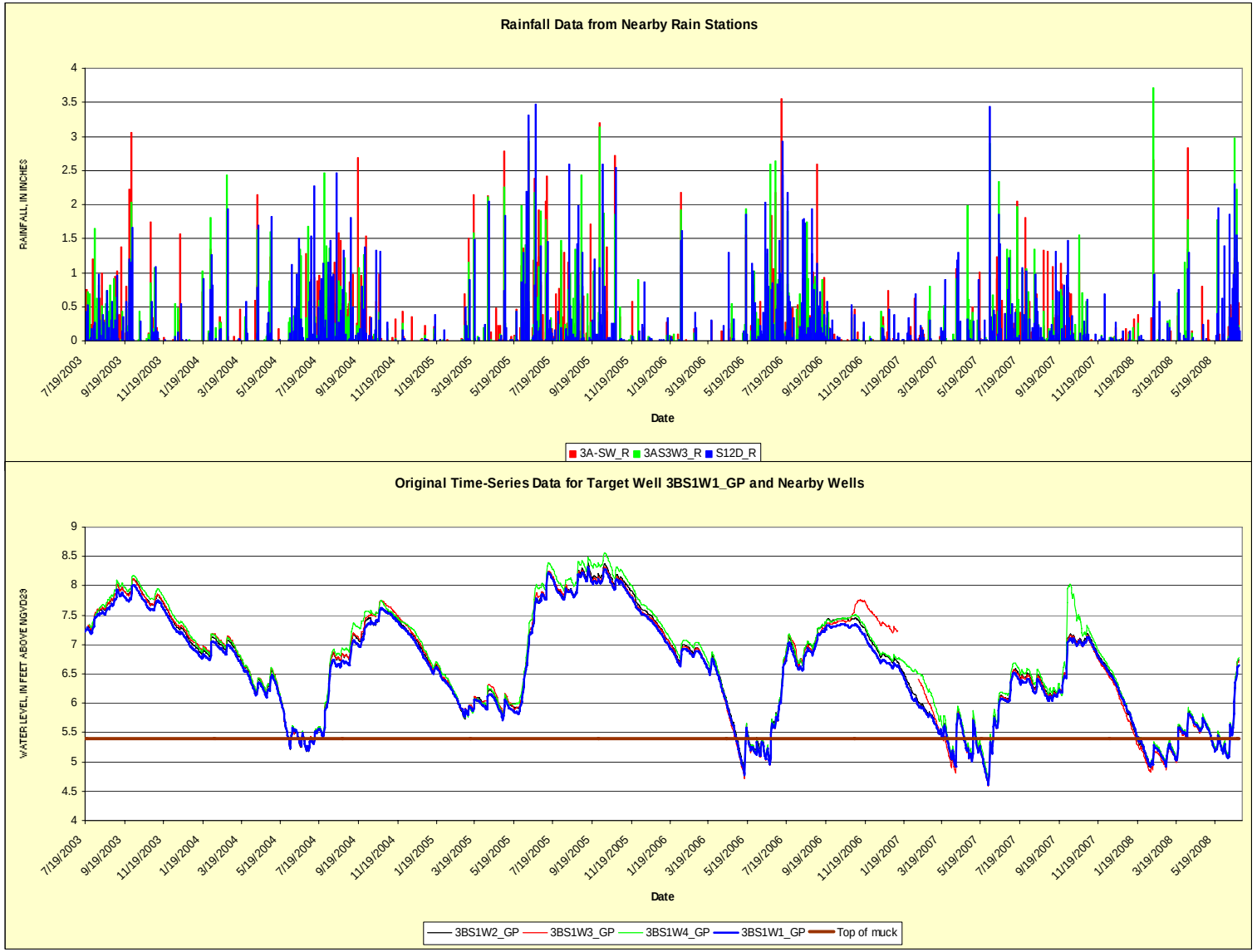
11/9/2007
2/9/2008
5/9/2008
Date
Original series
Revised series
Top of muck

3BS1W1_GP




Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
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11/19/2003
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1/19/2007
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11/19/2007
1/19/2008
3/19/2008
5/19/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W1_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
7/19/2003
9/19/2003
11/19/2003
1/19/2004
3/19/2004
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1/19/2005
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11/19/2007
1/19/2008
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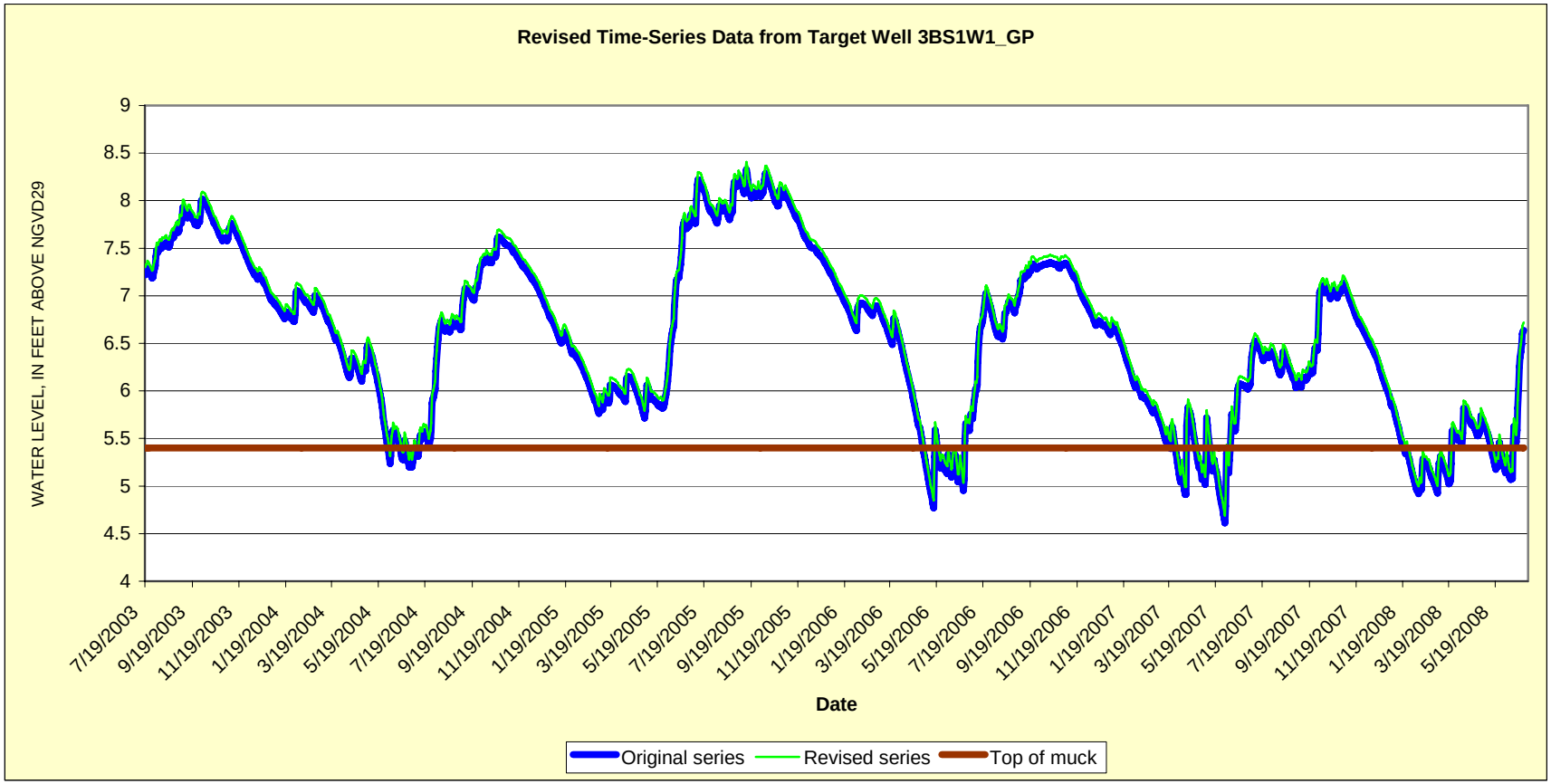
5/19/2008
Date
3BS1W2_GP
3BS1W3_GP
3BS1W4_GP
3BS1W1_GP
Top of muck


Revised Time-Series Data from Target Well 3BS1W1_GP
WATER LEVEL, IN FEET ABOVE NGVD29
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8.5
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7.5
7
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6
5.5
5
4.5
4
7/19/2003
9/19/2003
11/19/2003
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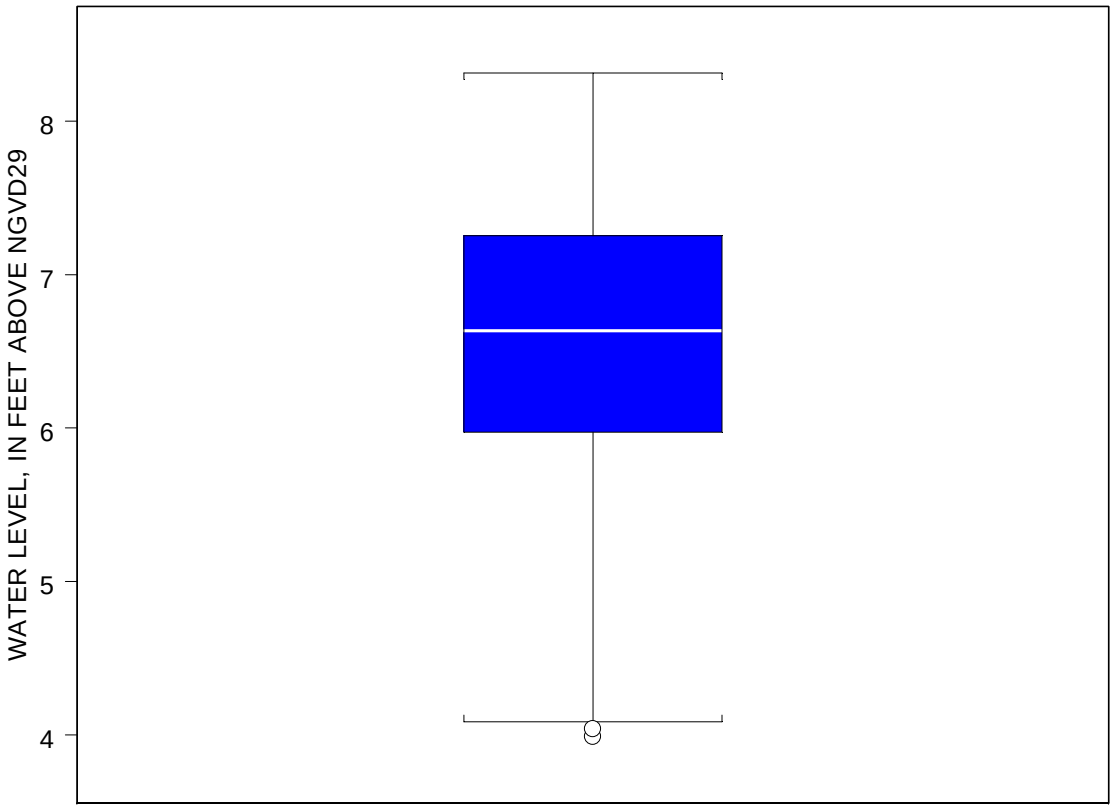
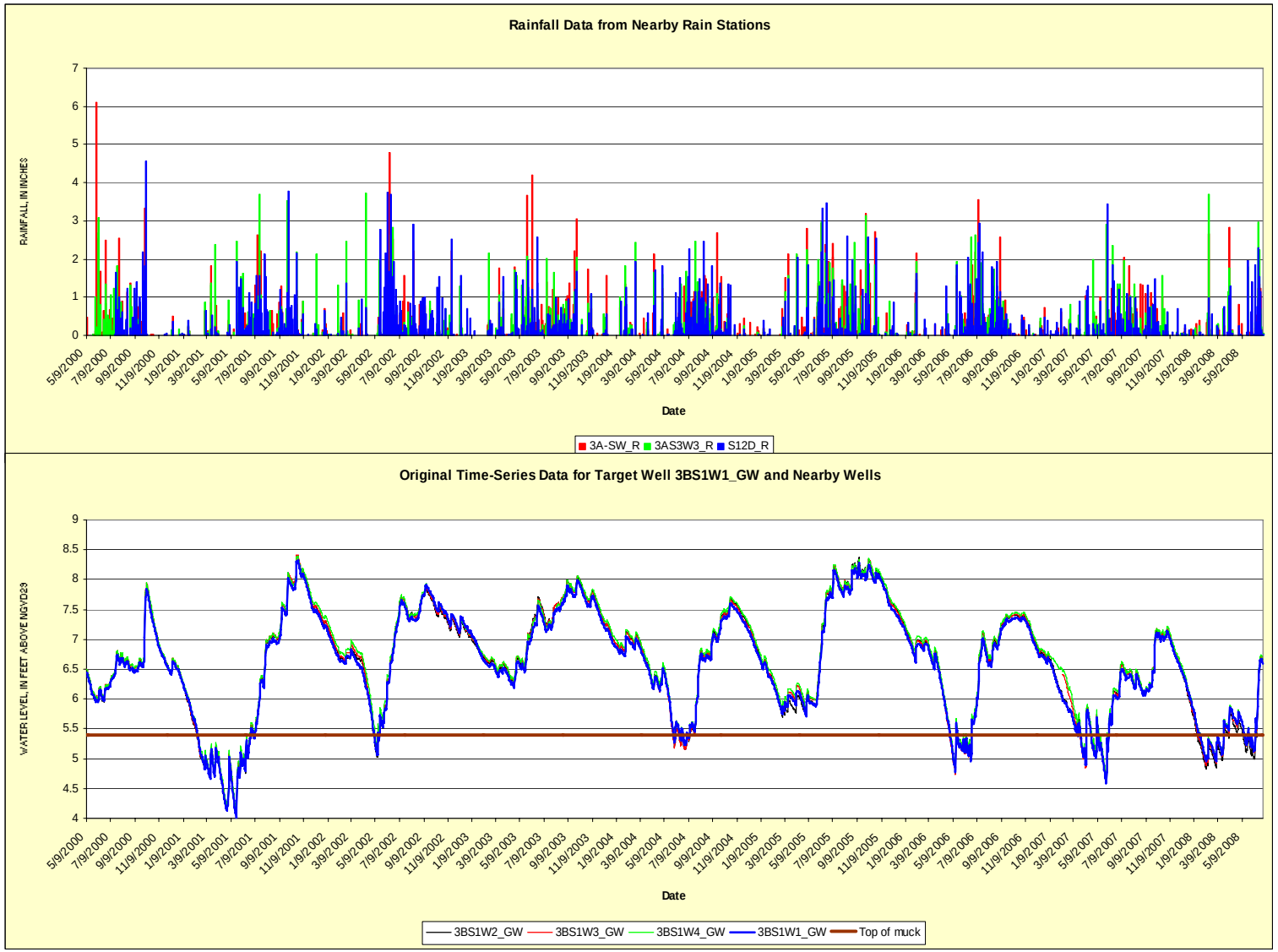
3/19/2008
5/19/2008
Date
Original series
Revised series
Top of muck

3BS1W1_GW




Rainfall Data from Nearby Rain Stations
RAINFALL IN INCHES
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5/9/2000
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1/9/2007
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7/9/2007
9/9/2007
11/9/2007
1/9/2008
3/9/2008
5/9/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W1_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
4
4.5
5
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6
6.5
7
7.5
8
8.5
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5/9/2000
7/9/2000
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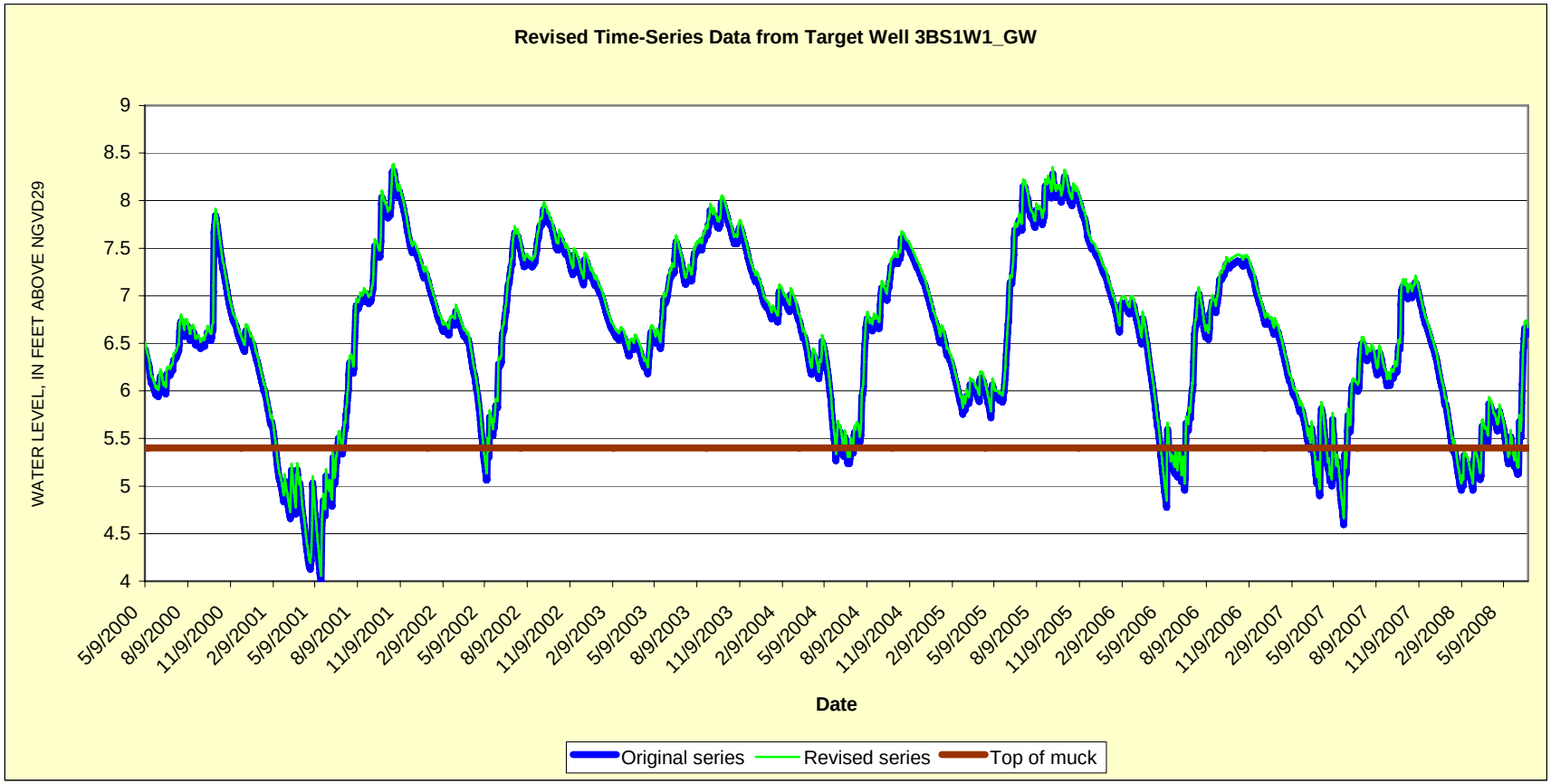
5/9/2008
Date
3BS1W2_GW
3BS1W3_GW
3BS1W4_GW
3BS1W1_GW
Top of muck


Revised Time-Series Data from Target Well 3BS1W1_GW
WATER LEVEL, IN FEET ABOVE NGVD29
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6.5
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5.5
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4.5
4
5/9/2000
8/9/2000
11/9/2000
2/9/2001
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8/9/2006
11/9/2006
2/9/2007
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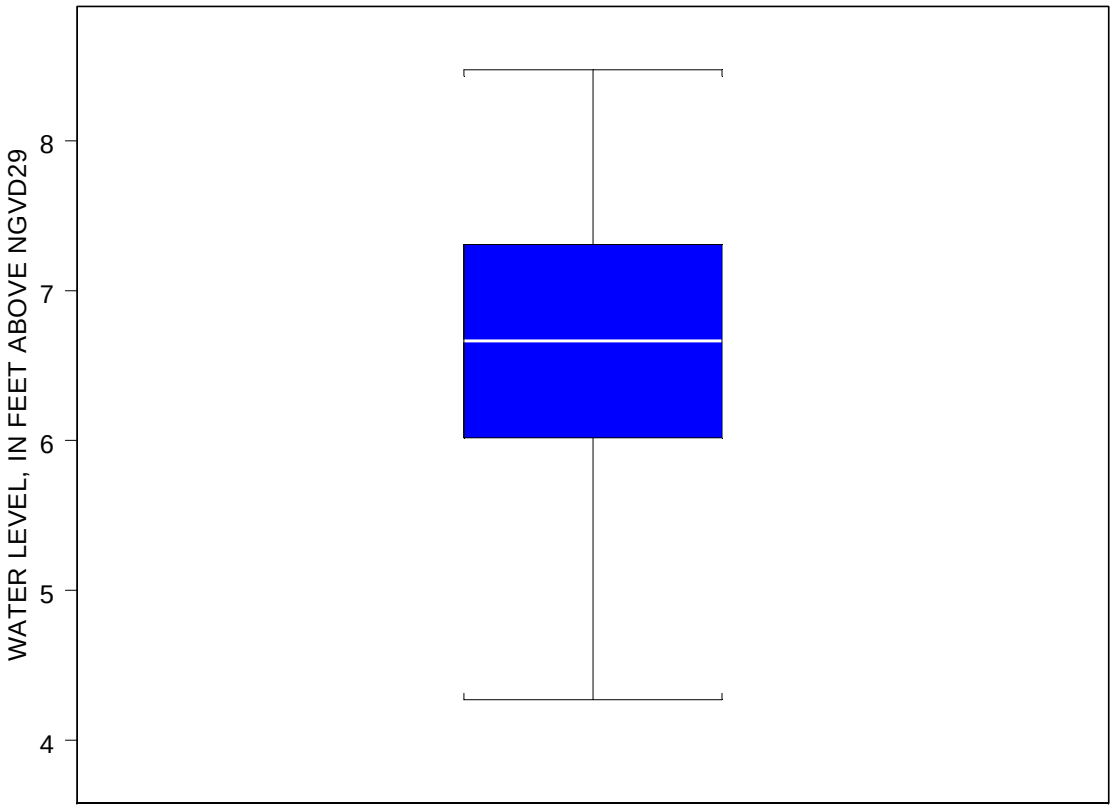
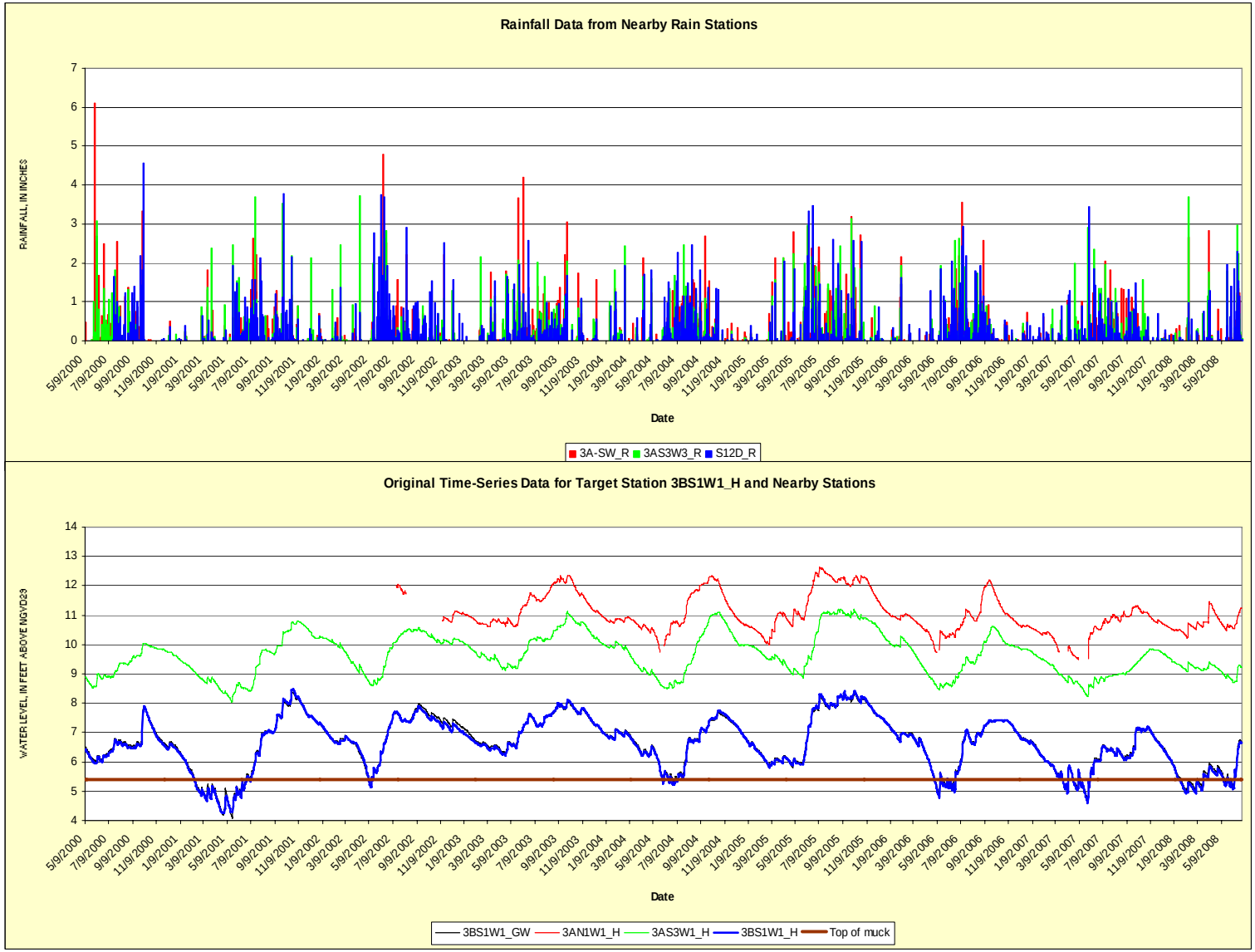
5/9/2008
Date
Original series
Revised series
Top of muck

3BS1W1_H




Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
Date
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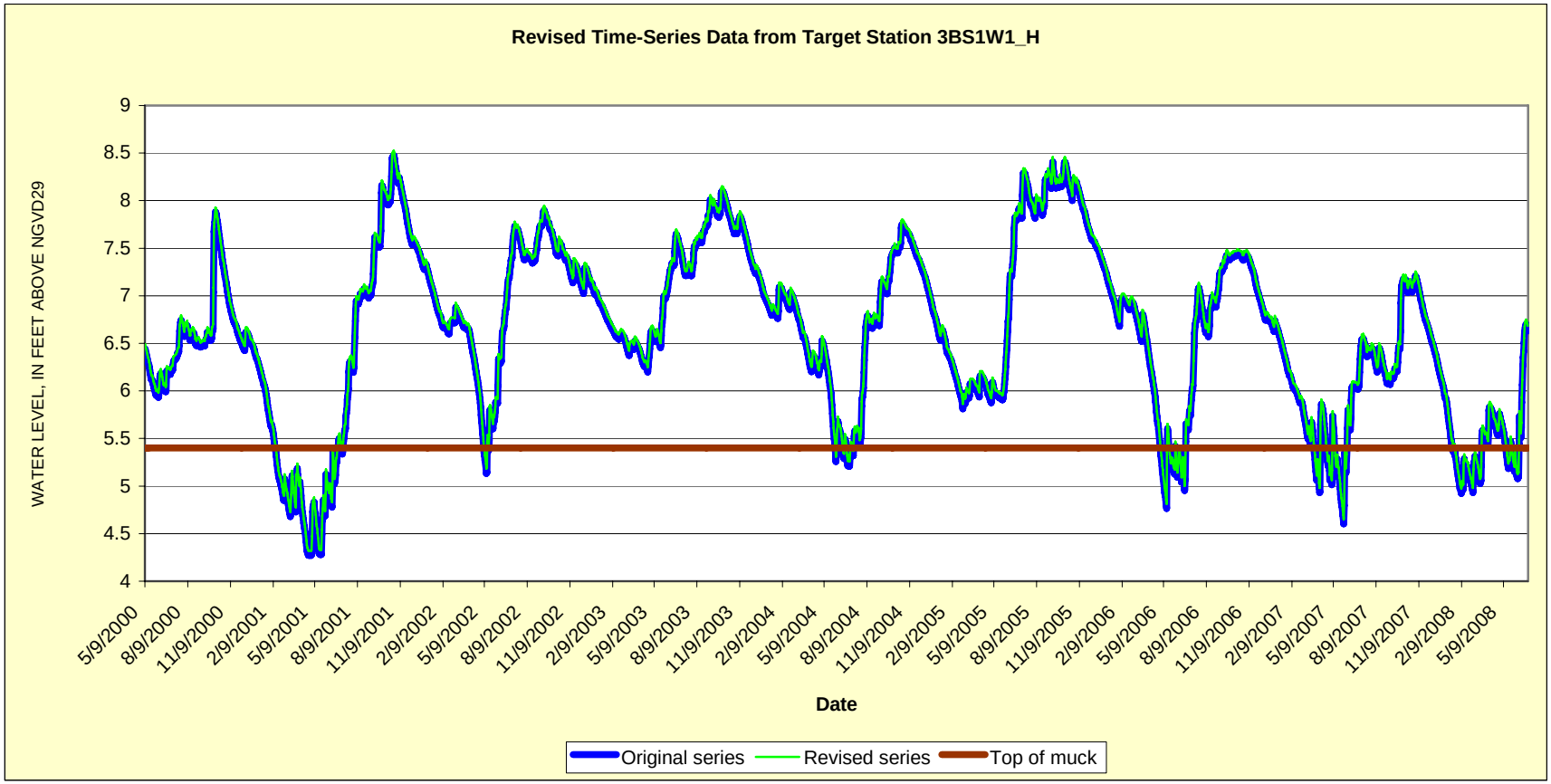
3AS3W3_R
S12D_R
Original Time-Series Data for Target Station 3BS1W1_H and Nearby Stations
WATER LEVEL, IN FEET ABOVE NGVD29
Date
3BS1W1_GW
3AN1W1_H
3AS3W1_H
3BS1W1_H
Top of muck


Revised Time-Series Data from Target Station 3BS1W1_H
WATER LEVEL, IN FEET ABOVE NGVD29
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8.5
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7.5
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6.5
6
5.5
5
4.5
4
5/9/2000
8/9/2000
11/9/2000
2/9/2001
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8/9/2001
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2/9/2002
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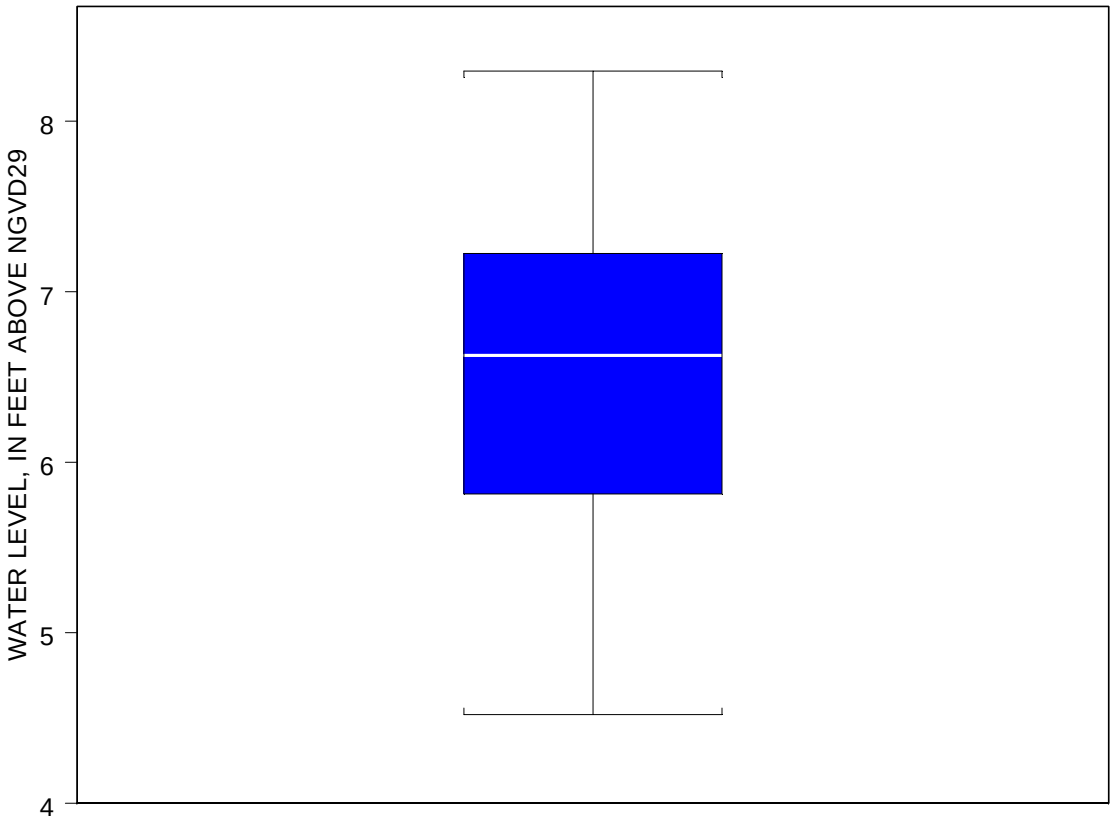
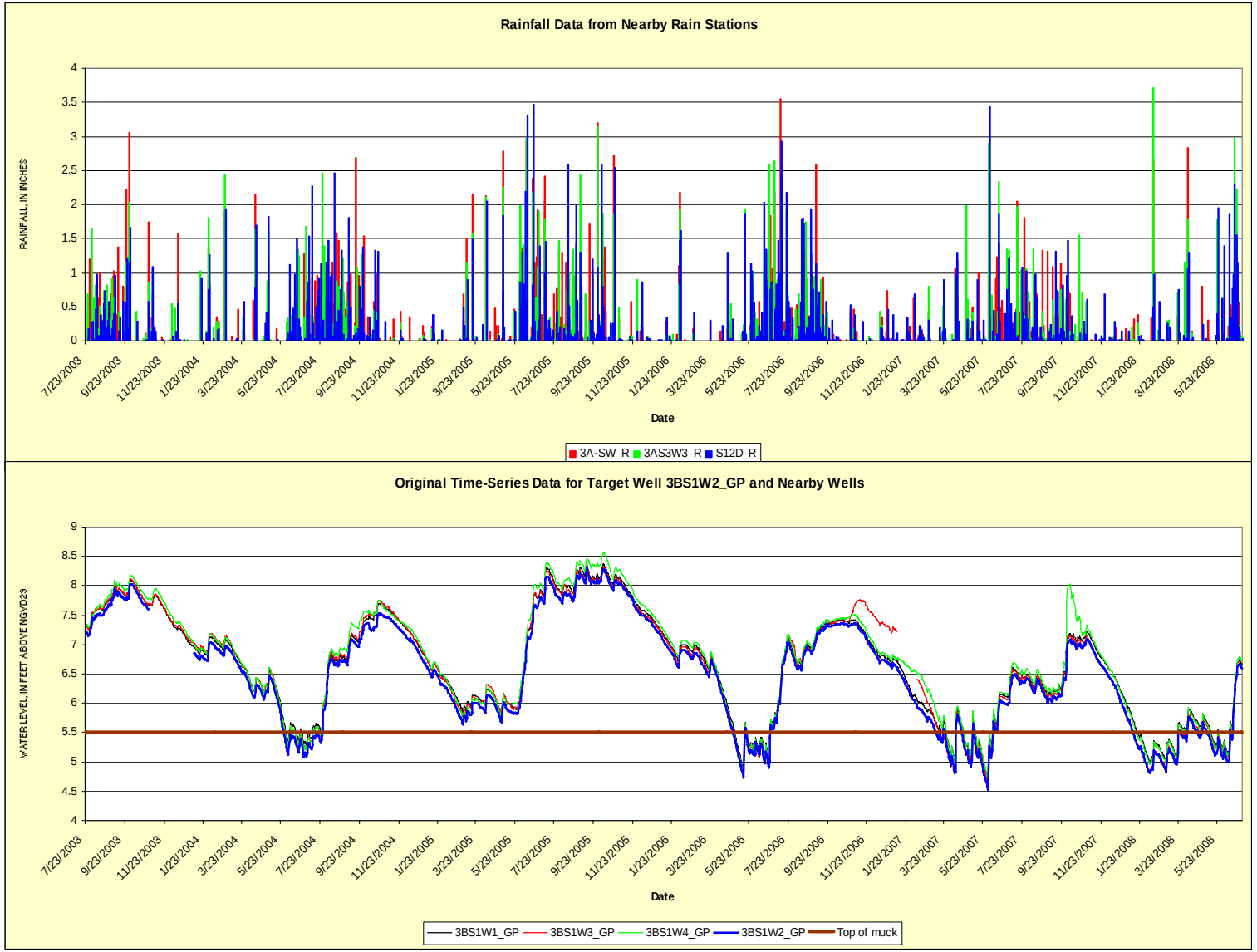
5/9/2008
Date
Original series
Revised series
Top of muck

3BS1W2_GP




Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
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3.5
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2.5
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9/23/2003
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1/23/2008
3/23/2008
5/23/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W2_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
9
8.5
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7.5
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7/23/2003
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Date
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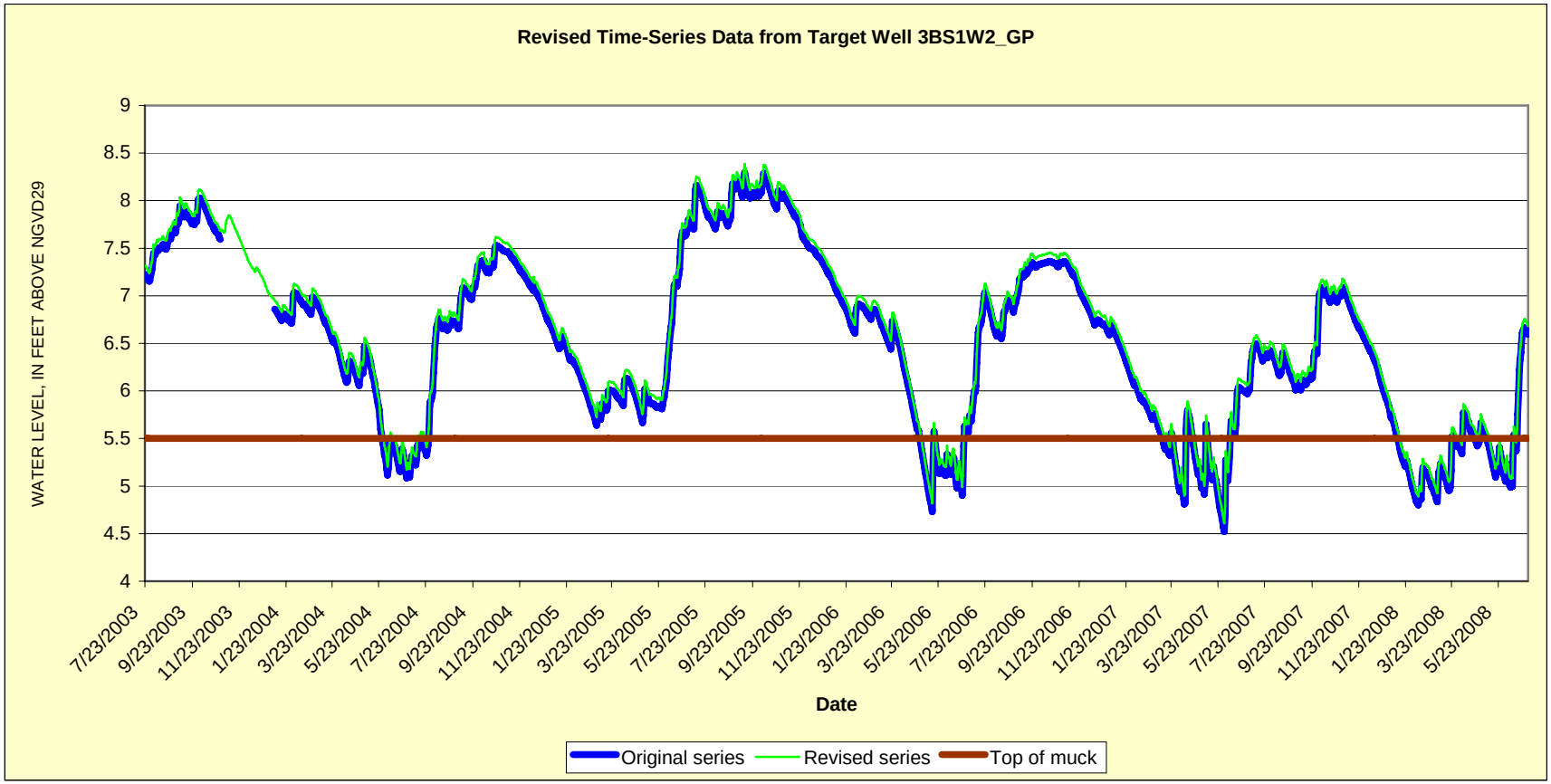
3BS1W4_GP
3BS1W2_GP
Top of muck


Revised Time-Series Data from Target Well 3BS1W2_GP
WATER LEVEL, IN FEET ABOVE NGVD29
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5.5
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4.5
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7/23/2003
9/23/2003
11/23/2003
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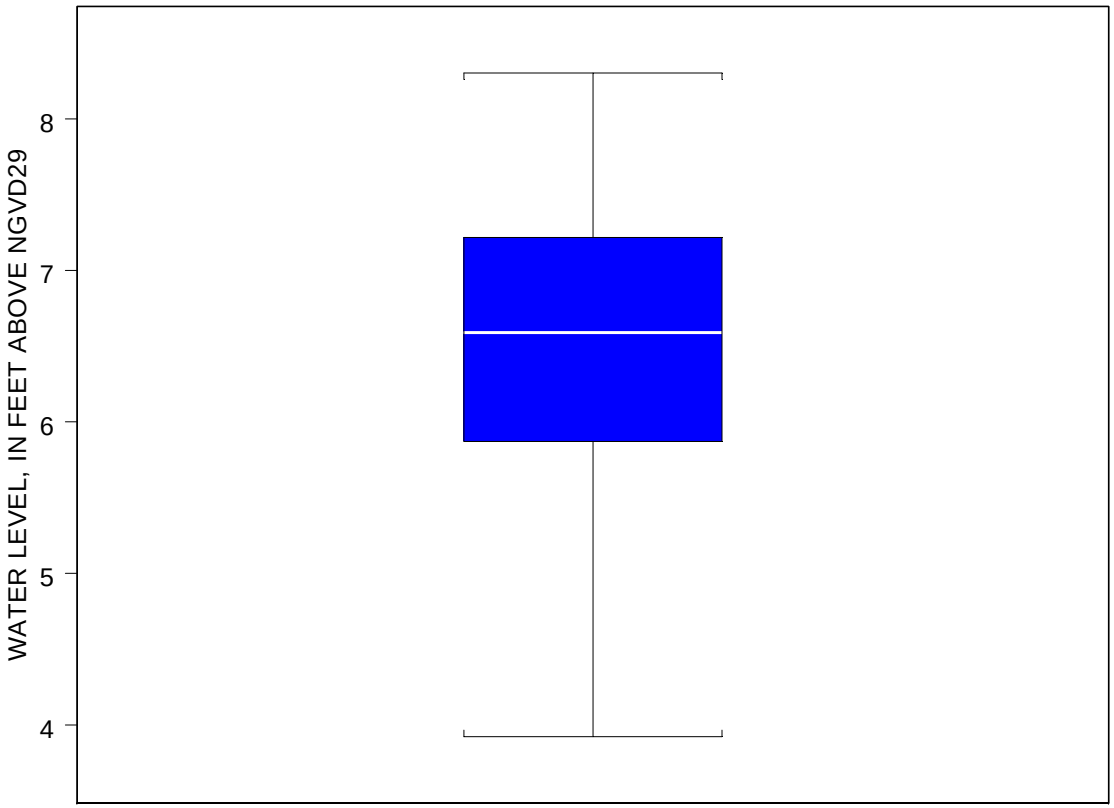
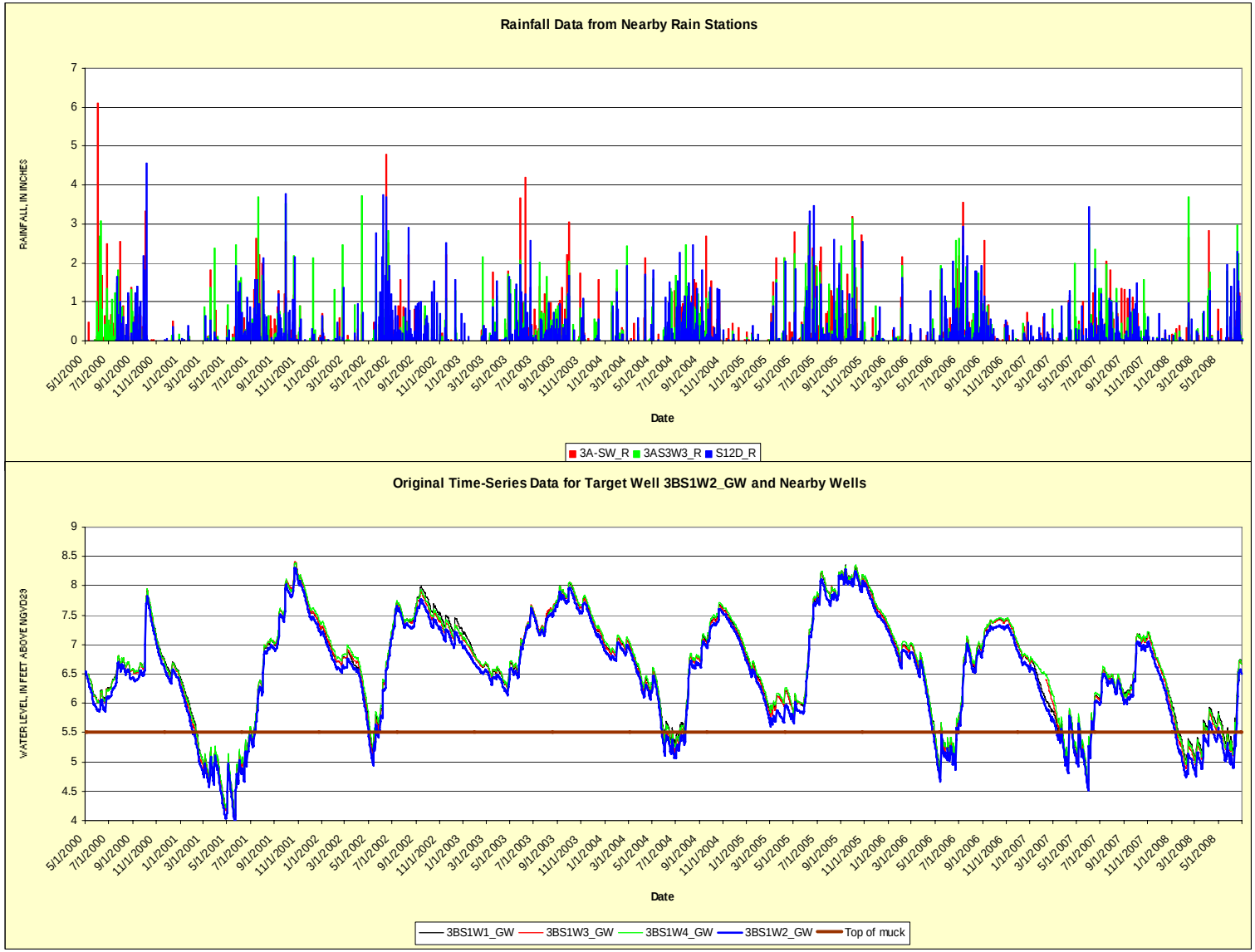
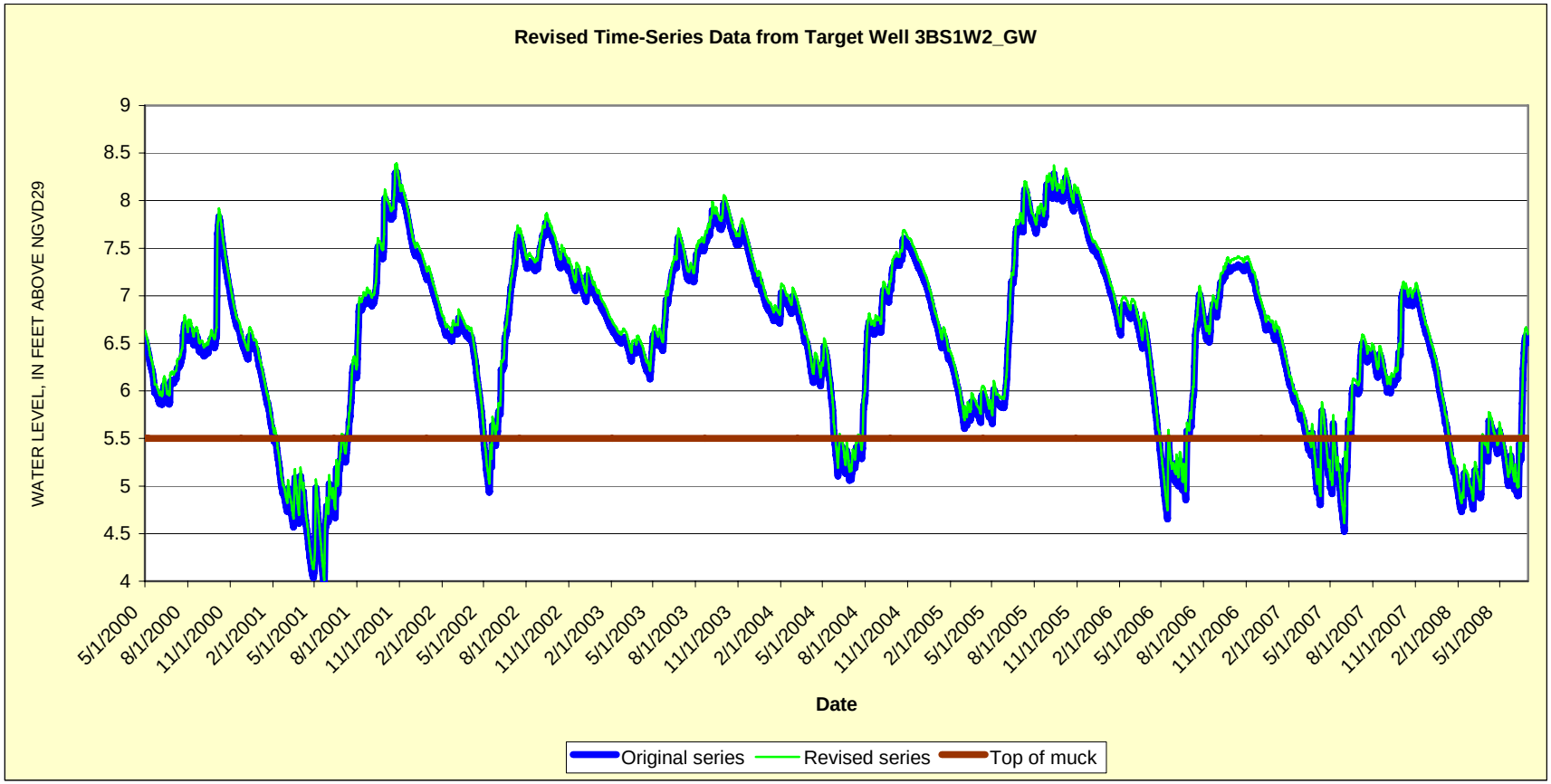
5/23/2008
Date
Original series
Revised series
Top of muck

3BS1W2_GW




Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W2_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
Date
3BS1W1_GW
3BS1W3_GW
3BS1W4_GW
3BS1W2_GW
Top of muck


Revised Time-Series Data from Target Well 3BS1W2_GW
WATER LEVEL, IN FEET ABOVE NGVD29
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5.5
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4.5
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5/1/2000
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11/1/2000
2/1/2001
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8/1/2001
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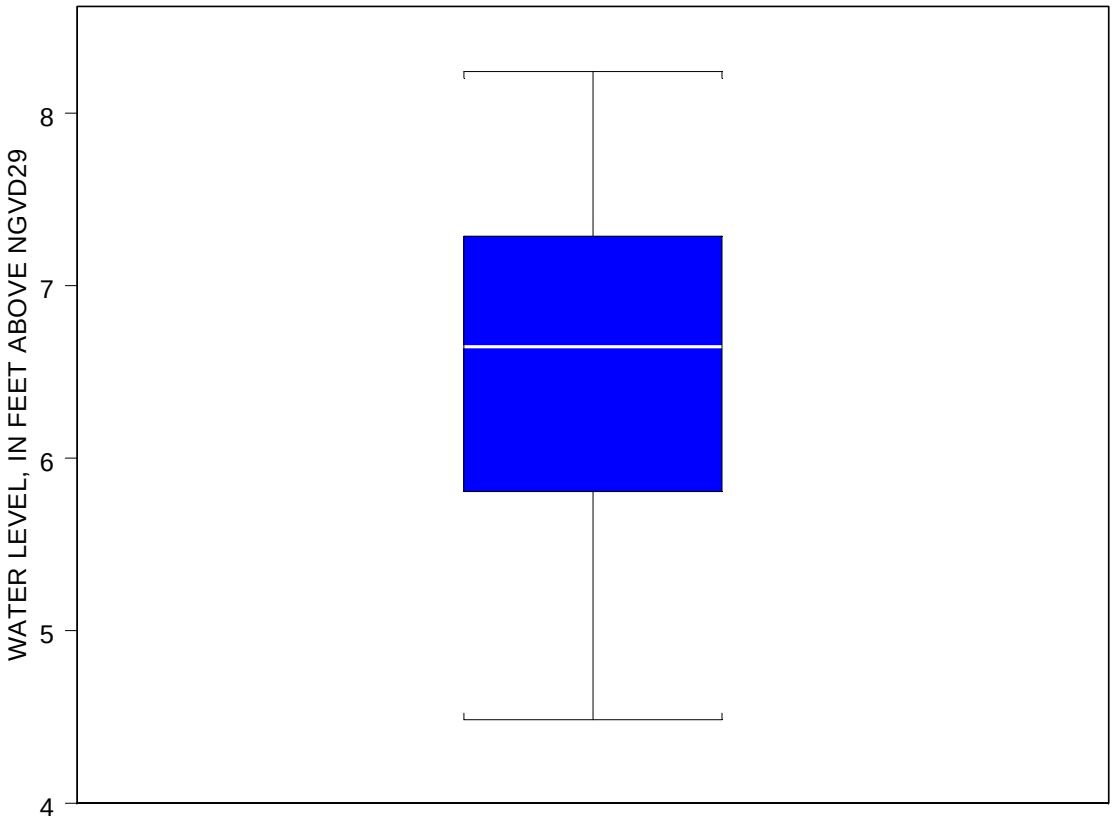
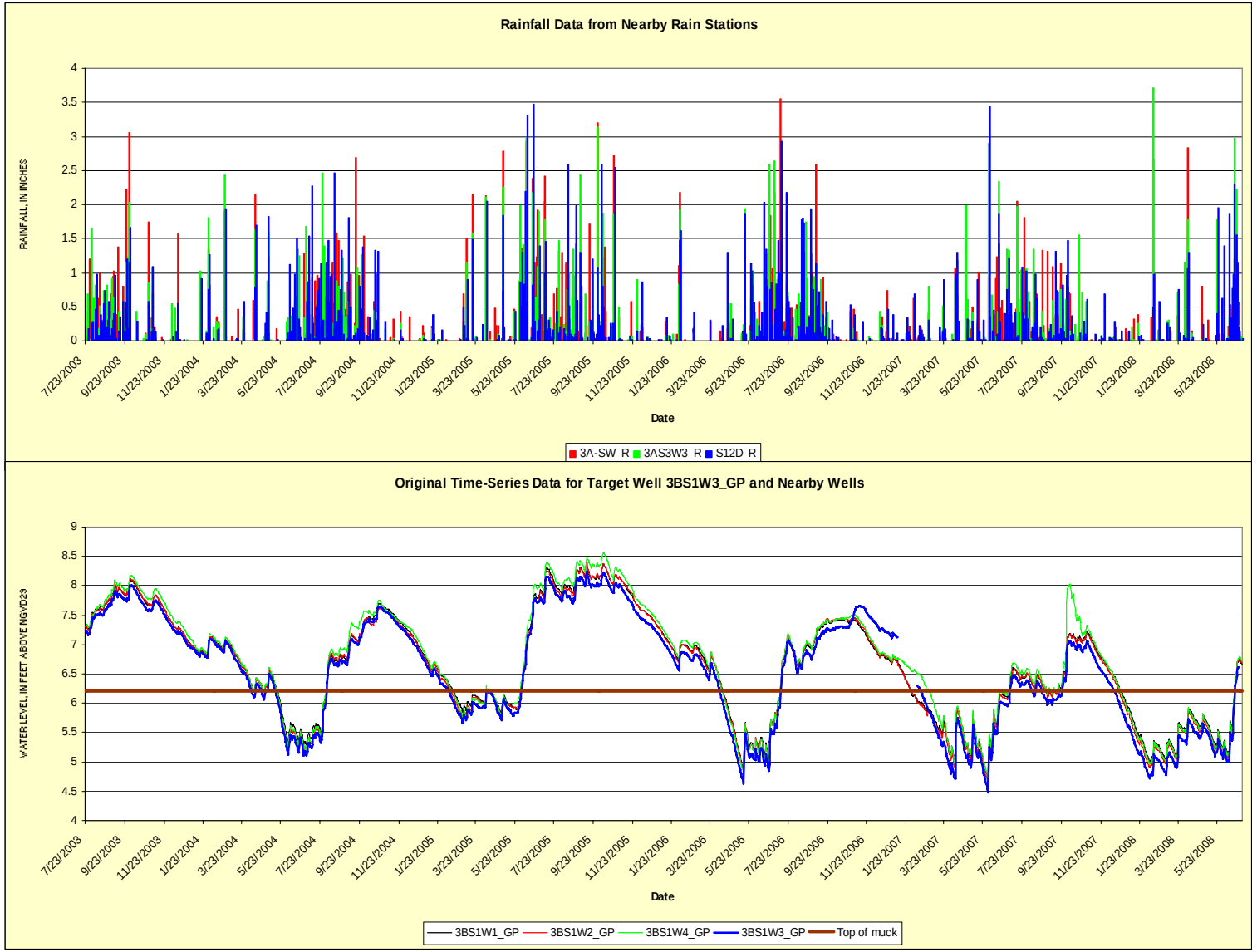
Date
Original series
Revised series
Top of muck

3BS1W3_GP




Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
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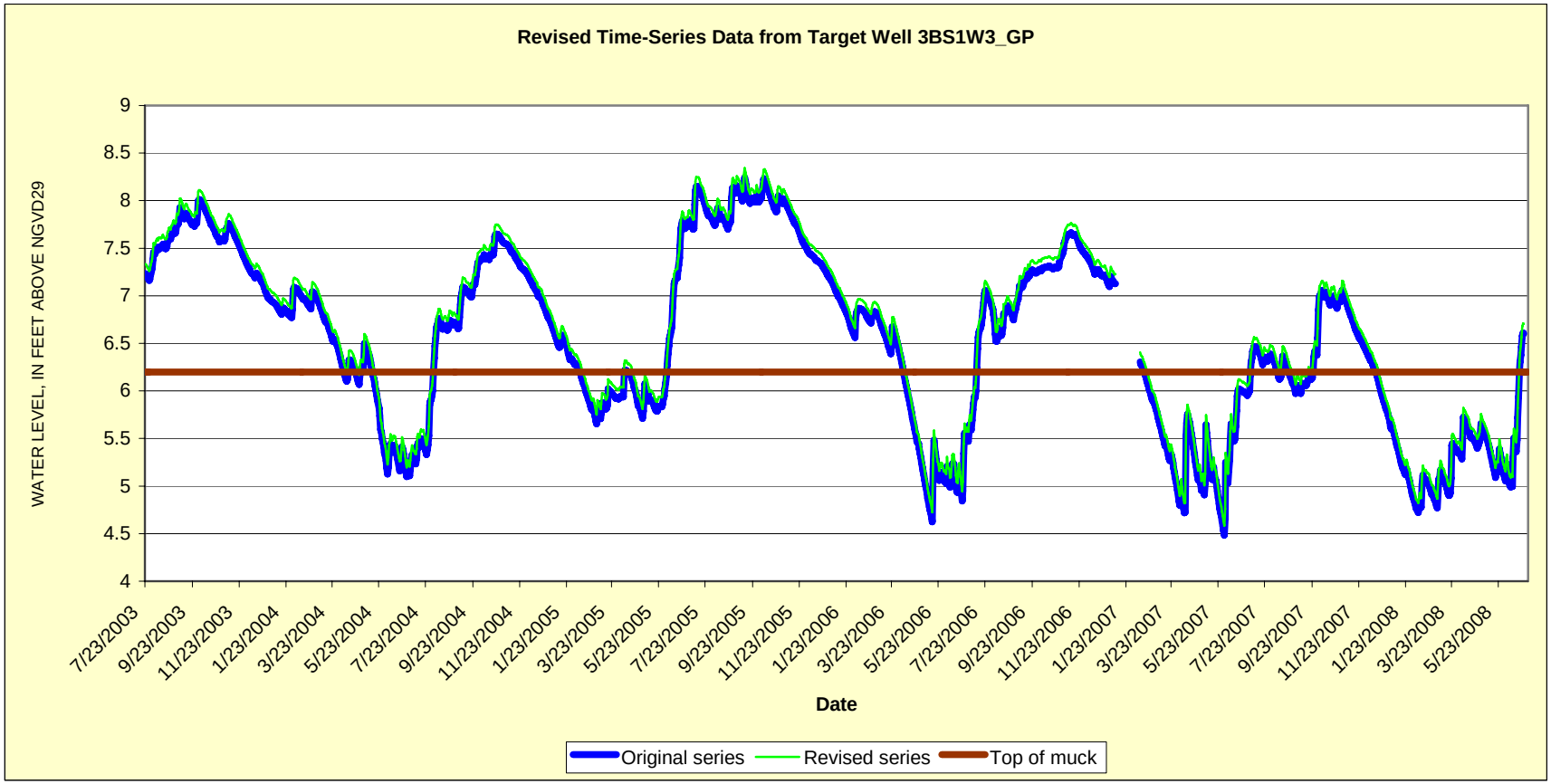
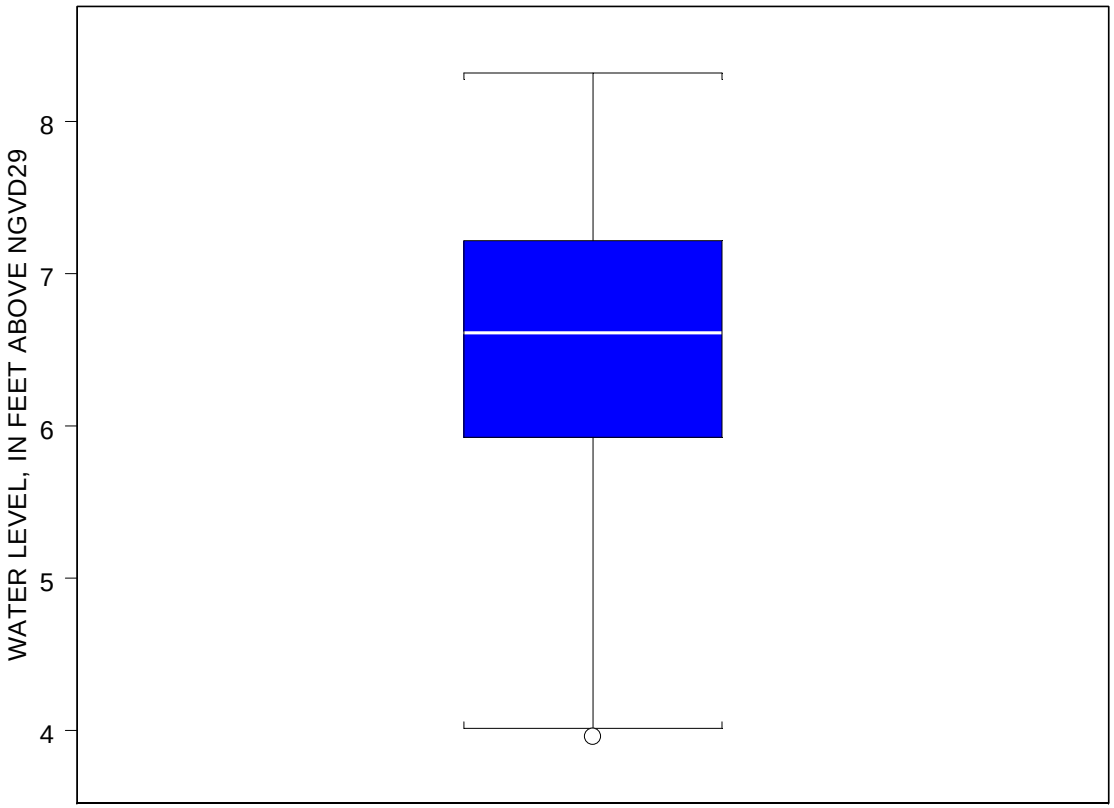
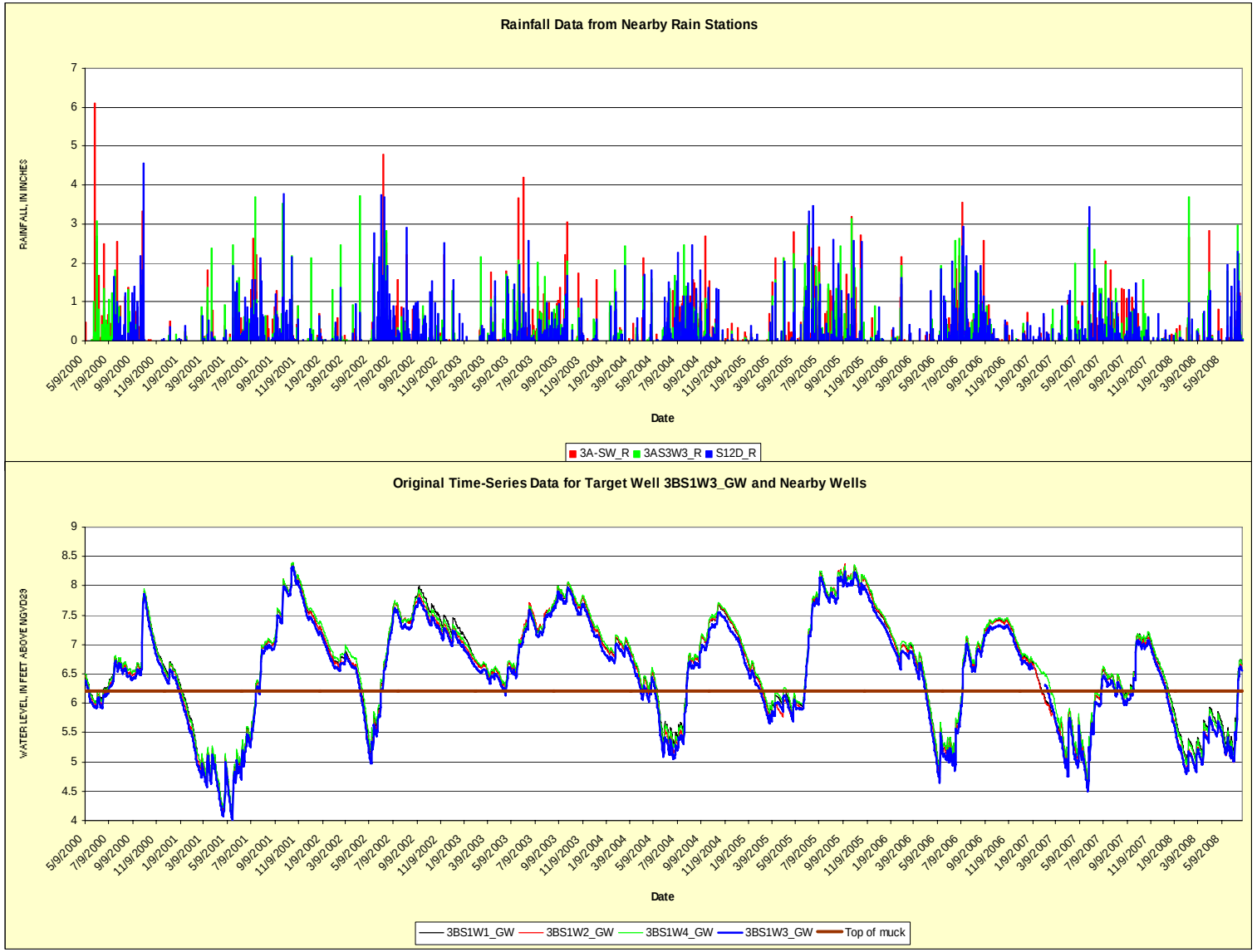
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W3_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
7/23/2003
9/23/2003
11/23/2003
1/23/2004
3/23/2004
5/23/2004
7/23/2004
9/23/2004
11/23/2004
1/23/2005
3/23/2005
5/23/2005
7/23/2005
9/23/2005
11/23/2005
1/23/2006
3/23/2006
5/23/2006
7/23/2006
9/23/2006
11/23/2006
1/23/2007
3/23/2007
5/23/2007
7/23/2007
9/23/2007
11/23/2007
1/23/2008
3/23/2008
5/23/2008
Date
3BS1W1_GP
3BS1W2_GP
3BS1W4_GP
3BS1W3_GP
Top of muck


Revised Time-Series Data from Target Well 3BS1W3_GP
WATER LEVEL, IN FEET ABOVE NGVD29
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
7/23/2003
9/23/2003
11/23/2003
1/23/2004
3/23/2004
5/23/2004
7/23/2004
9/23/2004
11/23/2004
1/23/2005
3/23/2005
5/23/2005
7/23/2005
9/23/2005
11/23/2005
1/23/2006
3/23/2006
5/23/2006
7/23/2006
9/23/2006
11/23/2006
1/23/2007
3/23/2007
5/23/2007
7/23/2007
9/23/2007
11/23/2007
1/23/2008
3/23/2008
5/23/2008
Date
Original series
Revised series
Top of muck

3BS1W3_GW




Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
0
1
2
3
4
5
6
7
5/9/2000
7/9/2000
9/9/2000
11/9/2000
1/9/2001
3/9/2001
5/9/2001
7/9/2001
9/9/2001
11/9/2001
1/9/2002
3/9/2002
5/9/2002
7/9/2002
9/9/2002
11/9/2002
1/9/2003
3/9/2003
5/9/2003
7/9/2003
9/9/2003
11/9/2003
1/9/2004
3/9/2004
5/9/2004
7/9/2004
9/9/2004
11/9/2004
1/9/2005
3/9/2005
5/9/2005
7/9/2005
9/9/2005
11/9/2005
1/9/2006
3/9/2006
5/9/2006
7/9/2006
9/9/2006
11/9/2006
1/9/2007
3/9/2007
5/9/2007
7/9/2007
9/9/2007
11/9/2007
1/9/2008
3/9/2008
5/9/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W3_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
5/9/2000
7/9/2000
9/9/2000
11/9/2000
1/9/2001
3/9/2001
5/9/2001
7/9/2001
9/9/2001
11/9/2001
1/9/2002
3/9/2002
5/9/2002
7/9/2002
9/9/2002
11/9/2002
1/9/2003
3/9/2003
5/9/2003
7/9/2003
9/9/2003
11/9/2003
1/9/2004
3/9/2004
5/9/2004
7/9/2004
9/9/2004
11/9/2004
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3/9/2005
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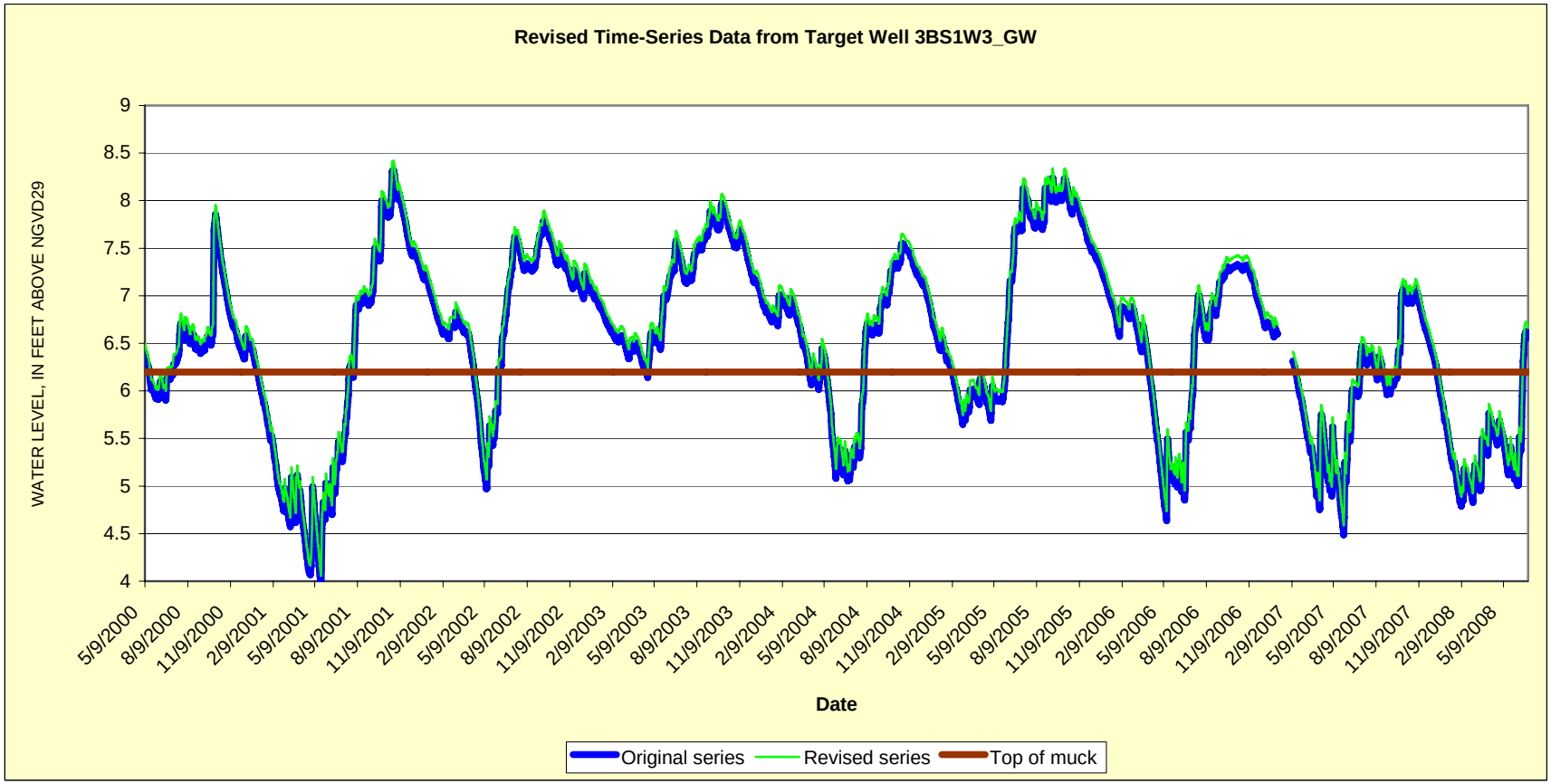
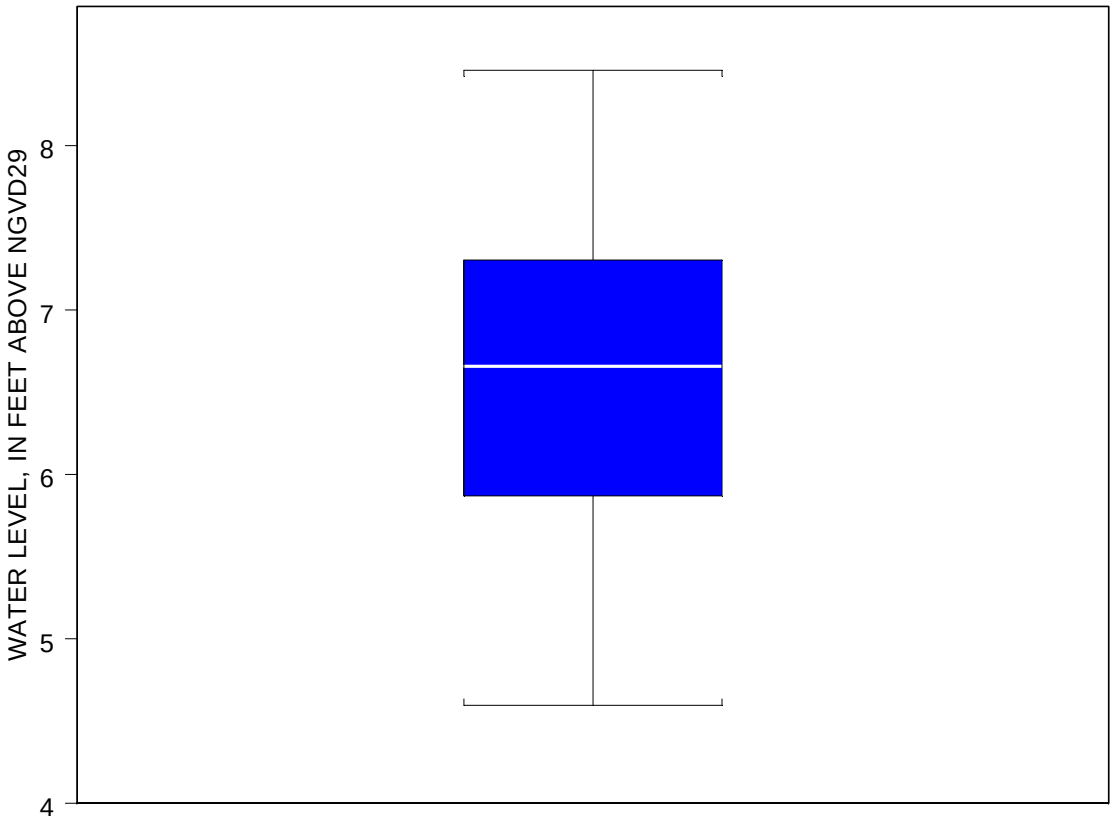
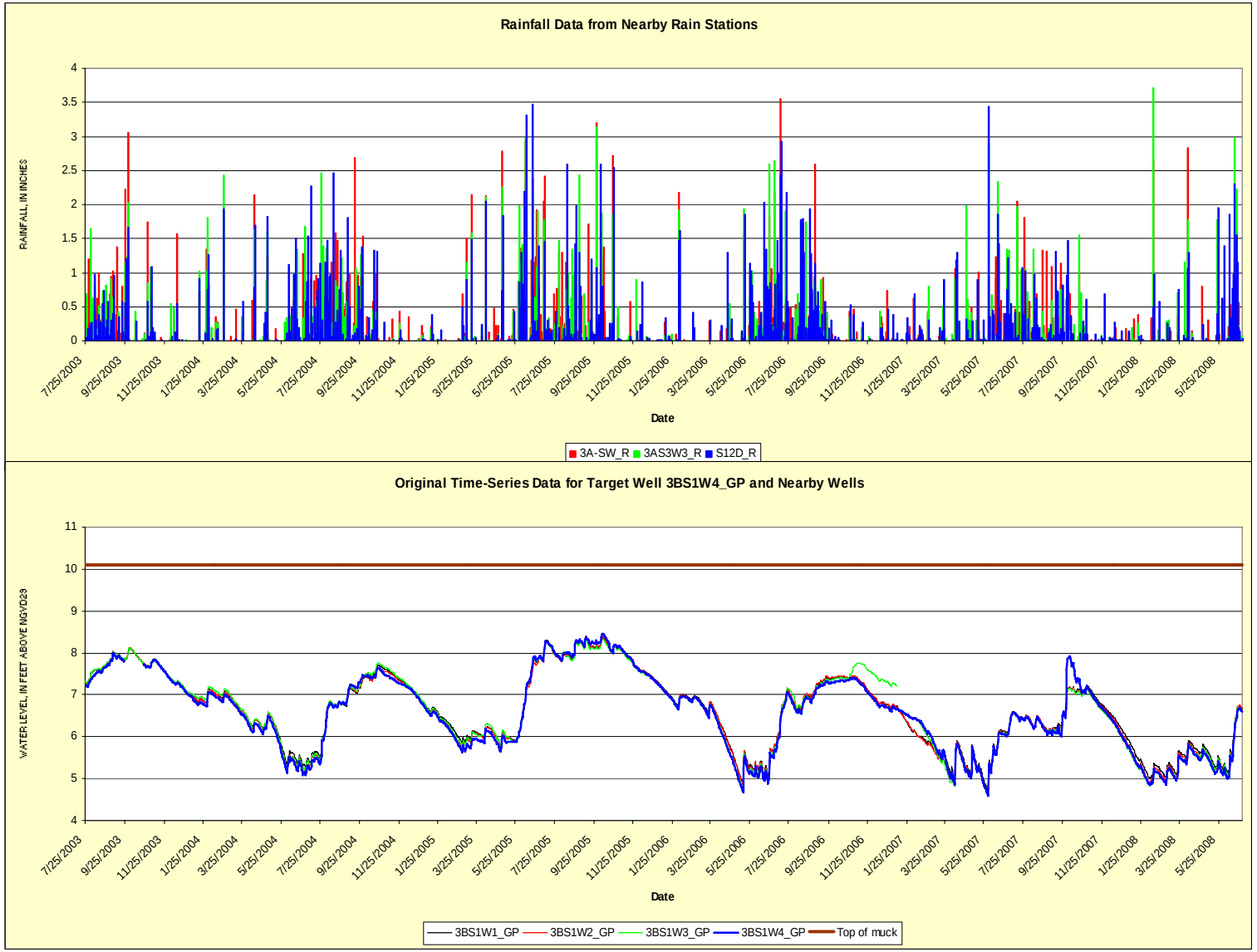
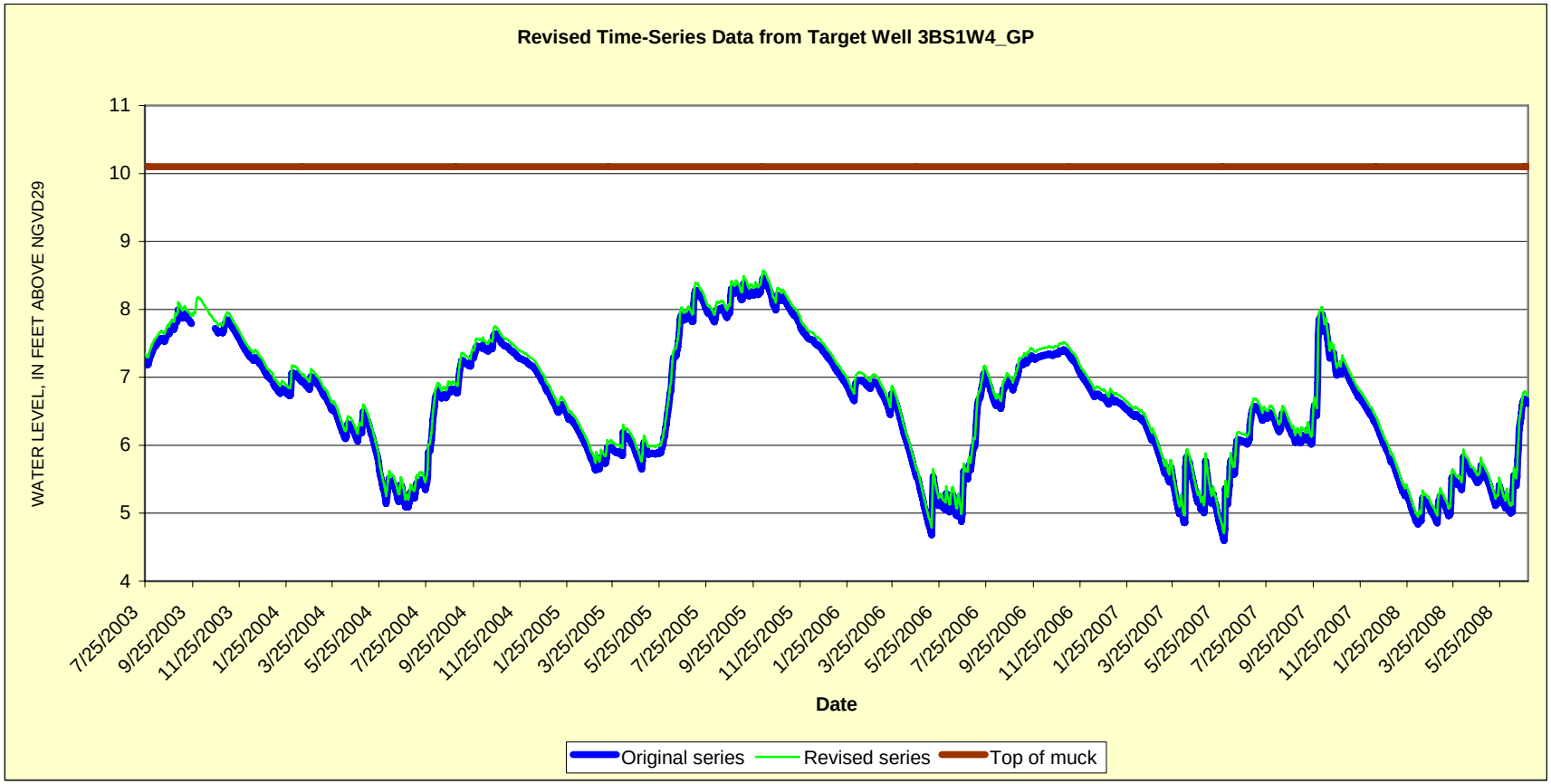
7/9/2005
9/9/2005
11/9/2005
1/9/2006
3/9/2006
5/9/2006
7/9/2006
9/9/2006
11/9/2006
1/9/2007
3/9/2007
5/9/2007
7/9/2007
9/9/2007
11/9/2007
1/9/2008
3/9/2008
5/9/2008
Date
3BS1W1_GW
3BS1W2_GW
3BS1W4_GW
3BS1W3_GW
Top of muck


Revised Time-Series Data from Target Well 3BS1W3_GW
WATER LEVEL, IN FEET ABOVE NGVD29
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
5/9/2000
8/9/2000
11/9/2000
2/9/2001
5/9/2001
8/9/2001
11/9/2001
2/9/2002
5/9/2002
8/9/2002
11/9/2002
2/9/2003
5/9/2003
8/9/2003
11/9/2003
2/9/2004
5/9/2004
8/9/2004
11/9/2004
2/9/2005
5/9/2005
8/9/2005
11/9/2005
2/9/2006
5/9/2006
8/9/2006
11/9/2006
2/9/2007
5/9/2007
8/9/2007
11/9/2007
2/9/2008
5/9/2008
Date
Original series
Revised series
Top of muck

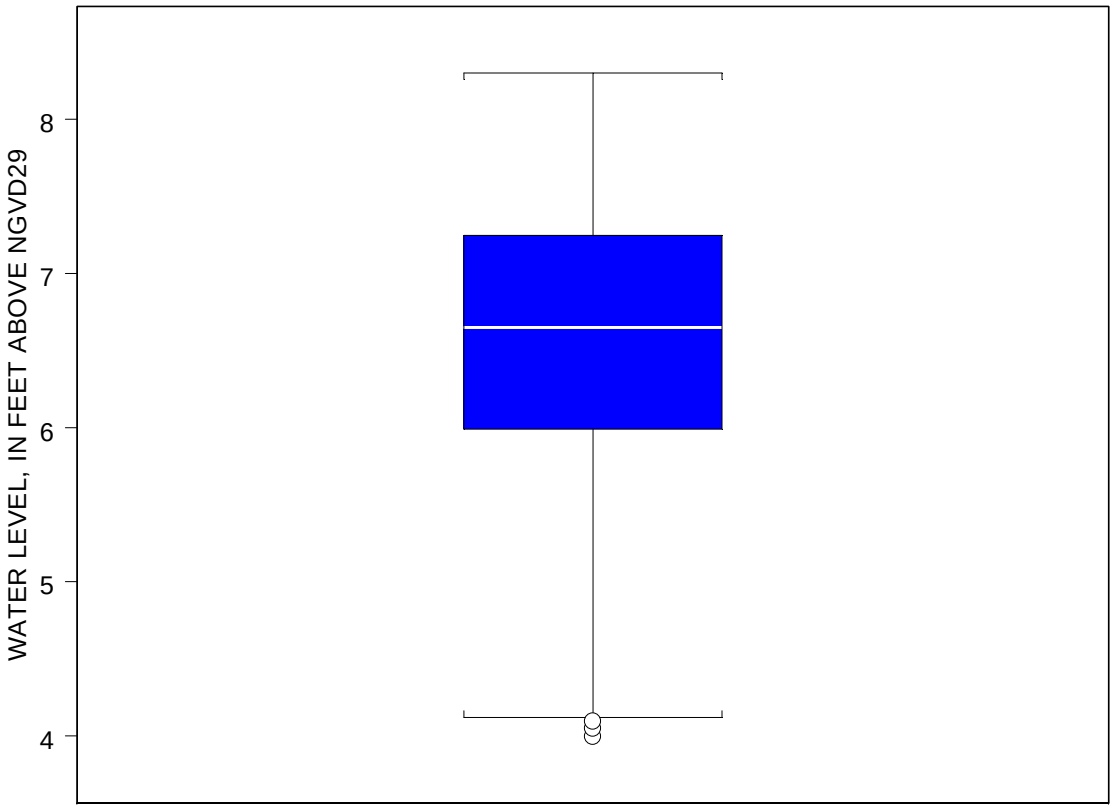
3BS1W4_GP

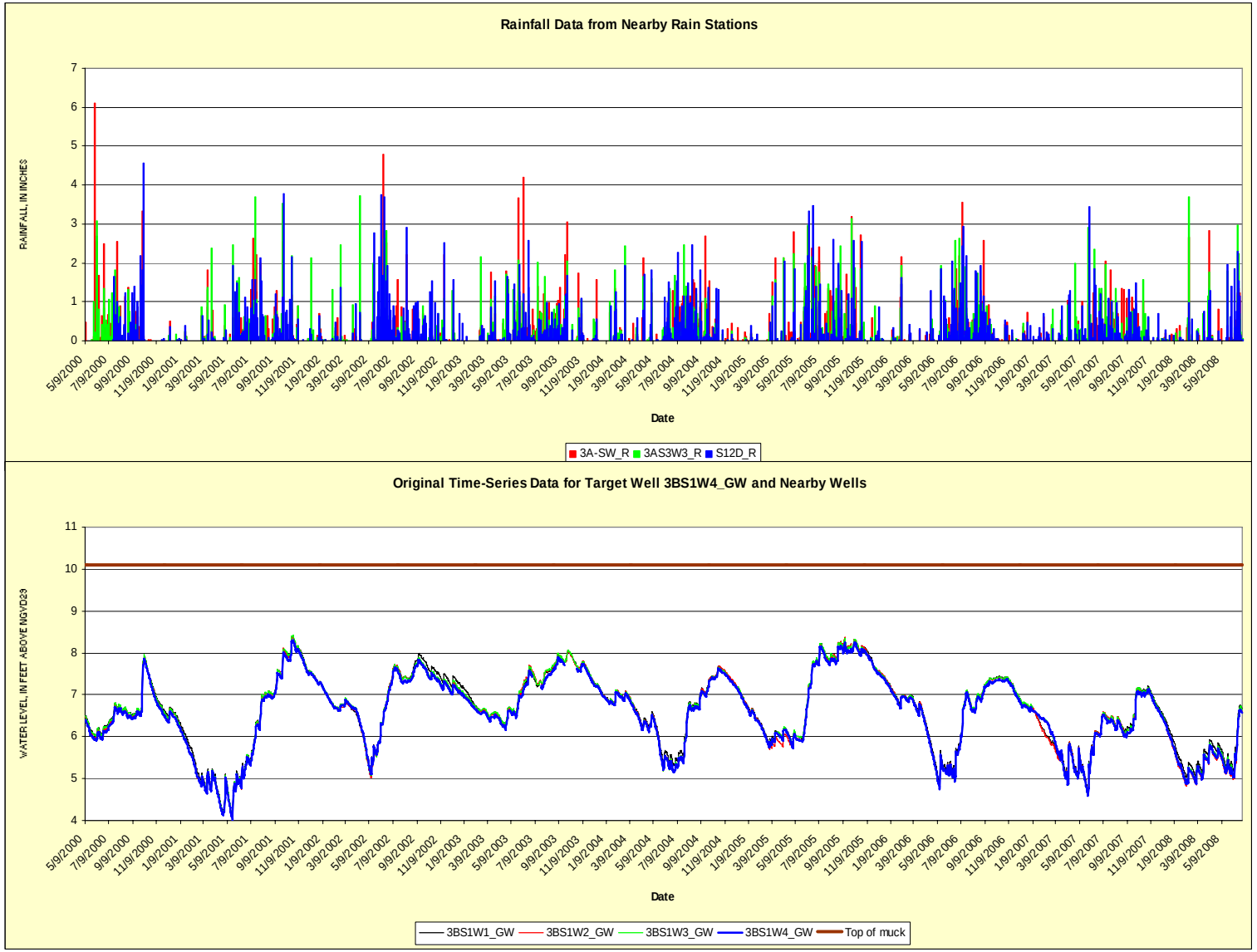


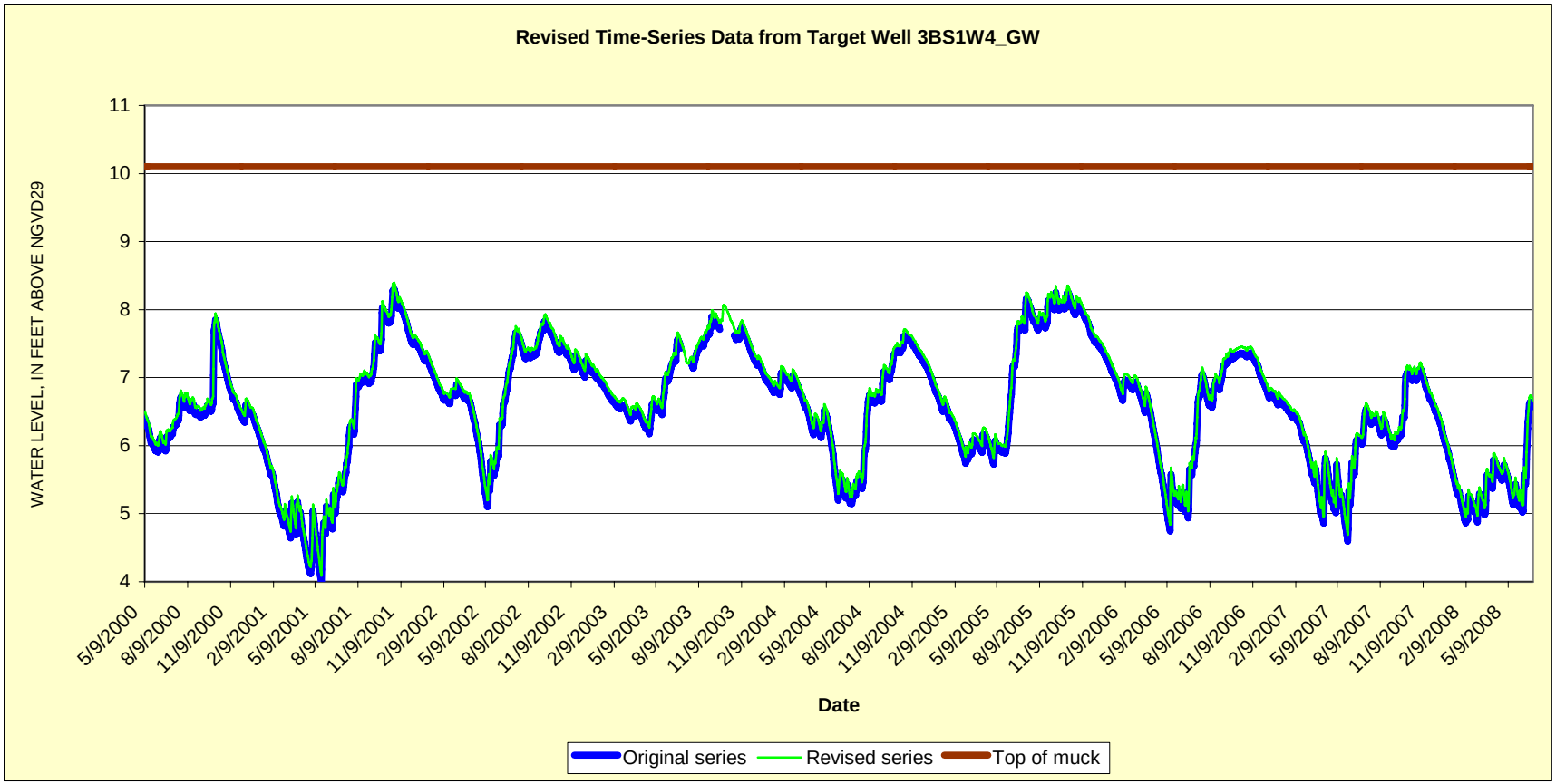

Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
4
3.5
3
2.5
2
1.5
1
0.5
0
7/25/2003
9/25/2003
11/25/2003
1/25/2004
3/25/2004
5/25/2004
7/25/2004
9/25/2004
11/25/2004
1/25/2005
3/25/2005
5/25/2005
7/25/2005
9/25/2005
11/25/2005
1/25/2006
3/25/2006
5/25/2006
7/25/2006
9/25/2006
11/25/2006
1/25/2007
3/25/2007
5/25/2007
7/25/2007
9/25/2007
11/25/2007
1/25/2008
3/25/2008
5/25/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W4_GP and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
11
10
9
8
7
6
5
4
7/25/2003
9/25/2003
11/25/2003
1/25/2004
3/25/2004
5/25/2004
7/25/2004
9/25/2004
11/25/2004
1/25/2005
3/25/2005
5/25/2005
7/25/2005
9/25/2005
11/25/2005
1/25/2006
3/25/2006
5/25/2006
7/25/2006
9/25/2006
11/25/2006
1/25/2007
3/25/2007
5/25/2007
7/25/2007
9/25/2007
11/25/2007
1/25/2008
3/25/2008
5/25/2008
Date
3BS1W1_GP
3BS1W2_GP
3BS1W3_GP
3BS1W4_GP
Top of muck


Revised Time-Series Data from Target Well 3BS1W4_GP
WATER LEVEL, IN FEET ABOVE NGVD29
11
10
9
8
7
6
5
4
7/25/2003
9/25/2003
11/25/2003
1/25/2004
3/25/2004
5/25/2004
7/25/2004
9/25/2004
11/25/2004
1/25/2005
3/25/2005
5/25/2005
7/25/2005
9/25/2005
11/25/2005
1/25/2006
3/25/2006
5/25/2006
7/25/2006
9/25/2006
11/25/2006
1/25/2007
3/25/2007
5/25/2007
7/25/2007
9/25/2007
11/25/2007
1/25/2008
3/25/2008
5/25/2008
Date
Original series
Revised series
Top of muck

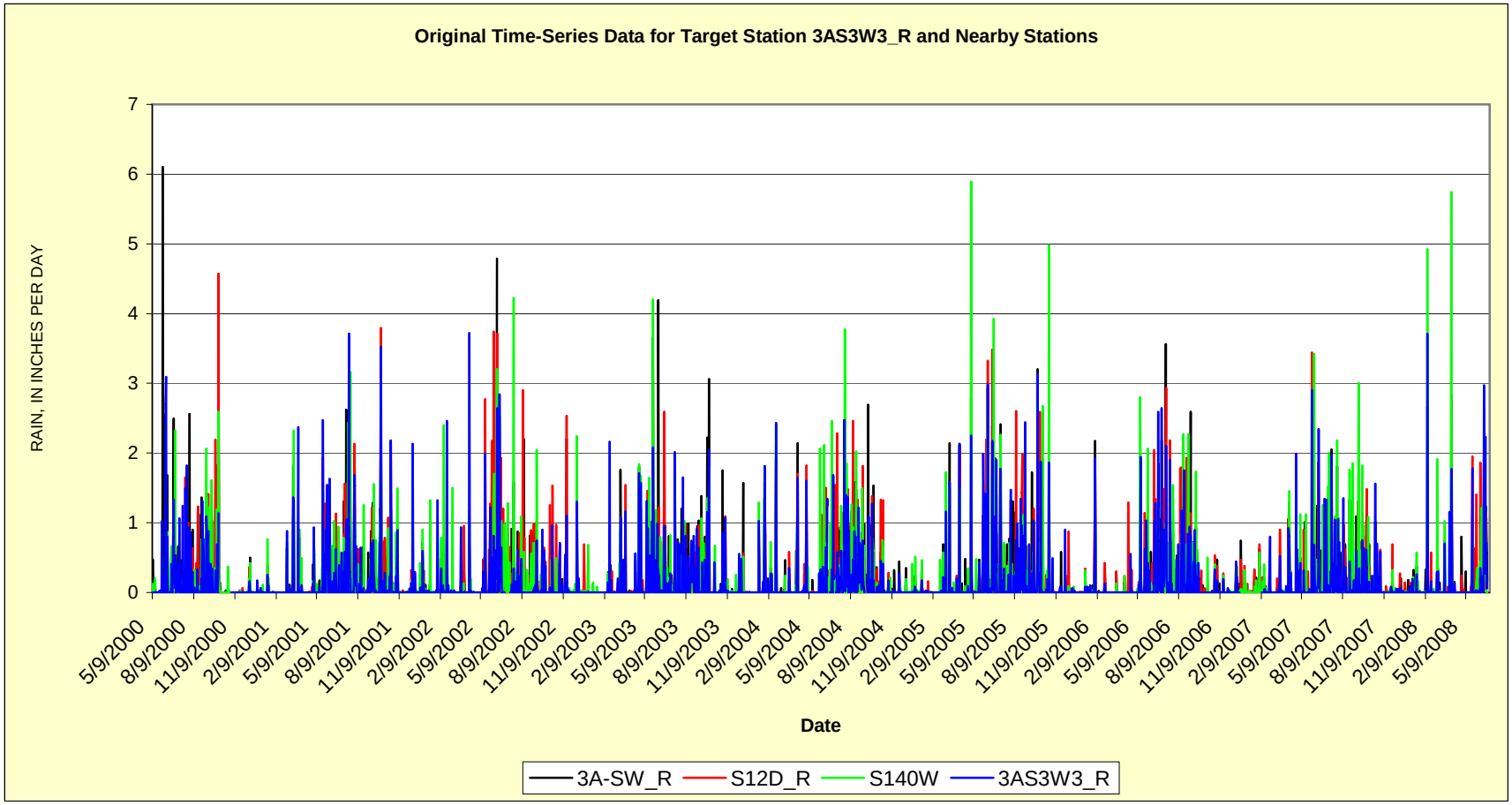
3BS1W4_GW

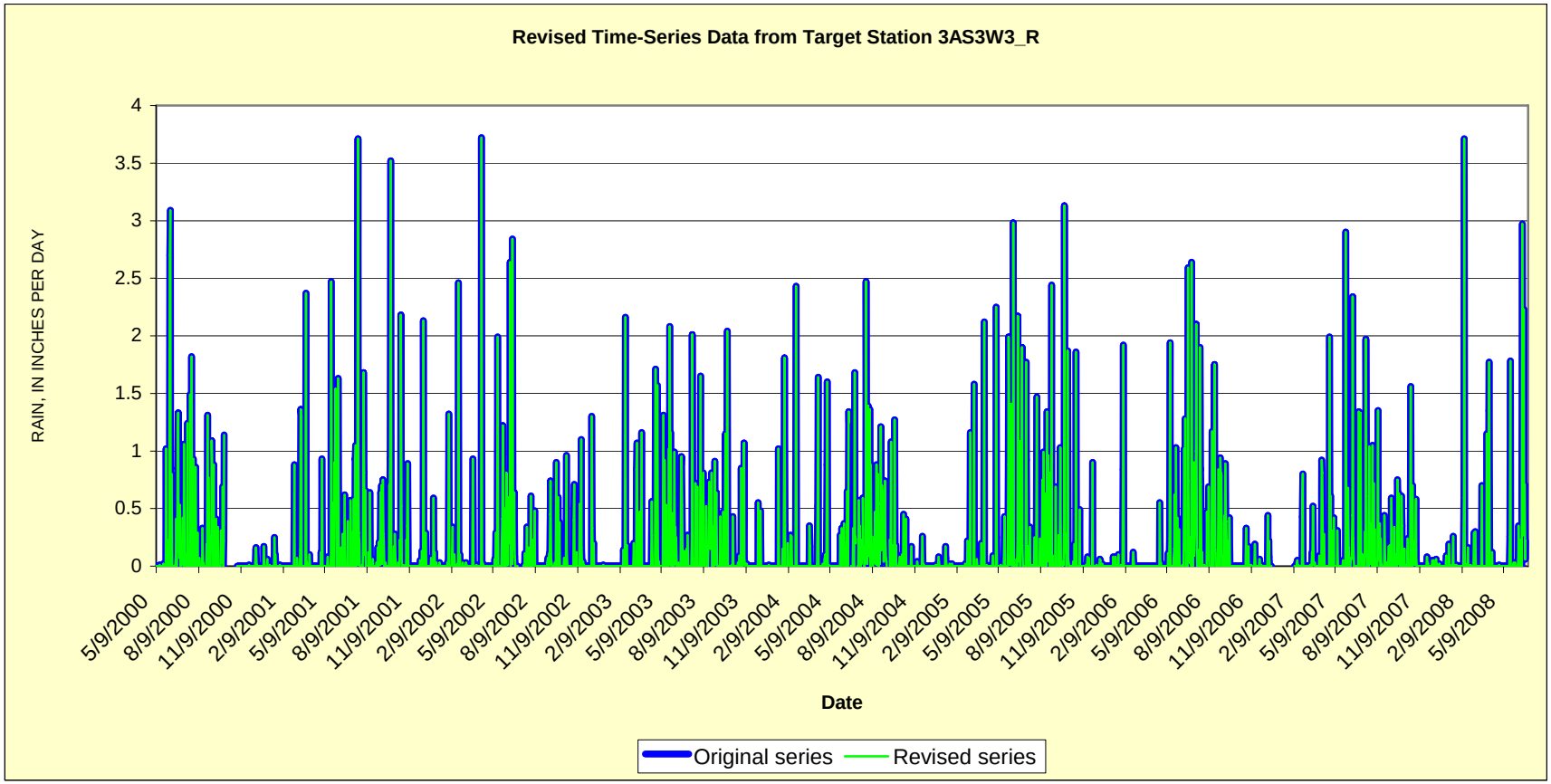



Rainfall Data from Nearby Rain Stations
RAINFALL, IN INCHES
0
1
2
3
4
5
6
7
5/9/2000
7/9/2000
9/9/2000
11/9/2000
1/9/2001
3/9/2001
5/9/2001
7/9/2001
9/9/2001
11/9/2001
1/9/2002
3/9/2002
5/9/2002
7/9/2002
9/9/2002
11/9/2002
1/9/2003
3/9/2003
5/9/2003
7/9/2003
9/9/2003
11/9/2003
1/9/2004
3/9/2004
5/9/2004
7/9/2004
9/9/2004
11/9/2004
1/9/2005
3/9/2005
5/9/2005
7/9/2005
9/9/2005
11/9/2005
1/9/2006
3/9/2006
5/9/2006
7/9/2006
9/8/2006
11/9/2006
1/9/2007
3/9/2007
5/9/2007
7/9/2007
9/9/2007
11/9/2007
1/9/2008
3/9/2008
5/9/2008
Date
3A-SW_R
3AS3W3_R
S12D_R
Original Time-Series Data for Target Well 3BS1W4_GW and Nearby Wells
WATER LEVEL, IN FEET ABOVE NGVD29
4
5
6
7
8
9
10
11
5/9/2000
7/9/2000
9/9/2000
11/9/2000
1/9/2001
3/9/2001
5/9/2001
7/9/2001
9/9/2001
11/9/2001
1/9/2002
3/9/2002
5/9/2002
7/9/2002
9/9/2002
11/9/2002
1/9/2003
3/9/2003
5/9/2003
7/9/2003
9/9/2003
11/9/2003
1/9/2004
3/9/2004
5/9/2004
7/9/2004
9/9/2004
11/9/2004
1/9/2005
3/9/2005
5/9/2005
7/9/2005
9/9/2005
11/9/2005
1/9/2006
3/9/2006
5/9/2006
7/9/2006
9/8/2006
11/9/2006
1/9/2007
3/9/2007
5/9/2007
7/9/2007
9/9/2007
11/9/2007
1/9/2008
3/9/2008
5/9/2008
Date
3BS1W1_GW
3BS1W2_GW
3BS1W3_GW
3BS1W4_GW
Top of muck

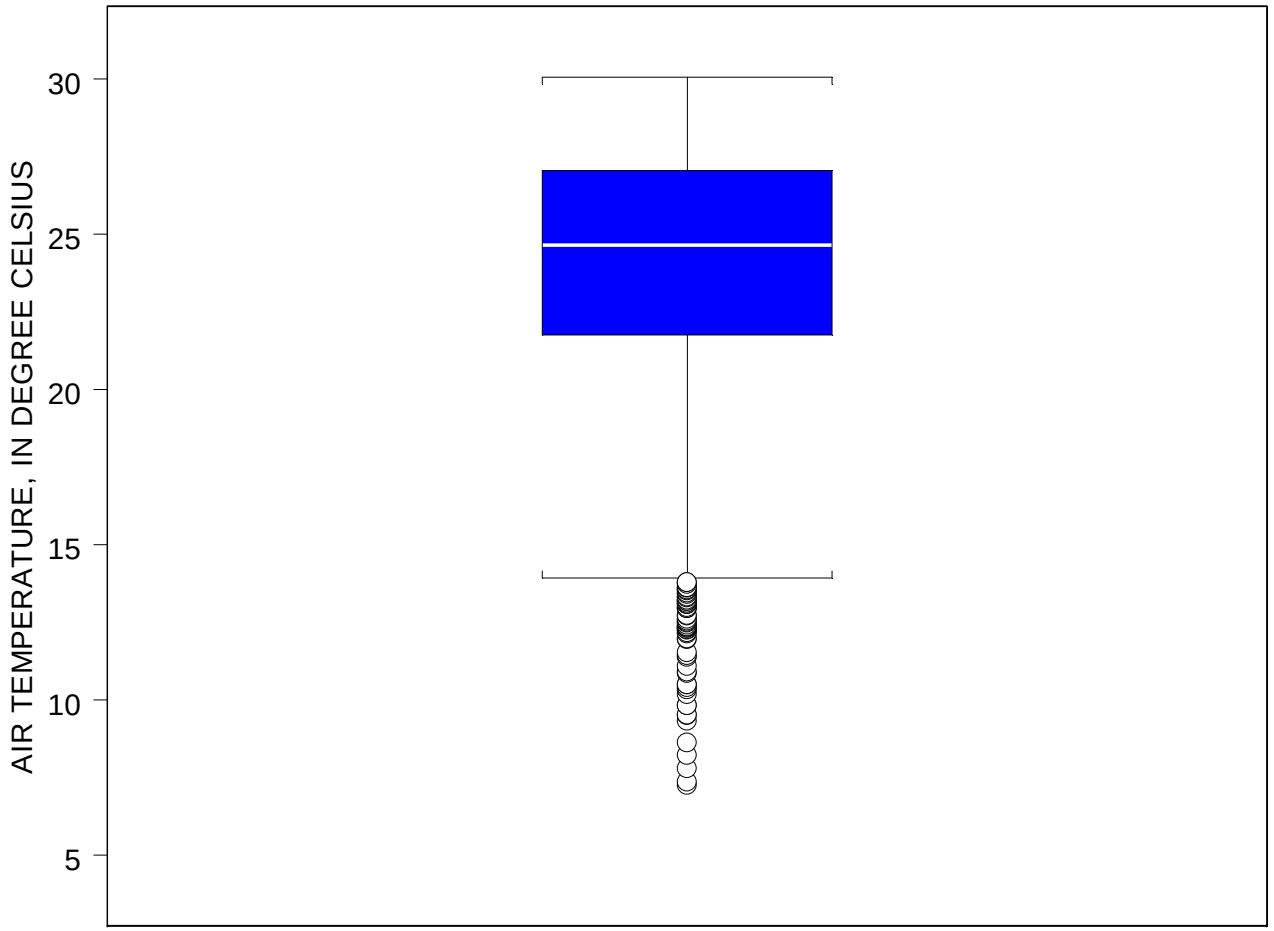

Revised Time-Series Data from Target Well 3BS1W4_GW
WATER LEVEL, IN FEET ABOVE NGVD29
11
10
9
8
7
6
5
4
5/9/2000
8/9/2000
11/9/2000
2/9/2001
5/9/2001
8/9/2001
11/9/2001
2/9/2002
5/9/2002
8/9/2002
11/9/2002
2/9/2003
5/9/2003
8/9/2003
11/9/2003
2/9/2004
5/9/2004
8/9/2004
11/9/2004
2/9/2005
5/9/2005
8/9/2005
11/9/2005
2/9/2006
5/9/2006
8/9/2006
11/9/2006
2/9/2007
5/9/2007
8/9/2007
11/9/2007
2/9/2008
5/9/2008
Date
Original series
Revised series
Top of muck

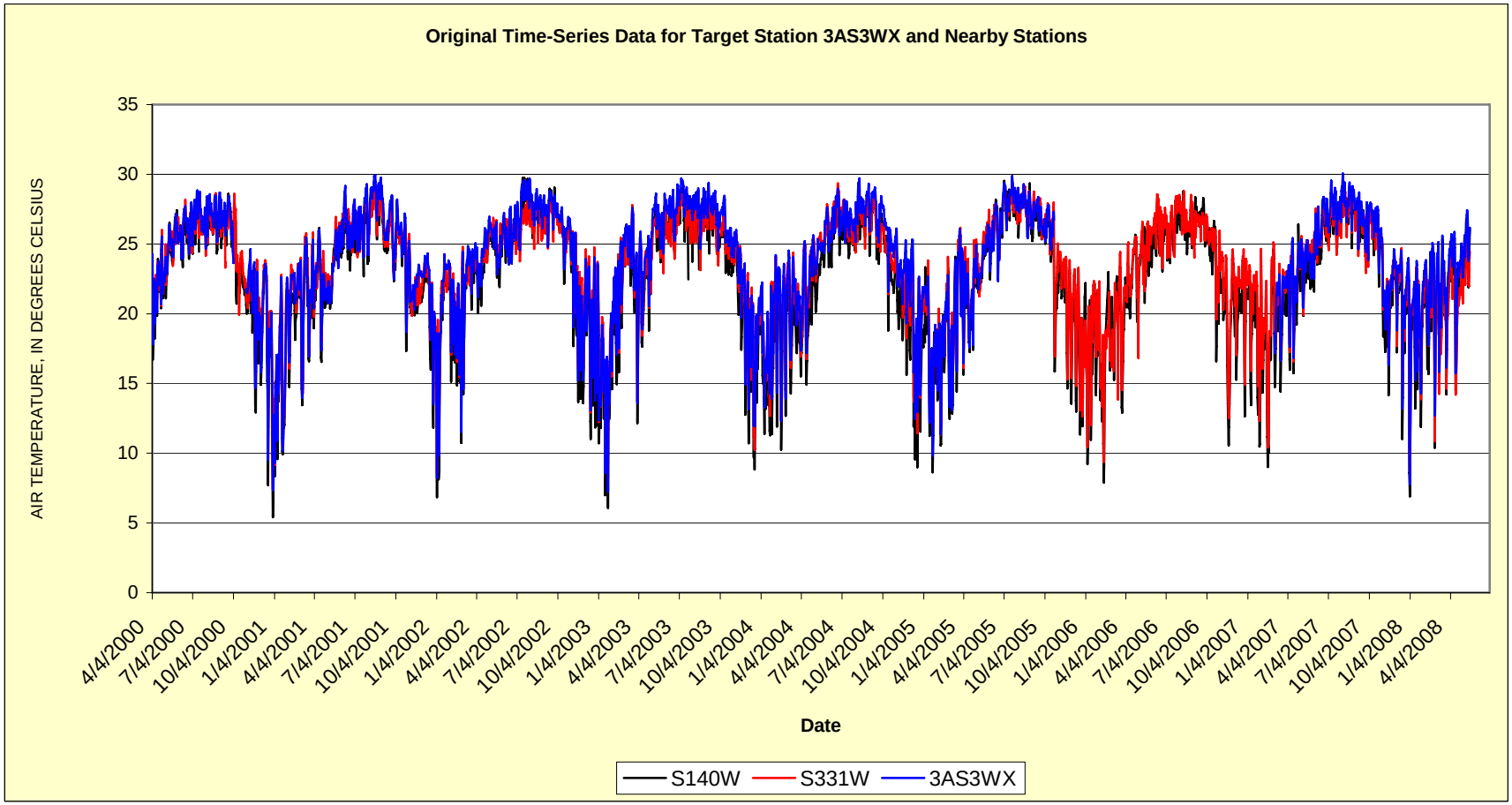
3AS3W3_R Precipitation




Revised Time-Series Data from Target Station 3AS3W3_R
RAIN, IN INCHES PER DAY
4
3.5
3
2.5
2
1.5
1
0.5
0
5/9/2000
8/9/2000
11/9/2000
2/9/2001
5/9/2001
8/9/2001
11/9/2001
2/9/2002
5/9/2002
8/9/2002
11/9/2002
2/9/2003
5/9/2003
8/9/2003
11/9/2003
2/9/2004
5/9/2004
8/9/2004
11/9/2004
2/9/2005
5/9/2005
8/9/2005
11/9/2005
2/9/2006
5/9/2006
8/9/2006
11/9/2006
2/9/2007
5/9/2007
8/9/2007
11/9/2007
2/9/2008
5/9/2008
Date
Original series
Revised series

3AS3WX Air Temperature




Original Time-Series Data for Target Station 3AS3WX and Nearby Stations
AIR TEMPERATURE, IN DEGREES CELSIUS
35
30
25
20
15
10
5
0
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
1/4/2003
4/4/2003
7/4/2003
10/4/2003
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4/4/2004
7/4/2004
10/4/2004
1/4/2005
4/4/2005
7/4/2005
10/4/2005
1/4/2006
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
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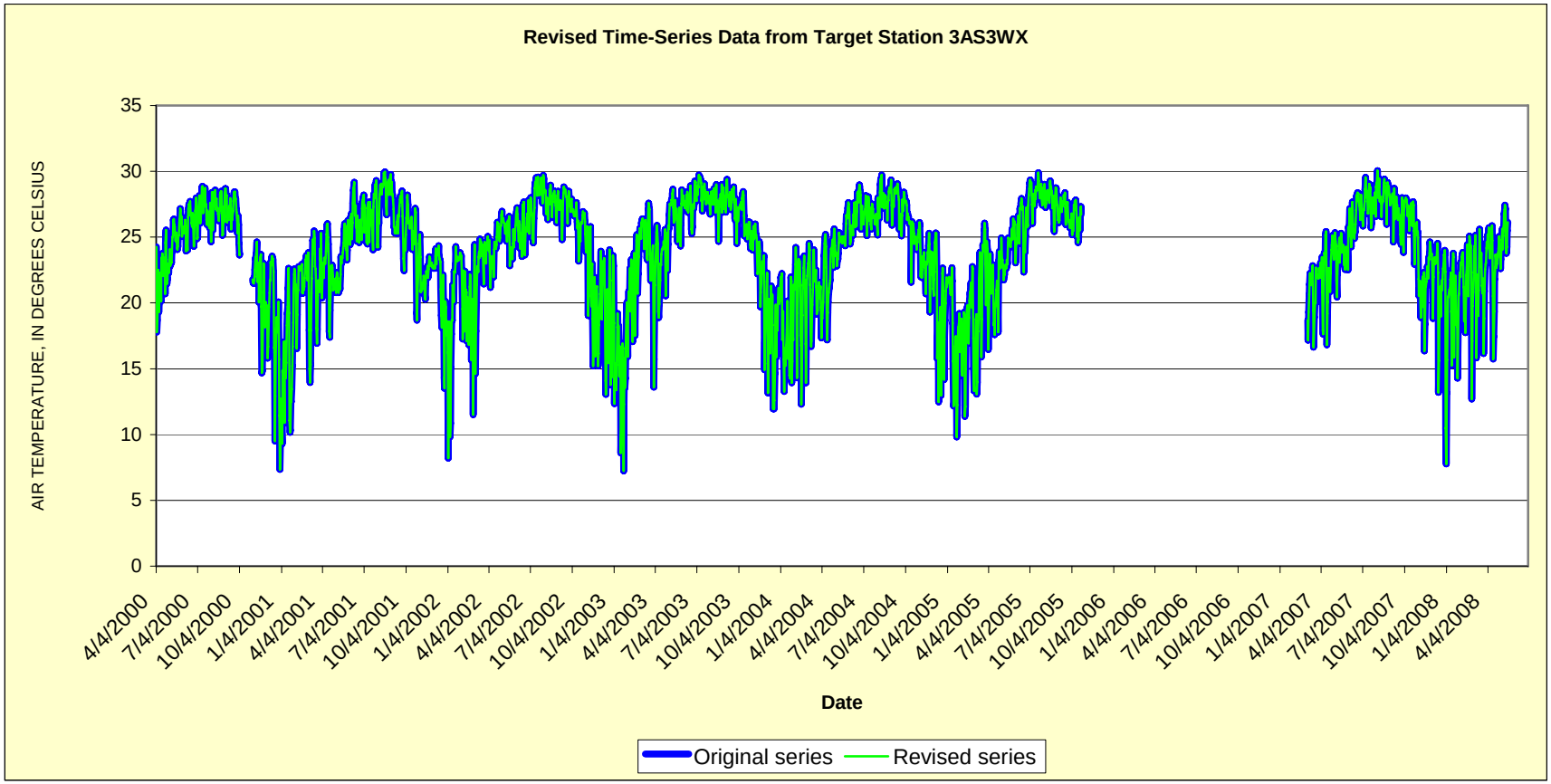
1/4/2008
4/4/2008
Date
S140W
S331W
3AS3WX


Revised Time-Series Data from Target Station 3AS3WX
AIR TEMPERATURE, IN DEGREES CELSIUS
35
30
25
20
15
10
5
0
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
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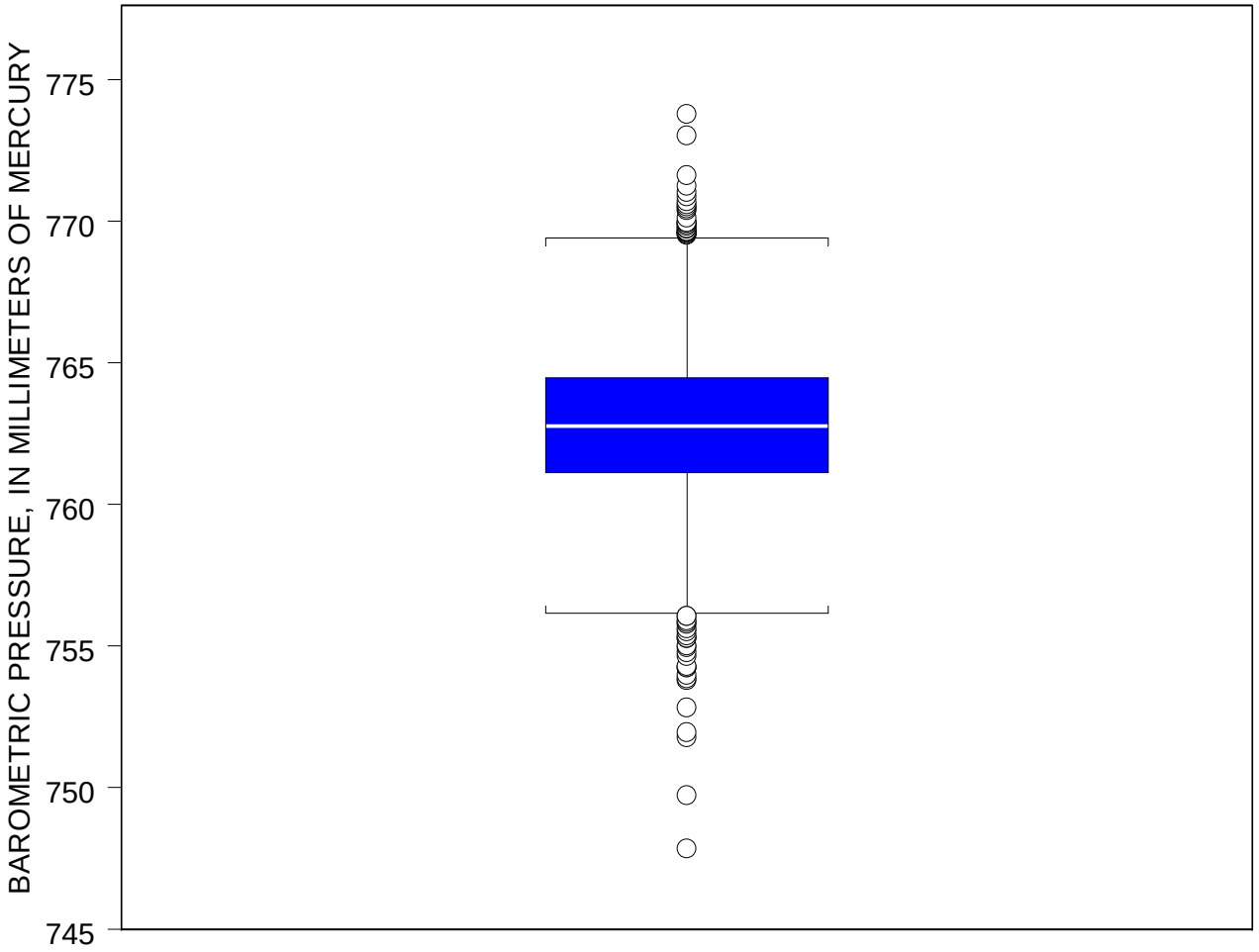
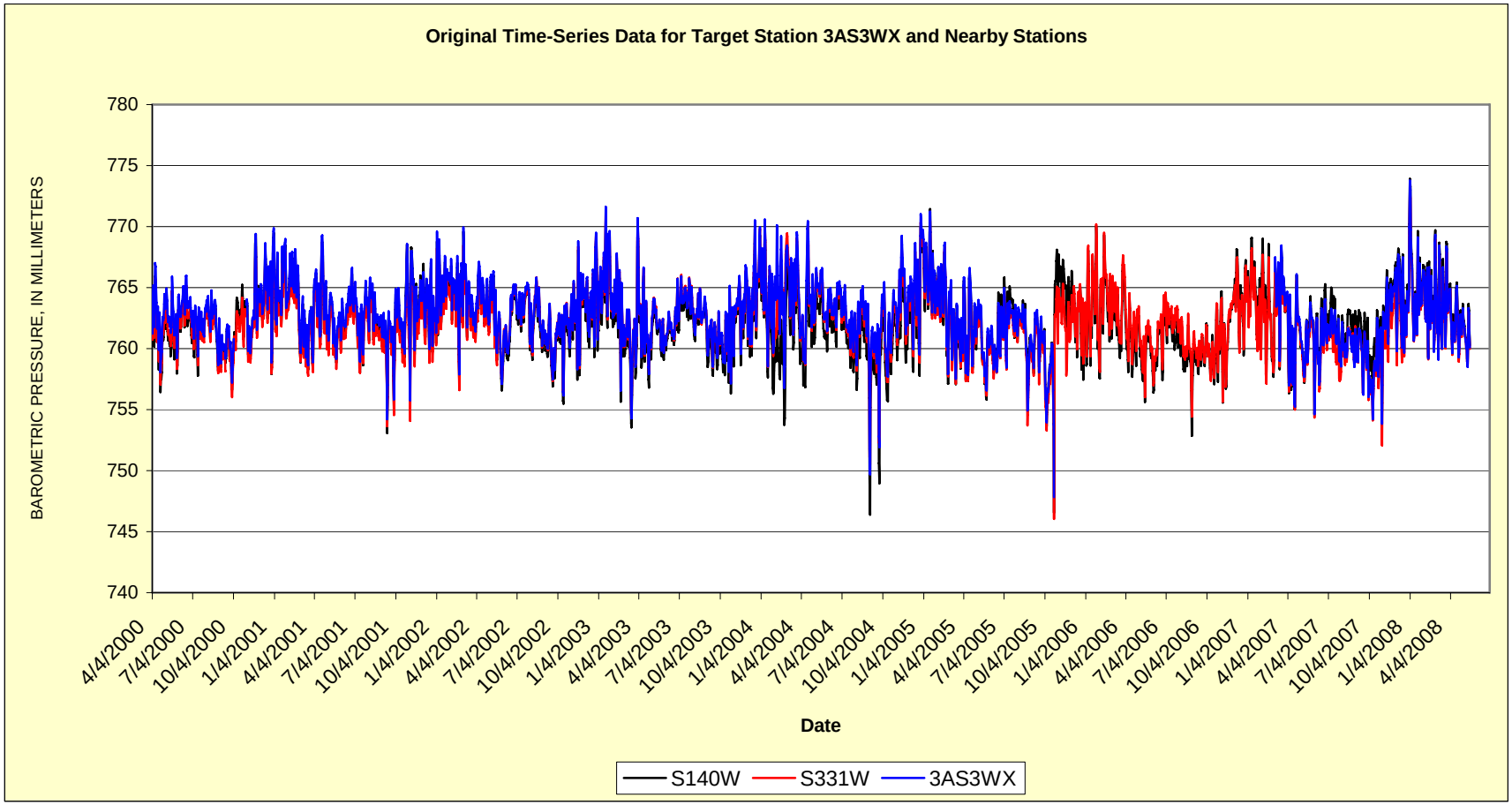
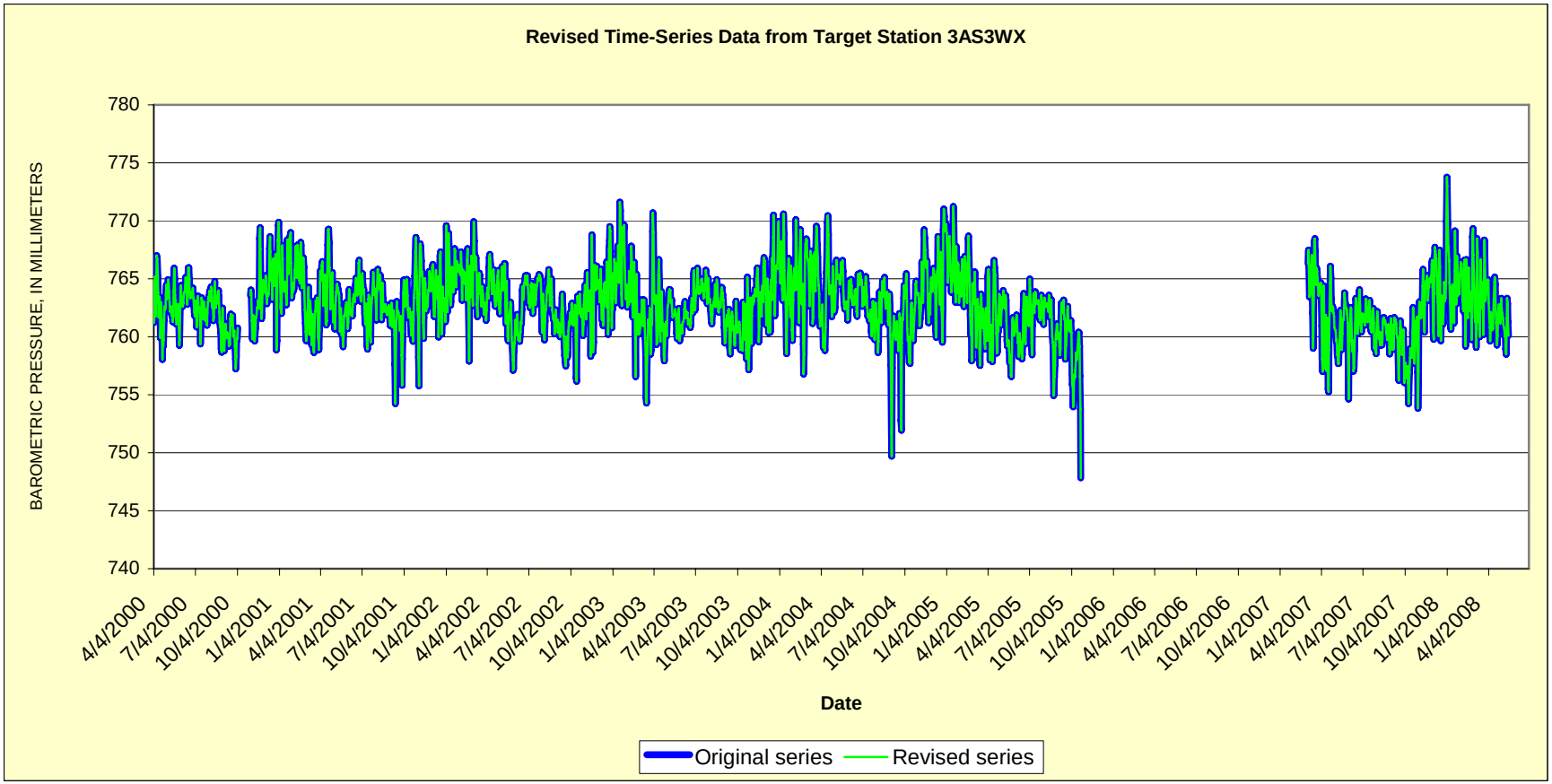
7/4/2005
10/4/2005
1/4/2006
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
Original series
Revised series

3AS3WX Barometric Pressure




Original Time-Series Data for Target Station 3AS3WX and Nearby Stations
BAROMETRIC PRESSURE, IN MILLIMETERS
780
775
770
765
760
755
750
745
740
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
1/4/2003
4/4/2003
7/4/2003
10/4/2003
1/4/2004
4/4/2004
7/4/2004
10/4/2004
1/4/2005
4/4/2005
7/4/2005
10/4/2005
1/4/2006
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
S140W
S331W
3AS3WX


Revised Time-Series Data from Target Station 3AS3WX
BAROMETRIC PRESSURE, IN MILLIMETERS
780
775
770
765
760
755
750
745
740
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
1/4/2003
4/4/2003
7/4/2003
10/4/2003
1/4/2004
4/4/2004
7/4/2004
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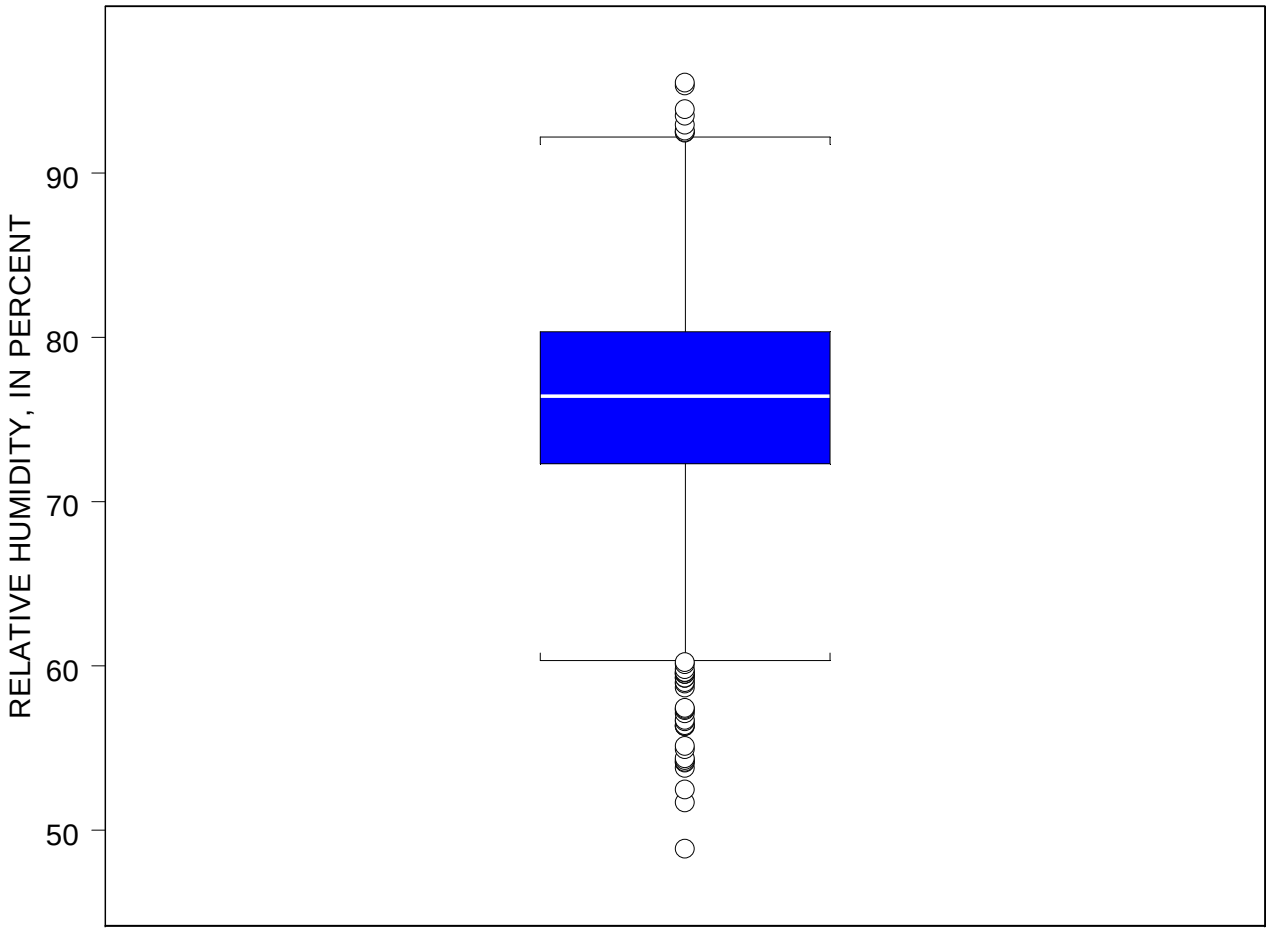
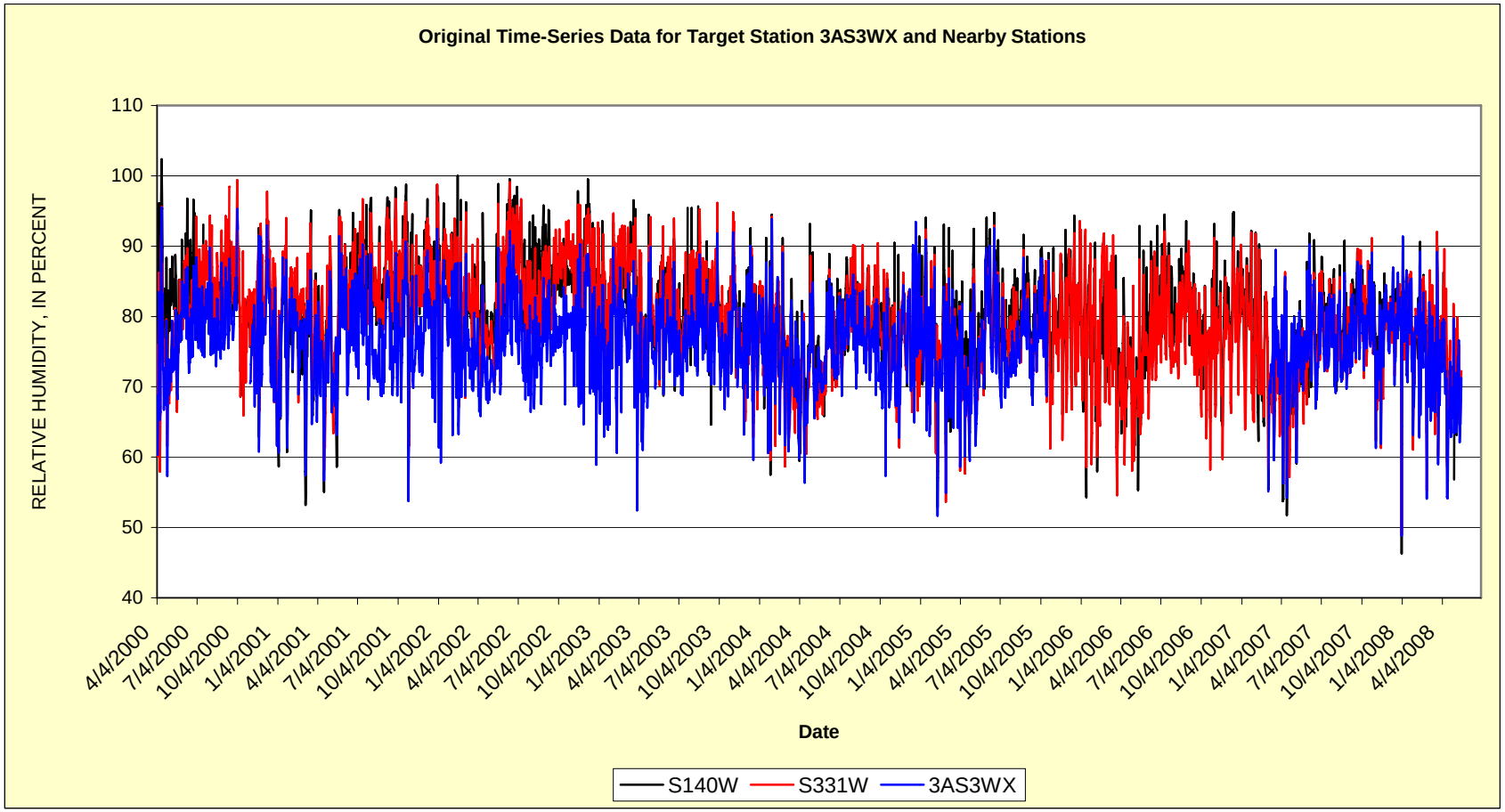
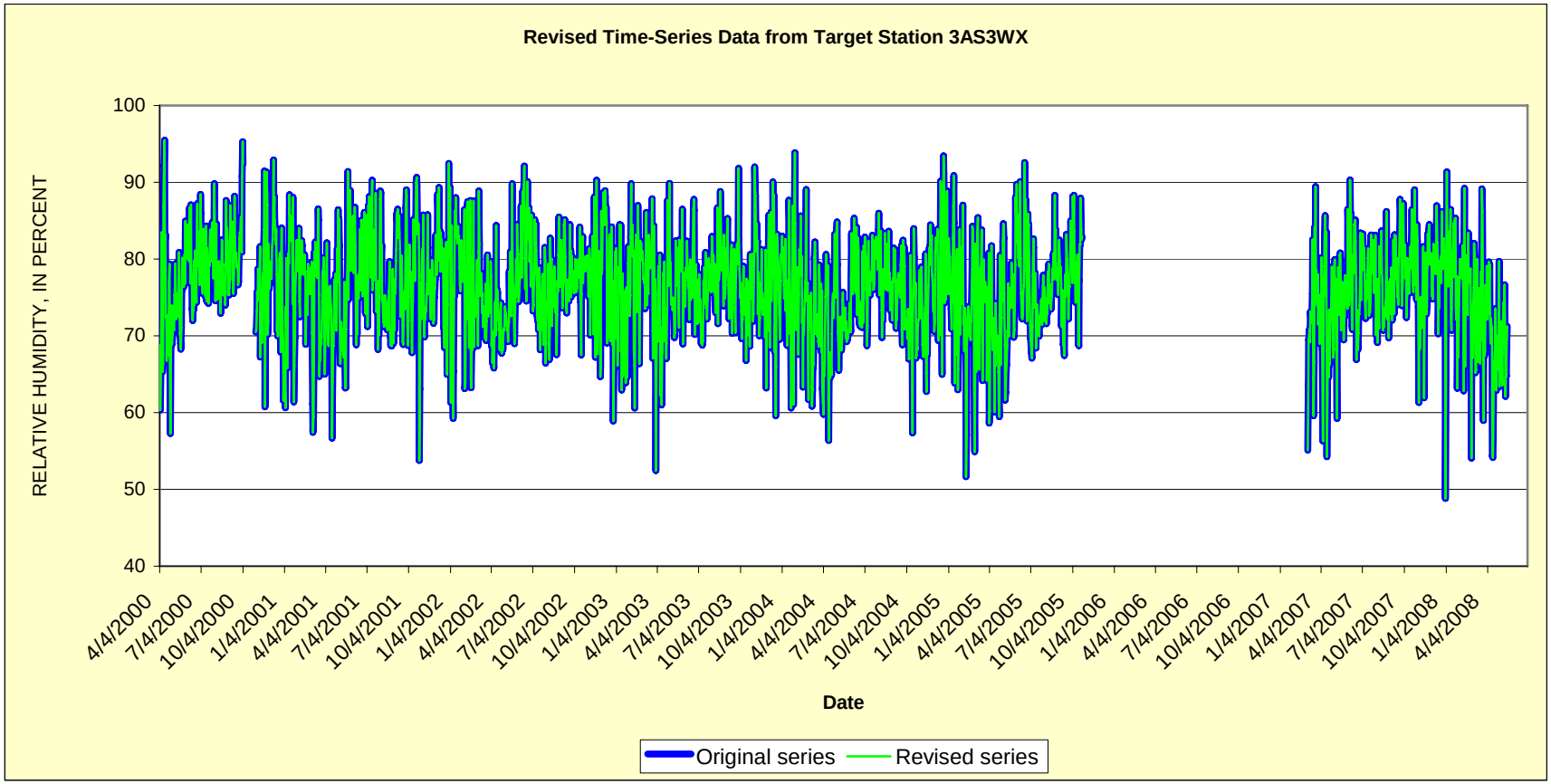
1/4/2005
4/4/2005
7/4/2005
10/4/2005
1/4/2006
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
Original series
Revised series

3AS3WX Relative Humidity




Original Time-Series Data for Target Station 3AS3WX and Nearby Stations
RELATIVE HUMIDITY, IN PERCENT
110
100
90
80
70
60
50
40
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
1/4/2003
4/4/2003
7/4/2003
10/4/2003
1/4/2004
4/4/2004
7/4/2004
10/4/2004
1/4/2005
4/4/2005
7/4/2005
10/4/2005
1/4/2006
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
S140W
S331W
3AS3WX


Revised Time-Series Data from Target Station 3AS3WX
RELATIVE HUMIDITY, IN PERCENT
100
90
80
70
60
50
40
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
1/4/2003
4/4/2003
7/4/2003
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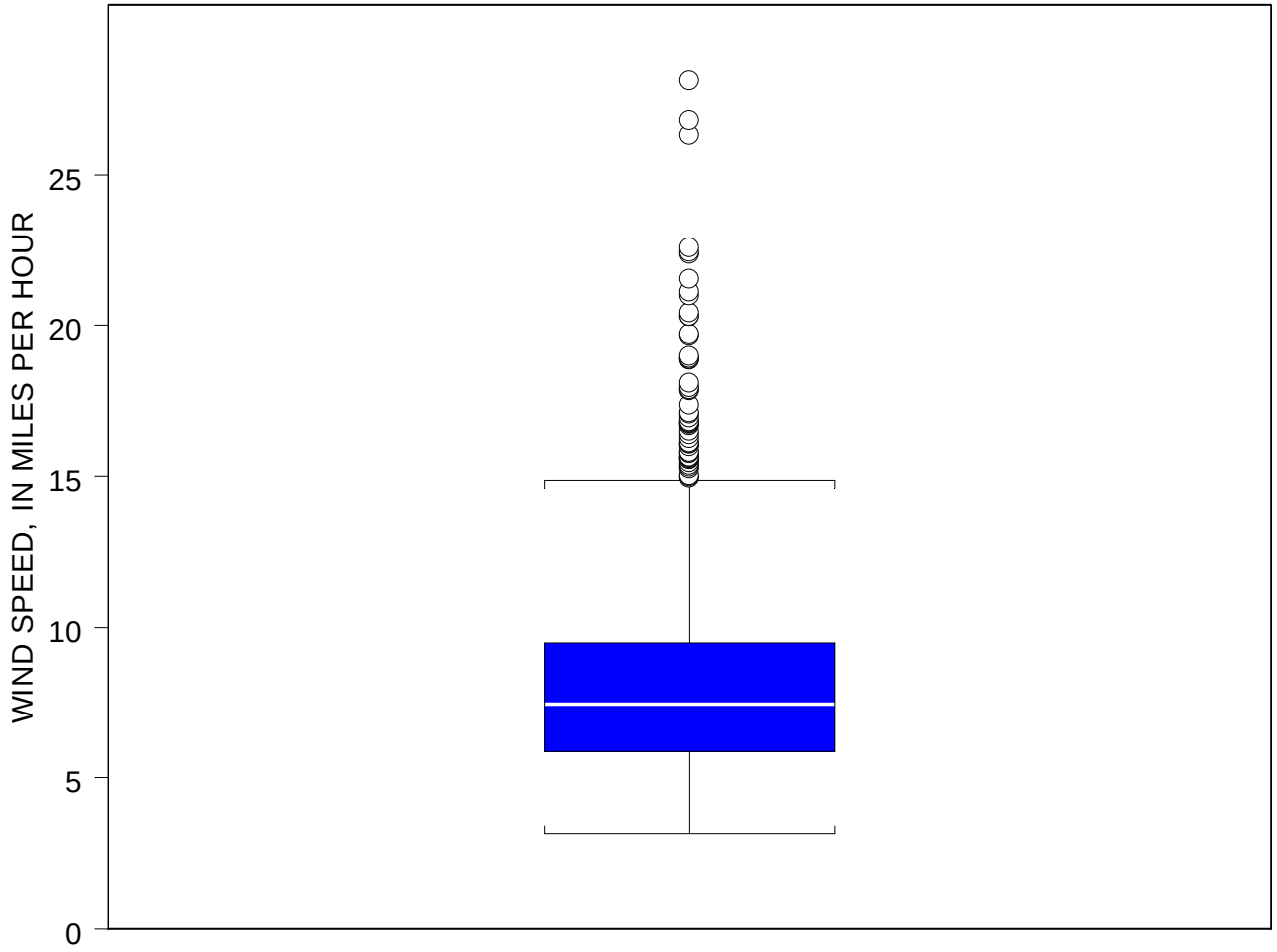
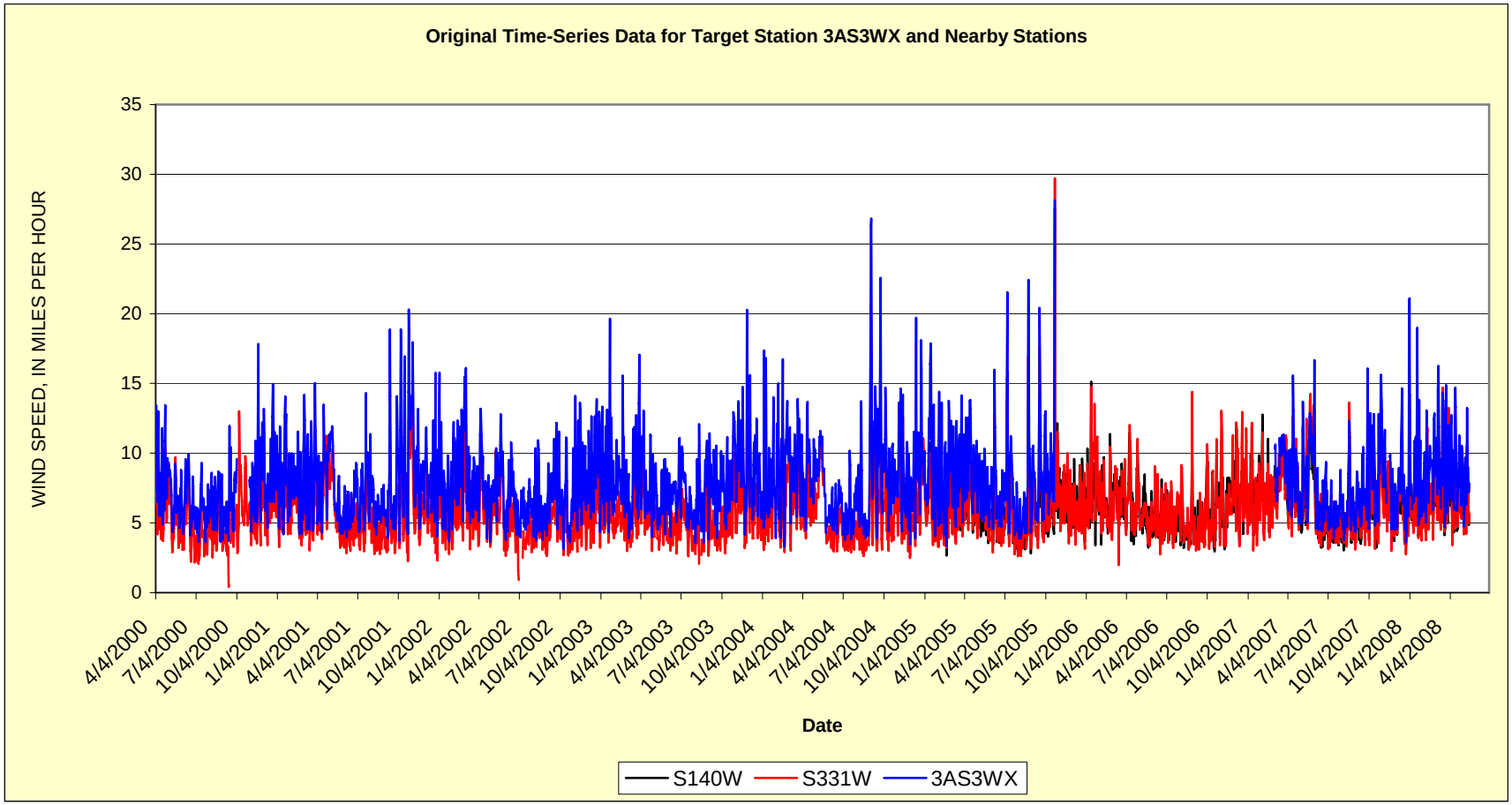
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
Original series
Revised series

3AS3WX Wind Speed (Scalar)




Original Time-Series Data for Target Station 3AS3WX and Nearby Stations
WIND SPEED, IN MILES PER HOUR
35
30
25
20
15
10
5
0
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
1/4/2003
4/4/2003
7/4/2003
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7/4/2004
10/4/2004
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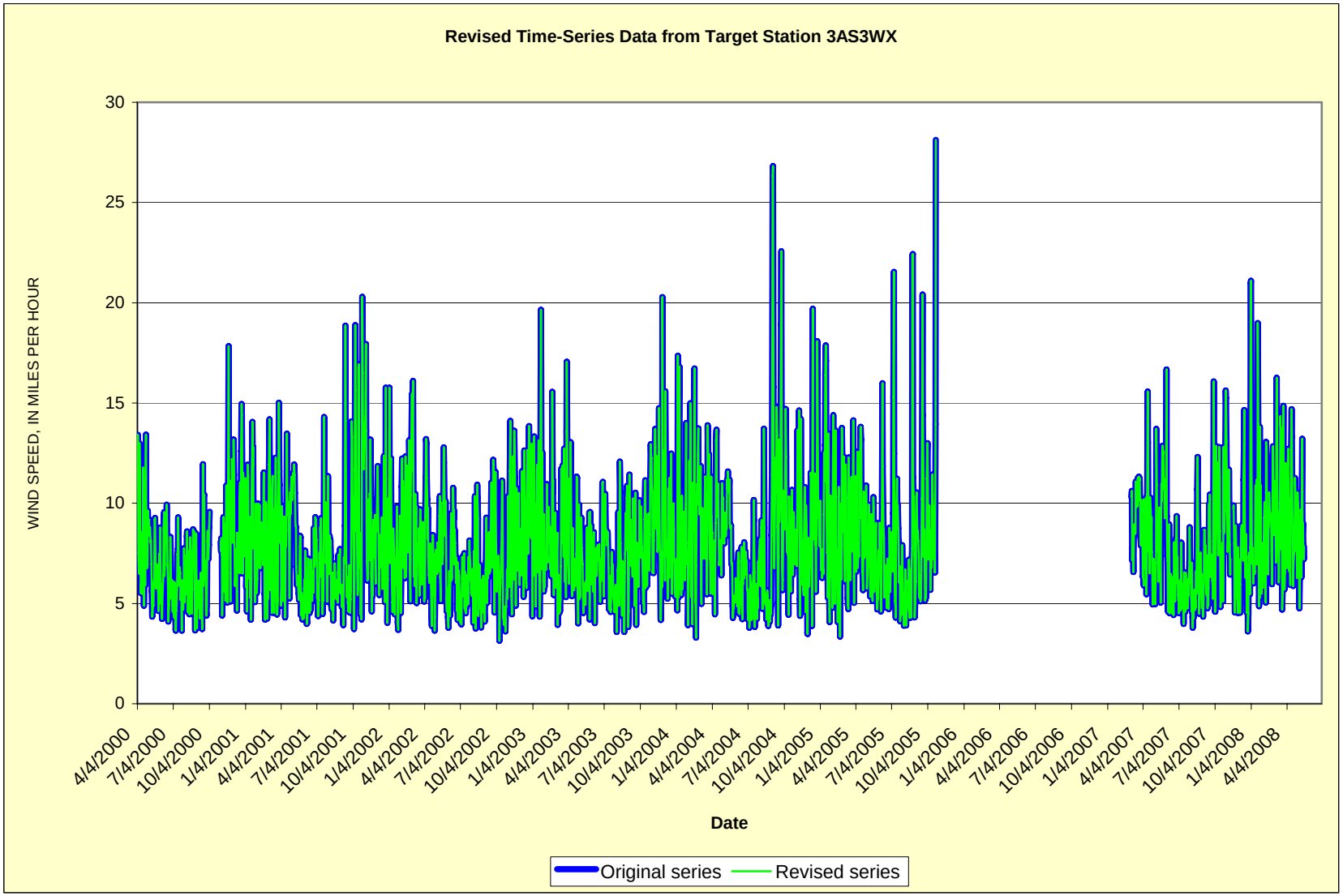
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
S140W
S331W
3AS3WX


Revised Time-Series Data from Target Station 3AS3WX
WIND SPEED, IN MILES PER HOUR
30
25
20
15
10
5
0
4/4/2000
7/4/2000
10/4/2000
1/4/2001
4/4/2001
7/4/2001
10/4/2001
1/4/2002
4/4/2002
7/4/2002
10/4/2002
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7/4/2003
10/4/2003
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4/4/2004
7/4/2004
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7/4/2005
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1/4/2006
4/4/2006
7/4/2006
10/4/2006
1/4/2007
4/4/2007
7/4/2007
10/4/2007
1/4/2008
4/4/2008
Date
Original series
Revised series

Table 1--Dates and values of annual minima and maxima in wells and piezometers at 3AN1

3AN1W1_GP

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.310	October 4, 2003	12.339
March 3, 2005	10.007	October 1, 2004	12.343
May 14, 2006	9.474	July 11, 2005	12.565
May 31, 2007	8.675	September 21, 2006	12.245
		September 30, 2007	11.345

3AN1W1_GW

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.34	October 4, 2003	12.34
March 3, 2005	9.991	October 7, 2004	12.332
May 14, 2006	9.311	July 11, 2005	12.648
May 31, 2007	8.699	September 21, 2006	12.204
		September 30, 2007	11.34

3AN1W1_H

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.753	October 4, 2003	12.359
March 3, 2005	9.979	October 3, 2004	12.329
May 14, 2006	9.738	July 11, 2005	12.632
May 31, 2007	9.487	September 21, 2006	12.21
		September 30, 2007	11.318

3AN1W2_GP

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.339	October 4, 2003	12.334
March 3, 2005	10.01	October 7, 2004	12.227
May 15, 2006	9.286	July 11, 2005	12.56
May 5, 2007	8.561	September 21, 2006	12.194
		September 28, 2007	11.3

3AN1W2_GW

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.316	October 3, 2003	12.352
March 3, 2005	10.008	October 7, 2004	12.349
May 14, 2006	9.334	July 11, 2005	12.668
May 31, 2007	8.64	September 21, 2006	12.238
		October 5, 2007	11.32

3AN1W3_GP

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.304	October 4, 2003	12.36
March 3, 2005	10.035	October 7, 2004	12.293
May 14, 2006	9.138	July 11, 2005	12.542
May 31, 2007	8.585	September 21, 2006	12.178
		October 5, 2007	11.216

3AN1W3_GW

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.42	October 4, 2003	12.345
March 2, 2005	10.014	October 1, 2004	12.329
May 14, 2006	9.223	July 11, 2005	12.606
May 31, 2007	8.56	September 21, 2006	12.216
		September 30, 2007	11.283

3AN1W4_GP

Minimum		Maximum	
Date	Value	Date	Value
June 3, 2004	9.312	October 4, 2003	12.371
March 2, 2005	9.972	October 7, 2004	12.327
May 14, 2006	9.253	July 11, 2005	12.571
May 31, 2007	8.531	September 21, 2006	12.291
		September 30, 2007	11.35

Table 2--Dates and values of annual minima and maxima in wells and piezometers at 3AS3

3AS3W1_GP

Minimum		Maximum	
Date	Value	Date	Value
		September 30, 2003	11.197
June 14, 2004	8.549	October 23, 2004	11.106
May 29, 2005	8.877	September 2, 2005	11.232
May 15, 2006	8.485	September 29, 2006	10.578
May 31, 2007	8.309	November 1, 2007	9.912

3AS3W1_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	8.087	November 6, 2001	10.834
May 18, 2002	8.606	September 12, 2002	10.636
April 25, 2003	9.022	September 30, 2003	11.147
June 14, 2004	8.559	October 24, 2004	11.08
May 29, 2005	8.896	September 2, 2005	11.273
May 15, 2006	8.549	September 29, 2006	10.645
May 31, 2007	8.294	November 1, 2007	9.892

3AS3W1_H

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	8.035	November 6, 2001	10.792
May 18, 2002	8.581	September 12, 2002	10.585
April 25, 2003	9.094	September 30, 2003	11.126
June 14, 2004	8.486	October 24, 2004	11.1
May 29, 2005	8.871	September 2, 2005	11.216
May 15, 2006	8.448	September 29, 2006	10.61
May 31, 2007	8.225	November 15, 2007	9.828

3AS3W2_GP

Minimum		Maximum	
Date	Value	Date	Value
		September 30, 2003	11.287
June 14, 2004	8.49	October 23, 2004	11.106
May 29, 2005	8.891	September 2, 2005	11.246
May 15, 2006	8.429	September 29, 2006	10.54
May 31, 2007	8.245	November 1, 2007	9.83

3AS3W2_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	8.806	November 6, 2001	10.82
May 18, 2002	8.647	September 12, 2002	10.621
April 25, 2003	9.109	September 30, 2003	11.153
June 14, 2004	8.513	October 23, 2004	11.111
May 29, 2005	8.909	September 2, 2005	11.259
May 15, 2006	8.469	September 29, 2006	10.619
May 31, 2007	8.26	November 1, 2007	9.901

3AS3W3_GP

Minimum		Maximum	
Date	Value	Date	Value
		September 30, 2003	11.143
June 30, 2004	8.552	October 24, 2004	11.137
May 29, 2005	8.929	September 2, 2005	11.263
May 14, 2006	8.435	September 29, 2006	10.524
May 31, 2007	8.208	November 1, 2007	9.88

3AS3W3_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	8.077	November 7, 2001	10.848
May 18, 2002	8.643	September 12, 2002	10.606
April 25, 2003	9.112	September 30, 2003	11.111
June 14, 2004	8.512	October 21, 2004	11.102
May 29, 2005	8.886	September 2, 2005	11.266
May 15, 2006	8.457	September 29, 2006	10.634
May 31, 2007	8.232	November 14, 2007	9.879

3AS3W4_GP

Minimum		Maximum	
Date	Value	Date	Value
		September 30, 2003	11.184
June 14, 2004	8.547	October 23, 2004	11.143
May 29, 2005	8.9	September 2, 2005	11.223
May 15, 2006	8.48	September 29, 2006	10.642
May 31, 2007	8.237	November 1, 2007	10.116

3AS3W4_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	8.066	November 6, 2001	10.832
May 18, 2002	8.667	September 12, 2002	10.642
April 25, 2003	9.173	September 30, 2003	11.158
June 14, 2004	8.542	October 21, 2004	11.108
May 29, 2005	8.882	September 2, 2005	11.278
May 15, 2006	8.509	September 29, 2006	10.649
May 31, 2007	8.237	November 1, 2007	9.898

Table 3--Dates and values of annual minima and maxima in wells and piezometers at 3BS1

3BS1W1_GP

Minimum		Maximum	
Date	Value	Date	Value
		October 2, 2003	8.093
July 2, 2004	5.279	October 23, 2004	7.695
May 2, 2005	5.793	September 12, 2005	8.407
May 15, 2006	4.85	October 14, 2006	7.43
May 31, 2007	4.691	November 1, 2007	7.211

3BS1W1_GW

Minimum		Maximum	
Date	Value	Date	Value
May 21, 2001	4.057	October 25, 2001	8.384
May 13, 2002	5.134	September 14, 2002	7.982
April 25, 2003	6.251	October 2, 2003	8.053
July 2, 2004	5.306	October 23, 2004	7.674
May 2, 2005	5.786	September 12, 2005	8.35
May 15, 2006	4.848	October 14, 2006	7.436
May 31, 2007	4.665	November 1, 2007	7.209

3BS1W1_H

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	4.32	October 25, 2001	8.525
May 13, 2002	5.184	September 14, 2002	7.947
April 25, 2003	6.249	October 2, 2003	8.15
July 2, 2004	5.259	October 23, 2004	7.8
March 3, 2005	5.863	September 12, 2005	8.457
May 15, 2006	4.814	October 14, 2006	7.487
May 31, 2007	4.653	November 1, 2007	7.255

3BS1W2_GP

Minimum		Maximum	
Date	Value	Date	Value
		October 2, 2003	8.115
June 28, 2004	5.173	October 23, 2004	7.617
March 3, 2005	5.727	September 12, 2005	8.385
May 15, 2006	4.82	October 14, 2006	7.453
May 31, 2007	4.61	November 1, 2007	7.178

3BS1W2_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	4.012	October 25, 2001	8.392
May 13, 2002	5.025	September 14, 2002	7.866
April 25, 2003	6.215	October 1, 2003	8.057
June 28, 2004	5.151	October 23, 2004	7.691
March 3, 2005	5.694	September 12, 2005	8.371
May 15, 2006	4.745	October 14, 2006	7.415
May 31, 2007	4.613	October 6, 2007	7.148

3BS1W3_GP

Minimum		Maximum	
Date	Value	Date	Value
		October 1, 2003	8.11
June 28, 2004	5.198	October 24, 2004	7.748
March 3, 2005	5.752	September 12, 2005	8.341
May 15, 2006	4.725	November 12, 2006	7.763
May 31, 2007	4.584	November 1, 2007	7.158

3BS1W3_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	4.057	October 25, 2001	8.418
May 13, 2002	5.071	September 14, 2002	7.894
April 25, 2003	6.241	October 1, 2003	8.069
June 28, 2004	5.155	October 23, 2004	7.649
March 3, 2005	5.748	September 12, 2005	8.388
May 15, 2006	4.737	October 14, 2006	7.427
May 31, 2007	4.588	October 6, 2007	7.175

3BS1W4_GP

Minimum		Maximum	
Date	Value	Date	Value
		October 1, 2003	8.174
June 28, 2004	5.201	October 23, 2004	7.746
March 3, 2005	5.743	October 8, 2005	8.568
May 15, 2006	4.791	November 3, 2006	7.516
May 31, 2007	4.706	October 6, 2007	8.033

3BS1W4_GW

Minimum		Maximum	
Date	Value	Date	Value
May 22, 2001	4.096	October 25, 2001	8.394
May 13, 2002	5.2	September 14, 2002	7.931
April 25, 2003	6.269	October 1, 2003	8.066
July 2, 2004	5.241	October 23, 2004	7.711
May 2, 2005	5.82	October 8, 2005	8.353
May 15, 2006	4.839	November 3, 2006	7.458
May 31, 2007	4.69	November 3, 2007	7.222

3AN1

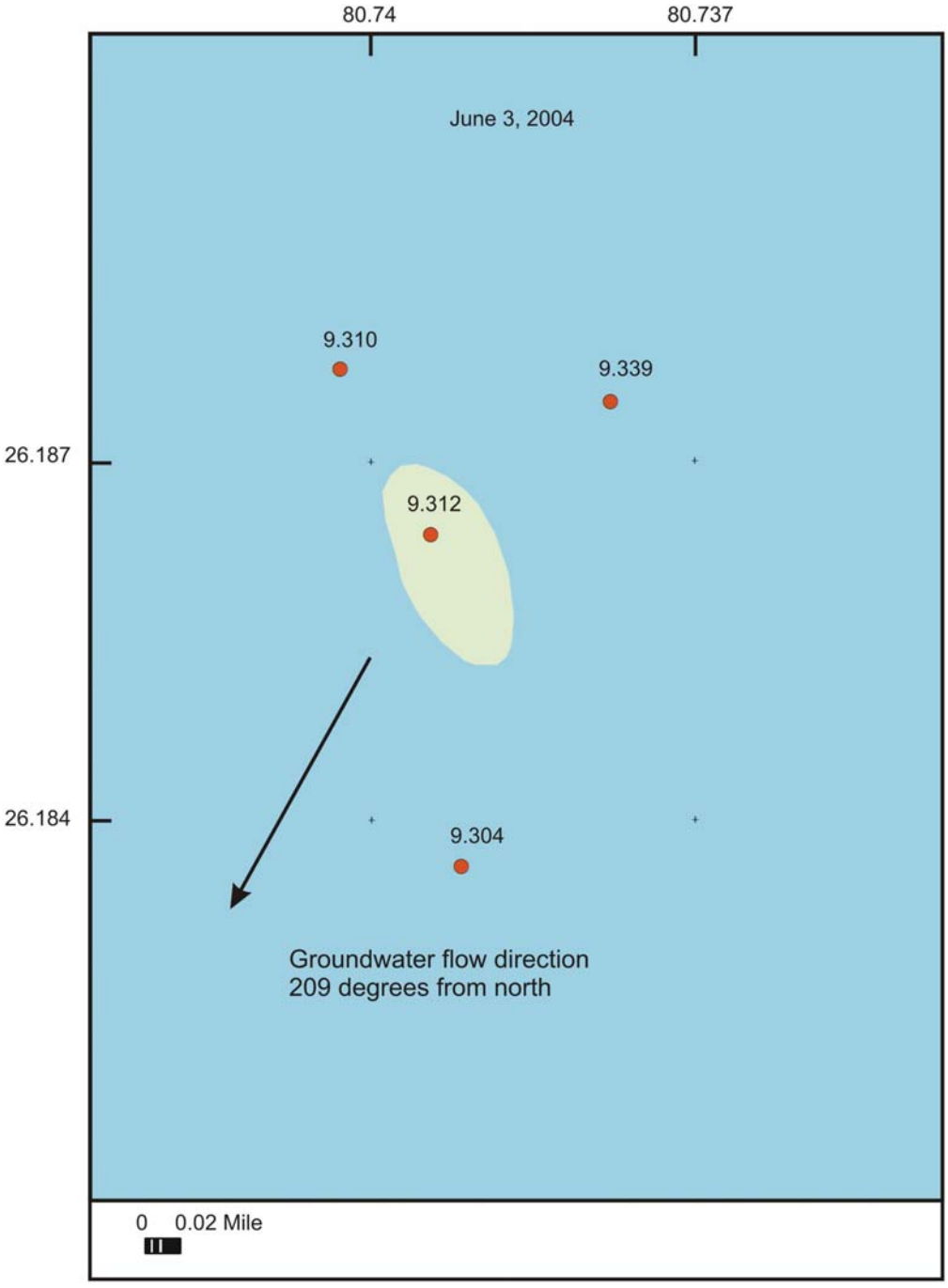

Figure 1 Water levels (ft above NGVD29) in piezometers at 3AN1 on June 3, 2004 (annual minimum).

3AN1

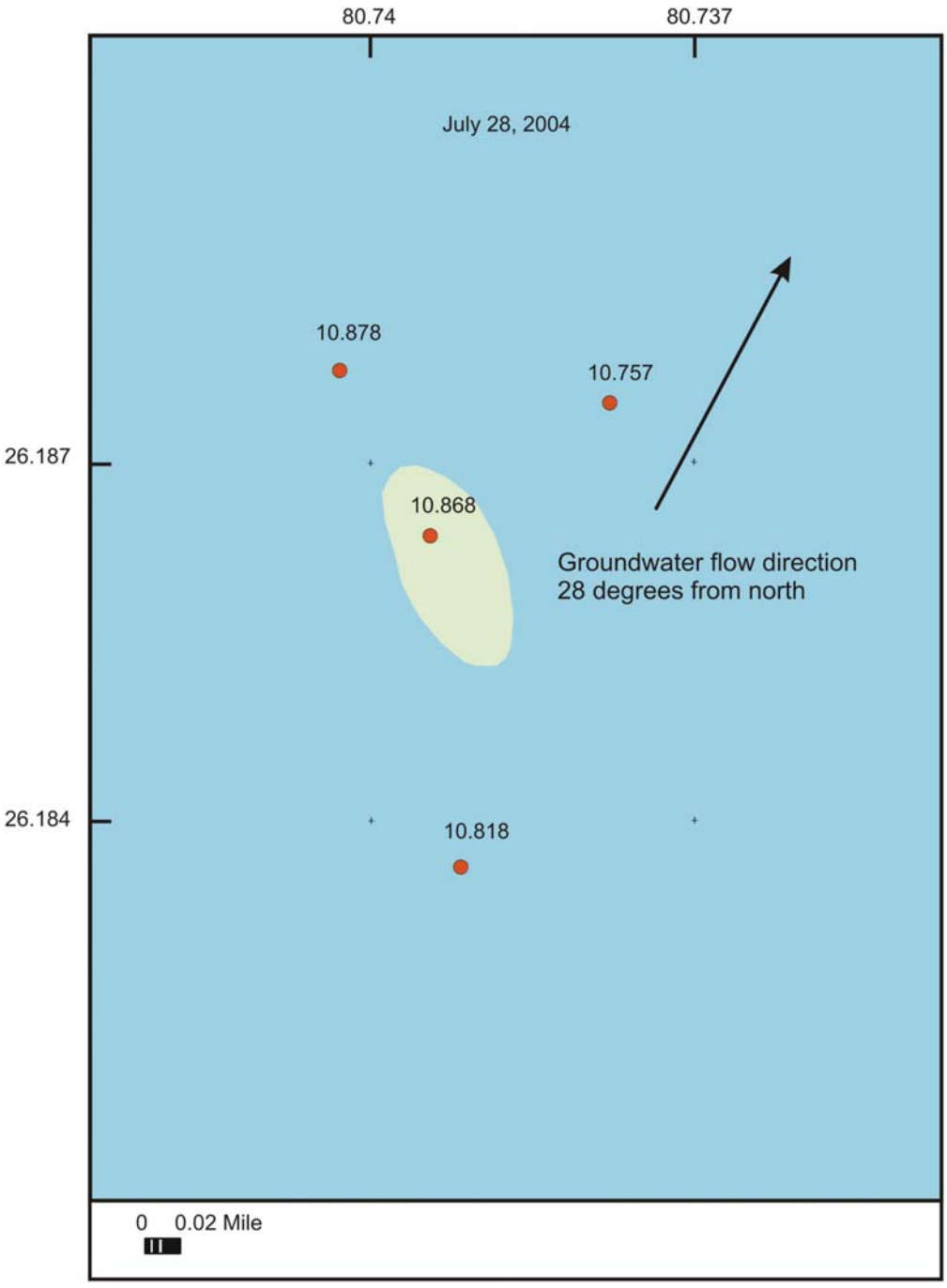

Figure 2 Water levels (ft above NGVD29) in piezometers at 3AN1 on July 28, 2004 (average conditions)

3AN1

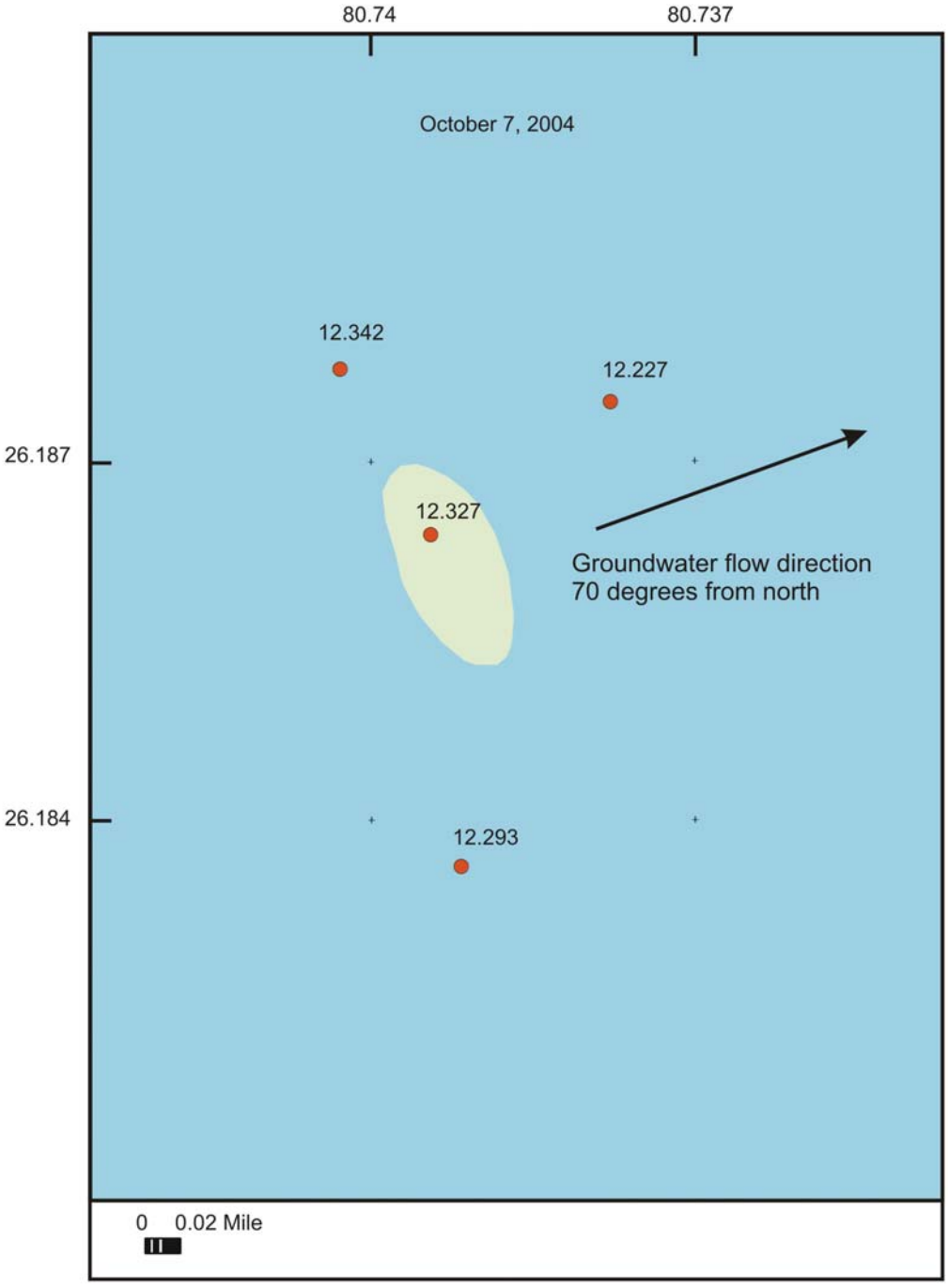

Figure 3 Water levels (ft above NGVD29) in piezometers at 3AN1 on October 7, 2004 (annual maximum).

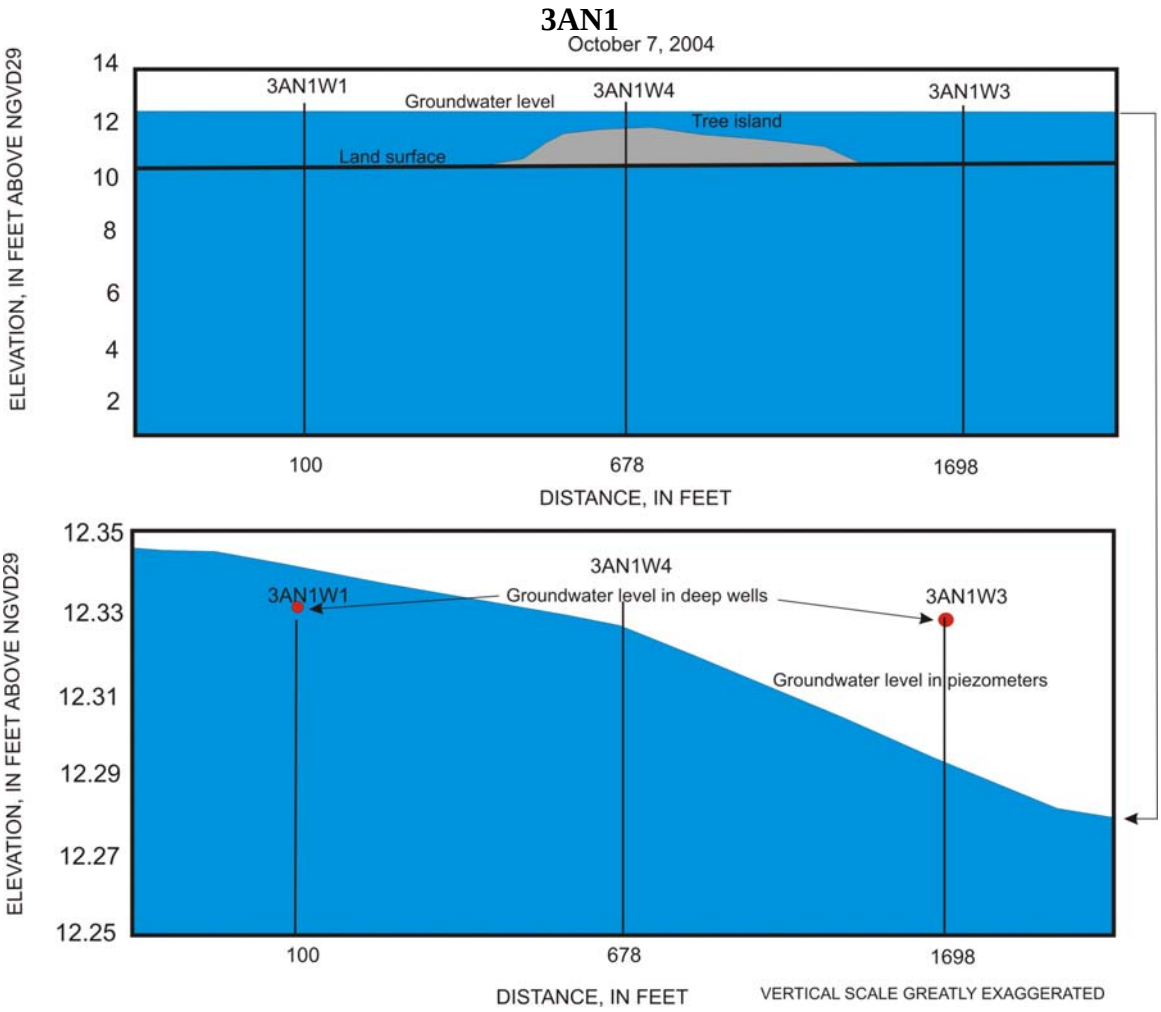

Figure 4 Cross section showing water levels in piezometers and deep wells at 3AN1 on October 7, 2004 (annual maximum).

3AN1

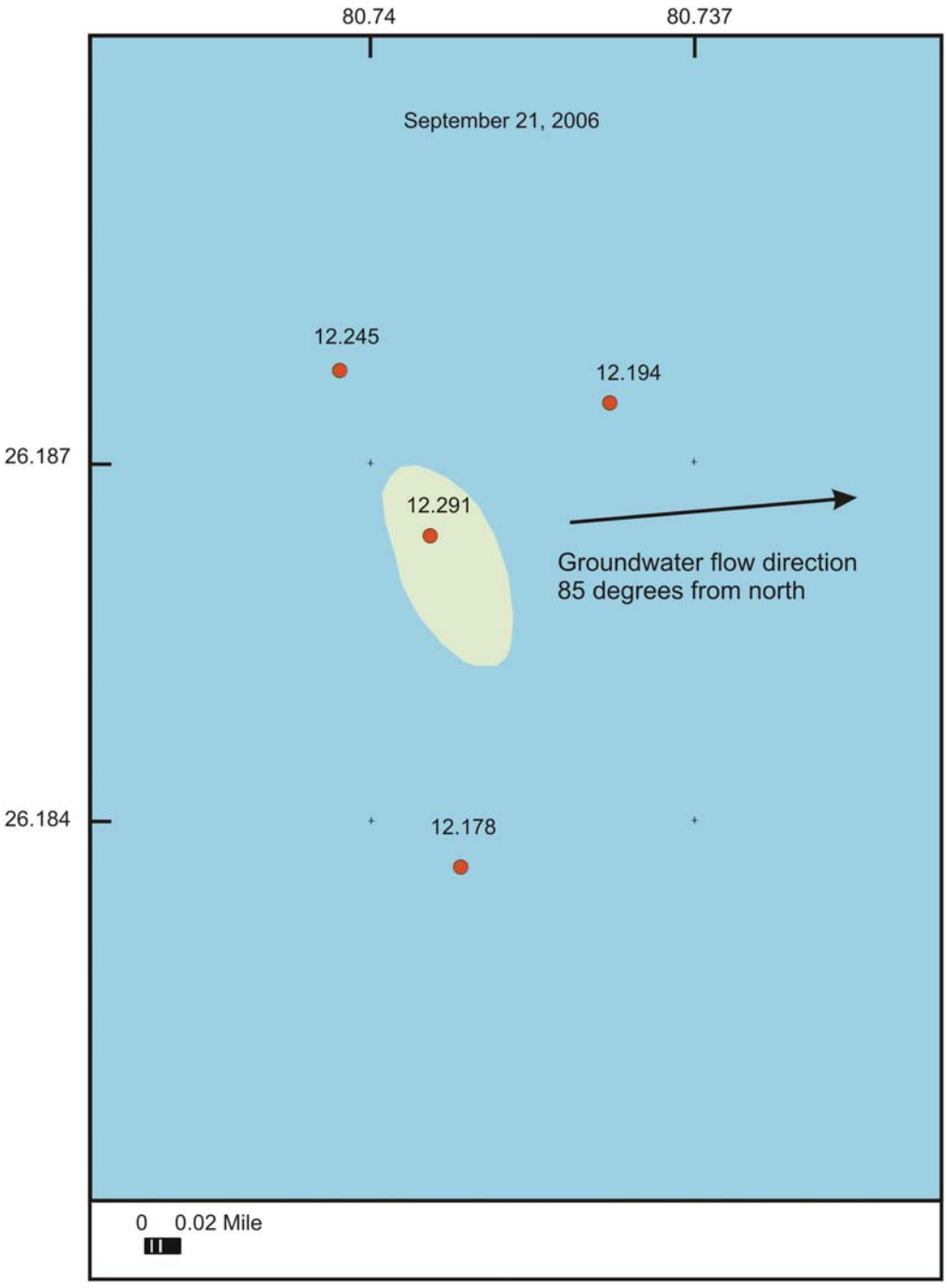

Figure 5 Water levels (ft above NGVD29) in piezometers at 3AN1 on September 21, 2006 (annual maximum).

3AN1

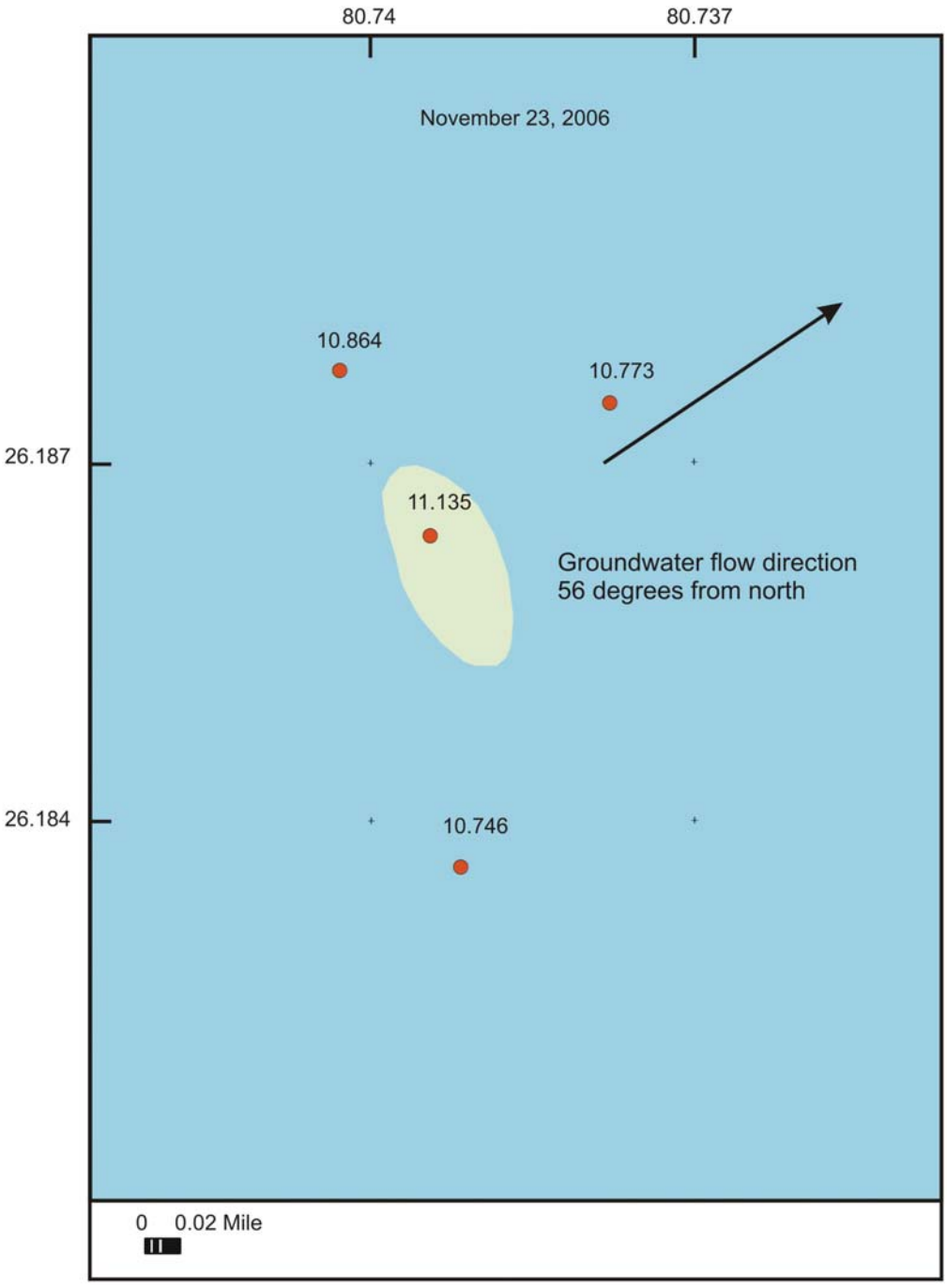

Figure 6 Water levels (ft above NGVD29) in piezometers at 3AN1 on November 23, 2006 (average conditions).

3AN1

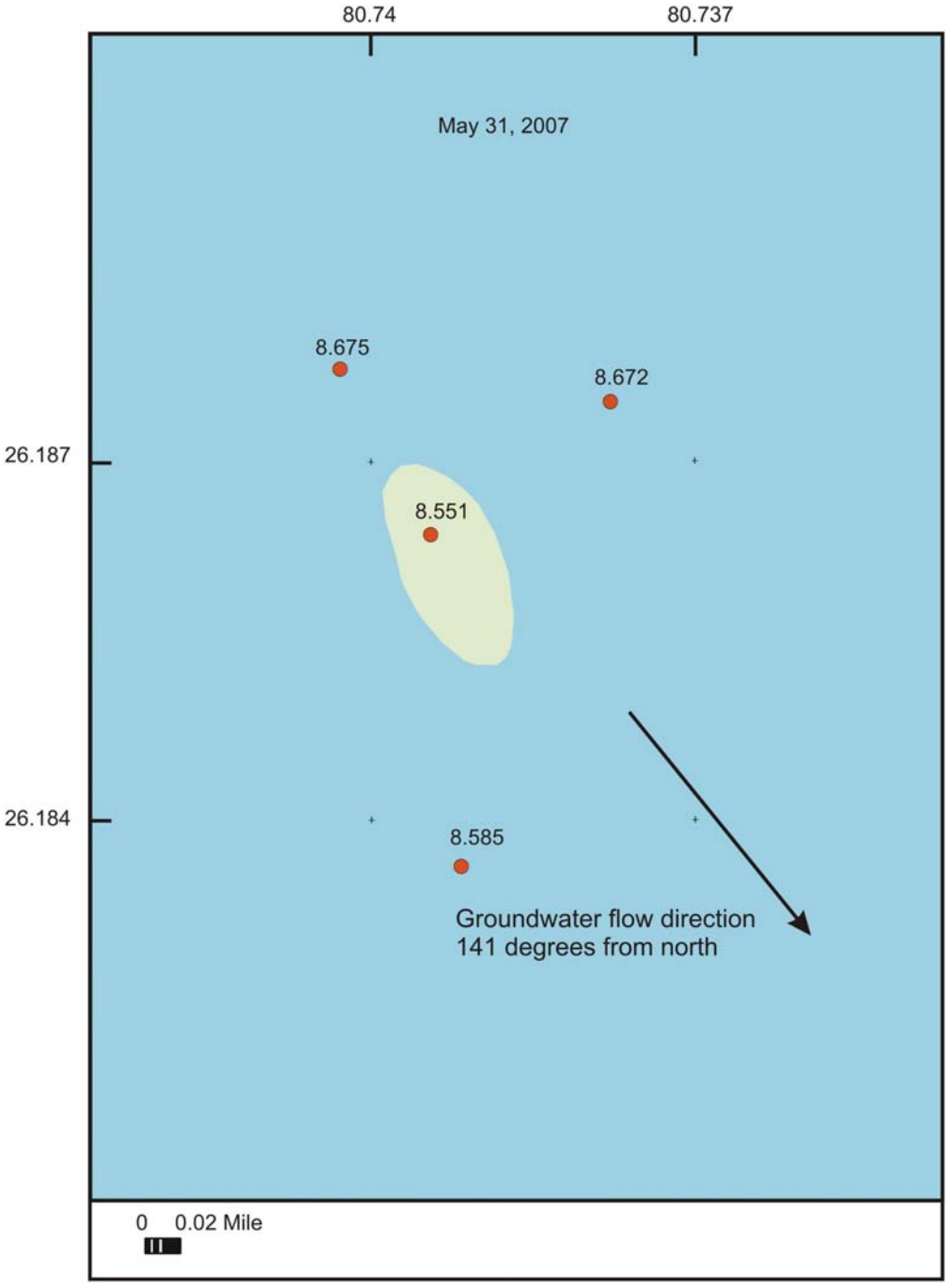

Figure 7 Water levels (ft above NGVD29) in piezometers at 3AN1 on May 31, 2007 (annual minimum).

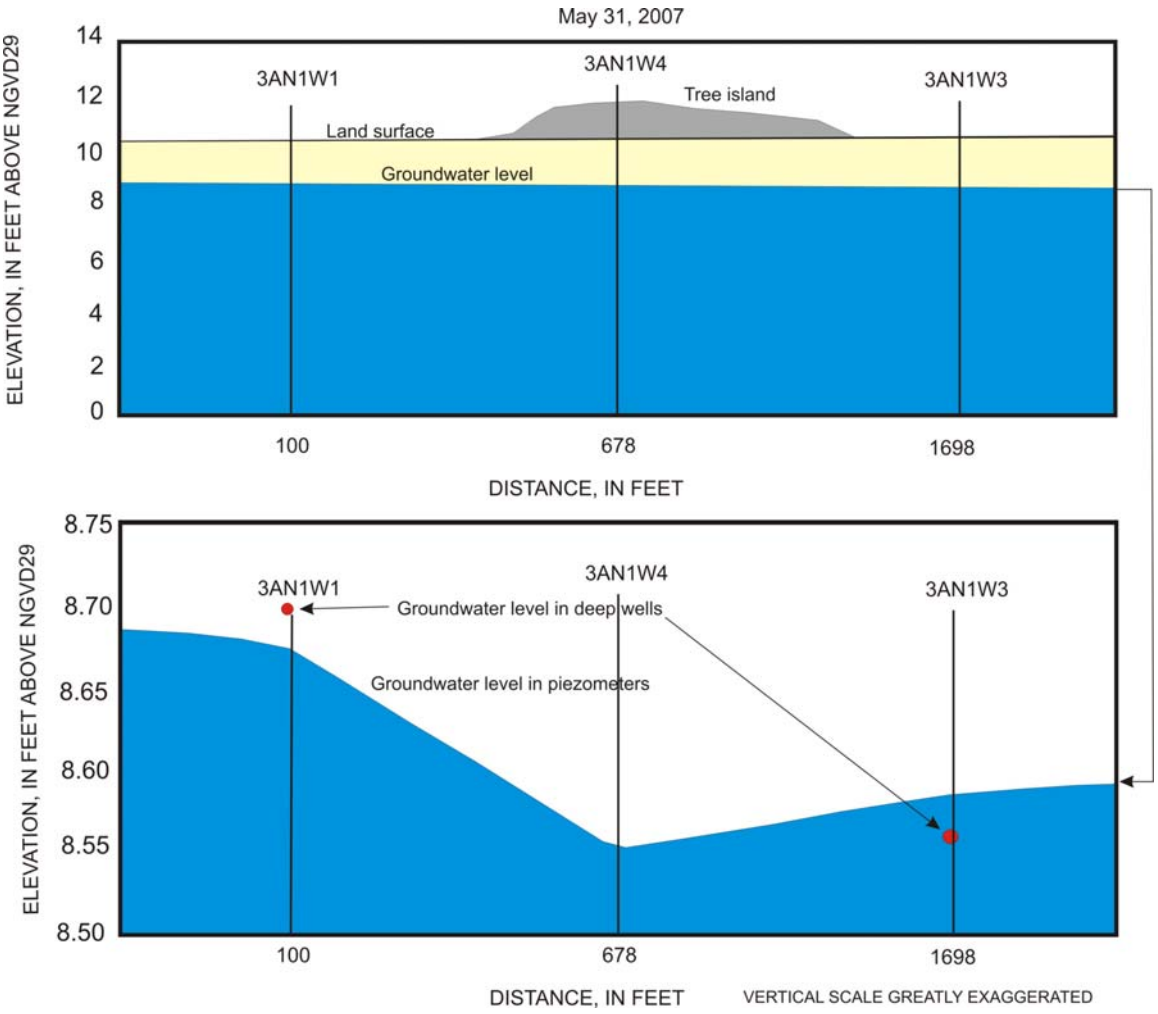

Figure 8 Cross section showing water levels in piezometers and deep wells at 3AN1 on May 31, 2007 (annual minimum).

3AS3

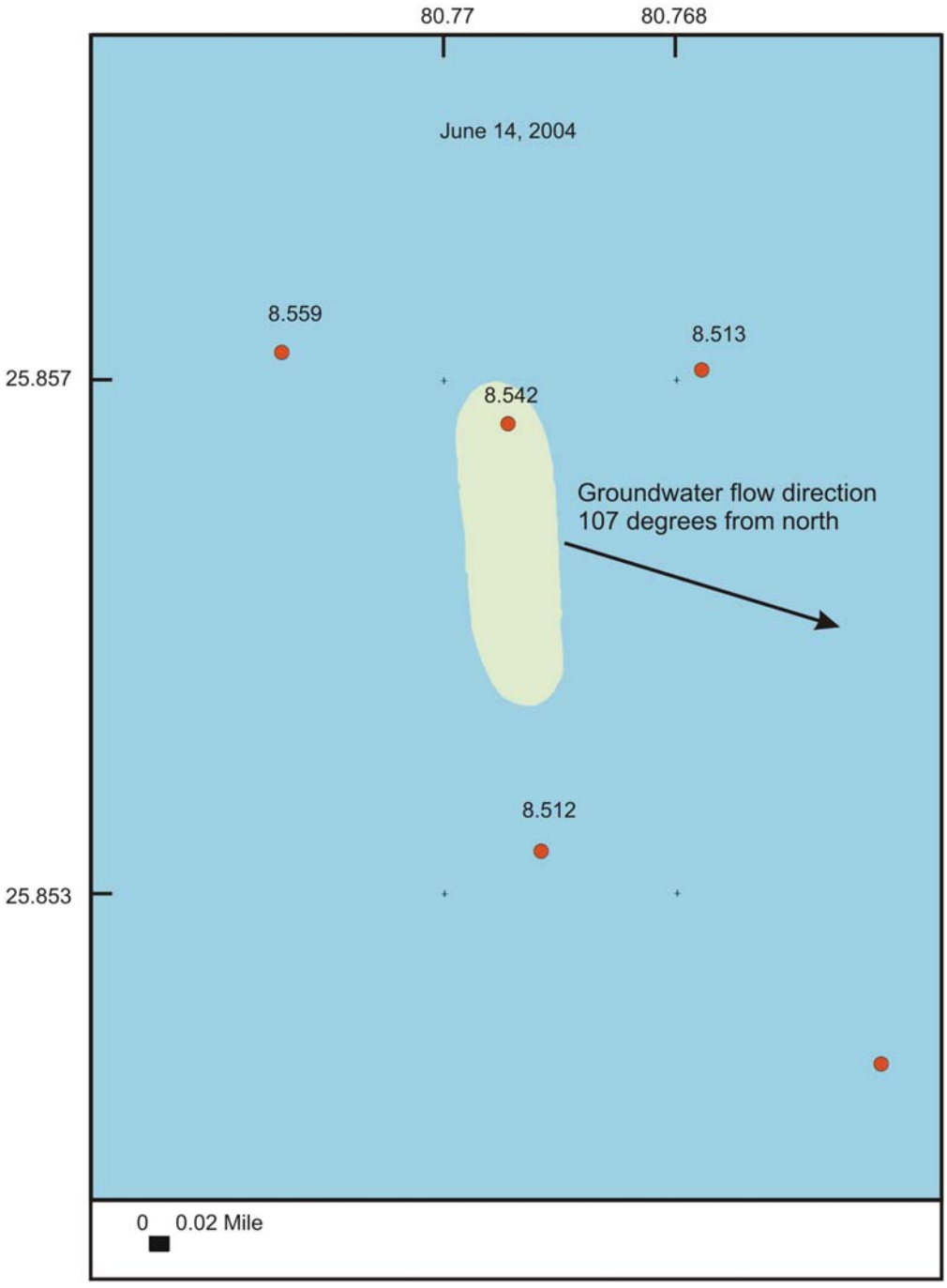

Figure 9 Water levels (ft above NGVD29) in deep wells at 3AS3 on June 14, 2004 (annual minimum).

3AS3

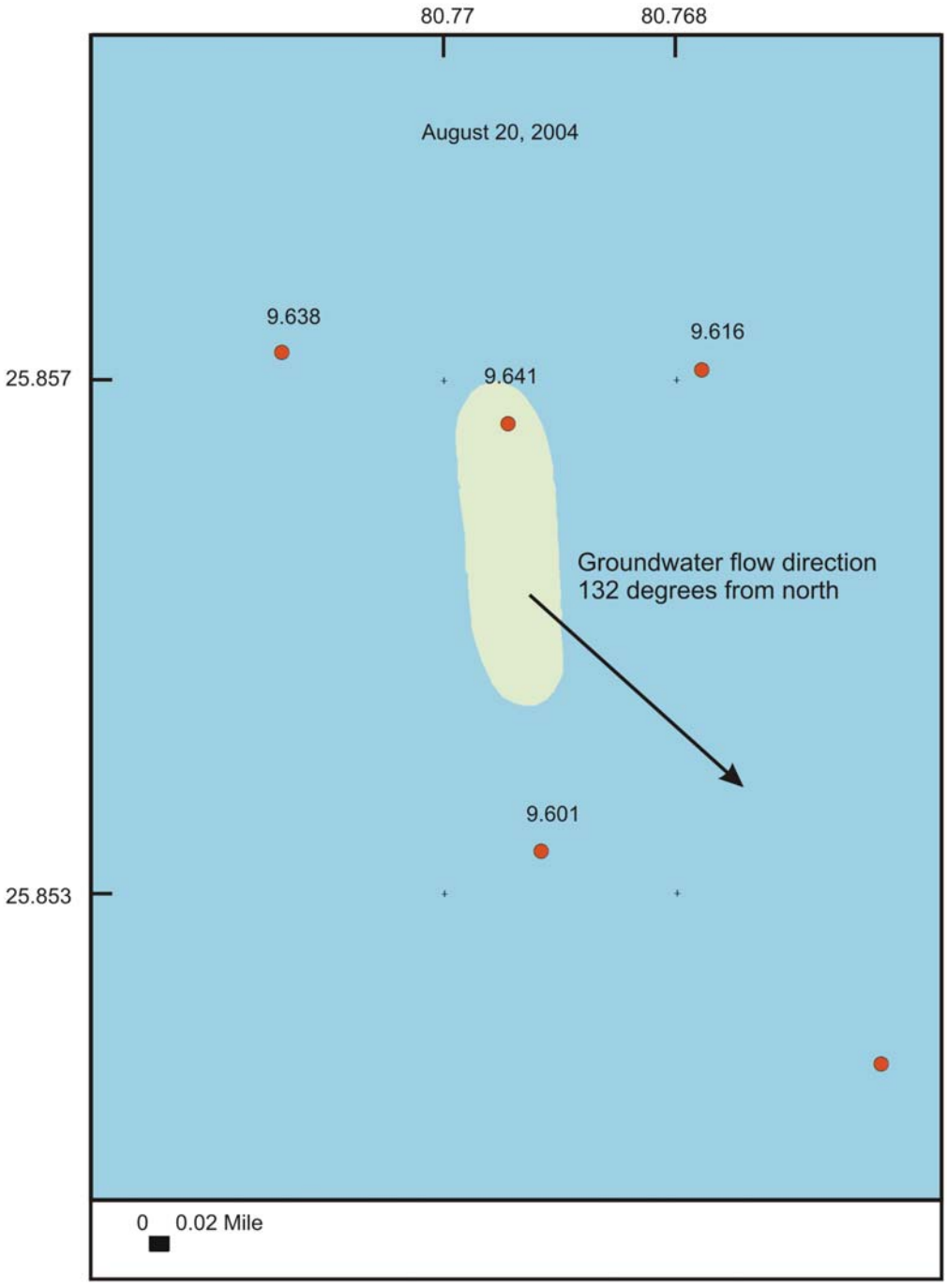

Figure 10 Water levels (ft above NGVD29) in deep wells at 3AS3 on August 20, 2004 (average conditions).

3AS3

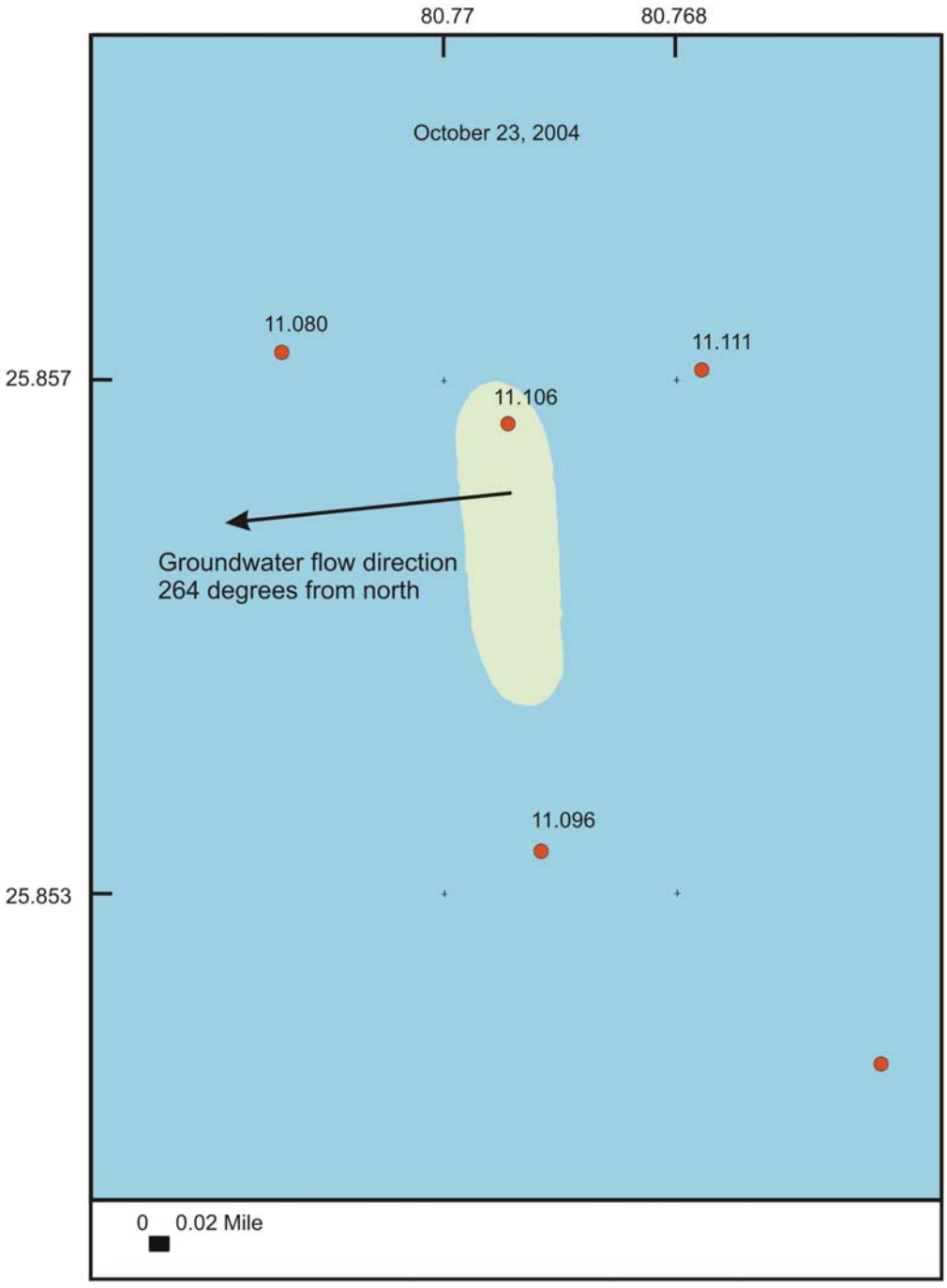

Figure 11 Water levels (ft above NGVD29) in deep wells at 3AS3 on October 23, 2004 (annual maximum).

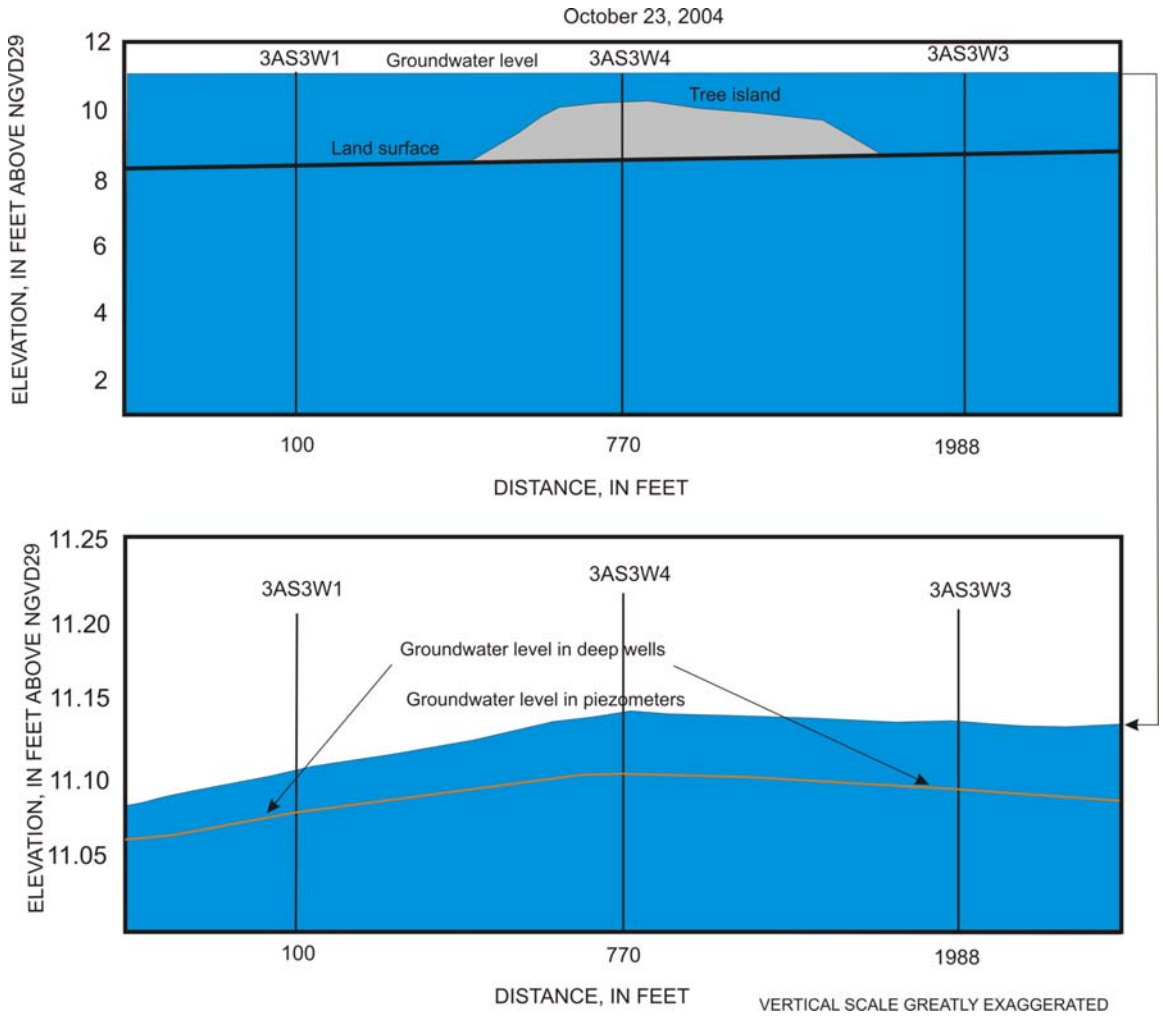

Figure 12 Cross section showing water levels in piezometers and deep wells on October 23, 2004 (annual maximum).

3AS3

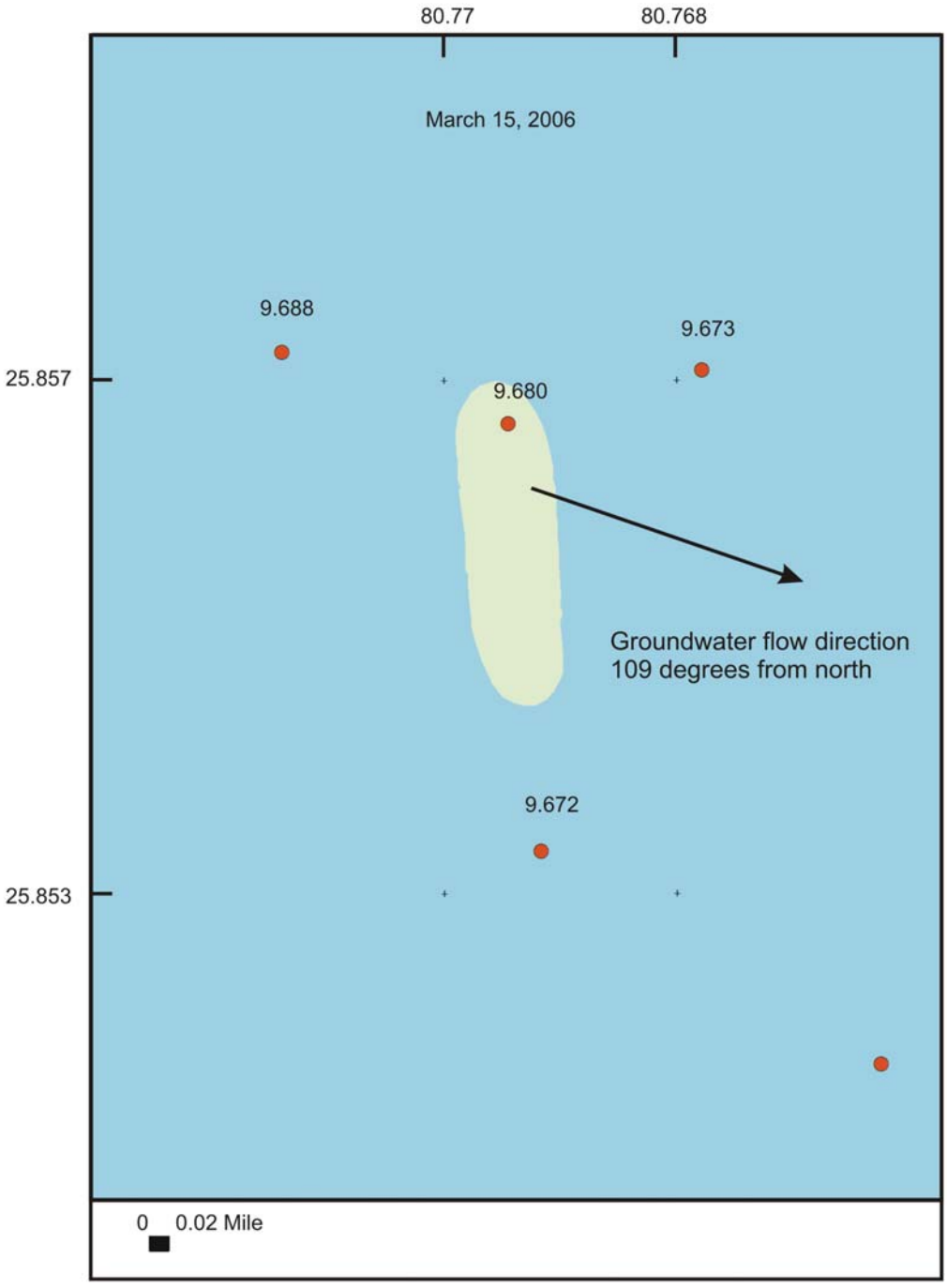

Figure 13 Water levels (ft above NGVD29) in deep wells at 3AS3 on March 15, 2006 (average conditions).

3AS3

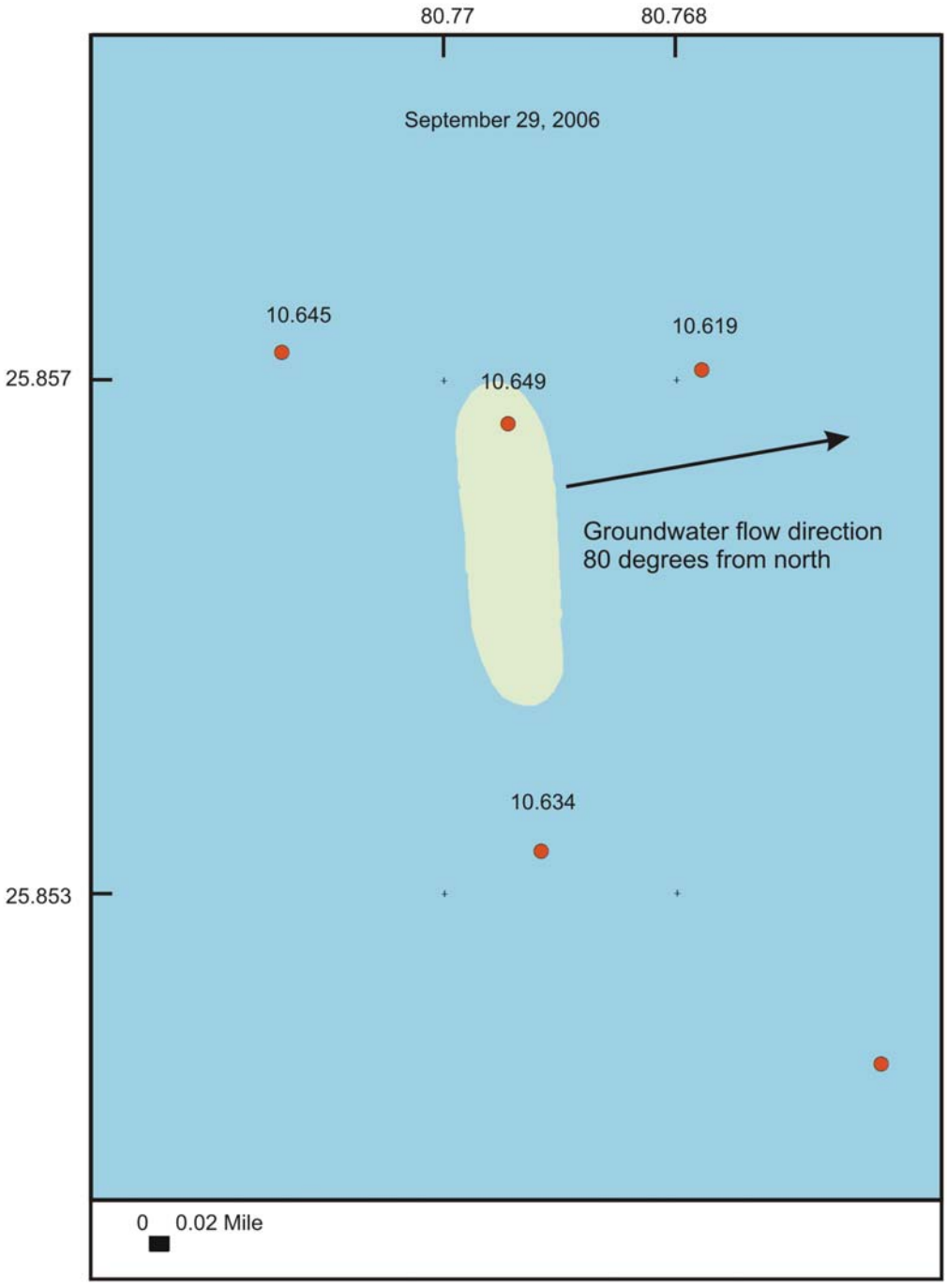

Figure 14 Water levels (ft above NGVD29) in deep wells at 3AS3 on September 29, 2006 (annual maximum).

3AS3

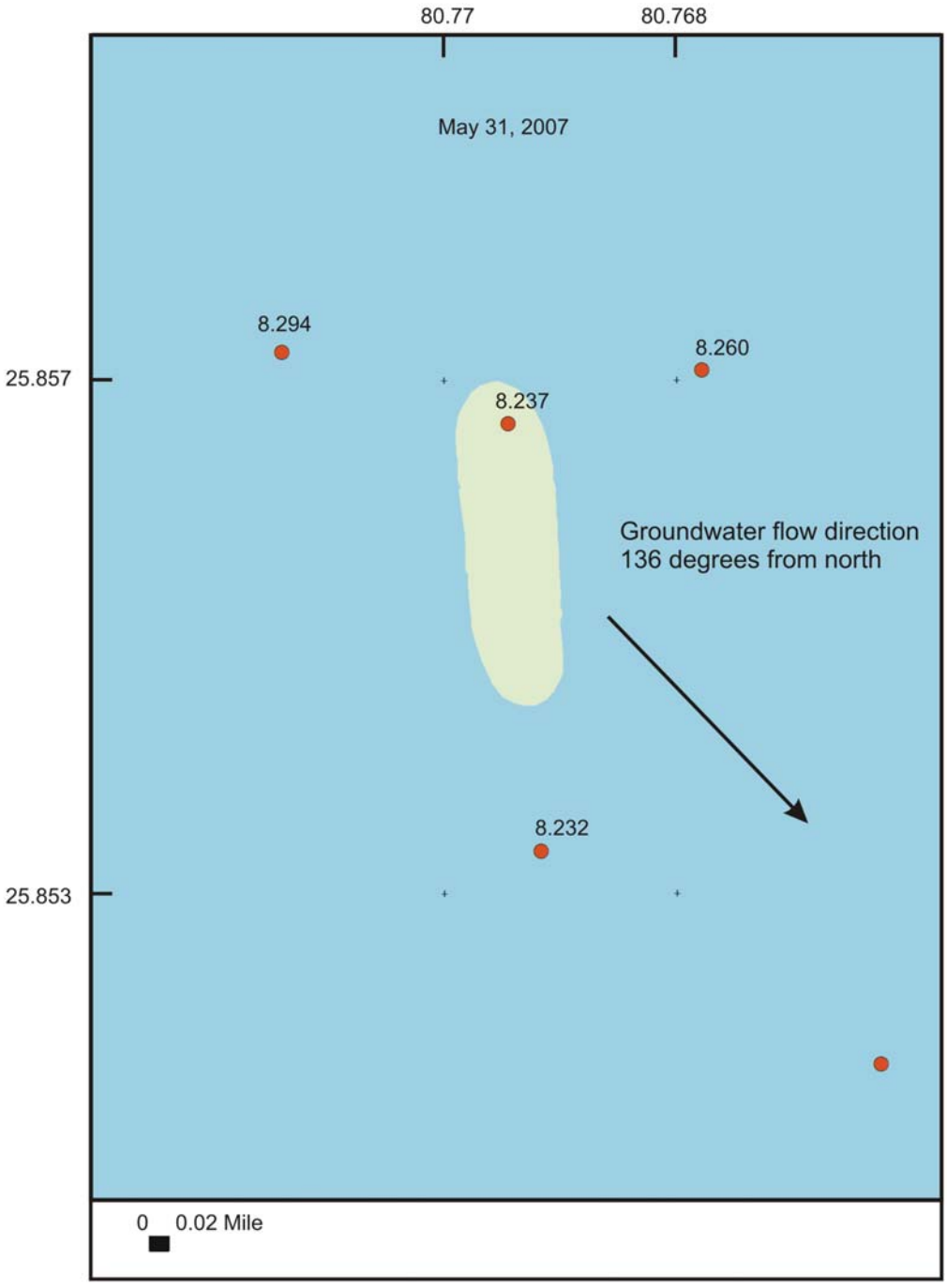

Figure 15 Water levels (ft above NGVD29) in deep wells at 3AS3 on May 31, 2007 (annual minimum).

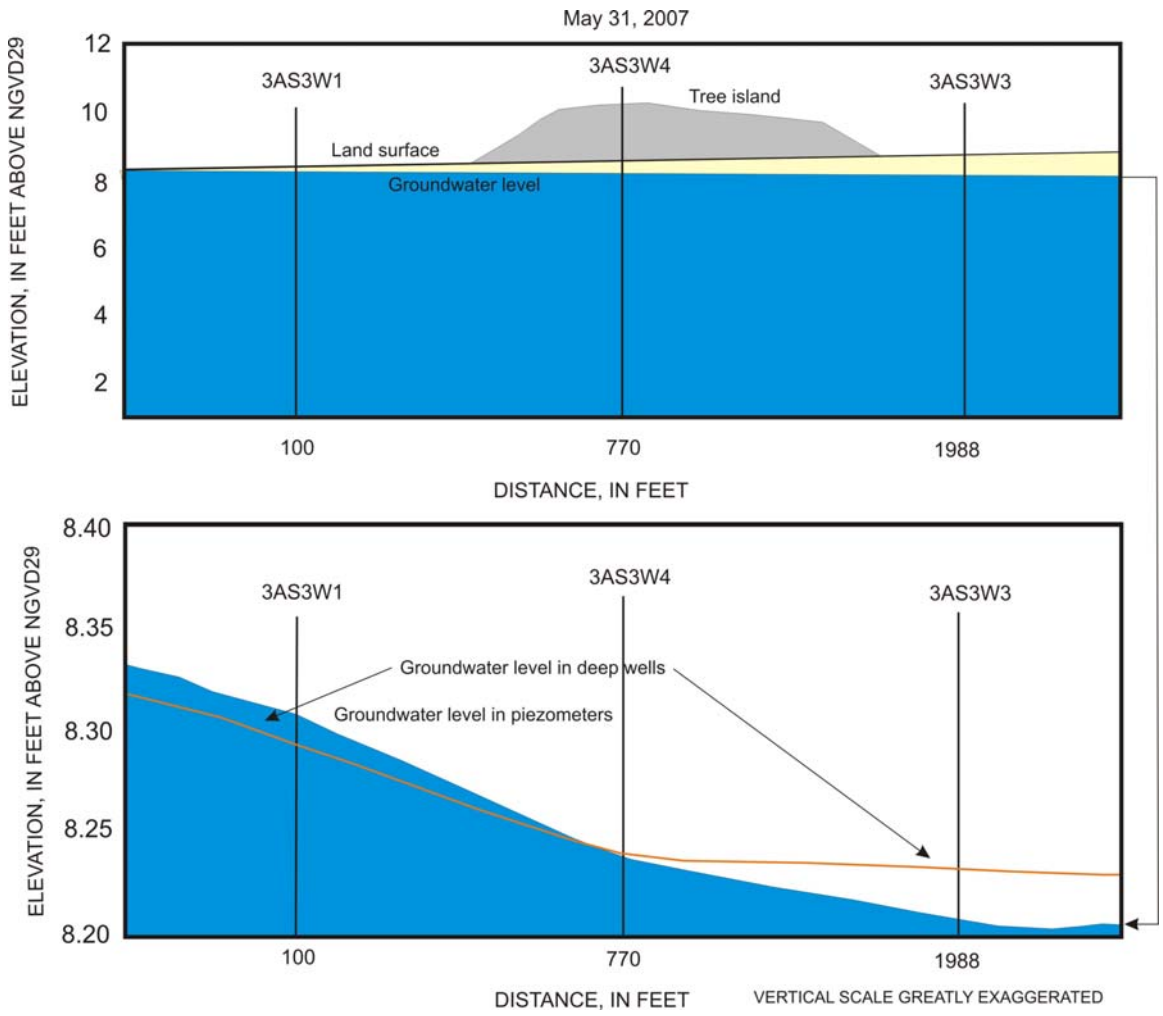

Figure 16 Cross section showing water levels in piezometers and deep wells at 3AS3 on May 31, 2007.

3BS1

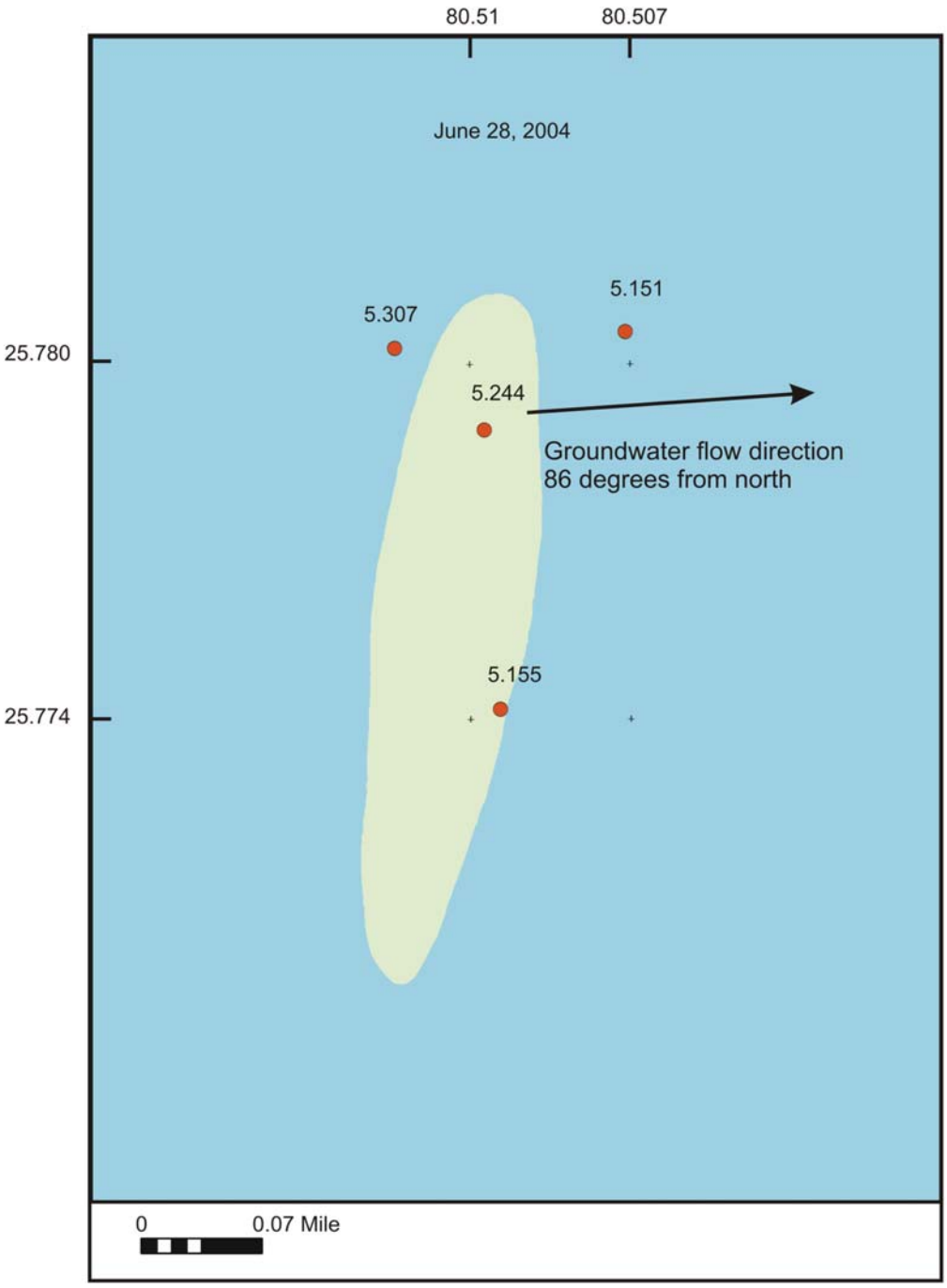

Figure 17 Water levels (ft above NGVD29) in deep wells at 3BS1 on June 28, 2004 (annual minimum).

3BS1

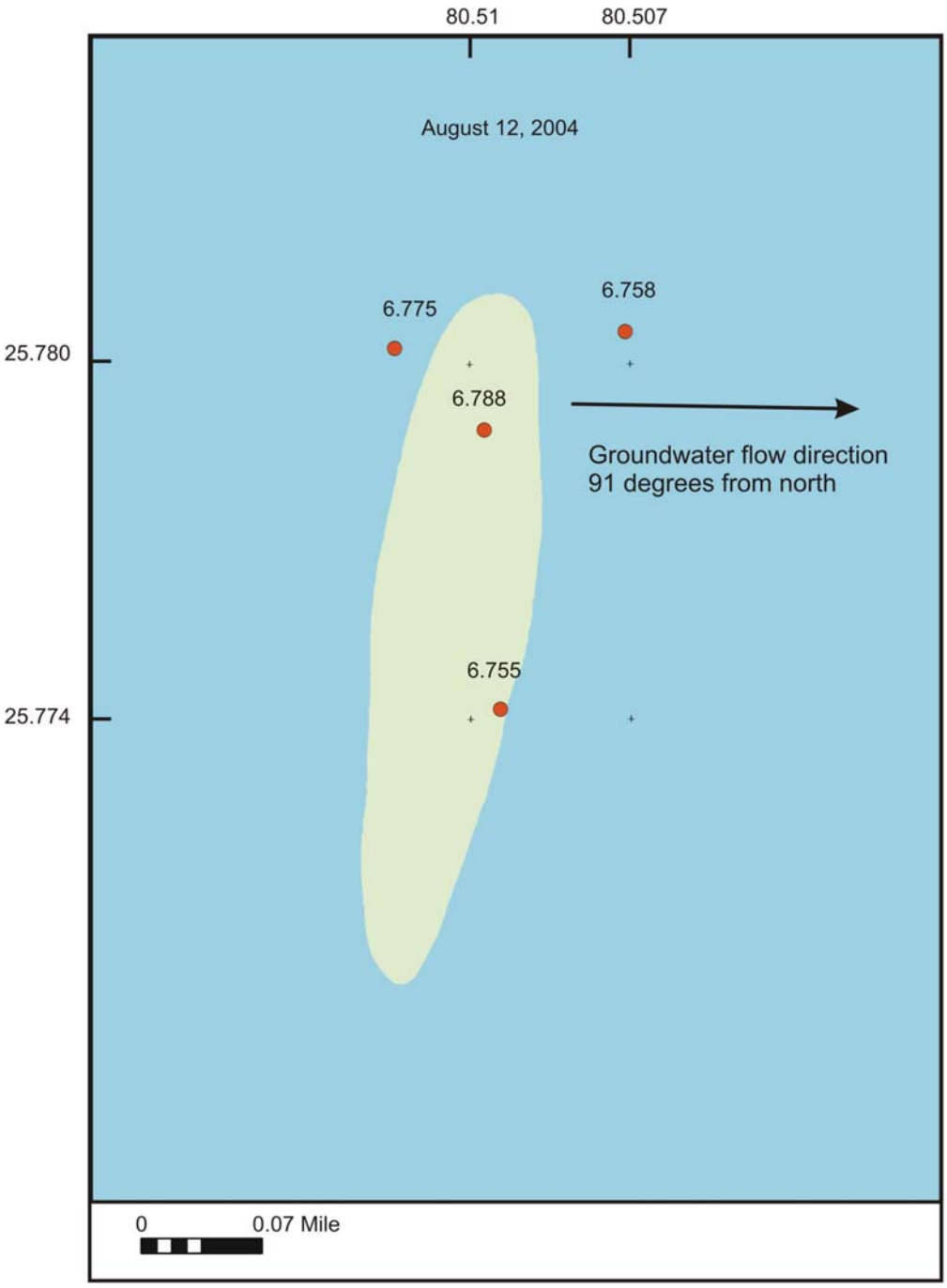

Figure 18 Water levels (ft above NGVD29) in deep wells at 3BS1 on August 12, 2004 (average conditions).

3BS1

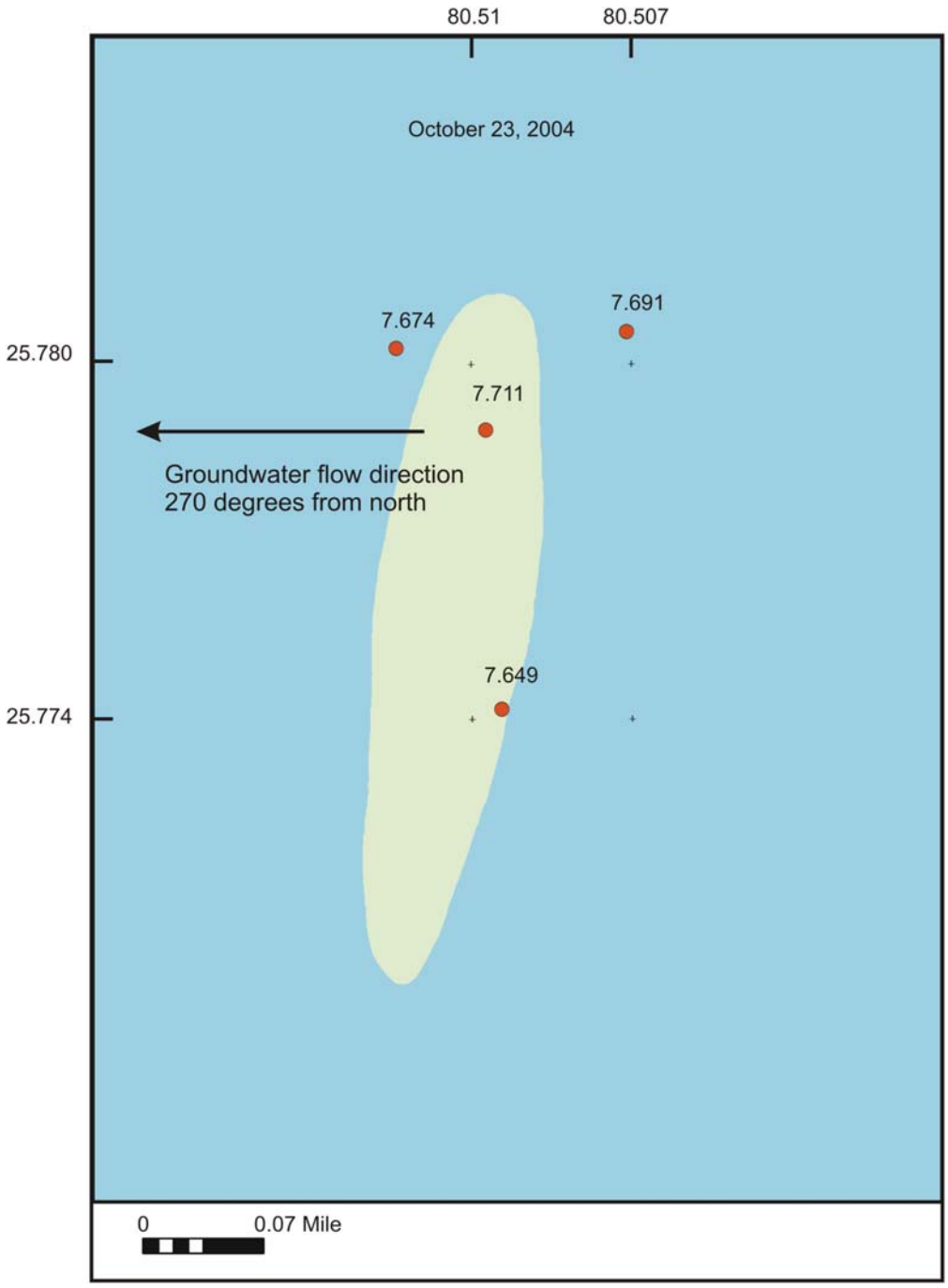

Figure 19 Water levels (ft above NGVD29) in deep wells at 3BS1 on October 23, 2004 (annual maximum).

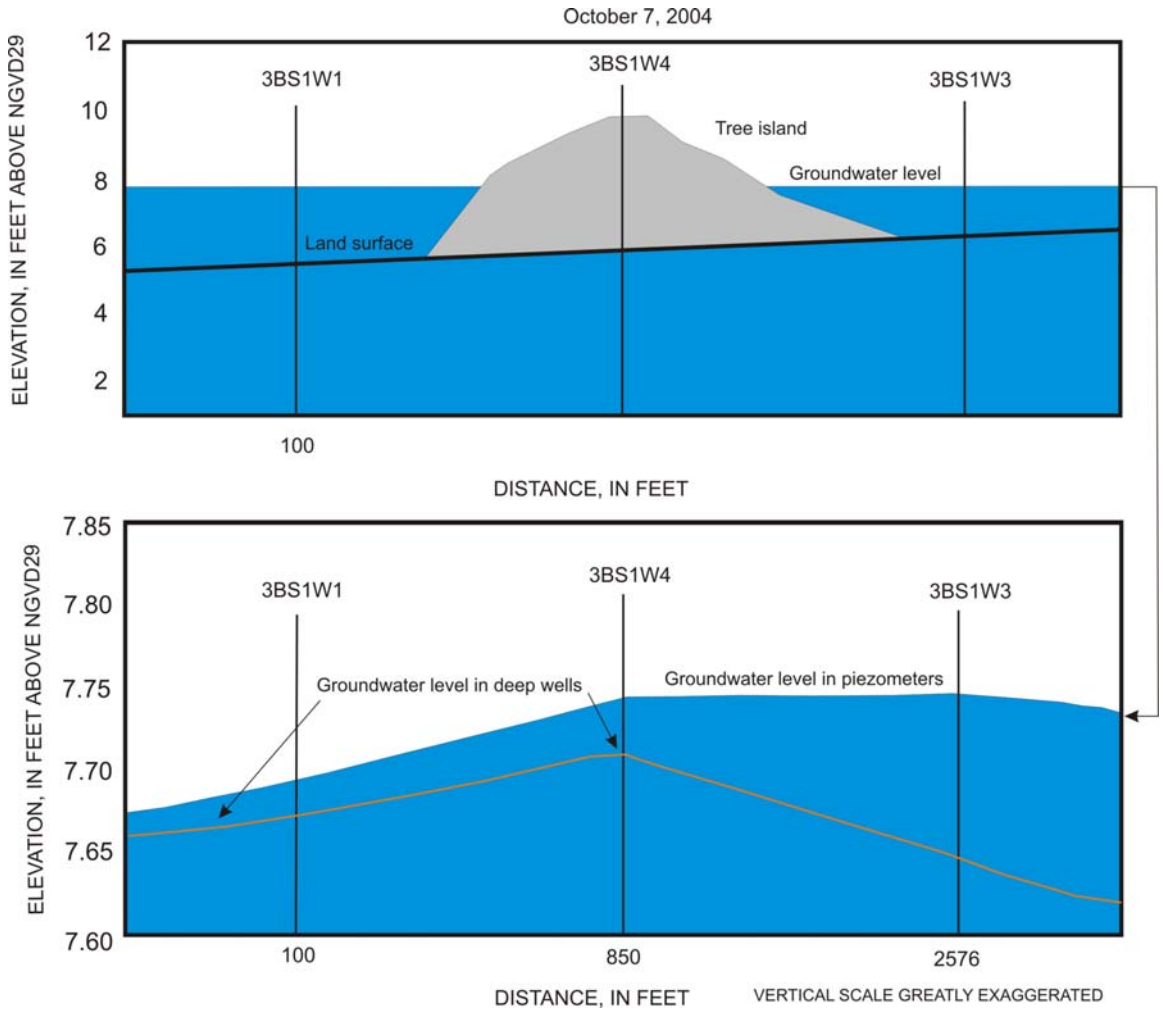

Figure 20 Cross section showing water levels in piezometers and deep wells at 3BS1 on October 7, 2004.

3BS1

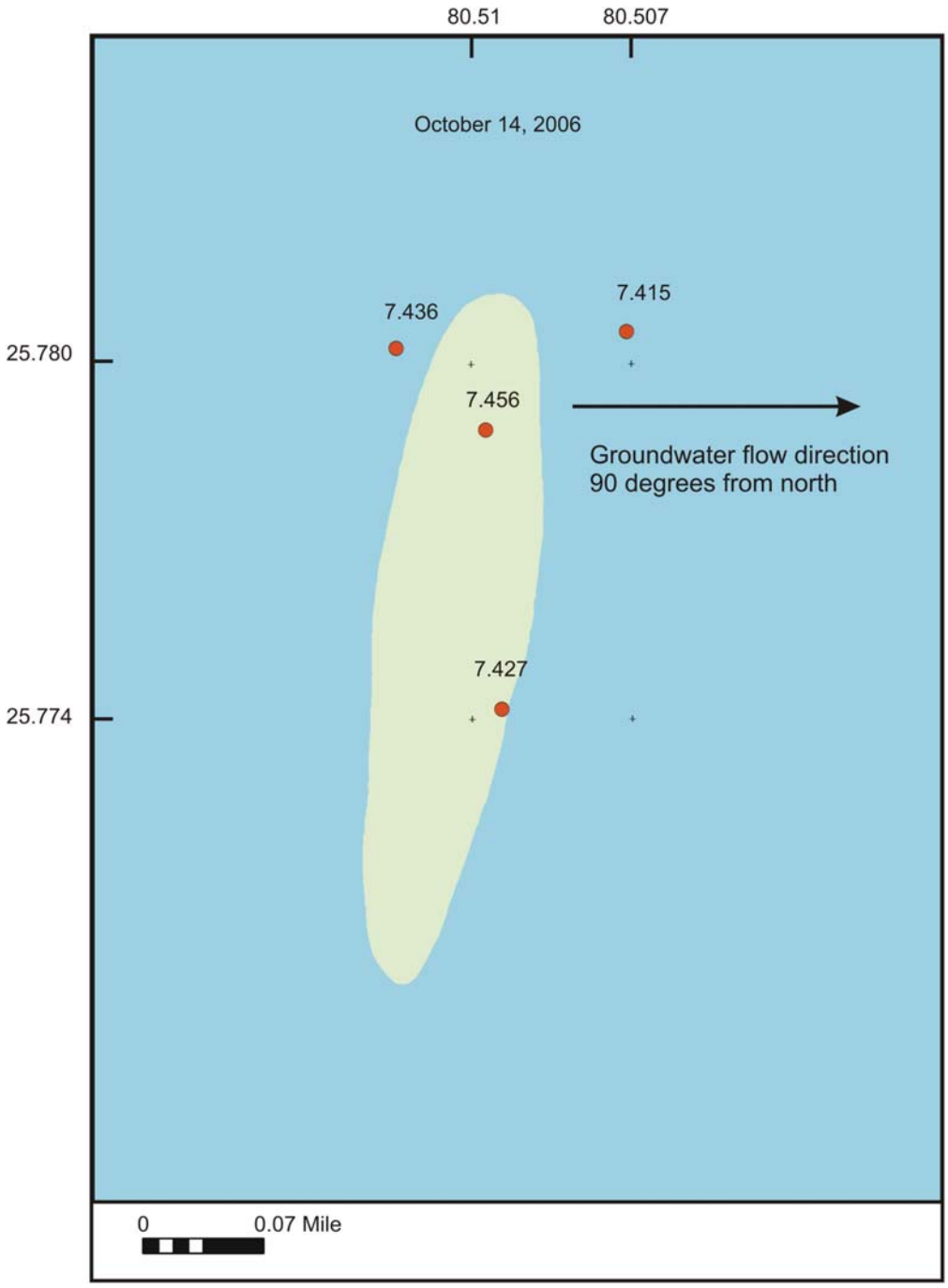

Figure 21 Water levels (ft above NGVD29) in deep wells at 3BS1 on October 14, 2006 (annual maximum).

3BS1

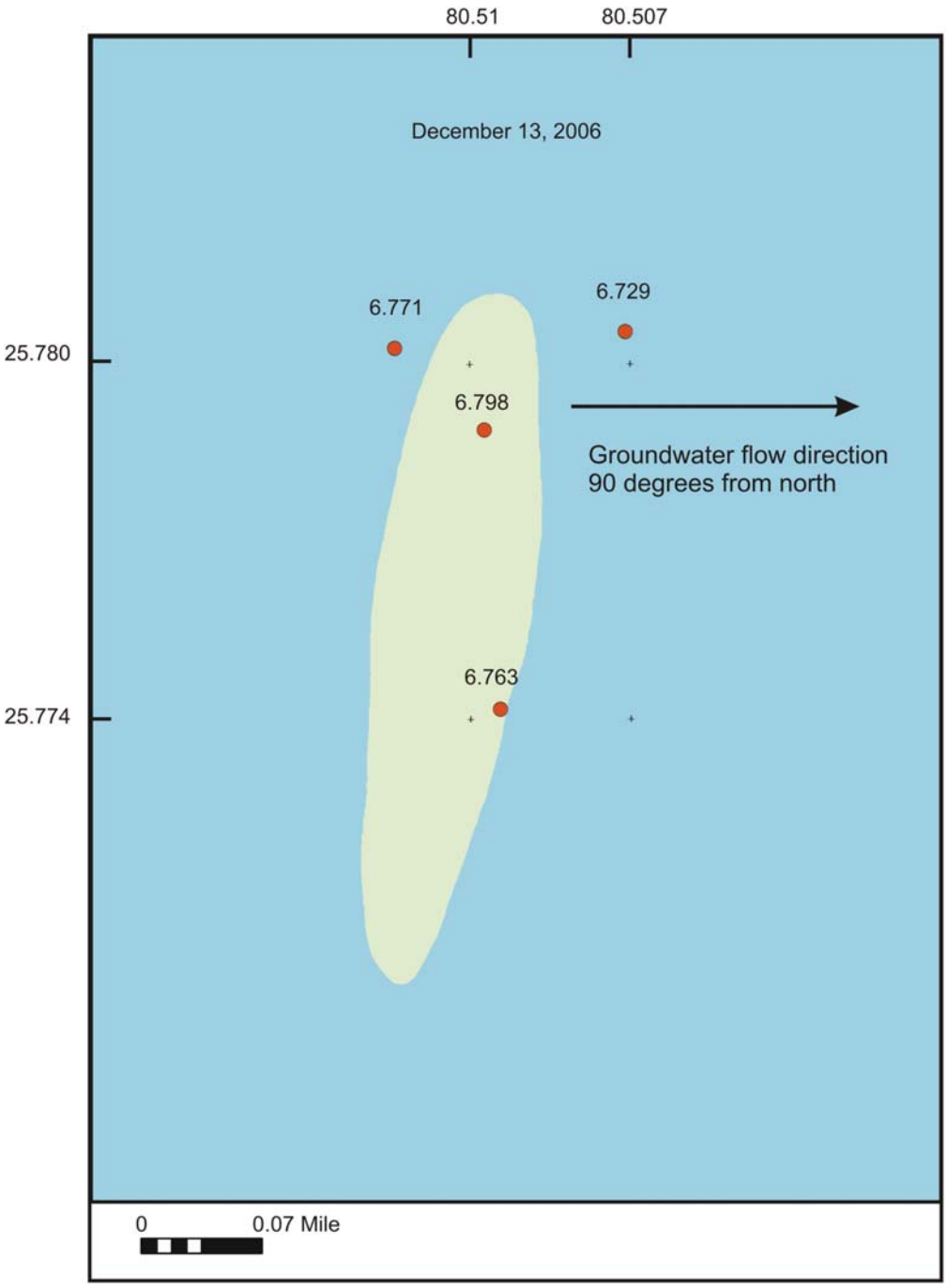

Figure 22 Water levels (ft above NGVD29) in deep wells at 3BS1 on December 13, 2006 (average conditions).

3BS1

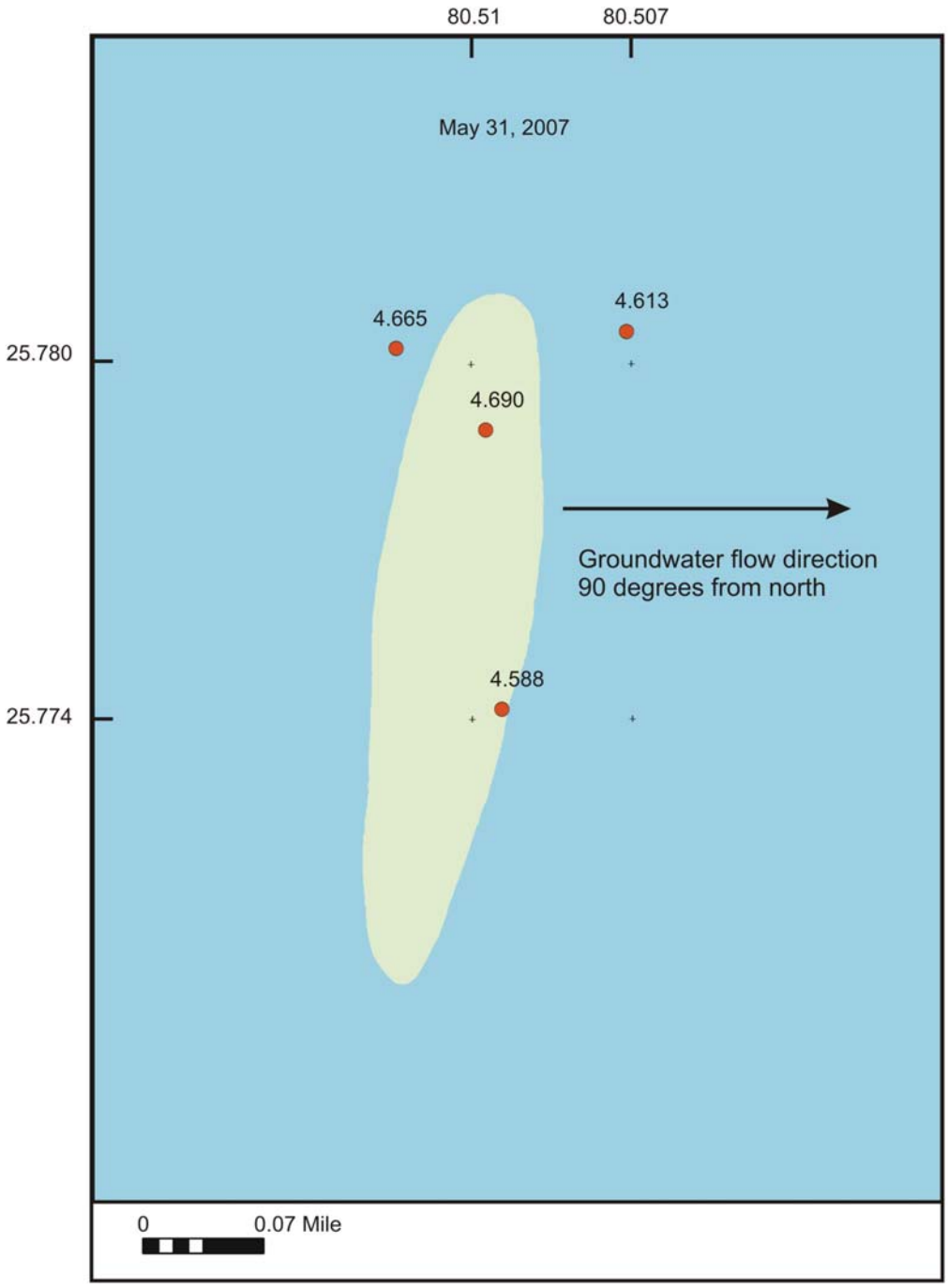

Figure 23 Water levels (ft above NGVD29) in deep wells at 3BS1 on May 31, 2007 (annual minimum).

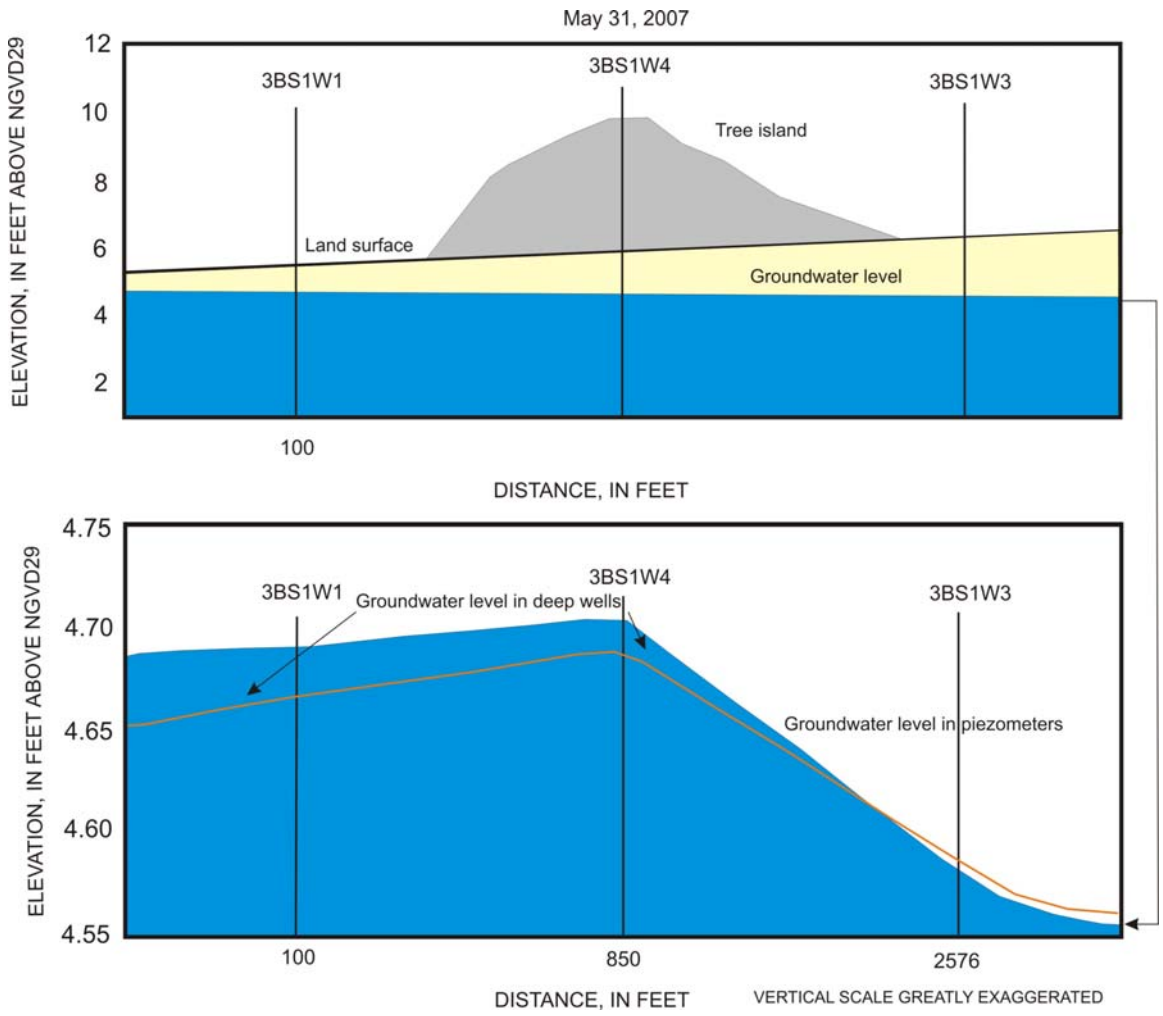

Figure 24 Cross section showing water levels in piezometers and deep wells at 3BS1 on May 31, 2007 (annual minimum).