HYDROLOGIC ASSOCIATES U.S.A., INC.
ENVIRONMENTAL CONSULTANTS • HYDROGEOLOGIC TESTING
WELL DRILLING SERVICES • PETROLEUM CONTRACTOR

HYDROLOGIC ANALYSIS

for

Doral Crossings

at

NORTHWEST 41ST STREET

and

Homestead Extension of the Florida Turnpike
(Snapper Creek Extension Canal)

Prepared for

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EXECUTIVE SUMMARY

Hydrologic Associates U.S.A., Inc. (HAI) was retained by Turnberry Doral Development LP to complete a detailed hydrologic analysis of its property located at theoretical NW 41st Street and immediately west of the Homestead Extension of the Florida Turnpike (Snapper Creek Extension Canal) in Miami-Dade County, Florida. The purpose of this analysis was to document the preliminary hydrologic situation within and adjacent to the subject property and relate these findings to the Miami-Dade County's existing Northwest Wellfield protection overlay. The analysis was completed by determining current and historic hydrologic conditions, documenting groundwater flow and travel time by use of empirical data and mathematical models, and completing a detailed review of the wellfield protection overlay to determine the validity of Miami-Dade County's assumptions and conclusions for regulatory purposes.

Implementation of hydraulic improvements to recharge canals around the Northwest Wellfield was completed in the early 1990's. Phase I of the improvements was designed to provide recharge water to the Snapper Creek Extension Canal along the northern and eastern edge of the wellfield. This recharge water is discharged from the Levee 30 Borrow Canal through a county water management structure and transported along the northern edge of the wellfield by the Northwest Wellfield Recharge canal. The county design criteria for the control elevation of the stage in the Snapper Creek Extension Canal is 3.5 feet above sea level. Phase II of the hydraulic improvements include the widening and deepening of Snapper Creek Extension Canal southward to NW 58th Street and the construction of a water control structure at the southern terminus of the canal at NW 12th Street. Phase III implementation of the recharge enhancement included the improvement to the Dade-Broward Levee Canal along the western edge of the wellfield. This final phase has yet to be completed.

Miami-Dade County evaluated and adopted the Northwest Wellfield protection overlay in the mid-1980's to limit certain land use and material handling within the cone of influence of the wellfield. The overlay boundaries were derived from a computer model

designed to simulate groundwater flow in the wellfield area. The current overlay boundary places the Doral Crossings property within the protection area for the wellfield. The primary purpose of HAI's analyses were to determine the relation of Doral Crossings to the wellfield protection boundaries and evaluate current hydrologic conditions as they relate to the wellfield recharge area.

Four major hydrologic changes have occurred in the Northwest Wellfield area. First, the construction of Levee 30 in 1952 cut off flow from the Everglades to the west. Second, after the extreme drought in 1971, an automatic water control structure was constructed in the Tamiami Canal, at NW 37th Avenue. Third, in 1978 the South Dade Conveyance system became operational and finally in 1984 the Northwest Wellfield became operational. All available data from continuous water-level recording stations and discharge stations were analyzed for their period of record to determine groundwater flow direction and gradients, water availability for recharge to the Northwest Wellfield and location of groundwater divides.

Pumpage at the Northwest Wellfield over the last five years has gradually been reduced to an average monthly pumpage of approximately 44 MGD (million Gallons per Day). The range in monthly pumpage varied from a low of 33 MGD to a high of 84 MGD and is dependent on hydrologic conditions and seasonal consumptive use.

Average monthly groundwater levels along NW 41st Street are analyzed to determine groundwater flow direction near the subject development site. Since 2004, the groundwater gradient along NW 41st Street has been from west to east --- away from the Northwest Wellfield. Analysis of US Geological survey water level data indicate that there is a groundwater divide during the wetter months between the Snapper Creek Extension Canal and the Northwest Wellfield, whereas in the drier months the canal serves as a source of recharge to the wellfield. The county now maintains the Snapper Creek Extension Canal at 3.0 feet throughout most of the year through controlled eastward discharge at Northwest 25th Street thus providing continuous controlled drainage of the development site through induced groundwater flow.

The following is a summary of the major deficiencies in Dade County Northwest Wellfield model, used for the wellfield protection overlay.

1. Water levels predicted by the model are lower than observed field data in vicinity of the pumping wells. This would tend to increase the size of the protection area.

2. Grid spacing is too large to accurately predict the location of the 0.1 foot drawdown line (maximum protection line).

The Miami-Dade County wellfield protection model was reviewed to determine the accuracy of the Wellfield protection overlay.

3. The model code does not handle multiple sources of recharge to a node. Only the last value input will be used, i.e. if a block has canal recharge input last, all previous inputs such as rainfall and E.T. will be overwritten.

4. The model lacks computer code calculate travel times. Travel times were hand calculated.

5. Leakages input into the model for Snapper Creek Canal are low compared to actual field measurement values. Increasing the leakage to field measurement values had minimal effect on water levels.

These deficiencies all tend to over-predict the size of the cone-of-influence of the wellfield. Wellfield pumpage used in the protection overlay was 235 MGD or over five times what the actual average monthly pumpage which occurred in 2012.

Snapper Creek Extension Canal functions as an effective ground water divide down to a stage of 2.6 feet; below this stage the divide will vary depending on regional ground water levels. Regardless of the stage in Snapper Creek, as long as the regional ground water levels are lower to the east and west of the canal, it will function as a groundwater divide. A worst case condition was evaluated with rainfall volumes lower than ever recorded in the last 40 years and the stage in Snapper Creek held 1.0 foot above sea level. Under this worst case condition, the Doral Crossings property would be in a two to three year travel time zone.

INTRODUCTION

Turnberry Doral Development LP would like full use of their approximately 81 acre parcels (figures 1 and 2) for development of approximately 850,000 square feet of office space and retail complex. Development of this property could potentially be in a sensitive area of the County because of water-related issues. The maximum day protection overlay boundary for the Northwest Wellfield includes the subject property. This overlay, which would restrict certain uses based on groundwater travel time to the well heads, is shown on figure 3. This overlay was developed and promulgated in the early 1980's based on mathematical modeling, assumed hydraulic improvements, assumed water level conditions, maximum pumpage, and historic drought conditions.

Hydrologic Associates USA, Inc. (HAI) of Miami, Florida was retained by Turnberry Doral Development LP to evaluate the hydrologic situation in the area of their proposed development site to determine if the overlay boundaries from mathematical simulations used by the County are technically valid, and analyze current hydrologic conditions. Turnberry Doral Development LP would like the highest and best use of their property while conforming to the permitting rules and restrictions placed on them by regulatory agencies. To obtain maximum use of the property, they must determine how their property conforms to these rules and restrictions, and relate these uses to the current and proposed hydrologic regime near the property.

PURPOSE AND SCOPE OF WORK

The purpose of this report is to document the hydrologic situation in and around the Turnberry Doral Development LP property referred to as Doral Crossings and relate these findings to Miami-Dade County's existing Northwest Wellfield protection overlay. Also included in this report is an analysis of the groundwater simulation model developed by Camp Dresser & McKee (CDM) that Miami-Dade County personnel used to determine the overlay boundaries, including deficiencies, technical accuracy, and potential improvements to the model.

The scope of work includes analysis of historic hydrologic conditions (water levels, canal discharge, rainfall and wellfield pumpage), comparison of recently collected data with historic conditions, analysis of the groundwater simulation model used by Miami-Dade, and a comparison of present hydrologic conditions with those the county consider a "worst case" condition. Groundwater models completed by CH2M Hill (1996) and the US Geological Survey (2013) are evaluated and compared to the CDM model used for wellfield protection overlay. The focus of all these analyses is to provide Turnberry Doral Partners LP personnel and advisors with technical information on which to base development decisions.

GEOLOGY AND GROUNDWATER HYDROLOGY

Please note: the section on "Geology" has been adapted from several previous works, including Parker and others (1955), Causauras (1987), Labowski (1988), and Reese and Cunningham (2000), as well as unpublished HAI files on core data in the vicinity of the current project. The section on "Groundwater Hydrology" has been adapted from Fish and Stewart (1991).

Geology –In the vicinity of the study site, geology generally consists of a surficial layer of oolitic limestone (Miami Oolite) ranging from 5 to less than 10 ft, underlain by a thin indurated freshwater limestone layer known as the Q_4 layer. The Q_4 layer is noted in Miami-Dade County for the lowest hydraulic conductivity of the lithologic materials that comprise the Biscayne aquifer. This layer also marks the top of the Fort Thompson Formation.

The Q_4 layer is underlain by lithologies that comprise the most productive layers of the aquifer. These lithologies include cavity-riddled arenaceous and/or fossiliferous (in some parts, coquinoid) marine limestone, and calcareous sandstones, also of marine origin. These beds are referable to the Fort Thompson and Anastasia Formations. Interbedded in these sequences are thin fresh or brackish water limestones of the Fort Thompson Formation, which have in some portions of Miami-Dade County been shown to be of lower hydraulic conductivity than the productive limestones and sandstones of the aquifer.

The Biscayne aquifer in the vicinity of the study site is approximately 75 to 80 ft thick. The Biscayne is underlain by low hydraulic conductivity beds referable to the Tamiami Formation. Below these confining beds lies the Grey Limestone aquifer. The Grey Limestone aquifer is approximately 26 ft thick in the NW Wellfield area in Miami-Dade County (Reese and Cunningham, 2000).

Groundwater Hydrology –Hydraulic testing at U.S. Geological Survey test well G-3298 (located north of the study site, adjacent to the Florida Turnpike) as conducted and reported in Fish and Stewart (1991) show a surficial aquifer that is approximately 100 ft thick, with nearly the entire aquifer section showing hydraulic conductivities of 1,000 ft/day or greater. The Grey Limestone aquifer is shown as approximately 30 ft thick, with hydraulic conductivities of 100 to 1,000 ft/day.

WELLFIELD OPERATIONS

The Northwest Wellfield consists of 15 supply wells that have a maximum design capacity pumping rate of 225 MGD, making it the largest wellfield for water supply in Florida. The Northwest Wellfield's design capacity is much larger than actual historical pumpage (see attached tables showing total and average monthly pumpages for the period from 2008-2013). Per a recent U.S. Geological Survey report (Brakefield and others, 2013), actual volumetric daily pumping rates for the wellfield over the period from January 1996 through December 2004 ranged from 18.5 to 166 MGD. The attached table showing average monthly pumpage from 2008 through 2012 shows a steady drop in average monthly pumpage for this time period. (See Table 1)

Average monthly pumpage in the Northwest Wellfield during the period 2008 through 2012 ranged from 33 MGD to 84 MGD depending on hydrologic conditions and seasonal consumptive use. The average monthly pumpage by year is shown in the table below. The average monthly pumpage declined gradually from 68.6 MGD in 2008 to 44.3 MGD in 2012. These recent pumpage rates will continue at these lower levels of 40 to 50 MGD (A. Baldwin, MDWASD, 2013, Oral Communication).

AVERAGE MONTHLY PUMPAGE by year at the NORTHWEST WELLFIELD (2008 – 2012)

Year	Average Monthly Pumpage (mgd)
2008	68.588
2009	59.302
2010	49.708
2011	48.636
2012	44.338

Water level duration at station G-3253 in the center of the wellfield shows the drawdown effect at the center of the cone of depression (figure 11). Ambient (before pumpage) water levels were collected in 1983 and show a normal (unaffected) duration ranging from about 3.0 to 5.5 feet above sea level. After pumping began water levels declined in all the percentile categories. Water levels were about 1.5 feet below ambient at high water level conditions and over 6.5 feet below ambient during dry conditions.

Table 1. - - MONTHLY PUMPAGE at the NORTHWEST WELLFIELD(1/08 – 5/13)

Year/Month	Pumpage (MGD)
2008	
January	75.265
February	80.756
March	70.821
April	70.277
May	84.132
June	82.059
July	61.425
August	54.395
September	67.616
October	54.382
November	58.093
December	63.835
2009	
January	69.455
February	63.934
March	67.674
April	64.665
May	68.474
June	59.261
July	63.330
August	70.112
September	62.947
October	59.095
November	62.682
December	60.158
2010	
January	59.104
February	58.406
March	58.975
April	52.943
May	57.763
June	54.618
July	57.185
August	52.374
September	48.744
October	50.363
November	46.026
December	41.034

2011	
January	48.026
February	42.178
March	59.059
April	54.483
May	50.930
June	54.380
July	51.880
August	33.612
September	44.557
October	45.282
November	48.790
December	50.744
2012	
January	66.227
February	60.600
March	57.334
April	54.469
May	49.403
June	52.324
July	51.334
August	51.905
September	37.516
October	48.367
November	51.976
December	35.685
2013	
January	43.695
February	49.677
March	52.763
April	54.685
May	52.373

<u>Wellfield Recharge Implementation</u> Construction of the recharge canals for the Northwest Wellfield and water-control structures is broken down into three phases. Phase I included the construction of an improved canal extending from Levee 30 just south of the Miami Canal, southward along the Dade - Broward Levee (NW 157th Avenue) to theoretical NW 122nd Street, then eastward to connect with Snapper Creek Extension Canal at approximately NW 114th Street. A gated water control structure has been completed at Levee 30 to regulate flow into the Phase I canal. Where this canal connects to Snapper Creek Extension Canal, a 14-foot corrugated metal pipe will be installed to allow unregulated flow between the canals. Phase I was completed in 1990. Phase II, which was partially completed when the Northwest Wellfield became operable, includes the enlargement of the Snapper Creek Extension Canal between NW 114th Street and NW 12th Street. A gated culvert water control structure will be installed at the southernmost terminus of the enlarged section of canal. Phase III (which has yet to be implemented) includes the enlargement of the Dade -Broward Levee borrow canal along the western side of the Northwest Wellfield and improvements to the Levee.

HYDROLOGIC BACKGROUND

Historically, the area of the Doral Crossings was part of a major overflow of the Everglades that eventually drained eastward through the Miami River. Descriptions of these historic hydrologic conditions can be found in Parker and others (1955). They indicate this area was characteristic of the Everglades and exhibited extended inundation throughout much of the year. Because of the Hurricanes of 1947 and 1948, when Hialeah and other areas were extensively flooded, a continuous north-south flood protection levee was constructed by the Corps of Engineers in 1952 from Miami-Dade County northward into Palm Beach County. This levee essentially divided Southeast Florida into those areas which would receive drainage (to the east) and the Everglades (to the west). In Miami-Dade County, the area that required drainage immediately was designated as "Area A." The area that did not require immediate drainage was designated as "Area B." (figure 4). The Doral Crossings and the Northwest Wellfield along with the Bird Drive Basin and part of Kendall were included in the Area B designation (Kohout and Hartwell, 1967). The Corps of Engineers realized that this area would, in the future, need some type of flood protection, but they had not formulated any plans by the early 1960's.

The major hydrologic features near the Doral Crossings are the Miami Canal, Levee 30 Canal, Tamiami Canal, Snapper Creek Extension Canal, and the Dade-Broward Levee (see figure). Water levels in the Levee 30 Canal are primarily controlled by the water stage in Conservation Area 3B, and resulting under seepage, and some surface discharge from the Miami Canal. Both Tamiami and Miami Canal water levels and flows are automatically controlled by water control structures S-25B and S-26, respectively. Water levels at these structures are maintained for flood protection and coastal salinity control. These water control structures open when the stage in the canals reaches 3.0 and 2.8 feet above sea level, respectively. To increase the water levels in Snapper Creek Extension Canal, the connection to Miami Canal was plugged in 1983, thus preventing drainage northward to this primary canal.

There is a control structure in the Snapper Creek Extension Canal at NW 12th Street to maintain water levels and prevent a direct connection to the Tamiami Canal. Pumpage from the Northwest Wellfield diverts water from the Snapper Creek Extension Canal especially during low water, thus reducing surface flow to the south. The old Dade Broward Levee, built before 1920, is primarily a muck and peat levee. Although it has been breached in areas where the levee has burned and oxidized, it still locally ponds water to the west. Miami-Dade County (Water Control) designed and constructed water control structures on the Dressels Dairy Canal (NW 58th Street) and the Northline Canal (NW 25th Street) in the 1980's. Both of these canals have been plugged to the west of the Turnpike (NW 117th Avenue) to prevent surface flow towards the Northwest wellfield. The water control structures allow for drainage of the Snapper Creek Extension Canal. Based on discussions with Miami-Dade County personnel, the NW 58th Street structure remains closed most of the time to facilitate recharge to the Northwest Wellfield while the NW 25th Street structure is open at 3.0 feet continuously to facilitate drainage until canal stage drops below 3.0 feet.

Currently the major means of drainage in the area of the proposed Doral Crossings are the Tamiami Canal, pumpage at the Northwest Wellfield, and, during periods of high stages in the Snapper Creek Extension Canal, the Dressels Dairy Canal (N.W. 58th Street) and continuously through the Northline Canal (N.W. 25th Street). Major recharge areas (upgradient) include seepage from Conservation Area 3 B, Levee 30 Canal and the Pennsuco Wetlands west of the Dade Broward Levee. Completion of the Phase I hydraulic connection between the Levee 30 canal and Snapper Creek Extension Canal, at a design stage of 3.5 feet above sea level allows for continuous recharge to the Northwest Wellfiled from the north and east. At an optimum hydrologic situation, the Northwest wellfield will have recharge boundaries on the west, north, and east; on the south where the Doral Crossings project is located there will be a variable ground water divide with the Tamiami Canal basin, the Northline Canal (NW 25th Street) and the Dressels Dairy Canal (NW 58th Street).

WATER MANAGEMENT

Groundwater levels in the area (historically referred to as "Area B") were initially controlled by the naturally occurring low elevations, which rendered the area as part of the historical everglades. This condition persists today in Conservation Area 3B to the west of the study area, where high water levels are impounded by L-30 as well as the Dade-Broward Levee. As development progressed, water levels in the area became generally controlled to the north and northeast by the Miami Canal and to the south by the Tamiami Canal.

With the installation and operation of the production wells for the Northwest Wellfield, several additional factors were introduced that affected groundwater levels. Firstly, the operation of the wellfield served to lower groundwater levels in the wellfield area (i.e., east of the Dade-Broward Levee, south of the Miami Canal, and north of the Tamiami Canal). Subsequently, as part of Miami-Dade County's Wellfield Protection Program, the Snapper Creek Extension Canal (paralleling the Florida Turnpike) was deepened (improved) and an east-west conveyance canal connected it to the Dade-Broward Levee, enabling high water levels to be maintained in the area west of the Snapper Creek Extension Canal.

Historic water level conditions were analyzed to determine trends in hydrologic conditions and to document conditions near the Doral Crossings property. The stations listed in table 1 are used in this analysis. Most of these stations are continuous water level and discharge stations operated by the U.S. Geological Survey Water Resource Division. HAI operates the stations at NW 41st Street and Snapper Creek Extension Canal at NW 25th Street for compliance monitoring at Beacon Lakes. No continuous recording stations in the area are operated by Miami-Dade County, the South Florida Water Management District, or the Corps of Engineers in the area.

Significant hydrologic change has occurred in Area B since the 1950's, after the completion of the continuous north-south levee (Levee 30) before any continuous water level recorders were installed. This change is well documented in Leach, Klein, and Hampton (1972) and was further analyzed by Waller (1978). A double-mass curve (figure 6) was constructed to show periods of hydrologic change in Area B. This curve plots cumulative discharge at Tamiami Canal near Coral Gables versus cumulative rainfall at Miami Airport. The theory behind this analysis is that if there is a break in the rainfall-runoff relation, then some type of hydrologic change has occurred in the basin. Note that the breaks in the curve occurred in 1971, 1978, and 1984. Respectively, these three breaks correspond with the installation of an automatic salinity control structure S-25B on the Tamiami Canal after the severe drought of 1971, the implementation of the South Dade conveyance system in 1978 designed to provide supplemental canal flow recharge to South Dade County, and the beginning of pumping at the Northwest Wellfield. Note that the curve shows that since 1984 more rainfall is required to produce an equivalent amount of discharge in the Tamiami Canal, thus indicating that the Northwest Wellfield is efficient in capturing upgradient waters from the Tamiami Canal.

Table 2. - - Hydrologic Station names, identification numbers and period of record.

STATION NAMES	IDENTIFICATION NUMER	PERIOD OF RECORD
G-3253	255027080245501	1981-present
G-3259A	255026080240302	1983-present
G-3264A	255027080221602	1984-present
Snapper Creek Canal at N.W. 74th Street	255026080231300	1984-present
Tamiami Canal Near Coral Gables	02289500	1940-90
NW 41st Street	Hydrologic Associates	2004-present
Snapper Creek Extension Canal at NW 25th Street	Hydrologic Associates	2004-present

Water Levels and Groundwater Flow Direction-Hydrologic Associates maintains continuous water level recorders for the Beacon Lakes development compliance monitoring. Two of these stations are designated as NW 41st Street and Snapper Creek Extension Canal NW 25th Street (See figure 5). The groundwater level station at NW 41st Street records water levels approximately 2.1 miles west of the Snapper Creek Extension Canal and 1 mile south of the Northwest Wellfield. The Snapper Creek Extension Canal station at NW 25th Street (SCEC) records water levels in the canal for the continuous reach from NW 58th Street to NW 12th Street.

Hydrographs for the period of record at each of these two stations are shown in figures 7 and 8, respectively. These data indicate that for the period of record, groundwater flow direction along NW 41st Street was from west to east - - away from the cone of the influence of the Northwest Wellfield. The average daily water levels for the period of record are 4.10 ft for the NW 41st Street station and 3.31 ft for the SCEC station. Values are given in feet above NGVD of 1929. The computed water levels indicate that there is an overall gradient during the last eight years of approximately 0.4 ft/mile to the east along NW 41st Street. This gradient is nearly double what is present throughout the developed areas of Miami-Dade County. Therefore, the groundwater flow direction at the Doral Crossings property is to the east - - away from the Northwest Wellfield.

Water levels within and adjacent to the Northwest Wellfield are measured and reported by the US Geological Survey. These stations are shown on figure 5 and are designated as Snapper Creek Extension Canal at NW 74th Street (NW 74th Street), G-3259A, and G-3253. Long-term hydrographs of daily water levels for these three stations are shown in figures 9 – 11. Station G-3253 (figure 10) is located in the center of the cone-of-depression of the Northwest Wellfield. Station G-3259A (figure 9) is located approximately half way (1 mile) between G-3253 and Snapper Creek Extension Canal which is a source of recharge for the wellfield.

The hydrograph for G-3253 shows the drawdown maximum to date at the Northwest Wellfield through the Mid- 1980's into the early 1990's. The drawdowns maximum to date were minimized since approximately 1993 when pumpage decreased as a result of that the Hialeah-Miami Springs wellfields returning to higher pumpage and the implementation of Phase I and II of the recharge canal construction was operational to supply recharge to the west, north and east of the Northwest Wellfield.

Analysis of the daily water level hydrographs for G-3259A and NW 74th Street (figures 9 and 11) indicate that during periods of high water levels from rainfall there is a groundwater divide (mound) established between the Snapper Creek Extension Canal and the cone of depression in the Northwest Wellfield. During periods of low water levels, the groundwater divide dissipates and the Snapper Creek Extension Canal provides recharge to the Northwest Wellfield by induced groundwater flow.

GROUNDWATER QUALITY

Hydrologic Associates USA, Inc. (HAI) has been sampling groundwater monitor wells at the Beacon Lakes Development Property in the vicinity of the study site since September, 2004 and submitting these data to Miami-Dade County. In all, three groundwater monitor wells are sampled annually, for water quality parameters that include VOA and VOH parameters, Oil & Grease, and the metals Arsenic, Chromium, Iron, Lead, and Zinc. (Barium, Cadmium, Selenium, and Silver were sampled and analyzed for in the 2009 sampling).

The attached tables in Appendix A summarize the data to date. As the tables show, all water quality parameters at all three groundwater monitor wells are within Groundwater Criteria (per Chapter 62-777 FAC) save for slight exceedances for Iron at MW-1 for the initial two samplings in September, 2004 and June, 2006. (Iron can occur ubiquitously in the South Florida groundwater realm). As such, these data reflect that groundwater quality is good in the vicinity and that the Beacon Lakes Development has not caused any adverse impacts.

SIMULATION OF GROUND WATER FLOW

Two methods are used to mathematically evaluate water table conditions near Doral Crossings under a given set of hydrologic conditions. Initially the Miami-Dade County DERM Wellfield Protection Model (CDM,1984) was evaluated to determine if their model was valid in predicting travel time boundaries, which in turn, are used to determine protection overlays which restrict zoning and land use. The evaluation included analysis of parameter input, model assumptions, and validity of modeled hydrologic conditions (i.e: normal rainfall dry wet seasons, wet dry seasons, and extended drought conditions).

The second evaluation involved the technical review of the models developed for Miami-Dade County by CH2M Hill(1996) and the US Geological Survey (Brakefield and others, 2013). The CH2M Hill model provided the county agencies with information on travel drawdowns times in Northwest Wellfield Area as they relate to limestone mining in the designated Lake Belt area (figure 12). The USGS model report presented a comprehensive simulation of both the West Wellfield and Northwest Wellfield areas. This latter modeling effort presented both water level predications and subsequent travel time simulations under various hydrologic conditions. Evaluation of the CDM model used to establish the Northwest Wellfield Protection Area Overlay was evaluated in cooperation with E.J. Wexler of Earth FX in Toronto, Canada. The two subsequent models mentioned above were not used by the county agencies to modify the Northwest Wellfield Protection Area overlay.

To better assess the impact of the Northwest Wellfield on groundwater flow and to design a wellfield protection strategy, numerical models for predicting water levels under existing and predicted stresses were developed. The natural hydrologic boundaries which affect regional ground-water flow in the region are defined by the Conservation areas to the west and the shoreline to the east. The northern boundary of the area was set slightly north of Snake Creek canal. The southern boundary was set at what was considered to be a sufficient distance from the well field area so no boundary effects would occur, and lies south of approximately SW 280th Street.

All mathematical simulation models discussed below represent the surficial aquifer system as a single layer, wherein variation of effective transmissivity as a function of change in saturated thickness is assumed to be minor. The models allow for simulation of aquifer stresses including recharge, evapotranspiration, discharge to public-supply wells, and leakage to or from canals.

The finite-difference method has been applied extensively in the simulation of ground-water flow. The mathematical code are discussed below and used by Miami-Dade County was supplied by their consultants and limitations of this model are discussed.

A ground-water flow model for the Northwest wellfield area was developed by Camp Dresser and McKee, Inc. and is described in a report entitled Groundwater Flow Model for the Northwest Wellfield (CDM, 1984). The model represents the eastern portion of Miami-Dade County with an irregular finite difference grid composed of 92 rows and 92 columns with blocks varying in size from 750 ft by 1000 ft to a maximum of 8000 ft by 8000 ft. The smallest size was probably based on the distance between wells at the Northwest Wellfield. This model was utilized to prepare the Northwest Wellfield Protection Overlay.

Boundary Conditions- Prescribed-head boundary conditions were applied to nodes along the western boundary of the modeled area used to represent water levels in the Conservation Area 3B. The value of known head was varied between 6.0 and 7.8 ft between dry and wet season.

Prescribed-head boundary conditions were also applied along the eastern boundary and are set equal to 0.0 ft to represent mean sea level. The effect of the freshwater/saltwater interface, which lies to the west of the shoreline, was not simulated.

No-flow boundaries are automatically prescribed at all external model boundaries and at the face of all cells adjacent to inactive cells. No-flow conditions were applied in this manner to represent the base of the aquifer. No-flow conditions were applied along the north and south boundaries to represent that flow is believed to be predominantly from west to east, and there is little inflow across the boundaries selected.

The water table was treated as a prescribed-flux boundary. Recharge to the water table was computed from monthly average precipitation, adjusted for losses due to runoff. Rates of recharge were assumed to equal 70% of actual precipitation.

Groundwater discharge from the aquifer due to evapotranspiration is quite significant due to the shallow depth to the water table over most of the area. Discharge from the aquifer is calculated by the model such that the rate of discharge has a maximum value when the water table is at or above land surface and decreases linearly to zero when the depth to water exceeds the extinction depth. The maximum rate of evapotranspiration in the CDM model was calculated by the Thornthwaite method and was decreased by 50% in urbanized areas. An extinction depth of 11.5 ft was specified.

Leakage to or from canals can be described by a head dependent flux term. Flow across lower-permeability material underlying the canal is dependent on the canal geometry, the controlled stage in the canal, values for the thickness and permeability of the bed materials and the head in the aquifer beneath the canal. Stage in the canals are presumed to be well regulated and held relatively constant during each wet or dry season. Values for thickness and permeability of the canal bed materials were not known but were determined by CDM through model calibration. Values of about .5 ft/day/ft. were used for most canals.

The principal stress on the surficial aquifer system is groundwater withdrawls for public water supply at the Northwest Wellfield. Location of wells and monthly pumping rates for each well were presented by CDM with input from the county agencies.

Deficiencies- Since 1983, several studies have been done by the Dade County Department of Environmental Protection or their consultants to develop plans to ensure the quality of ground water at the Northwest Wellfield. Most studies used a groundwater flow model developed by Camp Dresser and McKee, Inc which is documented in the report "Groundwater Flow Model for the Northwest Wellfield (CDM, 1984)".

The computer code used by CDM is essentially is a version of the PLASM (Prickett - Lonnquist Aquifer Simulation Model) developed by the Illinois State Water Survey (Prickett and Lonnquist, 1971) with minor modifications. The PLASM code has been used for many years by hydrologists and while free from errors, it has some limitations, which will be described below.

The model is based on a block-centered finite difference technique ("block centered" indicates that water levels are calculated at a node located at the center of each block in the finite-difference grid). The governing equations represent a water balance wherein the difference between the inflows (flow across each face of the block plus recharge due to rainfall and canal leakage) and outflow (flow across the block face plus withdrawls from wells and losses to evapotranspiration (ET)) equals the change of the volume of water stored in the block over a given time interval. Flows across the block faces are proportional to the difference in water-levels (head) between the nodes in adjacent blocks and to the transmissivity (T). The change in volume stored related to the change in water level in the block through the storage coefficient. The computer code solves a set of equations, one for each block, to determine the water levels that satisfy the mass balance equations. The code can solve the set of equations for steady-state (equilibrium) conditions when all inflows balance outflows. To solve a transient problem, for example, to observe the changes in water-levels over a wet season/dry season cycle, the time period is divided into a number of finite time intervals and the model solves the set of a equations at each time step and the change in water level from a specified starting condition is determined.

Changes made by CDM to the PLASM code were identified by a line by line check of the two codes. Most changes were relatively minor, affecting the way data is read by the code or output, not the way ground-water levels are calculated. The following is a summary:

A table of monthly pumping rates for each well is be read in and printed out at the beginning of a model run. Values are read in MGD (millions of gallons per day) and converted to gallons per day internally.

Because the size of blocks vary, the distance between adjacent nodes differs. Transmissivity values between nodes are calculated internally and adjust for this condition. The method was checked and found to be correct.

An input routine was written to handle assignment of transmissivity, recharge, ET, land surface elevation, and canal data for each aquifer block. The method is very cumbersome and would easily allow for input errors. Data is assigned to a group of cells defined by a starting row and column number and ending row and column. Typographical errors in these values could allow previous data to be over-written. The input data is also difficult to verify visually. Maps of transmissivity, as read by the code, were generated and appear correct. No source was cited for the land surface data used in the CDM model. The input of the data seems error free. Input data for defining zones of high and low ET appear to be correct. Canal location data is also correctly input.

The code calculates leakage along a segment of Snapper Creek Extension Canal and outputs this data along with final head values. Head values at intermediate time steps are not printed.

Some strong points of code include:

1. The PLASM code is well documented, has been in use for many years, and is considered to be error-free.
2. Methodology is consistent with other models. Conversion to MODFLOW (the USGS ground-water flow code) is time-consuming but straightforward.

Some of the weaknesses associated with the PLASM code include:

The weakest point is that only one constant discharge value or head-dependent discharge value can be defined for each model block. Thus, if a block contains a well and a canal and is subject to recharge and ET, a choice must be made as to which of these three types of stresses will be specified. The order in which items are specified is critical, because if data is used to specify precipitation and ET over a large part of the grid, this will be overwritten when canal data is specified and no recharge or ET will be calculated. Similarly, if two canals intersect, data for only the last one specified is stored. This leads to errors in mass balance.

In the Northwest Wellfield model, canal leakage takes precedence over other stresses. In the vicinity of the wellfield, the error in neglecting recharge is small, because the block size is small. In other areas of the grid where blocks are larger, the mass balance error can be quite large because the amount of canal leakage which is accounted for is smaller in proportion to the recharge which is neglected. It is unclear why CDM did not choose to modify the code because the changes required are relatively simple.

The PLASM code uses a backwards difference approximation for the time derivative which is only first-order correct. But because the approximation is only first-order correct, it is very sensitive to the size of the time step used, particularly at the start of simulations.

The code is written in single precision which allows storage of 7 significant figures. Because the numbers being used are unusually large (e.g. T's of 10,000,000 gpd per ft and Q's of 14,700,000 gpd) and because accuracy to the nearest 0.01 ft is needed, the model should have been changed to double precision (15 significant figures).

The model appears to represent regional ground-water flow adequately. The 1000-ft square cell, where used, allows for reasonable simulation of canal/aquifer interaction. The distribution of T values is based on data from previous studies, and although probably oversimplified, is still the best available published data. Other data, such as canal leakage factors, rates of recharge and ET, are less easily verified, but appear to lie within reasonable ranges.

The minimum grid cell used in the wellfield area is 750 ft by 1000 ft. While adequate for regional flow analysis, the size may be too large to accurately predict local conditions close to the well. The calculation of water-levels is affected in two ways: 1) Wells are not simulated as point sources, rather the total withdrawal is divided over the area of the block and treated as a distributed (i.e., more diffuse) source. Only as the grid size is reduced does the well begin to approximate a true point source. 2) The finite-difference method works best in areas where the rate of change in the slope of the head surface is small. In the vicinity of pumping wells, the change in gradient is large and thus, heads can be accurately approximated only if small blocks are used. Block sizes of 50 to 100 ft on a side would not be unreasonable.

The model currently overpredicts drawdown in the wellfield area by as much as 2 feet. The overprediction of drawdown would yield a large cone-of-influence.

The errors in calculated drawdowns due to block size tend to diminish with distance from the wellfields. However, the exact extent of the drawdown cone and rates of induced infiltration from canals in the wellfield vicinity are probably affected to some degree. To analyze the affect requires rediscritization of the model or development of a second, smaller-scale model, both options requiring a substantial effort.

Additional errors are introduced in modeling blocks containing canals, aside from the fact that recharge over the block is neglected. In the model, leakage is calculated using a single value to represent the head in the aquifer block and the flux is distributed over the area of the block. Again, simulation using small blocks produces more accurate results.

Because of the models sensitivity to initial time step size, the use of a constant large time step introduces error. Initial steps should probably be of the order of hours, rather than the 30 days used in the simulation. The time step size can increase every time step if neccessary, but should be reset to the initial value every time new stresses are imposed. The errors introduced can be determined by comparing model runs using different time-step sizes, although, since the model was found to approach equillibrium quickly, the errors in the final heads calculated by the model are probably not too significant.

A convergence criterion of 5 ft for the sum in total change in head over an iteration was used. This was the value used in the PLASM documentation for a typical aquifer. Because a high degree of accuracy was required for heads in the wellfield area, where the changes in head during an iteration would be greatest, a much smaller value should have been used.

The model is run assuming that transmissivity of the aquifer is constant for a cell block. In actuality, the transmissivity, which is the product of the formation hydraulic conductivity and the saturated thickness, changes as water levels in the aquifer change. Drawdowns in the vicinity of wellfields, especially in the western part of the area where the aquifer thins out, would probably be higher if true water-table conditions were simulated. Model calibration, which was done to match levels in the well field vicinity would have to be redone and large values for K would be needed to match observed data.

Constant head boundaries were applied along the shore and along the southern part of the west boundary. Changes in the shoreline head value to reflect changes in mean sea level had little effect in the vicinity of the Northwest Wellfield. Boundaries along the west side are adjusted to reflect water levels in the conservation area. No change was observed when Conservation areas 3A and 3B in the Northwest corner of the model were treated as constant heads rather than leakage type boundaries. Other boundaries appear reasonable.

Rainfall recharge is set to 0.7 of actual rainfall. A constant average value is applied over the wet season and a lower value over the dry season. Becasue average monthly rainfall data are available, these rates should have been used in transient simulations.

Potential ET (PET) was determined using the Thorntwaite method and averages 2.88 inches/month in the dry season and 6 inches/month in the wet. Monthly values should be used here too. PET is reduced by 50% in urban areas to account for more impervious areas and less vegetation. Rainfall over urban areas was not adjusted to account for increased runoff, which appears to be inconsistent.

Actual ET losses are calculated based on the depth to water table from land surface, where ET is equal to PET when the water-table is at land surface and decreases linearly to 0.0 when the water-table lies below the extinction depth. Adequate documentation of the land surface data and the reason for selecting this extinction depth were not provided. Model sensitivity to these values is high, and these data should be verifiable.

The model calculates the rate of leakage from a canal as a function of the permeability and thickness of streambed material, length and width of the area contributing leakage in a given block, and the difference between aquifer head and controlled water surface elevation on the canal.

A single value for the canal recharge factor is provided for each canal segment which is calculated as:

$$RF = LF * L * W / (dx * dy * 5280 \text{ ft/mi} * 5280 \text{ ft/mi})$$

Where L is the length of the canal segment in the block, W is the canal width, LF is a leakage factor for the canal (a function of permeability and thickness of the streambed material), and dx and dy are the block dimensions. An attempt was made to verify these data, using the limited data supplied in tables of canal widths and leakage factors in the CDM report. Most values seem reasonable. However, some values, which appear unreasonable, could not be verified. Discrepencies could be due to errors or attempts to adjust recharge factors to account for features such as lakes or multiple canals in a single block, although the model, as implemented, does not appear to account for intersection and presence of multiple canals in a single block. The raw data used in the generation of these data are needed for more adequate verification.

Canal bottom elevation is specified for each canal segment. This data would be used if the water-table ever dropped below this height. However, this is not likely to happen and variation in these values have no affect.

The PLASM code does not contain software to predict travel time lines. Travel time was hand calculated by Miami-Dade County personnel using the model generated water levels.

POTENTIAL IMPACT ON SITE DEVELOPMENT

From a technical standpoint, based on analyses of hydrologic data and information, there is a strong case to support that the Doral Crossings project will have minimal or no effect on the Northwest Wellfield. This conclusion is based upon quantative technical data and review of the Northwest Wellfield Protection Area overlay and recent mathematical modeling information.

A Summary of findings is as follows:

1. The Northwest Wellfield Protection Area overlay includes the Doral Crossings development site in the maximum day drawdown, but is not included in any of the travel time zones.

2. The model used to develop the protection overlay had a number of deficiencies as noted in the text above which tended to enlarge the protection area. Also, travel time boundaries and zones of drawdown were hand calculated.

3. The protection overlay was developed using an extreme drought condition with minimal recharge and pumping at full capacity (235 MGD).

4. Current wellfield pumpage is less than 20 percent of the maximum pumpage rate and has held fairly steady for the last 20 years.

5. Implementation of Phase I and II of the Northwest Wellfield recharge canals has greatly improved water supply to the wellfield from west, north and east thus extending the major recharge zones to the west of the wellfield – away from the Snapper Creek Extension Canal and the Doral Crossings development site.

6. Water level data collected by the US Geological Survey indicates that there is a groundwater divide established east of the Northwest Wellfield during wetter months

and recharge from the Snapper Creek Extension Canal north of NW 58th Street occurs only during the drier periods.

7. Water level data collected along NW 41st Street indicated that for the last eight years, groundwater has flowed from west to east – away from the Northwest Wellfield recharge areas. Therefore, groundwater flow at the Doral Crossings development site is also in a west to east direction.

8. Operational criteria by Miami-Dade County for the NW 25th Street water control structure allows for continuous drainage of the Snapper Creek Extension Canal thus inducing groundwater flow from the Doral Crossings development site to the east – away from the Northwest Wellfield recharge areas.

9. Groundwater quality data collected at the Beacon Lakes development near Doral Crossings indicate that there has been no adverse effect of this development on the shallow aquifer.

10. The Doral Crossings development site was not included in the Lake Belt Implementation Plan (Dade County Implementation Committee, 1997; 1998; 1999; Wallae Roberts & Todd LLC, 2001). This is likely due to failure to petition the Implementation Committee for inclusion, as well as that the Miami-Dade County DERM did not included the vicinity of the study in its protection overlay with respect to rockmining.

11. A worst case condition was evaluated with rainfall volumes lower that ever recorded in the last 40 years and the stage in Snapper Creek held 1.0 foot above sea level. Under this worst case condition, the Doral Crossings property would be in a two to three year travel time zone.

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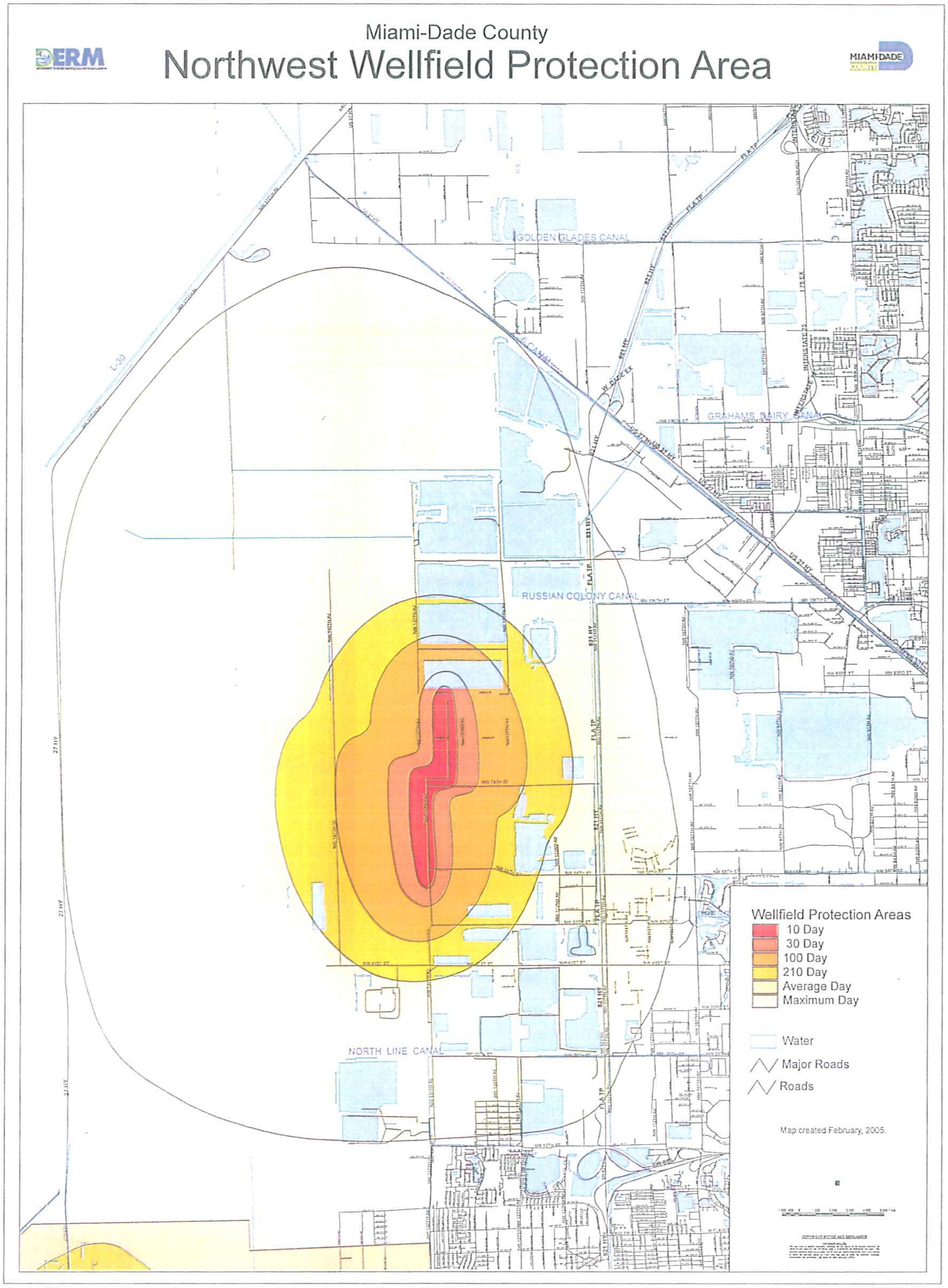
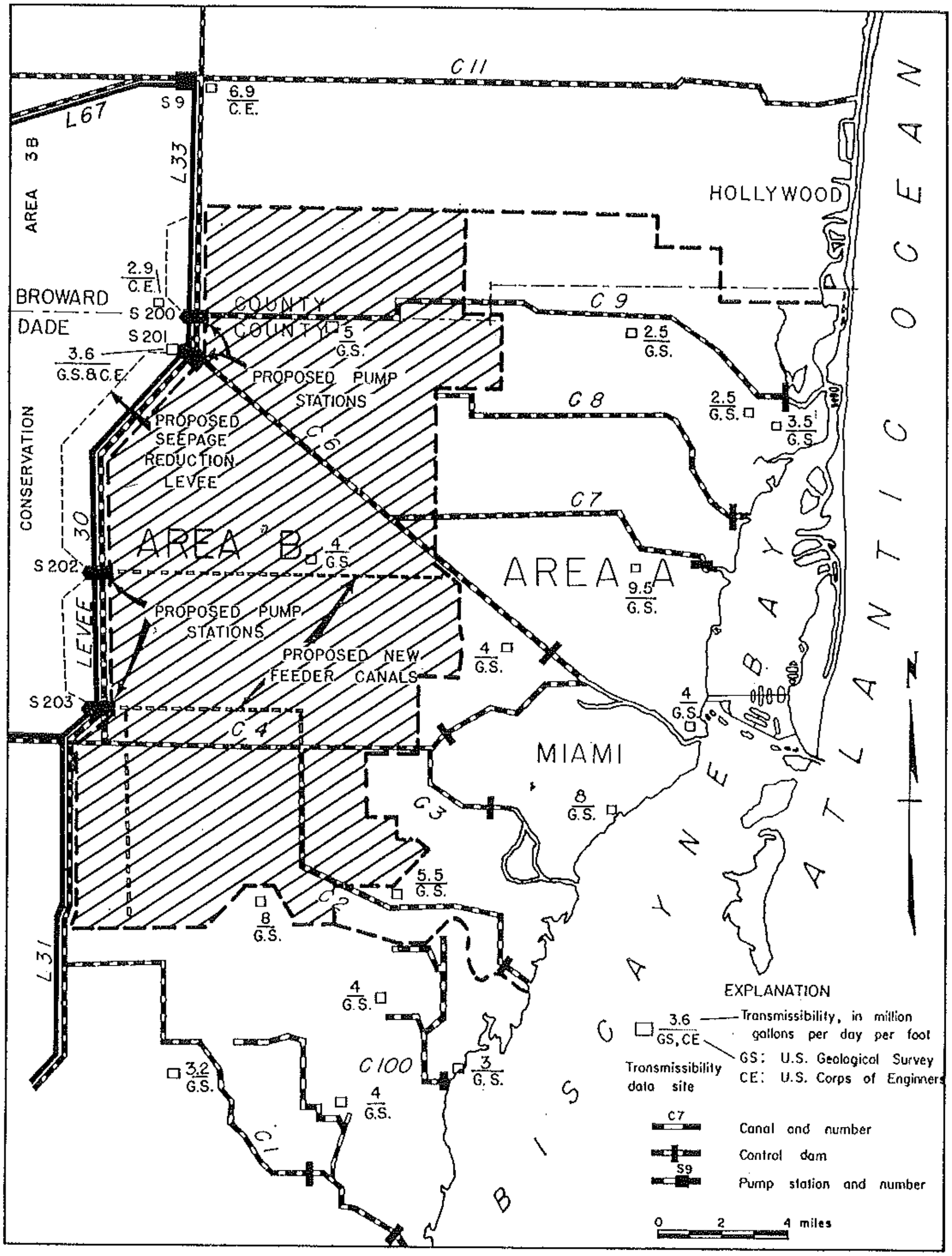
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 1 - Map of Miami-Dade County showing location of Doral Crossings	Doral Crossings

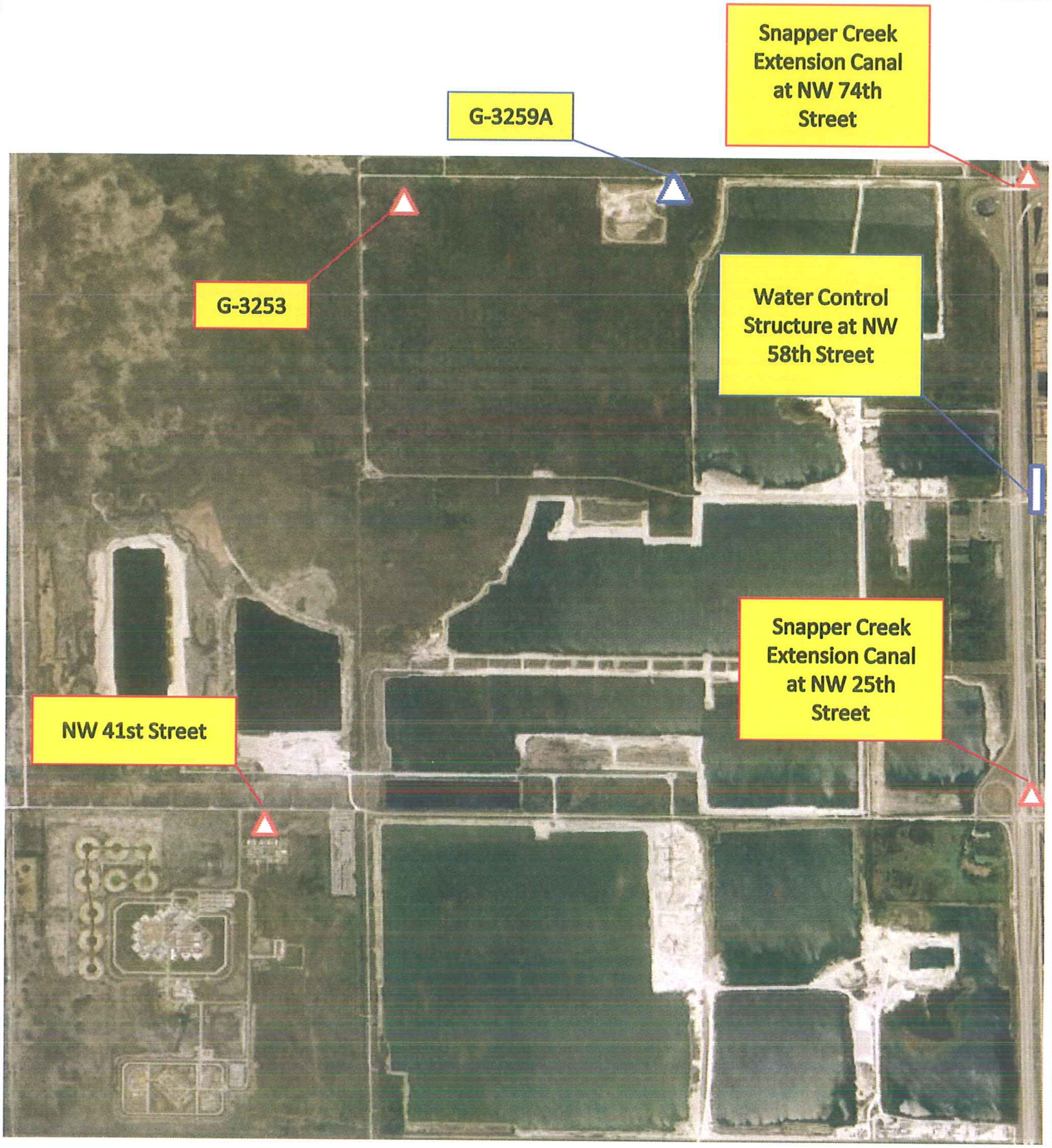
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 2 - Aerial photo showing location of Doral Crossings properties	Doral Crossings



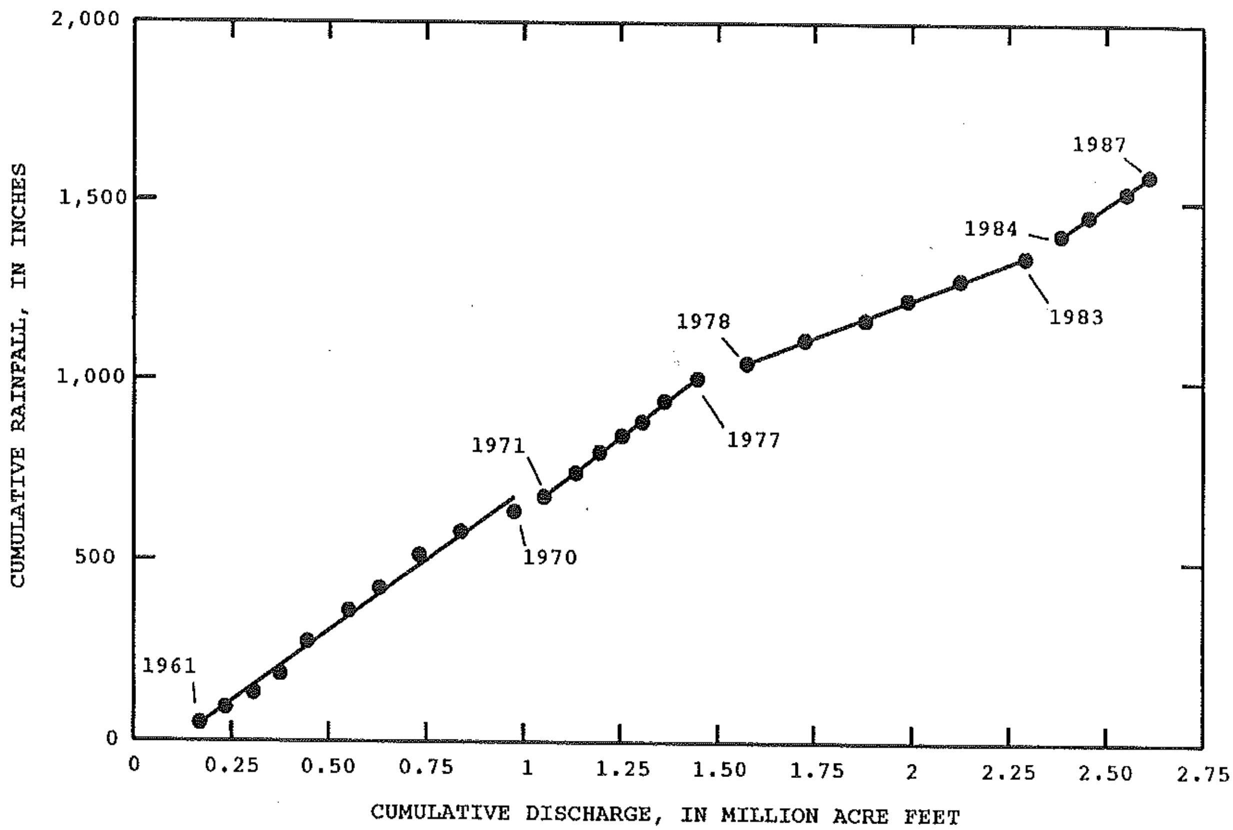
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 3 - Northwest Wellfield Protection Area overlay (2005)	Doral Crossings



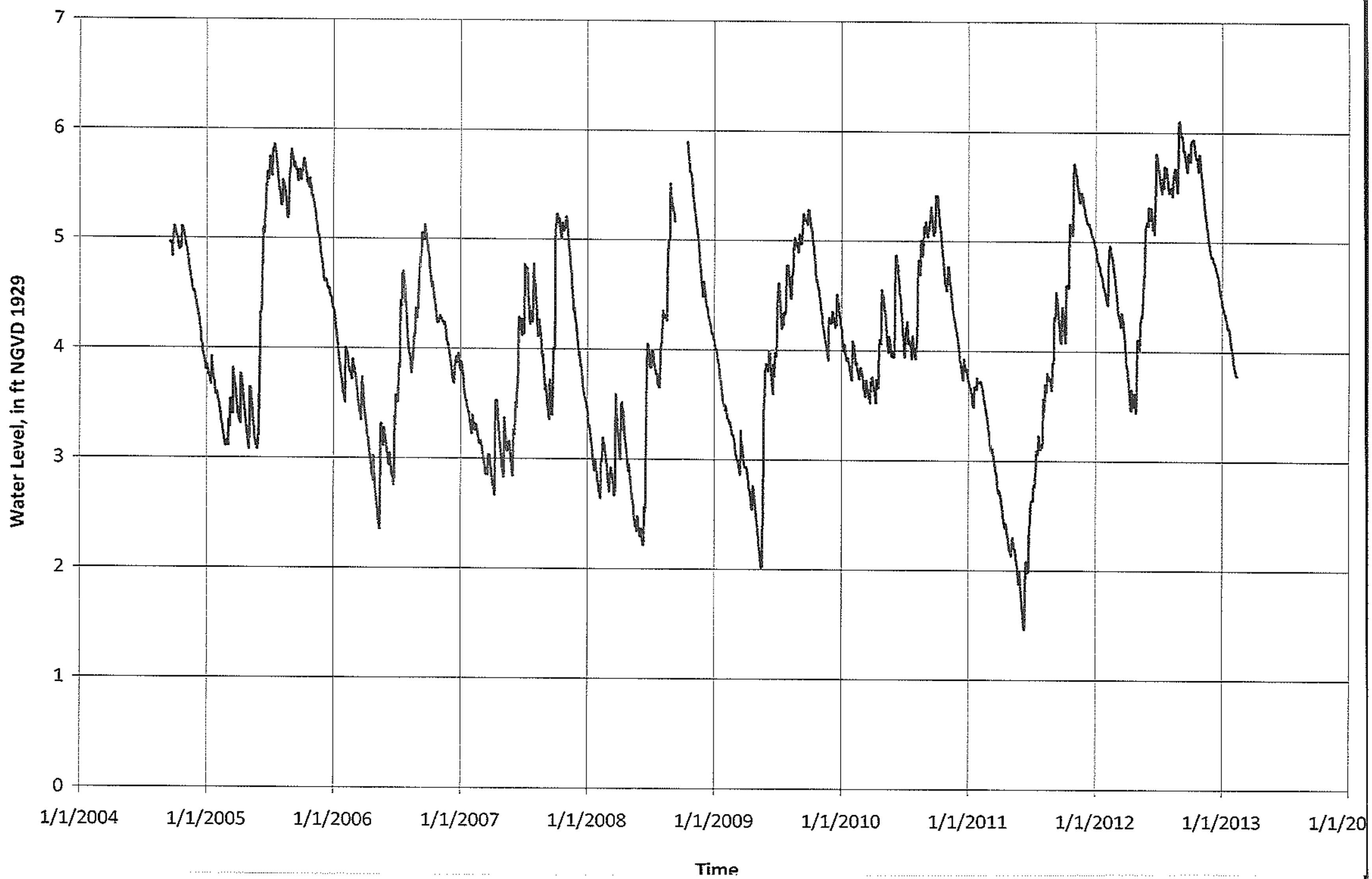
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 4 - Map showing location of Area B (adapted from USGS)	Doral Crossings



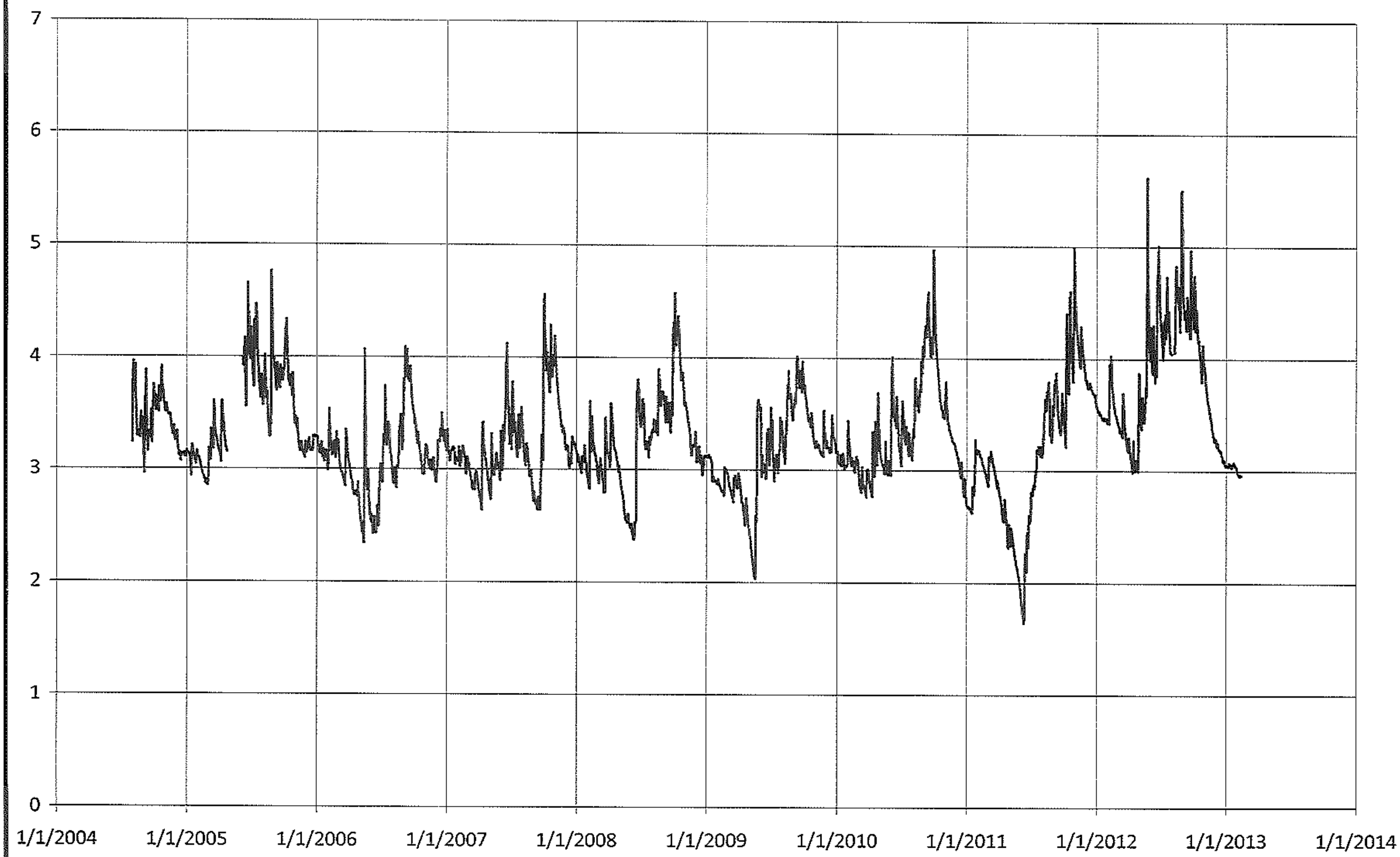
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 5 - Hydrologic features in the Northwest Wellfield Area and location of monitor stations.	Doral Crossings



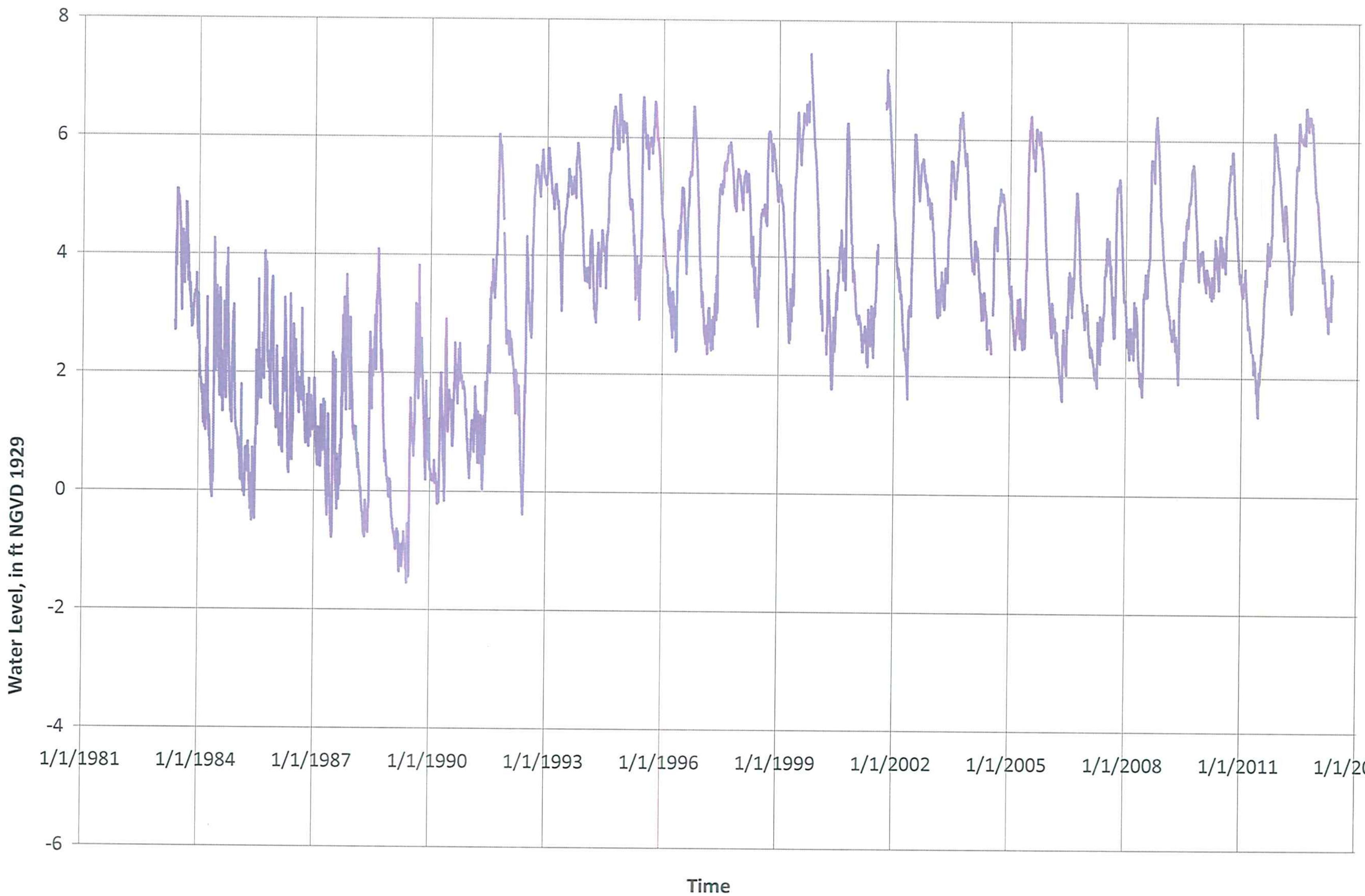
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 6 - Double Mass Curve of discharge at Tamiami Canal near Coral Gables and cumulative rain fall at Miami International Airport	Doral Crossings



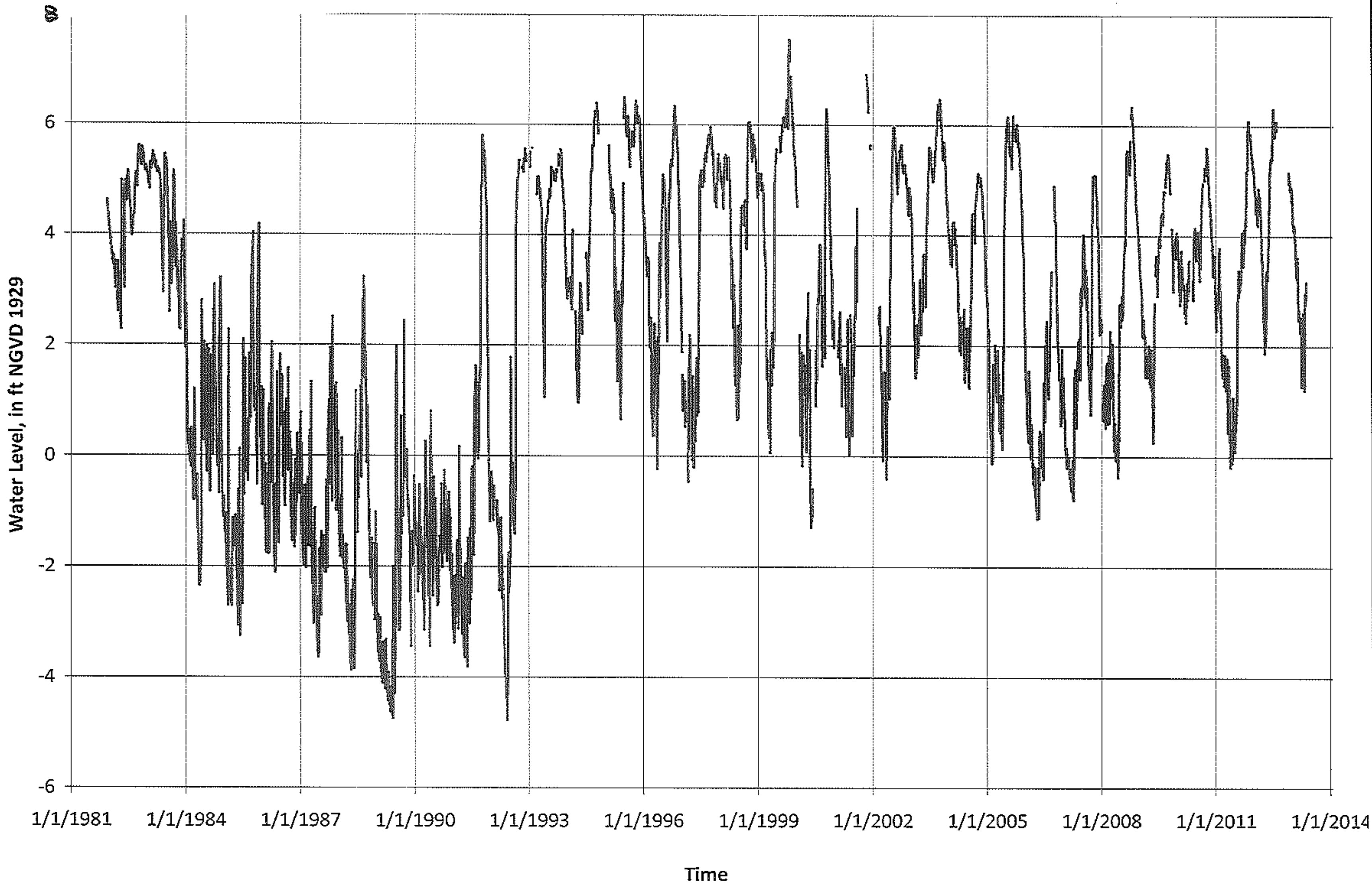
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 7 - Hydrograph of water levels at ground water station NW 41st Street (2004 to present)	Doral Crossings



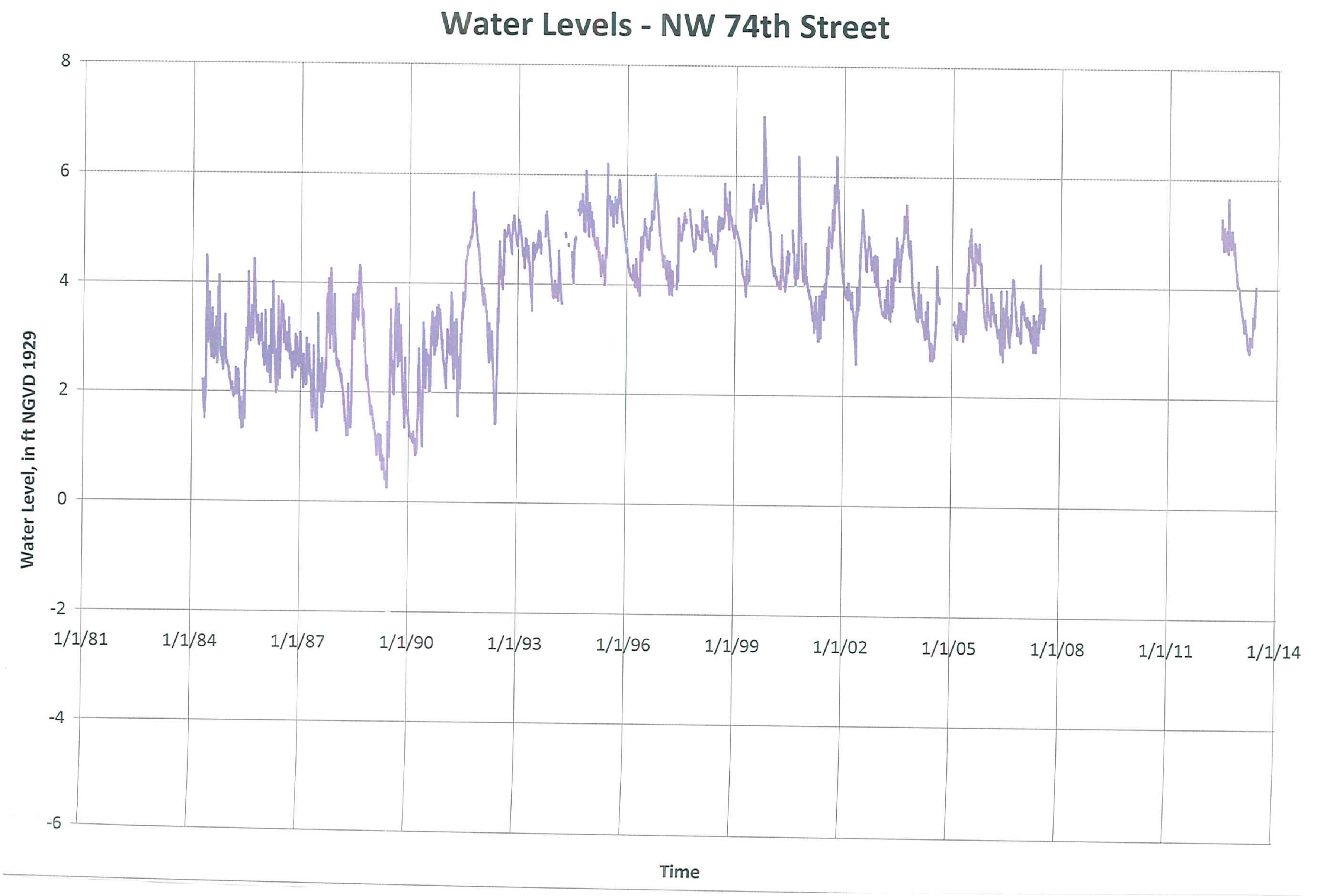
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 8 - Hydrograph of water levels at Snapper Creek Extension Canal near NW 25th Street (2004 to present)	Doral Crossings



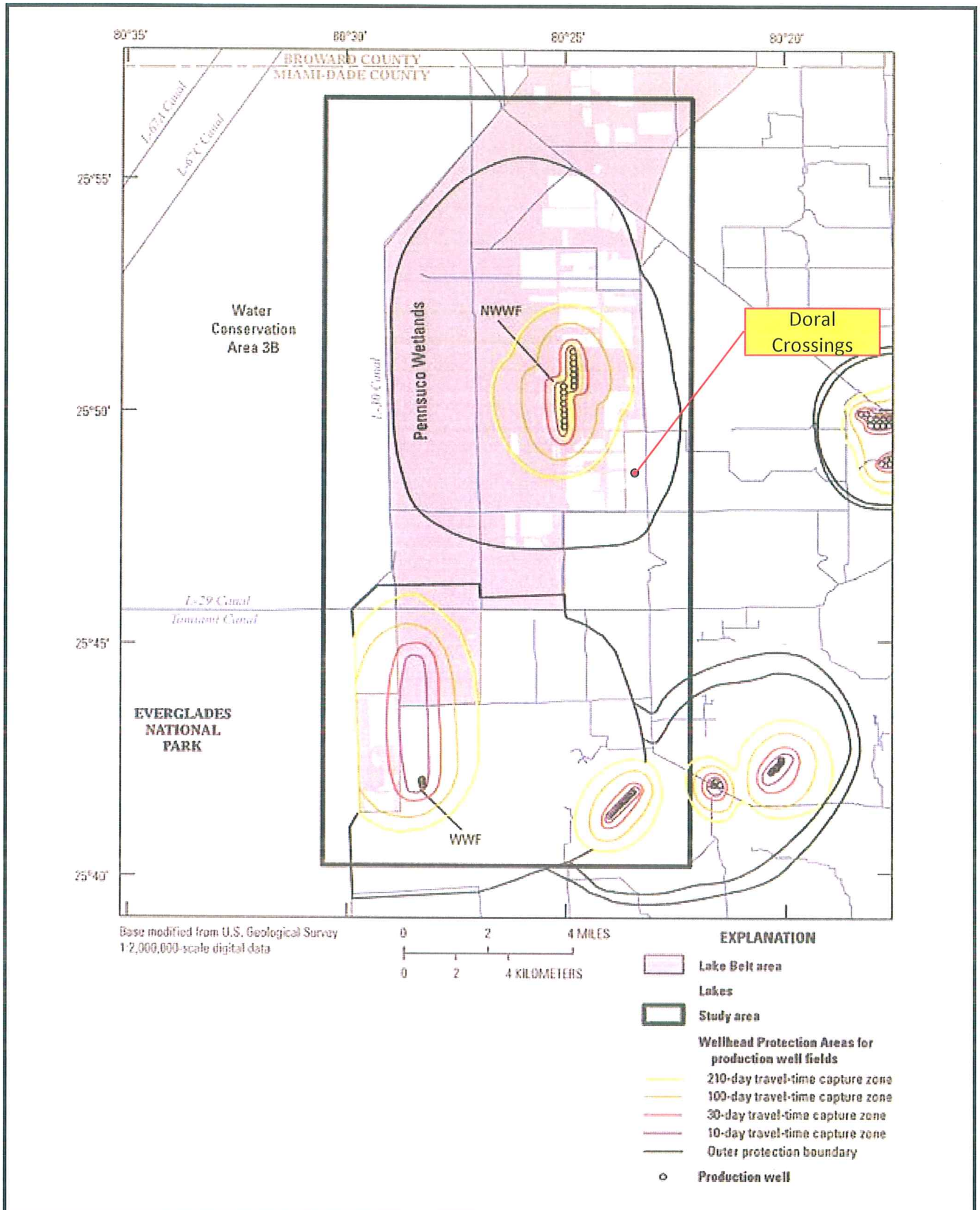
Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 9 - Hydrograph of water levels at USGS station G-3259A (1982 to present)	Doral Crossings



Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 10 - Hydrograph of water levels at USGS station G-3253 (1982 to present)	Doral Crossings



Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 11 - Hydrograph of water levels at USGS station Snapper Creek Extension Canal at NW 74th Street (1984 - present)	Doral Crossings



Hydrologic Associates USA, Inc. 10406 SW. 186 Terrace Miami, FL 33157	Figure 12 - Map showing location of the Lake Belt area and well field protection overlays	Doral Crossings

APPENDIX A

Groundwater Quality from the
Beacon Lakes Development
(2004 to 2012)

SUMMARY TABLE: 1-- GROUNDWATER ANALYTICAL RESULTS (VOA)
BEACON LAKES

Well ID	Date Sampled	Benzene	Toluene	Ethylbenzene	MTBE	Total Xylenes	FLPRO*
MW-1	9/17/2004	BDL	BDL	BDL	BDL	BDL	BDL
	6/27/2006	0.36 U	0.31 U	0.33 U	0.32 U	0.83 U	0.060 U
	7/25/2007	0.09 U	0.14 U	0.13 U	0.50 U	0.32 U	0.07 U
	6/25/2008	0.37 U	0.63 U	0.59 U	0.21 U	1.24 U	0.07 U
	6/29/2009	0.21 U	0.28 U	0.17 U	0.23 U	0.59 U	0.28 U0
	6/23/2010	0.30 U	0.28 U	0.17 U	0.31 U	0.63 U	0.28 U0
	8/1/2011	0.21 U	0.28 U	0.17 U	0.23 U	0.59 U	0.180 U
	6/13/2012	0.36 U	0.49 U	0.38 U	0.24 U	1.1 U	0.180 U
MW-2	9/17/2004	BDL	BDL	BDL	BDL	BDL	BDL
	6/27/2006	0.36 U	0.31 U	0.33 U	0.32 U	0.83 U	0.061 U
	7/3/2007	0.09 U	0.14 U	0.13 U	0.50 U	0.38 U	0.07 U
	6/25/2008	0.37 U	0.63 U	0.59 U	0.21 U	1.24 U	0.07 U
	6/29/2009	0.21 U	1.3	0.23 I	0.23 U	1.4 I	0.28 U0
	6/24/2010	0.30 U	0.28 U	0.17 U	0.31 U	0.63 U	0.28 U0
	8/1/2011	0.21 U	0.28 U	0.17 U	0.23 U	0.59 U	0.180 U
	6/13/2012	0.36 U	0.49 U	0.38 U	0.24 U	1.1 U	0.180 U
MW-3	9/17/2004	BDL	BDL	BDL	BDL	BDL	BDL
	10/21//05	BDL	BDL	BDL	BDL	BDL	BDL
	6/27/2006	0.36 U	0.31 U	0.33 U	0.32 U	0.83 U	0.061 U
	7/3/2007	0.09 U	0.14 U	0.13 U	0.50 U	0.38 U	0.07 U
	6/25/2008	0.37 U	0.63 U	0.59 U	0.21 U	1.24 U	0.07 U
	6/29/2009	0.21 U	4	0.67 I	0.23 U	4.4	0.28 U0
	6/23/2010	0.30 U	0.28 U	0.17 U	0.31 U	0.63 U	0.28 U0
	8/1/2011	0.21 U	0.28 U	0.17 U	0.23 U	0.59 U	0.180 U
Criteria	**N/A**	**1.0**	**40**	**30**	**20**	**20**	**5**

Notes: Criteria - FAC 62-777 (Groundwater Criteria)
All units reported in ug/l
* - reported in mg/l but by method FLPRO

6/22/2012

SUMMARY TABLE: 2 --GROUNDWATER ANALYTICAL RESULTS (VOH)
BEACON LAKES

Well ID	Date Sampled	PCE	TCE	Cis 1,2 Dichloroethene	Trans 1,2 Dichloroethene	Vinyl Chloride	Methylene Chloride	Acetone	Chloromethane
MW-1	9/17/2004	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	6/27/2006	<0.34	<0.42	<0.26	<0.38	<0.31	<0.42	<4.3	<0.72
	7/25/2007	<0.11	<0.09	<0.11	<0.50	<0.34	<0.99	NS	<0.35
	6/25/2008	<0.53	<0.48	<0.47	<0.95	<0.77	<0.99	NS	<0.29
	6/29/2009	<0.36	<0.36	<0.28	<0.40	<0.37	<0.32	NS	<0.29
	6/23/2010	<0.82	<0.36	<0.28	<0.40	<0.40	<0.32	9.7	0.90 I
	8/1/2011	<0.59	<0.36	<0.28	<0.40	<0.37	0.41 I,V	<3.3	<0.29
	6/13/2012	0.48 U	0.74 U	0.48 U	0.59 U	0.45 U	0.48 U	7.0 U	0.42 U
MW-2	9/17/2004	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	6/27/2006	<0.34	<0.42	<0.26	<0.38	<0.31	<0.42	<4.3	<0.72
	7/25/2007	<0.11	<0.09	<0.11	<0.50	<0.34	<0.99	NS	<0.35
	6/25/2008	<0.53	<0.48	<0.47	<0.95	<0.77	<0.99	NS	<0.29
	6/29/2009	<0.36	<0.36	<0.28	<0.40	<0.37	<0.32	NS	<0.29
	6/23/2010	<0.82	<0.36	<0.28	<0.40	<0.40	<0.32	11	0.95 I
	8/1/2011	<0.59	<0.36	<0.28	<0.40	<0.37	0.43 I,V	<3.3	<0.29
	6/13/2012	0.48 U	0.74 U	0.48 U	0.59 U	0.45 U	0.48 U	7.0 U	0.42 U
MW-3	9/17/2004	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	10/21/2005	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
	6/27/2006	<0.34	<0.42	<0.26	<0.38	<0.31	<0.42	<4.3	<0.72
	7/3/2007	<0.11	<0.09	<0.11	<0.50	<0.34	<0.99	NS	<0.35
	6/25/2008	<0.53	<0.48	<0.47	<0.95	<0.77	<0.99	NS	<0.29
	6/29/2009	<0.36	<0.36	<0.28	<0.40	<0.37	<0.32	NS	<0.29
	6/23/2010	<0.82	<0.36	<0.28	<0.40	<0.40	<0.32	<3.3	<0.60
	8/1/2011	<0.59	<0.36	<0.28	<0.40	<0.37	<0.23	<3.3	<0.29
Criteria	**NA**	**3**	**3**	**70**	**100**	**1.0**	**5**	**6300**	**2.7**

Notes: Criteria Fac 62-777
U- Below method detection limits
PCE- Tetrachloroethene
TCE- Trichloroethene
All Units reported in ug/L

6/22/2012

SUMMARY TABLE: 3 -- ANALYTICAL RESULTS (METAL)
Beacon Lakes

Well ID	Date Sampled	Arsenic	Chromium	Copper	Iron	Lead	Zinc	Barium	Cadmium	Selenium	Silver
MW-1	9/17/2004	9	BDL	BDL	650	BDL	29	NS	NS	NS	NS
	6/27/2006	8.2 U	1.6 U	1.4 I,V	710	3.5 U	7.9 I,V	NS	NS	NS	NS
	7/25/2007	2.0 U	0.5 U	0.62 U	230	1 U	0.04 U	NS	NS	NS	NS
	6/25/2008	2.0 U	0.2 U	0.10 U	207	1.1 U	0.04 U	NS	NS	NS	NS
	6/29/2009	8.5 U	0.50 U	2.5 U	50 I	1.3 U	10 V,I	34	0.32 U	6.8 U	0.70 I
	8/1/2011	8.5 U	0.67 I	2.5 U	100 I	1.3 U	27	NS	NS	NS	NS
	6/13/2012	8.5 U	0.94 I	2.5 U	0.13 I	1.3 U	10	NS	NS	NS	NS
MW-2	9/17/2004	9	BDL	BDL	290	BDL	26	NS	NS	NS	NS
	6/23/2010	8.5 U	1.1 I	2.5 U	72 I	1.3 U	12	NS	NS	NS	NS
	6/27/2006	8.2 U	1.6 U	1.2 U	230	3.5 U	5.4 I,V	NS	NS	NS	NS
	7/25/2007	2.0 U	0.4 U	0.16 U	180	1 U	2	NS	NS	NS	NS
	6/25/2008	2.0 U	0.2 U	0.10 U	143	1.1 U	0.04 U	NS	NS	NS	NS
	8/1/2011	8.5 U	0.66 I	2.5 U	91 I	1.3 U	23	NS	NS	NS	NS
	6/13/2012	8.5 U	0.79 I	2.5 U	72 I	1.3 U	11	NS	NS	NS	NS
MW-3	9/17/2004	8	BDL	BDL	240	BDL	18	NS	NS	NS	NS
	6/29/2009	8.5 U	0.50 U	2.5 U	110 I	1.3 U	9.1 V,I	18	0.32 U	6.8 U	2.3 I
	10/21/2005	BDL	BDL	BDL	157	BDL	BDL	NS	NS	NS	NS
	6/24/2010	8.5 U	1.2 I	2.5 U	86 I	1.3 U	11 V	NS	NS	NS	NS
	6/27/2006	8.2 U	1.6 U	1.8 I,V	190 U	3.5 U	9.0 I,V	NS	NS	NS	NS
	7/25/2007	2.0 U	0.4 U	0.16 U	170	1 U	2 U	NS	NS	NS	NS
	6/25/2008	2.0 U	0.2 U	0.10 U	22	1.1 U	0.04 U	NS	NS	NS	NS
	6/29/2009	8.5 U	0.50 U	2.5 U	38 U	1.3 U	8.6 V,I	13	0.32 U	6.8 U	1.7 I
	6/23/2010	1.3 V	0.85 I	2.5 U	1.1 I	1.3 U	12	NS	NS	NS	NS
	8/1/2011	8.5 U	0.56 I	2.5 U	350	1.3 U	28	NS	NS	NS	NS
Criteria	**N/A**	**10**	**100**	**1000**	**300**	**15**	**5000**	**2000**	**5**	**50**	**100**

Criteria - FAC 62-777 (Groundwater Criteria)
BDL - Below detectable levels
I - The reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.
V- Method Blank Contamination
All units reported in ug/l
N/A - Not Applicable

SUMMARY TABLE: 4 -- ANALYTICAL RESULTS
OIL GREASE (HEM)
BEACON LAKES

Well ID	Date Sampled	Oil & Grease (HEM)
MW-1	9/14/2004	BDL
	6/27/2006	<0.72
	7/25/2007	12.5
	6/25/2008	<2.5
	6/29/2009	<1.4
	6/23/2010	<1.3
	6/13/2012	1.3 U
MW-2	9/17/2004	BDL
	6/27/2006	<0.72
	7/3/2007	<2.5
	6/25/2008	<2.5
	6/29/2009	<1.3
	6/24/2010	1.9
	6/13/2012	1.3 U
MW-3	9/17/2004	BDL
	10/21/2005	BDL
	6/27/2006	0.80 I
	7/3/2007	<2.5
	6/25/2008	<2.5
	6/29/2009	<1.3
	6/23/2010	<1.3
Criteria	**N/A**	**N/A**

Notes: Criteria - FAC 62-777 (Groundwater Criteria)
BDL - Below detectable levels
All units reported in mg/L
N/A - Not Applicable