CDM

ORANGE COUNTY GOVERNMENT FLORIDA

Orange County, Florida

Big Sand Lake Outfall Conceptual Improvements

January 2004

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Report

Evaluation of Big Sand Lake Outfall Conceptual Improvements (Contract Y1-902B)

January 2004

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Executive Summary

Background

On July 18, 2003, Orange County Stormwater Management Division (County) contracted with Camp Dresser & McKee Inc. (CDM) to prepare a feasibility study for alternative long-term flood control improvements associated with the Big Sand Lake outfall, which is part of the Shingle Creek Basin shown in **Figure ES-1**. The project study area encompasses approximately 5,400 acres (8.4 square miles) and includes Big Sand Lake, Little Sand Lake, Spring Lake, Lake Serene, Boo Boo Lake, Lake Crowell, and Lake Willis. In general, stormwater water in the chain-of-lakes moves in a southeasterly direction towards Big Sand Lake. Big Sand Lake acts as a closed basin until the water level reaches an elevation of 96.3 at the I-4 culvert, where it can then flow eastward through the Valencia Water Control District (VWCD) C-1 Canal to Shingle Creek.

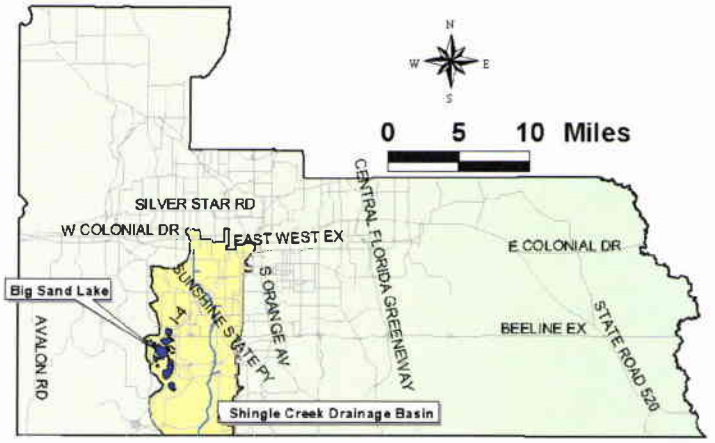


Figure ES-1
Shingle Creek Basin

Historically, lake levels in Big Sand Lake have fluctuated over a wide range. Between 1960 and 1980, water levels in Big Sand Lake have decreased from approximately elevation 100 ft-NGVD to as low as 80 ft-NGVD (20 feet). Between 1980 and 1997 the water level in Big Sand Lake gradually increased between elevation 80 ft-NGVD and elevation 95 ft-NGVD (15 feet). During the period between 1997 and 2000 water levels in Big Sand Lake generally decreased from elevation 95 ft-NGVD to elevation 87 ft-NGVD (18 feet). However, between 2000 and 2003 the lake levels in Big Sand Lake increased by approximately 10 feet (elevation 87 ft-NGVD to elevation 97 ft-NGVD). These changes in elevation trends can be directly correlated to the historical rainfall data.

Shortly after the initiation of this study, a new event occurred that further heightened concerns within the study area. During the weekend of August 9, 2003, the retaining wall constructed for the Vizcaya condominium development located between Little Sand Lake and Big Sand Lake failed (see **Figure ES-2**). Just prior to the failure (August 4, 2003), the County recorded water elevations for Big Sand Lake and Little Sand Lake of 95.2 ft-NGVD and 100.9 ft-NGVD, respectively. Following the failure, the lake stages of the two lakes equalized approximately at elevation 97.2 ft-NGVD (August 22, 2003 stage record).

Figure ES-2
New Event: Retaining Wall Breach

As a result of the wall failure, the County worked with the Florida Department of Transportation (FDOT) with support from the Big Sand Lake Advisory Board (BSLAB) to remove the accumulated sediment in the Big Sand lake outfall canal and pipe network that receives excess stormwater from Interstate 4 (I-4) and Big Sand Lake. Second, the County and the BSLAB undertook a joint effort to obtain an emergency pumping order from the South Florida Water Management District (SFWMD). The emergency pumping order allowed the County to pump water from Big Sand Lake to the I-4 discharge canal/pipe network under the control of the Valencia Water Control District (VWCD). The permit allowed the use of two, 6-inch diameter pumps and two, 12-inch diameter pumps to be active until November 19, 2003 (end of 90 day period). In concert with these efforts, the County and the BSLAB shared information with CDM with respect to existing lake data and study expectations. This collaborative effort was the foundation of this study.

Stormwater Modeling

CDM recommended to the County that the RUNOFF (hydrology) and EXTRAN (hydraulics) blocks of the *EPA* Stormwater Management Model (SWMM) be used for this project. This model is a public domain (free of charge) and provides the sophisticated hydraulic modeling required to represent the interconnections and outfall from this system. SWMM has been verified for stormwater design and master plan uses throughout Florida and is accepted by the Florida regulatory community. CDM compiled the following types of data for use in this report:

- Topographic Data;
- Rainfall Data;
- Evapotranspiration Data;
- Soil and Land Use Data;
- Stormwater Structure Survey Data;
- Dock Elevation Data;
- Drainage Well Data;
- Historical Lake Elevation Data;
- Groundwater Data; and,
- Lake Water Quality Data.

Data sources included the County, FDOT, SFWMD, the VWCD, the USGS, and the BSLAB. A detailed description of these data types and their use in this study is presented in Section 2 of this report.

Model Calibration

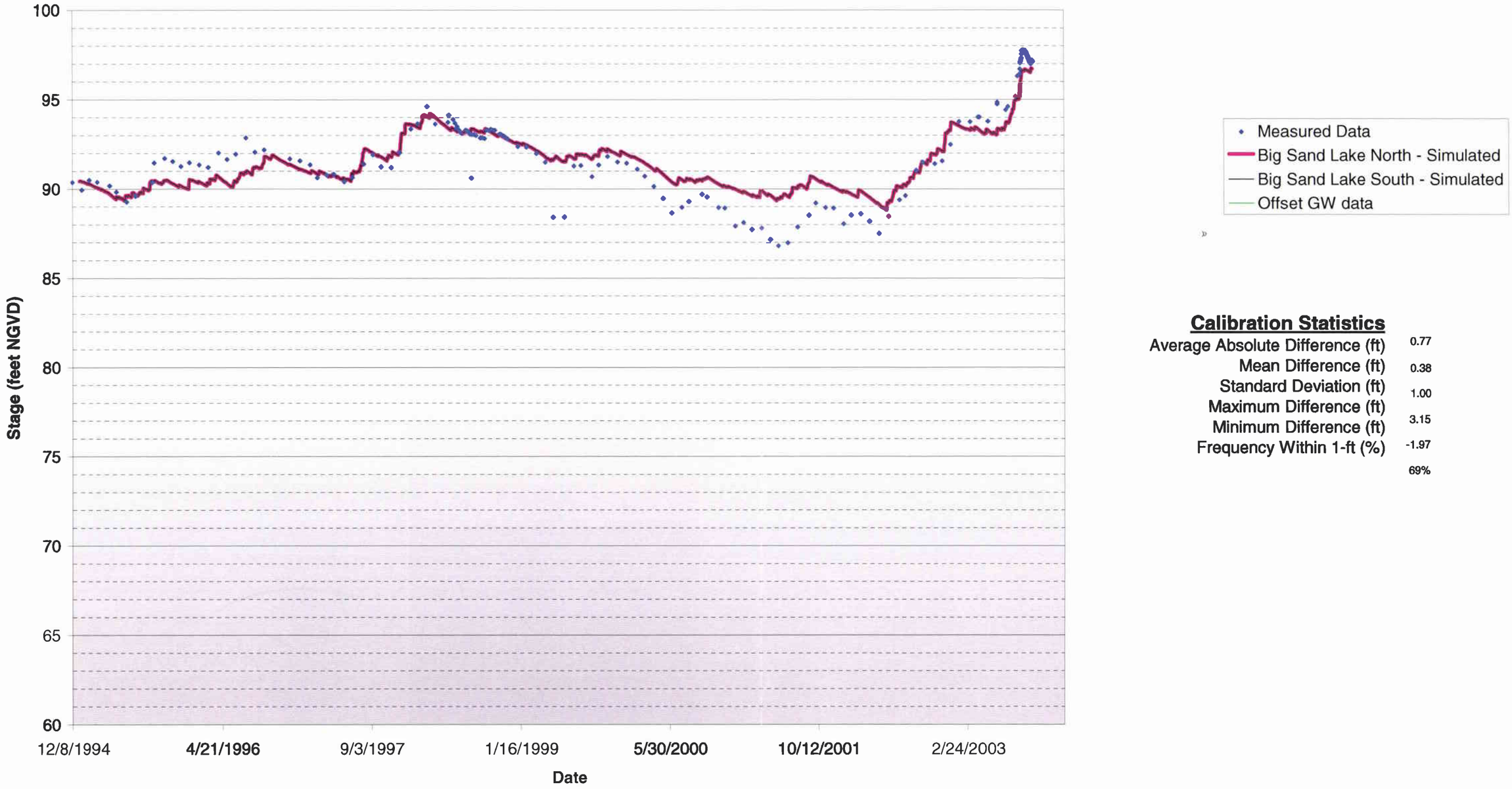
Model calibration refers to the adjustment of model parameters within reasonable limits so that the simulated response approximates measured data taken in the field during a real rainfall event. This exercise serves as a reality check on model results, and helps to establish model reliability and credibility. During the development of the hydrologic and hydraulic models, either measured or standard literature values were used for modeling parameters. During calibration, parameter values were fine-tuned within acceptable limits until the model output reflected the observed lake stage elevations.

CDM used the data described in Section 2 to develop a set of physically-based parameters used in SWMM to estimate stormwater runoff and corresponding lakes stages. Using the SWMM model, CDM simulated hourly rainfall data between January 1995 and August 2003 (pre-breach). A comparison of the resulting predicted lake stages for Big Sand Lake is presented in **Figure ES-3**. Similar plots for Little Sand Lake, Spring Lake, and Lake Willis are presented in Section 3 of this report. As indicated on these figures, the predicted lake levels match reasonably well with the observed water levels in the chain-of-lakes.

Alternatives Analysis

Using the calibrated SWMM model representation of the Big Sand Lake Study Area, CDM evaluated four lake level management strategies. The results of these evaluations are presented in the following paragraphs.

Figure ES-3
Calibration of Big Sand Lake (Pre-Breach)



Calibration Statistics

Average Absolute Difference (ft)	0.77
Mean Difference (ft)	0.38
Standard Deviation (ft)	1.00
Maximum Difference (ft)	3.15
Minimum Difference (ft)	-1.97
Frequency Within 1-ft (%)	69%

Alternative 1 - Improved Lake Interconnections

Alternative 1A

Alternative 1A evaluated the benefit of constructing 2440 feet of 24-in RCP from Big Sand Lake to an existing manhole located just east of I-4 (See **Figure ES-4**). The capacity of this proposed outfall system (control elevation 94.0 ft-NGVD) would be limited because of existing infrastructure invert elevations. The resulting peak stages predicted by the stormwater model are presented in **Figure ES-5**. As can be seen from the Figure, the peak stage reduction between the existing condition and proposed condition (Alternative 1A), were negligible. Therefore, this alternative was eliminated from further consideration.

Alternative 1B

Alternative 1B consisted of construction approximately 4540 feet of 24-in RCP from Big Sand Lake to the VWCD C-1 Canal headwaters located on the upstream end of the Central Florida Parkway. This configuration provides an opportunity to control Big Sand Lake at an elevation of 92 ft-NGVD, by avoiding the existing infrastructure surrounding I-4. As can be seen on Figure ES-5, predicted lake stages are reduced up to 1.5 feet below conditions predicted over the same period of time without any improvements. However, implementation of this improvement would be difficult because of potential conflicts with existing infrastructure and easement needs along this highly developed corridor.

Permit Considerations:

VWCD

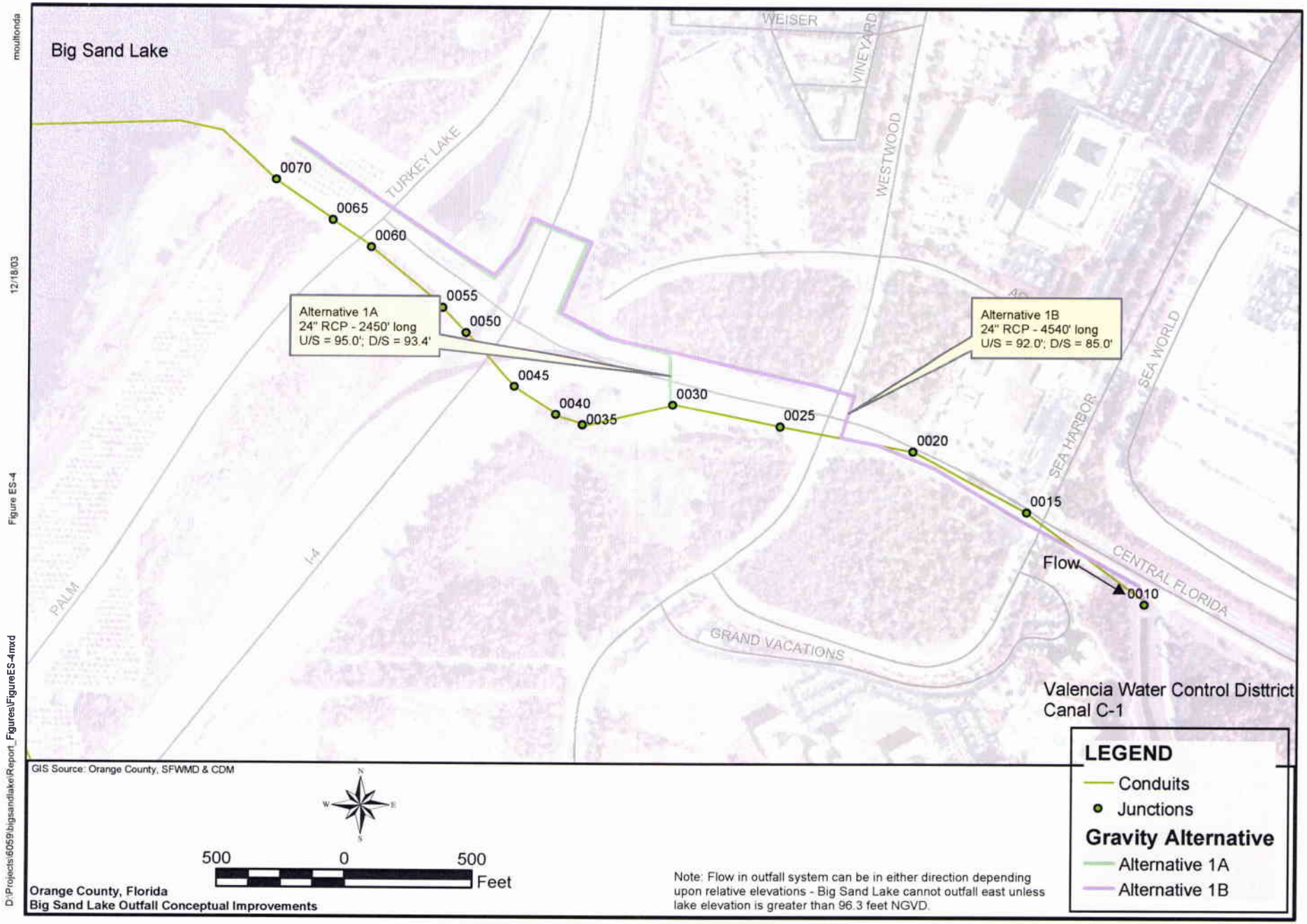
The VWCD C-1 Canal would be the receiving water body for the new outfall system permitted under this alternative. Review with VWCD staff indicated that the C-1 Canal has approximately 100 cfs of additional capacity, which could be allocated to Big Sand Lake. However, before additional flows were accepted, the "proposer" of the improvements would have to develop a bank stabilization plan for the canal segments downstream of VWCD Structures S-101 and S-102 (amil gates).

FDOT

CDM contacted FDOT regarding the permitting requirements associated with this alternative. FDOT stated that this improvement would require a Utility Permit. Typically, FDOT discourages construction of utilities under I-4. However, because of the historical concerns regarding high water levels in Big Sand Lake, it is likely they would support this type of improvement. The Utility Permit would require information on the bore path, water table, and existing utilities. The improvements cannot interfere with existing FDOT stormwater systems.

SFWMD

Under Chapter 373, FDEP and the SFWMD have joint authority to control the discharge of stormwater. This alternative would require an environmental resource permit (ERP) from the SFWMD. Initial reaction to this alternative is that it would be difficult to design a gravity-based system as described because of the potential utility conflicts. Also, there are concerns with downstream flooding in Shingle Creek, which



CDM

Figure ES-4
Central Florida Parkway Drainage Configuration

Figure ES-5
Alternative 1 Gravity Outfall Improvement

would lead to a controlled operating schedule to when excess stormwater from Big Sand Lake could be discharged to Shingle Creek.

Alternative 2 – Aquifer Recharge

In the 1960s, the Florida State Board of Health stopped granting permits for the construction of new drainage / recharge wells; however, replacement of existing recharge wells was allowed. In the 1970s, the state stopped granting permits for any recharge well projects as a result of concerns with aquifer contamination. Recently, the importance of recharge wells to aquifer recharge has come to the forefront as a result of predicted water shortages in central Florida. For this reason, it may be feasible to return the 1970's philosophy where existing recharge wells can be replaced because of the aquifer recharge benefit. This can be further supported because of the good water quality in Big Sand Lake.

Through this literature research, it was discovered that two recharge wells once existed within the Big Sand Lake basin at the locations shown on **Figure ES-6**. The 12-inch diameter recharge well located on Lake Serene (SFWMD Id. No. 1494053494574) was used for stormwater management associated with the former Minute Maid Company site. The 10-inch diameter well located on Big Sand Lake was constructed in 1930 for flood control. Based upon these records, it was determined that a development of an aquifer recharge plan using the existing recharge wells as a foundation is feasible and would provide for lake level management.

Using the SWMM model, CDM simulated the lake level benefit of rehabilitating an aquifer recharge well on Big Sand Lake. These results are presented graphically on **Figure ES-7.** Based upon these results, it can be concluded that the rehabilitation of the well on Big Sand Lake would provide improved lake level management and would provide for aquifer recharge.

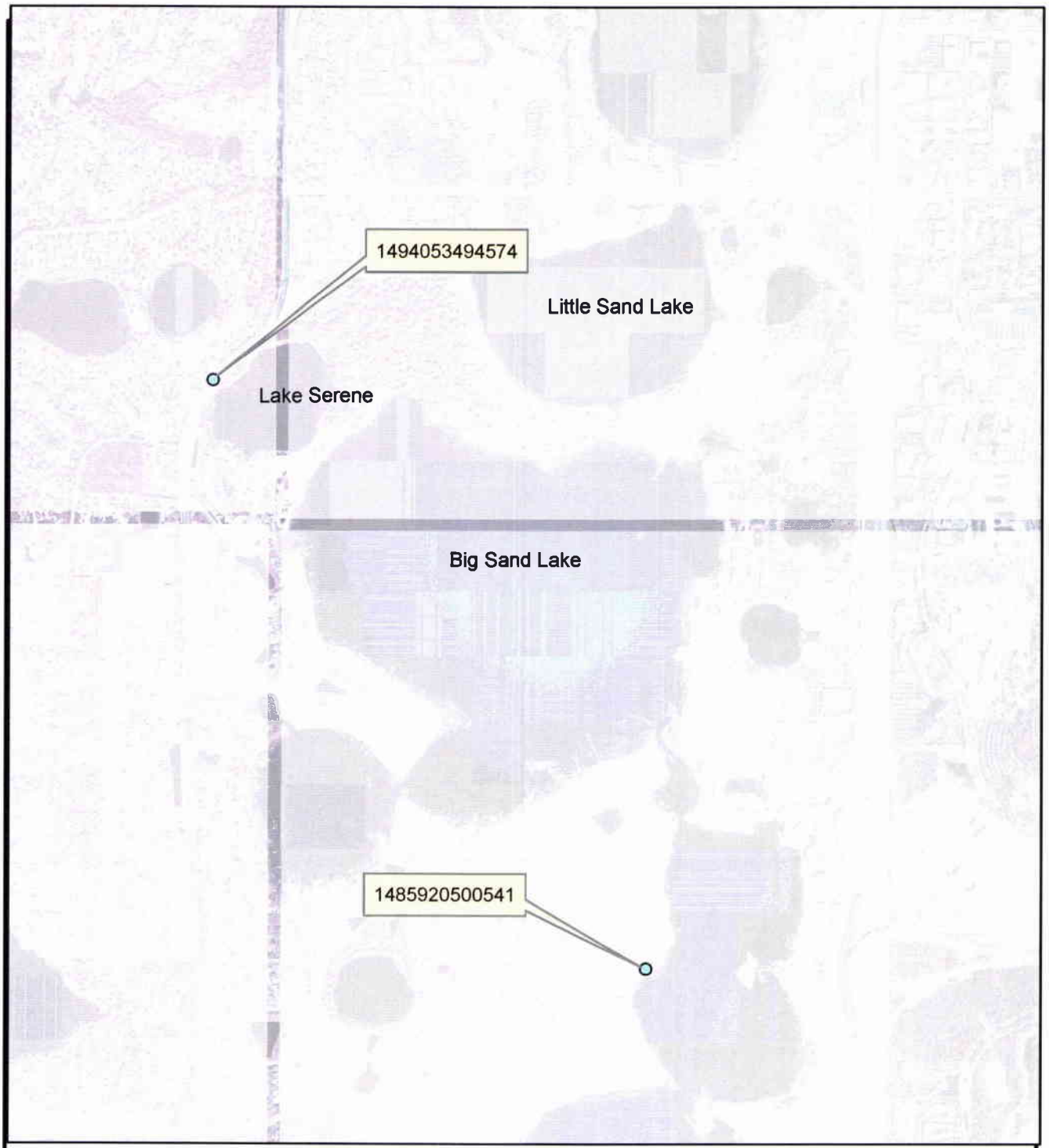
Permit Considerations

FDEP

For this alternative, the existing recharge well on Big Sand Lake would be reconstructed to the same specifications as the existing recharge wells under the FDEP Underground Injection Control (UIC) Program [Chapter 62-528, F.A.C.). If the existing recharge well can be located, then it would be abandoned and replaced with a new well with exactly the same construction as the existing well. If the existing recharge well cannot be located an UIC Permit would be required for the new well. Also, the discharged lake water would have to meet State of Florida Drinking Water Standards (Chapter 62-550, F.A.C.) including the microbiological requirements.

Alternative 3 – Stormwater Pump Station

For Alternative 3, CDM evaluated the benefit of adding a stormwater pump station to the Big Sand Lake study area for lake level management purposes. For this alternative, CDM evaluated two pumping scenarios with and without the August 9, 2003 retaining wall breach. The two scenarios are as follows:



GIS Source: Orange County, SFWMD & CDM

2,000 0 2,000 Feet

LEGEND
Basin Boundary
Drainage Wells

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

Note: ID numbers on figure are SFWMD Drainage Well IDs as referenced on Drain Well Inventory excerpt in Appendix B

CDM

Figure ES-6
Drainage Well Location Map

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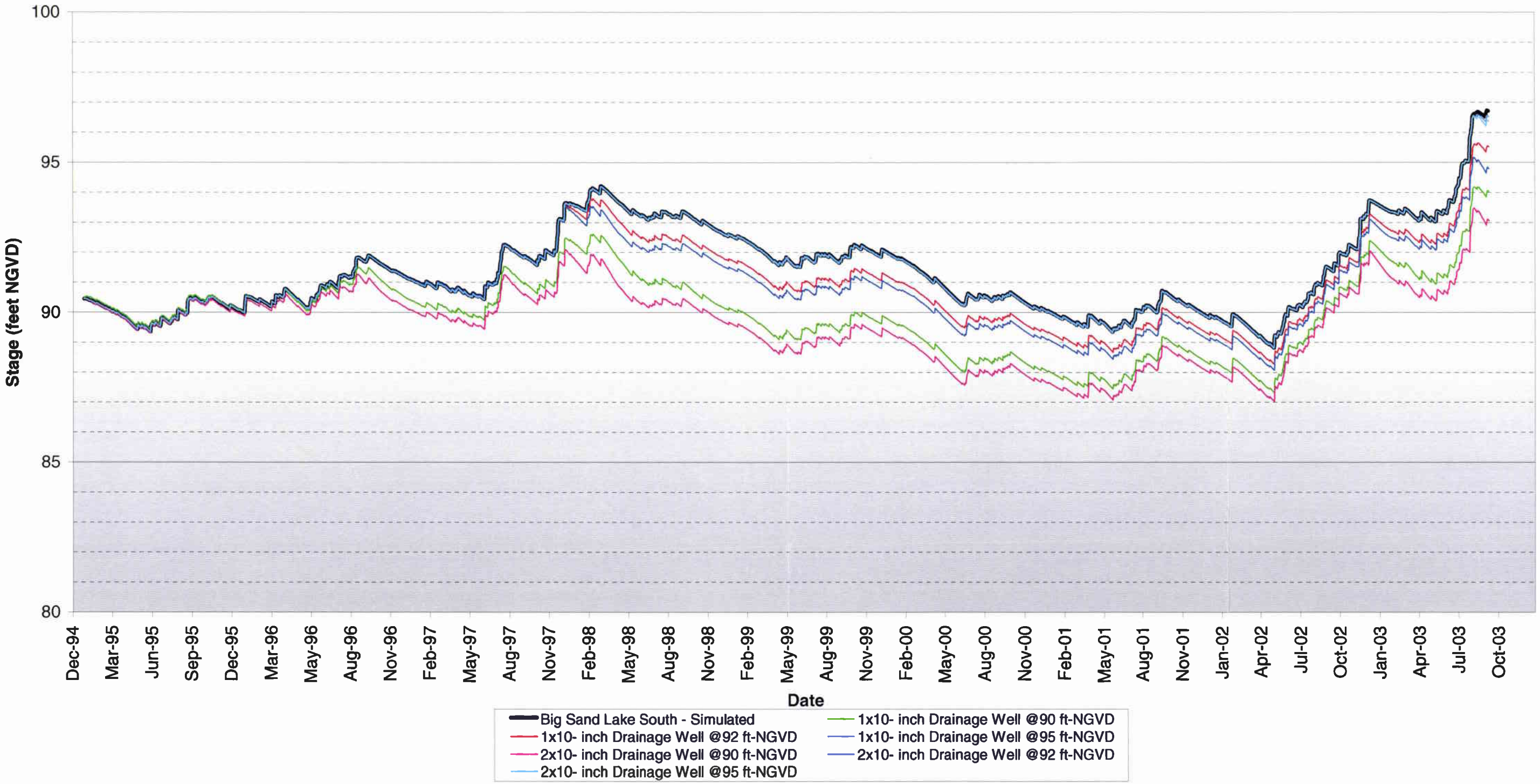
Figure ES-7
Alternative 2 Drainage Well (No Breach)



- Three pump system (20 cfs each pump), with start elevations of 93 ft-NGVD (pump 1), 95-ft-NGVD (pump 2), and 97 ft-NGVD (pump 3). The pumps shut-off when Big Sand Lake water levels recede to elevation 90 ft-NGVD; and

- Three pump system (10 cfs each pump), with start elevations of 93 ft-NGVD (pump 1), 95-ft-NGVD (pump 2), and 97 ft-NGVD (pump 3). The pumps shut-off when Big Sand Lake water levels recede to elevation 90 ft-NGVD.

Each scenario was simulated for the period of record between 1995 and October 2003 to evaluate the net effect on predicted water levels in Big Sand Lake. These results are presented graphically on **Figure ES-8**. These results indicate that pump-based system would provide lake level management control.

Permit Considerations

VWCD

The VWCD C-1 Canal would be the receiving water body for the new pump station outfall system permitted under this alternative. VWCD staff have indicated the C-1 Canal has sufficient capacity to receive the additional flow from Big Sand Lake, however, a bank stabilization plan would be required.

FDOT

FDOT would require a Utility Permit for this improvement.

SFWMD

This alternative would require an ERP from the SFWMD. Discussions with SFWMD staff have indicated that this type of improvement would most likely require a pump operation schedule that is dependent upon downstream water levels. One possible scenario would be the allowance of the draw down of Big Sand Lake and Little Sand Lake to an elevation of 93.0 ft-NGVD at the end of the dry season (if needed). This would provide storage in the lakes for stormwater runoff during the wet season. However, pumping of water from the Big Sand Lake during the wet season would require an emergency pumping permit from the SFWMD, which would require proof that there is eminent home flooding risk.

Alternative 4 – Stormwater Reuse

Public access reuse (PAR) requires treatment, filtration and disinfection. CDM has considered 2 reuse alternatives to provide improved lake level control as described in the following paragraphs.

Alternative 4A

Alternative 4a would integrate the existing reuse lines in the general area of Big Sand Lake into a lake level management strategy. The regulations (F.A.C. 62-610.472(3)(a)) require that the introduced flow be disinfected and treated for fecal coliform and total suspended solids (TSS) prior to being used for reuse. Continuous monitoring of introduced flow's disinfectant residual before mixing with existing reuse as well periodic monitoring of fecal coliforms and TSS is also required. Therefore, a treatment plant would be required for this alternative. According to County staff,

Figure ES-8
Alternative 3 Pump Station (No Breach)

there may be sufficient capacity in the reuse main along Sand Lake Road to allow introduction of additional flow. However, it will be necessary to specifically quantify the volume required to be introduced and obtain agreement with Orange County Utilities that this volume can be assimilated. If one considers the recent history of Big Sand Lake, the lake level problem occurred during the late summer of 2003. This was a period of above normal rainfall. As PAR is used largely for irrigation, it is unlikely that there would be a need for reuse water during such a period.

Alternative 4B

Alternative 4B would introduce the excess stormwater into the wastewater collection system for supplemental reuse. Current regulations only allow the introduction of supplemental reuse during dry weather conditions. This excess stormwater could then be treated by the existing wastewater treatment facility and then distributed through the existing effluent system. The benefit of this option is that a separate treatment plant is not needed. For this alternative, the County would need to verify that there is sufficient capacity in the wastewater collection system. This alternative would also provide limited benefit because the water could not be collected during the wet season, which is when the excess stormwater would be available.

Permit Considerations

For this alternative, it would be necessary to modify the existing operating permit for the Orange County Reuse system. It would be necessary to meet the stated water quality standards as well as the standards for monitoring. It is likely that this would be considered a minor modification.

Estimated Capital Cost

Preliminary capital cost estimates have been prepared for each alternative. The estimated cost of construction includes the probable cost of construction of the work by contractors, the costs of conventional engineering services during design, construction and start-up, and a 30-percent contingency as presented in **Table ES-1**.

Table ES-1
Summary of Estimated Capital Costs

Alternative	Estimate	Cost ($)
1	Improved Lake Interconnections	$1.9 million
2A	Aquifer Recharge Well without Treatment	$0.2 million
2B	Aquifer Recharge Well with Treatment	$2.0 million
3	Stormwater Pump Station	$2.4 million
4	Stormwater Reuse	$4.7 million

Recommendations

Five factors were considered in the formulation of the recommendations as a result of this study. These factors are described below:

Technical Feasibility and Reliability

The gravity based improvement (Alternative 1), the aquifer recharge well improvement (Alternative 2), and the pump station improvement (Alternative 3) are all feasible and reliable from a technical standpoint. The preliminary modeling efforts show that these three alternatives provide a higher level of control of water elevations in the chain of lakes. A reuse-based system (Alternative 4) would not provide adequate lake level management control as described in Section 3.

System Maintainability

The gravity based system (Alternative 1) and the aquifer recharge well system (Alternative 2) would require a lower level of maintenance responsibility than a pump based system (Alternative 3 and Alternative 4). Currently County drainage wells are inspected on a 2-week cycle and are inspected daily during heavy rainfall periods to verify they are operating as designed and not clogged by debris. Identified structural problems are then further evaluated and corrective measures are taken as needed. Pump stations are maintained once every two weeks to ensure they are fully operational. Maintenance activities include debris removal, fence inspection and repair, embankment inspection and repair, mechanical equipment lubrication, and running and inspecting motors and backup generators. Inspection of pump stations requires more time than does a drainage well or gravity based system. In addition to these considerations, it is important for the County and the BSLAB to encourage FDOT system maintenance along the I-4 system that conveys overflow from Big Sand Lake.

Sociopolitical Acceptability

Based upon input from the BSLAB, either alternative should be pursued by the County and a "do nothing" alternative is not acceptable. It should be noted, however, that a few residents did comment that lake level management controls should not be implemented because the observed lake level fluctuations have always occurred. Another issued that will need to be addressed by the OCBOCC is that the current County level-of-service policy for flooding is to protect finished floors of homes and businesses from flooding during a 100-year storm event. To date, no finished floors have been flooded and existing floor elevations are above the current 100-year BFE established by FEMA. Constructing improvements to protect investments other than finished floor elevations will require a change in policy by the OCBOCC because of the precedence set for other closed basins within the County in terms of level-of-service for flood protection.

Economics

The cost of the pump station and gravity-based alternatives (Alternative 1 and Alternative 3) would be approximately $1.9 million and $2.4 million, respectively as compared to the $200,000 cost of re-habilitating the existing drainage well for aquifer

recharge purposes (potentially $2.0 million if original well cannot be found) . Additionally, it is expected that the cost of acquiring drainage easements for 5,000 feet of pipe (Alternative 1) and costs of addressing the high potential of utility conflicts could significantly increase the estimated cost of Alternative 1.

Environment and Permitting

For Alternative 1 (gravity-based system) additional analysis would be needed to determine whether downstream flooding or erosion would result from additional flows. For Alternative 2 (aquifer recharge well), FDEP has fairly stringent regulations concerning the quality of water introduced into any "underground source of drinking water" (USDW). Basically, introduced water must be treated to drinking water standards. Due to the cost of water treatment, this regulation essentially stops new drainage wells from being constructed. However, existing drainage wells are "grandfathered in" and were allowed to continue to operate. It is also possible to retrofit and provide maintenance to existing drainage wells, which may have benefit to this project (Alternative 2). Therefore, if the drainage well can be located in the field, there is a high probability that the well can be rehabilitated and used for aquifer recharge. If the well cannot be located, then there is a higher likelihood that treatment would be required. For the pump station alternative (Alternative 3), an operation plan would need to be developed so that pumping of excess stormwater from the chain of lakes would not cause downstream flooding or erosion. This type of assessment would be required to permit a pump station based lake level management system. For alternative 4 (reuse), disinfection would be required.

Final Recommendation

Based on findings of this study and the items noted above, CDM recommends Alternative 2 because it promotes aquifer recharge while improving lake level management. Because this alternative's primary objective is not flood protection (ancillary benefit) but for aquifer recharge, it is likely that a policy change would not be required. The recharge well could be incorporated into the 40 acre park located along the southwest shores of Big Sand Lake.

that if the OCBOCC approves a policy change for flood protection, that the aquifer recharge well alternative be given first priority because of its feasibility and cost (Alternative 2). Also, maintaining a hydraulic connection between Big Sand Lake and Little Sand Lake (would require easement acquisition) with the recommended improvement alternative would allow for greater flexibility in lake level management and may warrant further consideration. Model results indicate that differences in the predicted water level for Big Sand Lake with and without the breach condition are minimal with the proposed aquifer recharge well improvement. Thus, the hydraulic connection between the lakes could remain as it is today (natural) or be a weir type structure (navigable or non-navigable) an incorporated into the lake level management plan. Lower water levels in Little Sand Lake would allow greater flexibility in managing water levels in the upstream lakes as needed without creating downstream flooding concerns. However, this interconnection is not a critical element of managing water levels in Big Sand Lake.

Section 1
Introduction

1.1 Background

On July 18, 2003, Orange County Stormwater Management Division (County) contracted with Camp Dresser & McKee Inc. (CDM) to prepare a feasibility study for alternative long-term flood control improvements associated with the Big Sand Lake outfall, which is part of the Shingle Creek Basin shown in **Figure 1-1**. The project study area encompasses approximately 5,400 acres (8.4 square miles) and includes Big Sand Lake, Little Sand Lake, Spring Lake, Lake Serene, Boo Boo Lake, Lake Crowell, and Lake Willis as shown in **Figure 1-2**. For the purposes of this report, these lakes will be referred as chain of lakes, though several of the lakes are not directly connected to one another.

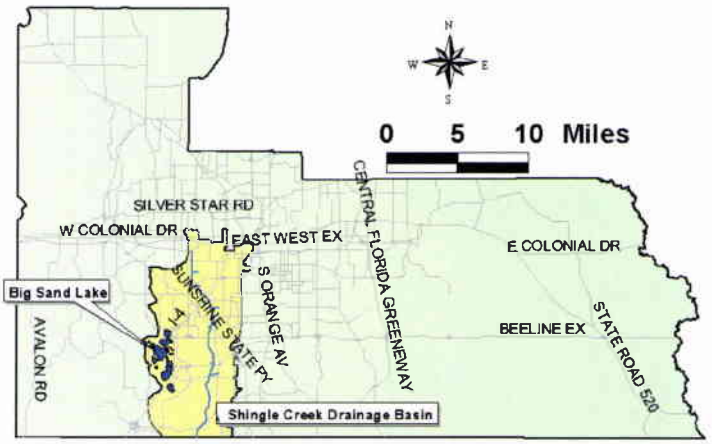


Figure 1-1
Shingle Creek Basin

Historically, lake levels in Big Sand Lake have fluctuated over a wide range. Between 1960 and 1980, water levels in Big Sand Lake have decreased from approximately elevation 100 ft-NGVD to as low as 80 ft-NGVD (20 feet). This corresponds to a period where rainfall volumes were relatively lower than normal. Between 1980 and 1997 the water level in Big Sand Lake gradually increased between elevation 80 ft-NGVD and elevation 95 ft-NGVD (15 feet). During the period between 1997 and 2000 water levels in Big Sand Lake generally decreased from elevation 95 ft-NGVD to elevation 87 ft-NGVD (18 feet). However, between 2000 and 2003 the lake levels in Big Sand Lake increased by approximately 10 feet (elevation 87 ft-NGVD to elevation 97 ft-NGVD). These changes in elevation trends can be directly correlated to the historical rainfall data, which is discussed later in this report. **Figure 1-3** shows the historical water levels recorded in Big Sand Lake for the period between 1960 and 2003. It is noted that a 50-year drought took place in the year 1981. It can be seen that Big Sand Lake had excessively low lake levels at this time. Similar changes have been recorded for Little Sand Lake, which is also discussed later in this report.

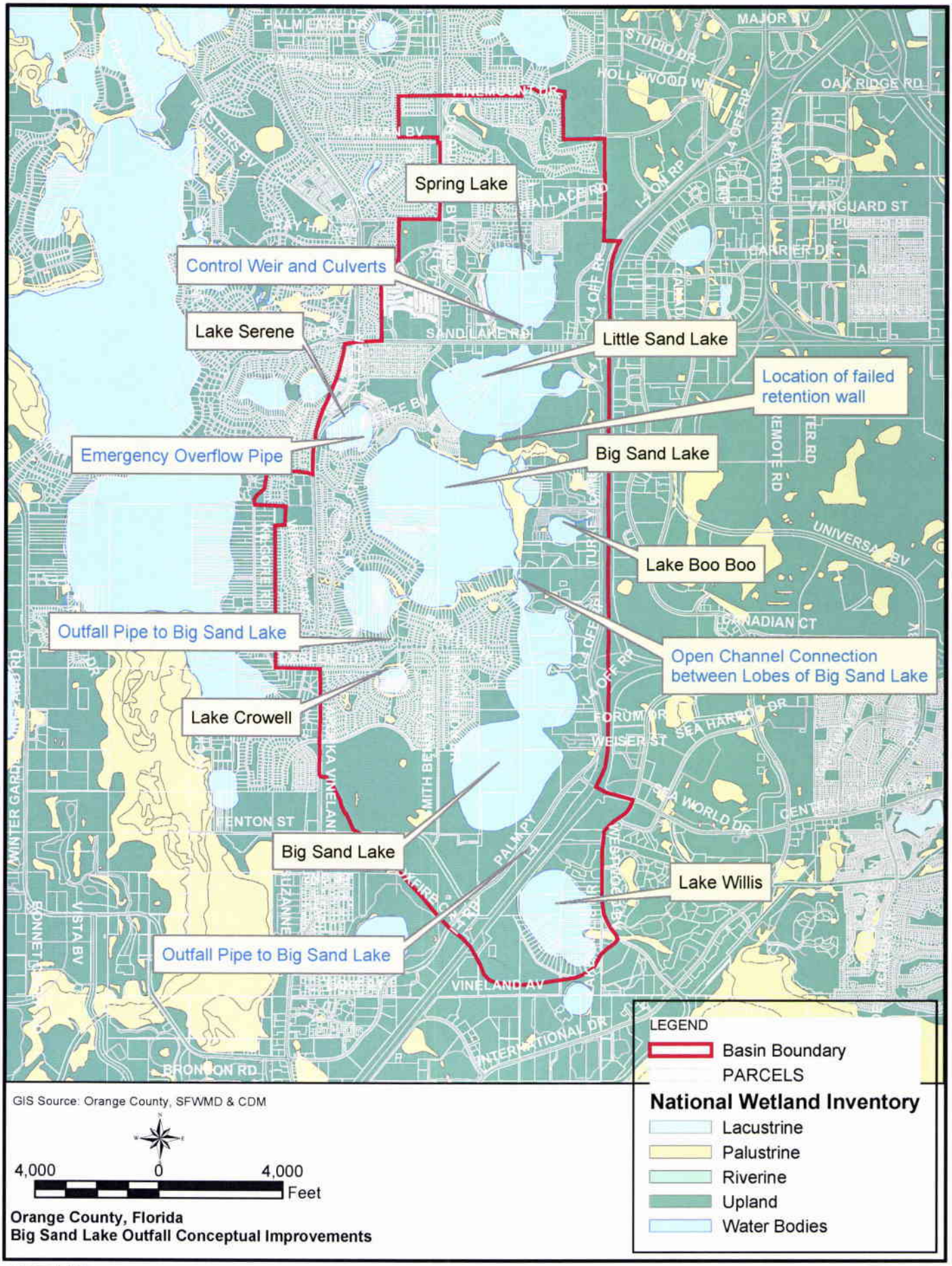


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Figure 1-2

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Figure 1-2
Project Area

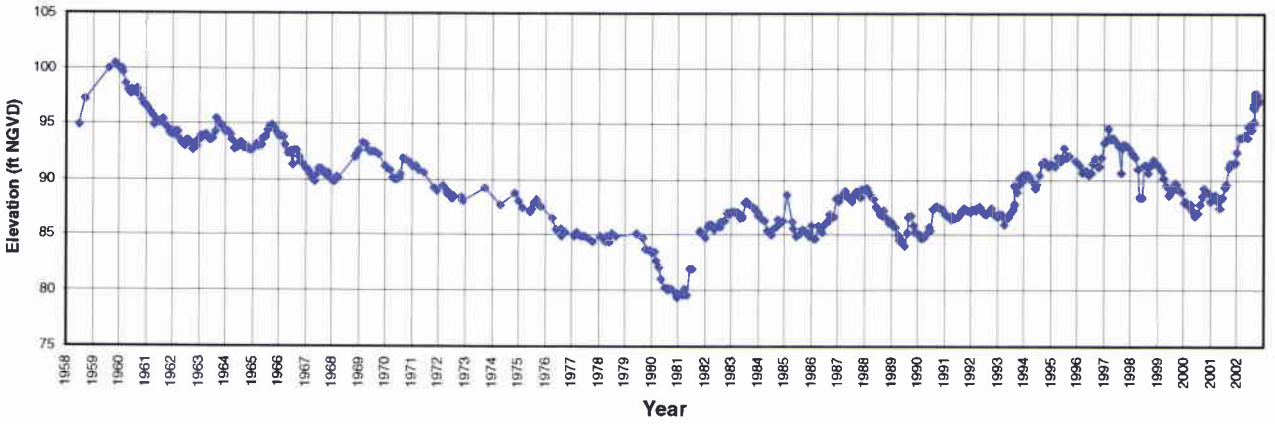


Figure 1-3
Historical Big Sand Lake Water Levels (1960 – 2003)

As a result of the elevated lake levels in Big Sand Lake over the past three years, the County began receiving an increased number of phone calls from residents around the chain of lakes concerning the potential for flooding if lake levels continue to rise. This concern was heightened during the months of August, September, and October 2003, which is the period when lake levels were above elevation 95 ft-NGVD and the area was experiencing above normal rainfall volumes. As a result of these heightened concerns, the County initiated this study with full support of the Orange County Board of County Commissioners (OCBOCC).

Shortly after the initiation of this study, a new event occurred that further heightened concerns within the study area. During the weekend of August 9, 2003, the retaining wall constructed for the Vizcaya condominium development located between Little Sand Lake and Big Sand Lake failed (see **Figure 1-4**). Just prior to the failure (August 4, 2003), the County recorded water elevations for Big Sand Lake and Little Sand Lake of 95.2 ft-NGVD and 100.9 ft-NGVD, respectively. Following the failure, the lake stages of the two lakes equalized approximately at elevation 97.2 ft-NGVD (August 22, 2003 stage record). This failure was also considered during the development of alternative improvements.

Figure 1-4
Retaining Wall Failure

As a result of the wall failure, actions were taken by the County with support from the Big Sand Lake Advisory Board (BSLAB). First the OCBOCC worked with the Florida Department of Transportation (FDOT) to remove the accumulated sediment in the Big Sand lake outfall canal and pipe network that receives excess stormwater from Interstate 4 (I-4) and Big Sand Lake. Second, the County and the BSLAB undertook a joint effort to obtain an emergency pumping order from the South Florida Water Management District (SFWMD). The emergency pumping order allowed the County to pump water from Big Sand Lake to the I-4 discharge canal/pipe network under the control of the Valencia Water Control District (VWCD). The permit allowed the use of two, 6-inch diameter pumps and two, 12-inch diameter pumps to be active until November 19, 2003 (end of 90 day period). In concert with these efforts, the County and the BSLAB shared information with CDM with respect to existing lake data and study expectations. This collaborative effort was the foundation of this study.

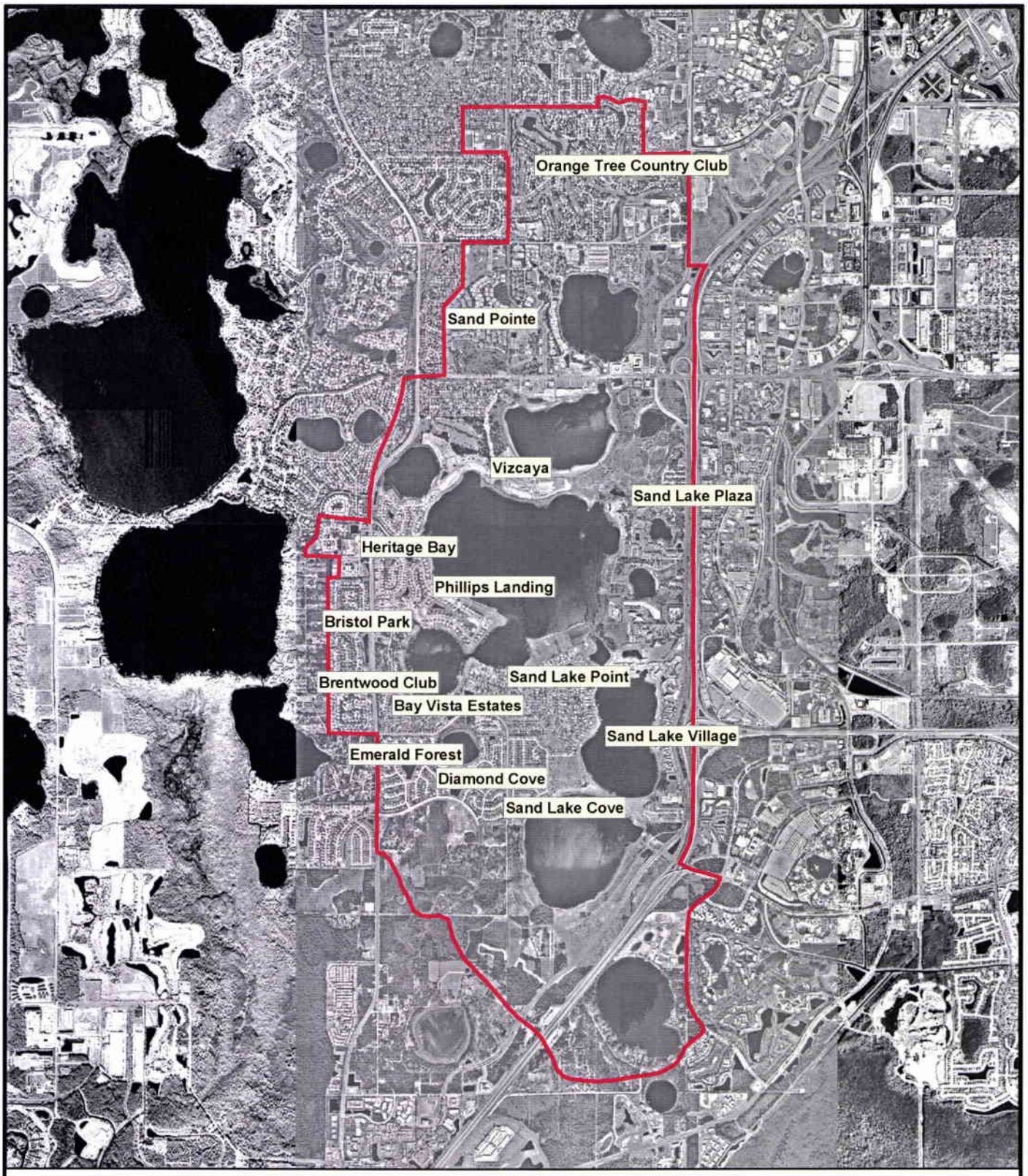
1.2 Physical Description

As previously discussed, the Big Sand Lake study area has tributary area of approximately 5,400 acres located in unincorporated Orange County. The dominant land use in the basin is medium-density residential development that was primarily constructed in the 1990s. **Figure 1-5** shows the named major subdivision names within the project study area. There are also commercial areas along Sand Lake Road that are generally located between Spring Lake and Little Sand Lake. There are also higher density land uses (e.g., hotels) located along Turkey Lake Road in the eastern portion of the study area. There also remains some agricultural/undeveloped land uses along the southwestern edge of Big Sand Lake.

In general, stormwater runoff sheet flows to each one of the lakes that comprise the chain of lakes. Water in the chain-of-lakes generally moves in a southeasterly direction towards Big Sand Lake. Big Sand Lake acts as a closed basin until the water level reaches an elevation of 96.3 at the I-4 culvert, where it can then flow eastward through the VWCD C-1 Canal to Shingle Creek. Below is a summary of each named lake previously presented in Figure 1-2.

Spring Lake

Spring Lake is the northernmost lake in the chain-of-lakes and has a surface area of approximately 106 acres (at an elevation of 95-ft NGVD) and a tributary area of 830 acres. The water level in Spring Lake is controlled by a weir structure located on the upstream end of Sand Lake Road. The control elevation of the weir is 98 ft-NGVD. Once the flow overtops the weir structure, it is conveyed under Sand Lake Road through twin 36-inch corrugated metal pipes (CMP) into Little Sand Lake. The normal water level established for Spring Lake by the County is 98.7 ft-NGVD. The base flood elevation (BFE) determined by the Federal Emergency Management Agency (FEMA) is 102.1 ft-NGVD.



Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure 1-5
Project Area with Subdivision Names

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Little Sand Lake

Little Sand Lake is located in the middle portion of the study area and has a surface area of approximately 154 acres (at an elevation of 95-feet NGVD) and a tributary area of 480 acres. Prior to the construction of the Vizcaya condominium development, it appears that an agricultural access road separated Little Sand Lake from Big Sand Lake (based upon historical aerial photography), resulting in a closed or limited discharge system. As part of the Vizcaya development, a retaining wall was constructed to border the property between the two lakes with a top elevation of approximately 101 ft-NGVD. Following the breach of this wall on August 9, 2003, a survey was completed by Orange County showing that the control elevation (bottom of breach) between Little Sand Lake and Big Sand Lake is approximately 93 ft-NGVD. The normal water level established for Little Sand Lake by the County is 95.5 ft-NGVD. The BFE determined by the FEMA is 101.8 ft-NGVD.

Big Sand Lake

Big Sand Lake is essentially divided into two lobes, one at the north end of the lake and one at the south end. The northern lobe has a surface area of approximately 715 acres (at an elevation of 95-ft NGVD) and a tributary area of 830 acres. The southern lobe has a surface area of approximately 424 acres (at an elevation of 95-ft NGVD) and a tributary area of 1100 acres. As previously described, the entire system has a single outfall located at the southeastern portion of the southern lobe of Big Sand Lake. The system flows through a series of open channels and culverts of various sizes crossing I-4, eventually ending up in Canal C-1 in the VWCD. It should be noted that the hydraulic divide of the outfall is defined by the cross drain under the I-4 west bound on-ramp which has an invert of 96.3 ft-NGVD. During periods when the elevation of Big Sand Lake is below 96.3 ft-NGVD, flow will be in a westerly direction from the I-4 culvert towards Big Sand Lake. Once the lake elevation exceeds 96.3 ft-NGVD, flow will be in an easterly direction towards the VWCD C-1 Canal. **Figure 1-6** illustrates these conditions. The normal water level established for Big Sand is 90.0 ft-NGVD. The BFE determined by the FEMA is 101.4 ft-NGVD.

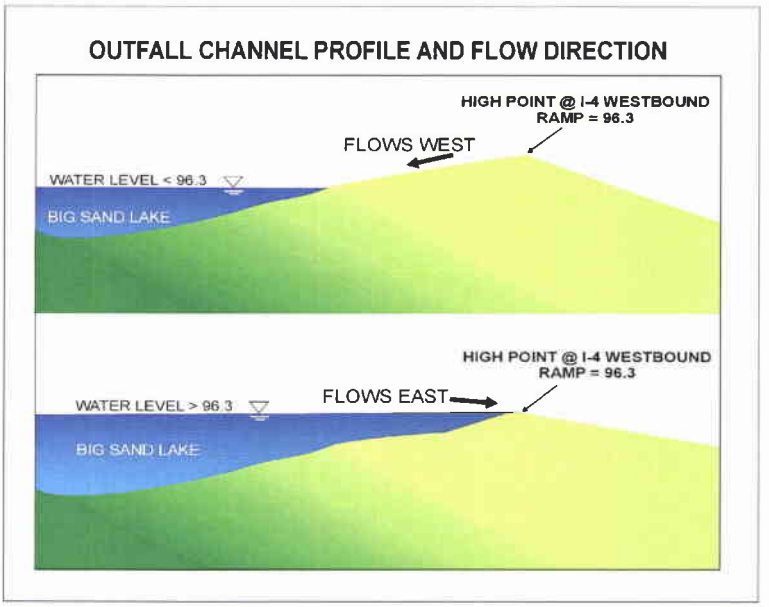

Figure 1-6
Big Sand Lake Outfall Flow Direction Illustration

Boo Boo Lake

Boo Boo Lake is a small lake located just east of the northern lobe of Big Sand Lake. The lake has a surface area of approximately 16 acres (at an elevation of 95-ft NGVD) and a tributary area of 80 acres. A review of both available development plans from Orange County and 2002 aerials indicates that Boo Boo Lake is land locked. Boo Boo Lake was modeled as a land-locked basin with an overland flow path to Big Sand Lake.

Lake Serene

Lake Serene is located on the northwest side of the northern lobe of Big Sand Lake. The lake has a surface area of approximately 45 acres (at an elevation of 95-ft NGVD) and a tributary area of 170 acres. There is an 18-inch diameter emergency drawdown pipe to Big Sand Lake that can be regulated for additional lake level control. The normal water level established for Lake Serene by the County is 94.25 ft-NGVD. The BFE established by the OCBOCC is 96.4 ft-NGVD.

Lake Crowell

Lake Crowell is located on the southwest side of the northern lobe of Big Sand Lake. The lake has a surface area of approximately 20 acres (at an elevation of 95-ft NGVD) and a tributary area of 180 acres. According to Orange County files, Lake Crowell outfalls to a detention pond north of Darlene Drive via a 15-inch RCP thence through the pond control structure to Big Sand Lake. The normal water level established for Lake Crowell is 100.5 ft-NGVD. The BFE determined by the FEMA is 103.5 ft-NGVD.

Lake Willis

Lake Willis is located in the southern portion of the study area and has a surface area of approximately 130 acres (at an elevation of 105-ft NGVD) and a tributary area of 210 acres. Lake Willis is connected to the southern lobe of Big Sand Lake through a series of culverts and ditches. Excess flow from Lake Willis is conveyed through a 30-inch diameter reinforced concrete pipe (RCP), under I-4, to a small ditch. Stormwater flows from the ditch into a junction box on the south side of Turkey Lake Road and then conveyed northward through a 38-inch by 60-inch elliptical RCP, which then ties into a 54-inch diameter RCP. The 54-inch RCP is the discharge pipe for a water quality pond constructed to provide water quality treatment for Turkey Lake Road extension. The 54-inch RCP flows into a spreader swale that discharges flows, from Lake Willis as well as from the pond, into Big Sand Lake. The normal water level established for Lake Willis by the County is 104.5 ft-NGVD. The BFE determined by the FEMA is 107.9 ft-NGVD.

1.3 Scope of Work

The scope of work for the Big Sand Lake Outfall Conceptual Improvement Study included five major tasks as summarized below.

- Task 1 – Data Review and Evaluation including the review of topographic data, land use data, soils data, existing engineering studies, and available development plans necessary to develop the hydrologic and hydraulic parameters characteristic of the basin. Additionally, it was necessary to define the problem as well as perform limited field reconnaissance.

- Task 2 – Water Quantity Modeling included the development and calibration of a stormwater model to historical rainfall and lake level records. The United States Environmental Protection Agency's Stormwater Management Model (SWMM) was chosen for this effort.

- Task 3 – Alternative Analysis to evaluate four potential alternatives for improved lake level management for the Big Sand Lake system. These alternatives included an improvement to outfall from Big Sand Lake to the VWCD C-1 Canal; re-construction of a historic drainwell located on Big Sand Lake to promote aquifer recharge; pumping of excess stormwater from the lake; and, augmentation of the existing reuse lines (alternative stormwater use).

- Task 4 – Report preparation.

Section 2
Data and Methodology

This section describes the data collection effort and methodology used to develop the Big Sand Lake Outfall Conceptual Improvement Study. The focus of the data collection effort was on the development of the hydrologic and hydraulic characteristics of the Big Sand Lake Basin. Once developed, the hydrologic and hydraulic characteristics of the study area were used to develop a conceptual stormwater model for use in evaluating alternative lake level management strategies for controlling flooding and protecting public interests.

2.1 Stormwater Modeling

Originally, CDM was planning to develop and calibrate a hydrologic model of the basin using the US Environmental Protection Agency's (EPA) Hydrological Simulation Program in Fortran (HSPF). Once calibrated, the model was to be used to simulate various surface water control alternatives. However, after reviewing the available data and the extent of the hydraulic interconnections, it was determined that the hydraulic interconnections between the lakes and the ultimate outfall to the VWCD were significantly more sophisticated than can be practicably modeled by HSPF. HSPF relies upon simplified rating curves developed by the user to represent hydraulic connections between water features such as lakes. For the Big Sand Lake system, there are several lake interconnections and an outfall system for which rating curves would need to be manually developed. Additional rating curves would be needed to represent potential lake level management strategies (flood control alternatives), which is the ultimate goal of the County and the public.

For these reasons, CDM recommended to the County that a more sophisticated stormwater modeling tool be used instead of the HSPF model to allow for a better evaluation of the lake interactions and proposed lake level management strategies. The model recommended by CDM was the RUNOFF (hydrology) and EXTRAN (hydraulics) blocks of the *EPA* Stormwater Management Model (SWMM). This model is also a public domain (free of charge) and provides the sophisticated hydraulic modeling required to represent the interconnections and outfall from this system. SWMM has been verified for stormwater design and master plan uses throughout Florida and is accepted by the Florida regulatory community. The County accepted this recommendation.

This section documents the methods used to perform the water quantity evaluation, including the structure of the model software, and the assumptions and guidelines for using the model to represent the Big Sand Lake study area.

2.1.1 Hydrologic Cycle

In order to represent the dynamics of any hydrologic basin there needs to be a consideration of the pertinent components of the hydrological cycle that make up the water budget. **Figure 2-1** shows a generalization of a typical water budget.

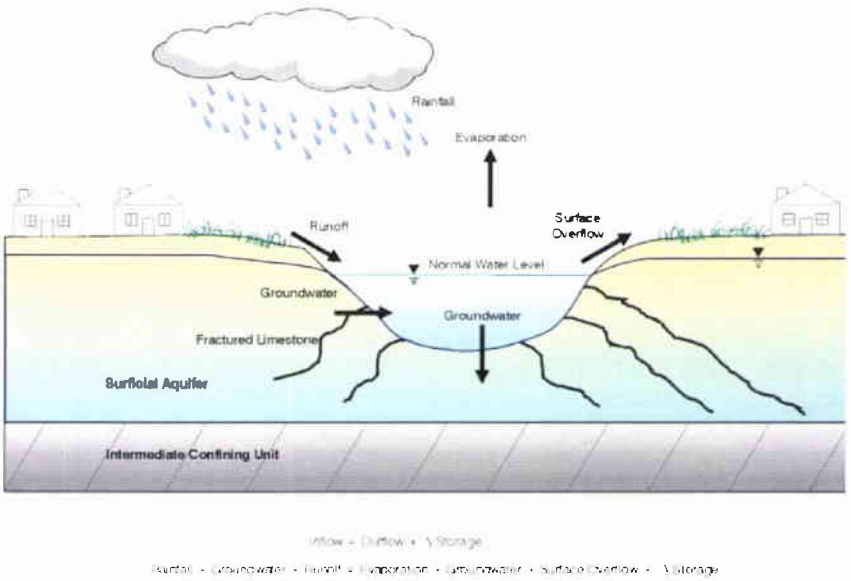

Figure 2-1
Hydrologic Cycle Schematic

As shown on Figure 2-1, the governing equation for water budget is Inflow = Outflow + Storage. Inflows to a system can consist of rainfall, inflow from groundwater and surface runoff. Outflows can consist of evaporation, infiltration to the underlying aquifer and surface outflow. The third component is the change in storage, in the case of Big Sand Lake it is evident that during August of 2003, the storage held in the lakes has increased significantly.

For the Big Sand Lake Basin (a limited discharge basin), rainfall is the most significant inflow. The most significant outflows are evaporation and infiltration to the underlying aquifer. There is the potential for surface outflow, but typically this will not occur until the water surface elevation in Big Sand Lake is greater that approximately 96.3 feet NGVD.

2.1.2 Stormwater Model Framework

The following paragraphs briefly highlight the water quantity framework.

- Hydrologic Model: SWMM RUNOFF (4.4)

  RUNOFF provides an analysis of rainfall, runoff, infiltration, recharge to the Floridan aquifer, and simple hydrologic routing. The model is used to develop runoff hydrographs. In this study, RUNOFF was used to develop continuous hydrographs for the period of simulation, from which the output was then entered into EXTRAN at load points in the hydraulic network.

- Hydraulic Model SWMM EXTRAN (4.4)

  EXTRAN provides dynamic flood routing for the channels, lakes, and structures in the County's primary stormwater management system (PSWMS). Stages and flows from EXTRAN are the basis for the flood profiles and flood summary tables in the remaining sections of this report. EXTRAN also reports average conduit peak velocities. In this study, EXTRAN was used to route flow throughout the Big Sand Lake basin. The EXTRAN version of SWMM used in this study was modified slightly to add evapotranspiration (ET) as an abstraction. This was to allow ET to be a function of the varying surface areas of the lakes. This feature will also be included in SWMM Version 5 to be released in 2004 (non-beta version).

2.1.3 Hydrologic Model

The hydrologic model used for this study is the EPA SWMM RUNOFF (Version 4.4). The program simulates the rates of runoff developed from basins using a non-linear reservoir approximation (Mannings' equation). Hydrologic routing techniques are then used to route the overland flows through the pipe, culvert, and channel as required. Program results can be saved for input to the EXTRAN block of SWMM to perform dynamic hydraulic routing in downstream reaches.

RUNOFF was originally developed in 1970 as part of the original EPA SWMM. The program has been applied many times since its inception and has gained worldwide acceptance. Over the years, the program has undergone many changes and modifications, although the main formulations and calculations remain mostly unchanged from the original codes. A more complete documentation of the model's background and theory can be found in the SWMM 4.4 User's Manual.

2.1.4 Hydraulic Model

The hydraulic model used for this study was EPA SWMM EXTRAN, (Version 4.4) which is a hydraulic flow-routing model for open channel and/or closed conduit systems. It uses a link-node (conduit-junction) representation of the stormwater management system in an explicit finite difference solution of the equations of gradually varied, unsteady flow. EXTRAN receives hydrograph input at specific junctions by file transfer from a hydrologic model such as RUNOFF or TR20, and/or by manual input. The model performs dynamic routing of stormwater flows through the PSWMS to the points of discharge or outfalls. Since it is dynamic, it simultaneously considers both the storage and conveyance aspects of stormwater management facilities. The program will simulate branched or looped networks; backwater due to tidal or nontidal conditions; free surface flow; pressure flow or surcharge; flow reversals; flow transfer by weirs, orifices, and pumping facilities; and storage at online or offline facilities. Types of conduits that can be simulated include circular, rectangular, horseshoe arch, elliptical, and basket handle pipes, plus trapezoidal or irregular channel cross-sections. Simulation output takes the form of water surface elevations and inundated areas at each junction and flows and velocities at each conduit.

EXTRAN was developed for the City of San Francisco in 1973. At that time, it was called the San Francisco Model or the WRE Transport Model. In 1974, EPA acquired this model and incorporated it into the SWMM package, calling it the Extended Transport Model-EXTRAN to distinguish it from the TRANSPORT Model developed by the University of Florida as part of the original SWMM package. Since that time, the model has been refined, particularly in the way the flow routing is performed under surcharge conditions and in large open channel networks.

Several enhancements to EXTRAN have been implemented over the years since EXTRAN was originally released. In addition, minor changes were made to several algorithms for program efficiency and improved accuracy. The SWMM 4.4 User's Manual includes further details.

2.2 Hydrologic Parameters

Hydrologic model parameters used for the model simulations are described in this section. **Appendix A** (Tables A-1 through A-3) provides the resultant RUNOFF model data organized by hydrologic unit including hydrologic unit alphanumeric identification, width, area, percent directly connected impervious area (DCIA), slope, Manning's roughness values, initial abstractions, and infiltration rates, and soil storage values.

2.2.1 Topographic Data

Topographic data were used to define hydrologic boundaries, overland flow slopes, channel slopes, critical flood elevations, and stage-area-storage relationships. Topographic data was available for the Study area from four major sources:

- 1982 scanned section aerials with 1-foot contour data provided by the County. The Adobe Acrobat version supplied by the County were converted to tif format and imported into ArcView.
- 5-foot contours provided by Orange County – these were digitized from the USGS quad maps.
- 1-foot DEM provided by the FDEP Land and Boundary Information System (LABINS) web site – this DEM was generated from the USGS 5-foot contours.
- Subdivision and drainage improvement plans provided by the Orange County Public Works Department.

2.2.2 Hydrologic Unit Areas

Hydrologic units (HU) are generally defined by natural physical features or constructed stormwater management systems that control and direct stormwater runoff to a common outfall. CDM started with the basin and HU (subbasin) boundaries presented in the Shingle Creek Drainage Basin Master Stormwater

Management Study final report (DRMP, 1997). CDM extracted the HU delineations from this report and refined using the following general criteria:

- The Shingle Creek Basin and HU boundaries defining the Big Sand Lake chain of lakes were reviewed and adjusted using the existing 1-foot DEM.
- The resulting HU delineations were then overlain in ArcView with the 1999 digital aerials obtained from Labins Web site. Modifications to the HU delineation were made based upon apparent development divides. Also, large-scale physical features such as roads between the lakes were used to establish hydrologic divides.
- Existing construction drawings and studies were used, along with field verification, to define ambiguous boundaries.
- The level of detail used in the delineations was consistent with the overall scale of the project analysis.

These hydrologic basins were digitized as polygons using the Geographic Information Systems (GIS) software package ArcView© Version 8.2. The mathematical features of ArcView© were used to calculate the tributary area of each hydrologic unit. These hydrologic units are illustrated on **Figure 2-2**, and the areas are indicated in Tables A-1 and A-4.

For modeling purposes, the Big Sand Lake Basin was subdivided into sixteen (16) hydrologic units ranging from 15 to 1100 acres in size for the purposes of analyzing each of the major lakes that comprise the Big Sand Lake Study Area. It should be noted that this version of SWMM allows for ET in both the RUNOFF block (land surface) and EXTRAN block (lakes). To prevent the "double counting" of ET, a separate HU was created for each lake, which are also shown on Figure 2-2 and listed in Table A-1. For each lake HU, the ET value in RUNOFF was set to zero and then set to the appropriate value in the EXTRAN block. The rainfall interaction with the basin would allow historical volume of rain to enter the appropriate "lake junction" where ET would only be removed in EXTRAN based upon the lake's varying surface area.

2.2.3 Rainfall Intensities and Quantities

Specified rainfall data were used to generate stormwater runoff hydrographs for each HU in the hydrologic model. These resulting runoff hydrographs were then input into the EXTRAN block of the model to determine their effect on water levels in the chain of lakes. Because the high water levels are a result of above normal rainfall patterns as compared to a single discrete rainfall event, CDM used long-term rainfall records to evaluate its impact on the Big Sand Lake study area. Observed rainfall data are generally characterized by an amount (depth, measured in inches), intensity (inches per hour), duration (hours), spatial distribution (local variance), and temporal distribution (time variance).

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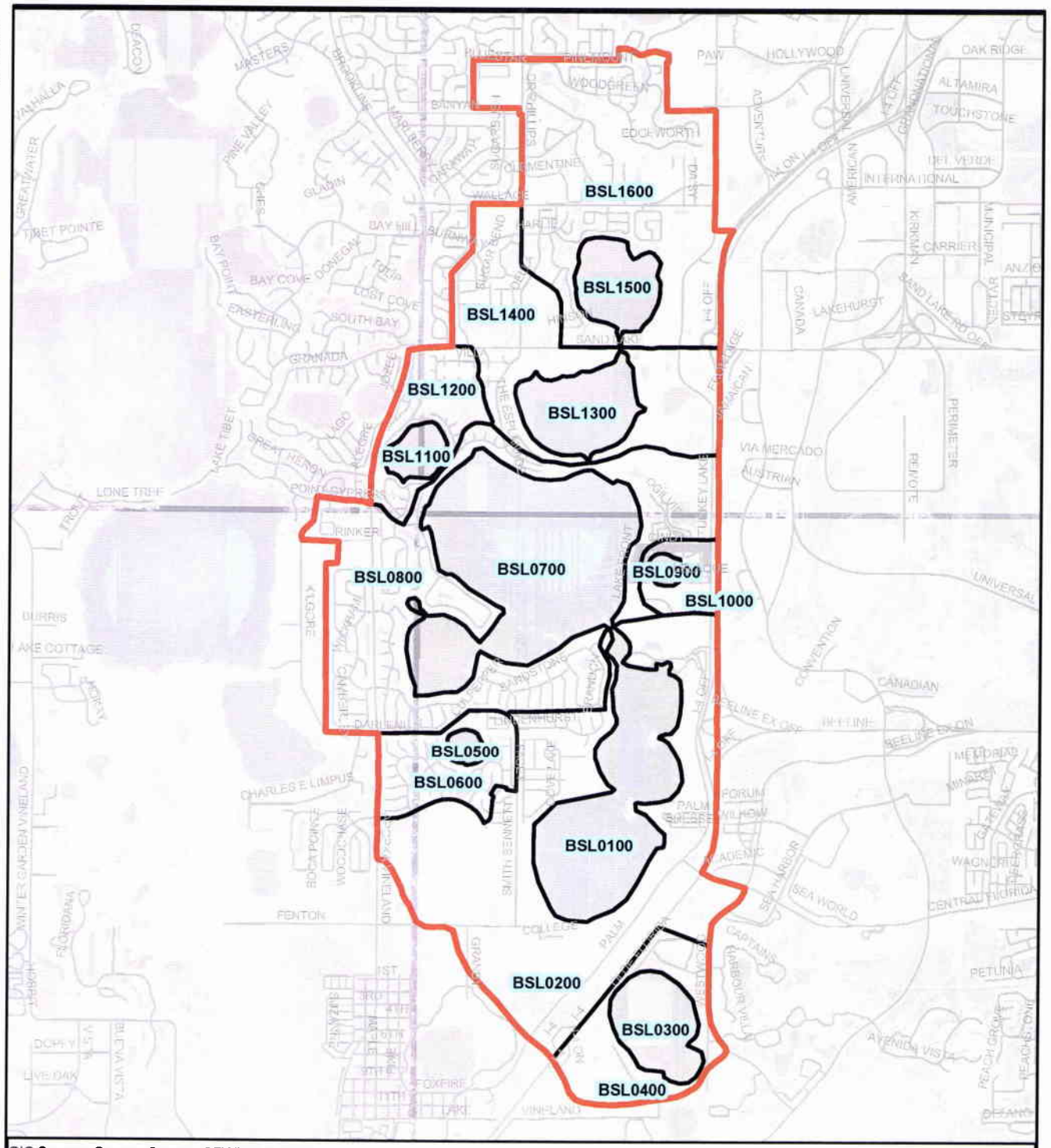


GIS Source: Orange County, SFWMD & CDM

4,000 0 4,000 Feet

LEGEND
Hydrologic Units
Basin Boundary

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure 2-2
Hydrological Units Map

Long-term rainfall records (hourly) are available for the Orlando International Airport (OIA) rainfall station, which has been in operation since 1942. This station records hourly rainfall data, which are available from the National Climatic Data Center in a format that can be read by several public domain stormwater models including SWMM. The monthly total rainfall for the OIA rainfall station is presented in **Table 2-1** for the period of record between 1948 and 2003 (September).

Currently, the County operates and maintains a network of 13 rainfall stations as shown in **Figure 2-3**. The County's rainfall monitoring network is reporting rainfall depths via telemetry. A radio transmitter transmits the measured data from the station's data loggers to the County Public Works Department. These data are then processed and reported as daily rainfall totals. One of the 13 County rainfall stations is located on Spring Lake, which is part of the Big Sand Lake Study Area. The monthly total rainfall volumes for the Spring Lake rainfall station are presented in **Table 2-2** for the period of record between 1989 and 2003 (September).

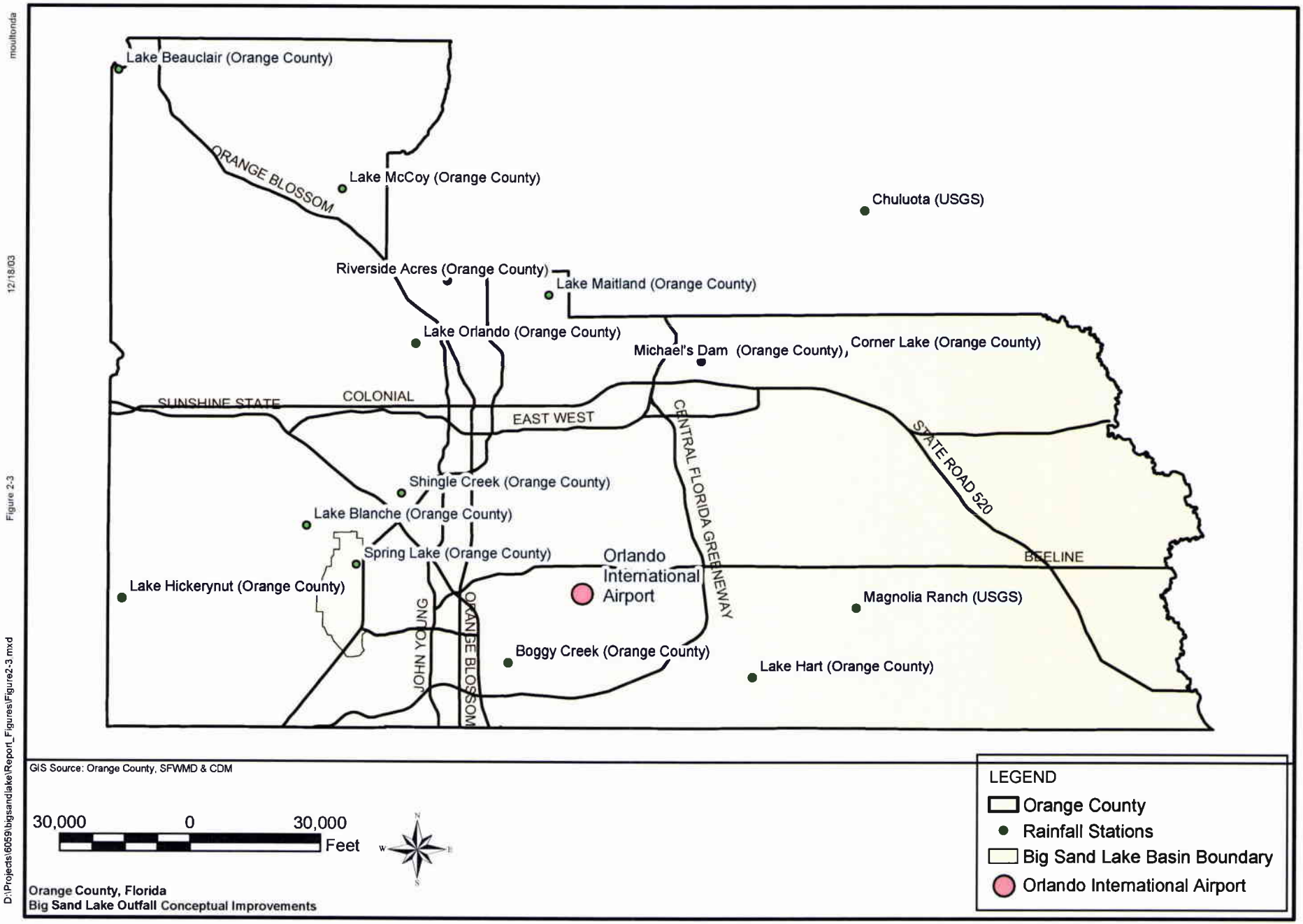
A comparison of the daily rainfall records recorded at the Spring Lake rainfall station was made with the daily rainfall values recorded at the OIA station. In several instances, the rainfall values recorded at the Spring Lake rainfall station were greater than the values recorded at OIA. For this reason CDM requested hourly rainfall records for the Spring Lake rainfall station for the period of record. Unfortunately, the hourly data was not readily available for use in the model. However, the daily rainfall totals were available. Therefore, CDM combined the information into a rainfall data set for use in the continuous simulations. This was accomplished by temporally distributing the daily Spring Lake rainfall volume across the hourly readings recorded at OIA so the resulting total daily rainfall matched the values recorded at the Spring Lake station. In the absence of rainfall in the OIA data to provide a temporal distribution, the Spring Lake rainfall data was equally distributed between the hours of 12 noon and 7 PM. Using the hybrid rainfall data set, CDM compared the yearly rainfall volumes to the average rainfall volume for the area. This comparison is shown graphically in **Figure 2-4**. By using this method, the actual rainfall totals measures at the Spring Lake rainfall station are the values used in the model.

2.2.4 Evapotranspiration

Evapotranspiration (ET) is the combined process by which water is transferred to the atmosphere from vegetative surfaces (transpiration) and from open water bodies (evaporation). In general, the majority of rainfall returns to the atmosphere through evapotranspiration. The amount of water transferred by ET is governed by a number of environmental factors. Minimal ET rates occur during dark cloudy days with high relative humidity, low temperatures, and no wind. ET rates are maximized on bright sunny days with low relative humidity, high temperatures, and moderate to high winds. The evaporation component is also a direct function of the free water surface area, specifically the larger the spatial extent of the water body, the greater the volume of evaporation. The transpiration component is maximized during the

Table 2-1
Orlando International Airport Rainfall Data

Year	Rainfall (Inches)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1948	No Data	No Data	No Data	No Data	No Data	No Data	8.80	12.32	10.91	2.58	0.47	1.36	36.41
1949	0.33	0.49	0.33	3.05	2.58	8.00	6.08	8.85	8.28	1.54	1.23	3.85	44.58
1950	0.18	0.50	3.46	4.83	2.95	5.58	8.31	3.48	7.93	14.54	0.12	4.33	56.18
1951	0.54	2.29	0.98	6.02	1.44	5.10	14.51	7.87	9.35	3.11	4.88	2.09	58.15
1952	0.73	5.26	6.69	2.90	2.46	2.37	4.45	6.52	4.97	3.72	0.76	0.68	41.47
1953	2.89	2.91	3.06	6.20	1.89	6.30	6.89	15.21	8.86	3.53	4.81	3.63	66.14
1954	0.48	1.17	1.00	4.47	3.57	5.83	13.65	4.43	4.01	5.10	2.72	1.82	48.22
1955	2.00	1.13	1.61	1.37	3.15	4.75	6.92	6.69	6.99	4.10	2.18	1.59	42.46
1956	1.68	0.91	0.19	4.05	3.74	5.43	5.89	6.10	6.28	8.25	1.28	0.32	44.11
1957	0.94	1.96	3.80	4.76	8.60	4.41	4.40	9.47	7.49	1.70	0.84	2.86	51.21
1958	4.50	2.84	6.19	3.83	2.70	3.85	9.96	3.45	1.68	7.29	2.51	2.72	51.48
1959	2.80	4.57	7.71	4.93	4.48	7.99	8.07	6.80	8.37	6.01	1.01	1.39	64.10
1960	1.50	5.65	10.55	2.58	0.53	9.53	19.60	3.24	11.24	3.18	0.31	0.92	68.80
1961	1.77	2.83	2.23	0.30	0.47	8.13	9.96	6.78	4.46	2.89	0.94	0.68	41.41
1962	1.14	2.10	3.58	1.59	2.76	3.16	12.79	5.16	12.28	1.92	2.47	1.72	50.64
1963	3.19	4.77	2.71	1.24	3.59	6.71	3.87	3.57	6.76	0.50	6.41	2.27	45.57
1964	6.19	3.45	4.67	2.16	2.75	6.14	6.70	9.03	9.49	1.66	0.49	1.93	54.64
1965	1.81	3.69	3.06	0.68	0.53	7.39	11.58	5.53	6.00	4.08	1.08	2.27	47.67
1966	4.47	6.32	2.59	1.94	6.60	9.79	6.75	7.80	6.27	1.91	0.13	1.02	55.56
1967	0.88	5.50	1.33	0.28	1.70	11.19	4.66	6.85	5.91	0.36	0.04	2.44	41.11
1968	0.68	2.78	2.30	0.32	3.73	18.30	5.63	3.47	5.94	5.49	2.82	0.90	52.33
1969	2.26	3.32	5.53	2.39	1.44	5.07	6.76	7.19	6.47	9.48	0.92	4.67	55.46
1970	4.10	6.77	3.68	0.46	4.10	4.94	5.99	5.94	3.27	2.62	0.25	2.07	44.15
1971	0.47	3.00	1.48	1.54	4.33	4.40	8.31	7.53	3.01	3.09	1.22	1.95	40.32
1972	1.00	4.99	5.07	1.41	3.79	6.35	4.00	16.16	0.45	2.36	4.12	1.92	51.59
1973	4.83	2.74	4.14	2.84	4.75	6.65	6.28	7.37	11.55	1.14	0.74	2.58	55.59
1974	0.20	0.63	3.68	1.19	2.70	15.32	6.03	6.60	5.83	0.49	0.33	1.65	44.61
1975	1.01	1.51	1.13	1.37	7.54	9.75	9.29	4.78	4.99	4.75	0.68	0.54	47.30
1976	0.39	0.85	1.73	2.18	10.38	9.95	7.07	3.27	5.88	0.77	2.06	2.80	47.29
1977	1.83	1.78	1.85	0.17	1.49	4.48	6.63	6.31	7.06	0.45	2.62	3.71	38.35
1978	2.51	5.46	2.17	0.62	3.17	10.03	11.95	5.14	4.33	1.52	0.19	3.73	50.80
1979	6.48	1.46	3.25	1.08	7.67	4.03	7.96	5.91	9.20	0.45	1.94	0.97	50.38
1980	2.46	1.66	1.53	4.09	6.98	5.27	5.16	2.94	3.72	0.58	6.56	0.50	41.42
1981	0.22	4.36	1.86	0.20	2.03	12.51	3.57	5.62	8.29	3.14	2.51	2.99	47.28
1982	1.72	1.36	4.86	6.29	5.30	6.07	11.83	5.07	6.98	0.77	0.57	1.04	51.83
1983	2.11	8.34	5.38	3.22	1.78	7.84	6.51	4.86	5.17	3.81	1.39	5.36	55.73
1984	2.04	2.75	1.87	6.22	3.21	5.36	6.22	7.90	6.22	0.59	2.11	0.21	44.66
1985	0.94	1.28	4.59	1.70	3.00	4.56	7.31	11.66	5.47	2.58	0.83	3.47	47.36
1986	7.25	1.86	2.64	0.50	0.90	9.52	5.86	6.01	4.51	5.64	1.70	3.62	49.99
1987	1.29	1.76	11.40	0.60	1.43	3.56	7.96	6.09	8.66	3.42	10.30	0.55	57.00
1988	3.16	1.41	6.08	2.04	2.83	4.19	9.47	7.97	5.70	1.44	7.46	1.02	52.72
1989	3.82	0.16	1.37	2.29	2.39	6.81	4.76	6.22	10.31	1.77	1.45	4.51	45.83
1990	0.25	4.15	1.93	1.74	0.57	6.24	6.71	3.81	2.50	2.11	1.07	0.85	31.90
1991	2.39	1.00	6.66	7.73	9.50	6.00	10.80	7.15	4.54	4.77	0.30	0.26	61.07
1992	1.37	2.46	3.69	9.12	1.20	8.70	2.62	8.05	7.14	5.19	2.79	0.92	53.23
1993	4.91	1.49	6.28	1.79	2.35	4.50	6.51	5.95	5.38	4.63	0.21	0.78	44.75
1994	4.02	3.60	1.25	3.05	2.89	10.30	13.28	6.25	7.85	5.20	7.34	3.07	68.09
1995	1.52	1.15	2.14	0.84	4.25	8.25	5.12	9.51	3.63	4.38	1.75	0.77	43.28
1996	5.40	1.53	9.89	0.70	5.13	6.53	4.08	11.35	6.05	3.30	0.76	2.15	56.84
1997	1.15	2.44	3.48	4.04	3.20	8.22	11.54	8.01	2.61	4.26	3.17	12.64	64.74
1998	2.03	8.75	5.27	0.53	3.19	1.58	8.62	5.61	5.37	0.66	1.70	0.65	43.93
1999	3.00	0.38	0.57	2.41	5.46	13.87	5.16	4.53	6.42	8.42	2.15	2.67	55.02
2000	1.24	0.39	0.48	2.25	1.03	6.22	4.10	4.49	6.40	1.35	1.12	1.58	30.62
2001	0.67	0.23	3.73	2.11	5.85	7.68	18.30	2.86	10.49	1.05	1.37	0.51	54.83
2002	1.11	3.51	0.54	1.21	2.49	13.02	10.24	10.99	4.77	4.98	2.35	11.39	66.57
2003	0.81	1.58	5.28	4.32	2.43	6.56	8.02	10.61	4.55	1.82	1.42	1.56	48.96
AVERAGE	2.16	2.75	3.53	2.57	3.47	7.17	7.92	6.83	6.39	3.33	2.05	2.33	50.10



Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

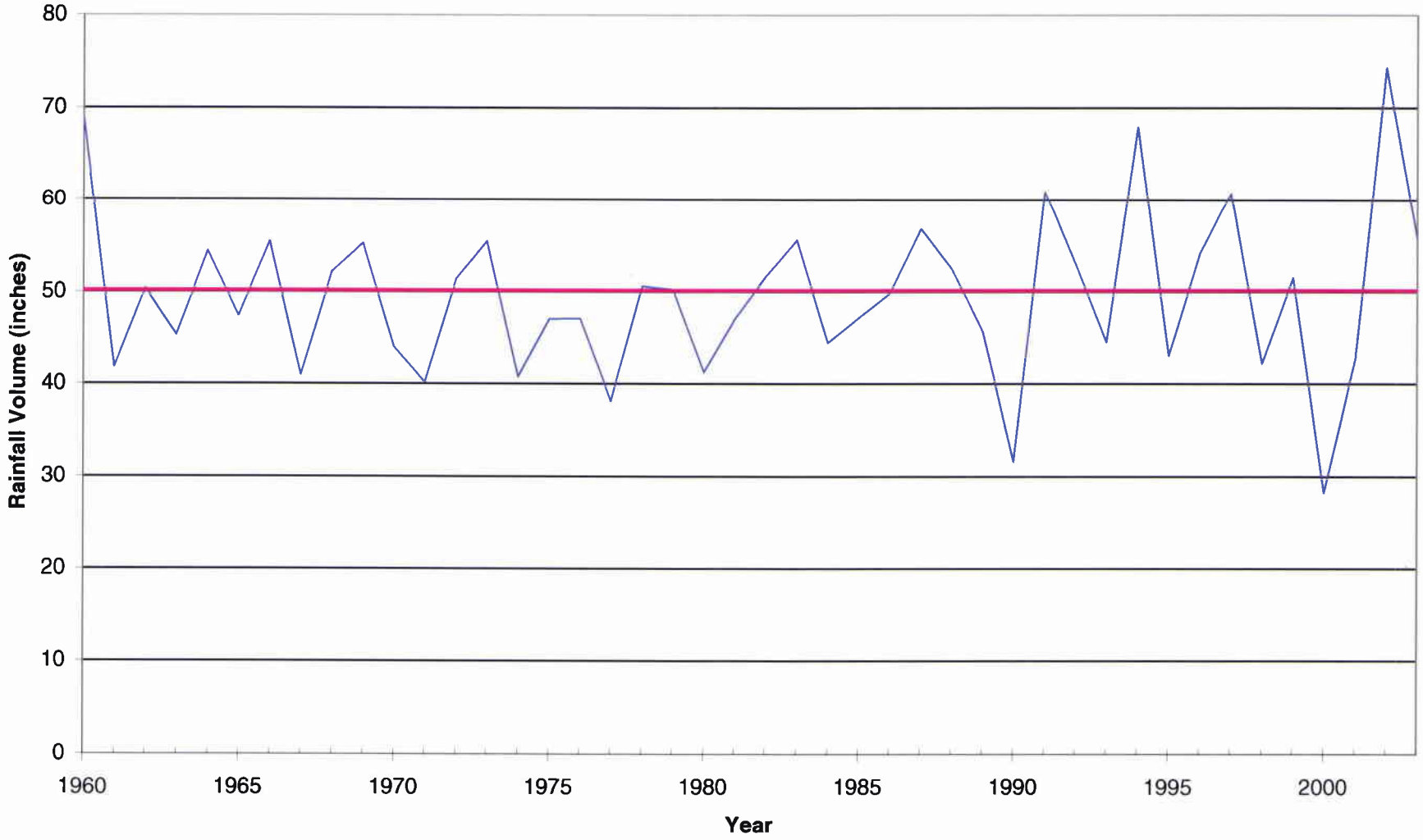
Figure 2-3
Orange County Rainfall Stations

moultonda 12/18/03 Figure 2-3 D:\Projects\6059\bigsandlake\Report_Figures\Figure2-3.mxd

Table 2-2
Orange County Spring Lake Rainfall Data

Year	Rainfall (inches)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1989											0.00	4.50	36.41
1990	0.00	4.00	1.62	1.38	1.80	5.40	6.60	11.60	3.80	2.60	1.70	0.00	44.58
1991	0.00	0.00	0.20	1.00	5.60	0.00	0.00	0.00	0.00	0.40	0.10	0.10	56.18
1992	1.10	3.10	3.70	6.40	1.20	6.20	2.80	5.80	5.10	3.00	3.20	0.70	58.15
1993	4.90	2.40	4.90	2.20	6.40	2.80	8.40	7.50	3.00	4.10	0.50	1.10	41.47
1994	4.80	1.80	1.80	4.20	1.80	11.30	6.20	5.50	11.30	2.70	6.10	4.50	66.14
1995	1.70	1.00	1.70	1.30	2.50	8.10	10.80	12.30	4.20	4.00	0.40	0.40	48.22
1996	5.40	1.53	9.89	0.70	5.13	6.53	4.08	11.35	6.05	3.30	0.76	2.15	42.46
1997	0.80	0.00	0.00	0.00	2.70	1.30	2.90	2.60	0.00	4.30	2.00	2.30	44.11
1998	1.86	2.00	2.60	0.00	2.90	0.70	3.50	3.80	7.70	0.90	0.80	0.60	51.21
1999	2.30	0.90	1.00	2.50	5.10	8.50	2.20	6.80	7.70	7.30	3.10	2.40	51.48
2000	1.24	0.17	0.20	1.20	0.20	4.70	7.60	5.10	3.30	0.80	1.01	0.90	64.10
2001	1.40	0.20	6.30	2.70	2.50	6.00	8.00	4.40	8.60	1.10	1.10	0.30	68.80
2002	1.80	4.30	0.30	1.30	4.80	11.59	5.35	11.56	7.86	7.26	3.97	14.11	41.41
2003	0.87	2.03	5.69	3.52	2.51	9.01	13.36	14.26	4.18	1.52	2.81	2.17	50.64
AVERAGE	2.01	1.67	2.85	2.03	3.22	5.87	5.84	7.33	5.20	3.09	1.84	2.42	51.02

Figure 2-4
Yearly Rainfall Total Compared with Average Rainfall (50.1 inches)



Source: Orlando International Airport Rainfall Record

growing season (warmer months) due in part to the increased leaf surface area associated with fully-grown vegetation.

In the Big Sand Lake study, open-water evaporation was approximated using the Jensen-Haise method. The Jensen-Haise method calculates potential evapotranspiration based on average temperature and incoming solar radiation and is not crop specific. These same climatic factors affect open water evaporation and allow for calculation of daily variation in evaporation. The Jensen-Haise equation for approximating potential ET (Jensen and Haise, 1963) was used to estimate the open-water evaporation, as follows:

$$ET_p = C_t * (T_{avg} - T_x) * R_s \setminus \lambda$$

Where:

ET_p =Daily potential ET, mm;

C_t =Air temperature Coefficient;

T_{avg} =Average daily temperature, degrees Celsius;

T_x =linear equation intercept on the temperature axis, degrees Celsius;

R_s =daily incoming solar radiation, cal/cm^2/day; and,

λ =latent heat of vaporization of water, cal/cm^2/mm.

Daily average temperature data for the project area were taken from the Orlando International Airport. Since solar evaporation data are typically scarce, average monthly values for Daytona Beach were applied. Once a daily time series for open-water evaporation was developed, average monthly values were computed and used as SWMM input. The monthly evaporation rates used in the model are given in **Table 2-3**. The volume of water lost to open-water evaporation was calculated as the product of the evaporation rate and corresponding lake area for that time step.

In the RUNOFF block ET was abstracted from the rainfall intensity base upon user supplied monthly values. It is also used to replenish depression storage during simulated dry weather periods. This methodology does not consider evaporation from the spatial extent of water bodies (surface area), and therefore, lake evaporation had to be accounted for using a separate mechanism. The spatial extent of the water surface in the Big Sand Lake Basin is approximately 40 percent of the study area.

Table 2-3
Model Evaporation Values

Month	Total Evaporation (in)
Jan	2.49
Feb	2.64
Mar	3.66
Apr	4.58
May	4.78
Jun	4.08
Jul	4.24
Aug	4.11
Sep	3.55
Oct	3.46
Nov	2.92
Dec	2.47
Total	42.57

In the Big Sand Lake SWMM, both the RUNOFF and EXTRAN blocks had an ET component. In RUNOFF, those basins that represented the tributary land surface area had the monthly ET values applied whereas the basins that represented the various lakes did not. In EXTRAN, ET was applied to the junctions that represented the lakes. Using this methodology, it was possible to have ET replenish the depressional storage on the land surface and have ET abstracted from the rainfall as well as having ET applied as a function of lake surface area. This provides a reasonable representation of ET within the basin.

2.2.5 Soil Types and Characteristics

Soil data were used to evaluate stormwater runoff, infiltration, and recharge potential for pervious areas. Information on soil types was obtained from the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) Soil Survey of Orange County, Florida. Each soil type has been assigned a soil series and Hydrologic Soil Group designated by the NRCS. Hydrologic Soil Group A is comprised of soils having very high infiltration potential, high soil storage and low runoff potential. Hydrologic Soil Group D is characterized by soils with very low infiltration potential, low soil storage and a high runoff potential. Hydrologic Soil Groups B and C are designated between these two categories. For the purposes of this study, dual class soil groups were assigned to the more conservative value (wet season). The percentage of each Hydrologic Soil Group within a hydrologic unit are listed in Tables A-1 and A-4 for existing and future land use conditions, respectively.

The Horton infiltration equation option in RUNOFF was used to calculate the rate and volume of water that infiltrates into the soil. According to the Horton equation, infiltration is computed as:

$$f_t = f_{min} + (f_{max} - f_{min})e^{-kt};$$

Where:

f_t = the maximum infiltration capacity of the soil at time t (in/hr);

f_{min} = the minimum (or final) infiltration capacity (in/hr);

f_{max} - the maximum (or initial) infiltration capacity (in/hr);

k = an exponential decay constant (hr^{-1}); and

t = time (hr).

The decay constant, k, is an empirical parameter that controls the rate of decrease in infiltration capacity during a rainfall event. In the Horton equation, the infiltration rate decreases exponentially from the maximum capacity down to the minimum capacity. The infiltration rates and the decay constants that were used for each hydrologic soil group for this project are indicated in Table A-1.

The Horton infiltration equation is based upon conveyance through an unsaturated soil zone, and must be modified in order to represent saturated soil conditions. EPA-SWMM Version 4.4 includes a soil storage shut-off option that restricts the infiltration of stormwater once the soil storage capacity is exceeded. Soil storage capacity is a measure of the amount of soil pore space (in inches) available for the storage of infiltrated water. **Table 2-4** lists the global infiltration parameters that were used for this study. The table lists maximum and minimum infiltration rates and soil storage capacities. ArcView Version 8.2 was used to generate the percent of each soil group for each hydrologic unit. **Figure 2-5** illustrates this delineation.

Table 2-4
Global Soil Parameters

Soil Type	Initial Infiltration Rate (in/hr)	Final Infiltration Rate (in/hr)	Decay Rate (1/sec)	Soil Storage (in)
A	12.00	1.00	0.000556	5.50
B	9.00	0.50	0.000556	4.50
C	6.00	0.25	0.000556	3.80
D	4.00	0.10	0.000556	1.40

2.2.6 Overland Flow Parameters

The RUNOFF module of SWMM uses overland flow data in the form of width, slope, and Manning's roughness to create a physically based overland flow runoff plane to route runoff to conduits and storage for further routing. The overland flow hydraulic length (L) is the weighted-average travel length to the point of interest. The need for a weighted average is apparent for areas with odd geometry where a long, thin portion of the area may be misrepresented with a biased L. For ponded areas, the point of interest chosen was the centroid of ponding. For areas where ponding does not occur, the point of interest is the outflow from the area. Overland flow length is

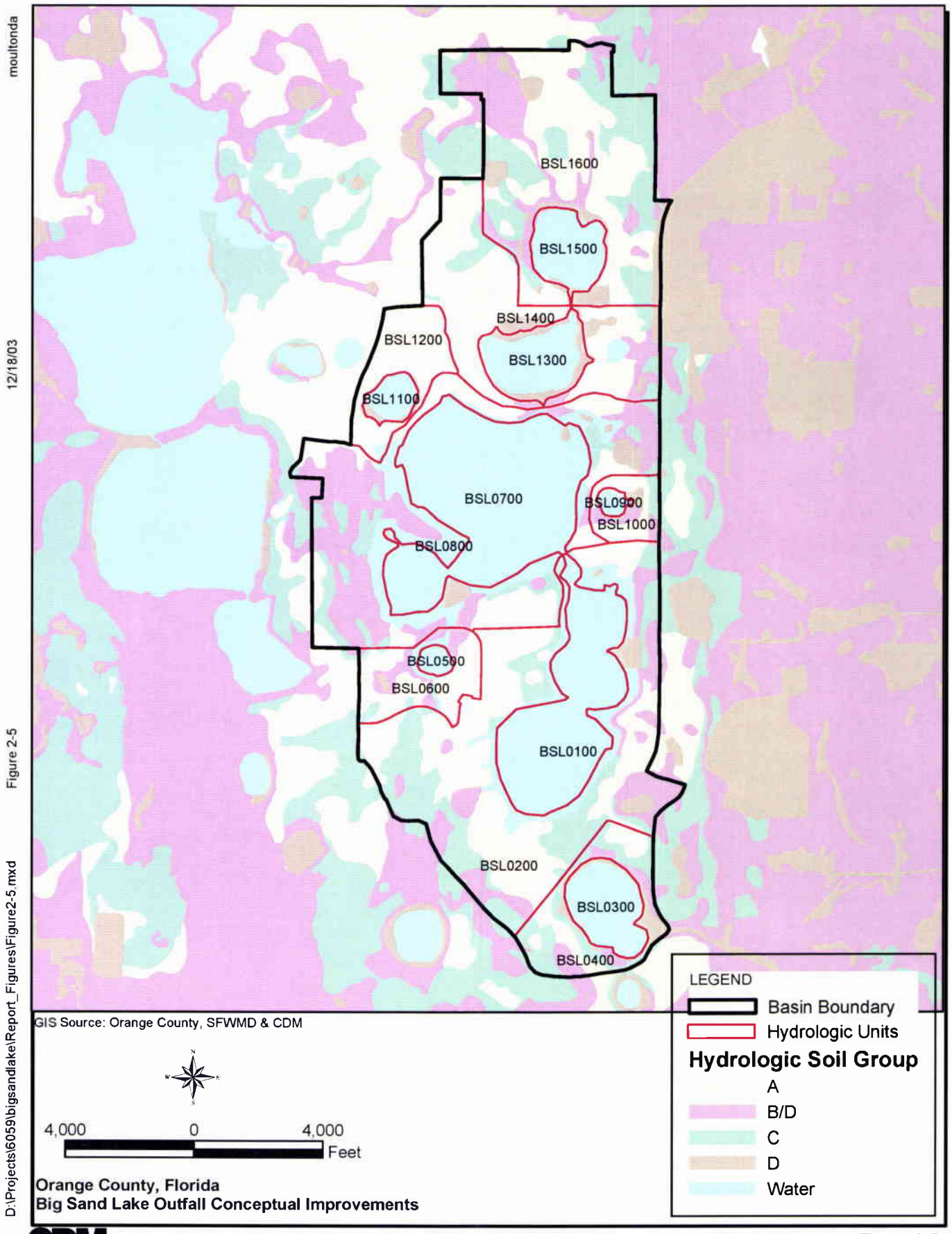


Figure 2-5
Soils Map

used to better estimate hydrologic unit width for the RUNOFF overland flow routing by use of the equation:

$$A = LW;$$

Where:

A = basin area (sq. ft.);

L = overland flow length (ft.); and

W = overland flow width (ft.).

The width is then checked using the base map.

Overland flow slope is the average slope over the hydraulic length and is calculated by dividing the difference in elevation by the hydraulic length. Length and slope information was estimated from topographic map data and field inspection data. This information is indicated in Tables A-2 and A-5 for the existing and future land use conditions, respectively.

Manning's roughness is used for the overland flow routing using Manning's equation. **Table 2-5** lists typical values for shallow overland flow Manning's n.

Table 2-5
Estimate of Manning's Roughness Coefficients for Overland Flow

Source	Ground Cover	Manning's n	Range
Crawford and Linsley (1966)[a]	Smooth asphalt	0.012	
	Asphalt of concrete paving	0.014	
	Packed clay	0.03	
	Light turf	0.20	
	Dense turf	0.35	
	Dense shrubbery and forest litter	0.4	
Engman (1986)[b]	Concrete or asphalt	0.011	0.01-0.013
	Bare sand	0.01	0.01-0.16
	Graveled Surface	0.02	0.012-0.03
	Bare clay-loam (eroded)	0.02	0.012-0.033
	Range (natural)	0.13	0.01-0.32
	Bluegrass sod	0.45	0.39-0.63
	Short grass prairie	0.15	0.10-0.20
	Bermuda grass	0.41	0.30-0.48

Notes:
[a] Obtained by calibration of Stanford Watershed Model.
[b] Computed by Engman (1986) by kinetic wave and storage analysis of measured rainfall-runoff data.

2.2.7 Land Use and Impervious Areas

Land use data were used to estimate the imperviousness, surface friction factors, and initial abstractions for each hydrologic unit. Existing land use conditions were obtained from the County. The existing land use was compared with the 1999 and more recently hardcopy 2002 aerial photography. The land use coverage was updated based upon the aerials. Using these data sets, CDM developed a matrix grouping of the County's land use data into 12 categories for modeling purposes.

This matrix is presented in **Table 2-6**. ArcView© was then used to generate the percent of each land use category (existing land use) for each hydrologic unit as shown in Tables A-3 and A-6 respectively. The resulting land use map is presented in **Figure 2-6**.

Table 2-6
Land Use Matrix

Orange County Big Sand Lake Basin Land Use Categories	Orange County Existing Land Use Categories
1. Forest	Rural/Agriculture (400 Series FLUUCS)
2. Rangeland	Rural/Agriculture (300 Series FLUUCS)
	Institutional ("UTTL" Orange County Land Use)
3. Parks/Golf Course	Parks/Recreation
	Rural/Agriculture ("UO" Orange County Land Use)
4. Agriculture	Rural/Agriculture (200 Series FLUUCS none Identified)
	Rural/Agriculture ("A" Orange County Land Use)
5. Low Density Residential	Low Density Residential
6. Medium Density Residential	Low - Medium Density Residential
	Medium Density Residential
7. High Density Residential	High Density Residential
8. Institutional	Institutional
9. Commercial/Office	Commercial
10. Industrial	Industrial
11. Wetland/Conservation	Conservation
12. Water Body	Water Body
13. Major Roads	Institutional ("UTHW" Orange County Land Use)

The percent imperviousness of each hydrologic unit is one of the parameters used by the SWMM RUNOFF model to determine the volume and rate of surface water runoff. As discussed above, the imperviousness is based on land use percentages. A summary of the land use categories is presented in **Table 2-7**. Additionally, the table lists the percent of Directly Connected Impervious Area (DCIA) and the percent of Non-DCIA (NDCIA) assigned to each land use category. The DCIA represents all the impervious surfaces that are directly connected to the stormwater system. The NDCIA represents the impervious surfaces that have a pervious buffer prior to discharge into the stormwater system. Based on this information, the area-weighted average percent imperviousness for each hydrologic unit was computed using the percent of each land use category within a hydrologic unit for existing land use conditions.

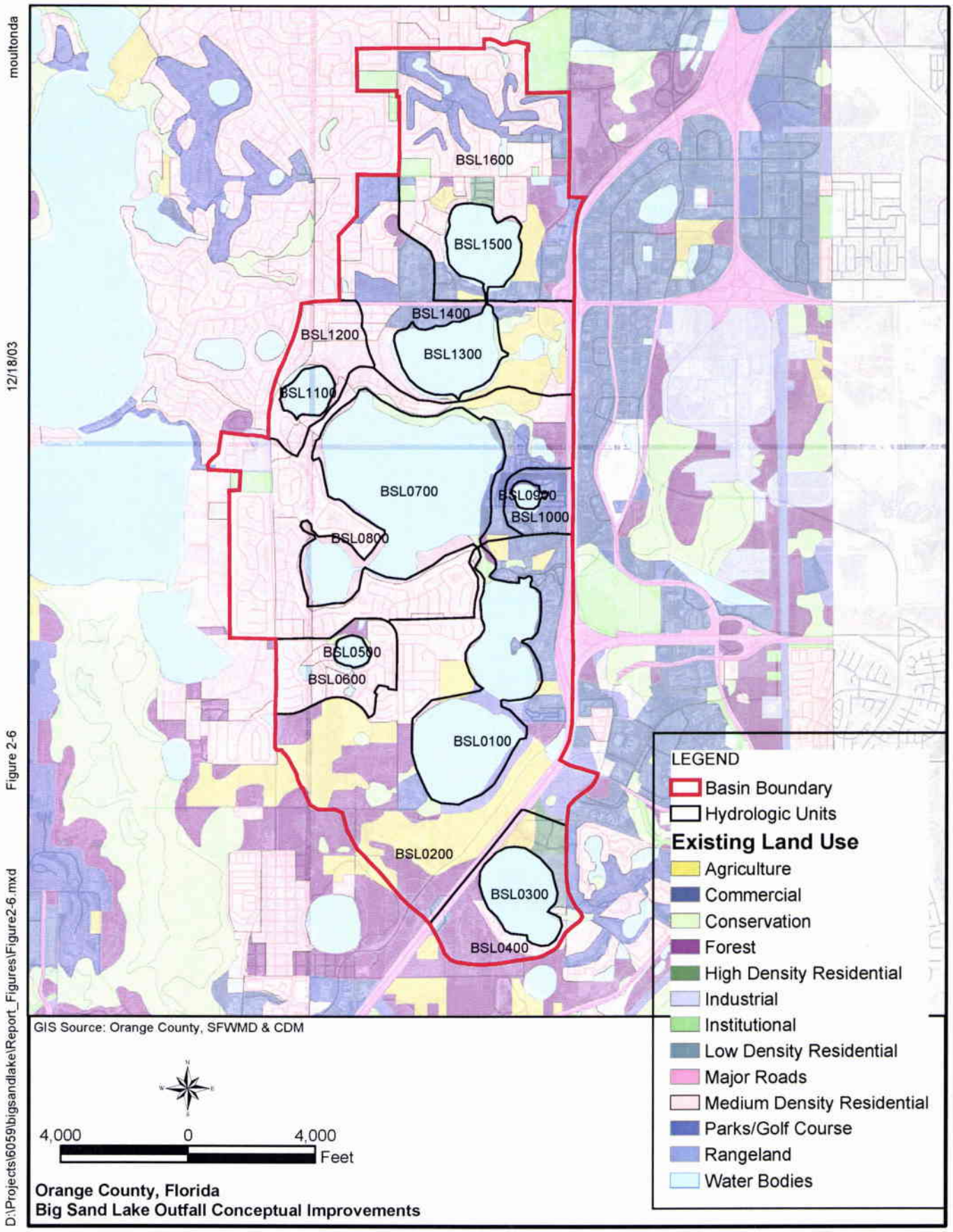


Figure 2-6
Existing Land Use

Table 2-7
Imperviousness by Land Use Category

Land Use Category	Percent Impervious[1]	Percent DCIA	Percent NDCIA	Percent Pervious
1. Forest, Open, & Park	5	1	4	95
2. Agriculture & Golf Course	5	1	4	95
3. Low Density Residential	15	7.5	7.5	85
4. Medium Density Residential	35	24.7	10.3	65
5. High Density Residential	82.5	65	17.5	17.5
6. Institutional	90	81	9	10
7. Industrial	90	81	9	10
8. Commercial	90	81	9	10
9. Wetlands	100	100	0	0
10. Watercourses & Waterbodies	100	100	0	0
11. Roads	90	81	9	10

Note:
[1] Total Impervious Area

2.3 Hydraulic Parameters

The primary stormwater management system (PSWMS) for the Big Sand Lake Study Area consists lakes interconnected by open channels, culverts, weirs, or overland flow. Characteristic data of this system was obtained from construction drawings, field reconnaissance, topographic map data, and survey. A necessary task of this study was the creation of a simplified representation of the actual system modeled (model schematic). Channels, pipes, weirs, and pumps are represented as links, and are the elements where flows are computed. Lakes and manholes are represented by junction nodes and are the locations where elevations are calculated. The model schematic for the Big Sand Lake Study Area is presented in **Figure 2-7**.

As indicated by **Figure 2-8**, stormwater runoff from Big Sand Lake flows through a series of open channel segments and culvert under I-4 before ultimately outfalling into the VWCD C-1 Canal. This canal is located east of the intersection of Central Florida Parkway and Sea Harbor Drive. From Big Sand Lake to the east side of I-4 the flow passes through the following sized culverts: 2 - 42 inch CMPS (access road adjacent to Big Sand Lake, 1 - 54 inch RCP and 1 - 48 inch RCP (under Turkey Lake Road), 2- 48 inch RCP (under I-4 east bound entrance ramp), 1 - 6 foot by 4 foot CBC (under I-4), 2 - 48 inch RCP (under I-4 west bound exit ramp), 3 - 36 inch RCP (from small open channel to VWCD system, 1 -54 inch CMP (connection from 3 - 36 inch RCP to Central Florida Parkway collector system), and finally, along the Central Florida Parkway through a series of 48 inch RCPs. The Central Florida Parkway system also conveys stormwater from the adjacent streets. It should be noted that the piped portion of the conveyance system has a maximum cross sectional area of approximately 28 square feet under Turkey Lake Road to a minimum of 12.33 square feet along Central Florida Parkway.

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Figure 2-7

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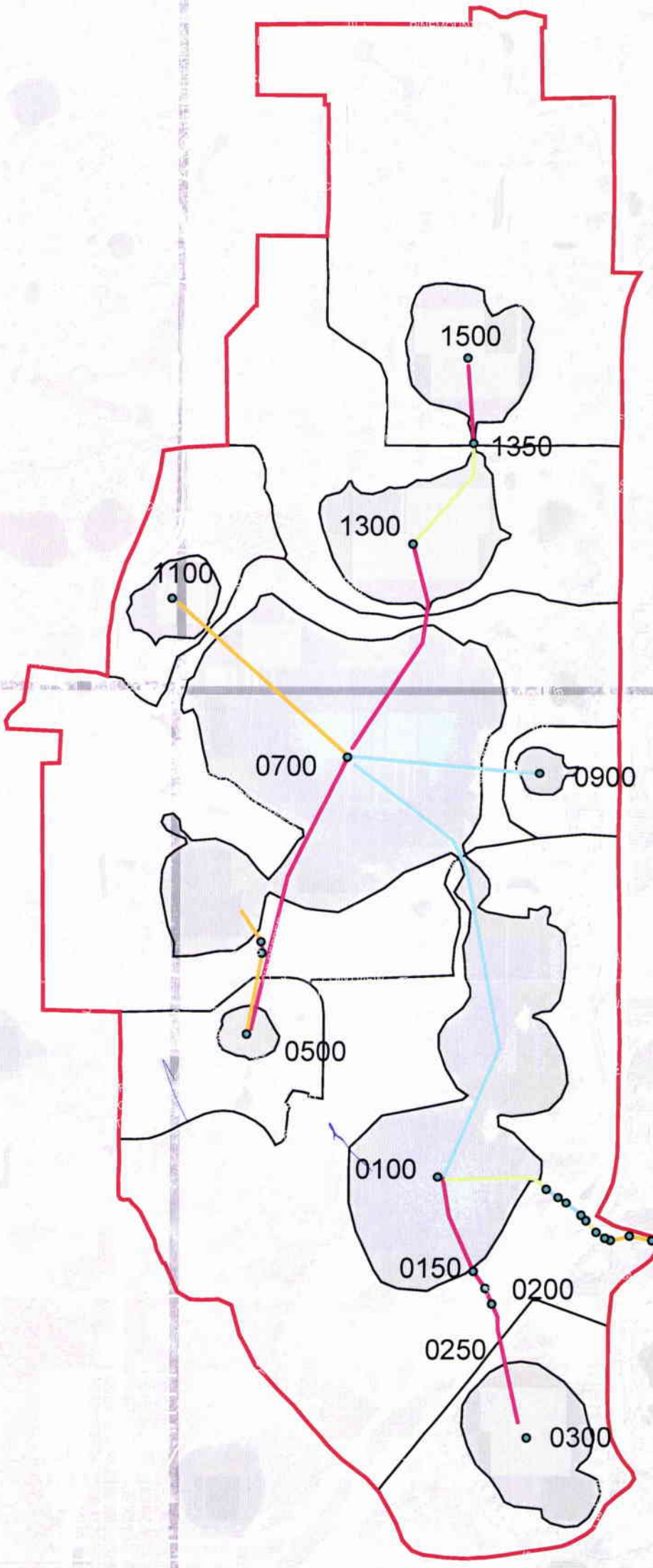


GIS Source: Orange County, SFWMD & CDM

N
W
E
S

2,500 0 2,500
Feet

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

LEGEND

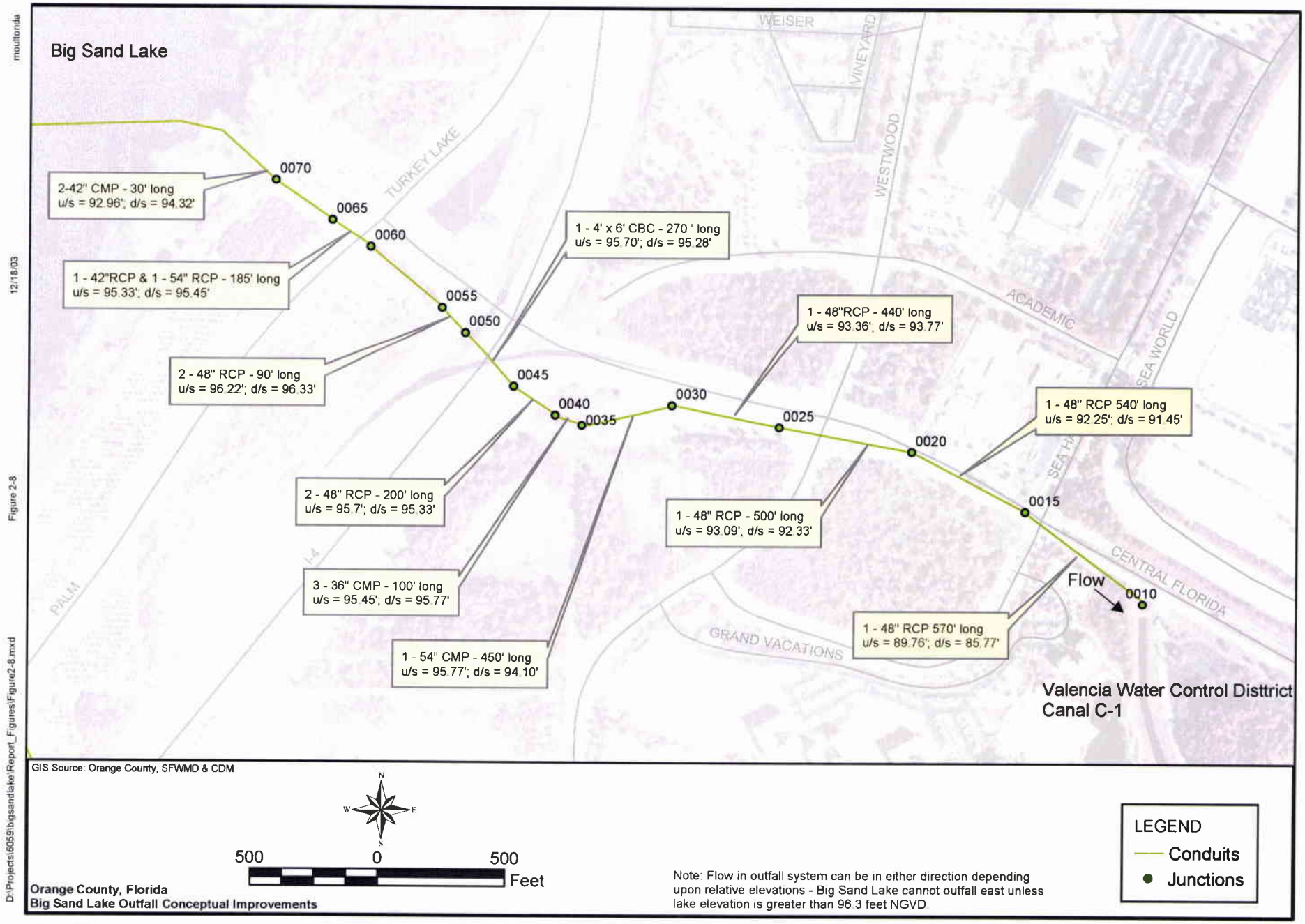
- Basin Boundary
- Hydrologic Units
- Junctions

Conduits

- CROSS DRAIN
- OPEN CHANNEL
- STORMPIPE
- WEIR

CDM

Figure 2-7
SWMM Model Schematic



CDM

Figure 2-8
Stormwater Management Model Outfall Configuration

2.3.1 Structures

One of the primary components in developing the stormwater model representation of the PSWMS was an inventory of stormwater structures connecting each of the lakes and the structures that comprise the outfall canal flowing under I-4 to the VWCD C-1 Canal. These characteristic data form the foundation for the model representation of the hydraulic system. As previously stated, these data were obtained from construction drawings, field reconnaissance, and new survey. A summary of these data sources are presented below:

- Bay Lakes at Granada - Section II
- Bay View Reserve
- Bay Vista Estates
- Bay Vista Estates - Phase III
- Citrus Chase Phase II
- Diamond Cove Recreation Area
- Diamond Cove Unit 1A
- Diamond Cove Unit 2
- I-4 and Sand Lake Stormwater System Maps
- Emerald Forest - Units 2 & 3
- Lake Serene Emergency Overflow Pipe
- Phillips Landing Phase 1 & 3
- Sand Lake Point Units 1, 2, 3, & 5
- Sand Lake Road Plans
- Spring Lake Condominiums
- Vizcaya Condominiums
- Turkey Lake Road Construction Plans

To supplement these data, the County collected new survey data that included the outfall configuration and inverts and the details of the cross drain under Sand Lake Road (i.e. Spring Lake to Little Sand Lake crossing), and the geometric characteristics of the outfall system from Big Sand Lake to the VWCD C-1 Canal. These data were used to develop the stormwater model representation of the hydraulic model (EXTRAN).

In addition to these data, the BSLAB completed an inventory of existing docks surrounding the lakes. In total of 124 structures were inventoried that included 116 fixed docks, 6 floating docks, and 2 miscellaneous structures. Deck elevation data were obtained for the 116 fixed docks. Of these fixed docks, 9 have deck elevations below 93.0 ft-NGVD, 21 are located between elevations 94.0 ft-NGVD and 93.0 ft-NGVD, 18 are between elevations 95.0 ft- NGVD and 94 ft-NGVD, and 68 are above elevation 95 ft-NGVD.

2.3.2 Drainage and Recharge Wells

Recently, the SFWMD completed a review and characterization of the drainage wells within Orange County. This report indicated that there are two drainage wells within the Big Sand Lake basin. The apparent location of these wells is shown on **Figure 2-9**; additionally the data sheets for these two wells are located in **Appendix B**. The existing well on Big Sand Lake is 10-inches in diameter with a cased depth of 173 feet below land surface (bls) and a total depth of 484 feet bls, and was privately owned. The existing well on Lake Serene is 12-inches in diameter with a cased depth of 114 feet bls and a total depth of 356 feet bls. This well was used for the stormwater management system on the property that was formerly owned and operated by Minute Maid Corporation.

Historically drainage or recharge wells were used in many parts of Central Florida, typically in land locked basins to provide lake level elevation control or street drainage. In general, drainage wells are vertical casings that connect surface water features with the Upper Floridan aquifer. Drainage wells operate by gravity and are technically feasible in areas where the surface water elevation is greater than the potentiometric surface of the upper Floridan aquifer. A schematic of the typical lake drainage well design preferred by the Orange County Roads and Drainage Division for drainage well construction is presented in **Figure 2-10**. The intake structure consists of a mitered end section pipe extending into the lake below the normal water level. This reduces the likelihood of surface debris from entering the system. The normal water elevation is controlled by the rim elevation of the well. The well chamber (manhole) is used to capture sediments and debris (settling basin) and can also be fitted with a trash control device ("birdcage").

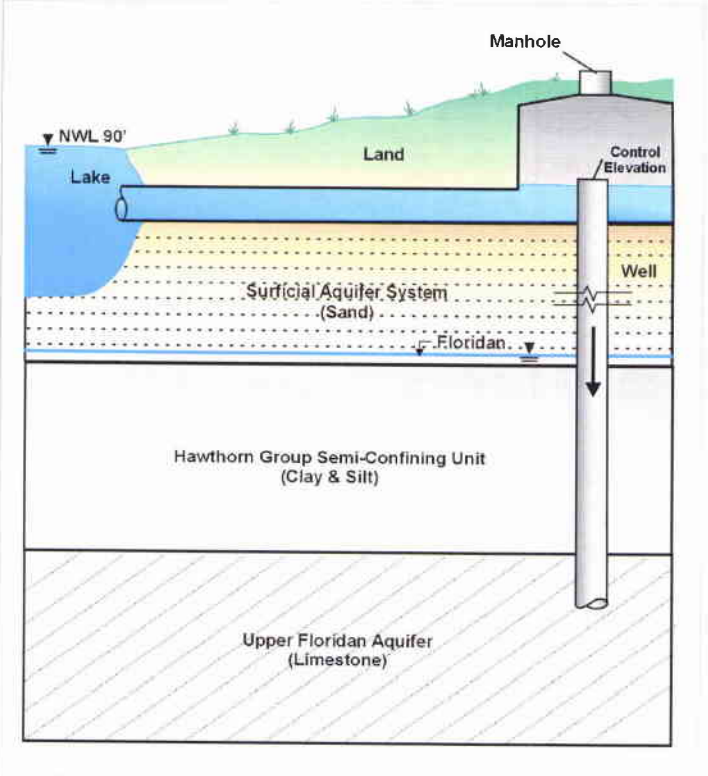


Figure 2-10
Typical Lake Drainage Well Control

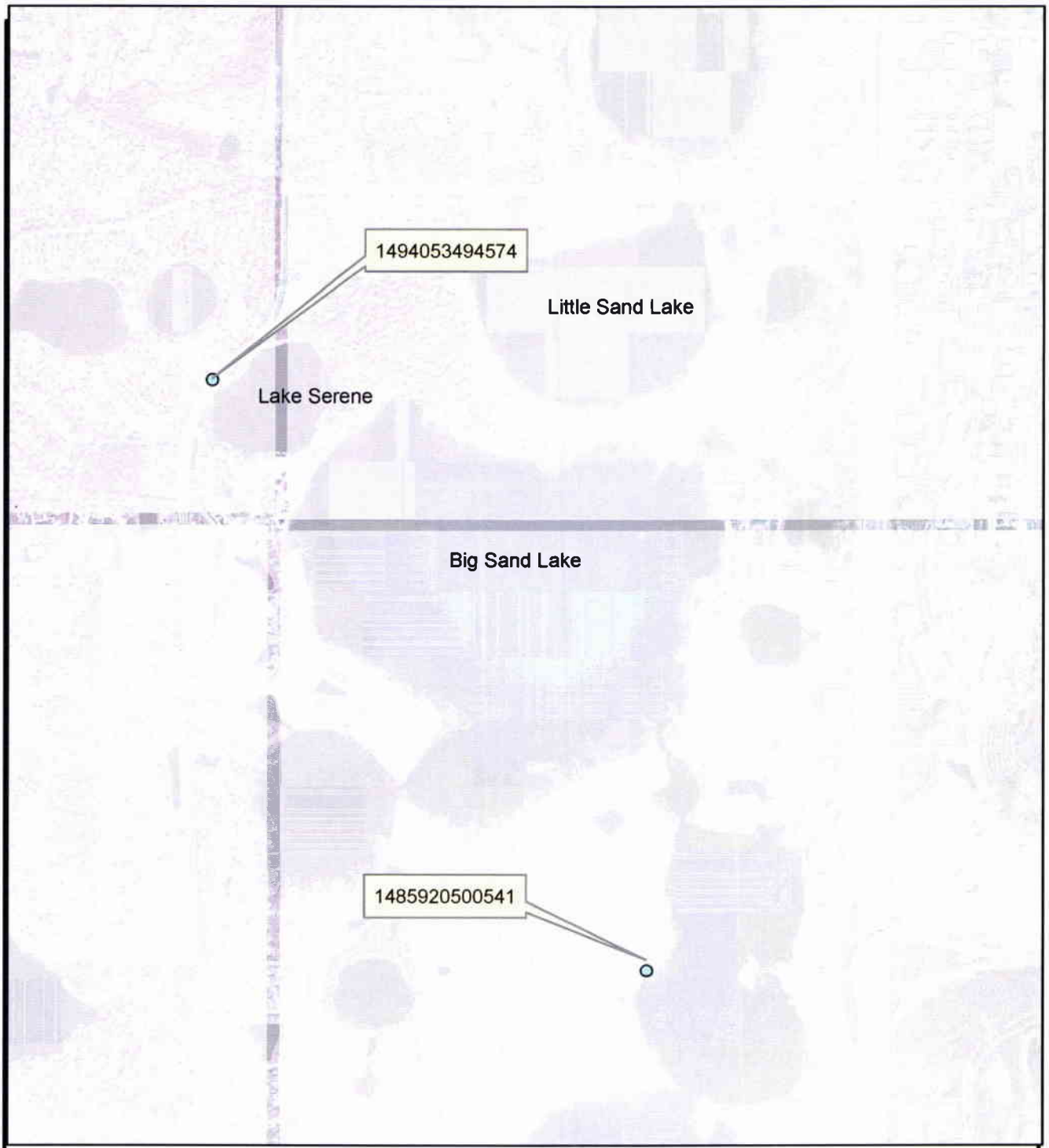
To protect Florida's groundwater resources, the Florida Department of Environmental Protection (FDEP) has regulations concerning the quality of water that is allowed to be introduced into any "underground source of drinking water" (USDW). Basically, introduced water must be treated to primary and secondary drinking water standards. Due to the cost of water treatment, this regulation essentially stops new drainage wells from being constructed. However, existing drainage wells are "grandfathered in" and are allowed to continue to operate. It is also possible to retrofit and provide maintenance to existing drainage wells, which may benefit to this project for lake level management.

2.3.3 Field Reconnaissance

To supplement the data obtained through construction drawings and survey, CDM conducted several field investigations within the study area. Copies of the field photographs taken are presented in **Appendix C**. It should be noted that the observed sedimentation in the culverts at the outfall from Big Sand Lake was cleared through cooperative efforts between the OCBOCC and FDOT as a result of public concern of flooding.

2.3.4 Local Losses

Local losses in closed conduit systems can cause abrupt changes in the hydraulic grade line. The EXTRAN block of SWMM Version 4.4 allows the user to directly input local losses for each closed conduit. Typical values are presented in **Table 2-8** and **Table 2-9**. These typical values were used in the stormwater model developed for this project.



GIS Source: Orange County, SFWMD & CDM

2,000 0 2,000 Feet

LEGEND
Basin Boundary
Drainage Wells

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

Note: ID numbers on figure are SFWMD Drainage Well IDs as referenced on Drain Well Inventory excerpt in Appendix B/

CDM

Figure 2-9
Drainage Well Location Map

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Table 2-8
Entrance Loss Coefficients
(From SFWMD, 1989)

Type of Structure and Design of Entrance	Coefficient K_{ent}
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radium = 1/12 D)	0.2
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

Table 2-9
Exit and In-Pipe Loss Coefficients (CDM, 1992)

Description	K
Inlet to manhole	0.25
Manhole in straight section of closed circuit	0.10
Manhole at a 45 degree bend	0.25
Manhole at a 90 degree bend	0.50
Exit closed conduit to lake	1.00
Exit closed conduit to open channel	0.3 - 0.7

2.3.5 Historical Lake Levels

Orange County has been recording monthly lake elevations for Big Sand Lake, Little Sand Lake, Spring Lake, Lake Serene, Lake Crowell, and Lake Willis. **Figure 2-11** shows the recorded historical lake level data. As can be seen from the figure, Big Sand Lake and Little Sand Lake equalized by mid-August following the retaining wall breach that occurred on August 9, 2003.

CDM developed a percentile distribution plot of the lake elevations recorded for Big Sand Lake since 1960 (458 readings) as shown in **Figure 2-12**. As can be interpreted from the figure, 95 percent of the water elevations measured in Big Sand Lake are below 95.4 ft-NGVD. Approximately 50 percent of the measured values are below 90 ft-NGVD (current normal water elevation). Additionally, the historical lake level data indicate that elevation 96.3 ft-NGVD (outflow elevation) has only been exceeded during 19 monthly readings, 13 of which were in the early 1960s.

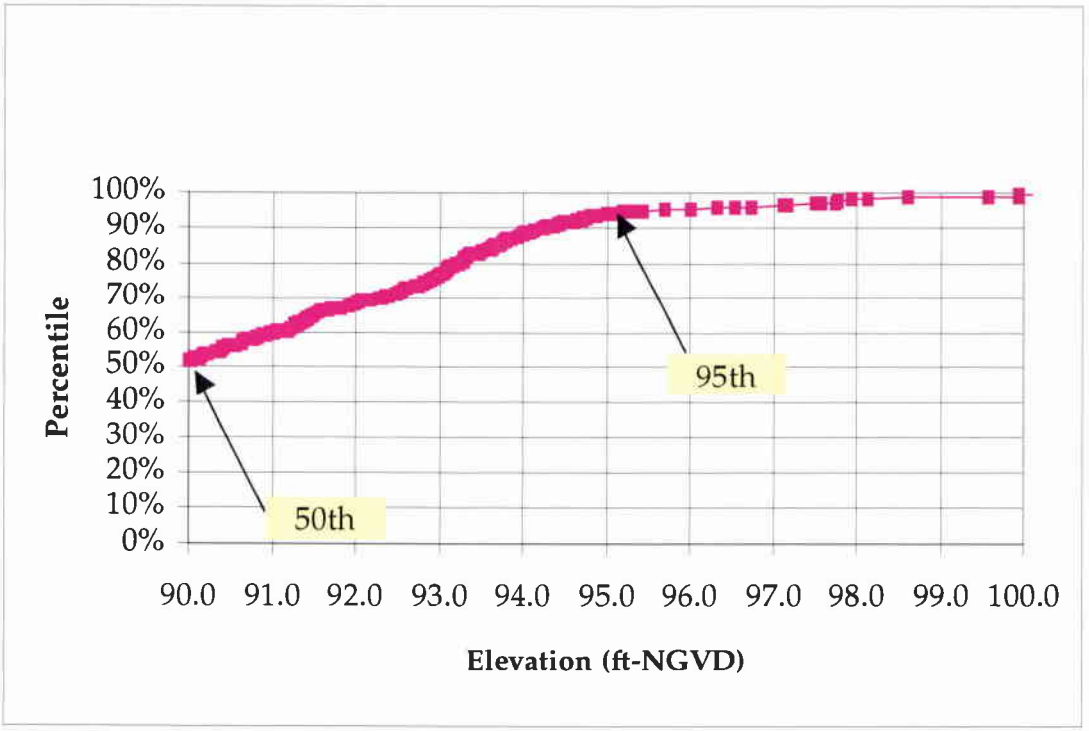


Figure 2-12
Lake Elevation Percentile Distribution

The last comparison made was the measured water levels recorded in Big Sand Lake versus the cumulative difference volume of rainfall compared to an annual average of 50 inches of rainfall. This comparison is presented in **Figure 2-13**. As indicated on this figure, lake levels generally follow the cumulative rainfall difference.

Figure 2-11
Historical Lake Water Surface Elevations (1960 to Present)

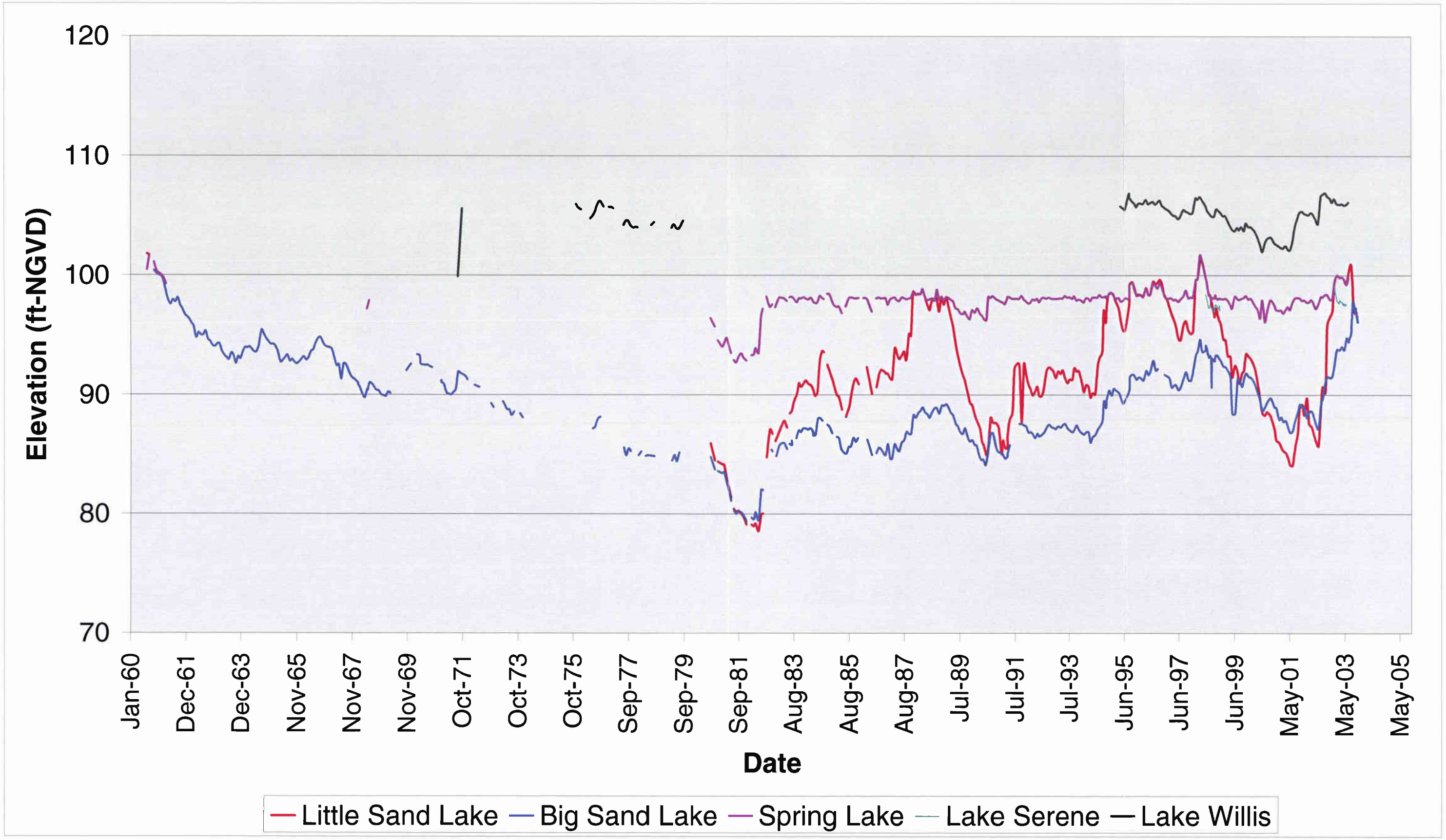
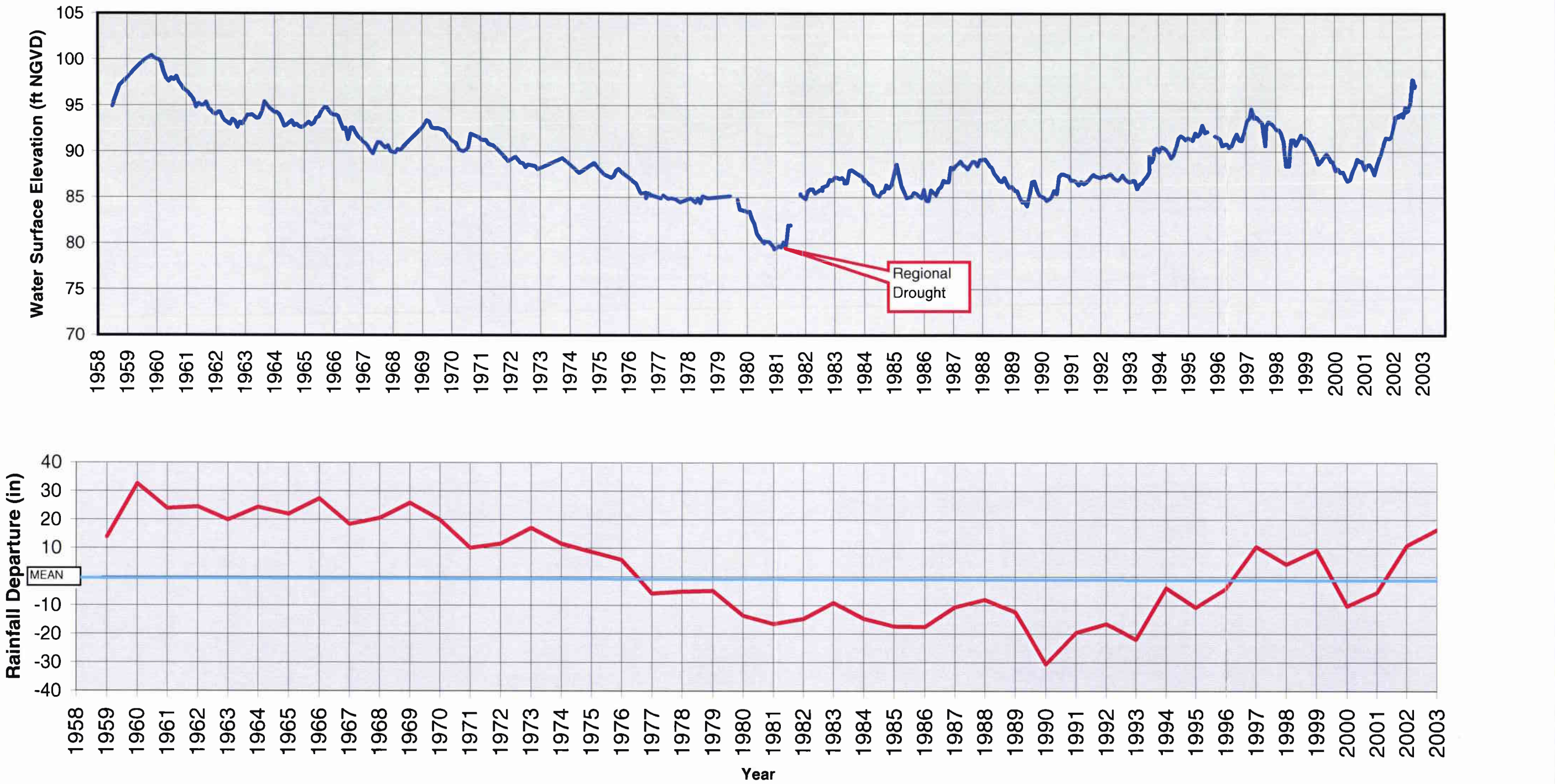


Figure 2-13
Big Sand Lake Water Surface Elevations versus Rainfall Variation



Note: Mean annual rainfall equals 50 inches per year

2.3.6 Stage-Area Relationships

Storage volumes were computed internally by EXTRAN based upon stage-area relationships that were developed for each lake using topographic map data and construction drawings. **Figure 2-14** presents the plotted surface area to depth relationships developed for the major lakes.

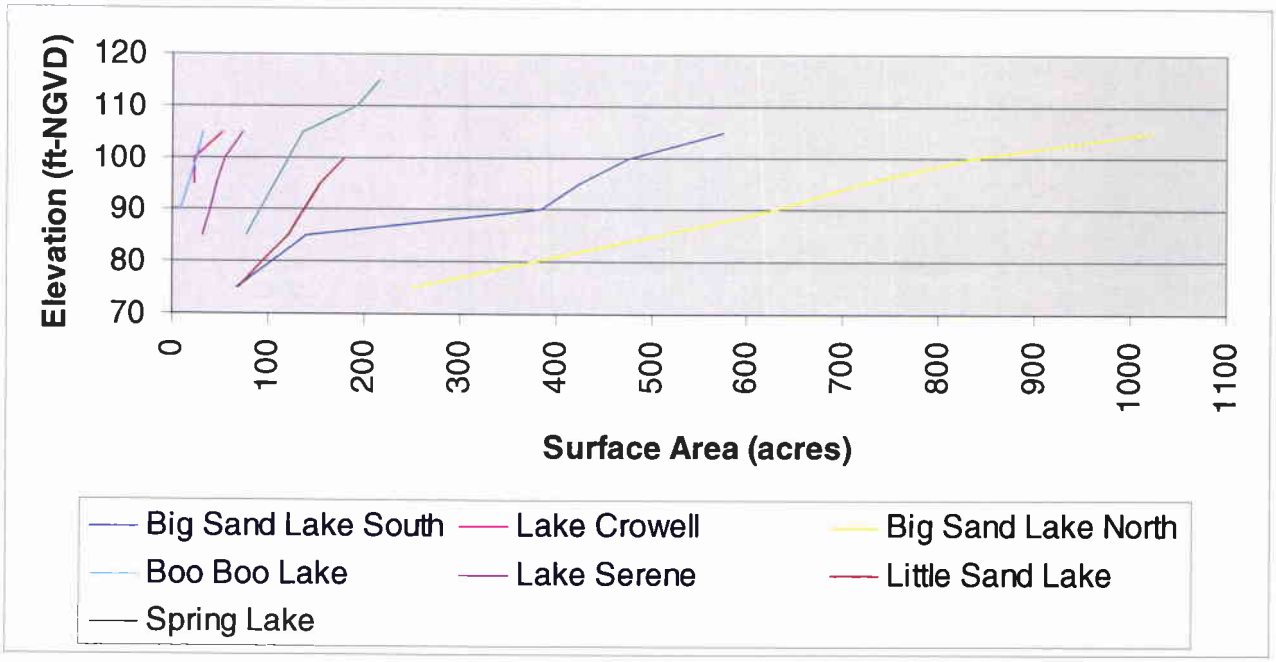


Figure 2-14
Lake Stage-Area Curves

2.3.7 Boundary Condition

For the purposes of the study, CDM used a fixed boundary condition of 92.0 ft-NGVD, which is the control elevation for the existing amil gate operated by the VWCD (VWCD Structure S-101). CDM also reviewed the modeling results presented in the 1997 Shingle Creek Drainage Basin Master Stormwater Management Study (1997 Study). The model results presented in the 1997 Study list a predicted peak stage of 92.0 ft-NGVD at this location for both the 10-year and 25-year design storm results.

2.3.8 Groundwater Interaction

Hydrogeologic Overview

The geologic system in Central Florida is composed primarily of undifferentiated sediments, the Hawthorn Group, Ocala limestone, the Avon Park Formations, the Oldsmar Formation, and the Cedar Key formation (McGurk and Presley, 2002). The three main aquifer systems are the surficial aquifer system (SAS), the Upper Floridan

Aquifer System (UFA), and the Lower Floridan Aquifer (LFA). These aquifers are separated by confining units, such as the Hawthorn Group, which separates the SAS and the UFA.

The area surrounding the project site is referred to as karst. This characterization indicates that a significant degree of interaction occurs between the SAS and FAS and is prone to the formation of sinkholes (in some cases, these sinkholes form lakes). Water-bearing lenses of sand, referred to as intermediate aquifers, are occasionally found within the Hawthorn Group. These lenses, in addition to solution cavities and areas where the Hawthorn Group is thin, are often associated with an increased hydraulic connection between the SAS and FAS.

Big Sand Lake is in contact with the SAS, which is approximately 50 feet thick in this area and consists of moderately permeable sand and clay-sand. The intermediate confining unit (Hawthorn Group), which underlies the SAS, consists approximately 100 feet of low permeability clay and silt. The top of the LFA underlies the intermediate confining unit and consists of highly weathered limestone. In summary, there is approximately 120 feet of moderate to low permeability soils between the bottom of Big Sand Lake and the UFA. Based upon the estimated deepest point within Big Sand Lake by the BSLAB (30 feet), there is no direct connection to the UFA.

Lake Seepage

Lakes act as a source for SAS recharge and a sink for groundwater discharge depending on the water elevation difference between the lake and the water table surrounding the lake and the hydraulic conductivity of the lake bed sediments. The rate of interchange is usually small due to the low hydraulic conductivity (10 feet per day or less) and a relatively thin saturated thickness (100 feet or less) of the surficial aquifer. Lake level variations due to seepage from or recharge to lakes connected to surficial aquifers are typically small.

In areas where the recharge rate to the Floridan aquifer is high and the hydraulic conductivity of the lake bed sediments is high, lakes commonly have large fluctuations in water level. However, when a lake is located in an area of high recharge to the Floridan aquifer and the hydraulic conductivity of the lake bed sediments is low, lake water level fluctuations can be dampened. A review of the measured water levels in Big Sand Lake (Figure 2-14) indicates that this lake is located in an area where the hydraulic conductivity of the lake bed sediments is probably high.

Since the lakes in the Big Sand Lake system are relatively deep compared to the saturated thickness of the SAS, the water level at each lake will control the underlying SAS groundwater elevation. Flow between the lakes and the SAS occurs predominantly from the sides of the lakes, which is minimal in comparison to the exchange of flow that occurs at the lake bottom. The exchange of flow at the bottom of the lake is a function of the lake water level, the piezometric head in the UFA, and

the hydraulic properties of the aquifer between the lake bottom and the top of the UFA. To estimate the rate of seepage from the lakes, it was assumed that the hydraulic leakance (the product of hydraulic conductivity and layer thickness) of the intermediate confining unit (ICU) separating the surficial aquifer from the UFA is the rate-limiting term. Lake seepage to the Floridan aquifer was calculated as follows:

$$Q_L = (K_V \Delta h A)/B$$

Where:

Q_L = the rate of seepage from the lake to the UFA;

K_V = vertical hydraulic conductivity of the ICU;

Δh = the head (water elevation) difference between the lake and the upper Floridan aquifer;

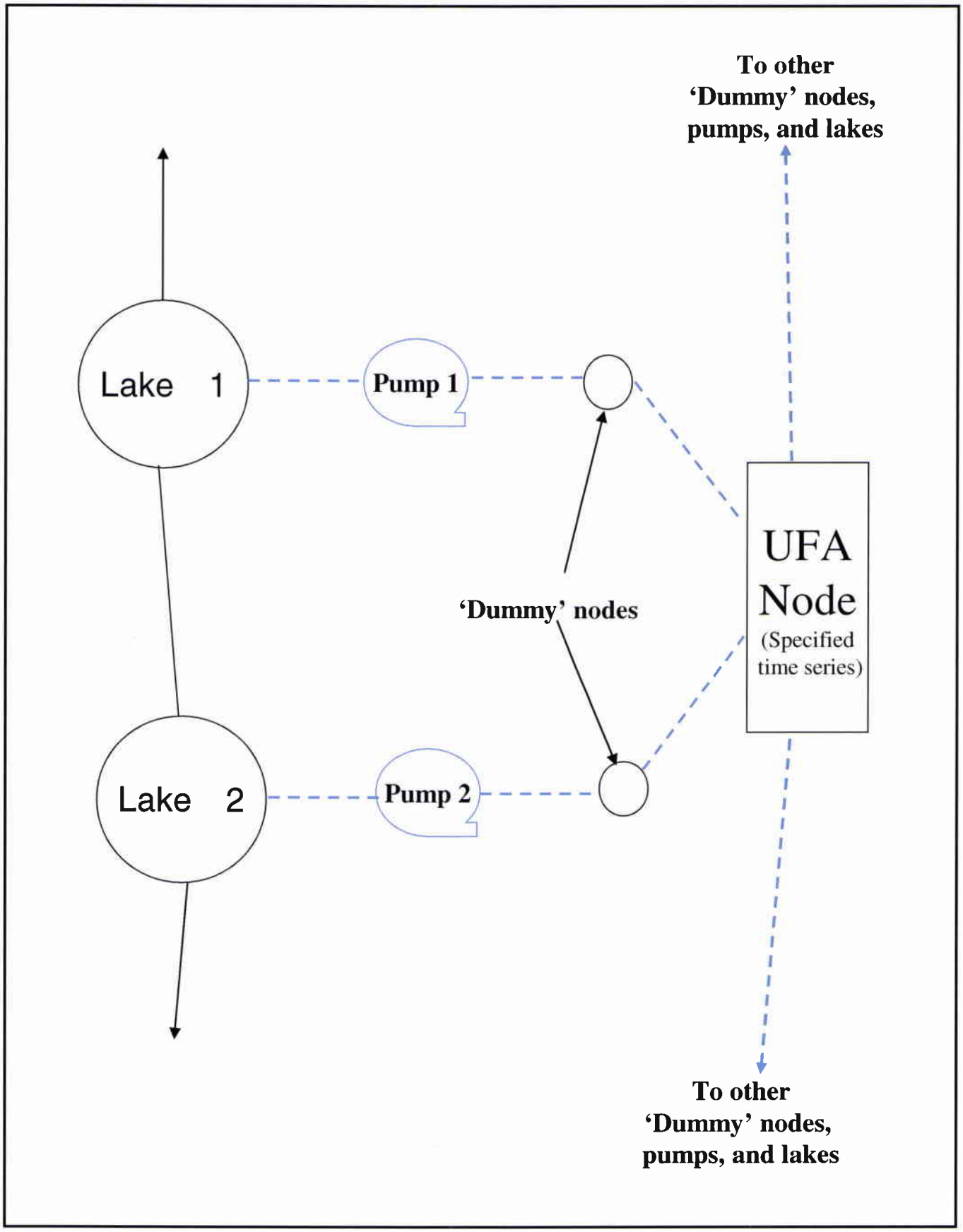
A = Cross sectional flow area (i.e. area of the lake at a given stage); and,

B = Thickness of the ICU.

In this particular region, there is a downward head gradient toward the UFA, indicating that the direction of flow will almost always be from the lake to the UFA (Boniol et al., 1993).

Hydraulic Model Representation of Lake Seepage

The flow of water from lakes to the underlying groundwater system (UFA) was represented in the SWMM model by using an equivalent, head-dependent pump (stage-discharge relationship) in the EXTRAN block for each lake. The flow from this hypothetical pump is a function of the modeled lake elevation, the lake area, the hydraulic properties of the aquifer, and the piezometric elevation of the UFA. The piezometric elevation of the UFA was modeled as a boundary condition with a monthly time series. The use of pumps within the SWMM EXTRAN block has two main restrictions. The first restriction is that the pump outflow node must be unique for each pump; in other words, the receiving node can not have any other pumps connected to it. Secondly, the receiving node may not have a specified time series. Therefore, a series of 'dummy' nodes and conduits were used to simply allow the pumps to operate as specified. Each pump is connected to a lake and to a downstream 'dummy' node. Each downstream 'dummy' node is then connected to the UFA boundary condition node (with a specified time series of piezometric elevation) using a 'dummy' conduit. The characteristics of the 'dummy' conduits were specified so that the elevation of the 'dummy' node was equal to the piezometric elevation of the UFA. As such, the flow from each pump is dependent on the modeled lake elevation and the elevation in the downstream 'dummy' node. An example of the conceptual model schematic for the representation of the groundwater outflow is shown in **Figure 2-15**.



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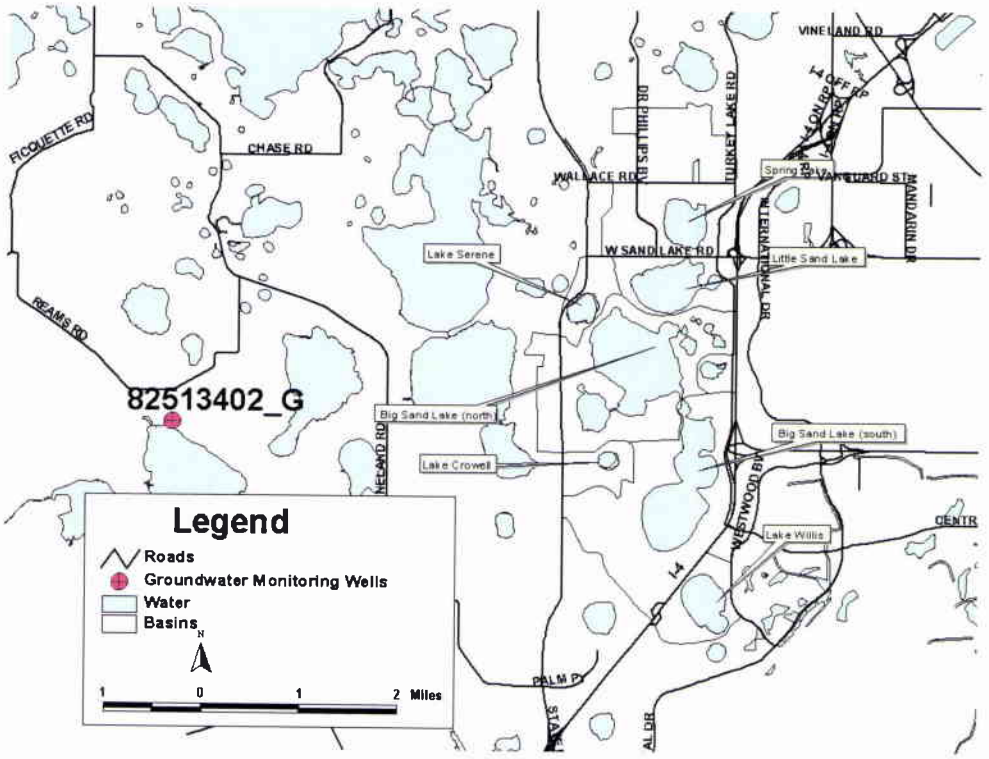
Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

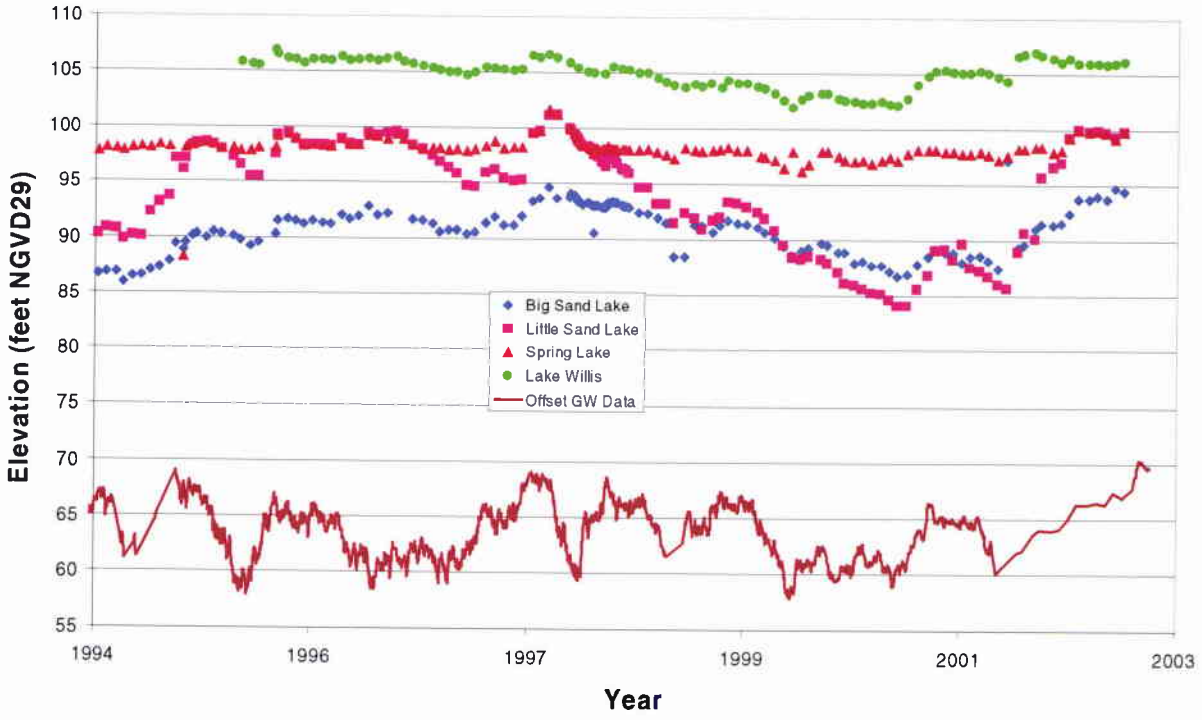
Figure 2-15
Conceptual Model Schematic for the Representation of Groundwater Outflow

CDM

A time series for the piezometric elevation of the UFA was developed based on data obtained from the South Florida Water Management District DBHYDRO database (SFWMD, 2003). Daily data from monitoring well 82513402_G was obtained from March 1966 to April 2002 (**Figure 2-16**). Since this well is located roughly 4 to 5 miles from the Big Sand Lake System, it was necessary to adjust this data using USGS Potentiometric Surface Maps of the Floridan Aquifer. These maps show contours of the potentiometric surface for the months of May and September. Starting with 1994, the groundwater data was offset according to these published contours for the wet and dry season. The average offset was 20.5 feet NGVD, and did not typically fluctuate by more than a few feet. Since the period of record for the groundwater data ended in April of 2002, the values through 2003 were developed by subtracting the elevation of Big Sand Lake by the average difference between the Big Sand Lake elevation and the offset groundwater data (average difference = 27.47 feet, standard deviation = 2.58). After the offset groundwater data time series was developed for the model simulation period, average monthly values were computed and translated into a SWMM-formatted time series.

As indicated on **Figure 2-17**, the long-term hydrograph for the potentiometric surface of the UFA has steadily declined about 15 feet over the period of record. This is attributable to the large population increase and an associated increase in demand for potable water over this time period. However, the long-term decreasing trend in UFA piezometric elevation does not correlate with the increasing lake stages during the 80s and 90s. This observation is attributed to two main factors: (1) increased runoff to the lakes associated with increased development, and (2) increased sediment accumulation associated with the use of fertilizers and other agents. The hydraulic properties of the aquifer were initially estimated based on published values for leakance through the Hawthorn Unit, which is the least transmissive portion of the aquifer. Published leakance (K/t) values for the Hawthorn Unit vary by up to 5 orders of magnitude throughout the east-central Florida region (McGurk and Presley, 2002; Szell, 1993). This wide range of leakance values is typical of karst areas. For the initial model setup, a value of $0.5*10^{-5}$ $days^{-1}$ was assumed based on the values used in *Mapping Recharge to the Floridan Aquifer* (Boniol et al, 1993). Since the EXTRAN input requires a relationship between head differential and pumpage, the leakance term and bottom area were lumped into one parameter (conductance term). For the model input, a pumpage relationship was developed based on a head differential of 25 and 50 feet. The model-computed pumpage (or lake outflow to the groundwater system) varies linearly based on the pumpage vs. head differential relationship. Once the initial values were developed, the model pumpage was adjusted during model calibration. A summary of the calibrated pumpage values (based on a head differential of 25 feet) and the corresponding leakance is presented in **Table 2-10.**





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Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

Figure 2-16
Floridan Aquifer
Groundwater Data

CDM

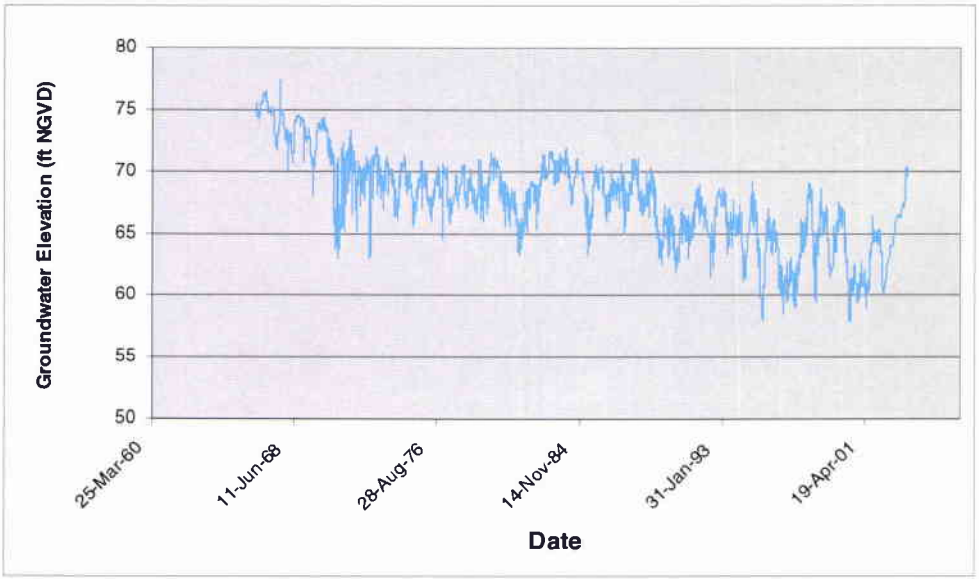


Figure 2-17
Potentiometric Surface Elevation of the Upper Floridan Aquifer in the Vicinity of Big Sand Lake

Table 2-10
Calibrated Model Groundwater Leakance Values

EXTRAN Junction	Name	Area (acres)	Lake Bottom Area (ft^2)	Calibrated Pumping Rate (CFD/s)[1]	Corresponding Leakance (1/days)
100	Big Sand Lake - South	4.24E+02	1.85E+07	0.96	1.80E-04
300	Lake Willis	1.82E+02	7.91E+06	0.06	2.62E-05
500	Lake Crowell	2.28E+01	9.93E+05	0.06	2.09E-04
700	Big Sand Lake North	7.16E+02	3.12E+07	0.90	9.98E-05
900	Boo Boo Lake	2.14E+01	9.32E+05	0.06	2.22E-04
1100	Lake Serene	4.61E+01	2.01E+06	0.06	1.03E-04
1300	Little Sand Lake	1.54E+02	6.71E+06	3.10	1.60E-03
1500	Spring Lake	1.36E+02	5.92E+06	0.18	1.05E-04

[1]Calibrated Pumping Rate is based on a head difference of 25 feet

2.4 Water Quality Data Summary

CDM reviewed two sources of water quality data. The first source was the 2003 Aquatic Plant Management Plan for Big Sand Lake (2003 Plan) prepared for the Orange County Environmental Protection Division (EPD) and the second source was the water quality data available from the EPD web site. CDM only summarized these data. A detailed evaluation of these data was not part of this study.

2003 Plan

This report provides an overview of the lake system and included a management plan for the control of invasive and non-native aquatic vegetation. The species of concern include primarily cattail (*Typha latifolia*) and torpedo grass (*Panicum repens*). It was noted that an effective management plan has been in place since the 1990s to control *Hydrilla*.

Lake Watch data is cited in the report and suggests that the quality of the water in Big Sand Lake is good. Total phosphorous averages 7 ug/l, total nitrogen averages 500 ug/l, total chlorophyll averages 2.3 ug/l and the Secchi depth averages 14.7 feet. The period of record considered was from 1996 to 1999.

The FDEP 305(b) Report is also referenced in the 2003 Plan and notes that the water quality index (WQI) for Big Sand Lake is less than or equal to 30, which indicates "good" water quality. The WQI is a derived index number that takes into account water clarity, dissolved oxygen, oxygen demand, bacteria, nutrient concentration and biological diversity.

The 2003 Plan recommended the use of hand and mechanical harvesting, herbicide application, bio-control, lake drawdown and sediment removal to control the invasive/non-native plant populations.

EPD Sampling Data

The EPD *Lake Ranking Report by Tropic State Index* (Lake Report) and various water quality sampling data for Big Sand Lake was downloaded from the Orange County web site. The Lake Report has ranked Big Sand Lake (North and South), Little Sand Lake, and Spring Lake according to their Tropic State Index (TSI). The TSI values are 24, 25, 26 and 34 for Big Sand Lake North, Big Sand Lake South, Little Sand Lake, and Spring Lake, respectively. Each of these lakes is characterized as "Oligotrophic" in which the TSI ranges from 0 to 49. This type of lake is generally associated with good water quality, with low levels of nutrients and algae and often a limited fish population.

EPD has also collected limited water quality sampling for Big Sand Lake, Little Sand Lake, Spring Lake and Lake Willis. Lake Willis has only recently been added and as such has a limited period of record available from the web site. Additional data was obtained from EPD. There are approximately 30 to 40 readings for each lake sampled. The period of record is approximately from 1994 to the present. A summary of these data is presented in **Table 2-11**.

Table 2-11
Average Water Quality Parameter Values and Number of Samples

Lake Name	Secchi Depth (m)	D.O. (mg/l)	Temp. (Celcius)	BOD (mg/l)	TP (filtered) (mg/l)	NO2 (mg/l)	NO3 (mg/l)	NH3 (mg/l)	TKN (mg/l)	TSS (mg/l)
Spring Lake	3.8	7.6	24.6	1.4	0.028	0.005	0.043	0.087	0.505	2.4
Count	37	37	37	28	23	9	29	27	36	24
Little Sand Lake	3.7	7.6	24.6	1.5	0.009	0.037	0.019	0.039	0.483	2.8
Count	22	24	24	8	12	6	6	9	22	10
Big Sand Lake North	3.9	7.9	27.8	1.4	0.010	0.005	0.032	0.067	0.535	10.0
Count	44	44	44	30	22	6	23	28	41	26
Big Sand Lake South	3.4	7.9	24.3	1.2	0.010	N/A	0.047	0.048	0.512	2.1
Count	24	36	37	23	18		20	19	34	17

As shown in the table, there are sufficient readings for each of the tabulated parameters to have a moderate amount of confidence in the average readings. The clarity of all the lakes is very good, with an average secchi depth of 3.7 meters (approximately 12 feet). The dissolved oxygen is also very good in all lakes. BOD and the reported nutrients do not appear to be problematic. Finally, TSS is very low. From this brief review of the available data, it would appear that there are no obvious water quality concerns regarding these lakes, which may be a consideration in alternatives that include an aquifer recharge component.

Section 3
Results

3.1 Introduction

Using the data described in Section 2, CDM developed the SWMM model representation of the Big Sand Lake Study Area that was used to evaluate the four alternatives defined in the scope of services for improved lake level management. The four alternatives evaluated included:

- Alternative 1 - Improved Lake Interconnections
- Alternative 2 – Stormwater Aquifer Recharge Well
- Alternative 3 – Stormwater Pump Station
- Alternative 4 – Stormwater Reuse

This section of the report discusses the calibration of the stormwater model followed by its application for evaluating the different lake level management alternatives considered for this study.

3.2 Model Calibration

Model calibration refers to the adjustment of model parameters within published limits so that the simulated response approximates measured data taken in the field during a real rainfall event. This exercise serves as a reality check on model results, and helps to establish model reliability and credibility. During the development of the hydrologic and hydraulic models, either measured or standard literature values were used for modeling parameters. During calibration, parameter values were fine-tuned within acceptable limits until the model output reflected the observed lake stage elevations.

For this study, the model was calibrated to several years of rainfall data using continuous simulation techniques as compared to a discrete (single) storm event. Continuous model simulation was warranted because the observed high lake levels in the chain of lakes were a result of above normal rainfall over a period of time and not a result of a discrete event. As defined in the scope of services, CDM calibrated the stormwater model to a period of record mutually agreed upon by the County. The two primary factors used to select the calibration period were land use and availability of measured data (rainfall and lake level data).

Land use is important because it is the primary factor in estimating the volume and rate of which rainfall is converted to stormwater runoff. As the impervious area increases (development), the potential for higher runoff volumes also increases. The amount of increased runoff volume is dependent upon the types of stormwater controls associated with new development. Therefore, consideration was given to

selecting a period of record where the existing land use was relatively constant. Most of the development within the Big Sand Lake Study Area occurred in the mid to late 1990s. Therefore, it was agreed that the period of record should start no earlier than 1995.

As presented in Section 2, the County has measured rainfall data and lake stage data for the Big Sand Lake Study Area. Specifically, the County monitors lake level data for Big Sand Lake (1959- Present), Little Sand Lake (1960-Present), Spring Lake (1960-Present), Lake Serene (1998-Present), Lake Crowell (1963-Present), and Lake Willis (1970-Present). The frequency of the lake level readings varies over time by lake. Lake level readings were collected on a consistent basis for Big Sand Lake and Little Sand Lake (monthly readings). Currently, the lake levels are recorded on a monthly basis with the last 10 years being the most consistent in terms of lake level recording frequency. Additionally, the County maintains a rainfall station on Spring Lake, which is also in the study area. Rainfall has been recorded at this station since 1989. Following CDM's review of rainfall data, lake level data, and land use information, CDM selected a calibration period between January 1995 and October 2003. It should be noted that CDM factored in the effect of the August 9, 2003 breach between Big Sand Lake and Little Sand Lake into the model calibration.

3.2.1 Model Calibration Results

CDM used the data described in Section 2 to develop a set of physically-based parameters used in SWMM to estimate stormwater runoff and corresponding lakes stages. Select parameters were then adjusted plus and minus 10 percent to see the impact on predicted lake levels. Parameters included in this sensitivity analysis included:

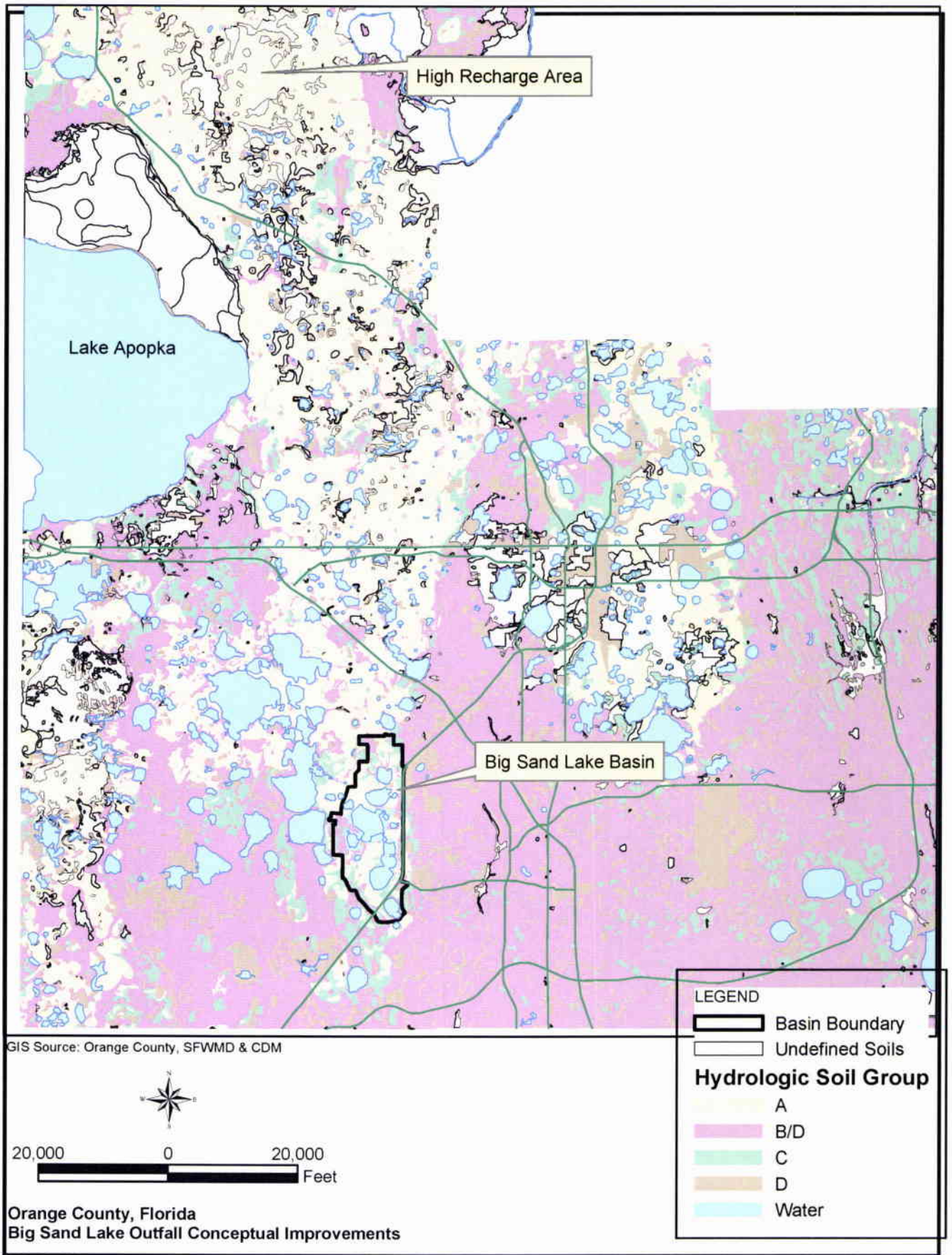
- Land Use Percent Imperviousness
- Lake Stage-Area Relationships
- Available Soil Storage
- Available Land Surface Depression Storage
- Lake Seepage to the Floridan Aquifer

Using the SWMM model, CDM simulated hourly rainfall data for a 1-year period of record (2002) with initial estimates of hydrologic parameters. The resulting predicted lake levels were typically below measured values. CDM then increased each parameter by 10 percent to see the net effect on the predicted lake levels. Only one parameter was adjusted per simulation. The results showed that the lake seepage representation had the greatest impact on predicted lake levels during both dry and wet periods. The land use percent imperviousness values, stage-area relationships, available soil storage, and available depression storage had little effect on predicted

stages. Typically, these parameters resulted in a peak stage change at any one time of less than 0.3 feet whereas a 10 percent change in the seepage representation changed predicted lake stages by several feet at any one time. This sensitivity analysis showed that the lake seepage representation is a critical factor in model calibration.

Following these initial model runs, CDM used the historical rainfall data between January 1995 and August 2003 (pre-breach) to see how the predicted lake stages compared to the measured lake stages. This initial simulation showed that lake levels were under estimated throughout the period of record by several feet especially during 2001 and 2002. During these periods, a comparison was made between the rainfall volumes measured at the OIA station (hourly rainfall) and the Spring Lake station. This comparison showed that the annual rainfall volumes reported at OIA (54.8 inches and 66.6 inches) did not correlate well to the annual totals tabulated at the Spring Lake station (42.6 inches and 72.6 inches). Therefore, the rainfall data was modified by replacing the OIA data with the Spring Lake data. As discussed in Section 2, the Spring Lake rainfall data was not available in hourly format. Therefore, CDM distributed the daily totals reported at Spring Lake temporally following the OIA rainfall data. If no rainfall was measured at OIA and rainfall was measured at Spring Lake, then CDM distributed the rainfall evenly between the hours of 12 noon and 7 pm. Where no rainfall was recorded at Spring Lake and there was rainfall recorded at OIA, CDM removed these rainfall volumes from the data set. The hourly rainfall file was then checked so that the annual rainfall volume in the data set matched that recorded at Spring Lake. One future consideration may be for the County to format its collected rainfall data (typically recorded in 5-minute intervals) into a standard hourly NWS format that could be more readily incorporated into public domain used for continuous simulation. Many of the public domain models can directly read hourly rainfall data in NWS format.

Once these adjustments were made, CDM repeated the continuous simulation and the match between simulated and observed lake levels improved. However, further parameter adjustment was needed. Therefore, CDM slightly adjusted the lake seepage representation (increased) for each lake and repeated the simulation. Predicted lake levels reasonably matched measured lake levels with the exception of Little Sand Lake after just a few iterations. The predicted rate of change in Little Sand Lake was significantly less than the measured rate of change, even during periods of little or no rainfall. Therefore, it was concluded that the hydraulic leakance in Little Sand Lake was relatively high. In addition to the high fluctuations in lake levels in this primarily closed basin, **Figure 3-1** shows that the Big Sand Lake Study Area is located at the southern end of a large area of sandy soil types that has its northern end in the Big Wekiva/Lake Apopka area. The northern end is well known as a high recharge area to the Floridan aquifer (Boniol et. al, 1993). This sensitivity may suggest that an integrated or linked groundwater surface water model may be warranted as part of a final design of any recommended lake level control structures. Once the seepage term (hydraulic leakance of the intermediate confining unit) was adjusted,



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12/18/03

Figure 3-1

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Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure 3-1
Big Sand Lake Location

CDM made minor adjustments to the less sensitive terms (described above) until predicted lake stages matched reasonably well with measured stages.

A comparison of the resulting predicted lake stages for Big Sand Lake, Little Sand Lake, Spring Lake, and Lake Willis are shown in **Figures 3-2** through **Figure 3-5**, respectively. As indicated on the graphs of the results, the model is matching observed water levels in the chain-of-lakes moderately well. The model reproduces the general trends in lake water level fluctuation reasonably well. Additionally, the model reproduces the frequency and magnitude of high lake water levels very well which is critical for this study.

Following this simulation, CDM used the model to simulate lake levels under post-breach conditions (post August 9, 2003). The model-predicted peak lake stages were close to measured stages. CDM again slightly lowered the lake seepage parameter for Little Sand Lake, which resulted in predicted stages closely matching measured stages. The results of the post-breach simulation are presented in **Figure 3-6**. As indicated by the close match between simulated and observed lake levels shown on Figure 3-2 through Figure 3-6, the model is considered to be reasonably calibrated and, therefore, acceptable for comparing the benefits of the conceptual lake level control management strategies.

3.3 Alternatives Analysis

Using the calibrated SWMM model representation of the Big Sand Lake Study Area, CDM evaluated the four lake level management strategies previously discussed. The results of these evaluations are presented in the following subsections.

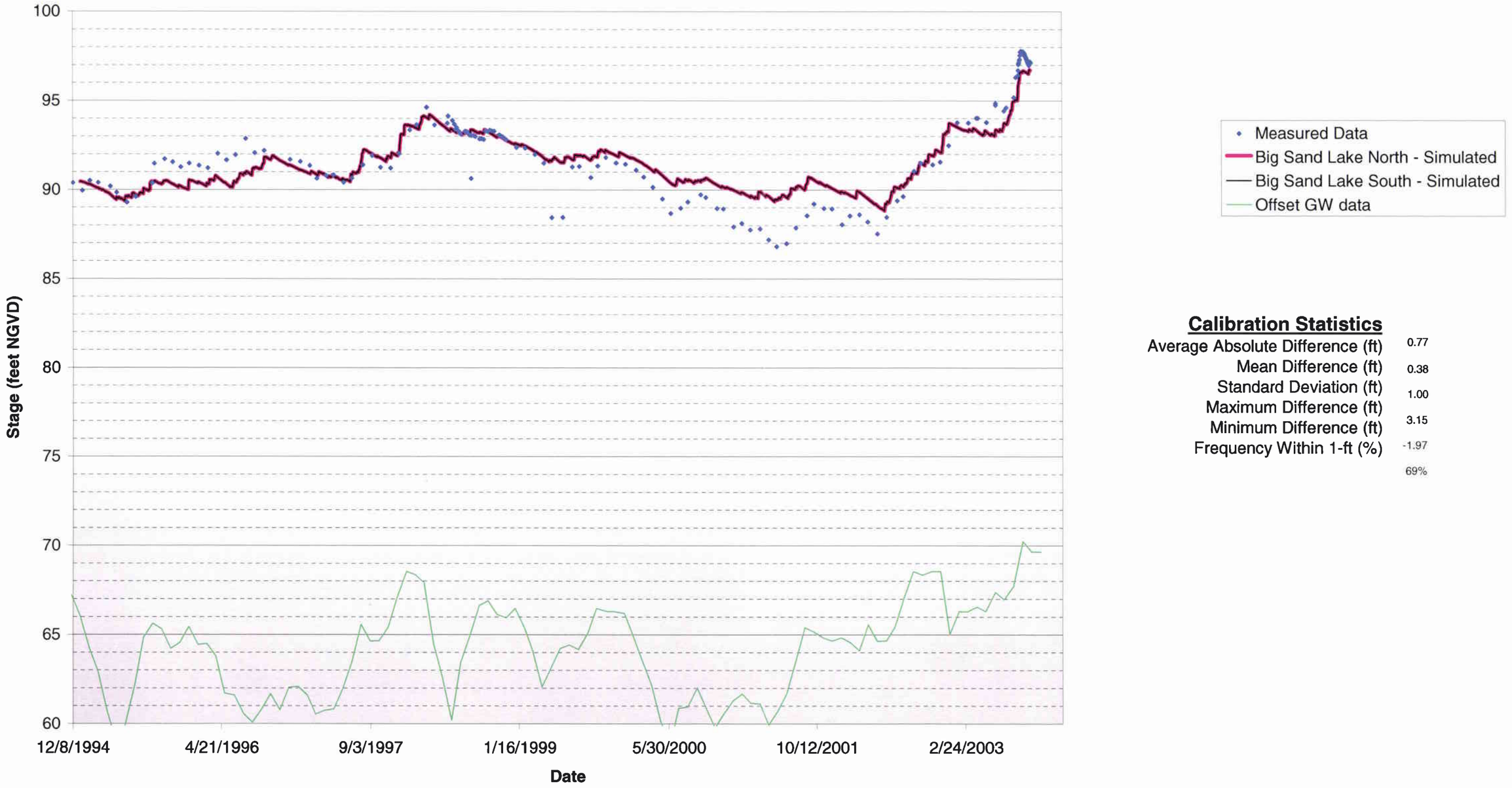
3.3.1 Alternative 1 - Improved Lake Interconnections

This alternative primarily consisted of evaluating the feasibility of a gravity driven outfall pipe (24-in RCP) from Big Sand Lake to the road drainage system on Central Florida Parkway. Because of the elevations of the existing stormwater infrastructure under I-4 (See **Figure 3-7**), two versions of this scenario were examined. Alternative 1A (first scenario) considered an interconnection of a 24-in RCP with the existing I-4 infrastructure. Alternative 1B included the construction of a new stormwater outfall system around the existing I-4 infrastructure with a connection to the VWCD C-1 Canal just downstream of Central Florida Parkway. These two stormwater pipe alignments are generally shown on **Figure 3-8**.

Alternative 1A

Alternative 1A evaluated the benefit of constructing 2440 feet of 24-in RCP from Big Sand Lake to the junction box located at Model Node 0030, which is part of the existing stormwater pipe system east of I-4. The upstream invert of the new outfall was set at elevation 94.0 ft-NGVD and the downstream invert was set at 93.4 ft-NGVD, which is the invert of the existing 48-in RCP conveying stormwater runoff to the VWCD C-1 Canal. This configuration would be below the outfall pipe from the

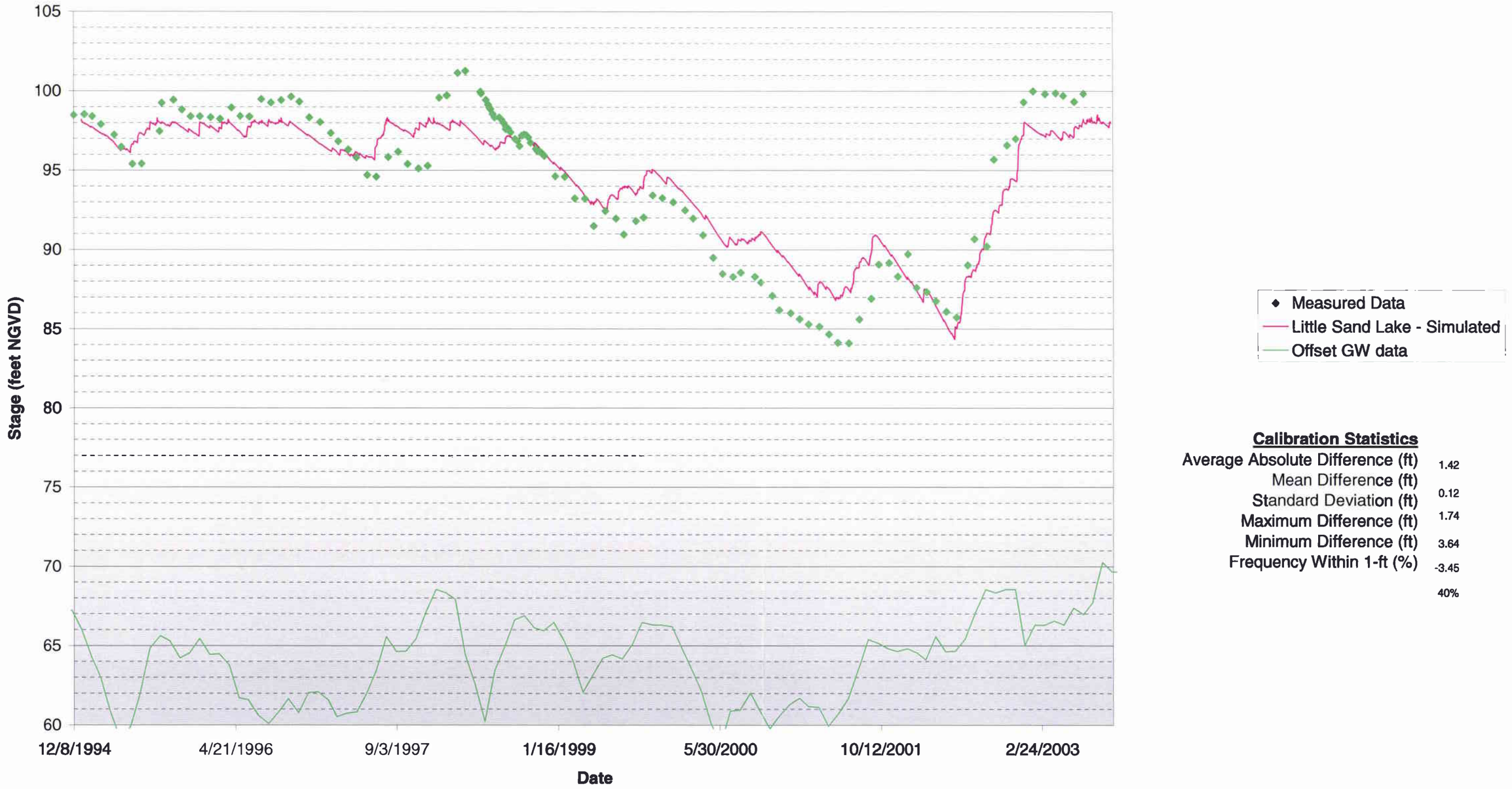
Figure 3-2
Calibration of Big Sand Lake (Pre-Breach)



Calibration Statistics

Average Absolute Difference (ft)	0.77
Mean Difference (ft)	0.38
Standard Deviation (ft)	1.00
Maximum Difference (ft)	3.15
Minimum Difference (ft)	-1.97
Frequency Within 1-ft (%)	69%

Figure 3-3
Calibration of Little Sand Lake (Pre-Breach)



Calibration Statistics

Average Absolute Difference (ft)	1.42
Mean Difference (ft)	0.12
Standard Deviation (ft)	1.74
Maximum Difference (ft)	3.64
Minimum Difference (ft)	-3.45
Frequency Within 1-ft (%)	40%

Figure 3-4
Calibration of Spring Lake (Pre-Breach)

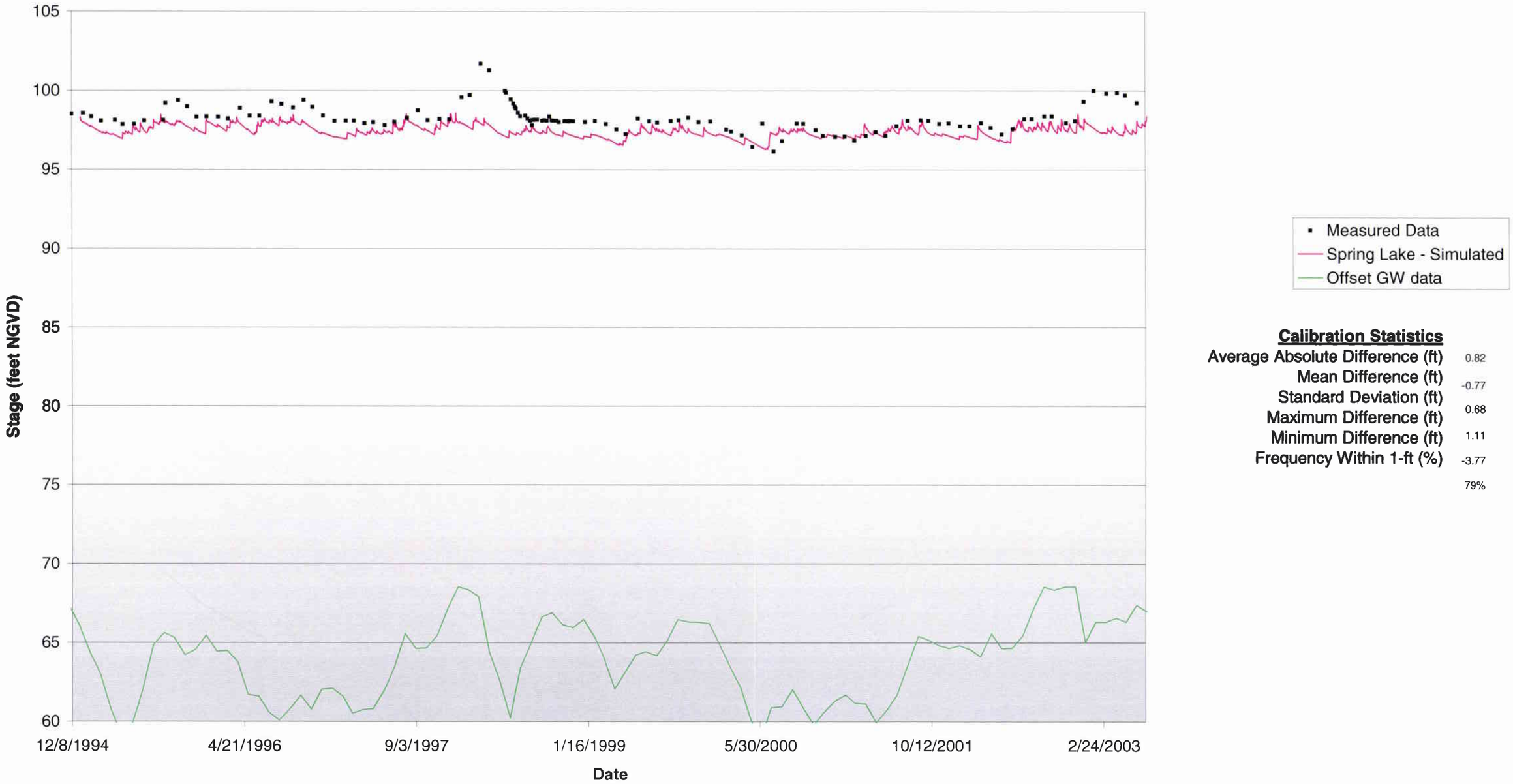


Figure 3-5
Calibration of Lake Willis (Pre-Breach)

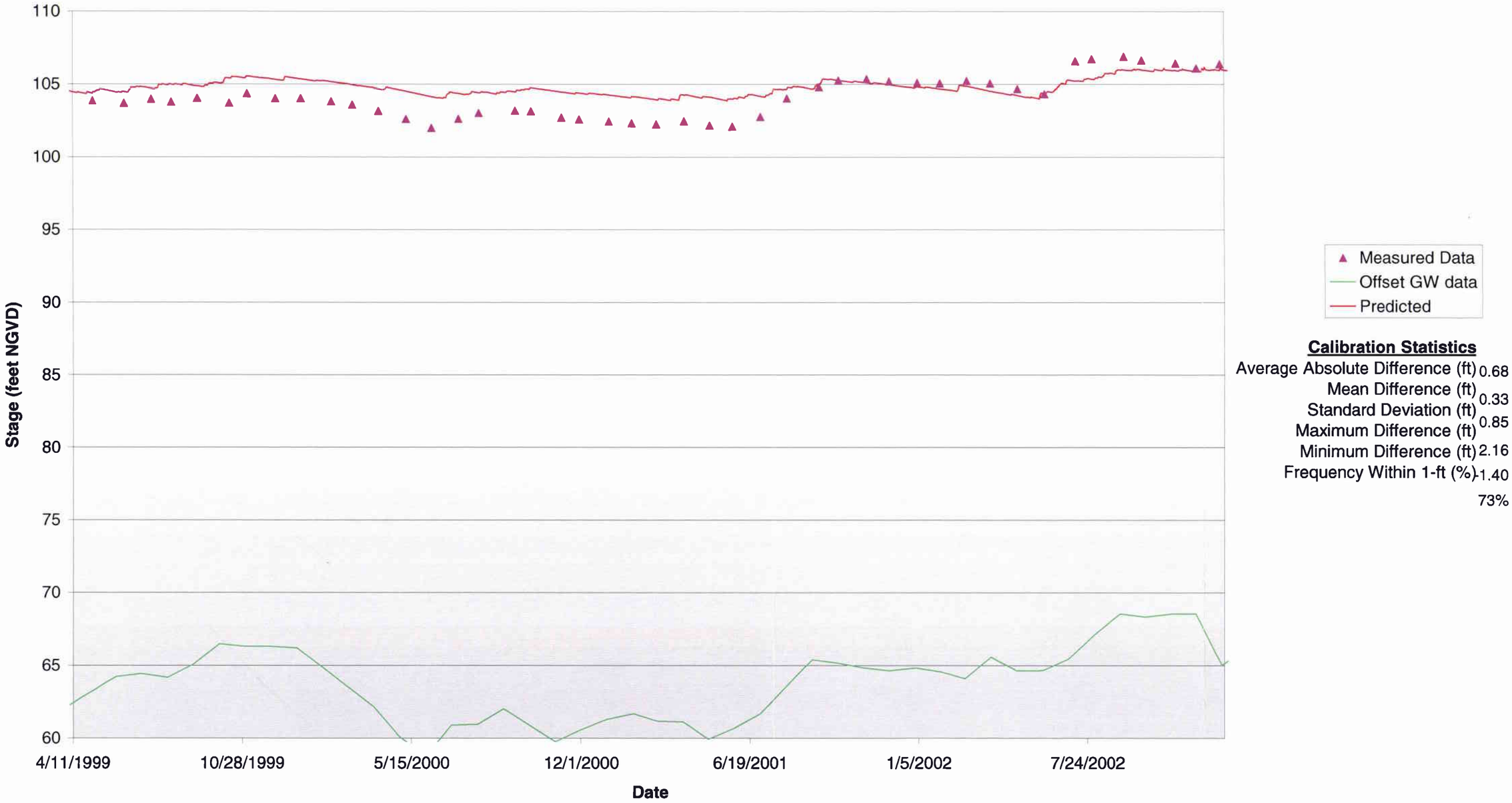
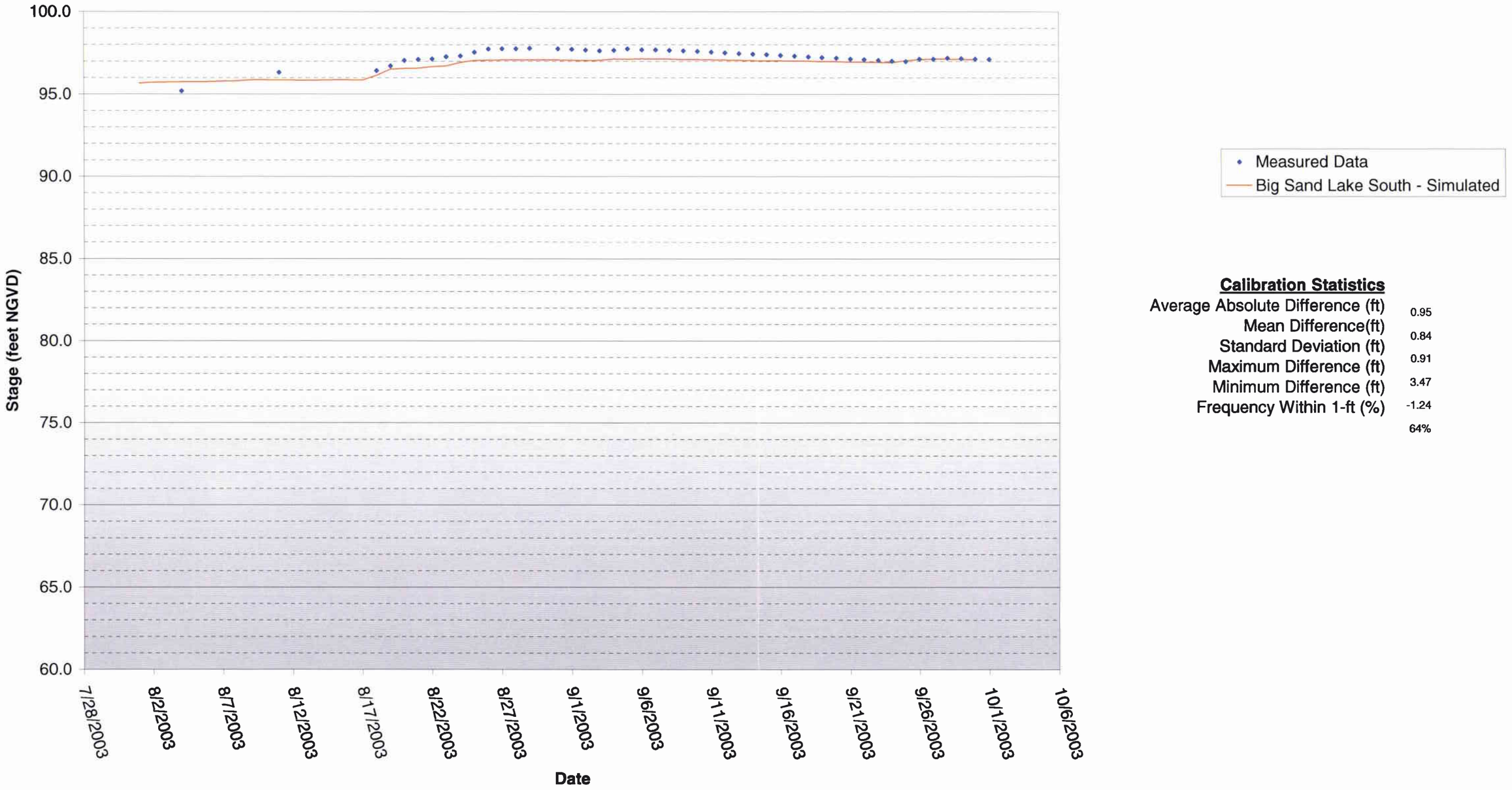
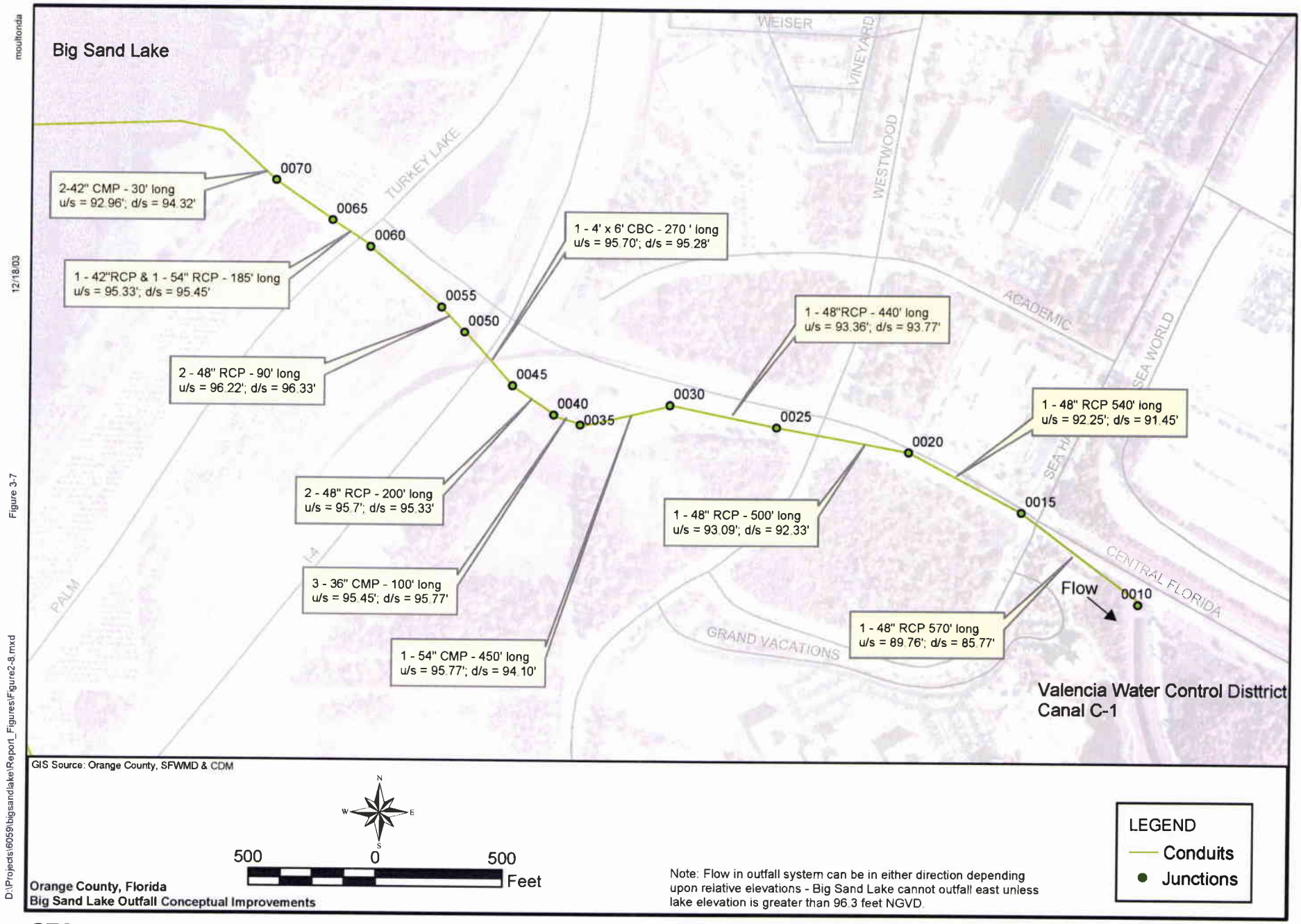


Figure 3-6
Calibration of Big Sand Lake (Post-Breach)



Calibration Statistics

Average Absolute Difference (ft)	0.95
Mean Difference(ft)	0.84
Standard Deviation (ft)	0.91
Maximum Difference (ft)	3.47
Minimum Difference (ft)	-1.24
Frequency Within 1-ft (%)	64%



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CDM

Figure 3-7
Central Florida Parkway Drainage Configuration

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Figure 3-8

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Big Sand Lake

BRESSE

WILKOW

WEISER

VINEYARD

FALLBROOK

FLORIDA FESTIVAL

WESTWOOD

TURKEY LAKE

ACADEMIC

SEA HARBOR

PALM

I-4

CENTRAL FLORIDA

GRAND VACATIONS

0070

0065

0060

0055

0050

0045

0040

0035

0030

0025

0020

0015

0010

0200

0250

0150

Alternative 1A
24" RCP - 2450' long
U/S = 95.0'; D/S = 93.4'

Alternative 1B
24" RCP - 4540' long
U/S = 92.0'; D/S = 85.0'

Valencia Water Control Disttrict
Canal C-1

GIS Source: Orange County, SFWMD & CDM

N

W E

S

400 0 400

Feet

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

Note: In both alternatives flow can be either from Big Sand Lake to the east (VWCD) or from the east to Big Sand Lake. The direction is a function of the relative tailwater/headwater elevations.

LEGEND

Conduits

Junctions

Outfall Improvement

Alternative 1A

Alternative 1B

CDM

Figure 3-8
Gravity Outfall Improvement

stormwater pond located just northeast of Central Florida Parkway between Turkey Lake Road and I-4 (invert elevation 100.0 ft-NGVD). The capacity of this proposed outfall system would be limited (approximately 4 cfs) because of the relatively flat slope (0.03 percent) that would be required to tie into the existing stormwater infrastructure.

These data were input to the stormwater model and simulated for the 1995 to 2003 (October) study period. The resulting peak stages predicted by the stormwater model are presented in **Figure 3-9**. As can be seen from the Figure, the peak stage reduction between the existing condition and proposed condition (Alternative 1A), were negligible. This is primarily because of the limited capacity that can be achieved by gravity based upon the existing slope. Therefore, this alternative was eliminated from further consideration.

Alternative 1B

As previously described, Alternative 1B consisted of construction approximately 4540 feet of 24-in RCP from Big Sand Lake to the VWCD C-1 Canal headwaters located on the upstream end of the Central Florida Parkway (See Figure 3-8). This configuration provides an opportunity to control Big Sand Lake at an elevation below 94 ft-NGVD, by avoiding the existing infrastructure surrounding I-4. For this alternative, the upstream invert elevation was set at 92.0 ft-NGVD and the downstream invert elevation was set at 85.0 ft-NGVD.

As can be seen on Figure 3-9, Alternative 1B provides improved lake level management over Alternative 1B. Predicted lake stages are reduced up to 1.5 feet below conditions predicted over the same period of time without any improvements. However, there are a number of potential implementation constraints to be considered. First, constructing a cross drain under I-4 would require a jack and bore operation as compared to an "open" cut. This would need to be done at a location that avoided the pilings and similar structural considerations associated with the I-4 bridge embankment. Therefore, it would be likely that the new crossing would need to occur north of Central Florida Parkway. Once the new outfall crossed I-4, it may be able to align the system within the existing Central Florida Parkway easement. The segment from Big Sand Lake through I-4 and back to the Central Florida Parkway would require a new easement, which because of existing development, may be expensive and difficult to achieve along this highly traveled corridor. Also, it would be a significant challenge with permitting a new outfall system under I-4. Several permits would be required in order to construct this alternative. The SFWMD, FDOT and VWCD will have to be consulted and permits would need to be obtained from each entity.

Figure 3-9
Alternative 1 Gravity Outfall Improvement

Permit Considerations

For this alternative, CDM discussed permit concerns with the VWCD, FDOT, and the SFWMD. Presented below is a summary of the issues that would need to be addressed through permitting:

VWCD

The VWCD C-1 Canal would be the receiving water body for the new outfall system permitted under this alternative. Review with VWCD staff indicates that the C-1 Canal has a capacity of 300 cfs, of which 200 percent has been accounted for by existing development. Therefore, the VWCD would be able to accommodate additional flows to the C-1 Canal from Big Sand Lake. However, before additional flows were accepted, the "proposer" of the improvements would have to develop a bank stabilization plan for the canal segments downstream of VWCD Structures S-101 and S-102 (amil gates). During the 2003 emergency pumping from Big Sand Lake to the C-1 Canal, the channel banks were scoured and collapsed just downstream of these structures. Scouring occurred for a distance of approximately 20 feet downstream of S-101 and for a distance of approximately 200 feet of S-102.

FDOT

CDM contacted FDOT regarding the permitting requirements associated with this alternative. FDOT stated that this improvement would require a Utility Permit. Typically, FDOT discourages construction of utilities under I-4. However, because of the historical concerns regarding high water levels in Big Sand Lake, it is likely they would support this type of improvement. The Utility Permit would require information on the bore path, water table, and existing utilities. The improvements can not interfere with existing FDOT stormwater systems.

SFWMD

Under Chapter 373, FDEP and the SFWMD have joint authority to control the discharge of stormwater. This alternative would require an environmental resource permit (ERP) from the SFWMD. Initial reaction to this alternative is that it would be difficult to design a gravity-based system as described because of the potential utility conflicts. Also, there are concerns with downstream flooding in Shingle Creek, which would lead to a controlled operating schedule to when excess stormwater from Big Sand Lake could be discharged to Shingle Creek. It is not expected that there would be ecological concerns by lowering the peak stages of Big Sand Lake, though this would need to be evaluated in more detail as part of the ERP process.

3.3.2 Alternative 2 - Aquifer Recharge

As previously described in Section 2, drainage or recharge wells have been used in the central Florida area since the early 1900s for the purpose of stormwater management. This became a common practice for urban drainage following the hurricanes that impacted central Florida between 1920 and 1960 (Hurricane Donna). In the 1960s, the Florida State Board of Health stopped granting permits for the construction of new drainage wells; however, replacement of existing drainage wells was allowed. In the

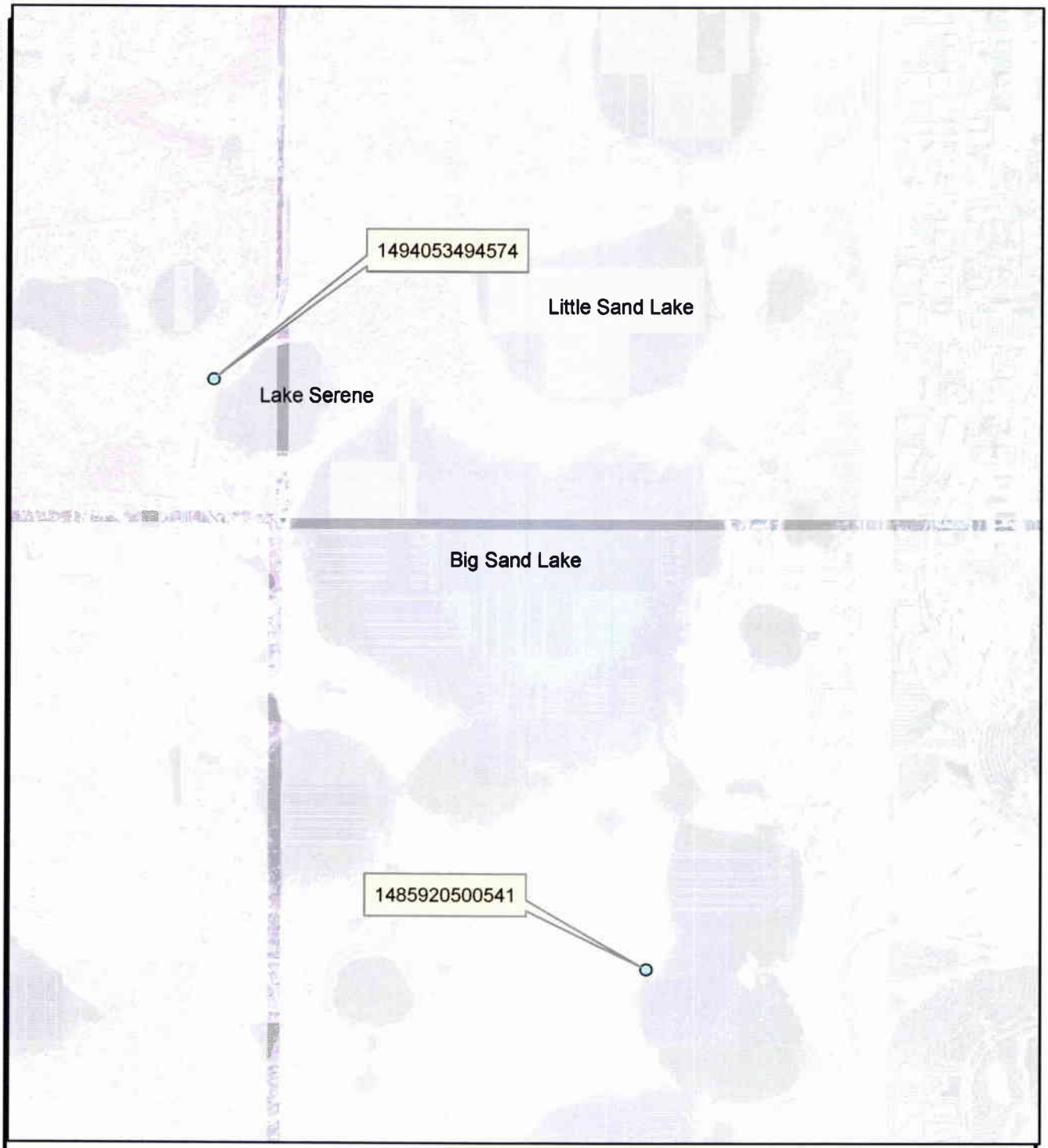
1970s, the state stopped granting permits for any drainage well projects as a result of concerns with aquifer contamination. Recently, the importance of wells to aquifer recharge has come to the forefront as a result of predicted water shortages in central Florida. Therefore, it may be feasible to return the 1970s philosophy where existing drainage wells can be converted to recharge wells because of the aquifer recharge benefit. This can be further supported because of the good water quality in Big Sand Lake (See Section 2).

CDM researched the drainage well records available from the SFWMD and the United States Geological Survey. Through this literature research, it was discovered that two drainage wells once existed within the Big Sand Lake basin at the locations shown on **Figure 3-10**. The 12-inch diameter recharge well located on Lake Serene (SFWMD Id. No. 1494053494574) was used for stormwater management associated with the Minute Maid Co. (company no longer present at this site). The 10-inch diameter well located on Big Sand Lake was a private well constructed in 1931 for flood control (See Appendix B). Based upon these records, it was determined that a recharge well based lake level management strategy is feasible. The potential location of the relocated recharge well is shown on **Figure 3-11**. It is noted that the conceptual cost includes a cost to obtain an easement, Orange County Board of County Commissioners owns a large parcel to the southwest of the historical recharge well location and it may be possible to relocate the recharge well to this parcel, thus enjoying a cost benefit.

Alternative 2 consisted of the evaluation of 6 recharge well rehabilitation alternatives and their resulting benefit on lake level control with and without the breach between Big Sand Lake and Little Sand Lake (12 total scenarios). The six recharge well combinations evaluated are:

- 1x 10-inch diameter well at elevation 90 ft-NGVD
- 1x 10-inch diameter well at elevation 92 ft-NGVD
- 1x 10-inch diameter well at elevation 95 ft-NGVD
- 2x 10-inch diameter well at elevation 90 ft-NGVD
- 2x 10-inch diameter well at elevation 92 ft-NGVD
- 2x 10-inch diameter well at elevation 95 ft-NGVD

Each scenario was simulated for the period of record between 1995 and October 2003 to evaluate the net effect on predicted water levels in Big Sand Lake. These results are presented graphically on **Figure 3-12** and **Figure 3-13**. The following conclusions can be drawn from the data on these figures:



GIS Source: Orange County, SFWMD & CDM

2,000 0 2,000 Feet

LEGEND
Basin Boundary
Drainage Wells

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

Note: ID numbers on figure are SFWMD Drainage Well IDs as referenced on Drain Well Inventory excerpt in Appendix B

CDM

Figure 3-10
Drainage Well Location Map

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moultonda

10348 Pointview Ct

Location of drainage well
based upon SFWMD database

Relocated drainage well
within obtained easement

Big Sand Lake

Parcel owned by OCBCC

GIS Source: Orange County, SFWMD & CDM

300 0 300
Feet

LEGEND
- Basin Boundary
- Drainage Wells
- Drainage RoW

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure 3-11
Drainage Well Alternative

12/18/03

Figure 3-11

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Figure 3-12
Alternative 2 Drainage Well (No Breach)

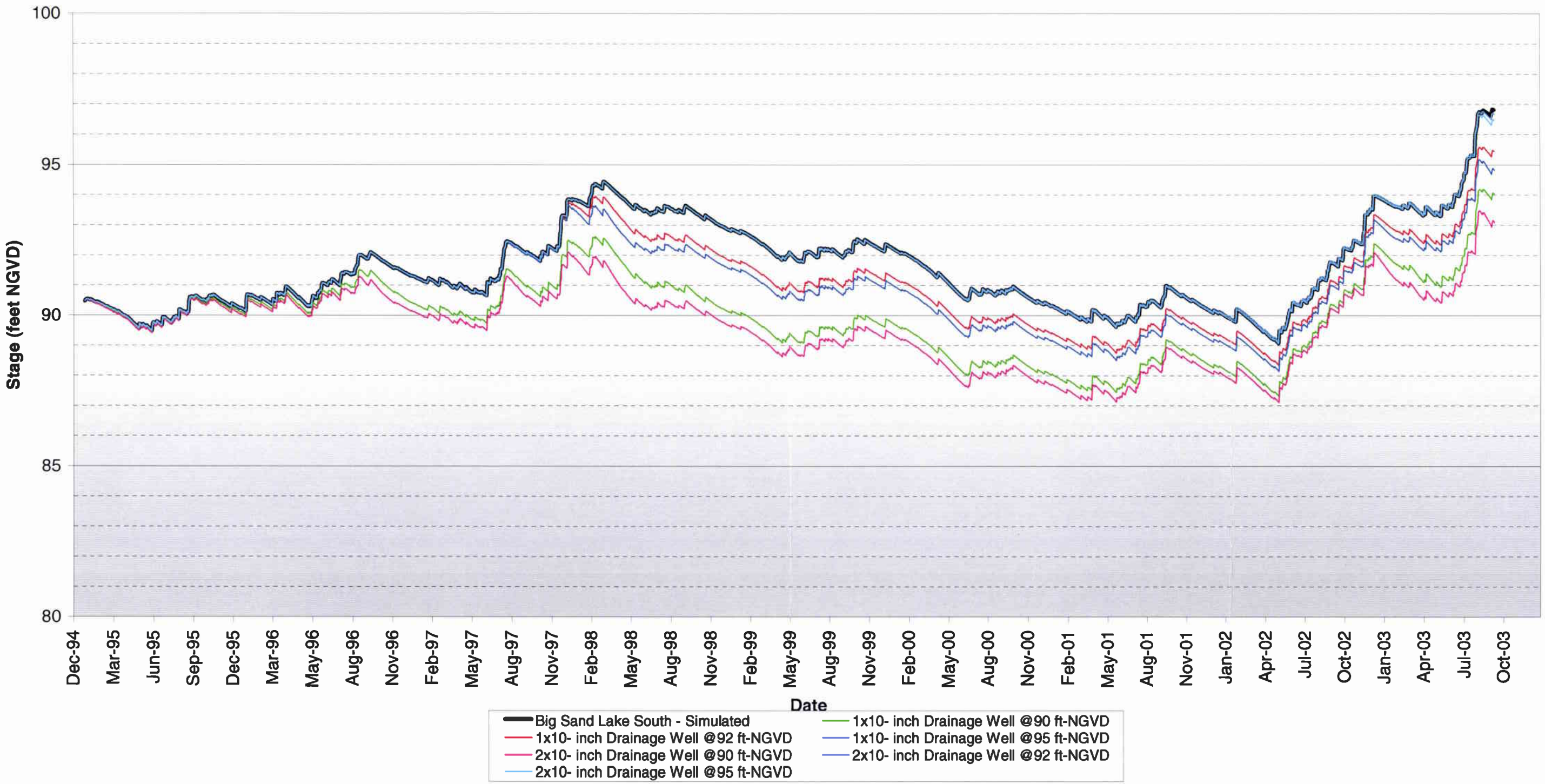

Figure 3-13
Alternative 2 Drainage Well (Breach)

- There is a minimal difference in the predicted peak stages (typically 3- to 6-inches lower) between the use of one or two 10-inch diameter recharge wells;
- The August 9, 2003 breach has minimal impact on the predicted water levels in Big Sand Lake with a recharge well system in place;
- A recharge well with a control elevation at 95 ft-NGVD does not appear to provide any lake level management benefit;
- Model results indicate that a recharge well with a control elevation at 92 ft-NGVD would reduce water levels in Big Sand Lake between 1 and 2 feet (peak below elevation 96 ft-NGVD), assuming similar hydrologic conditions as recorded since 1995; and,
- Model results indicate that a recharge well with a control elevation at 90 ft-NGVD (current normal water elevation) would reduce water levels in Big Sand Lake between 2 and 4 feet (peak below elevation 95 ft-NGVD), assuming similar hydrologic conditions as recorded since 1995.

Based upon these results, it can be concluded that the rehabilitation of the recharge well on Big Sand Lake would provide improved lake level management and would provide for aquifer recharge.

Permit Considerations

FDEP

For this alternative, the existing well on Big Sand Lake would be rehabilitated to the same specifications as the 1931 drainage well under the FDEP Underground Injection Control (UIC) Program [Chapter 62-528, F.A.C.). The location of the new well would have to placed on county-owned property or property donated by a landowner on Big Sand Lake. In this case, CDM has obtained a copy of the drainage well log from both the SFWMD and the United States Geological Service (USGS), though the well has not been physically located in the field. If the existing drainage well can be located, then it would be abandoned and replaced with a new recharge well with exactly the same construction as the existing well (a 10-inch diameter casing extending from land surface to a depth of 173 feet below land surface and 311 foot open hole section). A copy of the well log is not sufficient for this purpose (has to be physically located in field).

If the existing drainage well cannot be located an UIC Permit would be required for the new well. Also, the discharged lake water would have to meet State of Florida Drinking Water Standards (Chapter 62-550, F.A.C.) including the microbiological requirements. At a minimum, the lake water will not meet the Drinking Water Standards for iron, color, and coliforms. Water quality exemptions can be obtained from FDEP for iron and color ($6,000 a piece) since these parameters have Secondary Drinking Water Standards. However, there are no exemptions for microbial organisms. The lake water would be to be disinfected prior to discharge into the new

recharge well. This would require that the lake water be pumped into the UFA with liquid chlorine (sodium hypochlorite) injected in to discharged lake water at a prescribed rate using a metering pump system. Other treatment systems such as ozone could also be considered.

SFWMD
As described above, the permitting of recharge wells is through FDEP. However, any dewatering activities associated with the construction of a recharge well would require a water use permit from the SFWMD. Of the alternatives evaluated, the SFWMD would support this improvement because it lessens the likelihood of downstream impacts in Shingle Creek.

3.3.3 Alternative 3 – Stormwater Pump Station

For Alternative 3, CDM evaluated the benefit of adding a stormwater pump station to the Big Sand Lake study area for lake level management purposes. For this alternative, CDM evaluated two pumping scenarios with and without the August 9, 2003 retaining wall breach. The two scenarios are as follows:

- Three pump system (20 cfs each pump), with start elevations of 93 ft-NGVD (pump 1), 95-ft-NGVD (pump 2), and 97 ft-NGVD (pump 3). The pumps shut-off when Big Sand Lake water levels recede to elevation 90 ft-NGVD; and

- Three pump system (10 cfs each pump), with start elevations of 93 ft-NGVD (pump 1), 95-ft-NGVD (pump 2), and 97 ft-NGVD (pump 3). The pumps shut-off when Big Sand Lake water levels recede to elevation 90 ft-NGVD.

A potential site for a newpump station is adjacent to the existing outfall canal. **Figure 3-14** shows a potential alignment for the proposed pump station.

Each scenario was simulated for the period of record between 1995 and October 2003 to evaluate the net effect on predicted water levels in Big Sand Lake. These results are presented graphically on **Figure 3-15** and **Figure 3-16**. Several conclusions can be drawn from these figures as summarized below:

- There is a minimal difference in the predicted peak stages between the use of a 20 cfs or 10 cfs pumps;

- The model results presented graphically in Figure 3-15 and Figure 3-16 indicate that the predicted water elevations in Big Sand Lake would be below elevation 95 ft-NGVD under this alternative. Therefore, only the first pump would become operational (control elevation 93.0 ft-NGVD) if similar rainfall patterns occurred as was experienced since 1995.

- Model results indicate that either pump station configuration would have reduced water levels in Big Sand Lake by approximately 2 feet if in operation during this last wet season.

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Figure

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GIS Source: Orange County, SFWMD & CDM

150 0 150 300 Feet

LEGEND

Land Acquistion

- Access Road to Pump Station
- Outfall Drainage Easement
- Pump Station

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure 3-14
Potential Pump Station Location

Figure 3-15
Alternative 3 Pump Station (No Breach)

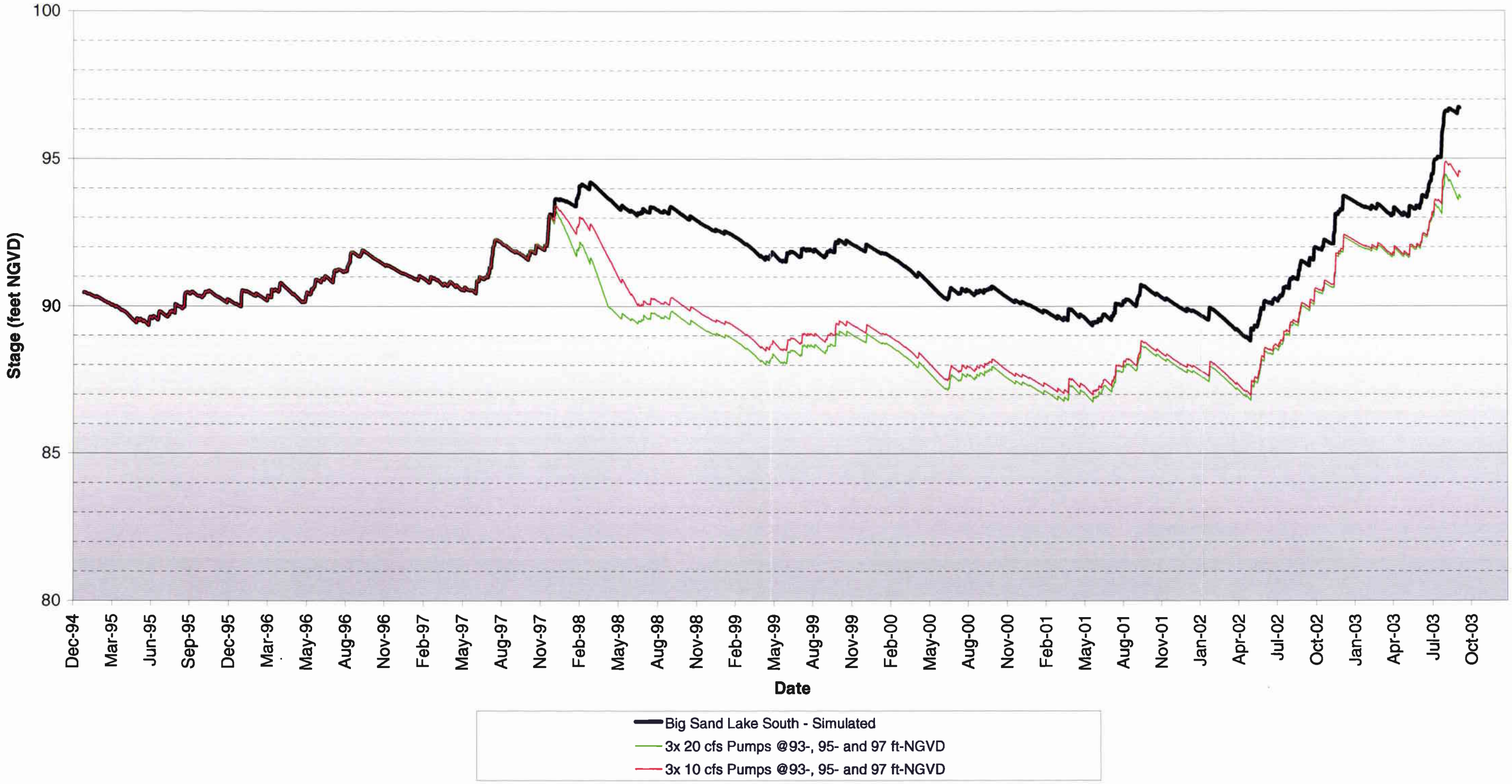

Figure 3-16
Alternative 3 Pump Station (Breach)

These results indicate that pump-based system would provide lake level management control. However, based upon historical lake level data, there could be several periods where the pump station would not be used for extensive periods of time (periods longer than 3 years). Additionally, this alternative does not promote water conservation since the water would be sent downstream as compared to the aquifer recharge benefits described under Alternative 2. For this reason, an alternative scenario may warrant further consideration. This would be to construct a permanent intake and discharge structure where the County could temporarily connect a high capacity portable pumping station.

This alternative may also be difficult to implement. The VWCD is currently responsible for the management of the canal system to which Big Sand Lake discharges when water levels exceed 96.3 ft-NGVD. This canal system serves multiple interests that include private development and FDOT. Therefore, there may be periods when the pumps would not be able to operate as a result of downstream flood impacts.

Permit Considerations

For this alternative, CDM discussed permit requirements with the VWCD, FDOT, and the SFWMD. The requirements would be the same as previously described for Alternative 1 and are summarized below:

VWCD

The VWCD C-1 Canal would be the receiving water body for the new pump station outfall system permitted under this alternative. VWCD staff have indicated the C-1 Canal has sufficient capacity to receive the additional flow from Big Sand Lake, however, a bank stabilization plan would be required.

FDOT

FDOT would require a Utility Permit for this improvement. Typically, FDOT discourages construction of utilities under I-4. However, because of the historical concerns regarding high water levels in Big Sand Lake, it is likely they would support this type of improvement. The Utility Permit would require information on the bore path, water table, and existing utilities. The improvements can not interfere with existing FDOT stormwater systems.

SFWMD

This alternative would require an ERP from the SFWMD. Discussions with SFWMD staff have indicated that this type of improvement would most likely require a pump operation schedule that is dependent upon downstream water levels. One possible scenario would be the allowance of the draw down of Big Sand Lake and Little Sand Lake to an elevation of 93.0 ft-NGVD at the end of the dry season (if needed). This would provide storage in the lakes for stormwater runoff during the wet season. However, pumping of water from the Big Sand Lake during the wet season would

require an emergency pumping permit from the SFWMD, which would require proof that there is imminent home flooding risk.

3.3.4 Alternative 4 - Stormwater Reuse

The development of reuse systems has evolved from a means of reducing pollutant loadings associated with surface water discharge to a critical part of the water supply in Central Florida. Through this evolution, municipalities have realized that seasonal differences in reclaimed water supplies and nonpotable water demands for irrigation tend to limit the average annual volume of reclaimed water that can be committed to beneficial reuse. The ability to use storage to overcome this limitation presents significant challenges due to the tremendous volumes required to equalize seasonal differences in supply and demand. Recognizing this limitation, the FDEP has included rules for the use of surface water, groundwater, treated stormwater and even drinking water to augment reclaimed water supplies (FAC 62-610.472). A copy of these regulations is included in **Appendix D.**

Figure 3-17 shows the alignment of the existing reuse lines in the vicinity of the Big Sand Lake chain as well as a potential treatment facility location. Many of the reuse lines are very large, especially in the vicinity of Sand Lake Road in the northern portion of the basin. According to Orange County staff the reuse in the Big Sand Lake area is public access reuse (PAR). PAR requires treatment, filtration (to reduce turbidity), and disinfection. There are 2 alternatives for the disposal of excessive water from Big Sand Lake. Alternative 4A - on-site treatment and disposal by tying into existing reuse line and Alternative 4B - introduction of excess lake water into wastewater treatment facility collection system.

Alternative 4A

Orange County staff have indicated that the reuse lines in the general project study area could conceivably accept the excess flow from Big Sand Lake. The regulations (F.A.C. 62-610.472(3)(a)) require that the introduced flow be disinfected and treated for fecal coliform and total suspended solids (TSS). Additionally, the quality of the mixture (of existing reuse and introduced flow) must be acceptable for the permitted uses of the reuse water. A check valve must also be included upstream of the connection to the existing reuse main to prevent backflow of reuse into surface water source. Continuous monitoring of the introduced flow's disinfectant residual before mixing with existing reuse as well periodic monitoring of fecal coliforms and TSS is required. The supplemental reuse pipe must also be marked and color-coded to differentiate them from the existing reuse lines.

For this alternative, there must be a quantification of the potential rate of supplemental flow into the reuse system and concurrence from the operating agency (the County) that there is a need for this supplemental flow. Additionally, on-site treatment and monitoring must be provided prior to the introduction of the supplemental reuse water. As the introduction of flows from Big Sand Lake will tend to be sporadic, it is likely that an unmanned treatment facility could be constructed

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Figure 3-17

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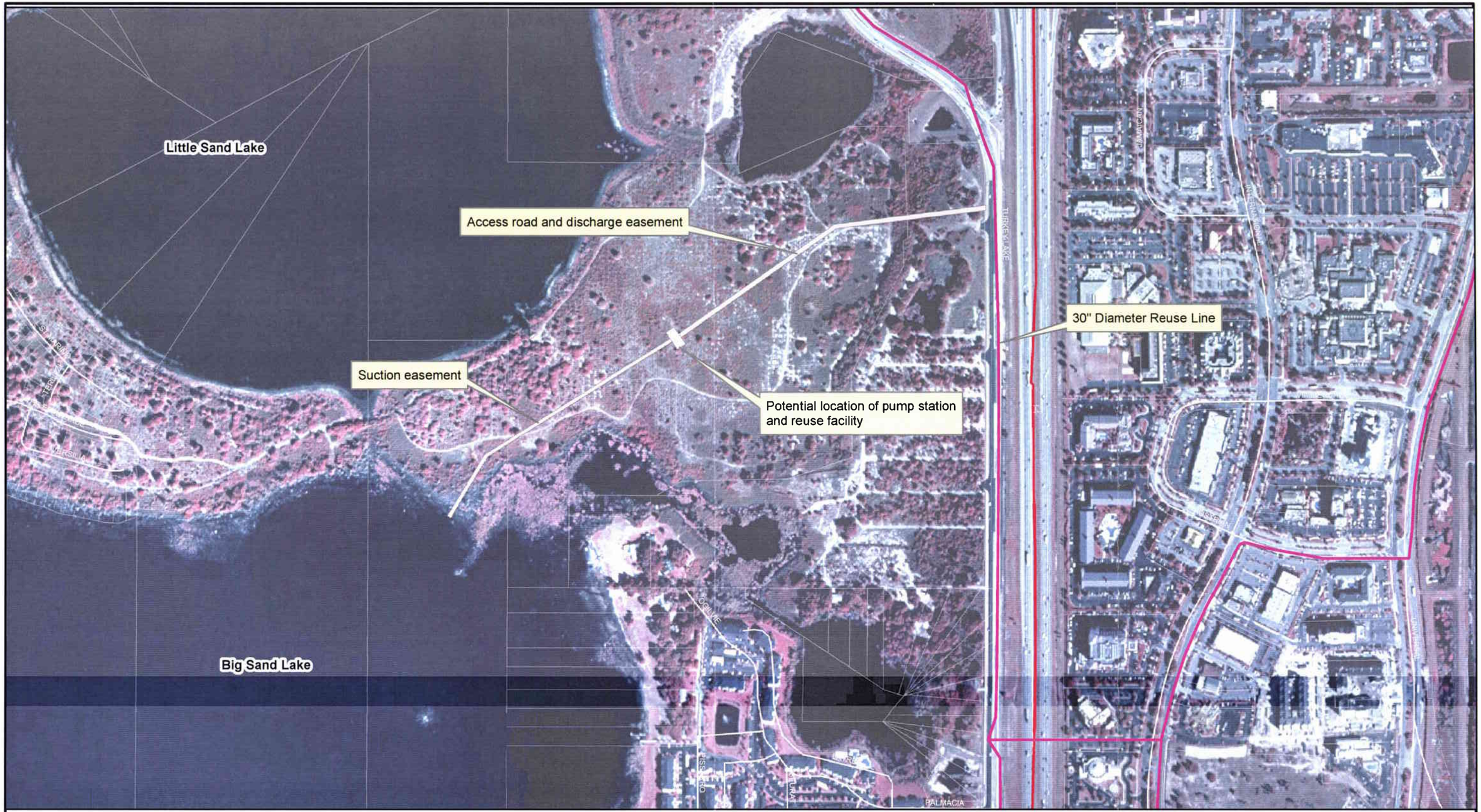


Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure 3-17
Potential Reuse Facility Location

and operated on an "as needed" basis. Another issue with this alternative is that excess stormwater in the chain of lakes would be available when supplemental reuse water is not needed (wet season). During the wet season rainfall lessens the demand for supplemental reuse water.

Alternative 4B

Alternative 4B would introduce the excess stormwater collected in Big Sand Lake into the wastewater collection system and have the required treatment be provided by the wastewater treatment facility. The obvious benefit of this option would be the removal of the treatment requirement discussed under Alternative 4A. The regulations (62-610.472(3)(c) require that the mixture of septic influent and introduced flow receive the full level of treatment and that the capacity of both the collector and treatment facility are adequate to accommodate the increase in flow. Additionally, the flow must only be introduced into the collection system during dry weather low-flow periods. There are two main issues associated with this alternative. First, there must be sufficient capacity in the wastewater collection and treatment system.2) Second, the additional flow must only be introduced during dry weather periods.

According to FDEP staff, the intent of this regulation is to allow stormwater to supplement the reuse system when there is an irrigation demand in the reuse service area. Typically, unmet irrigation demand would occur during the dry season of the year. While non-rain periods during the wet season are "dry weather periods" it is unlikely that irrigation supply would need to be supplemented.

It is possible that supplementing the irrigation system during the dry period may provide some benefit, primarily by lowering the lake stage at the start of the rainy season. There may be some attraction for this version of the alternative, however it should be noted that there have been periods of time when the level of Big Sand Lake has been very low, this alternative would rely on the rainy season providing a "normal" or even "high" amount of rainfall in order to be effective. Lower than normal rainfall could adversely affect the rainy season lake stage.

Due to the prohibition of introduction during the wet periods, the first option, on-site treatment and monitoring will be the considered during the development of the conceptual cost.

Permit Considerations

For this alternative, it would be necessary to modify the existing operating permit for the Orange County Reuse system. It would be necessary to meet the stated water quality standards as well as the standards for monitoring. It is likely that this would be considered a minor modification.

3.4 Little Sand Lake/Big Sand Lake Retaining Wall

In review of SFWMD permit No. 48-01088-P (Vizcaya condominiums), the retaining wall was permitted for constructed around the perimeter of the development. The retaining wall averages 3 feet in height with a top elevation of 101 ft-NGVD along Little Sand Lake and 98 ft-NGVD along Big Sand Lake. The permit allowed for the grading of the lake embankment and associated removal of nuisance vegetation along the lakeside of the retaining wall and the filling of material behind the retaining wall. A mitigation plan was developed to offset identified wetland impacts. The site of the retaining wall was along a land bridge created for agricultural purposes back in the 1950s (possibly earlier). The land bridge allowed access to each side of the lake.

As previously described, during the weekend of August 9, 2003 the retaining wall constructed for the Vizcaya condominium development failed. Just prior to the failure (August 4, 2003), the County recorded water elevations for Big Sand Lake and Little Sand Lake of 95.2 ft-NGVD and 100.9 ft-NGVD, respectively. Following the failure, the lake stages of the two lakes equalized approximately at elevation 97.2 ft-NGVD. As a result of the wall failure, there has been debate by community members, the County, and the regulatory agencies regarding the purpose of the retaining wall and whether or not it should be reconstructed.

There have been mixed opinions given by residents surrounding Big Sand Lake and Little Sand Lake. One general opinion is that the retaining wall should be reconstructed so that stormwater runoff from the upstream lakes will not directly influence the water levels (increase) in Big Sand Lake. Additionally, keeping the lakes separate will reduce the likelihood of inter-lake transfer of pollution associated with stormwater runoff. Conversely, community input has been received requesting the breach remain open to allow for better flood protection in Little Sand Lake by providing greater storage capacity via lake level equalization between Little Sand Lake and Big Sand Lake.

Per input provided by the SFWMD, the retaining wall was constructed for decorative purposes and is not part of a stormwater management system. Therefore, the SFWMD does not have the authority to require the replacement of the wall. Replacement of the wall is the responsibility of the Vizcaya Master Homeowners Association. Because the retaining wall is privately owned, Orange County does not have the authority to reconstruct the retaining wall. However, if shown to be a benefit, Orange County will support the SFWMD and the community in the development of a lake level control structure at this location within their authority. If the land bridge area (retaining wall area) becomes part of a lake level management strategy, then an ERP would be needed from the SFWMD for its construction.

From an engineering perspective, the modeling results indicate that lake levels are approximately the same with or without the breach with the alternative improvements in place. However, lower lake levels in Little Sand Lake could allow for a higher degree of lake level control in the upstream lakes by providing for more

downstream storage than would occur if the retaining wall was intact. The lowering of lake levels would have to be balanced about environmental concerns associated with an artificial change in the lake level hydroperiod.

3.5 Estimated Capital Cost

Preliminary capital cost estimates have been prepared for each alternative. These capital cost estimates include the probable cost of construction for the work described in this report for the following alternatives:

- Alternative 1 - Improved Lake Interconnections
- Alternative 2 – Aquifer Recharege Well
- Alternative 3 – Stormwater Pump Station
- Alternative 4 – Stormwater Reuse

The estimated cost of construction includes the probable cost of construction of the work by contractors, the costs of conventional engineering services during design, construction and start-up, and a 30-percent contingency.

Improved Lake Interconnections

This alternative would consist of constructing a new outfall pipe from Big Sand Lake (at the approximate location of the existing outfall at the southeastern portion of the lake) to VWCD Canal C-1. CDM The estimated capital cost of the improved lake interconnections is provided in **Table 3-1**. The estimated construction cost for work to be completed by a contractor is approximately $1.2 million. The total project (capital) cost, including engineering and technical services and a 30 percent contingency, is estimated at $1.9 million.

Table 3-1
Alternative 1 - Improved Lake Interconnections
Capital Cost Estimate

Item	Cost ($)
Easement Acquisition	$50,000
Road Crossings – Turkey Lake Road	$30,000
Jack and Bore under I-4,Westwood and Central Fl Pkwy	$200,000
Excavation and Hauling	$200,000
24" RCP (5000 feet)	$350,000
Manholes (15)	$65,000
Clear and Grub	$25,000
Erosion Control	$15,000
Utilities Adjustment	$150,000
Misc. Restoration (e.g. s/w, c/g, landscaping, irrigation)	$30,000
Subtotal for Gravity Alternative	**$1,115,000**
Mob/Demob Insurance (8%) (incl MOT)	$89,200
Total Construction Cost for Gravity Alternative	**$1,204,200**
Contingency (30%)	$361,260
Engineering/Technical Services (20%)	$313,092
Total Capital Costs	**$1,878,552**

Aquifer Recharge Well

For this alternative, the existing well on Big Sand Lake would be rehabilitated to the same specifications as the existing drainage well under the FDEP UIC Program for the purpose of aquifer recharge. The existing well on Big Sand Lake is 10-inches in diameter with a cased depth of 173 feet below land surface (bls) and a total depth of 484 feet bls. FDEP has stated that the original well must be field located in order for a rehabilitated well to be constructed in its place. It is conceivable that there could be two potential scenarios. The first scenario, Alternative 2a, would that be the original well is found, capped and a new well constructed without a water treatment requirement. Additionally, lake water would be introduced to the recharge well by gravity. The second and third scenarios, Alternatives 2b and 2c, would be that the original well cannot be found, a new well would be constructed however, there would be a requirement for water treatment and disinfection. Additionally, lake water would need to be injected (pumped) into the well. In order to quantify the potential cost, all alternative costs were estimated and a range reported. There are two water treatment alternatives for this project:

- Alternative 2b - Filtration and disinfection, and
- Alternative 2c - Coagulation (precipitation), filtration, and disinfection

Alternative 2b would consist of sand filtration followed by chlorination. Two one-acre sand filters would be constructed along the shore of the lake at the proposed control elevation. The lake water would infiltrate through the sand filter with exfiltration pipe to clear well. The filtered water will then be pumped into the recharge wells. Sodium hypochlorite is injected into the filtered lake water using a metering pump for disinfection purposes. Discharge from the lake to the well would be controlled with a shutoff valve. Each sand filter would occupy an area of around 1.0 acre and the total foot print would occupy around 3 acres of land. Again, it was assumed that this facility would be constructed on the park property on the southwest shore of the lake. Additionally, two recharge wells would be used for redundancy.

Alternative 2c would consist of coagulation (precipitation) and settling using alum addition followed by sand filtration and chlorination. This alternative configuration would reduce suspended solids, phosphorus, metals, and a portion of the coliforms. The lake water would be pumped to a contact to a roughing (sand) filter located on the shore of the lake. Alum would be injected in the force main before the filter using a metering pump. The filtered water would then flow in to a second polishing filter. Sodium hypochlorite would be injected for disinfection purposes in the roughing filter discharge ahead of the polishing filter. The discharge from the polishing filter would then gravity flow into the recharge well. Settled sludge on the roughing and polishing filters would be would be backwashed to a storage tank. The alum sludge and backwash water would have to be pumped out of the storage tank to a sanitary sewer. It is assumed that this facility would be constructed on the park property on the southwest shore of the lake. The estimated capital cost for this alternative is approximately $6.3 million.

The estimated capital cost of rehabilitating the existing 10-inch diameter recharge well on Big Sand Lake is provided in **Table 3-2a** and **Table 3-2b**. In the event that the original recharge well is field located it is estimated that the construction cost for work to be completed by a contractor is approximately $123,000. The total project cost, including engineering and technical services and a 30 percent contingency, is estimated at $192,000. If the original recharge well cannot be field located it is estimated that the construction cost for the work to be completed by a contractor is approximately $1.3 million. The total project cost, including engineering and technical services and a 30 percent contingency, is estimated at $2.0 million.

Table 3-2a
Alternative 2a - Rehabilitate/Reconstruct New Recharge Well on Big Sand Lake
Capital Cost Estimate - Original Recharge Well Located

Item	Cost ($)
Easement Acquisition	$0*
Location of recharge	$3,900
Install one 10-inch Recharge Well	$100,000
Clear and Grub	$10,000
Subtotal for Recharge Well	**$113,900**
Mob/Demob Insurance (8%)	$9,112
Total Construction Cost for Recharge Well	**$123,012**
Contingency (30%)	$36,904
Engineering/Technical Services (20%)	$31,983
Total Capital Costs	**$191,899**

Note: * - easement acquisition reported as $0 with the assumption that drainage well can be located in OCBCC park – otherwise easement acquisition estimated at $95,000 in vicinity of existing recharge well.

Table 3-2b
Alternative 2b - Rehabilitate/Reconstruct New Recharge Well on Big Sand Lake
Capital Cost Estimate - Original Recharge Well Not Located

Item	Cost ($)
Land Acquisition	$0*
Location of recharge well	$3,900
Install two 10-inch Recharge Well	$200,000
Sand Filtration and Disinfection	$975,000
Clear and Grub	$10,000
Subtotal for Recharge Well and Treatment System	**$1,188,900**
Mob/Demob Insurance (8%)	$95,112
Total Construction Cost for Recharge Well	**$1,284,012**
Contingency (30%)	$385,204
Engineering/Technical Services (20%)	$333,843
Total Capital Costs	**$2,003,059**

Note: * - easement acquisition reported as $0 with the assumption that drainage well can be located in OCBCC park – otherwise easement acquisition estimated at $95,000 in vicinity of existing recharge well.

Stormwater Pump Station

CDM estimated the capital cost of constructing a 30 cfs stormwater pump station is provided in **Table 3-3**. The pump station will consist of quadraplex design with three 10 cfs submersible pumps operated in a lead lag mode and the fourth as an emergency/standby. The estimated construction cost for work to be completed by a contractor is approximately $1.5 million. The total project cost, including engineering and technical services and a 30 percent contingency, is estimated at $2.4 million.

Table 3-3
Alternative 3
30 cfs Stormwater Pump Station
Capital Cost Estimate

Item	Cost ($)
Easement Acquisition	$195,000
Access Road to Pump Station (200' x 24' x 1')	$8,000
Fenced Enclosure around Pump Station (50'x50')	$9,000
Transfer Pump Station	$400,000
Electrical for Pump Station	$650,000
Overflow Flumes	$26,000
Transfer Piping	$125,000
Clear and Grub	$10,000
Subtotal for Pump Station	**$1,423,000**
General Conditions/Mobilization (8%)	$113,840
Total Construction Cost for Pump Station	**$1,536,840**
Contingency (30%)	$461,052
Engineering/Technical Services (20%)	$399,578
Total Capital Costs	**$2,397,470**

Stormwater Reuse

The estimated capital cost of constructing an interconnection to the Orange County Reuse System is provided in **Table 3-4**. The estimated construction cost for work to be completed by a contractor is approximately $3.0 Million. The total project cost, including engineering and technical services and a 10 percent contingency, is estimated at $4.7 Million.

Table 3-4
Alternative 4 Stormwater Reuse
Capital Cost Estimate

Item	Cost ($)
Easement Acquisition	$400,000
Pump Station (from Alternative 3)	$1,423, 000
Sand Filtration and Disinfection	$975,000
Clear and Grub	$10,000
Subtotal for Reuse Facility	**$2,808,000**
General Conditions/Mobilization (8%)	$224,640
Total Construction Cost for Reuse Facility	**$3,032,640**
Contingency (30%)	$909,792
Engineering/Technical Services (20%)	$788,486
Total Capital Costs	**$4,730,918**

Summary of Total Estimated Capital Costs

A summary of the total capital costs for each alternative is provided in **Table 3-5**. As indicated in Table 3-5, the rehabilitation/reconstruction of the existing Big Sand Lake recharge well is the most cost-effective alternative to provide improved lake level management.

Table 3-5
Summary of Estimated Capital Costs

Alternative ID	Estimate	Cost ($)
1B	Improved Lake Interconnections	$1,878,552
2	Rehab/Reconstruct one Recharge Well (assume original well not found)	$2,003,059
3	30 cfs Stormwater Pump Station	$2,397,470
4	Stormwater Reuse	$4,730,918

Section 4
Conclusions and Recommendations

This section summarizes the data collection, model development, calibration and use of the model to evaluate the different stormwater improvement alternatives, and the preliminary estimates of probable cost for each alternative.

4.1 Summary

Historically, lake levels in Big Sand Lake have fluctuated over a wide range. Between 1960 and 1980, water levels in Big Sand Lake have generally decreased from approximately elevation 100 ft-NGVD to as low as 80 ft-NGVD (20 feet). Between 1980 and 1997 the water level in Big Sand Lake gradually increased to an elevation 95 ft-NGVD. During the period between 1997 and 2000, water levels in Big Sand Lake generally decreased from elevation 95 ft-NGVD to elevation 87 ft-NGVD (18 feet). However, between 2000 and 2003 the lake levels in Big Sand Lake increased by approximately 10 feet (elevation 87 ft-NGVD to elevation 97 ft-NGVD). These changes in elevation trends can be directly correlated to the historical rainfall data.

As a result of the elevated lake levels in Big Sand Lake over the past three years, the County began receiving an increased number of high water concerns from residents around the chain of lakes. Big Sand Lake is interconnected to the other lakes in the basin at a high level, but is the most downstream lake in the chain-of-lakes. The concerns were heightened during the months of August, September, and October 2003, which is the period when lake levels were above elevation 95 ft-NGVD and the area was experiencing above normal rainfall volumes.

On August 9, 2003, the retaining wall separating Big Sand Lake from Little Sand Lake breached causing the lake stages to equalize at approximately elevation 97 ft-NGVD. As a result of this breach several actions with full support of the BSLAB. These actions included obtaining a 90-day emergency pump permit that allowed pumping of water from Big Sand Lake to the VWCD C-1 Canal. **Figure 4-1** shows the historical lake level and rainfall data for 2003. The figure also highlights the start and end date of the emergency pumping operation. As a result of these heightened water level concerns, the County initiated this study with full support of the OCBOCC and the BSLAB.

Available hydrologic and hydraulic data was collected to develop and calibrate a screening level model of the chain-of-lakes. Due to the complex hydraulics of the lake overflow system, the SWMM was used to represent the chain-of-lakes. The model was calibrated to lake water elevation data for the period of 1995-2003 to represent current development conditions by adjusting the model input parameters with an appropriate range of values. After model calibration, the model was capable of simulating the magnitude and frequency of the observed high and low water elevations in each modeled lake.

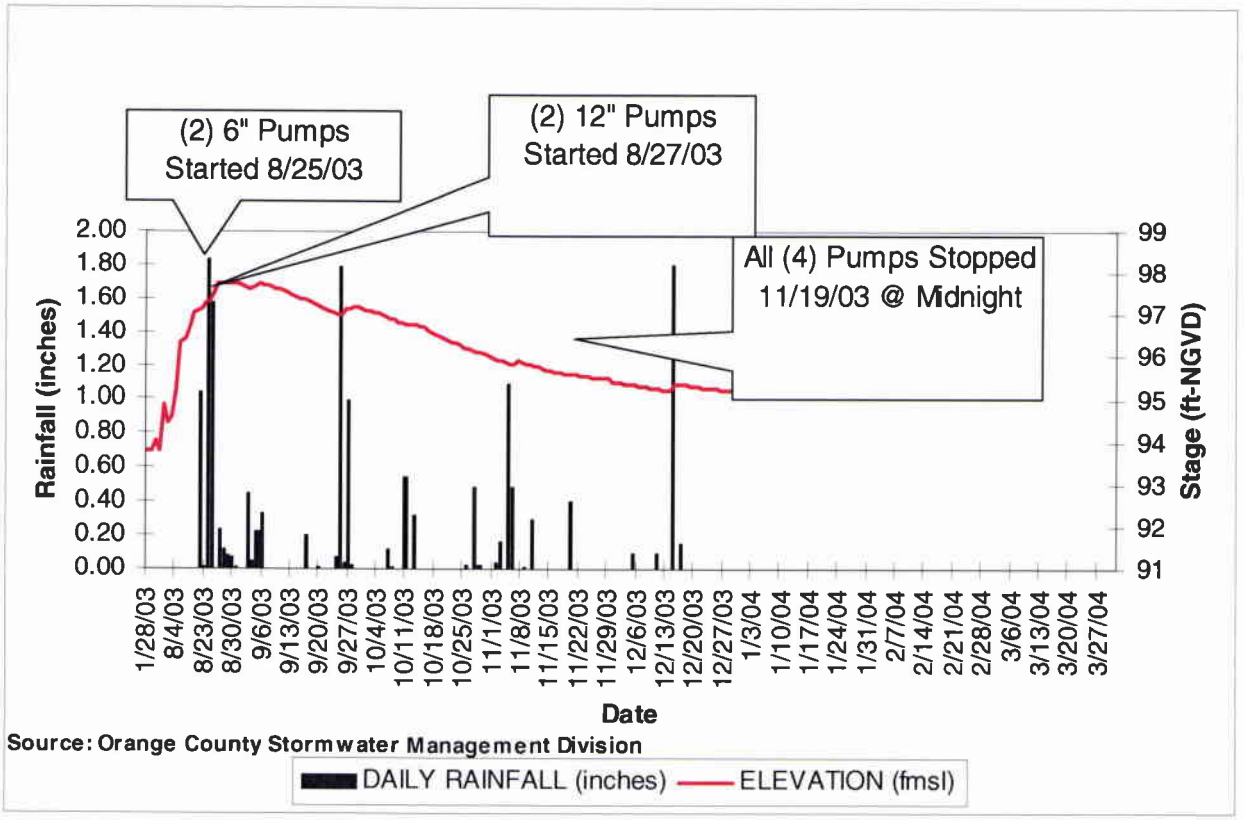


Figure 4-1
2003 Rainfall and Lake Level Data for Big Sand Lake

To evaluate the significance of each input parameter on model calibration a sensitivity analysis was conducted. Based on this analysis, lake seepage to the Floridan aquifer was determined to be the most sensitive parameter and produced the most pronounced difference between observed and simulated lake water elevations.

Finally, the calibrated model was used to evaluate the benefit of the following four lake level management alternatives:

- Alternative 1 - Improved Lake Interconnections
- Alternative 2 – Aquifer Recharge Well
- Alternative 3 – Stormwater Pump Station
- Alternative 4 – Stormwater Reuse

4.2 Conclusions

Based on the screening model developed for this project the pump station and the rehabilitation of the existing drainage wells would provide for some measure of lake

level management via aquifer recharge. The primary difference between these two alternatives is that a recharge well would operate under gravity flow conditions and the pump station requires electricity to operate under a pressurized condition. Additionally, the pump station delivers the excess stormwater to downstream surface waters (i.e. The Valencia Water Control District and Shingle Creek), which would require additional operation and maintenance and/or require bank stabilization along the C-1 Canal downstream of the two existing amil gates (S-101 and S-102). These wells would recharge the Floridan aquifer, providing a water supply benefit.

Alternative 1 included 2 options 1A and 1B. Alternative 1A included the construction of a 2-ft diameter RCP to convey excess flow under the I-4 interchange. This option provided very little lake level management benefit due to the hydraulics of the existing gravity outfall system immediately east of I-4. The second option (1B) included construction of approximately 4,500 feet of new RCP under the I-4 interchange to the VWCD C-1 Canal. This option did provide improved lake level management and has a similar capital cost to the pump station alternative. However, it is expected that the acquisition of easements for this type of system, the challenge of avoiding expected conflicts with existing infrastructure along the I-4/Central Florida Parkway corridor. Alternative 4 also does not provide much lake level management benefit since their isn't significant reuse demand during periods when the lake would be at high levels and the demand is minimal relative to the timing and volume of releases required to provide benefit at high lake stages. However, there would be potential to use excess water in Big Sand Lake during the dry season (if available). The two remaining alternatives (recharge well and pump station systems) are the most feasible from an engineering perspective.

From a cost perspective, the recharge well alternative is the lowest cost option and should be readily permittable. The estimated capital cost for the recharge well is $200,000 without treatment and $2.0 million with treatment, which is less than the cost of the pump station alternative. Additionally, the recharge well operation and maintenance costs are expected to be significantly lower than the pump station since the wells will be operated under gravity.

Another important consideration of any of these alternatives is that water will be removed from the lake system, resulting in the lakes becoming lower more quickly. For instance, lowering Big Sand Lake from an elevation of 96 ft-NGVD to an elevation of 93 ft-NGVD represents a loss of approximately 3,400 acre-feet of water. This water is then unavailable to offset additional water loss during periods of low rainfall, thus the lakes would recede to lower elevations more quickly.

4.3 Recommendations

Five factors were considered in the formulation of the recommendations as a result of this study. These factors are described below:

Technical Feasibility and Reliability

The gravity based improvement (Alternative 1), the recharge well improvement (Alternative 2), and the pump station improvement (Alternative 3) are both feasible and reliable from a technical standpoint. The preliminary modeling efforts show that these three alternatives provide a higher level of control of water elevations in the chain of lakes. A reuse-based system (Alternative 4) would not provide adequate lake level management control as previously described.

System Maintainability

The gravity based system (Alternative 1) and the recharge well system (Alternative 2) would require a lower level of maintenance responsibility than a pump based system (Alternative 3 and Alternative 4). Currently County drainage wells are inspected on a 2-week cycle and are inspected daily during heavy rainfall periods to verify they are operating as designed and not clogged by debris. Identified structural problems are then further evaluated and corrective measures are taken as needed. Pump stations are maintained once every two weeks to ensure they are fully operational. Maintenance activities include debris removal, fence inspection and repair, embankment inspection and repair, mechanical equipment lubrication, and running and inspecting motors and backup generators. Inspection of pump stations requires more time than does a drainage well or gravity based system. If treatment is added as part of an aquifer recharge system, an increased operation and maintenance level of effort would be required. In addition to these considerations, it is important for the County and the BSLAB to encourage FDOT system maintenance along the I-4 system that conveys overflow from Big Sand Lake.

Sociopolitical Acceptability

Based upon input from the BSLAB, either alternative should be pursued by the County and a "do nothing" alternative is not acceptable. It should be noted, however, that a few residents did comment that lake level management controls should not be implemented because the observed lake level fluctuations have always occurred. Another issued that will need to be addressed by the OCBOCC is that the current County level-of-service policy for flooding is to protect finished floors of homes and businesses from flooding during a 100-year storm event. To date, no finished floors have been flooded and existing floor elevations are above the current 100-year BFE established by FEMA. Constructing improvements to protect investments other than finished floor elevations will require a change in policy by the OCBOCC because of the precedence set for other closed basins within the County in terms of level-of-service for flood protection.

Economics

The cost of the gravity-based alternatives and pump station (Alternative 1 and Alternative 3) would be $1.9 million and $2.4 million respectively, as compared to the cost of rehabilitating the existing well. As was noted, if the original well is found, the estimated cost to rehabilitate the recharge well would be approximately $200,000, if

the original well is not found the additional treatment requirement would increase the conceptual cost to $2.0 million. Additionally, it is expected that the cost of acquiring drainage easements for 5,000 feet of pipe (Alternative 1) and costs of addressing the high potential of utility conflicts could significantly increase the estimated cost of Alternative 1.

Environment and Permitting

For Alternative 1 (gravity-based system) additional analysis would be needed to determine whether downstream flooding or erosion would result from additional flows and what level of stream bank erosion protection would be required. For Alternative 2 (recharge well), FDEP has regulations concerning the quality of water introduced into any "underground source of drinking water" (USDW). Basically, introduced water must be treated to primary and secondary drinking water standards. Due to the cost of water treatment, this regulation essentially stops new recharge wells from being constructed. However, existing recharge wells are "grandfathered in" and were allowed to continue to operate. It is also possible to retrofit and provide maintenance to existing recharge wells, which may have benefit to this project (Alternative 2). Therefore, if the drainage well can be located in the field, there is a high probability that the well can be rehabilitated and used for aquifer recharge. If the well cannot be located, then there is a higher likelihood that treatment would be required. For the pump station alternative (Alternative 3), an operation plan would need to be developed so that pumping of excess stormwater from the chain of lakes would not cause downstream flooding or erosion. This type of assessment would be required to permit a pump station based lake level management system. For alternative 4 (reuse), disinfection would be required.

Current County policy is to protect homes from the 100-year storm event. A higher level of protection would require a policy change by the OCBOCC. Alternative 2 promotes aquifer recharge while improving lake level management. Because this alternative's primary objective is not flood protection (ancillary benefit) but for aquifer recharge, it is likely that a policy change would not be required. The recharge well could be incorporated into the 40 acre park located along the southwest shores of Big Sand Lake.

Also, maintaining a hydraulic connection between Big Sand Lake and Little Sand Lake (would require easement acquisition) with the recharge well improvement alternative would allow for greater flexibility in lake level management and may warrant further consideration. Model results indicate that differences in the predicted water level for Big Sand Lake with and without the breach condition are minimal with the proposed recharge well improvement. Thus, the hydraulic connection between the lakes could remain as it is today (natural) or be a weir type structure (navigable or non-navigable) an incorporated into the lake level management plan. Lower water levels in Little Sand Lake would allow greater flexibility in managing water levels in the upstream lakes as needed without creating downstream flooding concerns.

However, this interconnection is not a critical element of managing water levels in Big Sand Lake.

4.4 Additional Considerations

The stormwater model (SWMM) used for this study is a surface water model and was sufficient for evaluating the lake level management strategies described in Section 3 of this report. Because SWMM is primarily a surface water model, the relationship between the lakes and the UFA was approximated based upon groundwater data and the existing features of SWMM. Additionally, the relationship between the lakes and the surficial aquifer system was not considered or needed to meet the objectives of this study. However, if the County elects to evaluate the interaction between the surface water and groundwater systems, and integrated model would be needed. An integrated model would account for all of the processes contributing to lake level fluctuation. In order to perform this higher level evaluation, additional groundwater data would be needed to better define groundwater parameters and the interaction between the two systems. Listed below is a summary of the types of data that would be needed to develop an integrated (more complex) model:

- Perform a hydraulic performance test at the proposed well site along with a treatability evaluation.
- Install a series of surficial aquifer piezometers in the Big Sand Lake Hydrologic Basin and collect water table elevation data for the model.
- Install a cluster of deeper piezometers one at the top of the ICU, one at the midpoint of the ICU and one at the top of the Floridan aquifer to match a water table piezometer installed at Big Sand Lake. This will provide needed data to define the vertical hydraulic gradient and the magnitude of Floridan aquifer recharge. These data are critical to the accurate representation of lake level fluctuation and design documentation of the anticipated recharge well performance.
- Perform a series of *in-situ* falling head permeability analysis of the lake bed sediments in each lake to better define the magnitude of lake seepage estimated by the existing model.

Appendix A

Hydrologic Parameters

Ap Ix A
Hydrologic Parameters
Big Sand Lake Conceptual Improvement Study
Orange County Florida
December 2003

Table A-1 Overland Flow Paths

BASIN: Big Sand Lake

SUBBASIN: Entire Basin

SCENARIO: Existing Conditions

NOTES:

		Existing Conditions				Existing Conditions				Existing Conditions			
	HYDROLOGIC UNIT ID	AREA (AC)	MAXIMUM ELEVATION (FT-NGVD)	MINIMUM ELEVATION (FT-NGVD)	OVERLAND FLOW LENGTH (FT)	WEIGHT FRACTION	MAXIMUM ELEVATION (FT-NGVD)	MINIMUM ELEVATION (FT-NGVD)	OVERLAND FLOW LENGTH (FT)	WEIGHT FRACTION	MAXIMUM ELEVATION (FT-NGVD)	MINIMUM ELEVATION (FT-NGVD)	OVERLAND FLOW LENGTH (FT)	WEIGHT FRACTION
1	BSL0200	1100.20	129.00	92.00	4038.53	0.50	120.00	91.00	3124.67	0.25	109	93	2235.307	0.25
2	BSL0400	207.20	134.00	109.00	1884.61	0.40	117.00	109.00	1202.09	0.40	109	108	926.333	0.2
3	BSL0600	182.40	125.00	98.00	1771.80	0.33	128.00	100.00	1675.57	0.33	120	102	1082.113	0.33
4	BSL0800	830.10	127.00	94.00	2822.85	0.33	123.00	92.00	1954.00	0.33	115	94	1442.808	0.33
5	BSL1000	80.40	115.00	97.00	1228.57	0.35	118.00	100.00	859.82	0.35	110	98	384.756	0.3
6	BSL1200	167.10	138.00	91.00	2257.40	0.50	110.00	94.00	691.09	0.20	116	100	1121.914	0.3
7	BSL1400	477.90	141.00	99.00	2942.43	0.50	135.00	93.00	2718.51	0.30	113	94	510.322	0.2
8	BSL1600	832.40	154.00	97.00	5379.11	0.33	129.00	97.00	4637.52	0.33	137	102	1787.479	0.33
		3,045.3 ACRES												
		4.76 SQ. MI.												

soil acres 10704.80
luse acres 2601.22

Basin ID	WEIGHTED SLOPE (FT/FT)	WEIGHTED LENGTH (FT)	CHECK WEIGHT	AREA (FT^2)	WIDTH (FT)
BSL0200	0.0087	3,359	1.00	47,924,712	14,266
BSL0400	0.0082	1,420	1.00	9,025,632	6,356
BSL0600	0.0160	1,495	0.99	7,945,344	5,316
BSL0800	0.0139	2,052	0.99	36,159,156	17,617
BSL1000	0.0218	846	1.00	3,502,224	4,138
BSL1200	0.0193	1,603	1.00	7,278,876	4,539
BSL1400	0.0192	2,389	1.00	20,817,324	8,714
BSL1600	0.0122	3,895	0.99	36,259,344	9,308

App...dix A
Hydrologic Parameters
Big Sand Lake Conceptual Improvement Study
Orange County Florida
December 2003

Table A-3 Soil Parameters

BASIN: Big Sand Lake

SUBBASIN: Entire Basin

SCENARIO : Existing Conditions

NOTES: 0

SOIL TYPE	INITIAL INFILT. RATE (IN/HR)	FINAL INFILT. RATE (IN/HR)	DECAY RATE (1/SEC)	SOIL STORAGE (IN)
A	9.00	1.00	0.000556	5.50
B	9.00	0.50	0.000556	4.50
C	4.00	0.25	0.000556	3.80
D	3.00	0.10	0.000556	1.40

	HYDROLOGIC UNIT ID	PERCENT BY HYDROLOGIC UNIT: TYPE A	TYPE B	TYPE C	TYPE D	TOTAL	PERVIOUS %	NDCIA %	INITIAL INFILT. RATE (IN/HR)	FINAL INFILT. RATE (IN/HR)	DECAY RATE (1/SEC)	SOIL STORAGE
1	BSL0100	0.00	0.00	0.00	100.00	100.0	8.8	0.7	2.77	0.09	0.000556	1.29
2	BSL0200	43.97	0.00	26.35	29.68	100.0	70.7	5.7	5.46	0.50	0.000556	3.55
3	BSL0300	0.00	0.00	0.00	100.00	100.0	0.7	0.1	2.71	0.09	0.000556	1.26
4	BSL0400	27.10	0.00	39.61	33.29	100.0	66.0	7.2	4.53	0.36	0.000556	3.12
5	BSL0500	0.00	0.00	0.00	100.00	100.0	0.2	0.0	2.59	0.09	0.000556	1.21
6	BSL0600	64.22	0.00	7.12	28.66	100.0	61.5	9.3	6.01	0.60	0.000556	3.65
7	BSL0700	0.10	0.00	0.00	99.90	100.0	8.8	1.3	2.63	0.09	0.000556	1.23
8	BSL0800	25.83	0.00	13.14	61.03	100.0	61.4	9.0	4.08	0.31	0.000556	2.42
9	BSL0900	15.58	0.00	0.00	84.42	100.0	15.8	0.7	3.78	0.23	0.000556	1.96
10	BSL1000	54.78	0.00	12.55	32.67	100.0	49.3	6.3	5.69	0.54	0.000556	3.50
11	BSL1100	0.45	0.00	0.00	99.55	100.0	3.2	0.5	2.61	0.09	0.000556	1.22
12	BSL1200	93.29	0.00	0.00	6.71	100.0	61.3	9.9	7.40	0.81	0.000556	4.50
13	BSL1300	4.48	0.00	0.00	95.52	100.0	0.3	0.1	2.26	0.10	0.000556	1.09
14	BSL1400	71.78	0.00	10.04	18.18	100.0	51.7	6.9	6.53	0.67	0.000556	4.04
15	BSL1500	1.62	0.00	0.00	98.38	100.0	1.3	0.2	2.77	0.10	0.000556	1.31
16	BSL1600	41.96	0.00	28.98	29.06	100.0	60.6	8.0	5.13	0.46	0.000556	3.37

Appendix A
Hydrologic Parameters
Big Sand Lake Conceptual Improvement Study
Orange County Florida
December 2003

Table A-2 Land Use

BASIN: Big Sand Lake
SUBBASIN: Entire Basin
SCENARIO : 2003 LAND USE
NOTES: Exisiting Conditions updated with 05/2002

#	GLOBAL LAND USE CATEGORIES
1	Agricultural Lands
2	Commercial
3	Forested/Open Space
4	Highway
5	Low Density Residential
6	Medium Density Residential
7	High Density Residential
8	Wetlands
9	Industrial
10	Institutional
11	Water

GLOBAL LAND USE PARAMETERS

	1	2	3	4	5	6	7	8	9	10	11
IMPERVIOUS n	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.100	0.015	0.015	0.024
PERVIOUS n	0.300	0.250	0.400	0.250	0.250	0.250	0.250	0.400	0.250	0.250	0.060
IMPERVIOUS Ia	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.50	0.10	0.10	12.00
PERVIOUS Ia	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.50	0.25	0.25	0.10
% IMPERVIOUS	5.0	90.0	5.0	90.0	15.0	35.0	82.5	100.0	90.0	90.0	100.0
% DCIA	1.0	81.0	1.0	81.0	7.5	24.7	65.0	100.0	81.0	81.0	100.0
% NDCIA	4.0	9.0	4.0	9.0	7.5	10.3	17.5	0.0	9.0	9.0	0.0
% PERVIOUS	95.0	10.0	95.0	10.0	85.0	65.0	17.5	0.0	10.0	10.0	0.0
CHECK %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PERCENT BY LAND USE CATEGORY

	HYDROLOGIC UNIT ID	1 Agriculture	2 Commercial	3 Forest/Open	4 Highway	5 LDR	6 MDR	7 HDR	8 Wetland	9 Industrial	10 Institutional	11 Water	CHECK %	PERVIOUS %	NDCIA %	DCIA %	CHECK %	NDCIA & DCIA n	PERVIOUS n	NDCIA & DCIA Ia	PERVIOUS Ia
1	BSL0100	1.05	3.11	7.15	0.00	0.00	1.11	0.00	1.86	0.00	0.00	85.71	100.0	8.8	0.7	90.4	100.0	.025	.344	.39	.24
2	BSL0200	33.78	10.85	29.00	7.99	0.00	13.90	0.56	2.78	0.00	0.00	1.13	100.0	70.7	5.7	23.6	100.0	.025	.307	.72	.24
3	BSL0300	0.00	0.00	0.01	0.01	0.65	0.29	0.01	0.46	0.00	0.00	98.59	100.0	0.7	0.1	99.2	100.0	.024	.228	.93	.24
4	BSL0400	8.39	1.67	40.01	9.09	8.87	14.29	12.11	2.57	0.00	0.00	3.01	100.0	66.0	7.2	26.8	100.0	.024	.310	.47	.24
5	BSL0500	0.00	0.00	0.00	0.00	0.00	0.30	0.00	4.85	0.00	0.00	94.85	100.0	0.2	0.0	99.8	100.0	.028	.218	.43	.23
6	BSL0600	0.01	0.00	3.77	0.00	0.00	89.03	0.00	2.25	0.00	0.00	4.95	100.0	61.5	9.3	29.2	100.0	.023	.227	.15	.23
7	BSL0700	0.00	0.85	1.39	0.00	0.81	10.27	0.00	3.98	0.00	0.00	82.70	100.0	8.8	1.3	90.0	100.0	.027	.240	.06	.23
8	BSL0800	3.54	1.48	7.59	1.59	1.11	75.59	0.00	3.51	2.49	1.83	1.27	100.0	61.4	9.0	29.6	100.0	.025	.238	.66	.23
9	BSL0900	0.00	0.00	16.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.32	100.0	15.8	0.7	83.5	100.0	.024	.384	.98	.24
10	BSL1000	0.00	36.51	46.72	12.76	0.00	0.00	0.00	0.00	0.00	0.00	4.01	100.0	49.3	6.3	44.4	100.0	.016	.343	.17	.23
11	BSL1100	0.00	0.00	0.00	0.00	0.00	4.92	0.00	0.00	0.00	0.00	95.08	100.0	3.2	0.5	96.3	100.0	.024	.218	.85	.23
12	BSL1200	0.00	0.00	0.02	2.03	0.00	93.94	0.00	0.00	0.27	0.00	3.70	100.0	61.3	9.9	28.8	100.0	.016	.217	.63	.23
13	BSL1300	0.12	1.21	0.00	0.14	0.00	0.08	0.00	4.00	0.00	0.00	94.46	100.0	0.3	0.1	99.6	100.0	.027	.190	.41	.20
14	BSL1400	17.42	19.96	13.01	8.08	0.00	30.76	0.00	5.50	0.00	0.11	5.16	100.0	51.7	6.9	41.4	100.0	.027	.268	.64	.23
15	BSL1500	0.64	0.00	0.00	0.00	0.00	1.05	0.12	0.00	0.00	0.00	98.20	100.0	1.3	0.2	98.5	100.0	.024	.246	.96	.23
16	BSL1600	5.75	11.01	23.60	2.25	0.00	46.96	1.84	0.00	0.00	5.17	3.43	100.0	60.6	8.0	31.4	100.0	.016	.276	.40	.23

Appendix B

SFWMD and USGS Drainage Well Data Sheets

SFWMD DRAINAGE WELL INVENTORY

Location

Big Sand Lake | Pointview Court

On lake

Alternate IDs

City N/A
County N/A
District 1485920500541
USGS 282514081290301

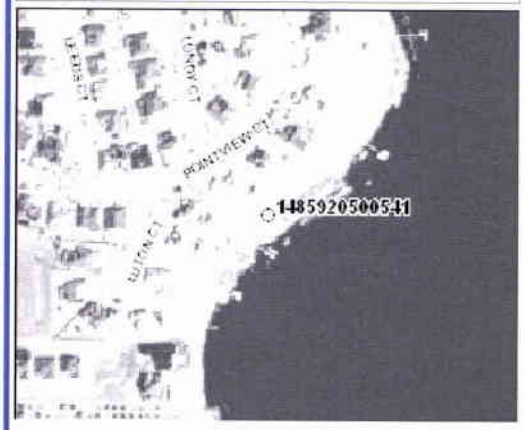
Access Requirements

N/A N/A

Handheld Coordinates

Northing	Easting
1485919.9	500540.7

LOCATION MAP



WELL SKETCH

NO WELL SKETCH AVAILABLE

WELL PHOTOGRAPH

1485920500541-A

No. of Inlets 9999

Inlet type: N/A

Inlet elevation: 9999 ft

Inlet type: N/A

Inlet elevation: 9999 ft

Inlet type: N/A

Inlet elevation: 9999 ft

Casing/Well Information

9999 or N/A indicates that data is unavailable.

Construction Date:	1931
Casing diameter (in)	10
Casing depth (ft)	173'
Total depth (ft)	484'
Manhole Elev. (ft)	9999
Depth to water:	-24.14
Water Quality:	N/A

Well Status: lost

Drainage source: lake

Major basin:

Basin size (ac): 0

Video log: No

Geophysical log: No

Hartman & Associates, Inc.

SFWMD DRAINAGE WELL INVENTORY

Location

Apopka-Vineland Roa \ Sandlake Road

south of Sandlake, in S-curve,former Minute-Mai

Access Requirements

N/A N/A

Alternate IDs

City N/A District 1494053494574

County N/A USGS 282636081300801

Handheld Coordinates

Northing	Easting
1494052.9	494574.5

LOCATION MAP

WELL SKETCH

NO WELL SKETCH AVAILABLE

WELL PHOTOGRAPH

No. of Inlets 9999

Inlet type: N/A

Inlet elevation: 9999 ft

Inlet type: N/A

Inlet elevation: 9999 ft

Inlet type: N/A

Inlet elevation: 9999 ft

Casing/Well Information

9999 or N/A indicates that data is unavailable.

Construction Date:	9999
Casing diameter (in)	12
Casing depth (ft)	114
Total depth (ft)	356
Manhole Elev. (ft)	9999
Depth to water:	9999
Water Quality:	N/A

Well Status: lost

Drainage source: street

Major basin: Shingle Creek

Basin size (ac): 70715.33

Video log: No

Geophysical log: No

Hartman & Associates, Inc.

WRD Exp. (GW)
Aug. 1964

U. S. DEPARTMENT OF THE INTERIOR — GEOLOGICAL SURVEY

Water Resources Division Well Schedule Form

R.I.5 MASTER CARD 11-22-65 1:24000

ecord by HEALY (UNKLESBY) Source of data well sched Date 7- -43 Map LAKE JESSAMINE

tate FLA 09 County (or town) ORANGE 48

atitude: 282514N Longitude: 0812903 Sequential number: 1

at-long ccuracy: 1 T. 24 S R. 28 E Sec 2 SE SE SW TALLA

Local ell number: 82512901 344 Other number: ORANGE 62

ocal use: W 218 24S28E02 Owner or name: W. F. BENNETT

wner or name: W. F. BENNETT Address:

wnership: (C) County, (F) Fed Gov't, (M) City, (N) Corp or Co, (P) Private, (S) State Agency, (W) Water Dist P

se of ater: (A) Air cond, (C) Comm, (D) Dewatering, (F) Fire, (H) Dom, (I) Irr, (N) Ind, (P) P S, (S) Stock, (T) Instit, (U) Unused DRAINAGE U

se of ell: (A) Anode, (D) Drain, (G) Seismic, (O) Obs, (P) Oil-gas, (R) Recharge, (S) Spring, (T) Test, (U) Unused, (W) Withdraw, (X) Waste, (Z) Destroyed D

ATA AVAILABLE: Well data 2 Freq. W/L meas.: INTERMITTENT I Field aquifer char.

d. lab. data:

al. water data; type:

eq. sampling: Pumpage inventory: yes no, period:

erture cards: yes

g data: FGS W-218

WELL-DESCRIPTION CARD

SAME AS ON MASTER CARD Depth well: 484 ft 484 Meas. rept RPTD accuracy 6

epth cased; irst perf.) 173 ft 173 Casing type: IRON; Diam. 10 in 10

nish: (C) porous concrete, (F) gravel w. (perf.), (G) gravel w. (screen), (H) horiz. gallery, (O) open end, (P) perf., (S) screen, (T) sd. pt., (W) shored, (X) open hole, (Z) other X

thod illed: (A) air rot, (B) bored, (C) cable, (D) dug, (H) hyd rot., (J) jetted, (P) air percussion, (R) reverse rotary, (T) trenching, (V) driven, (W) drive wash, (Z) other C

te illed: 1931 931 Pump intake setting: ft

iller: H. RAEHN name, ORLANDO address

ft ype): (A) air, (B) bucket, (C) cent, (J) jet, (L) multiple, (cent.) (M) multiple, (turb.) (N) none, (P) piston, (R) rot., (S) submerg, (T) turb, (Z) other N Deep Shallow

wer ype): diesel, elec, nat gas, gasoline, hand, LPG gas, wind; H.P. Trans. or meter no.

scrip. MP Top concrete m.H level with surf. ft above below lsd, Alt. MP 99.36

t. LSD: 99.36 99 Accuracy: (source) INSTR. LEVEL 0

ter vel 24.14 ft above below MP; Ft above below lsd 24 Accuracy: Taped A

te as: 8-21-43 843 Yield: gpm Method determined

wdown: ft Accuracy: Pumping period hrs

LITY OF ER DATA: Iron ppm Sulfate ppm Chloride ppm Hard. ppm

Conduct K x 10^6 Temp. °F Date sampled

te, color, etc. [redacted]

Well Number 28 25 140 081 29 03.1
d m s d m s

HYDROGEOLOGIC CARD

SAME AS ON MASTER CARD Physiographic Province: COASTAL PLAIN 03 Section: FLORIDAN

SECTION C Drainage Basin: LAKE OKEECHOBEE 10B Subbasin: INFLOW AREA 1

Topo of well site: (D) local depression, (F) flat surface, (H) hilltop, (S) hillside, (T) terrace, (V) valley flat, SINK S

MAJOR AQUIFER: TERTIARY system, EOCENE series TE aquifer, formation, group FLORIDAN 1F

Lithology: CAVERNOUS limestone 0L Origin: MARINE 6 Aquifer Thickness: ft

Length of well open to: 311 ft 311 Depth to top of: 140? ft 140

MINOR AQUIFER: system series aquifer, formation, group

Lithology: Origin: Aquifer Thickness: ft

Length of well open to: ft Depth to top of: ft

Intervals Screened:

Depth to consolidated rock: 140 ft 140 Source of data: SUBSURF. MAP L

Depth to basement: 6600 ft 6600 Source of data: DRILLER'S LOG D

Surficial material: MED SAND 35 Infiltration characteristics: EXCELLENT 1

Coefficient Trans: gpd/ft Coefficient Storage:

Coefficient Perm: gpd/ft²; Spec cap: gpm/ft; Number of geologic cards:

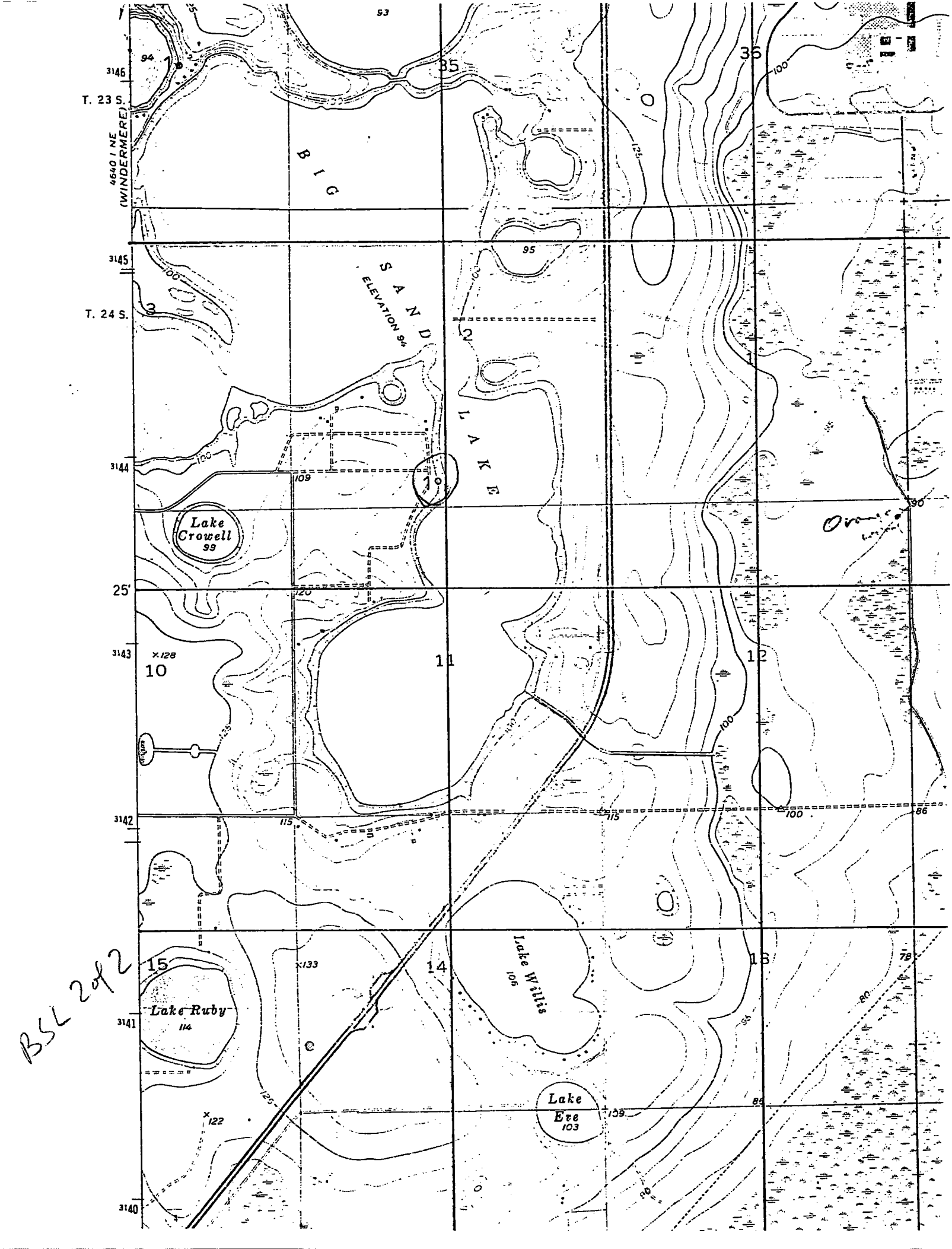
R28E

T24S 2

290

BSL 1 42

GPO 844-225



T. 23 S.
T. 24 S.
4640 I NE (WINDERMERE)
BIG SAND LAKE
ELEVATION 94
Lake Crowell 99
Lake Ruby 114
Lake Willis 106
Lake Eve 103
35
36
3
2
1
10
11
12
15
14
13
25'
3146
3145
3144
3143
3142
3141
3140

BSL 2 of 2

Serene 104

FORM NO 9-1904-A

SITE NO. 282636081300801

Recorded by J. C. Fiduk

U.S. DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
GROUND WATER SITE INVENTORY
SITE SCHEDULE

Date 8/28/79

Check One X English ___ Metric Units

(DR. Phillips)

GENERAL SITE DATA (0)

Site Ident No 282636081300801 (5–19) | RG Number R=0 * | Transaction T= A D M V * (add, delete, modify, verified)

Site-Type 2= C D H I M P T W * (collector, drain, sinkhole, connector, multiple, pond, tunnel or, well, well shaft) | Data Reliability 3= C U L M * (field checked, unchecked, location not, minimal accurate data) | Reporting Agency 4= USGS *

Project No. 5= 15400 * | District 6= 125 * | State 7= 12 * | County (or town) Orange 8= 095 *

Latitude 9= 282636 * (deg min sec) | Longitude 10= 0813008 * (deg min sec) | Lat-Long Accuracy 11= S F T M * (sec, 5 sec, 10 sec, Min)

Local Number 12= 82613003 * | Land Net Loc. 13= SWSENW S 34 T 23 S R 28 E * (1/4 1/4 1/4 section, township, range, merid)

Location Map 14= WINDERMERE * | Scale 15= 24000 *

Altitude 16= 101.88 * | Method of Measurement 17= A L M * (altimeter, level, map) | Accuracy 18= 5.0 *

Topo Setting 19= D C E F H K L Ø P S T U V W * (depression, stream, dunes, flat, hilltop, sink, swamp, offshore, pediment, hillside, terrace, undulating, valley, upland, channel, flat, draw) | Hydrologic Unit (OWDC) 20= 03090101 *

Date of First Construction/Completion 21= 11/17/1960 * (month day year) | Use of Site 23= A D E G H Ø M P R S T U W X Z * (anode, drain, geo-thermal, seismic, heat, reserv, observ-ation, mine, oil or, gas, recharge, repress, test, unused, with-drawal, waste, destroyed)

Use of Water 24= A B C D E F H I M N P R S T U Y Z * (air cond., bottling, commercial, dewater, power, fire, domestic, irrigation, medicinal, industrial, public, supply, recreation, stock, institution, unused, desal, other)

Secondary Water Use 25= * | Tertiary Use of Water 26= * | Depth of Hole 27= 366. * | Depth of Well 28= 366. * | Source of Depth Data ① 29= L *

Water Level 30= 33.12 * | Date Measured 31= 05/15/1979 * (month day year) | Source ① 33= S *

Method of Measurement 34= A C E G H L M R S T V Z * (airline, calibrated, estimated, pressure, calibrated, geophysical, manometer, reported, steel tape, electric, calibrated, other, airline, pressure gage, logs, tape, electric tape)

Site Status 37= D F G H Ø P R S T V X Z * (dry, flowing, nearby, flowing, nearby, recently flowing, obstruction, pumping, recently, pumped, nearby, pumping, nearby, recently pumped, foreign substance, surface water effects, other)

Source of Geohydrologic Data ① 36= S * | Pump Used 35= N * (no) | Measuring Point 266= 0.0 * | Measuring Point Date 267= 05/15/1979 * (month day year)

1-7

OWNER IDENTIFICATION (1)

R=158 * | T= A D M * (add, delete, modify) | Date of Ownership 159# 11/17/1960 * (month day year)

Name: Last 161= MINUTE MAID CO * | First 162= * | Middle Initial 163= *

OTHER SITE IDENTIFICATION NUMBERS (1)

R=189 * | T= A [redacted] M * (add, delete, modify) | Ident 190# [redacted] * | Assigner 191= *

New Card Same R & T | Ident 190# * | Assigner 191= *

SITE VISIT DATA (1)

R=186 * | T= A D M * (add, delete, modify) | Date of Visit 187# 05/15/1979 * (month day year) | Name of Person 188= SCHINER *

FIELD WATER QUALITY MEASUREMENTS (1)

R=192 * | T= A D M * (add, delete, modify) | Date 193# 05/15/1979 * (month day year) | Geohydrologic Unit 195# 120FLRD *

New Card Same R thru 195

Temperature	196# 00010 *	Degrees C	197= 24. *
Conductance	196# 00095 *	µ Mhos	197= 335. *
Other (STORET) Parameter	196# 00400 *	Value	197= 7.2 *
Other (STORET) Parameter	196# 00440 *	Value	197= 445. *

	BY	DATE
CHECKED		
PUNCHED		
EDITED		
SUBMITTED		
VERIFIED		

FOOT NOTES:

① Source of Data Codes:

S D Ø A R L G Z (reporting agency, driller, owner, other gov't, other reported, logs, geologist, other)

WELL CONSTRUCTION DATA (1)

R = 58 * | T = A D M * (add, delete, modify) | Entry No 59 # 001 * | Date of Construction Completion 60 = 11/17/1960 * (month day year) | Source of ① Const. Data 64 = L *

Name of Contractor/Driller 63 = LAYNE ATLANT * — Layne Atlantic

Method of Construction 65 = A B C D H J P R T V W Z *
air-rotary, bored, or augered, cable-tool, dug, hydraulic, rotary, jetted, air-percussion, reverse, rotary, trenching, driven, drive, wash, other

Finish 66 = C F G H Ø P S T W X Z *
porous, concrete, gravel w. perf, gravel, screen, horizontal, gallery, open, end, perforated, or slotted, screen, sand point, walled, open hole, other

Type of Seal 67 = B C G Z *
bentonite, clay, cement, grout, other

Bottom of Seal 68 = *

Method of Development 69 = A B C J N P S Z *
air-lift, pump, bailed, compressed, air, jetted, none, other, pump, surged, other

Number of Hours in Development 70 = *

Special Treatment During Development 71 = C D E F H M Z *
chemicals, dry ice, explosives, defloculent, hydrofracturing, mechanical, other

DIMENSIONS OF THE HOLE CONSTRUCTED (2)

R = 72 * | T = A D M * (add, delete, modify) | Construction Entry No 59 # 001 *

New Card for Each Hole Segment Same R, T & Field 59

Top of Hole Segment Below LSD	Bottom of Hole Segment below LSD	Diameter of Hole Segment
73 # 0. *	74 = 366. *	75 = 12. *
73 # . *	74 = . *	75 = . *
73 # . *	74 = . *	75 = . *
73 # . *	74 = . *	75 = . *
73 # . *	74 = . *	75 = . *

CASING SCHEDULE (2)

R = 76 * | T = A D M * (add, delete, modify) | Construction Entry No 59 # 001 *

New Card for Each Casing With Same R, T & Field 59

Top of Casing Segment Below LSD	Bottom of Casing Segment Below LSD	Diameter of Casing Segment	Casing Material ⑤	Thickness of Casing
77 # 2.0 *	78 = 116. *	79 # 12. *	80 = T *	81 = . *
77 # . *	78 = . *	79 # . *	80 = *	81 = . *
77 # . *	78 = . *	79 # . *	80 = *	81 = . *
77 # . *	78 = . *	79 # . *	80 = *	81 = . *
77 # . *	78 = . *	79 # . *	80 = *	81 = . *

OPENINGS SCHEDULE (2)

R = 82 * | T = A D M * (add, delete, modify) | Construction Entry No 59 # 001 *

New Card for Each Open Section With Same R, T and Field 59

	(Openings Data)	(Openings Data)	(Openings Data)
Top of Section Below LSD	83 # 116. *	83 # . *	83 # . *
Bottom of Section Below LSD	84 = 366. *	84 = . *	84 = . *
Type of Openings ⑥	85 = X *	85 = *	85 = *
Type of Material ⑦	86 = *	86 = *	86 = *
Diameter of Open Section	87 = . *	87 = . *	87 = . *
Width of Opening	88 = . *	88 = . *	88 = . *
Length of Opening	89 = . *	89 = . *	89 = . *

L-7

FOOT NOTES:

① Source of Data Codes:
S D Ø A R L G Z
reporting agency, driller, owner, other gov't, other reported, logs, geologist, other

⑤ Casing Material Codes
B C G I M P R S T U W Z
brick, concrete, galv. iron, wrought iron, other metal, PVC or plastic, rock or stone, steel, tile, coated steel, wood, other

⑥ Type of Openings Codes
F L M P R S T W X Z
fracture, louvered, shuttered, mesh, perforated or slotted, wire-wound, screen (unknown), sand point, walled, open hole, other

⑦ Type of Material Codes for Open Sections
B C G I M P R S T Z
brass or bronze, concrete, galv. iron, wrought iron, other metal, PVC or plastic, stainless steel, steel, tile, other

R = 134 [146] * (flowing, pumped) | T = [A] D M * (add, delete, modify) | Entry No 147# 00.1 * | Date 148 = 0,5/15/1979 * (month day year)

Discharge: 150 = 380.7 * | Source of Data ① 151 = S *

Method of Measurement 152 = B C E F [M] O P R T U V W Z * (bailer, current meter, estimated, flume, totalizing meter, orifice, pitot-tube meter, reported, trajectory, venturi, volumetric, weir, other)

Production Level 153 = 36.89 * | Static Level 154 = 33.12 * | Source ① of Data 155 = S * | Specific Capacity 272 = 1.01 *

Method of Measurement 158 = A C E G H L M R [S] T V Z * (airline, calibrated, estimated, pressure gage, calibrated pressure gage, geophysical logs, manometer, reported, steel tape, electric, calibrated, other electric tape) | Pumping Period 157 = 3 *

LIFT DATA (1)

R = 42 * | T = A D M * (add, delete, modify) | Type of Lift 43 # A B C J P R S T U Z * (air, bucket, centrifugal, jet, piston, rotary, submergible, turbine, unknown, other) | Entry No 254 # *

Pump Intake Setting 44 = * | Type of Power 45 = D E G H L N W Z * (diesel, electric, gasoline, hand, LP gas, natural gas, windmill, other) | Date 38 = / / * (month day year) | Horsepower 46 = *

MAJOR PUMP DATA (2)

R = 47 * | T = A D M * (add, delete, modify) | Type of Lift 43 # * | Lift Entry No 254 # * | Manufacturer of Pump 48 = *

Serial No of Pump 49 = * | Name of Power Company 50 = * | Power Company Account No 51 = * | Power Meter No 52 = * | Pump Rating 53 = *

AVAILABLE LOG DATA (1)

R = 198 * | T = [A] D M * (add, delete, modify) | New Card for Each Log Type Same R & T

Type of Log ②	Begin Depth 200 =	End Depth 201 =	Source of Data ① 202 =
199 # C *	100. *	366. *	S *
199 # J *	2. *	360. *	S *
199 # E *	200 *	364. *	S *
199 # F *	3.0 *	360. *	S *
199 # T *	30. *	369. *	S *
199 # J *	2. *	140. *	S *
199 # E *	100. *	360. *	S *
199 # V *	100. *	345. *	J *

WATER QUALITY DATA COLLECTION (1)

R = 114 * | T = [A] D M * (add, delete, modify) | Begin Year 115 # 1979 * | End Year 116 = * | Source Agency 117 = USGS *

Frequency of Collection ③ 118 = [9] * | Network Site 257 = * | Type of Analyses ④ 120 = M *

WATER LEVEL DATA COLLECTION (1)

R = 121 * | T = [A] D M * (add, delete, modify) | Begin Year 122 # 1971 * | End Year 123 = * | Source Agency 124 = USGS *

Frequency of Collection ③ 125 = * | Network Site 258 = *

WATER PUMPAGE/WITHDRAWAL DATA COLLECTION (1)

R = 127 * | T = [A] D M * (add, delete, modify) | Begin Year 128 # 1979 * | End Year 129 = * | Source Agency 130 = USGS *

Frequency of Collection ③ 131 = [9] * | Network Site 259 = * | Method of Collection 133 = C E [M] U Z * (calculated, estimated, metered, unknown, other)

OTHER DATA AVAILABLE (1)

R = 180 * | T = A D M * (add, delete, modify) | Type of Data 181 # * | Loc 182 = C D Z * (cooperator, district, other) | Format 261 = F M P Z * (files, machine, published, other readable)

New Card Same R & T | Type of Data 181 # * | Loc 182 = C D Z * | Format 261 = F M P Z *

FOOT NOTES:

① Source of Data Codes:

S D Ø A R L G Z (reporting, driller, owner, other gov't, other reported, logs, geologist, other agency)

L S T U V Z (sonic, temp, gamma, fluid, other gamma velocity)

③ Frequency of Collection Codes

A B C D F I M Ø Q S W Z (annual, bi-monthly, continuous, daily, semi monthly, intermittent, monthly, one time only, quarter annual, semi- annual, weekly, other)

② Type of Log Codes

A B C D E F G H I J K L M N Ø P Q (time, collar, caliper, driller's, electric, fluid conduct, geologist, magnetic, induction, gamma ray, dipmeter, laterlog, microlog, neutron, μ later, photo, radio-active)

④ Type of Quality Analyses Codes

A B C D E F G H J K L M Z (physical, common chemical, trace elements, pesticides, nutrients, sanitary, codes B&D, codes B&E, codes B&F, codes D&E, codes C,D&E, all or most, other)

Screen 4 of 7

GEOHYDROLOGIC UNIT DESCRIPTIONS (1)

R = 90 * | T = A D M * (add, delete, modify) | Entry No 256 # 001 * | Depth to Top 91 = 138. * | Depth to Bottom 92 = * |

Unit Identifier 93 = 120 FLAD * | Lithology 96 = LAGM * | Lithologic Modifier 97 = CAVERNOUS *

AQUIFER DATA (2)

R = 94 * | T = A D M * (add, delete, modify) | Geohydrologic Unit Entry No 256 # 001 *

Date 95 # 05 / 15 / 1979 * (month / day / year) | Water Level 126 = 33.12 * | % Water Contributed 132 = 95 *

GEOHYDROLOGIC UNIT DESCRIPTIONS (1)

R = 90 * | T = A D M * (add, delete, modify) | Entry No 256 # * | Depth to Top 91 = * | Depth to Bottom 92 = *

Unit Identifier 93 = * | Lithology 96 = * | Lithologic Modifier 97 = *

AQUIFER DATA (2)

R = 94 * | T = A D M * (add, delete, modify) | Geohydrologic Unit Entry No 256 # *

Date 95 # / / * (month / day / year) | Water Level 126 = * | % Water Contributed 132 = *

PERTINENT REMARKS

R = 183 * | T = A * (add)

185 = MINUTE MAID CO. - OR. PHILLIPS *

New Card Same R&T

185 = MH = MANHOLE GRATE AT LSD *

311 #010 *

185 = OK. PHILLIPS *

NOTES: 185 = YIELDING ZONES 120, 145 FT.

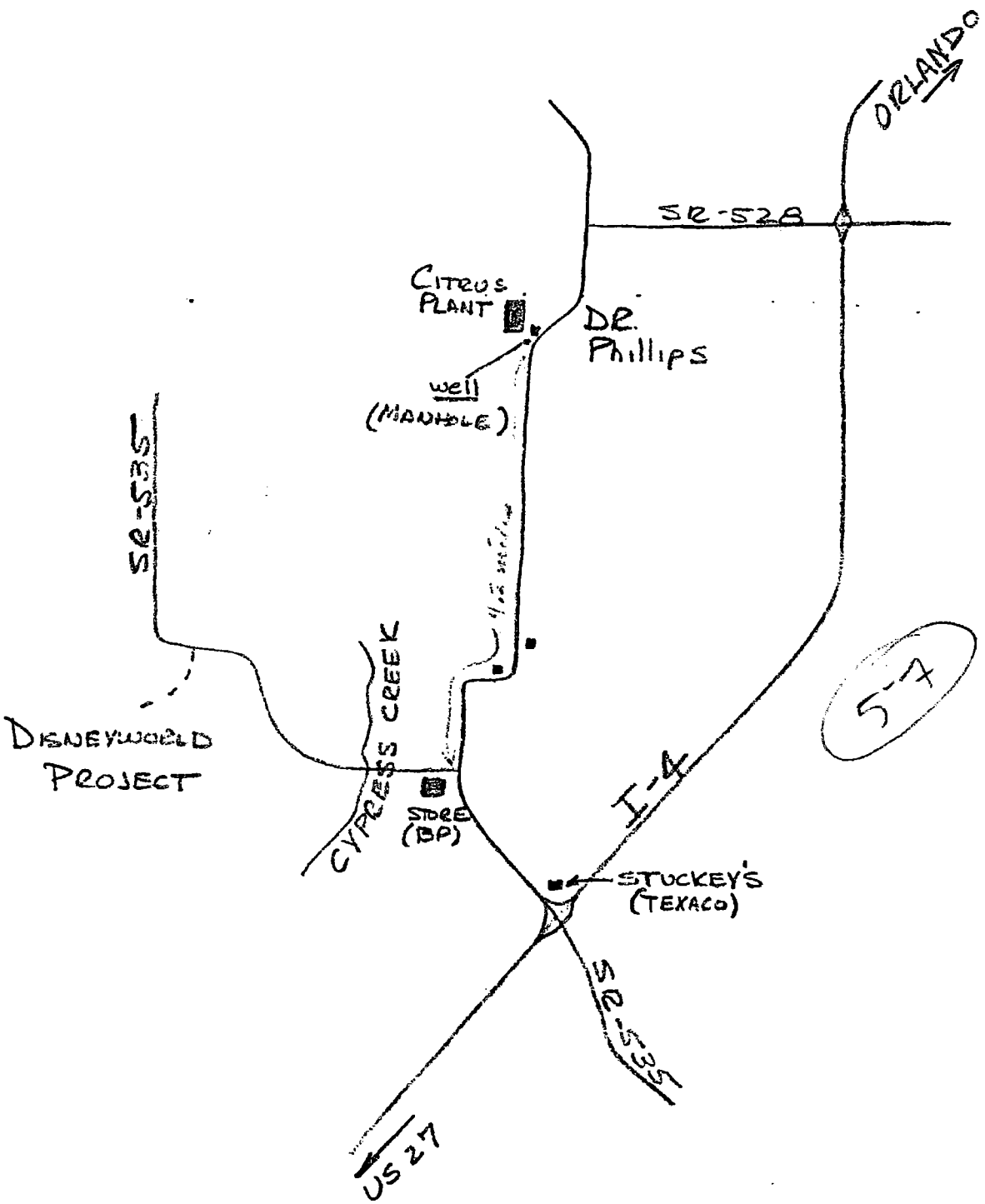
4-7

U. S. GOVERNMENT PRINTING OFFICE : 1976 O - 213-137

Serene 5 of 7

Dr. Phillips Deep (826-130-3)

282636 0813008



Letter 697

...ARTM. OF THE INTERIOR — GEOLOGICAL SURVEY

Water Resources Division Well Schedule Form

Well Number 28 26 36 0081 3X

MASTER CARD

...ord by W.F. LICHTLER Source data DRILLER Date 11-17-60 Map WINDERMERE

...te FLORIDA 09 County (or town) ORANGE COUNTY 48

...titude: 28 26 36 N Longitude: 081 30 08 Incremental number: 1

...ation: T. 23 S. 29 E. Sec. 34 SW SE NW

Local ...l number: 8261303 Other number:

...of use: 23 BTLG Owner or firm: MINUTE MAID

...ner or name: MINUTE MAID CO. Address: ORLANDO FLA

...ership: (C) County, Fed Gov't, City, (H) Corp or Co, (I) Private, State Agency, Water Dist M

...s of ...ter: (A) Air cond, (C) Comm, (D) Domestic, (F) Fire, Dom, Irr, Ind, P.S, (S) Stock, (T) Irrig, (U) Unused U

...s of ...: (A) Acode, (D) Drain, (G) Seismic, Obs, (O) Oil-gas, Recharge, (S) Spring, Test, (T) Unused, Withdrawn, (W) Waste, Destroyed D

...TA AVAILABLE: Well data 2 Freq. W/L meas.: INTERMITTENT Field aquifer char.

...l. lab. data:

...l. water data: type:

...m. sampling: Pumpage inventory: yes no period:

...rture cards: yes

...l data:

WELL-DESCRIPTION CARD

...ME AS ON MASTER CARD Depth well: 356 ft 356 Meas. (Repl.) RPTD Accuracy 6

...pth cased for perf.) 1144 ft 1144 Casing size: BLK TOP diam. 12 in 12

...ugh: (C) pervious concrete, (F) gravel w. (perf.), gravel w. (screen), (H) bored, gallery, shot, (O) open perf., screen, sd. pt., shoe, (X) open hole, (Z) other X

...hod ...lled: (A) air rot, (B) bored, (C) cable, (D) dug, (H) hyd rot., (J) jetted, (P) air percussion, rotary, (R) reverse trenching, (T) driven, (V) drive wash, (Z) other C

...e ...lled: Pump intake setting: ft

...ller: LAYNE ATLANTIC address ORLANDO FLA

...e ...p): (A) air, (B) bucket, cent, jet, (J) multiple, multiple (cent.), (M) (turb.) none, (P) piston, (R) rot, submerg, turb, other N Deep Shallow

...er ...p): diesel, elec, gas, gasoline, hand, gas, wind; N.P. LPG nat Trans. or meter no.

...ing. pt: LIP OF MANHOLE AT LSD above below lsd Alt. pt: FOG 101.88

...LSD: 101.5 FOG 106 Accuracy (meters): TOPO MAP 5FT 3

...ed: 20036 ft above (below) msl ft above (below) lsd 20 Accuracy: TAPED 0

...e: 11-17-60 1960 Yield: gpm Method determined

...mping: ft Accuracy: Pumping period: hrs

...ALITY OF ...ER DATA: Iron ppm Sulfate ppm Chloride ppm Hard. ppm

Geology: X = 10^6 Temp. °F Date sampled

...ap, color, etc.

104

HYDROLOGIC CARD

SAME AS ON MASTER CARD Physiographic Province: COASTAL PLAIN 03 Section: FLA...

SECT: C Drainage basin: Subbasin:

Type of well site: local depression, (F) flat surface, (H) hilltop, hillside, terrace, valley flat, F

MAJOR AQUIFER: EAT... system EOCE... series TE FLORIDAN AQUIFER 1 F aquifer, formation, group

Lithology: CAVERN LS. Q4 Origin MARINE 6 Aquifer Thickness ft

Length of well open to: 292 ft 292 Depth to top of: 140 ft 140

MINOR AQUIFER: system series aquifer, formation, group

Lithology: Origin: Aquifer Thickness ft

Length of well open to: ft Depth to top of: ft

Intervals screened:

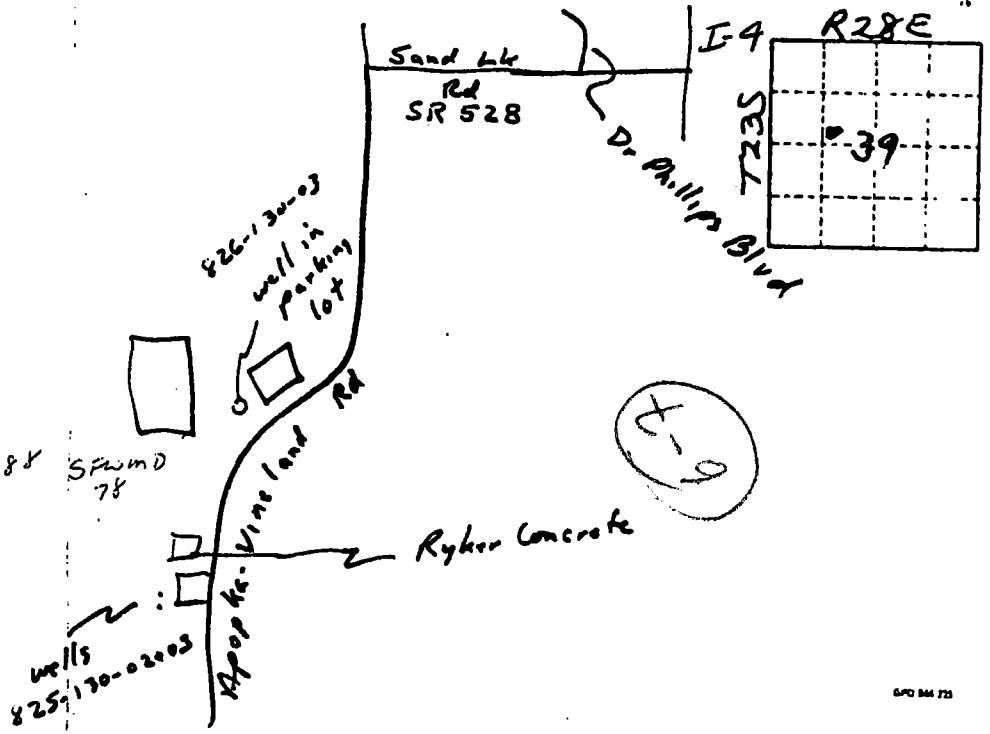
Depth to consolidated rock: 140 ft 140 Source of data: SUBSURFACE INF L

Depth to basement: 6600 ft 6600 Source of data: DRILL. LOG D

Surficial material: FINE SAND 25 Infiltration characteristics: EXCELLENT 1

Coefficient trans: gpd/ft Coefficient storage:

Coefficient perm: gpd/ft²; Spec cap: gpm/ft; Number of geologic cards:



Scene 24

WRD Rep. (DB)
Aug. 1964

U. S. DEPARTM OF THE INTERIOR GEOLOGICAL SURVEY

Water Resources Division Well Schedule Form

MASTER CARD

Record by W F LOVELACE Title DRILLER Date 11-17-60 Rep WINDERMERE

State FLORIDA 09 County (or town) ORANGE COUNTY 095

Latitude 2 8 2 6 3 6 N Longitude 0 8 1 3 0 0 W Sequential number 1

Location (Township) T. 23 S. Rge. 28 E. Sec. 34 SW. SE. NW.

Local well number: 23R/28E/34 Other number:

Local use: PACKING PLANT Name: MINUTE MAID

Owner or name: MINUTE MAID CO. Address: ORLANDO FLA

Ownership: (C) County, (F) Fed Gov't, (M) City, (C) Corp or Co, (P) Private, (S) State Agency, (W) Water Dist

Use of water: (A) Air Cond, (C) Comm, (D) Domestic, (F) Fire, (I) Irr, (N) Ind, (P) PS, (S) Stock, (T) Test, (U) Unused

Type of well: (A) Aband, (D) Drive, (C) Bedrock, Cbs, (D) Dug, (F) Flowing, (R) Recharge, (S) Spring, (T) Test, (U) Unused, (W) Withdraw, (X) Waste, (Y) Destroyed

DATA AVAILABLE: Well data 2 From, W/L meas.: INTERMITTENT Field aquifer char.

Anl. lab. data:

Qual. water data: Type:

Prod. sampling: Pumpage inventory: No. period:

Aperture cards: yes

Log data:

WELL-DESCRIPTION CARD

SAME AS IN MASTER CARD Depth well: 356 ft 356 (Tapl) RPTD 6

Depth cased (first perf.) 1144 ft 1144 Casing size: BLK TOWN diam. 12 in 12

Finish: (C) Perfor. concrete, (F) gravel w. (pref.), (G) gravel w. (screen), (H) bottle, (O) open gallery, and, (P) perf., screen, ad. pt., abrasive, (R) open hole, (Z) other

Method Drilled: (A) air rot, (B) bored, (C) cable, (D) dug, (H) hyd rot., (J) jetted, (P) air percussion, rotary, (R) reverse circulation, (T) driven, (V) drive wash, other (Z)

Date Drilled: Pump intake setting: ft

Driller: LAING ATLANTIC ORLANDO FLA

Lift (type): (A) air, bucket, cent, jet, (I) multiple, multiple (cent.), (K) multiple (turb.), (N) none, (P) piston, rot, submerg, turb, other, Deep Shallow

Power (type): diesel, elec, gas, gasoline, hand, gas, wind; Nat. LPG Engine or motor no.

Permits, MP TOP OF MANHOLE AT LSD above below lsd, Alt. MP 106 101.88

Alt. Log Dia. 106 116 Accuracy (feet) TOPO MAP 5FT 3

Water level 20.26 ft (Meas) (Rptd) above below lsd 20 Accuracy: TOPO 0

Date taken: 11-17-60 (M) (R) Yield: gpm Method determined

Drawdown: ft Accuracy: Pumping period: hr

WEIGHT OF WATER DATA: Iron ppm Sulfate ppm Chloride ppm Hard. ppm

Sp. Conduct. x 10⁶ Temp. °F Date sampled

Logging, caliper, etc.

10"

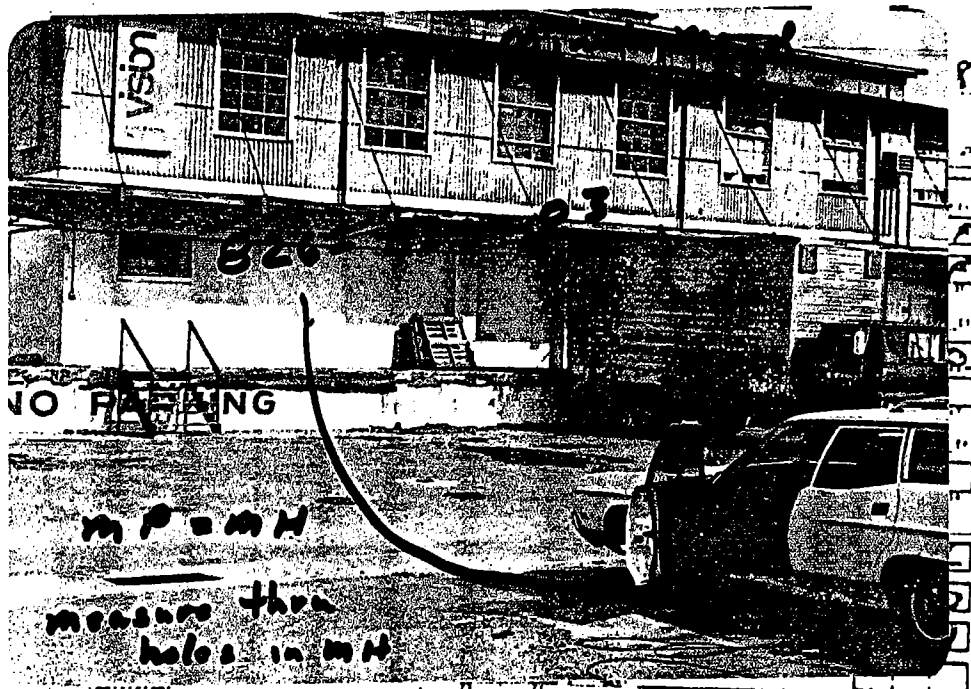
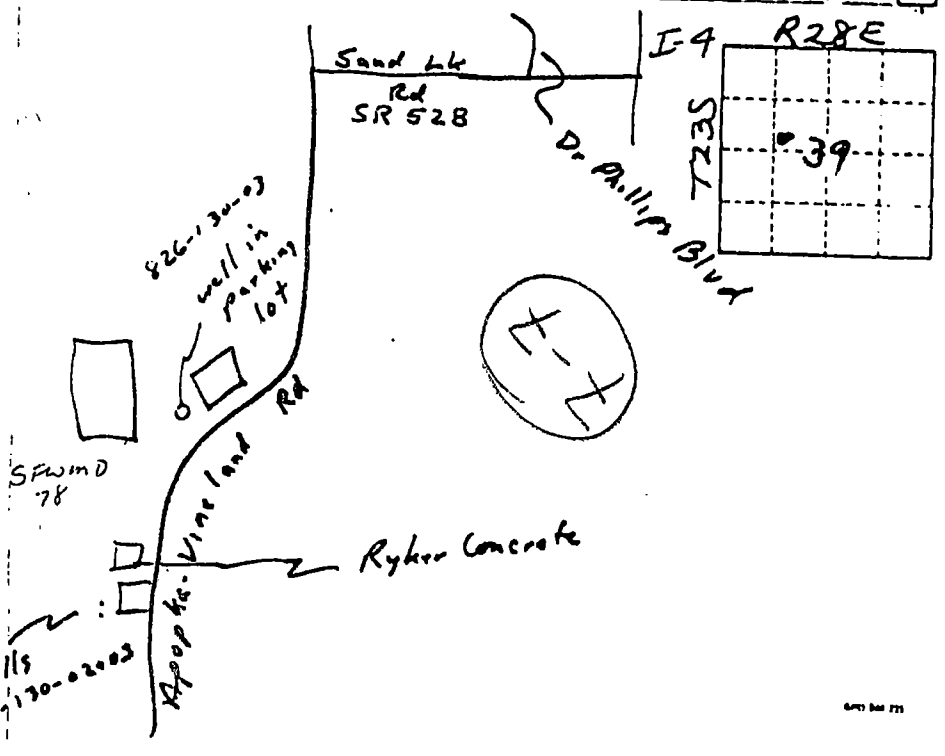


Fig. 1-A

Correlation Perm: gpd/ft²; Spec cap: gpm/ft; Number of geologic cards:



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Appendix C

Site Visit Photographs

GIS Source: Orange County, SFWMD & CDM

2,500 0 2,500 Feet

LEGEND

o Photo Locations

Orange County, Florida
Big Sand Lake Outfall Conceptual Improvements

CDM

Figure C-1
Photo Locations

moultonda 01/11/04 Appendix C-1 D:\Projects\6059\bigsandlake\Report_Figures\Appendix_C.mxd

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Outfall canal looking northwest towards Big Sand Lake – Location A (08/05/03)

Outfall canal looking southeast towards I-4 westbound on ramp – Location A (08/05/03)

First set of culverts immediately d/s of Big Sand Lake - under grove access road – Location A (08/05/03)

Excessive sedimentation located at I-4 cross drain - looking southeast (to I-4 cross drain) – Location B (08/05/03)

Outfall canal looking southwest towards Turkey Lake Road – Location A (08/05/03)

Excessive sedimentation located at I-4 cross drain - looking northwest (to I-4 west bound on ramp) – Location B (08/05/03)

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Excessive water surface elevation in Big Sand Lake – looking north – Location C (08/11/03)

Excessive drawdown in Little Sand Lake associated with retention wall failure – looking south east – Location D (08/11/03)

Northern edge of Little Sand Lake showing excessive drawdown subsequent to retention wall failure – looking southwest – Location D (08/11/03)

Location of retention wall failure looking east – Location E (08/11/03)

Excessive drawdown in wet retention pond immediately north of Little Sand Lake - associated retention wall failure – looking north – Location D (08/11/03)

Location of retention wall failure - looking east – Location E (08/11/03)

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Overgrown channel segment immediately east of I4 - looking west – Location F (08/11/03)

Outfall canal looking northwest towards Big Sand Lake and pumps – Location A (08/26/03)

Overgrown channel segment immediately east of I4 - looking northwest towards I4 – Location F (08/11/03)

Location of emergency pumps - looking northwest towards Big Sand Lake – Location A (08/26/03)

Water surface elevation at first set of culverts - grove access road - looking east – Location F (08/11/03)

Location of emergency pumps - looking southeast towards I-4 – Location A (08/26/03)

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Outfall canal looking southeast towards Turkey Lake Road – Location A (08/26/03)

Culvert under I-4 west bound on ramp - looking west – Location B (08/26/03)

Outfall canal at Turkey Lake Road - looking southeast – Location A (08/26/03)

Channel segment immediately east of I-4 - looking northwest – Location F (08/26/03)

Concrete box culvert under I-4 - looking southeast – Location B (08/26/03)

Channel segment immediately east of I-4 - looking southeast towards Valencia Water Control District – Location F (08/26/03)

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Outlet structure from pond to channel segment immediately east of I-4 - looking northwest – Location F (08/26/03)

C-1 Canal Structure S-101 - Radial Gate looking southeast – Location H (08/26/03)

Upstream end of Valencia Water Control Canal C-1 - looking north – Location G (08/26/03)

Canal Structure S-101 - Radial Gate looking northwest – Location H (08/26/03)

Upstream end of Valencia Water Control Canal C-1 looking southeast (d/s) – Location G (08/26/03)

Close up of Structure S-101 - looking northwest – Location H (08/26/03)

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Canal C-1 Structure S-102 immediately downstream of S-101 - looking southwest – Location I (08/26/03)

Weir structure from Spring Lake - immediately upstream of Sand Lake Road - looking southwest – Location J (08/26/03)

Structure S-102 looking northwest – Location I (08/26/03)

Headwall at connection between Spring and Little Sand Lakes at Little Sand Lake - looking northwest – Location J (08/26/03)

Outfall from Spring Lake under Sand Lake Road - looking south – Location J (08/26/03)

Excessive water elevation in Big Sand Lake - in approximate location of drainage well - looking northeast – Location K (08/26/03)

Appendix C – Site Visit Photographs
Big Sand Lake Outfall Conceptual Improvements – Orange County, Florida

Excessive water elevation in Big Sand Lake in approximate location of drainage well - looking east – Location K (08/26/03)

Cross drain (for Lake Willis flow) under Turkey Lake Road - looking northwest – Location L (10/24/03)

Downstream end of 30 inch RCP under I-4 draining Lake Willis - looking south – Location L (10/24/03)

Drainage ditch leading from I-4 (Willis cross drain) to Turkey Lake Road - looking northwest – Location L (10/24/03)

Appendix D

F.A.C. Regulations Regarding Supplemental Reuse

(11) This rule provides for exemptions, allowances and variations from requirements. Unless specifically provided otherwise, requirements in this rule shall be applicable only to new domestic wastewater collection/transmission facilities for which construction permit applications are approved by the Department after November 6, 2003. This rule also shall apply to all facilities existing prior to November 6, 2003, when such facilities are to be modified, but such applicability shall apply only to the modification thereof.

(12) Specific activities required to obtain a permit are outlined in Rule 62-604.600, F.A.C.

(13) Individual service connections from single family residences are not required to be permitted by the Department.

Specific Authority 403.061, 403.087 FS. Law Implemented 403.021, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088 FS. History–New 11-27-89, Amended 6-4-92, Formerly 17-604.100, Amended 12-26-96, 11-6-03.

62-604.120 Variations from Requirements.

Additional relief from the criteria established by this rule may be provided through an exemption, pursuant to Rule 62-4.243, F.A.C., or a variance, pursuant to Rule 62-110.104, F.A.C.

Specific Authority 403.061, 403.087 FS. Law Implemented 403.021, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088 FS. History–New 11-27-89, Formerly 17-604.120, Amended 12-26-96, 11-6-03.

62-604.130 Prohibitions.

The following acts and the causing thereof are prohibited.

(1) The release or disposal of excreta, sewage, or other wastewaters or residuals without providing proper treatment approved by the Department; construction or operation of a wastewater collection system not in compliance with this rule; or any act otherwise violating provisions of this rule or of any other rules of the Department.

(2) Violations of the odor prohibition in subsection 62-296.320(2), F.A.C.

(3) Cross-connection, as defined in Rule 62-550.200, F.A.C.

(4) Except to augment the supply of reclaimed water when all conditions of paragraph 62-610.472(3)(c), F.A.C., are met, the deliberate introduction of stormwater in any amount into collection/transmission systems designed solely for the introduction (and conveyance) of domestic/industrial wastewater and/or the deliberate introduction of stormwater into collection/transmission systems designed for the introduction or conveyance of combinations of storm and domestic/industrial wastewater in amounts which may reduce the efficiency of pollutant removal by the treatment plant.

(5) The acceptance, by the operating authority of a collection/transmission system or by the permittee of a treatment plant, of connections of wastewater discharges which have not received necessary pretreatment or which contain materials or pollutants (other than domestic wastewater constituents):

(a) Which may cause fire or explosion hazards; or

(b) Which may cause excessive corrosion or other deterioration of wastewater facilities due to chemical action or pH levels; or

(c) Which are solid or viscous and obstruct flow or otherwise interfere with wastewater facility operations or treatment; or

(d) Which result in the wastewater temperature at the introduction of the treatment plant exceeding 40°C or otherwise inhibiting treatment; or

(e) Which result in the presence of toxic gases, vapors, or fumes that may cause worker health and safety problems.

(6) The failure to maintain equipment in a condition which will enable the intended function.

(7) The submission, by the owner, manager, or operator of a collection/transmission system, or agent or employee thereof, of misleading, false, or inaccurate information to the Department, either knowingly or through neglect.

Specific Authority 403.061, 403.087 FS. Law Implemented 403.021, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088, 403.121, 403.131, 403.161 FS. History–New 11-27-89, Formerly 17-604.130, Amended 12-26-96, 11-6-03.

62-604.200 Definitions.

Terms used in this rule shall have the meaning specified below. The meaning of any term not defined below may be taken from definitions in other rules of the Department, unless such meaning would defeat the purposes or intent of Chapter 62-604, F.A.C.

(1) "Alternative collection/transmission systems" means those systems referenced in paragraphs 62-604.300(5)(b), (c), and (j), F.A.C., or other collection/transmission systems not comprised of strictly conventional gravity sewers, pump stations, and force mains.

(2) "Collection/transmission systems" means sewers, pipelines, conduits, pumping stations, force mains, and all other facilities used for collection and transmission of wastewater from individual service connections to facilities intended for the purpose of providing treatment prior to release to the environment.

(3) "Commission" means the Environmental Regulation Commission.

(4) "Delegated local program" means any county, municipality, or combination thereof that has established and administers a pollution control program approved by the Department in compliance with Section 403.182, F.S., as amended.

(5) "Department" means the State of Florida Department of Environmental Protection, or delegated local program, where applicable.

(6) "District office" means the regional district offices of the Department.

62-610.471 Setback Distances.

(1) There shall be a setback distance of 75 feet from the edge of the wetted area of the public access land application area to potable water supply wells that are existing or have been approved by the Department or by the Department of Health (but not yet constructed). To comply with this requirement a utility providing reclaimed water for residential irrigation may adopt and enforce an ordinance prohibiting private drinking water supply wells in residential areas. This setback distance requirement does not apply to closed loop heating or air conditioning return wells.

(2) No setback distance is required to any nonpotable water supply well.

(3) A 75-foot setback distance shall be provided from a reclaimed water transmission facility to a public water supply well. No setback distance is required to other potable water supply wells or to nonpotable water supply wells.

(4) Setback distances for potable water supply wells shall be applied only for new or expanded reuse facilities. Setback distances shall not be applied when considering renewal of a permit.

(5) Setback distances are not required for surface waters or developed areas.

(6) Within 100 feet from outdoor public eating, drinking and bathing facilities, low trajectory nozzles, or other means to minimize aerosol formation shall be used.

(7) No setback distances are required for private swimming pools, hot tubs, spas, saunas, picnic tables, or barbecue pits or grills.

(8) A setback distance of 100 feet shall be maintained from indoor aesthetic features (such as decorative pools or fountains) using reclaimed water to adjacent indoor public eating and drinking facilities where the aesthetic features and eating and drinking facilities are within the same room or building space.

(9) A setback distance of 200 feet shall be provided from unlined storage ponds to potable water supply wells. This setback distance shall be reduced, but in no case to less than 75 feet, if the applicant provides an affirmative demonstration in the engineering report that reclaimed water will not migrate to the potable water supply well as a result of conditions such as the following:

(a) Confining units exist which preclude migration of the reclaimed water to the potable water supply well, or

(b) Ground water flow will be away from the potable water supply well, or

(c) Other hydrogeologic conditions preclude migration of the reclaimed water to the potable water supply well.

(10) Unless specifically stated otherwise, all setback distances shall be measured horizontally.

(11) For aquifer storage and recovery projects regulated under Rule 62-610.466, F.A.C., setback distance requirements for injection and recovery wells and for extended zones of discharge are contained in Rules 62-610.466(13) and (14), F.A.C.

Specific Authority 403.051, 403.061, 403.087 FS. Law Implemented 403.021, 403.051, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088 FS. History–New 4-4-89, Amended 4-2-90, Formerly 17-610.471, Amended 1-9-96, 8-8-99.

62-610.472 Supplemental Water Supplies.

(1) Rule 62-610.472, F.A.C., applies to projects for which complete permit applications involving the use of supplemental water supplies were received by the Department on or after August 8, 1999. Rule 62-610.472, F.A.C., shall also apply to any existing reuse system which proposes to add a new supplemental water supply or to expand the facilities, structures, or pumps used for an existing supplemental water supply; however, these rule requirements shall only apply to the expanded or modified portion of the project. Incorporation of a supplemental water supply into the reuse system shall require a permit modification.

(2) Other water supplies may be used by the permittee to supplement the supply of reclaimed water. Surface waters, ground waters, treated stormwater, and drinking water may be used to supplement the reclaimed water supply.

(3) Surface water and stormwater supplies.

(a) Surface water supplies may be used to supplement the reclaimed water supply, if all of the following conditions are met:

1. Disinfection is provided and the fecal coliform and TSS limits established for high-level disinfection in Rule 62-600.440(5), F.A.C., are met for the treated surface water or stormwater supply before mixing with the reclaimed water. Operating protocols and reject storage facilities are not required for the supplemental water supply.

2. The applicant shall provide an affirmative demonstration that the quality of the resulting mixture of reclaimed water and treated surface water or stormwater will be acceptable for the permitted uses of the reclaimed water within the reclaimed water distribution system. The following factors shall be evaluated in assessing the acceptability of the mixture of reclaimed water and supplemental water:

a. The mixture shall not harm vegetation or crops grown in the reuse system.

b. The mixture shall enable compliance with ground water standards at the edge of the zone of discharge.

c. Public health shall be protected.

3. A one-way flow device shall be provided on each surface water or stormwater supply line to prevent backflow of reclaimed water into the surface water or into the stormwater treatment facilities. This does not have to be an approved device as listed in Rule 62-555.360, F.A.C. A check valve, flap valve, or other device may be used.

4. Continuous monitoring for disinfectant residual shall be performed on the disinfected surface water or stormwater supply at a point before mixing with the reclaimed water. Fecal coliforms and TSS shall be monitored at this point in accordance with the schedule established in Chapter 62-601, F.A.C., for high-level disinfection facilities, based on the permitted capacity of the largest domestic wastewater treatment facility providing reclaimed water to the reuse system.

5. The supplemental water supply pipes and appurtenances shall be color coded and marked to differentiate them from the reclaimed water and potable water facilities.

(b) Rules 62-610.472(3)(a)1. through 5., F.A.C., shall apply to situations involving the introduction of stormwater or surface water directly into a reclaimed water distribution system. Cases involving storage of reclaimed water in lakes and ponds which are part of a stormwater management system are described in, and regulated by, Rules 62-610.464 and 62-610.830, F.A.C., and are not subject to Rule 62-610.472, F.A.C., shall not apply to system storage and reclaimed water distribution facilities that are on the property of and are operated by the user of reclaimed water (such as a golf course or farm).

(c) Stormwater may be introduced into the sanitary sewerage system to augment the supply of reclaimed water, if all of the following conditions are met:

1. The resulting mixture of stormwater and domestic wastewater receives the full level of treatment and disinfection required by Part III of Chapter 62-610, F.A.C.

2. The applicant provides an affirmative demonstration that the sewerage system and treatment facilities have sufficient capacities to accommodate the added volumes of stormwater.

3. Introduction of stormwater into the sewerage system shall be limited to dry-weather, low-flow conditions in the sanitary sewerage system.

(d) Monitoring for Giardia and Cryptosporidium.

1. For treatment plants having capacities of 1.0 mgd or larger, the permittee shall sample the reclaimed water for Cryptosporidium and Giardia as follows:

a. Sampling shall be conducted at one time during each two-year period. Intervals between sampling shall not be greater than two years.

b. Samples shall be taken at a point after treatment of the supplemental water supply (before blending with reclaimed water).

2. For treatment plants having capacities less than 1.0 mgd, the permittee shall sample the reclaimed water for Cryptosporidium and Giardia as follows:

a. Sampling shall be conducted at one time during each five-year period. Intervals between sampling shall not be greater than five years.

b. Samples shall be taken at a point after treatment of the supplemental water supply (before blending with reclaimed water).

(4) Ground water supplies.

(a) Ground water supplies may be used to supplement the reclaimed water supply, if all of the following conditions are met:

1. The applicant shall provide an affirmative demonstration that the quality of the resulting mixture of reclaimed water and ground water will be acceptable for the permitted uses of the reclaimed water within the reclaimed water distribution system. This shall include an evaluation of the factors contained in Rule 62-610.472(3)(a)2., F.A.C. This shall include an analysis of the ground water source for all of the parameters included in the ground water quality standards listed in Chapter 62-520, F.A.C.

2. An approved backflow prevention device, as described in Rule 62-555.360, F.A.C., shall be provided on the pipe from each well connected into the reclaimed water system.

3. Monitoring of the ground water supply shall be conducted quarterly for fecal coliforms, unless additional monitoring is required by Rule 62-610.472(4)(b), F.A.C. At the end of the first year of operation, monitoring of the ground water supply shall be reduced if the applicant provides an affirmative demonstration that the ground water supply meets the high-level disinfection criteria for fecal coliforms and that public health will be protected.

4. The supplemental water supply pipes and appurtenances shall be color coded and marked to differentiate them from the reclaimed water and potable water facilities.

(b) If the initial analysis of the ground water supply reveals that the ground water supply does not meet ground water quality standards in Chapter 62-520, F.A.C., the parameters for which the ground water standards are not met shall be added to the quarterly monitoring of the ground water supply.

(c) For purposes of Rule 62-610.472(4), F.A.C., water withdrawn at a springhead shall be considered as "ground water."

(5) Drinking water supplies. Drinking water from a public water supply system may be used to supplement the reclaimed water supply, if all of the following conditions are met:

(a) An air gap separation, as described in Rule 62-555.360, F.A.C., shall be provided on each connection from the public water supply system into the reclaimed water system.

(b) The reuse permit shall not include requirements for monitoring of the drinking water supply.

(c) The supplemental water supply pipes and appurtenances shall be color coded and marked to differentiate them from the reclaimed water facilities.

(d) The number of connections from the public water supply system into the reclaimed water system shall be minimized.

(6) A consumptive use permit for the use of surface water or ground water to supplement the reclaimed water supply may be required by the appropriate water management district. A consumptive use permit from the water management district shall not be required at the time of application for a permit from the Department. The permittee shall be responsible for securing any needed consumptive use permits from the water management district before using ground water or surface water to supplement the reclaimed water supply.

(7) Facilities used to connect supplemental water supplies into the reclaimed water distribution system shall be located and documented in the record drawings for the reuse system.

Specific Authority 403.051, 403.061, 403.087 FS. Law Implemented 403.021, 403.051, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088 FS. History–New 8-8-99.

62-610.473 Hydraulic Loading Rates.

Loading rates generally shall be as specified in Rule 62-610.423, F.A.C.

Specific Authority 403.051, 403.061, 403.087 FS. Law Implemented 403.021, 403.051, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088 FS. History–New 4-4-89, Formerly 17-610.473.

62-610.475 Edible Crops.

(1) Irrigation of edible crops that will be peeled, skinned cooked or thermally processed before consumption is allowed. Direct contact of the reclaimed water with such edible crops is allowed.

(2) Irrigation of tobacco or citrus is allowed. Direct contact of the reclaimed water with tobacco or citrus is allowed, including citrus used for fresh table fruit, processing into concentrate, or other purposes.

(3) Irrigation of edible crops that will not be peeled, skinned, cooked, or thermally processed before consumption is allowed if an indirect application method that will preclude direct contact with the reclaimed water (such as ridge and furrow irrigation, drip irrigation, or a subsurface distribution system) is used.

(4) Irrigation of edible crops that will not be peeled, skinned, cooked or thermally processed before consumption using an application method that allows for direct contact of the reclaimed water on the crop is prohibited.

(5) The permittee shall maintain an inventory of commercial agricultural operations using reclaimed water to irrigate edible crops. The inventory of edible crop irrigation shall be submitted to the Department at least 30 days before any agricultural operation which will use reclaimed water for irrigation of edible crops will be added to the reused system. The inventory of edible crop irrigation shall be submitted annually to the Department with the annual report of reclaimed water utilization required by Rule 62-610.870(3), F.A.C. The inventory of edible crop irrigation shall include the following:

(a) Name of the agricultural operation.

(b) Name and telephone number of the owner or operator of the agricultural operation.

(c) Address of the agricultural operation.

(d) Edible crops irrigated with reclaimed water.

(e) Type of application (irrigation) method used.

(f) Approximate area under irrigation on which edible crops are grown.

(6) If requested, the Department shall authorize special demonstration projects to collect and present data related to the direct application of reclaimed water on crops which are not peeled, skinned, cooked, or thermally processed before consumption. Crops produced during such demonstration projects may be used as animal feeds or may be thermally processed or cooked for human consumption. If the applicant, based on the data collected, demonstrates to the Department that public health will be protected if their reclaimed water is directly applied to crops which are not peeled, skinned, cooked, or thermally processed, the Department shall waive the prohibition described in Rule 62-610.475(4), F.A.C., for that project. When considering such demonstration projects, the Department shall seek the advice of the Department of Health.

Specific Authority 403.051, 403.061, 403.087 FS. Law Implemented 403.021, 403.051, 403.061, 403.062, 403.085, 403.086, 403.087, 403.088 FS. History–New 4-4-89, Amended 9-13-89, Formerly 17-610.475, Amended 1-9-96, 8-8-99.

62-610.476 Toilet Flushing and Fire Protection.

(1) Toilet flushing.

(a) Reclaimed water may be used for toilet flushing in commercial or industrial facilities or buildings. Reclaimed water may be used for toilet flushing in motels, hotels, apartment buildings, and condominiums where the individual guests or residents do not have access to the plumbing system for repairs or modifications. Reclaimed water pipes shall be color coded. Reclaimed water shall not be used for toilet flushing in any residential property or dwelling unit where the residents have access to the plumbing system for repairs or modifications.

(b) If reclaimed water will be used only for toilet flushing, the Department shall approve alternative levels of reliability, operation controls, and operator attendance if the applicant provides an affirmative demonstration in the engineering report that alternative controls will provide controls on reclaimed water production equivalent to the full requirements of Part III of Chapter