ASCE WATER RESOURCES LUNCHEON 2010

ORANGE COUNTY'S FLORIDAN AQUIFER DRAINAGE WELLS

Recent Experience & Proactive Rehabilitation Program

Water Resources Technical Group Luncheon

ASCE

When: Thursday, February 18th
Where: Marriott Downtown,
400 West Livingston Ave

DEVO Engineering
CONSULTING GEOTECHNICAL ENGINEERS

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Presented by:

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  FDEP (Central District), UIC Program

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Outline of Presentation:

This presentation focuses on the critical subject of drainage well replacement and rehabilitation in Orange County and includes the perspectives of the Owner (Orange County), the regulatory agency (FDEP), and the consultant.

Orange County

Short and long range plans/approach for well inspection, maintenance, and replacement; Design philosophy for well replacement projects with some examples and budgeting the replacements well projects.

FDEP

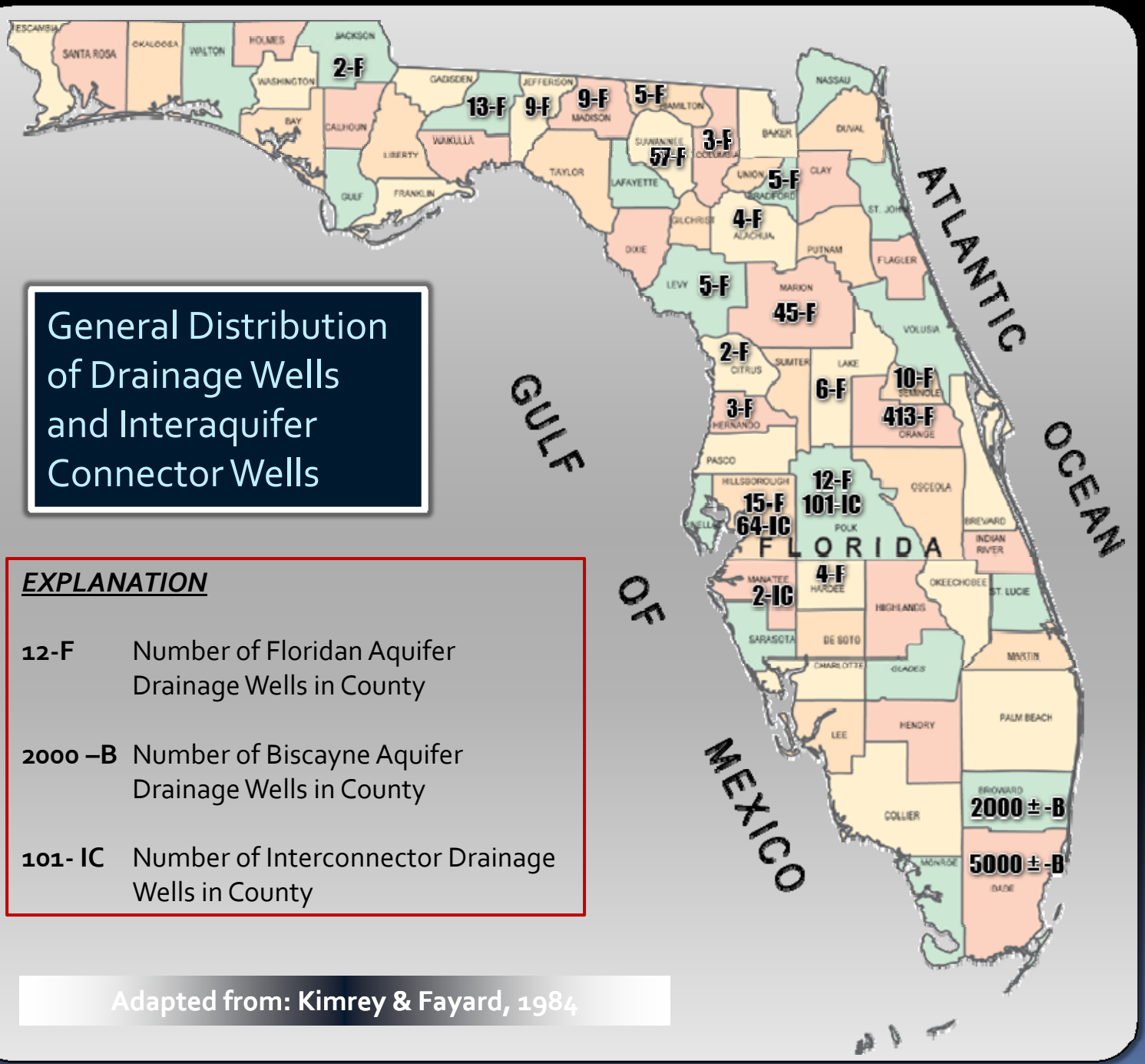
State and Federal regulations which apply to these well replacement projects; typical research and design phases in the justification process to gain approval, including post-construction certification.

Devo Engineering (Consultant)

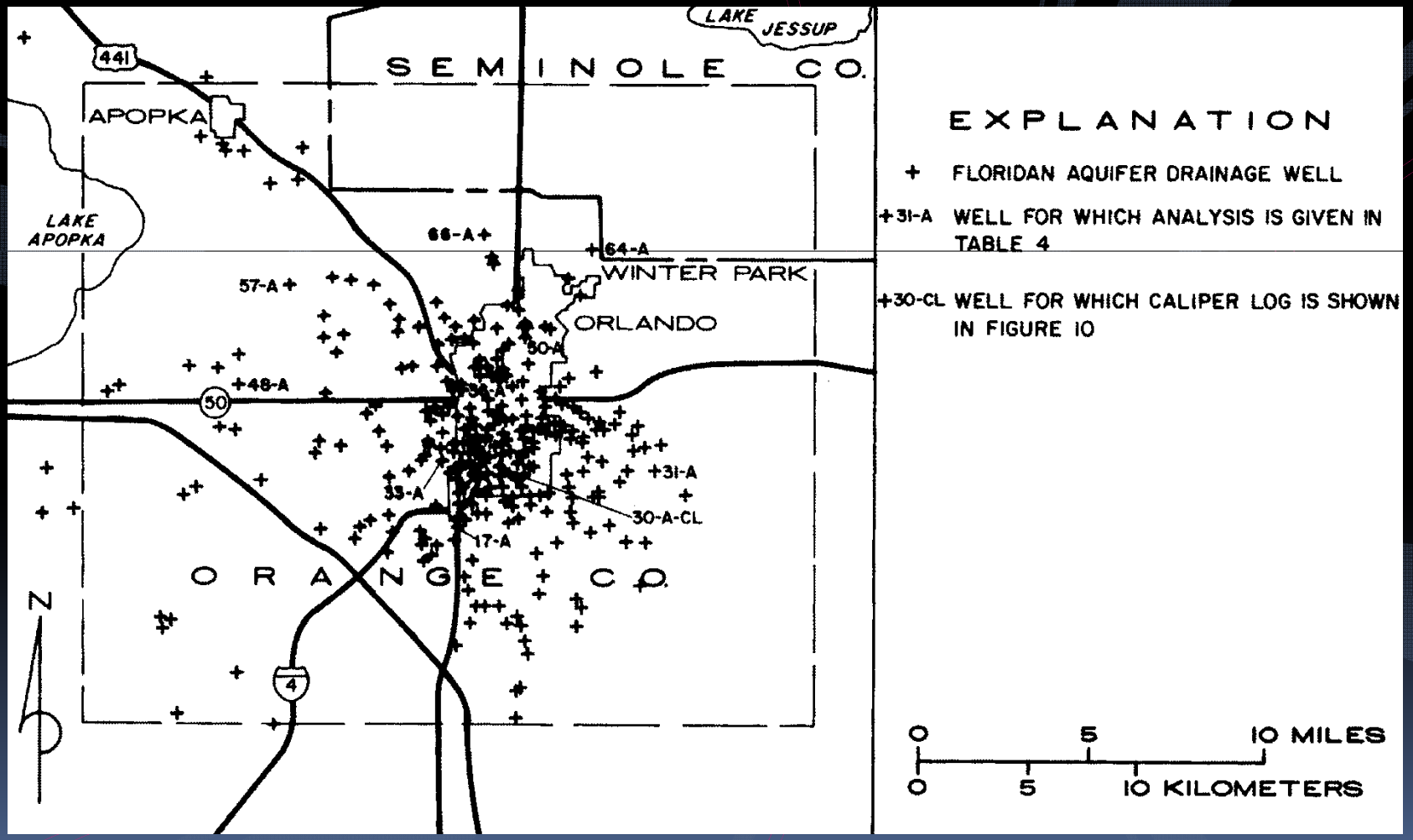
History of drainwells in Central Florida; Design and permitting consideration; discuss special problems encountered during well construction, how to handle emergency projects; Importance of wells on lake hydrology, flood control, & aquifer recharge, and present some significant success stories in Orange County.

Introductory Remarks:

- Nationwide: there are about 71,000 documented stormwater drainage wells, with an estimated total of about 248,000 wells when the undocumented wells are counted. 81% of the documented wells are in 7 western states (Washington, Arizona, Idaho, Oregon, Montana, California, and Utah, with the first mentioned having the most).
- Florida: 2,153 documented wells, with about 200 to 250 of these being lake level control wells.
- Floridan Aquifer wells in state of Florida: 607 records are available; note: these do not include Biscayne aquifer wells located in Broward and Dade County.
- Distribution of Floridan aquifer drainage wells within the state:
  1. Orlando area = 392 wells (highest density of drainage wells within the state)
  2. Live Oak area = 46 wells
  3. Ocala area = 35 wells
- Well diameters range from 6" to 24" are they are in the Upper Floridan aquifer; street wells are usually 12" in diameter or less

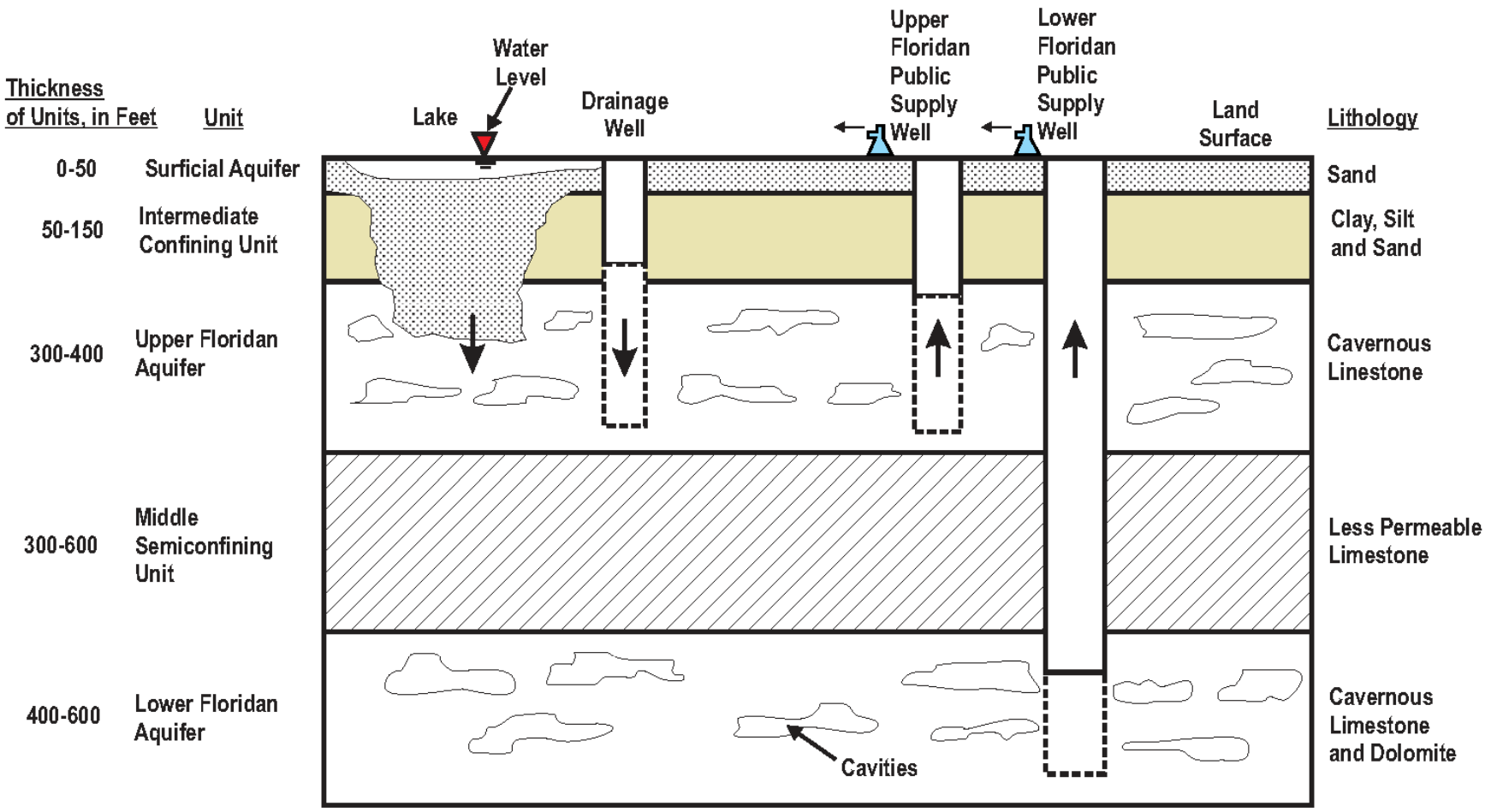

General Distribution of Drainage Wells and Interaquifer Connector Wells
ATLANTIC OCEAN
GULF OF MEXICO
FLORIDA
2-F
13-F
9-F
9-F
5-F
57-F
3-F
5-F
4-F
5-F
45-F
2-F
3-F
6-F
10-F
413-F
12-F
101-IC
15-F
64-IC
4-F
2-IC
2000 ± -B
5000 ± -B
EXPLANATION
12-F Number of Floridan Aquifer Drainage Wells in County
2000 –B Number of Biscayne Aquifer Drainage Wells in County
101- IC Number of Interconnector Drainage Wells in County
Adapted from: Kimrey & Fayard, 1984

Floridan Aquifer Drainage Wells in Orlando Area



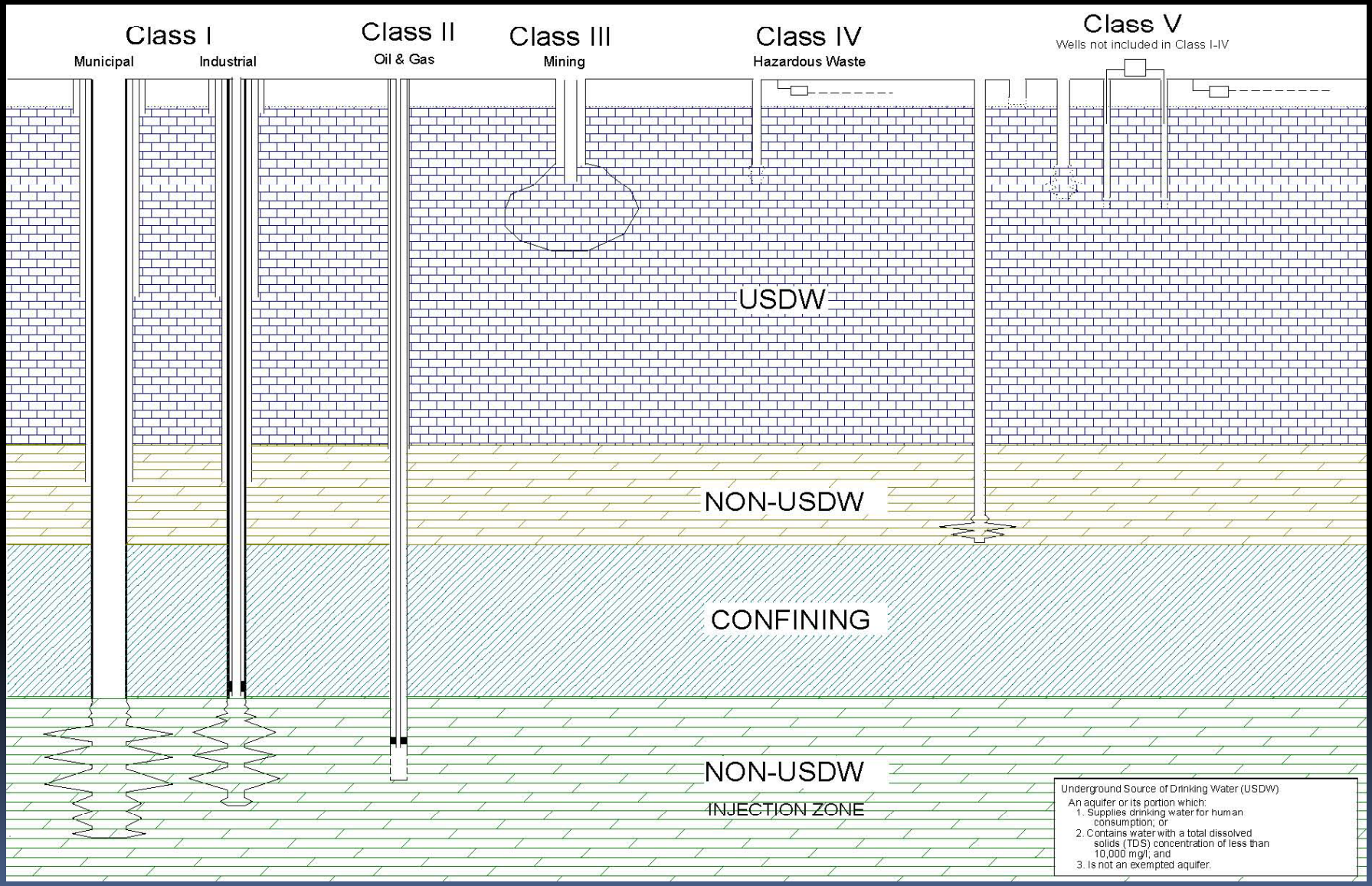
Adapted from: Kimrey & Fayard, 1984

Generalized Hydrogeologic Section in the Orlando Area



Public water supply withdrawals in Orange County/Orlando near drainage wells are completed into the Lower Floridan Aquifer - Adapted from: Bradner 1991

Injection Well Classes



FDEP website Graphic, 62-528

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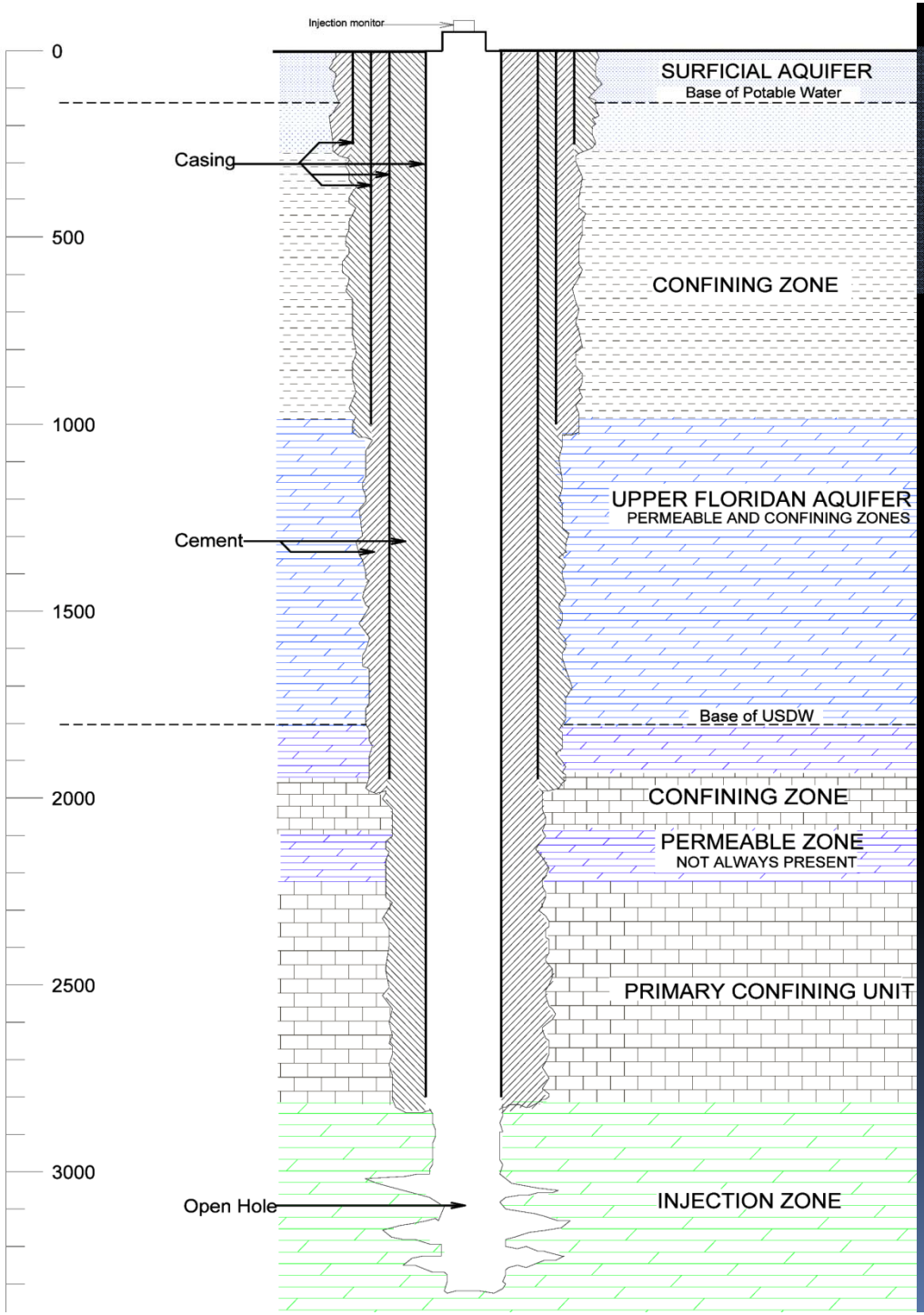
Typical Municipal Injection Well Construction



Casing	Outside Dia-meter	Wall Thick-ness	Typical Length	Material
Surface	52”	3/8”	100-250’	Steel
Shallow Inter-mediate	42”	3/8”	900-1000’	Steel
Deep Inter-mediate*	34”	3/8”	1500-2100’	Steel
Injection	24”	1/2"	2400-3000’	Seamless Steel

* The deep intermediate casing is set below the base of the lowermost underground source of drinking water.

Casing depths apply only to Southeast Florida.

FDEP website Graphic, 62-528

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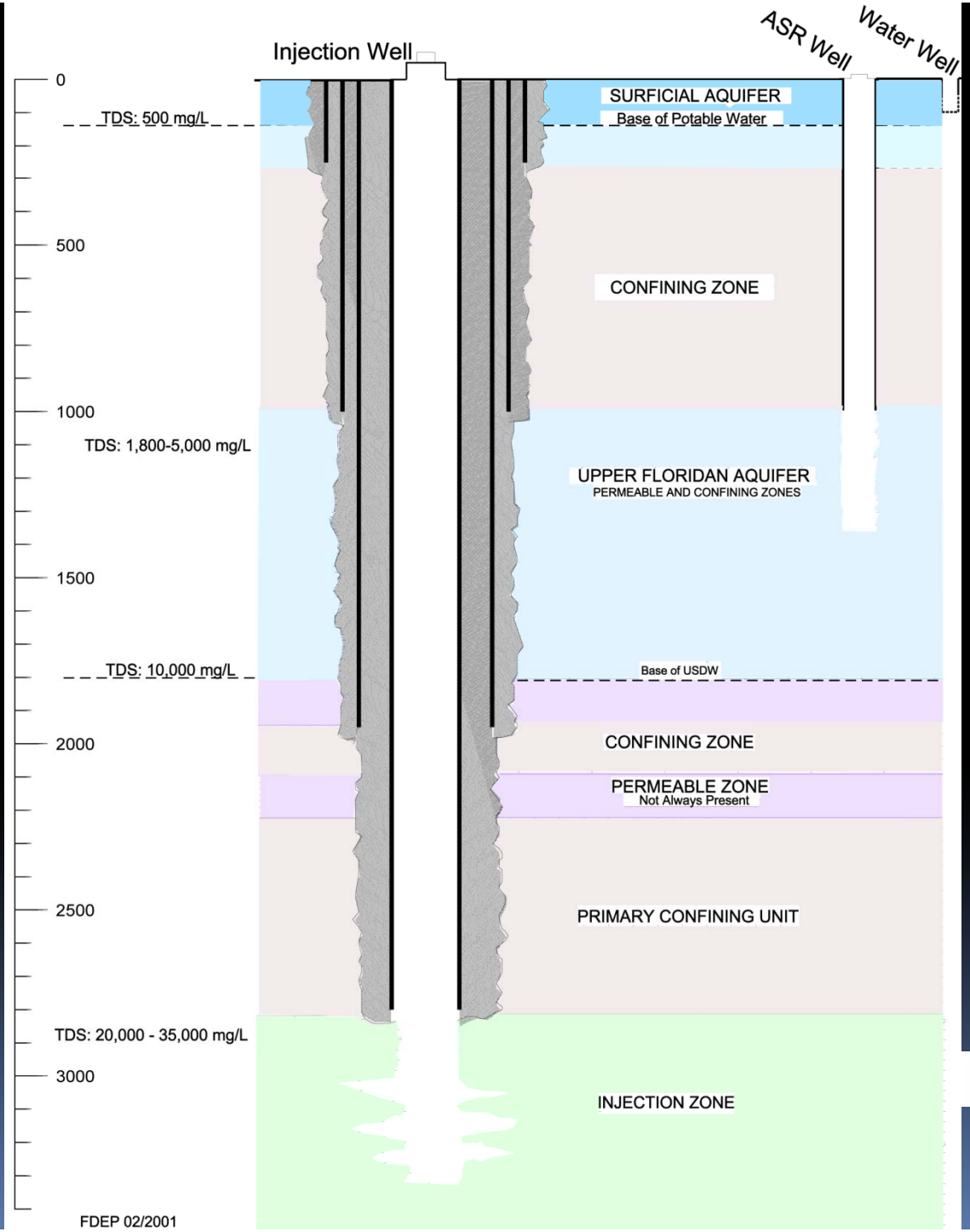

Typical Municipal Class I Injection Well, ASR Well and Water Well in Southeast Florida

FDEP website Graphic, 62-528

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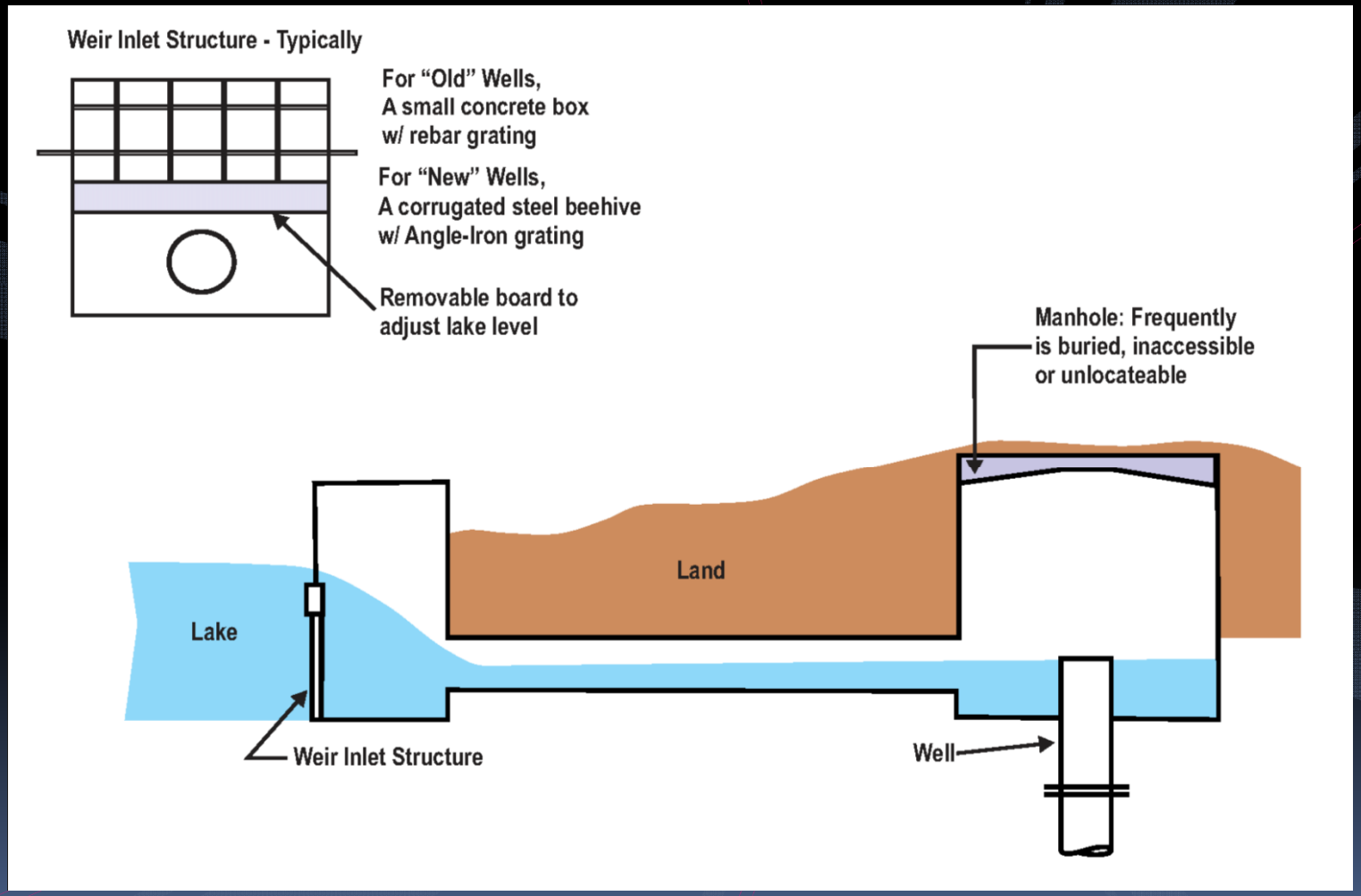
Types of Floridan Aquifer Drainage Wells in Central Florida:

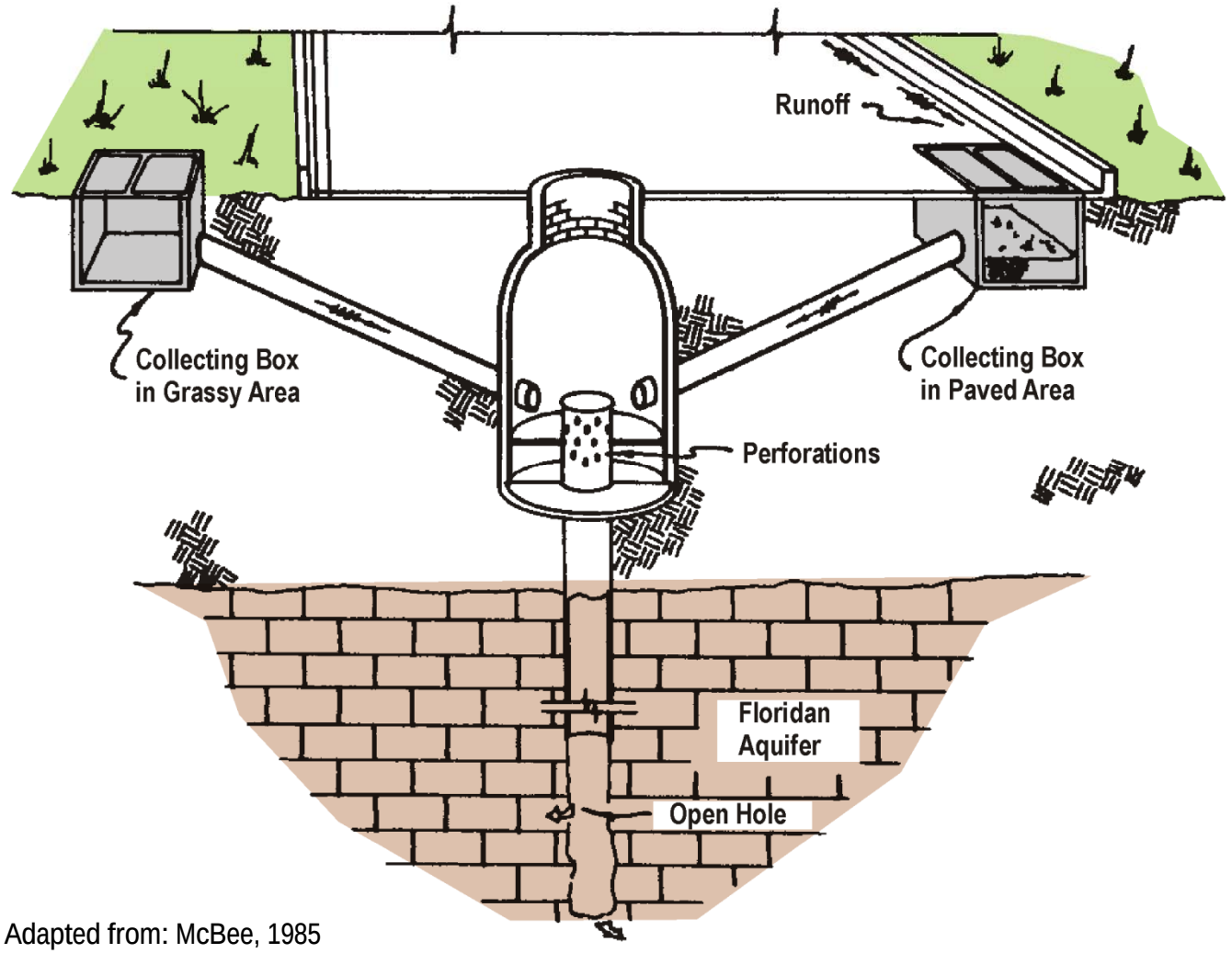
- Direct street runoff drainage wells
- Lake level control wells
- Pond level control wells
- Canal level control wells
- Local area drainage wells

Typical Lake Level Control Well



Adapted from: McBee, 1985

Typical Direct street runoff drainage wells



Adapted from: McBee, 1985

Drainage Well Chronology for Central Florida (1 of 4):

1904 - The first drainage well in Orange County was drilled. In April of that year, a sinkhole (probably Lake Greenwood) became clogged and a considerable area in southeastern Orlando was flooded by heavy rains. After several unsuccessful attempts to reopen the sink (inlcuding blasting), a drainage well was drilled as an experiment. In August, a two-inch test well was drilled, and it proved successful enough to warrant the construction of larger wells. The next year two more wells, one 8-inch and one 12-inch, were completed and these drained a large part of the flooded area. These wells, however, were not sufficient to drain the area completely, so in the winter of 1906 two more 12-inch wells were constructed, and by February 1907, a fourth 12-inch well had been completed. By the end of March 1907, the water was almost back to its normal level.

1906 - 6 wells documented

Following success of Lake Greenwood drainage, these wells became the commonly accepted solution to drainage problems in the Orlando area.

1910 - Lake Fairview well started geysering on Sep 26 of that year (3 years after it was constructed) and became a local attraction in 1912. it was subsequently plugged.

Photographer H. A. Abercromby recorded this flooded section of Orlando sometime in the **1880**'s and **1890**'s, according to Florida State Archives records. During heavy rains, the area near Greenwood Cemetery and the black community of Jonestown, east of downtown Orlando, was especially prone to flooding.

Drainage Well Chronology for Central Florida (2 of 4):

1926, 1928 - A large number of drainage wells were installed to deal with the excessively heavy rains in these years.

1936 - 120 wells documented (90 owned by the city and 30 owned by the county)

1939 - Permits became required to dig drainage wells

1943 - 200 wells documented (used their water elevations to construct a detailed pot surface map of the Orlando area and showed that the aquifer level rises very quickly due to drainage well recharge, 6 ft rise in 30 hr)

1948, 1954, 1959 - Drainage-well construction was accelerated again during these wetter-than-average years

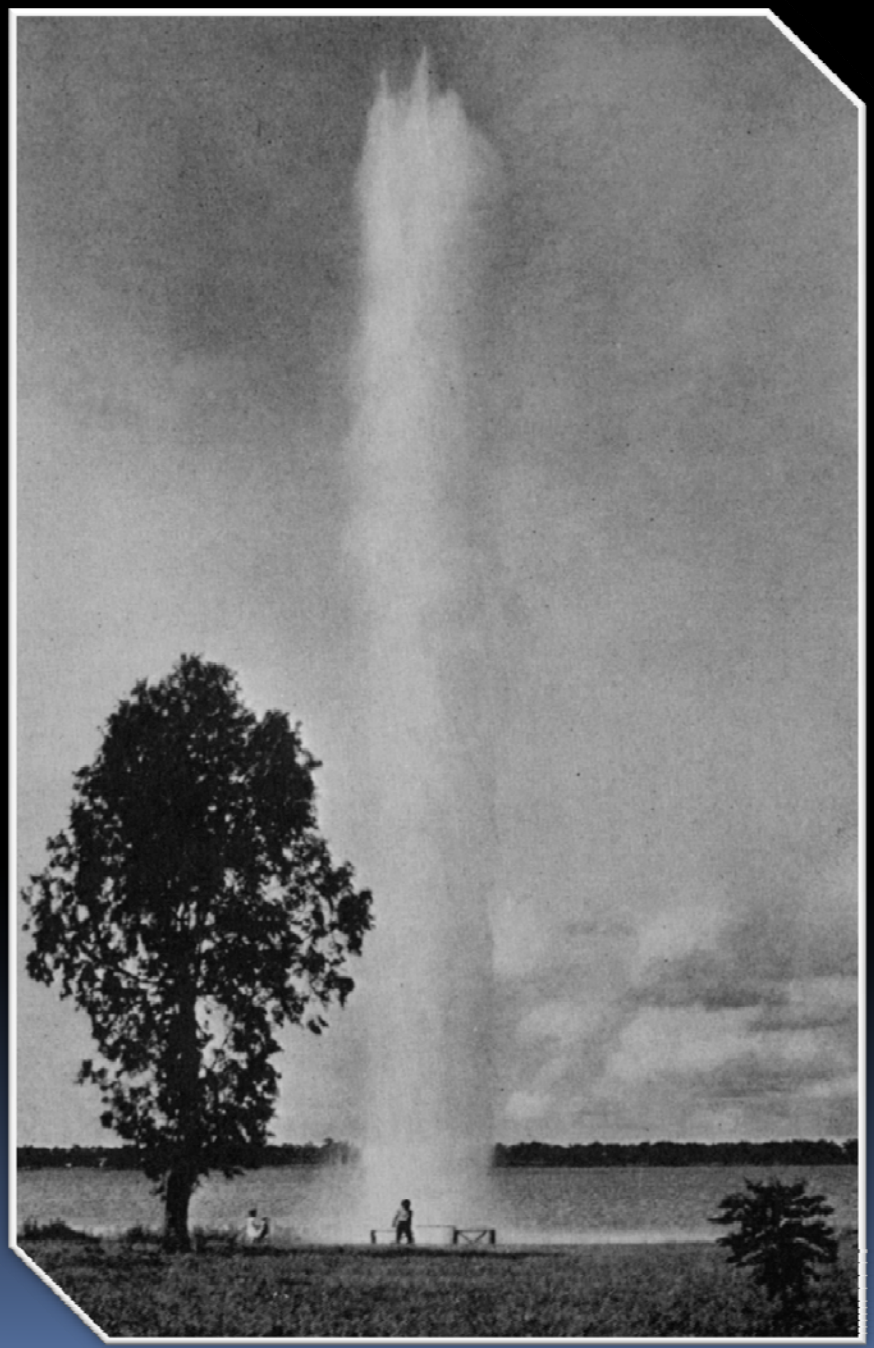
1960 (Hurricane Donna) - Highest rate ever of drainage-well construction (35 wells during 1960)

Flooded Hiawassee Road from heavy rainfall and ineffectiveness of drainage well 1930

This photo was taken before Hiawassee Rd was realigned

Lake Davis in southwest section of Orlando seen flooded after heavy rain **1930**

Rig in photograph was used to drill deeper drainage well



Orlando's "spouting well" on Lake Fairview, seen in **1934**, first became a local attraction about 1912. The geyser, which shot water 75 to 100 feet in the air, was on the Davis-McNeill farm on the lake's south side and was the result of a well drilling that unintentionally hit the great underground Floridan aquifer. Farm manager R.D. Eunice asked a small admission fee for the curious, and folks who didn't want to pay just parked their cars across the lake and waited out the interval between spouts. The well has been capped for many years.

Methane gas burning from newly drilled drainage well

Height of flame is between 80 and 100 ft. at 9:00 a.m., Friday, , March 12, **1948**. Gas flowed at a land surface depth of 100 ft.

Located on 31st and S. Westmoreland.

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Water shoots about 40 feet high toward the tall pine trees on March 12, **1948**, at South Westmoreland Drive and 31st Street in Orlando in an image from the Florida Geological Survey Collection. The temporary spout occurred during the drilling of a drainage well.

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Drainage Well Chronology for Central Florida (3 of 4):

1964 - An excessively wet year and the available records indicate that drainage-well construction was intensified as a result.

1965 - The Florida State Board of Health stopped granting permits for construction of new drainage wells. However, replacement of existing wells was still allowed.

1970's - The state stopped granting permits for the construction of any drainage wells including replacement wells.

1977 - 412 wells documented

1981 - 392 wells documented

1985 - 413 wells documented on USGS listing

1987, 1988 - USGS performs study of groundwater chemistry in vicinity of selected drainage wells in Orlando and compares to background groundwater quality.

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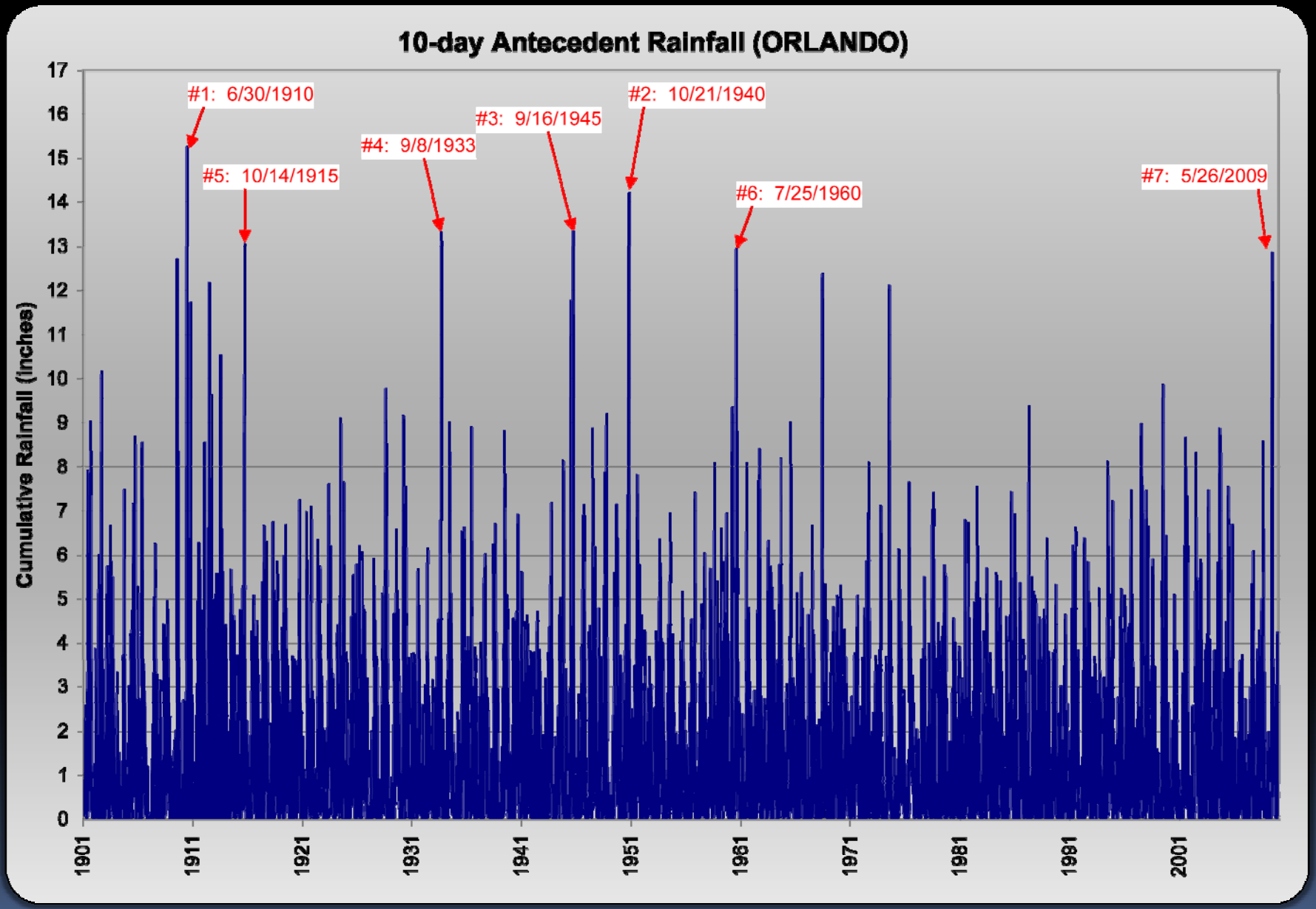

Orlando Rainfall Peaks Coincide with Active Drainage well Construction – 10 Day Peaks

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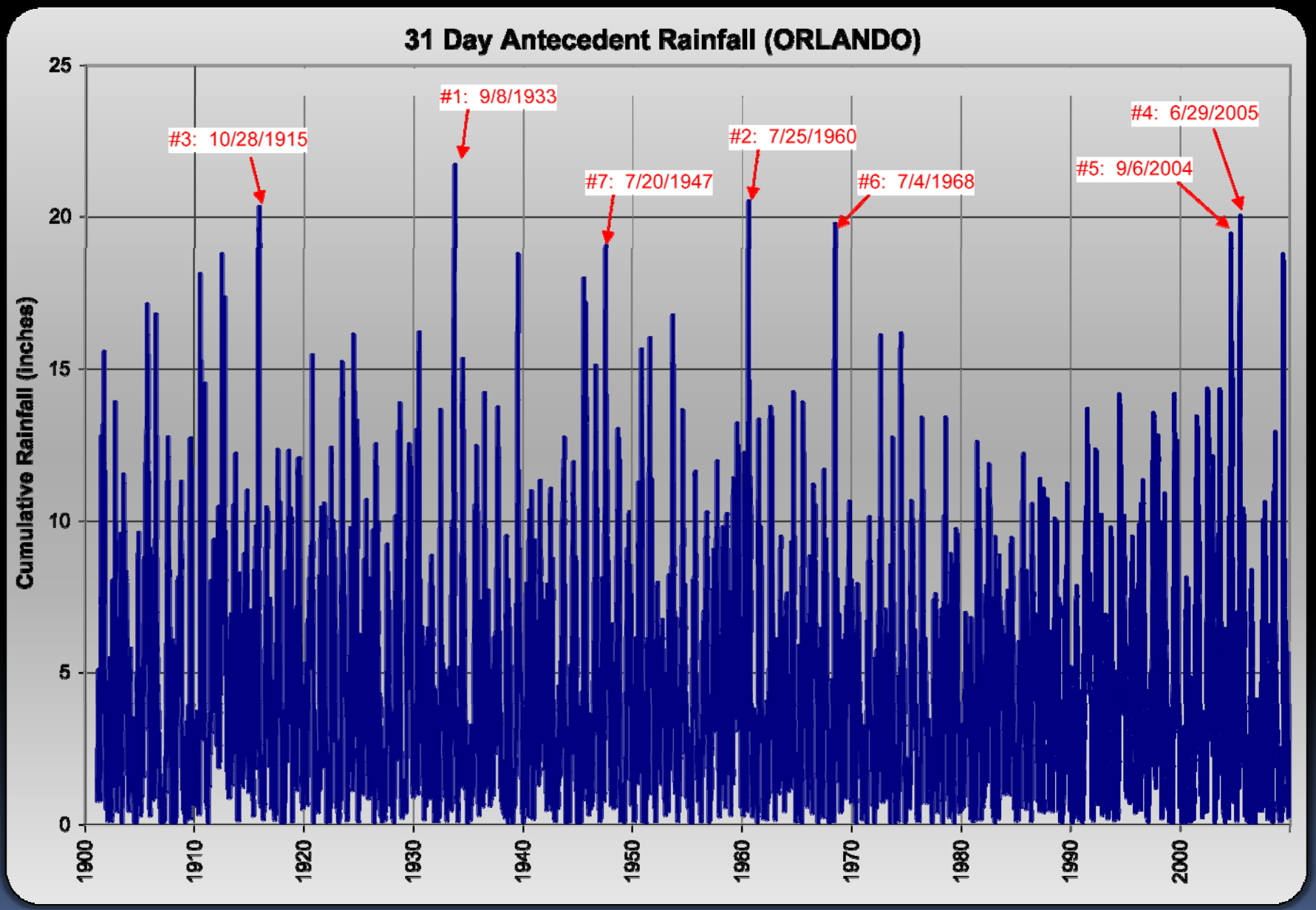
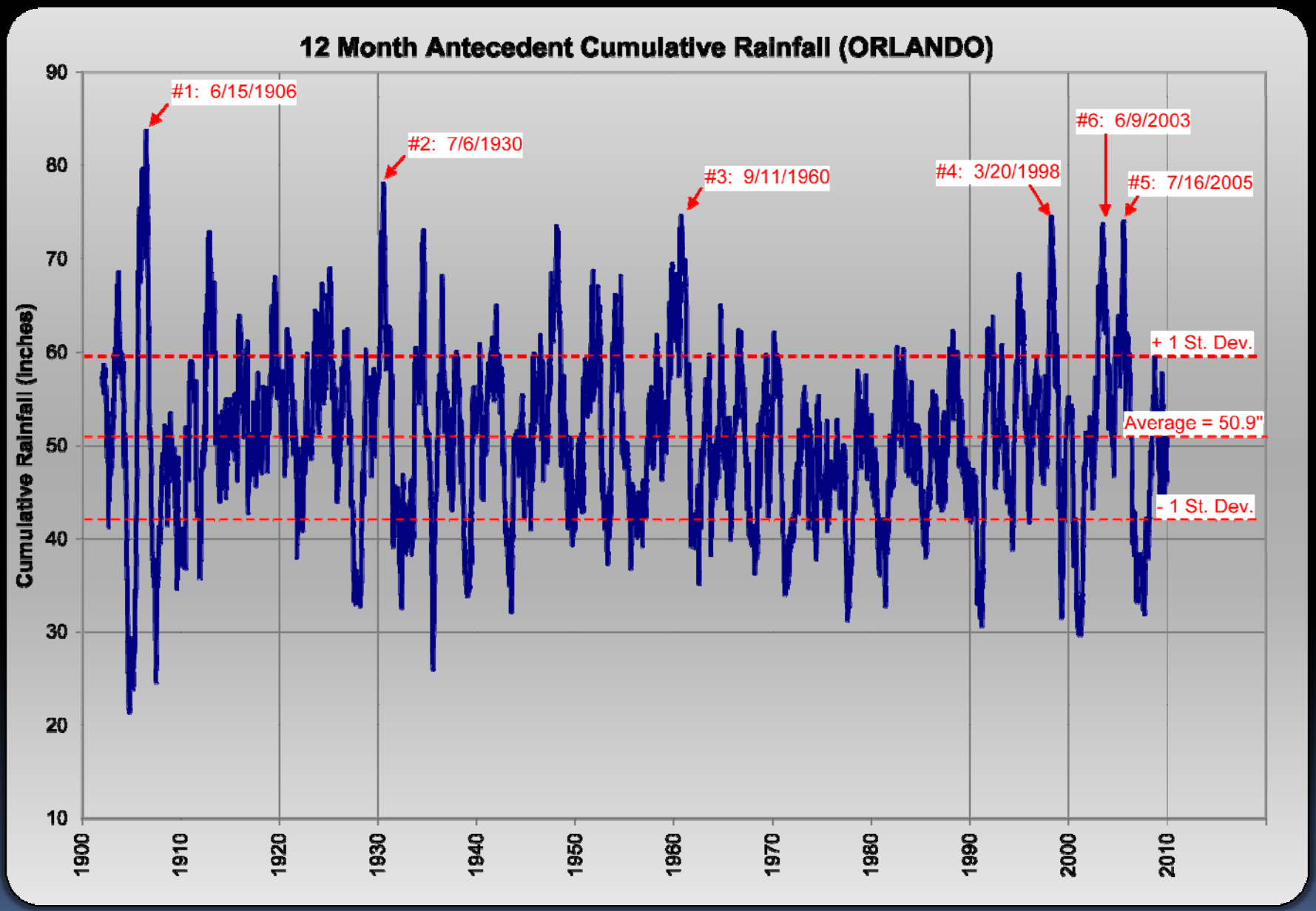


Orlando Rainfall Peaks Coincide with Active Drainage well Construction – Monthly Peaks



Orlando Rainfall Peaks Coincide with Active Drainage well Construction – Annual Peaks

Drainage Well Chronology for Central Florida (4 of 4):

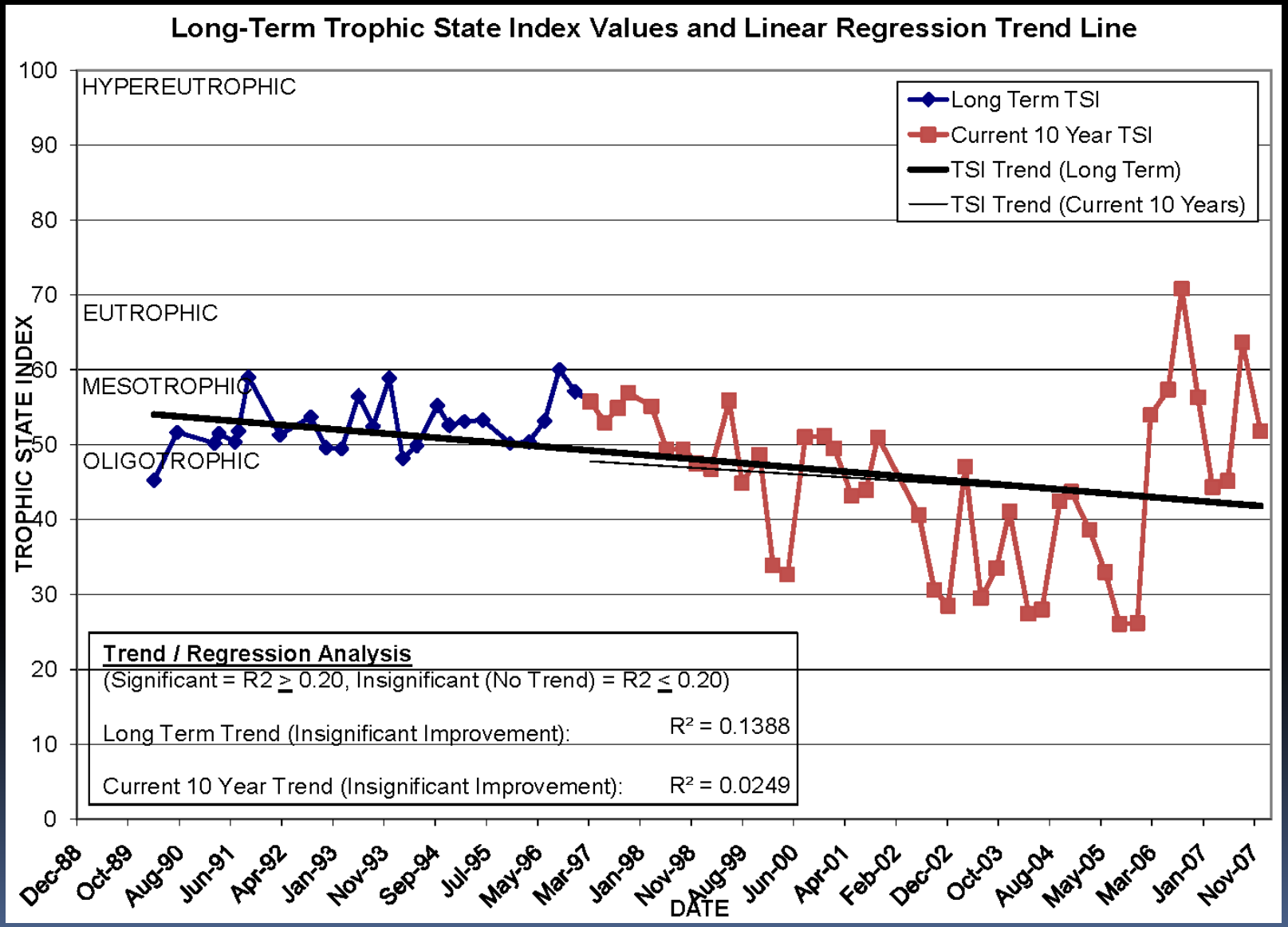
1997 - Under Chapter 403.088 Florida Statutes, FDEP started reviewing and approving drainage well replacement projects which would improve water quality. Lake Tennessee drainage well replaced by City of Orlando. Lake's water quality (TSI) seems to have improved since well replacement due to flush rate.

1998 (El Nino rains) - Orange County replaced the Lake Azalea drainwells in early part of 1998, then Lake Lilly drainwell right after, and Banana Bay and Daniels Road (SR 535) drainage wells in 1999. Numerous other wells have been replaced by the county since Lake Azalea. Orlando has replaced 9 wells.

2003 - Updated well inventory performed by SFWMD contractor (Hartman); 494 well records available with 475 of these 494 wells within Orange County. 411 wells are maintained by government agencies.
City of Orlando is responsible for 261 wells while Orange County is responsible for 71 wells.

2006 - Central Florida Aquifer Recharge Enhancement Program, Artificial Recharge Well Demonstration Project by CH2M Hill. Drainage wells: Sherwood, Orienta, Festival Park. oxygen-laden recharge water or change in carbonate balance mobilizing arsenic from dissolution of pyrite. Arsenic standard changed in Jan 2005 from 50 ppb to 10 ppb and all samples were lower than 20 ppb. No synthetic organics and coliform reduction of 2 to 6 orders. Coliform bacteria appears to have acclimatized in Floridan aquifer. Lake Sherwood not sampled since the well rarely flows.

Lake Tennessee TSI



Summary of Status of Drainage Wells of Four Municipal Owners, Central Florida:

Owner	Number of Wells				
	Street or Urban Drainage	Lake-Level Control	Inactive (Plugged or Capped)	Status Unknown or Unlocated	Total
City of Orlando	80	52	37*	60*	**229**
Orange County	24	51	2	0	**77**
City of Ocoee	0	5	0	2	**7**
City of Altamonte Springs	0	2	0	0	**2**
Total	104	110	39	62	**315**

Adapted from: McBee, 1985

Distribution of Diameter of Drainage Wells:

Well Diameter (Inches)	Lake1	Storm2	Alone3	Size Total
6”	2	6	3	11
8”	7	8	3	18
10”	4	12	3	19
12”	35	57	5	97
14”	3	1	1	5
16”	1	1	0	2
18”	10	8	1	19
20”	19	13	0	32
24”	0	1	0	1
Not Given	3	1	0	4
Totals	84	108	16	200

Depths of Drainage Wells and Public-Supply Wells, Central Florida:

Well Type	Number of Wells	Range of Depth (feet)	Percent of wells in which indicated depth is exceeded				
			90	75	50	25	10
Drainage	314	120-1,049	196	334	424	484	600
Public Supply	186*	94-1,500	200	324	420	558	1,300

Adapted from: McBee, 1985

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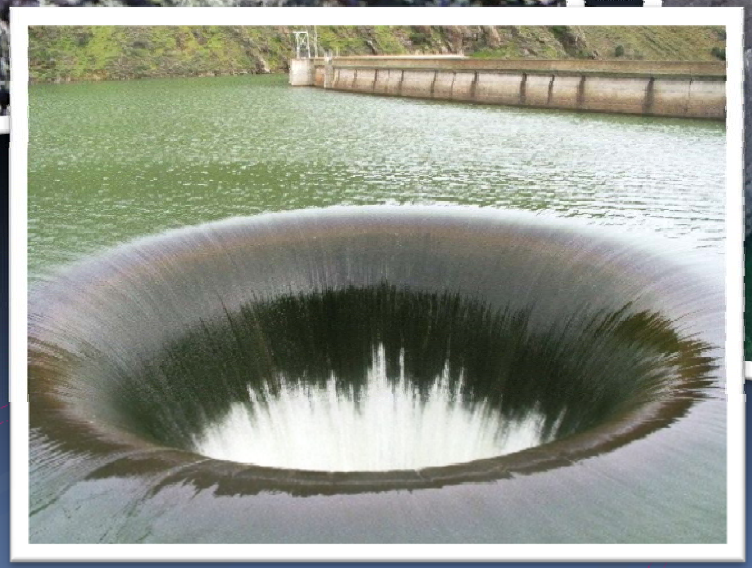
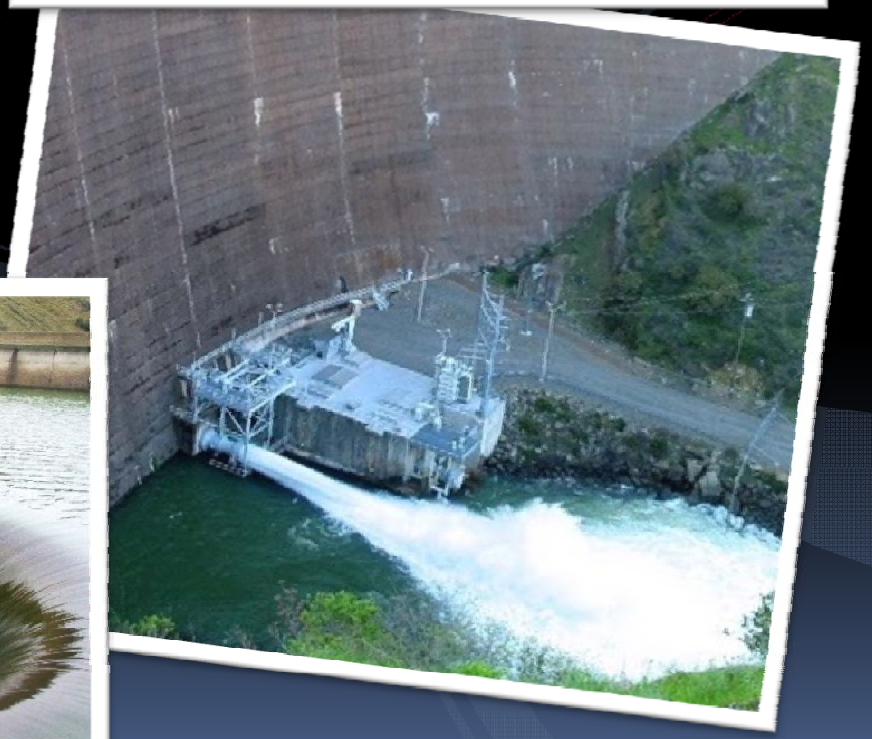
View of Morning Glory Spillway





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Values of Theoretical Acceptance Rates for Drainage Wells (Morning Glory Hydraulics):

Well Diameter in Inches	0.05'	0.10'	0.18'	0.25'	0.50'	1.00'
6	31.5	82.5	159	194	274	776
8	42.7	113.3	245	326	487	1024
10	54.3	148.0	335	489	775	1303
12	66.2	178.4	404	626	1097	1551
14	76.8	212.1	475	757	1446	2126
16	88.7	245.0	554	886	1843	2606
18	99.3	274.2	646	1013	2318	3490
20	109.9	303.5	733	1127	2731	4330
24	132.4	365.7	883	1393	3540	6205

Adapted from: McBee, 1985

Theoretical Acceptance Rates for Drainage Wells (Based on Aquifer Transmissivity)

A. T = 500,000 gpd/ft = 0.5 MGD/ft

Adapted from: McBee, 1985

Diameter (Inches)	Full Penetration (p=1.0)		60% Penetration (p=0.60)		6% Penetration (p=0.06)	
	(GPM)	(MGD)	(GPM)	(MGD)	(GPM)	(MGD)
6	**545**	0.79	327	0.47	32.7	0.05
8	**727**	1.05	436	0.63	43.6	0.06
10	**909**	1.31	545	0.79	54.5	0.08
12	**1,091**	1.57	654	0.94	65.4	0.09
14	**1,273**	1.83	764	1.10	76.4	0.11
16	**1,454**	2.09	873	1.26	87.3	0.13
18	**1,636**	2.36	982	1.41	98.2	0.14
20	**1,818**	2.62	1,091	1.57	109	0.16
24	**2,182**	3.14	1,309	1.88	131	0.19

Theoretical Acceptance Rates for Drainage Wells (Based on Aquifer Transmissivity)

B. T = 750,000 gpd/ft = 0.75 MGD/ft

Adapted from: McBee, 1985

Diameter (Inches)	Full Penetration (p=1.0)		60% Penetration (p=0.60)		6% Penetration (p=0.06)	
	(GPM)	(MGD)	(GPM)	(MGD)	(GPM)	(MGD)
6	818	1.18	491	0.71	49.1	0.07
8	1,091	1.57	654	0.94	65.4	0.09
10	1,364	1.96	818	1.18	81.8	0.12
12	1,636	2.36	982	1.41	98.2	0.14
14	1,909	2.75	1,145	1.65	115	0.16
16	2,182	3.14	1,309	1.88	131	0.19
18	2,454	3.53	1,473	2.12	147	0.21
20	2,727	3.93	1,636	2.36	164	0.24
24	3,272	4.71	1,963	2.83	196	0.28

Recharge Contribution of Drainage Wells to Upper Floridan Aquifer, Central Florida:

- Estimated recharge contribution of drainage wells: 40 to 50 mgd in Orlando area.
- If all wells are plugged, the potentiometric surface of the Upper Floridan aquifer is predicted to decline by 4 ft.
- This recharge water (from lake level control wells) should be considered a viable Alternative Water Supply.

Parameters which typically exceed Primary and Secondary Drinking Water Standards in Lake Water:

- Total Coliform (always exceeded) but there is no evidence of contamination although it has been exceeded for over 100 years (since 1906). Our experience indicates that these 2 parameters are exceeded:
  - Color
  - Total Coliform.
- Lead and Cadmium for some street wells; lead decreasing due to use of unleaded gasoline.

Known Contamination Events tied to Floridan aquifer drainage wells in Central Florida:

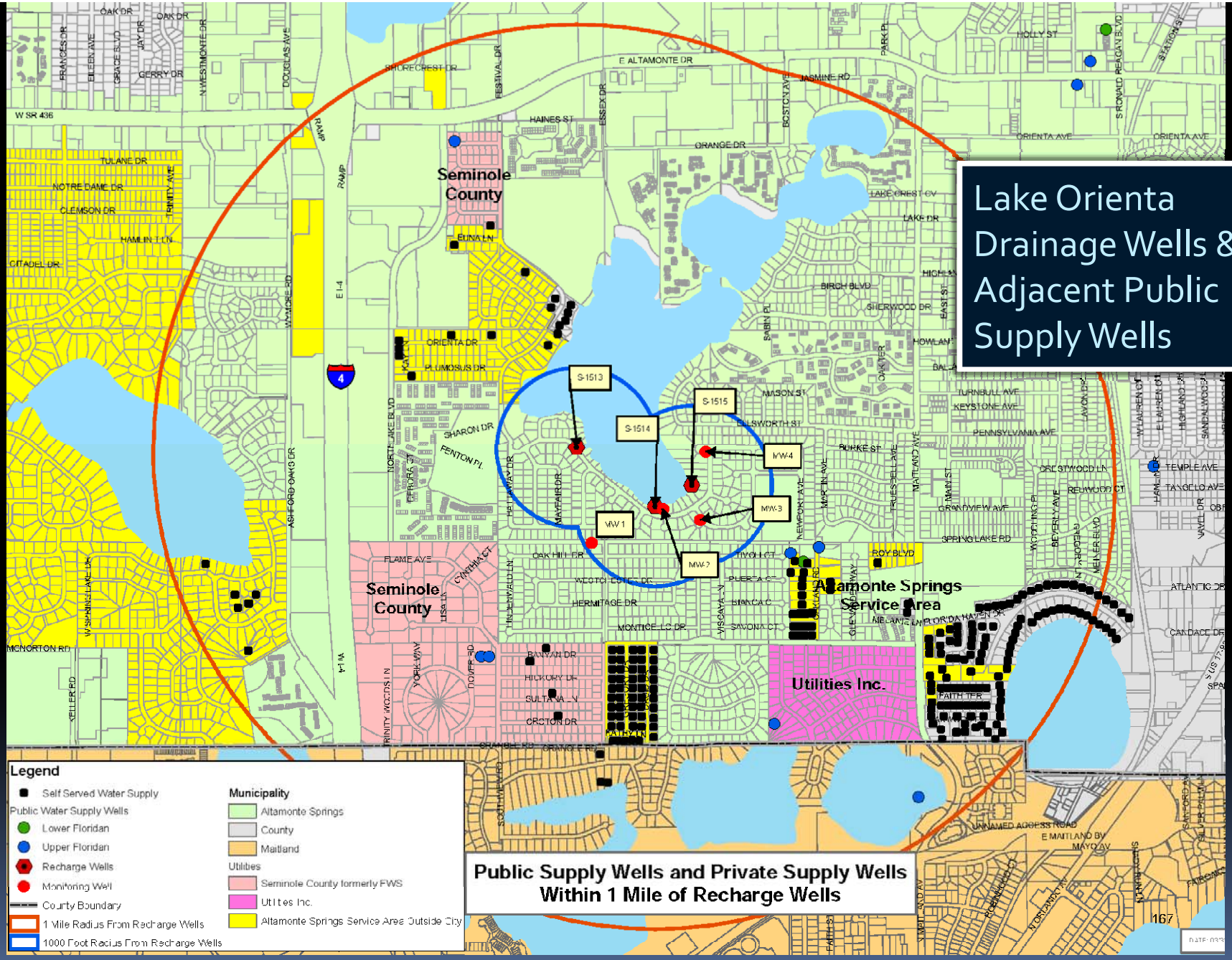
There is no documented evidence of significant aquifer contamination caused by recent drainage well operations in Orange or Seminole counties.

- ***1961:*** Lake Pleasant (near Apopka) - during high water of 1961, muddy water showed up in the nearby Northcrest public water supply well located about 1000 ft from the drainage well. delay time was hours. Muddy conditions, high in bacteria, and unpleasant taste and odor.

- ***1993:*** Lake Orienta (Altamonte Springs) - 1993 drinking water wells around the lake were reportedly contaminated. City abandoned 2 Upper Floridan potable wells at WTP 2 in 1995 due to high bacteria and replaced with Lower Floridan wells.

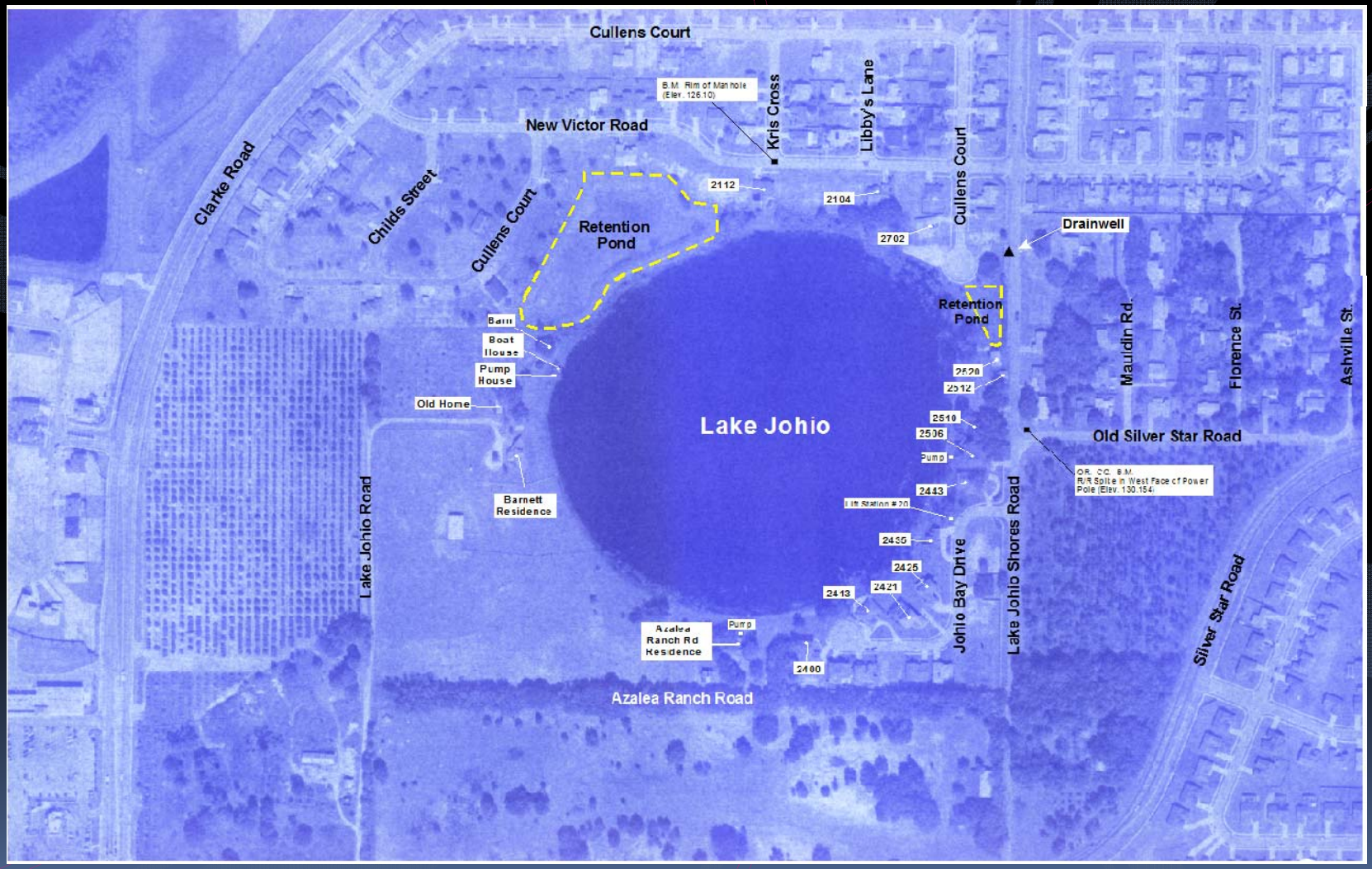
- ***1998:*** Lake Johio (Ocoee) - during high flow following El Nino storms in 1998, there was lake debris entering the well and impacting nearby residential wells. The subject drainwell was apparently blocked by Orange County sometime in the past (prior to 1980) due to complaints of "muddy water" from the nearby residents. The fitting that was used to block the flow into the drainwell apparently deteriorated and the well started flowing when the El-Nino rains hit early in 1998. complaints of air, lake vegetation debris, etc. the problem did not occur during low flow conditions or when a bleed-down was installed.

Lake Orienta Drainage Wells & Adjacent Public Supply Wells



Source: SJRWMD SP SJ2007-SP11

Lake Johio (lake contamination)



Lake Johio Critical Elevation Survey – Location Plan

Lake Johio (lake contamination)

Pump House on Barnett Property During High Water Stage A Few Days Before Hurricane Donna in 1960 - Source: Ms. Pat Barnett

Lake Johio (lake contamination)

Pump House on Barnett Property During High Water Stage (Not Peak) A Few Days Before Hurricane Donna in 1960 - Source: Ms. Pat Barnett

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Case Study # 1

Lake Sherwood

(Effective Lake Level Control)

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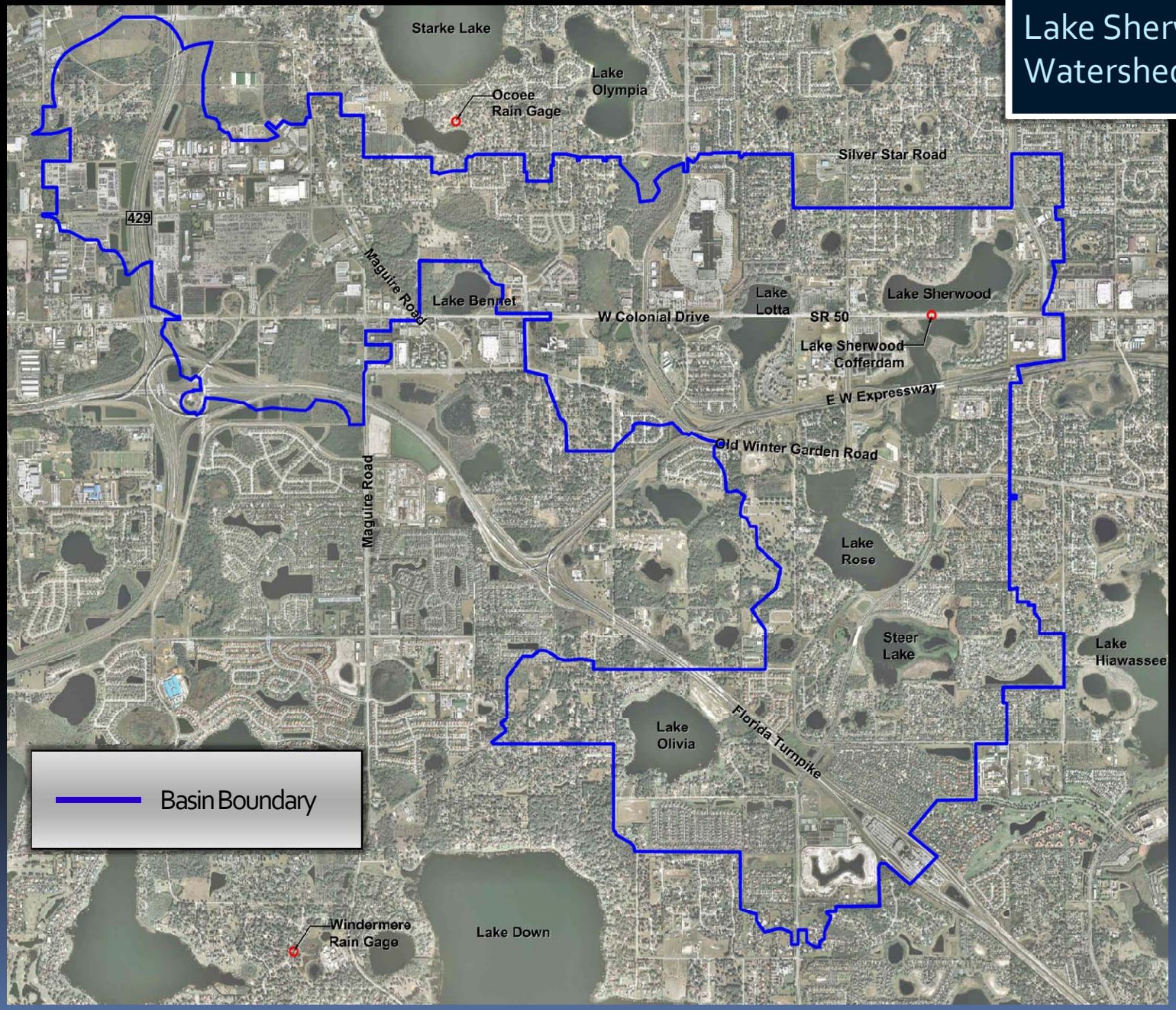
Lake Sherwood's Watershed Limits



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Lake Sherwood's Drainage Well Replacement Project – A Quiet Success Story (1 of 2):

Lake Sherwood is a land-locked lake in western Orange County (Fl).

It is the terminal point of a chain of interconnected lakes which include Lake Lotta, Lake Rose, and Steer Lake, with a combined watershed area of over 4,500 acres.

Development is progressing rapidly within the 4,500+ acre watershed and citrus groves are being transformed into residential and commercial land uses (i.e., additional impervious area).

Given the sheer size of this watershed (>4,500 acres) and its urban land cover, Lake Sherwood's drainage well is perhaps the most critical drainage well in Orange County.

The maximum recorded lake stage was approximately +88 ft NGVD in October 1960 following Hurricane Donna; the minimum was approximately +55 ft NGVD in December 1981 following a period of record drought. A recorded fluctuation range of over 33 ft.

Lake Sherwood's Drainage Well Replacement Project – A Quiet Success Story (2 of 2):

During the high water period of 1960, numerous homes on the north side of the lake were flooded for almost a year. As a result of the 1960 flooding, a 24-inch diameter drainage well was installed to discharge water from Lake Sherwood to the underlying Floridan aquifer. Water flows from the lake into the drainwell when the lake stage exceeds +76.9 ft NGVD. At the present time, there are no other outfalls from this "closed" lake other than the drainwell.

Following the 2004 Hurricanes, the lake level rose again and an emergency permit from the FDEP was sought and approved to replace this well since it was in a difficult location to maintain and there was evidence of holes in the well casing. The 24-inch diameter well was replaced with four (4) 12-inch diameter wells at a location approximately 2,500 feet southeast of the existing well.

These replacement wells came online in July 2005.

The replacement wells were tested during the storm of May 2009 (i.e., Gulf Gale).

Rainfall Data Representative of Lake Sherwood's Watershed for May 2009 storm		
Date	Ocoee (inch)	Windermere (inch)
Wednesday, May 13, 2009	1.83	0.29
Thursday, May 14, 2009	0.00	0.00
Friday, May 15, 2009	0.15	0.21
Saturday, May 16, 2009	0.00	0.00
Sunday, May 17, 2009	0.00	0.00
Monday, May 18, 2009	0.40	0.71
Tuesday, May 19, 2009	4.91	3.60
Wednesday, May 20, 2009	3.52	4.93
Thursday, May 21, 2009	2.61	2.50
Friday, May 22, 2009	0.11	0.18
Saturday, May 23, 2009	0.72	0.77
Sunday, May 24, 2009	0.68	0.55
Monday, May 25, 2009	2.52	1.55
Tuesday, May 26, 2009	0.01	0.28
Wednesday, May 27, 2009	0.76	1.22
Thursday, May 28, 2009	1.17	0.00
Friday, May 29, 2009	0.47	0.95
Saturday, May 30, 2009	0.06	0.00
Totals.	19.92	17.74

Rainfall Data Representative of Lake Sherwood's Watershed for May 2009 Storm

The lake level rose 6 ft over the 3 days May 19 to May 21 and caused a cofferdam failure which led to the shut down of a lane on State Road 50 due to undermining.

The wells kicked in and performed a remarkable job of controlling the lake level. see video and chart.

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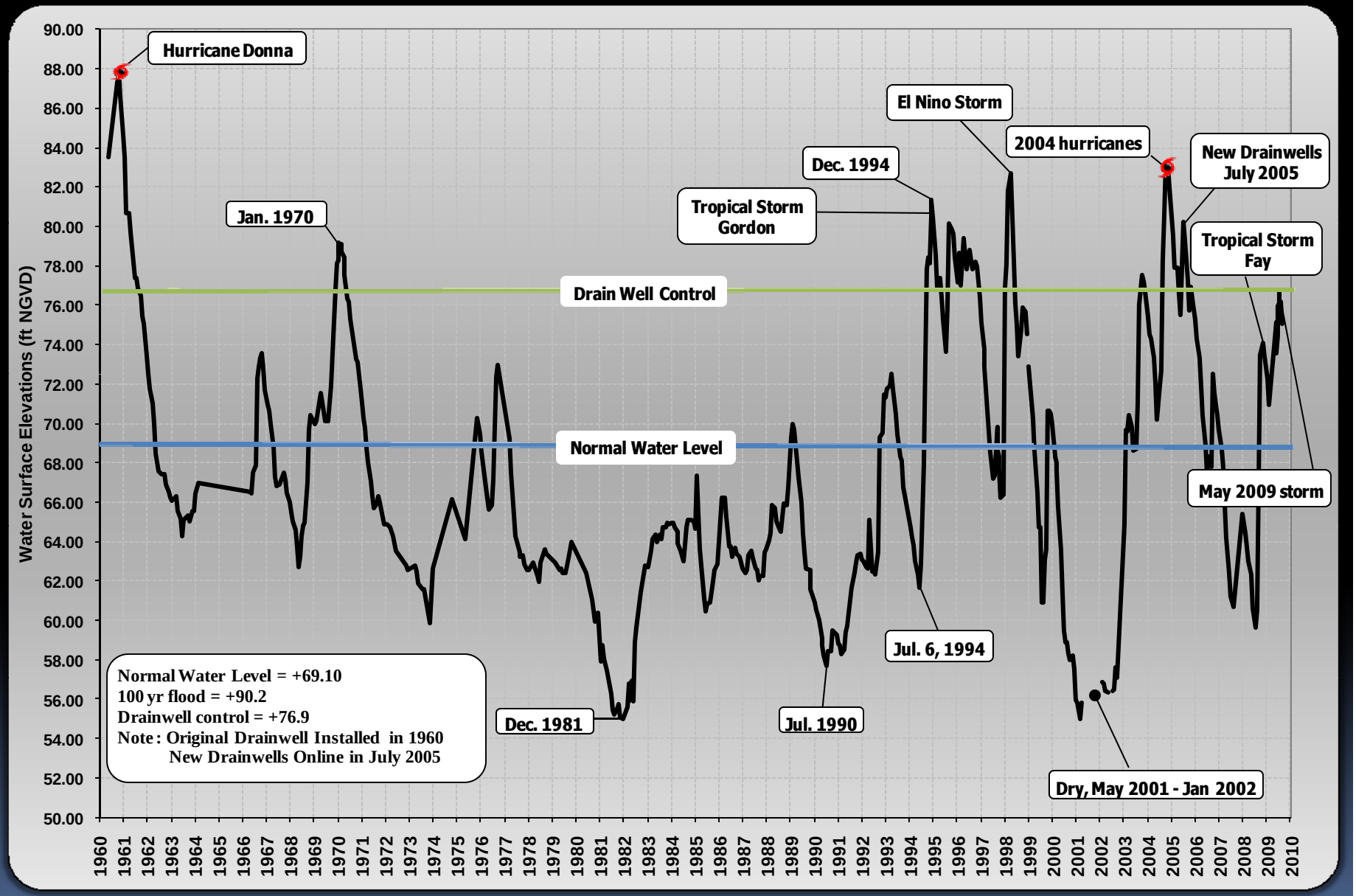

Normal Water Level = +69.10
100 yr flood = +90.2
Drainwell control = +76.9
Note: Original Drainwell Installed in 1960
New Drainwells Online in July 2005

Lake Sherwood - Lake Level Plot (1960 to Sept 2009)

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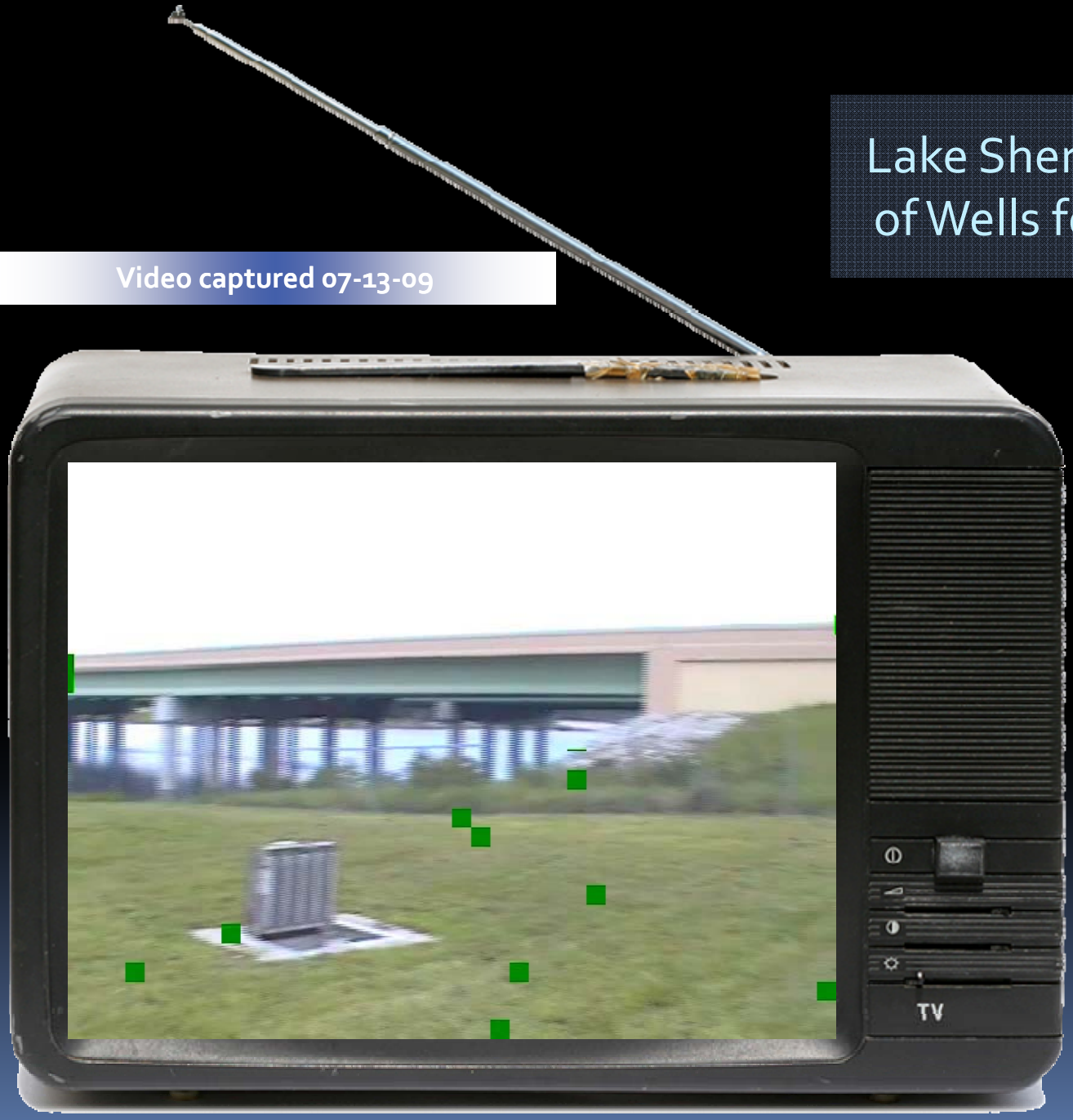
Lake Sherwood Video of Wells for July 2009

Video captured 07-13-09



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Case Study # 2

Lake Holden

(Geysering)

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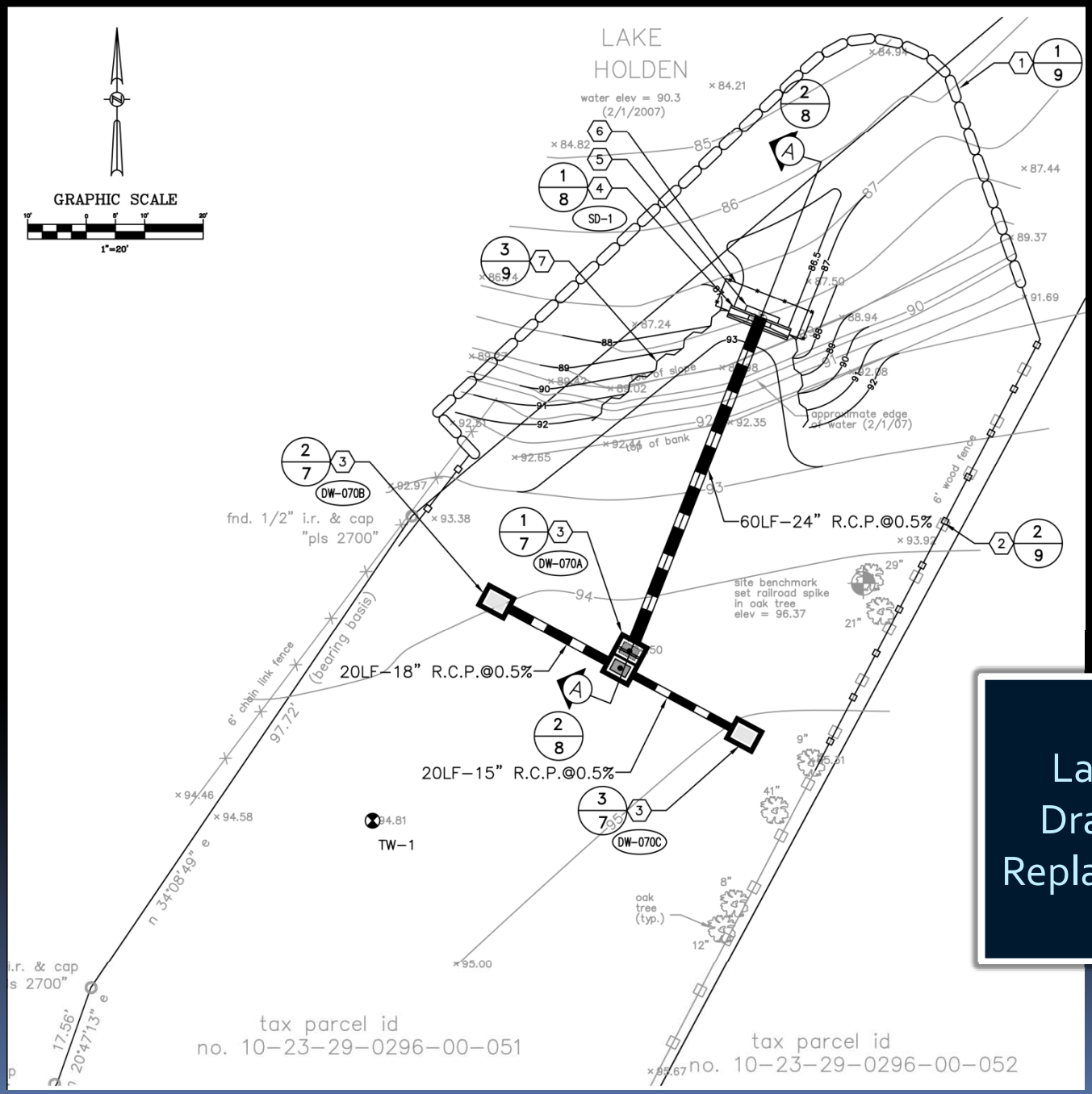

Lake Holden Drainage Well Replacement Plan

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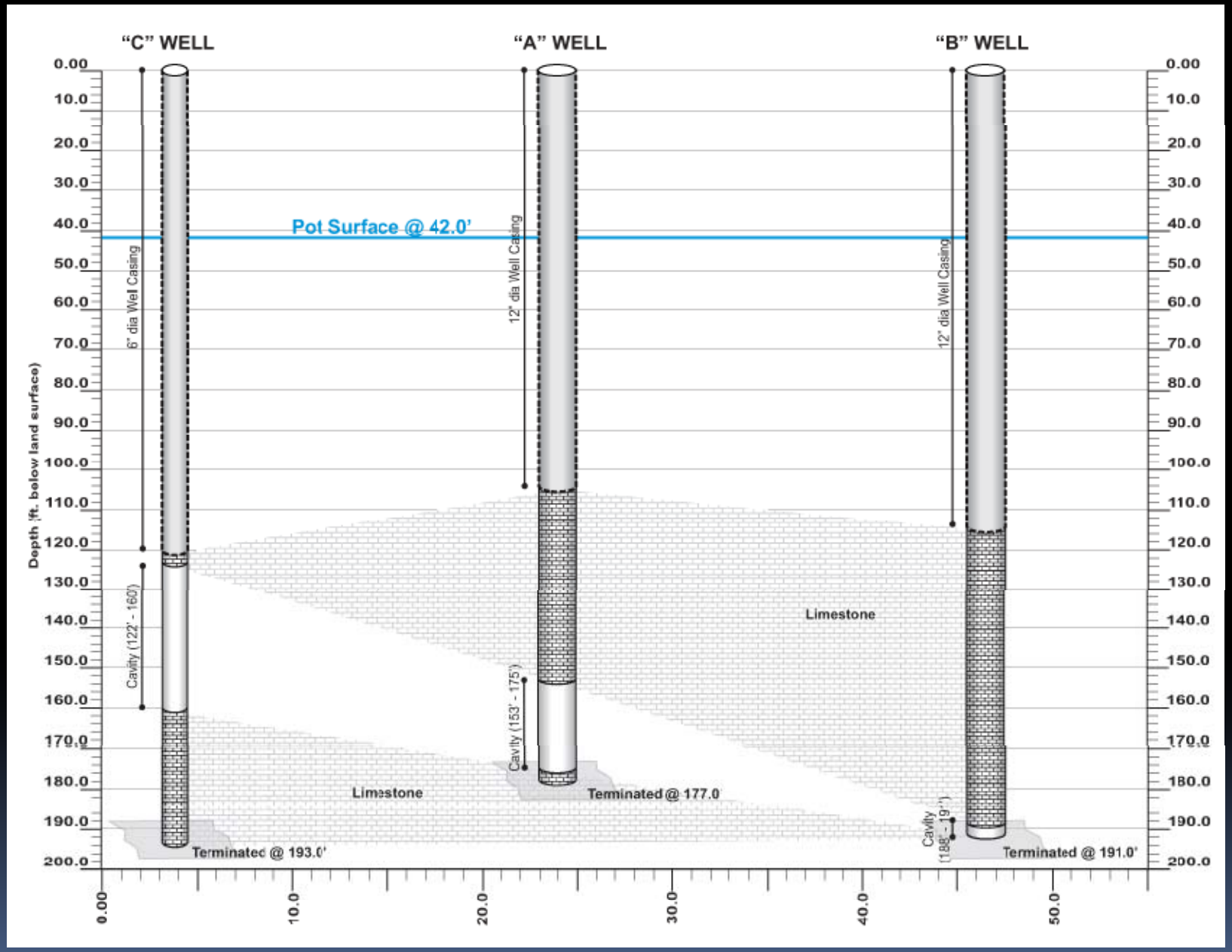

Lake Holden (geysering)

Lake Holden (geysering)

Video captured 12-15-09

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Lake Holden (geysering)

Video captured 12-21-09

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Case Study # 3

Goddard Ave

(Deep Muck)

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1: View of 2,000 pound pneumatic hammer used to drive 16-inch dia. surface casing

2: View of 16-inch dia. surface casing installation

3: View of 16-inch diameter drill bit used to drill borehole below surface casing in order to set 10-inch well casing

4: View of 10-inch dia. well casing being lowered through center of surface casing to a depth of 160 ft

5: View of packer and grout pipe being installed through well casing for pressure grouting annulus

6: View of setting grout pipe at bottom of casing and sealing wellhead for pressure grouting

7: View of cement pumping during pressure grouting

8: View of 10-inch dia. drill bit used to drill open borehole section

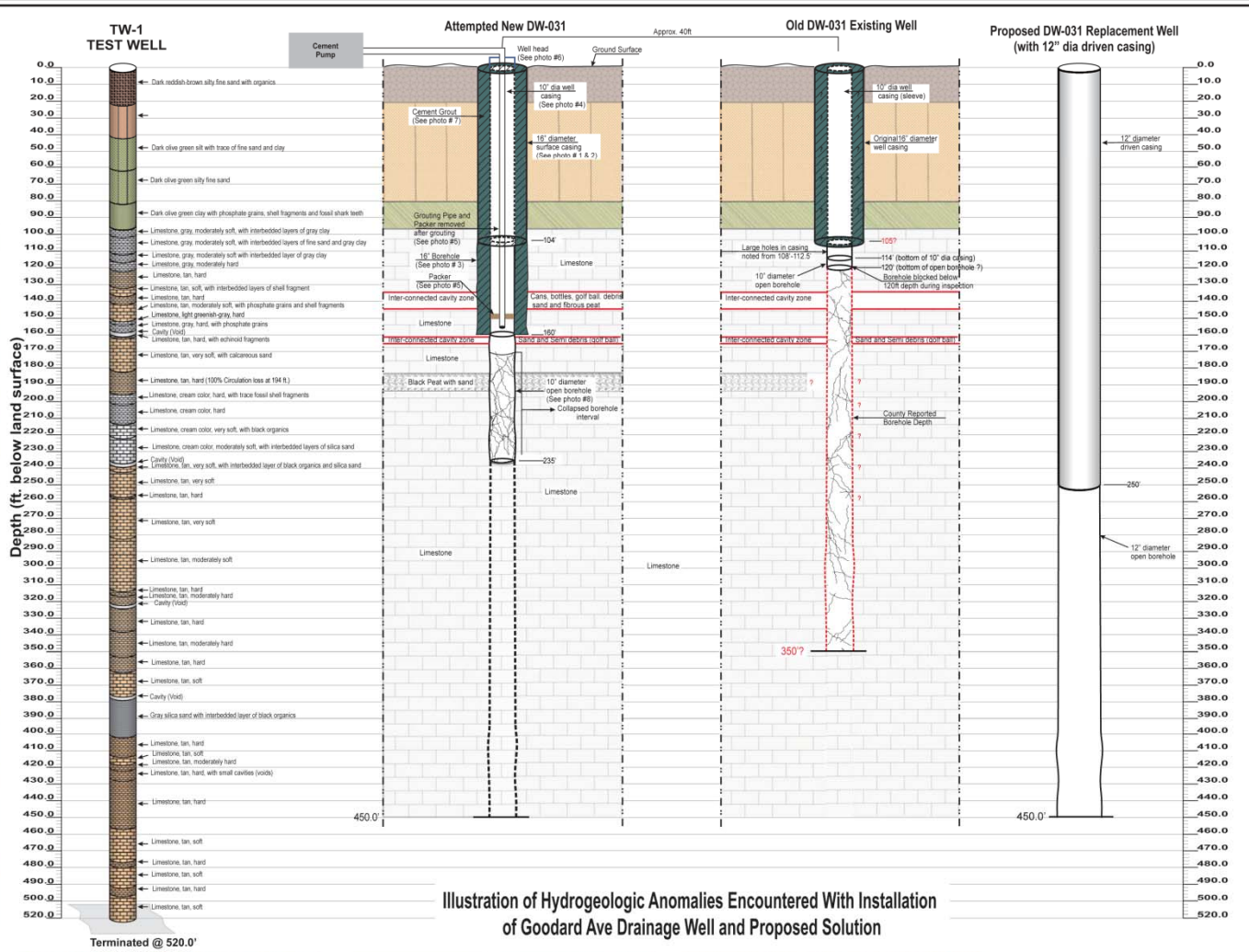

Illustration of Hydrogeologic Anomalies Encountered With Installation of Goddard Ave Drainage Well and Proposed Solution

Illustration of Hydrogeologic Anomalies Encountered With Installation of Goddard Ave Drainage Well and Proposed Solution

GODDARD AVENUE

Proposed Replacement Well Details (DW-031)

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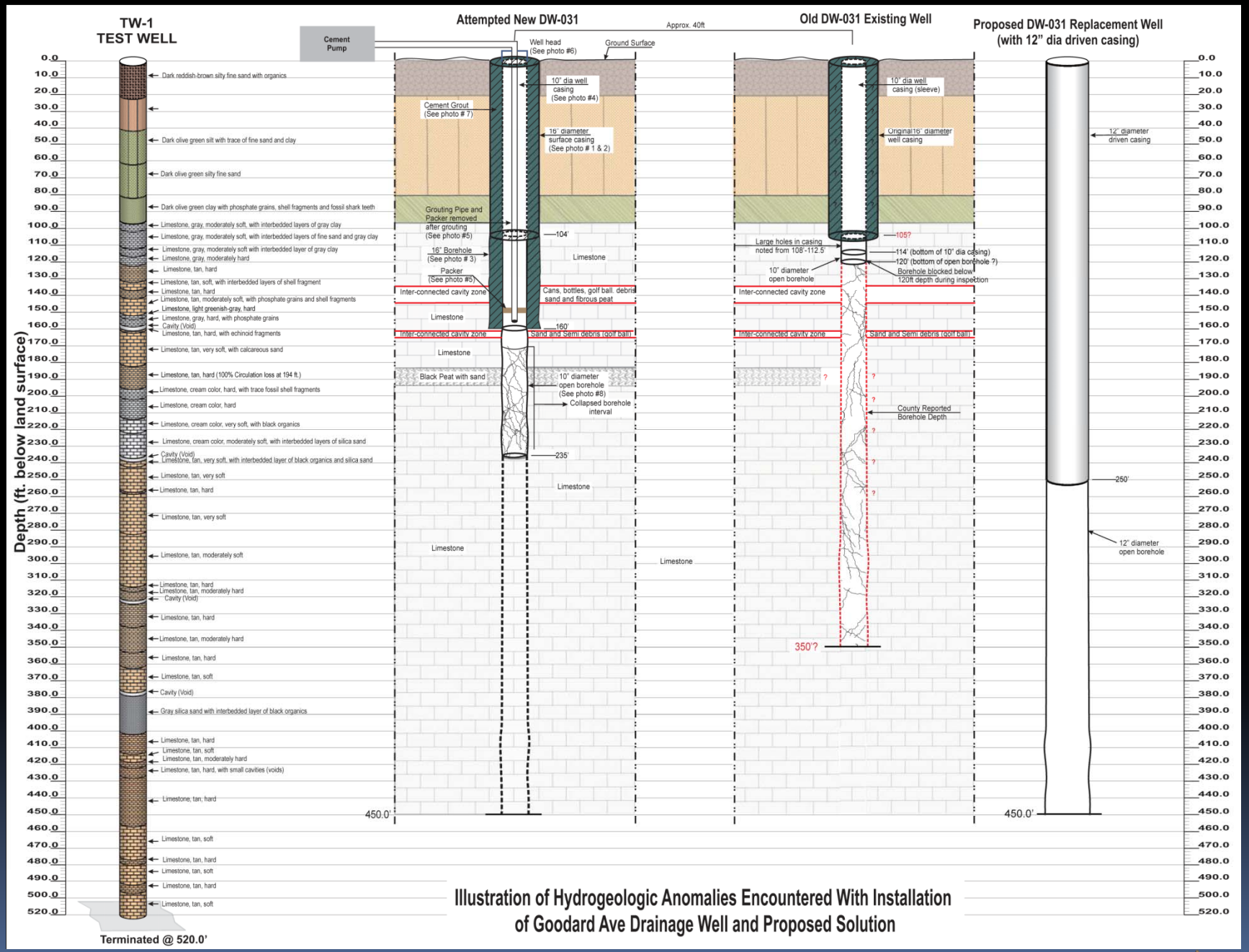

Illustration of Hydrogeologic Anomalies Encountered With Installation of Goodard Ave Drainage Well and Proposed Solution

Proposed Replacement Well Details (DW-031)

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Case Study # 4

Keystone Drive/ Lake Pineloch

(Geysering)

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Keystone Drive (geysering)

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Case Study # 5

Big Sand Lake

(Effective Lake Level Control)

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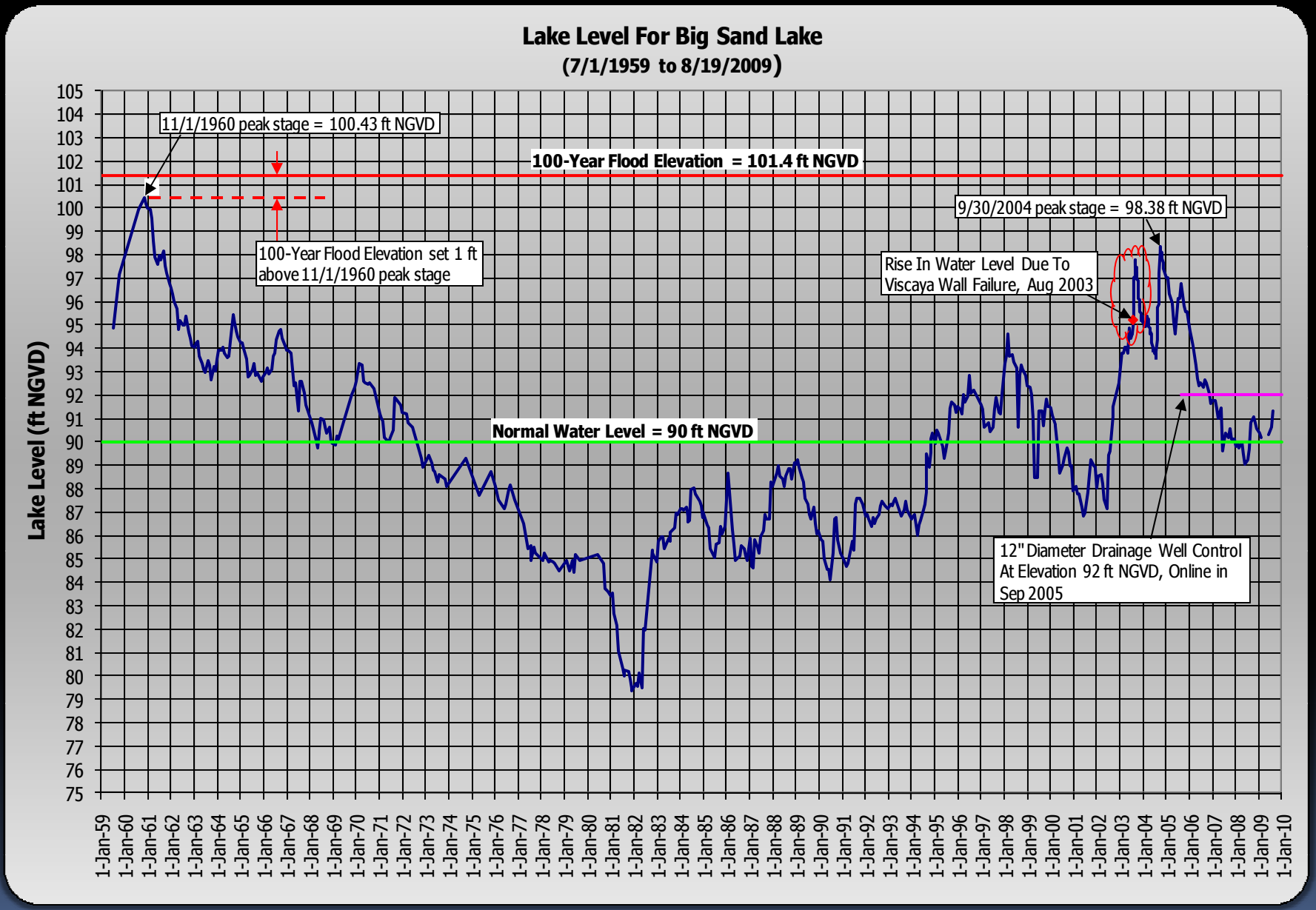

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Orange County's Perspective On Drainage Well Replacement

Presented by:

MaricelaTorres

Chief Engineer

Orange County Public Works Dept.

(Roads & Drainage Division)

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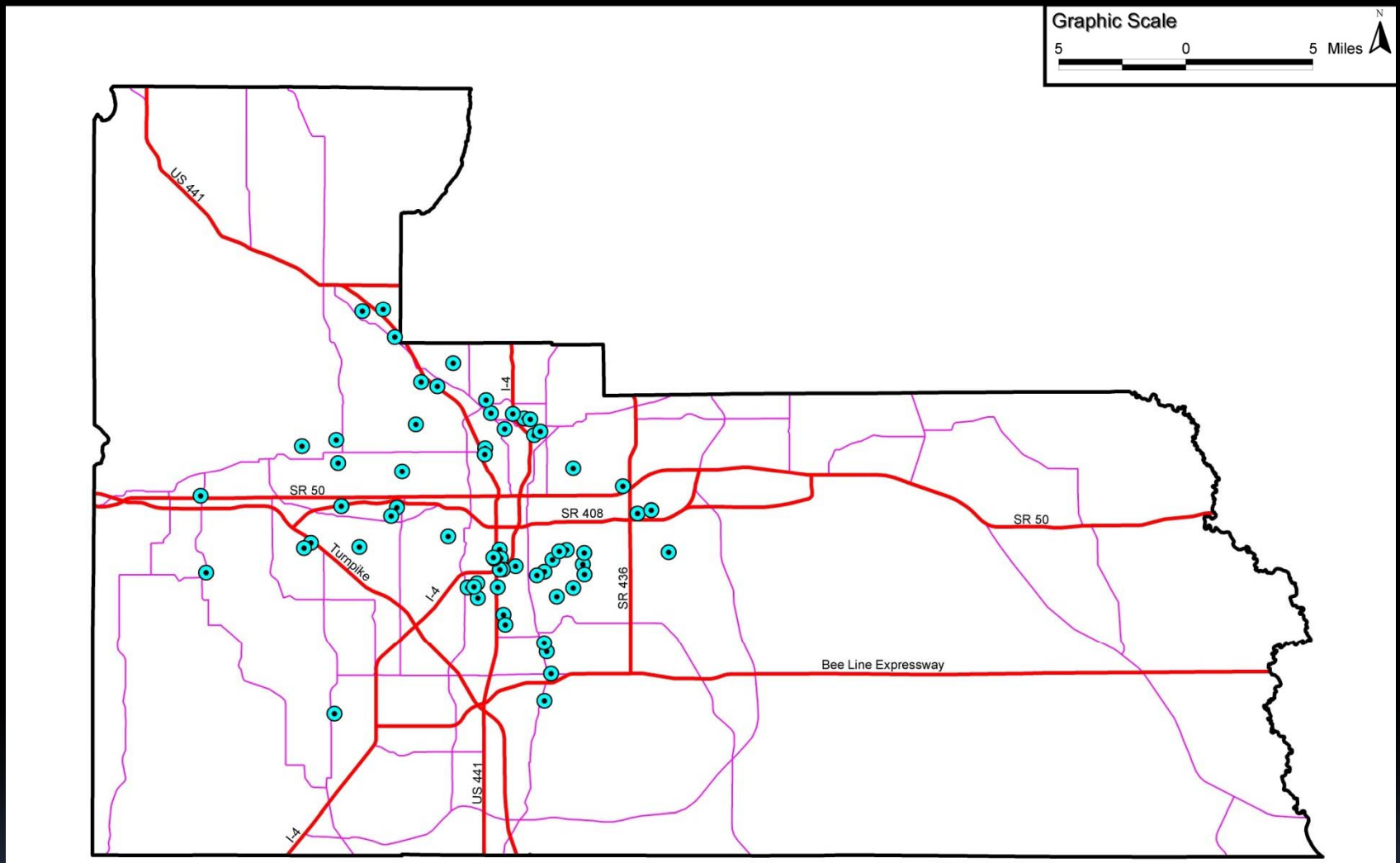
Drainage Wells Within Orange County Jurisdiction- Key Numbers:

- Total # of operational drainage wells within OC jurisdiction = 73
- Total # of abandoned drainage wells within OC jurisdiction = 8
- Total # of wells replaced by OC since 1998 = 24
- Total # of OC well replacement projects in progress = 15



Legend:

- Drainage Well Location

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Website: http://www.devoeng.com

Figure Name: Active Drainage Wells Maintined By Orange County

Project Name:

Checked & Approved By:	Drawn By:	Date:	Scale:	Project #:	
DS	RDC	02-15-2010	Noted		Figure 1

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Orange County's Guidance Principles for Replacement Well Projects:

- ensure the replacement well provides at least the same level of flood protection for citizens
- provide a replacement well which is built to the current water well construction standards to prevent inter-aquifer leakage and sinkhole development due to soil loss, and preserve aquifer recharge
- Require easements and access for maintenance by county's crew
- Design drainage structures with flashboards (for pre-storm bleed-down) and provide a water quality improvement where possible

Typical Design & Construction Phases for Replacement Wells:

- Clean, video logging, geophysical logging, and preliminary inspection of well conditions, prior to initiating any consultant studies for replacement.
- Phase 1A studies (mandatory) to obtain concept approval from FDEP before proceeding into the expense of detailed design
- Phase 1B studies (optional) which may emanate from the 1A task, if, for example, FDEP requests a groundwater quality/tracer study to investigate potential linkage between the drainage well and potable wells within Area of Review. A small area drainage study is also sometimes required if the well is shifted.
- Phase 2 follows Phase 1 concept approval by FDEP and involves preparation of detailed plans and specs for bidding the work through the county's procurement process. County does not want to expend funds on design until it is certain the FDEP will approve the replacement.
- Phase 3 involves construction oversight and load testing of the completed replacement well; Phase 3b may involve modifications to the plans during construction as geologic anomalies are sometimes encountered during well drilling.
- An occasional emergency well replacement due to flooding or well-induced sinkhole activity

Orange County Maintenance Program for Existing Wells:

- Well cleaning initiated based on maintenance personnel observations
- Routine cleaning of intake structures at well head and at lake, including channel entrances
- Routine checks on well head and bird cages
- React to resident's complaints of geysering or other well dysfunction including land subsidence
- Update the database with inspection details
- Adjust variable weirs prior to major storms

Budgeting Process for Drainage Well Replacement Projects:

- Less than $1M/Fiscal Year for design and construction of drainwell replacements
- Critical drainage wells are given a higher priority on the replacement list
- Funding on a case by case basis for emergency projects
- Operations budget for routine maintenance and cleaning

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FDEP Permitting Criteria & Regulations

Presented by:

Duane Watroba

Permitting Compliance and Enforcement

FDEP (Central District), UIC Program

DEVO Engineering

FDEP Permitting Criteria (1 of 2):

- Stormwater/lake level control drainage wells in Orange County are classified as Group 6-Class V injection wells per Chapter 62-528 of Florida Administrative Code (F.A.C.) titled Underground Injection Control (date of most recent version: October 9, 2008).

- Florida Department of Environmental Protection (FDEP) obtained delegation of the Underground Injection Control (UIC) program from EPA on March 9, 1983, following the adoption of Federal UIC regulations (tailored for Florida) via Chapter 17-28, F.A.C. which was effective on April 1, 1982.

- Chapter 17-28 F.A.C. recognized that many Class V (Group 6) wells existed prior to the adoption of state and federal UIC rules and therefore "grandfathered" all drainage wells which were operating prior to April 1, 1982.

- The pre April 1982 wells may continue to operate without a permit as long as they work as intended. However, if an existing well needs to be modified or restored to its original condition (or better), a permit will be needed per the requirements of 62-528.

FDEP Permitting Criteria (2 of 2):

- A detailed well inventory is required as part of the permit application for conceptual approval of a Class V (Group 6) replacement well. The inventory must cover an "area of review" which is defined as the project area plus a circumscribing area with a fixed width of not less than one mile.

- The inventory encompasses more than a count of wells; it includes an evaluation of the hydrogeology in this locality, ground water flow direction, ground water quality, future usage, etc. Many different professionals are involved in this process including an engineer to process all the well data in the area, GIS locations from water management district databases, field technicians for door to door review of wells within the review area, and hydrogeologists to review well lithology and groundwater quality characteristics and water use in the locality.

- If the well inventory is not comprehensive and/or lacks sufficient detail and explanation, the FDEP may require a groundwater monitoring program as part of the drainage well replacement project. They may even deny the permit if there is a major concern.

Discussion of Well Inventory for Class V (Group 6) Drainage Well Replacement (1 of 2):

- The following is a list of services which are typically performed by consultant as part of the well inventory process:

1. preparation of a high resolution color aerial in 24" by 36" format to delineate the area of review and to be used in the field investigation (the aerial date is usually 2007 or 2008);
2. door to door inventory of wells and potential pollution sources within the area of review;
3. download of GIS database from SFWMD and SJRWMD for the specified coverage
4. review and quality control of the downloaded well databases as there are frequently non-functional or abandoned potable wells which are relic in the database and need to be purged;
5. plot and tabulate GIS-inventoried wells and include in the field verification exercise;

Discussion of Well Inventory for Class V (Group 6) Drainage Well Replacement (2 of 2):

6. map ground water flow direction in Upper Floridan aquifer from published sources and identify wells which are upgradient and downgradient of the replacement well project;

7. where necessary, review city/county connections for potable water supply delivery;

8. where necessary, interview the owner of the potential impacted well to verify well details and water quality and future use of any well which may be impacted;

9. where necessary, review the thickness of the confining layer above the Upper Floridan aquifer if there is a concern about migration of contaminants from the surficial aquifer or added sources of contamination which recharge the well at the replacement location;

10. where necessary, review groundwater quality data in the Floridan aquifer;

Discussion of Well Inventory for Class V (Group 6) Drainage Well Replacement:

- where necessary, review lithologic well logs to check the flow zones and potable withdrawal zones in the Upper Floridan aquifer; and
- address potential wellfield impacts with FDEP prior to preparation of the justification report if any sensitive wells show up in the inventory;

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Design and permitting Special Problems

Presented by:

Dave Kincaid, P.G.

Hydrogeology Manager

Devo Engineering

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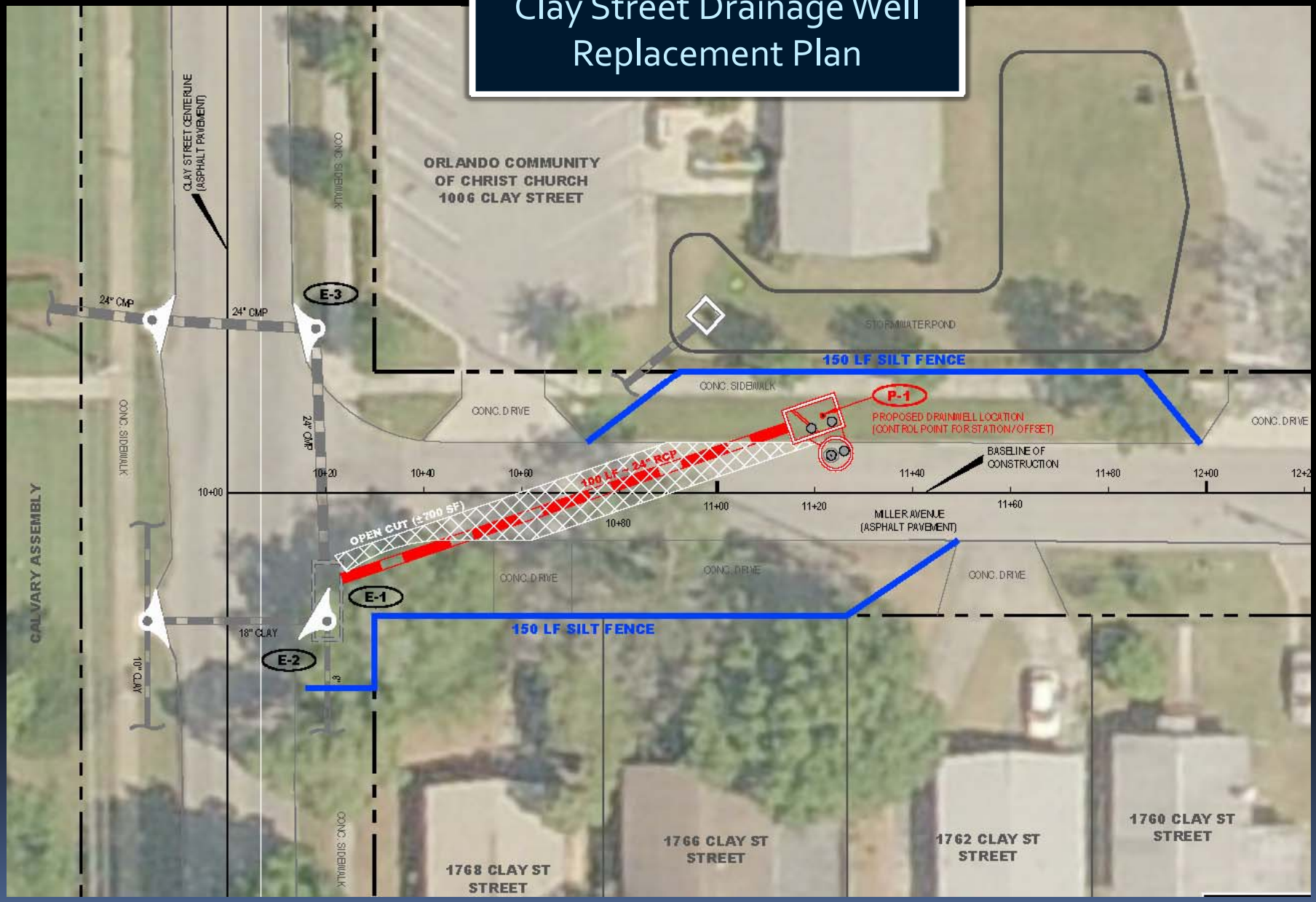
Some Problems During Well Construction:

- Sinkholes forming due to soil loss at the drainage well casing/soil interface. Note: no grout seal around the old well casings and some of the wells are short cased in the Hawthorn
- Many wells are within natural depressions in the landscape and some of these areas are characterized by deep deposits of muck (>200 ft) which results in aborting well construction and moving to a new location or deeper well casing
- A similar situation as above but with flowing sand and debris from deep cavities in the rock. Note that the old wells create enlarged flow channels in the aquifer and the proximate replacement well may intersect these enhanced flow channels.
- Borehole collapse (unstable rock) or large sand filled cavities which prevent advancement of the borehole
- Geysering of newly constructed wells due to extremely high transmissivity in the Floridan aquifer and high intake capacity from lake.

Clay Street Drainage Well Replacement Plan



Example of Street Level Control Well – Clay St. (1 of 4)

Clay Street - CDS stormwater treatment unit prior to installation.

Example of Street Level Control Well – Clay St. (2 of 4)

Clay Street - Additional view of CDS and drainage well structures.

Example of Street Level Control Well – Clay St. (3 of 4)

Clay Street - Oil baffle and separation screen within CDS structure.

Example of Street Level Control Well – Clay St. (4 of 4)

Clay Street - Access hatch and manhole cover for drainage well and weir structure.

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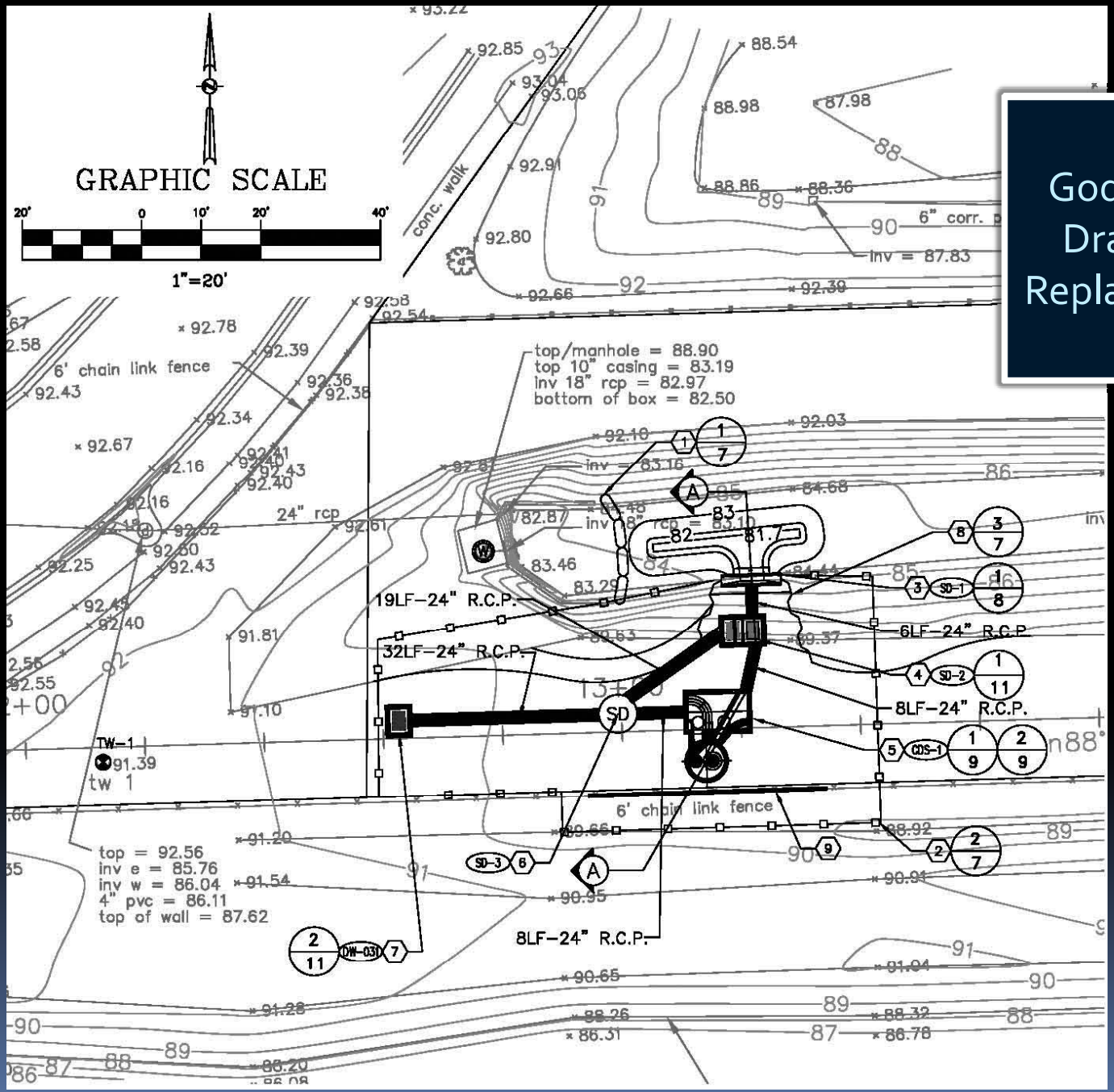
Goddard Street Drainage Well Replacement Plan



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Example of Canal Level Control Well – Goddard Ave. (1 of 5)

Goddard Avenue - Old headwall structure showing well intake (L) and roadway discharge (R)

Example of Canal Level Control Well – Goddard Ave. (2 of 5)

Goddard Avenue - Structure and pipe installations prior to backfilling.

Example of Canal Level Control Well – Goddard Ave. (3 of 5)

Goddard Avenue - Interior of DW-031 well structure.

Example of Canal Level Control Well – Goddard Ave. (4 of 5)

Goddard Avenue - Unstable ditch sideslope - note soil cracking.

Example of Canal Level Control Well – Goddard Ave. (5 of 5)

Goddard Avenue - Cable concrete ditch enhancement installed by Orange County personnel.

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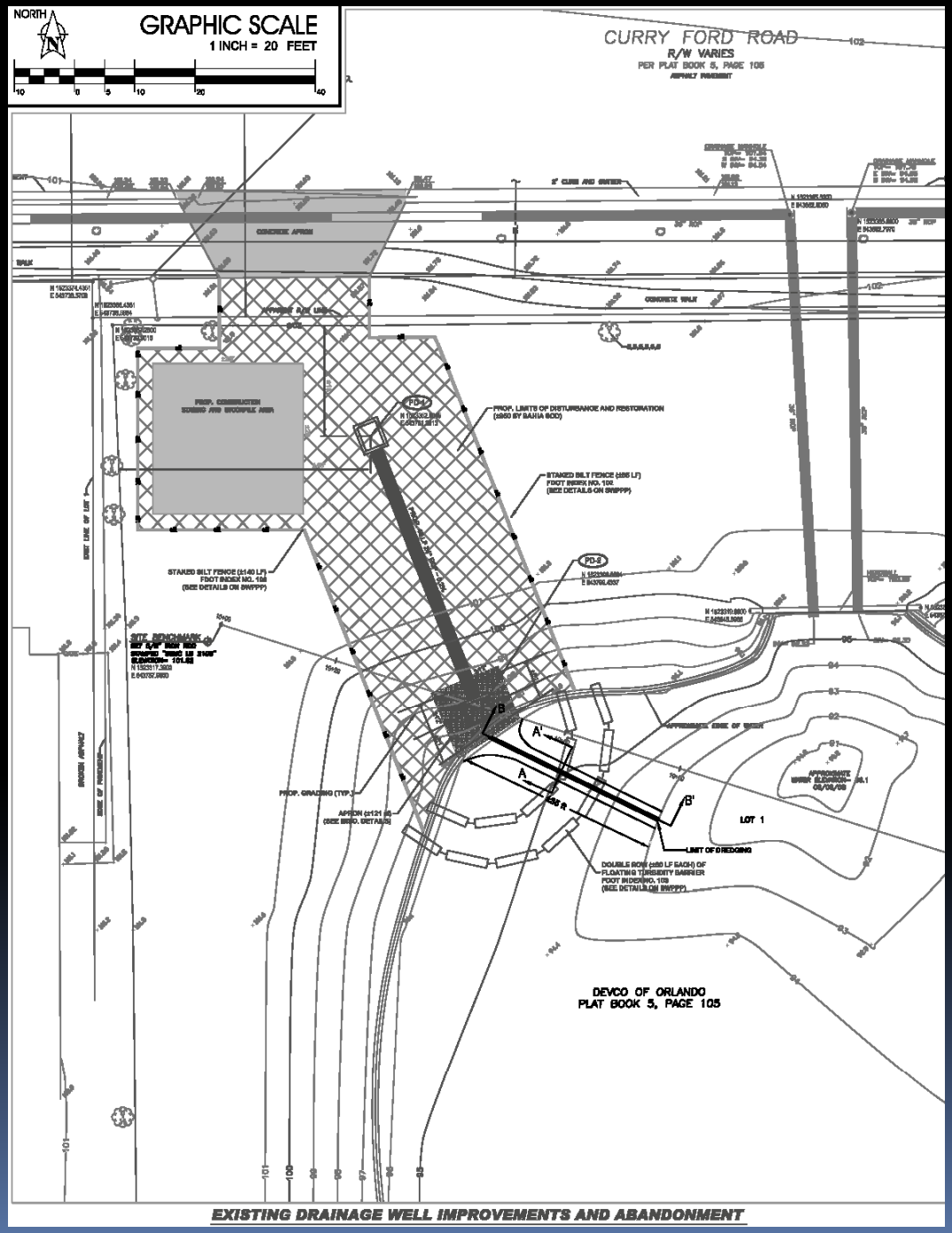

EXISTING DRAINAGE WELL IMPROVEMENTS AND ABANDONMENT

Bumby Avenue Drainage Well Replacement Plan

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Example of Pond Level Control Well – Bumby Ave. (1 of 3)

Bumby Avenue - Turbidity barriers being set up prior to construction activities.

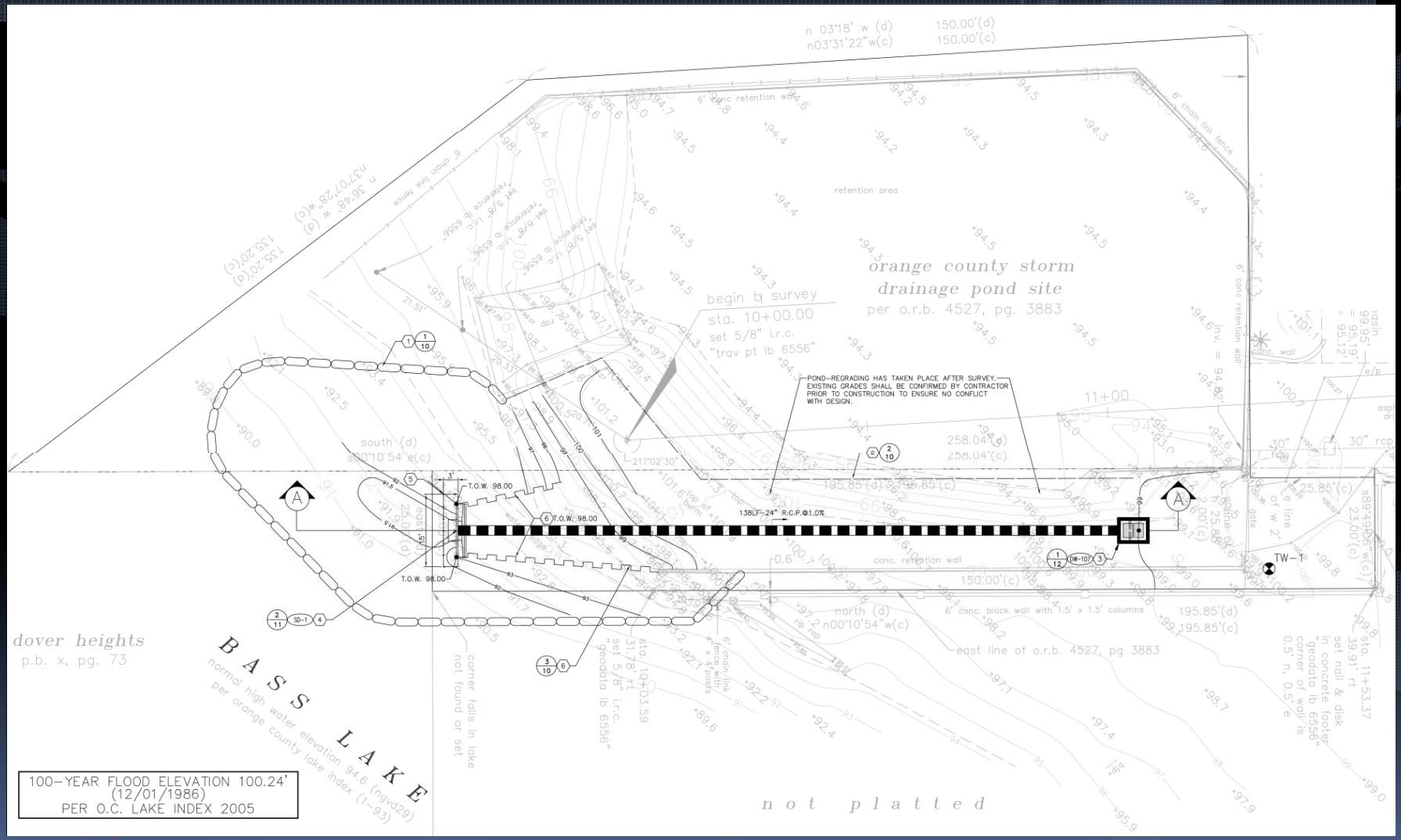
Example of Pond Level Control Well – Bumby Ave. (2 of 3)

Bumby Avenue - Backfilling and compacting area around new well enclosure.

Example of Pond Level Control Well – Bumby Ave. (3 of 3)

Bumby Avenue - Fiberglass skimmer being set into position on inflow structure.

Bass Lake Drainage Well Replacement Plan



Example of Lake Level Control Well – Bass Lake (1 of 4)

Bass Lake - View of 18-inch diameter surface casing being driven to depth using a pneumatic hammer.

Example of Lake Level Control Well – Bass Lake (1 of 4)

Bass Lake - Closeup view of 12-inch diameter drill bit.

Example of Lake Level Control Well – Bass Lake (1 of 4)

Bass Lake - View of headwall during installation activities.

Example of Lake Level Control Well – Bass Lake (1 of 4)

Bass Lake - View of enclosure being installed.

Example of Lake Level Control Well – Bass Lake (1 of 4)

Bass Lake - View of trackhoe-mounted hammer during sheet pile wall installation.

Example of Lake Level Control Well – Bass Lake (1 of 4)

Bass Lake - Complete sheetpile wall with end wall and skimmer

Example of Lake Level Control Well – Bass Lake (2 of 4)

Bass Lake - View showing enclosure with aluminum hatch at new well.

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Selected list of references For drainage well In central florida

Provided by:

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