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Average Altitude of the Water Table (1990-99) and Frequency Analysis of Water Levels (1974-99) in the Biscayne Aquifer, Miami-Dade County, Florida

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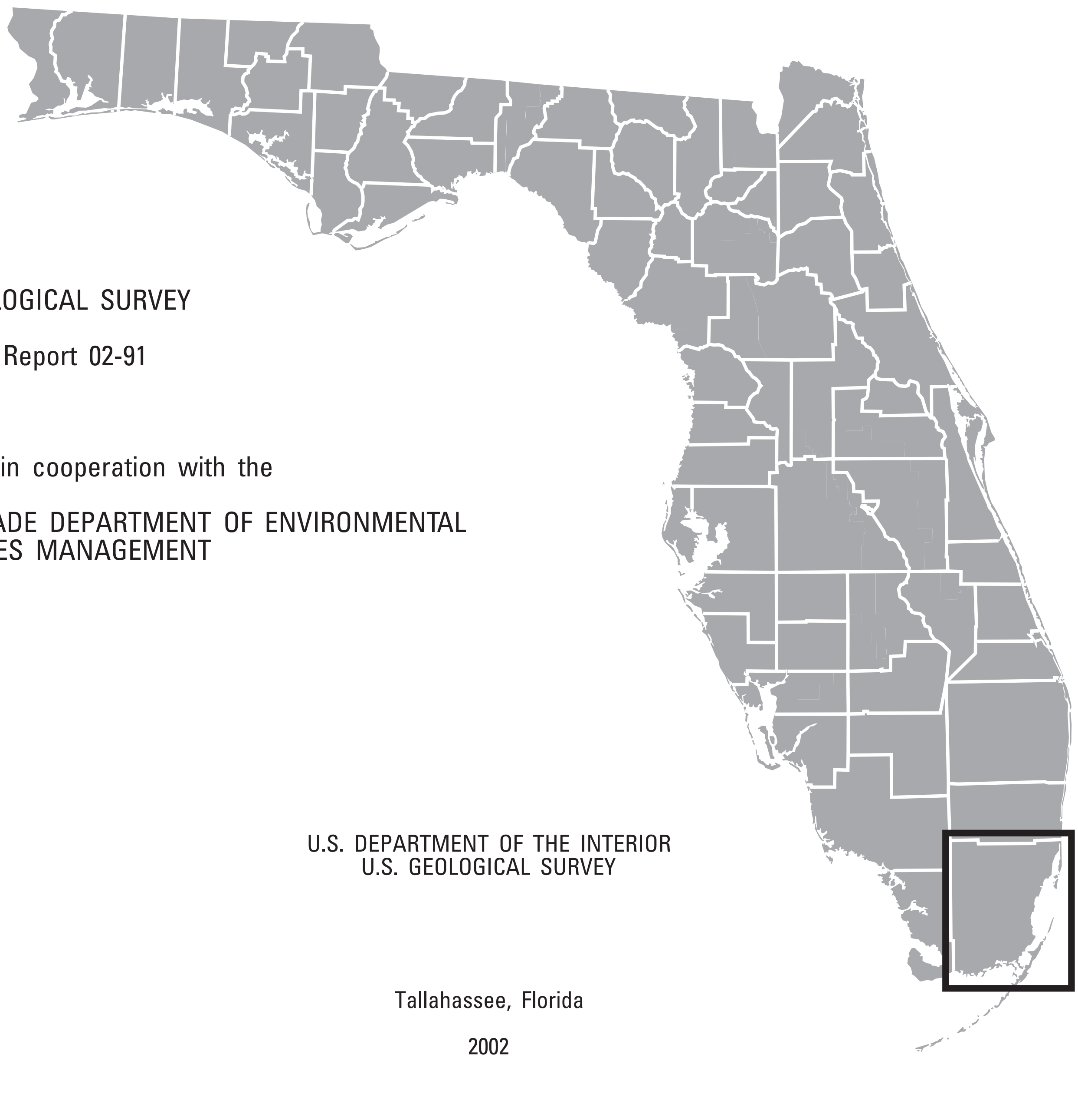

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INTRODUCTION

Miami-Dade County occupies about 2,000 square miles along the southeastern part of peninsular Florida. Five prominent physiographic features are located within the confines of Miami-Dade County and include the Atlantic Coastal Ridge, Big Cypress Swamp, the Sandy Flatlands, coastal marshes and mangrove swamps, and the Everglades (fig. 1). The highest altitudes occur along the Atlantic Coastal Ridge (2 to 10 miles wide), ranging from 8 to 15 feet above sea level but may be as high as 20 feet. The Atlantic Coastal Ridge forms a natural barrier to drainage from the interior. The Sandy Flatlands in northeastern Miami-Dade County ranges from 6 to 18 feet above sea level; this area was poorly drained prior to development. The Everglades forms a natural trough across the county, with altitudes ranging from 9 feet above sea level in the northwestern part to about 3 feet above sea level in the southwestern part. A small section of the Big Cypress Swamp occupies northwestern Miami-Dade County, with altitudes ranging from 7 to 10 feet above sea level. Along the coast, marshes and mangrove swamps have altitudes ranging from 0 to 3 feet above sea level (Fish and Stewart, 1991).

The U.S. Geological Survey (USGS), in cooperation with the Miami-Dade County Department of Environmental Resources Management (DERM), conducted a study to determine the average altitude of the water table in the Biscayne aquifer in Miami-Dade County and to perform a water-level frequency analysis for selected time periods. Water-table maps in this report are based on average yearly May, October, high, and low water levels during the 1990-94, 1995-99, and 1990-99 water years. Data collected in May and October are used to show the yearly water-level conditions at the end of the dry and wet seasons, respectively. Water-level frequency analysis maps (5-, 10-, and 25-year recurrence water levels) in this report are based on analysis of water-level data from continuous water-level recorders for the 1974-99 water year period.

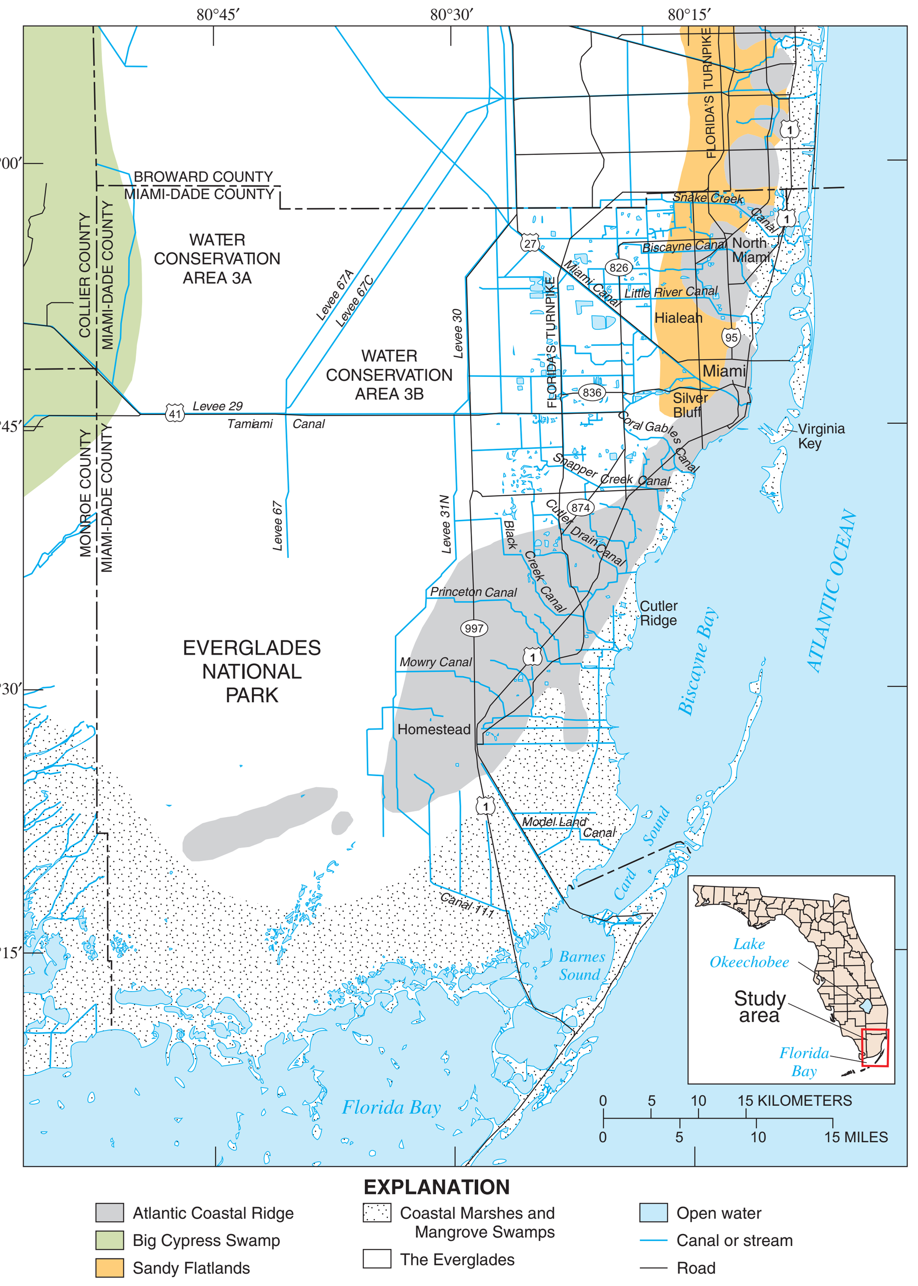

Figure 1. Physiographic features of Miami-Dade County (modified from Klein and others, 1975).

Water-level data for the maps were collected by Everglades National Park (ENP), the USGS, and the South Florida Water Management District (SFWMD). Data for ENP sites were provided as averages by ENP. Determination of averages for the USGS data was performed using options available in the USGS Automated Data Processing System (ADAPS), and averages for the SFWMD data were determined from options available in the SFWMD Hydrometeorologic and Water-Quality Database (DBHYDRO). The ENP, USGS, and SFWMD data are reported as mean daily water levels and are referenced to sea level. In this report, sea level refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)-a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929. In this report, horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

HYDROLOGIC ASSESSMENT OF THE BISCAYNE AQUIFER

The surficial aquifer system is the source of potable water supplies for Miami-Dade County and most of southeastern Florida. Sediments of the aquifer system have a wide range of permeability and locally may be divided into one or more aquifers separated by less-permeable or semiconfining units (Fish and Stewart, 1991, p. 10). The geologic materials comprising the surficial aquifer system are mainly limestone, sandstone, sand, shell, and clayey sand with minor clay or silt that range from Pliocene to Holocene (Causaras, 1987).

The uppermost layer of the surficial aquifer system is the highly permeable, unconfined Biscayne aquifer – the sole municipal water source for Miami-Dade County. The Biscayne aquifer may be more than 100 feet thick near the coast, but thins to just a few feet in the Everglades to the west. The aquifer is composed of the Pamlico Sand, Miami Limestone, Anastasia Formation, Key Largo Limestone, and Fort Thompson Formation of Pleistocene age. Contiguous, highly permeable beds of the Tamiami Formation of Pliocene and late Miocene age are present where at least 10 feet of the section is very highly permeable, with a horizontal hydraulic conductivity of about 1,000 feet per day or more (Fish and Stewart, 1991, p. 12). The Biscayne aquifer is highly transmissive, and solution-riddled limestone and sandstone may have hydraulic conductivities of more than 10,000 feet per day. Municipal supply wells in the aquifer are capable of high yields with very little drawdown (Klein and others, 1975).

Because of the close hydraulic connection that exists between ground water and surface water as a result of the highly transmissive nature of the Biscayne aquifer, the manmade control structures have a profound effect on the hydrology in Miami-Dade County. Consequently, canals may be classified as either "gaining" or "losing" depending on the canal stages in relation to the surrounding water table. During the wet season, gated control structures are opened to discharge excess water, and canal stages are lowered relative to the surrounding water table, and ground water seeps into the "gaining" canals. During the dry season, the canals continue to receive ground water and transport it seaward to the coastal control structures. However, owing to closed gates that retard advancement of saltwater intrusion, a steep hydraulic gradient exists at the control structures, and surface water recharges to the surrounding aquifer and the canals become "losing" (fig. 2). This phenomenon substantially affects the average altitude and configuration of the water table. Physical factors affecting the water table include: (1) recharge from rainfall and irrigation, (2) surface-water impoundment, (3) pumping from municipal well fields, (4) evapotranspiration, and (5) aquifer material permeability (the hydraulic gradient steepens as permeability decreases).

Average Altitude of the Water Table

Ground water flows in the direction of the steepest hydraulic gradient. For purposes of contour map development, it was assumed that the Biscayne aquifer exists under homogeneous and isotropic conditions and that the ground-water flow lines are perpendicular to the contour lines. However, because the contours are based on average water levels, they represent the average flow direction for a specific time period. Inventories of ground-water wells (fig. 3) and surface-water stations (fig. 4) used in the development of the water-table contour maps are presented in tables 1 and 2, respectively. However, not all wells were used for every map because of missing record or because some wells were not in service during the specific time periods (1990-99, 1990-94, and 1995-99). The ground-water data are from continuous recorder wells (10 to 100 feet deep) completed in the Biscayne aquifer.

Development of Water-Table Maps

Knowledge of the method used in the development of the water-table maps is necessary for an understanding of the information depicted by the maps themselves. The average or mean of a data set is a "nonresistant" measure of location in the data set, and as such, is subject to the effects of outliers, which commonly occur during extreme hydrologic events (Helsel and Hirsch, 1992). This is true for rainfall and its effects on water levels in southern Florida. Precipitation during the wet season generally results from high-intensity localized storms. Thus, average water levels may be much higher or lower in one area of Miami-Dade County based on localized rainfall than in another area. Additionally, seasonal changes in municipal pumping may affect average water levels at wells located within cones of depression. Seasonal changes in operation of the gated control structures on both the inland and coastal canals also may affect average ground-water and surface-water levels due to the close hydraulic connection between surface water and ground water in Miami-Dade County.

Evaluation of water-table contours tends to be difficult and may lend itself to various interpretations due to the highly subjective nature of contour development and lack of sufficient data points in local basins to adequately assess the water table. Thus, the contour maps portray the average altitude of the water table that has occurred over a wide range of hydrologic, meteorologic, and seasonal conditions and changes in water-management practices as opposed to the water table that would exist based on synoptic water-level measurements made over a short time period. An examination of the data was made to ensure that a nearly complete record existed for each of the wells to avoid skewing of the data due to excessive loss of record. Furthermore, installation of new wells in northeastern and central Miami-Dade County in 1994 resulted in additional data points for use in defining the water table during 1995-99.

Results

A general examination of the average water-table maps (pls. 1-4) in Miami-Dade County reveals patterns in the hydraulic gradient and consequent ground-water flow. The water-conservation areas, the extensive levee system, operation of the gated control system on the canals, and the existence of municipal pumping centers are major factors affecting the hydraulic gradient in Miami-Dade County. The highest ground-water levels are maintained in Water Conservation Area 3A, located west of Levee 67A and north of Tamiami Canal. South of Tamiami Canal in ENP, ground water flows to the south and southwest. East of ENP, ground water flows generally to the south and southeast as illustrated by the contour lines and the orientation of the canal system, which discharges water to the coast in that area. North of Tamiami Canal, west of Miami Canal, and east of Levee 30, the hydraulic gradient is predominately to the east and northeast. North of Miami Canal, the gradient is predominately to the east and southeast, with the water table generally assuming a flatter configuration than that to the south. The Hialeah-Miami Springs and Northwest Well Fields are major influences on the average altitude of the water table in these areas. Ground-water levels gradually decline until sea level is reached along the southern and eastern coasts of Miami-Dade County. Ground-water mounds occur during periods of high water levels as shown in the average yearly October and high water-table maps (pls. 2 and 3, respectively). The presence of ground-water mounds in northeastern Miami-Dade County is largely the result of less permeable surficial sands of the Biscayne aquifer in that region.

Steep hydraulic gradients are common at coastal canal control structures as well as at secondary canal control structures farther inland. As a result of the steep gradients (using a contour interval of 1 foot), convergence of the contour lines is evident at the coastal control structures especially when the gates are closed or partially open.

Six major municipal well fields substantially affect the average altitude of the water table in the Biscayne aquifer in Miami-Dade County (pls. 1-4). The Northwest and Hialeah-Miami Springs Well Fields are located north of Tamiami Canal as illustrated by the cones of depression in this region. The West, Southwest, Alexander Orr, and Snapper Creek Well Fields are all located south of Tamiami Canal. The West Well Field is relatively new and is located near Levee 31N canal. Pumping began in the West Well Field in 1996. Numerous smaller well fields are dispersed throughout Miami-Dade County.

Water-Level Trend and Frequency Analysis

The USGS software program, PEAKFQ (Thomas and others, 1998), was used for the frequency analysis of water levels. This analysis was performed on yearly maximum water levels for 58 USGS ground-water wells having at least 10 years of data, mostly from 1974 to 1999 (table 1). Prior to these determinations, the yearly maximum water levels were trend adjusted to more closely match current water levels. Trends were performed by use of a modification of Kendall's tau, called the Mann-Kendall test, in which the monotonic increase or decrease of a specific variable is determined (Helsel and Hirsch, 1992). Only about one-third of the wells showed any statistically significant trend in yearly maximum water levels.

Frequency analysis was performed on the trend-adjusted water levels. Estimates were determined for yearly maximum water levels having recurrence intervals of 5, 10, and 25 years (20, 10, and 4 percent yearly exceedance probabilities). Maps were created, showing ground-water wells and water levels corresponding to each recurrence interval (pl. 5). Using the PEAKFQ program, a Pearson Type III distribution was fitted to the logarithms of the yearly maximum water levels. The parameters of the Pearson Type III frequency curve were estimated by the logarithmic sample moments (mean, standard deviation, and coefficient of skewness), and the frequency curve was computed according to the following equation:

$$\log \hat{Q}_{s,p} = \overline{X} + Sk_{G,p} ,$$

where:

$\hat{Q}_{s,p}$ is the systematic frequency curve at exceedance probability p,

$\overline{X}$ is the mean logarithm,

S is the standard deviation, and

$k_{G,p}$ is the Pearson Type III standardized ordinate for station skew G, and exceedance probability p.

This distribution defines the probability that any given yearly maximum water level will exceed a specified altitude.

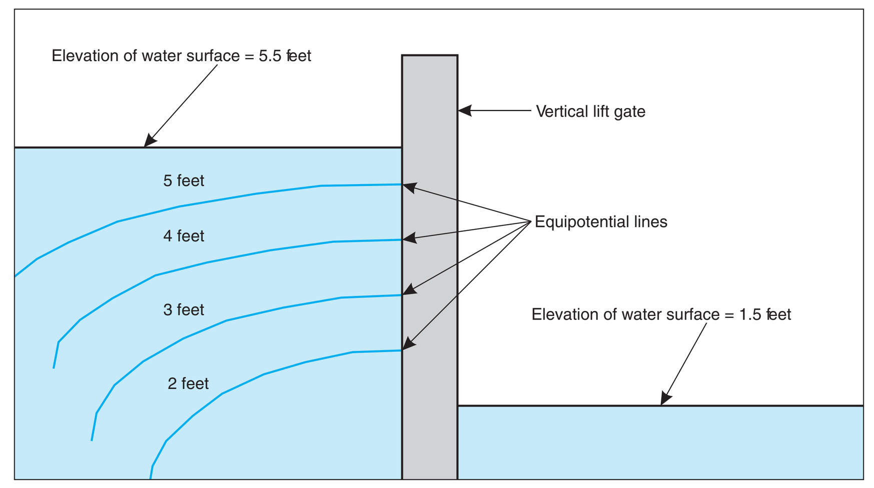

Figure 2. Vertical cross section of gated control structure and hydraulic gradient during closed gate condition.

Table 1. Inventory of ground-water wells used in development of the Miami-Dade County water-table maps

[Source of data: ENP, Everglades National Park; SFWMD, South Florida Water Management District; USGS, U.S. Geological Survey]

Well no.	Latitude	Longitude	Source of data	Period of record	Well no.	Latitude	Longitude	Source of data	Period of record
F-45	2549	8012	USGS	1990-99	G-3329	2547	8018	USGS	1990-99
F-179	2544	8014	USGS	1990-99	G-3353	2517	8034	USGS	1990-99
F-239	2550	8016	USGS	1990-99	G-3354	2518	8028	USGS	1990-99
F-319	2542	8017	USGS	1990-99	G-3355	2523	8030	USGS	1990-99
F-358	2528	8028	USGS	1990-99	G-3356	2525	8025	USGS	1990-99
G-3	2549	8018	USGS	1990-99	G-3437	2534	8034	USGS	1990-99
G-551	2541	8023	USGS	1990-99	G-3439	2544	8026	USGS	1990-99
G-553	2539	8020	USGS	1990-99	G-3465	2548	8017	USGS	1990-99
G-580A	2540	8018	USGS	1990-99	G-3466	2548	8017	USGS	1990-99
G-594	2552	8027	USGS	1990-99	G-3467	2548	8016	USGS	1990-99
G-596	2538	8030	USGS	1990-99	G-3473	2542	8026	USGS	1990-99
G-613	2524	8032	USGS	1990-99	G-3549	2529	8021	USGS	1995-99
G-614	2532	8026	USGS	1990-99	G-3550	2529	8021	USGS	1995-99
G-618	2545	8036	USGS	1990-99	G-3558	2543	8028	USGS	1995-99
G-620	2540	8046	USGS	1990-99	G-3559	2544	8029	USGS	1995-99
G-757A	2535	8028	USGS	1990-99	G-3560	2541	8028	USGS	1995-99
G-789	2529	8033	USGS	1990-99	G-3561	2540	8026	USGS	1995-99
G-852	2554	8010	USGS	1990-99	G-3562	2551	8015	USGS	1995-99
G-855	2540	8029	USGS	1990-99	G-3563	2543	8020	USGS	1995-99
G-858	2538	8024	USGS	1990-99	G-3564	2549	8014	USGS	1995-99
G-860	2537	8019	USGS	1990-99	G-3565	2542	8024	USGS	1995-99
G-864	2526	8030	USGS	1990-99	G-3566	2549	8019	USGS	1995-99
G-864A	2536	8030	USGS	1990-99	G-3567	2553	8026	USGS	1995-99
G-968	2556	8027	USGS	1990-99	G-3568	2546	8021	USGS	1995-99
G-970	2557	8022	USGS	1990-99	G-3570	2545	8017	USGS	1995-99
G-972	2555	8026	USGS	1990-99	G-3571	2556	8018	USGS	1995-99
G-973	2552	8021	USGS	1990-99	G-3572	2544	8024	USGS	1995-99
G-975	2552	8027	USGS	1990-99	G-3573	2540	8009	USGS	1995-99
G-976	2549	8025	USGS	1990-99	G-3574	2544	8029	USGS	1995-99
G-1074B	2542	8020	USGS	1990-99	G-3575	2542	8029	USGS	1995-99
G-1166	2553	8019	USGS	1990-99	G-3576	2544	8030	USGS	1995-99
G-1183	2529	8023	USGS	1990-99	G-3577	2542	8030	USGS	1995-99
G-1251	2519	8033	USGS	1990-99	G-3578	2542	8030	USGS	1995-99
G-1359	2547	8025	USGS	1990-99	G-3619	2522	8033	USGS	1995-99
G-1362	2536	8026	USGS	1990-99	G-3620	2523	8032	USGS	1995-99
G-1363	2532	8030	USGS	1990-99	G-3621	2521	8029	USGS	1995-99
G-1368A	2549	8017	USGS	1990-99	G-3622	2529	8034	USGS	1995-99
G-1486	2530	8026	USGS	1990-99	G-3626	2537	8032	USGS	1995-99
G-1487	2540	8029	USGS	1990-99	G-3627	2536	8030	USGS	1995-99
G-1488	2549	8028	USGS	1990-99	G-3628	2535	8032	USGS	1995-99
G-1502	2536	8035	USGS	1990-99	G-3660	2542	8029	USGS	1995-99
G-1637	2557	8025	USGS	1990-99	NP 44	2526	8043	ENP	1990-99
G-3073	2541	8021	USGS	1990-99	NP 46	2519	8047	ENP	1990-99
G-3074	2541	8021	USGS	1990-99	NP 62	2526	8046	ENP	1990-99
G-3253	2550	8024	USGS	1990-99	NP 67	2519	8039	ENP	1990-99
G-3259A	2550	8024	USGS	1990-99	NP 72	2523	8042	ENP	1990-99
G-3264A	2550	8022	USGS	1990-99	S-18	2555	8014	USGS	1990-99
G-3272	2540	8034	USGS	1995-99	S-19	2548	8017	USGS	1990-99
G-3273	2537	8034	USGS	1990-94	S-68	2548	8017	USGS	1990-99
G-3327	2548	8016	USGS	1990-99	S-182A	2535	8021	USGS	1990-99
G-3328	2547	8016	USGS	1990-99	S-196A	2530	8029	USGS	1990-99

Table 2. Inventory of surface-water stations and control structures used in development of the Miami-Dade County water-table maps

[Source of data: ENP; Everglades National Park; SFWMD, South Florida Water Management District; USGS, U.S. Geological Survey]

Site identification	Latitude	Longitude	Source of data	Period of record	Site identification	Latitude	Longitude	Source of data	Period of record
EL30	255628	802623	USGS	1990-99	S-25	254752	801444	SFWMD	1990-99
EVER1	251950	802606	USGS	1990-99	S-25B	254738	801545	SFWMD	1990-99
EVER2A	251857	802841	USGS	1990-99	S-26	254829	801549	USGS	1990-99
EVER2B	251843	802837	USGS	1990-99	S-27	255055	801120	SFWMD	1990-99
EVER3	252053	803028	USGS	1990-99	S-28	255215	801042	SFWMD	1990-99
EVER4	252019	803247	USGS	1990-99	S-29	255542	800903	SFWMD	1990-99
EVER5A	251710	803422	USGS	1990-99	S-30	255724	802553	SFWMD	1990-99
EVER5B	251714	803408	USGS	1990-99	S-31	255634	802625	SFWMD	1990-99
G-58	255400	800943	SFWMD	1990-99	S-32	255633	802622	SFWMD	1990-99
G-72	255209	802021	SFWMD	1990-99	S-118	253722	802030	SFWMD	1990-99
G-93	254418	801712	SFWMD	1990-99	S-119	253833	802018	SFWMD	1990-99
G-119	254542	802837	SFWMD	1990-99	S-120	254015	801917	SFWMD	1990-99
L30.L67	254540	803340	SFWMD	1990-99	S-121	254113	802139	SFWMD	1990-99
L31N.1	254453	802953	USGS	1995-99	S-122	253539	802053	SFWMD	1990-99
L31N.3	254302	802950	USGS	1995-99	S-123	253637	801828	SFWMD	1990-99
L31N.4	254206	802946	USGS	1995-99	S-148	253412	802258	SFWMD	1990-99
L31N.5	254109	802950	USGS	1995-99	S-149	253531	802140	SFWMD	1990-99
L31N.7	253947	802954	USGS	1995-99	S-165	253233	802434	SFWMD	1990-99
L67EXT	254100	804024	USGS	1990-99	S-166	253106	802556	SFWMD	1990-99
NESR1	254130	803805	USGS	1990-99	S-167	253009	802748	SFWMD	1990-99
NESR2	254311	803326	USGS	1990-99	S-174	252901	803348	SFWMD	1990-99
NESR4	253824	803910	USGS	1990-99	S-175	252504	803425	SFWMD	1990-99
NESR5	253755	803942	USGS	1990-99	S-176	252858	803346	SFWMD	1990-99
NP201	254306	804332	ENP	1990-99	S-177	252410	803330	SFWMD	1990-99
NP202	253941	804244	ENP	1990-99	S-178	252429	803126	SFWMD	1990-99
NP205	254123	805053	ENP	1990-99	S-179	252825	802452	SFWMD	1990-99
NP206	253243	804021	ENP	1990-99	S-194	253459	802842	SFWMD	1990-99
NWWELL	255328	802613	USGS	1990-99	S-195	253304	802346	SFWMD	1990-99
P 33	253654	804209	ENP	1990-99	S-196	253101	803041	SFWMD	1990-99
P 36	253142	804745	ENP	1990-99	S-197	251713	802629	SFWMD	1990-99
P 38	252214	805001	ENP	1990-99	S-331	265538	802035	SFWMD	1990-99
S-12A	254543	804911	USGS	1990-99	S-332	252523	803525	USGS	1990-99
S-12B	254540	804605	USGS	1990-99	S-333	254539	804027	USGS	1990-99
S-12C	254540	804334	USGS	1990-99	S-334	254542	803008	SFWMD	1990-99
S-12D	254543	804054	USGS	1990-99	S-335	254634	802858	SFWMD	1990-99
S-18C	251949	803131	USGS	1990-99	S-336	254541	802948	SFWMD	1990-99
S-20	252201	802235	SFWMD	1990-99	S-337	255632	802627	SFWMD	1990-99
S-20F	252746	802051	SFWMD	1990-99	S-338	253938	802849	SFWMD	1990-99
S-20G	252921	802050	SFWMD	1990-99	SNAKE67	255750	801840	USGS	1990-99
S-21	253234	801952	USGS	1990-99	SNEXT	255026	802313	USGS	1990-99
S-21A	253109	802046	SFWMD	1990-99	SRS1	254754	803343	USGS	1990-99
S-22	254012	801702	SFWMD	1990-99	TAMCG	254543	801942	SFWMD	1990-99
					TSB	252405	803625	ENP	1990-99

Table 3. Differences in average yearly May, October, high, and low water levels from selected sites in Miami-Dade County, 1990-94 and 1995-99

[Site locations shown in figures 3 and 4. Wells G-551, G-1074B, G-1368A, G-3073, and G-3253 are within municipal well fields. All other sites are outside municipal well fields. All sites are ground-water wells, except for NP206 and SRS1, which are surface-water stations]

Site no.	Average yearly water level, in feet											
	May			October			High			Low		
	1990-94	1995-99	Difference	1990-94	1995-99	Difference	1990-94	1995-99	Difference	1990-94	1995-99	Difference
F-179	2.01	2.02	0.01	2.91	2.76	-0.15	4.84	4.72	-0.12	1.44	1.52	0.08
G-551	.23	-.16	-.39	1.79	.79	-1.00	3.43	3.47	.04	-.55	-1.62	-1.07
G-973	2.47	2.90	.43	3.38	3.60	.22	4.52	4.61	.09	2.03	2.46	.43
G-1074B	-7.26	-5.06	2.20	-3.55	-3.75	-.20	1.50	.89	-.61	-8.78	-7.50	1.28
G-1362	3.44	4.08	.64	4.60	4.79	.19	6.13	6.57	.44	2.81	3.43	.62
G-1368A	-1.70	-2.10	-.40	-.75	-.49	.26	3.33	2.96	-.37	-4.79	-7.77	-2.98
G-3073	2.28	3.25	.97	3.05	3.26	.21	4.05	5.00	.95	.74	2.57	1.83
G-3253	-.59	1.70	2.29	2.90	5.89	2.99	4.65	6.36	1.71	-2.01	.13	2.14
G-3356	1.72	2.08	.36	2.52	2.63	.11	3.21	3.28	.07	1.05	1.30	.25
S-18	2.04	2.06	.02	2.46	2.41	-.05	4.03	4.48	.45	1.56	1.51	-.05
NP206	4.14	4.80	.66	5.80	6.56	.76	6.03	6.76	.73	3.36	4.23	.87
SRS1	6.30	7.36	1.06	7.32	8.49	1.17	7.87	8.89	1.02	4.94	7.16	2.22
Average			0.65			0.38			0.37			0.47

Table 4. Statistical summary of recurrence water levels and associated 95-percent confidence limits in Miami-Dade County

[RWL, recurrence water level]

Well no.	Period of record	5-year RWL	95-percent confidence limits		10-year RWL	95-percent confidence limits		25-year RWL	95-percent confidence limits	
			Lower	Upper		Lower	Upper		Lower	Upper
F-45	1974-99	5.7	5.3	6.2	6.4	5.9	7.2	7.3	6.6	8.5
F-179	1974-99	5.5	5.1	6.0	6.2	5.6	7.0	7.1	6.3	8.3
F-239	1974-99	5.3	4.9	6.0	6.0	5.4	6.9	6.7	6.0	8.0
F-319	1974-99	4.7	4.4	5.0	5.2	4.9	5.7	6.0	5.5	6.8
F-358	1974-99	6.9	6.5	7.5	7.6	7.1	8.4	8.6	7.9	9.4
G-3	1974-99	5.3	4.6	6.5	6.4	5.4	8.2	7.8	6.4	10.4
G-551	1985-99	4.0	3.6	4.6	4.3	3.9	5.1	4.6	4.1	5.5
G-553	1974-99	6.4	6.1	6.9	7.0	6.6	7.6	7.8	7.2	8.7
G-580A	1974-99	5.6	5.3	6.2	6.4	5.9	7.1	7.4	6.7	8.6
G-596	1974-99	8.1	7.9	8.3	8.3	8.1	8.6	8.6	8.4	9.0
G-613	1974-99	4.7	4.5	5.1	5.1	4.8	5.5	5.5	5.1	6.1
G-614	1974-99	7.4	7.0	8.0	8.3	7.7	9.2	9.6	8.7	11.0
G-618	1974-99	8.1	8.0	8.2	8.2	8.1	8.4	8.3	8.2	8.5
G-620	1974-99	7.9	7.8	8.1	8.1	8.0	8.4	8.4	8.2	8.7
G-757A	1974-99	7.8	7.4	8.3	8.4	8.0	9.1	9.3	8.7	10.2
G-789	1974-99	6.8	6.6	7.1	7.1	6.9	7.4	7.5	7.2	7.9
G-852	1974-99	5.6	5.2	6.2	6.2	5.7	6.9	6.7	6.1	7.7
G-855	1974-99	7.4	7.2	7.7	7.7	7.4	8.1	8.0	7.6	8.4
G-860	1974-99	5.1	4.7	5.5	5.8	5.4	6.4	6.9	6.2	8.0
G-864	1974-99	7.5	7.0	8.3	8.2	7.5	9.2	8.9	8.1	10.2
G-864A	1974-99	7.5	6.9	8.2	8.1	7.4	9.0	8.7	7.9	9.9
G-968	1974-99	8.5	8.3	8.7	8.6	8.4	8.9	8.7	8.5	9.0
G-970	1974-99	4.5	4.4	4.7	4.8	4.6	5.0	5.0	4.8	5.4
G-972	1974-99	6.0	5.9	6.1	6.0	6.0	8.2	6.1	6.0	6.2
G-973	1974-99	4.9	4.8	5.1	5.1	4.9	5.4	5.3	5.1	5.7
G-975	1974-99	6.8	6.7	6.9	6.9	6.7	7.0	6.9	6.8	7.1
G-976	1974-99	6.2	6.0	6.5	6.3	6.1	6.6	6.4	6.2	6.7
G-1166	1974-99	4.9	4.7	5.2	5.3	5.0	5.6	5.7	5.3	6.2
G-1183	1974-99	5.1	4.9	5.5	5.5	5.2	5.9	5.8	5.5	6.4
G-1251	1974-99	3.3	3.2	3.4	3.4	3.3	3.6	3.5	3.4	3.7
G-1362	1974-99	7.2	6.9	7.6	7.8	7.4	8.4	8.6	8.0	9.5
G-1363	1974-99	8.1	7.7	8.7	8.8	8.3	9.7	9.8	9.0	10.9
G-1486	1974-99	5.7	5.4	6.2	6.5	6.0	7.2	7.5	6.8	8.7
G-1487	1974-99	7.7	7.6	7.9	7.8	7.7	8.0	8.0	7.8	8.2
G-1488	1974-99	7.4	7.3	7.6	7.5	7.4	7.7	7.5	7.4	7.7
G-1502	1974-99	7.8	7.7	8.0	8.0	7.8	8.2	8.2	8.0	8.4
G-1637	1974-99	5.5	5.4	5.6	5.5	5.4	5.7	5.6	5.5	5.7
G-3073	1974-99	4.9	4.6	5.4	5.5	5.1	6.2	6.2	5.6	7.3
G-3074	1978-99	5.9	5.4	6.6	6.4	5.9	7.4	7.0	6.3	8.2
G-3253	1982-99	7.7	6.7	9.1	8.0	7.0	9.6	8.2	7.2	9.9
G-3259A	1983-99	7.6	7.2	8.2	7.9	7.4	8.6	8.1	7.6	9.0
G-3264A	1984-99	6.0	5.9	6.3	6.2	6.0	6.5	6.4	6.2	6.8
G-3327	1984-99	4.7	4.4	5.1	5.1	4.8	5.7	5.7	5.3	6.6
G-3328	1984-99	4.1	3.9	4.4	4.4	4.2	4.9	4.9	4.5	5.6
G-3329	1984-99	5.8	5.5	6.3	6.3	5.9	7.0	6.9	6.4	8.0
G-3353	1985-99	2.6	2.5	2.8	2.7	2.6	2.9	2.9	2.7	3.1
G-3354	1985-99	3.1	3.0	3.3	3.2	3.1	3.4	3.3	3.2	3.6
G-3355	1985-99	5.2	5.0	5.4	5.3	5.1	5.6	5.4	5.2	5.7
G-3356	1986-99	3.4	3.3	3.5	3.5	3.4	3.7	3.7	3.5	3.9
G-3439	1987-99	6.4	6.1	6.8	6.6	6.3	7.1	6.8	6.5	7.5
G-3465	1988-99	5.2	4.8	5.9	5.9	5.3	6.9	6.8	6.0	8.6
G-3466	1988-99	4.7	4.3	5.4	5.4	4.8	6.5	6.4	5.5	8.3
G-3467	1974-99	5.0	4.6	5.8	5.4	4.9	6.5	5.9	5.2	7.2
S-18	1974-99	5.1	4.8	5.5	5.6	5.2	6.1	6.1	5.7	6.9
S-19	1974-99	5.7	5.4	6.3	6.3	5.8	7.0	7.0	6.4	8.0
S-68	1974-99	6.3	5.7	7.1	7.0	6.3	8.2	8.0	7.1	9.5
S-182A	1974-99	5.9	5.5	6.4	6.5	6.1	7.2	7.3	6.7	8.3
S-196A	1974-99	7.5	7.1	8.2	8.3	7.8	9.2	9.4	8.4	10.6
Mean		5.96			6.38			6.91		

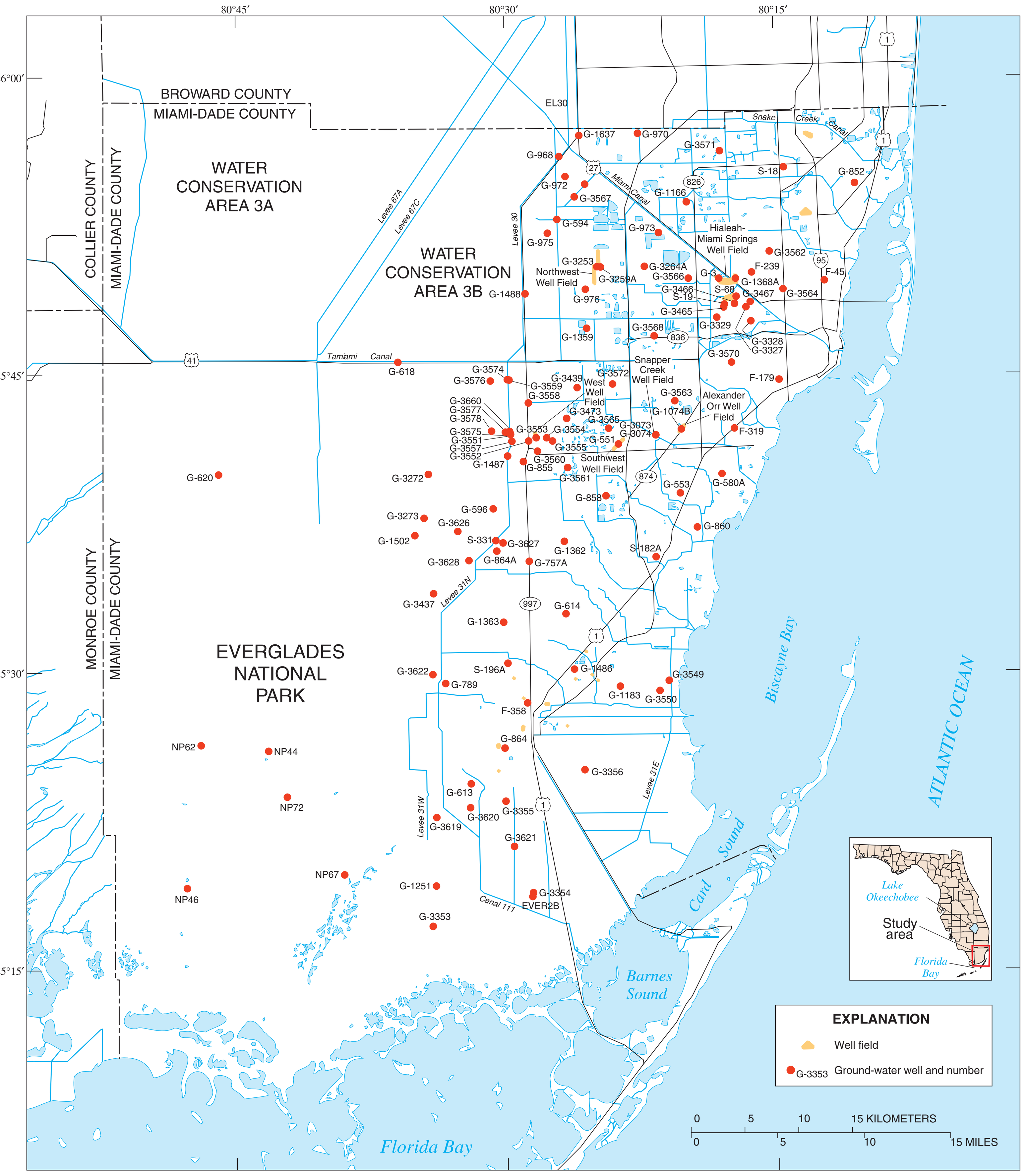

Figure 3. Location of ground-water wells and well fields in Miami-Dade County.

Changes in Water Levels

A comparison of differences in average water levels at various locations in the Biscayne aquifer was made for 10 ground-water wells and 2 surface-water stations. Results indicate that between 1990-94 and 1995-99, differences in average yearly May, October, high, and low water levels were 0.65, 0.38, 0.37, and 0.47 feet, respectively (table 3). Water levels generally were higher in 1995-99, which may be the result of above-normal rainfall (due to El Niño effects and tropical storms) that occurred during the latter period as well as changes in municipal pumping or water-management practices.

The greatest average yearly May, October, high, and low water levels in areas unaffected by municipal pumping occurred at surface-water stations SRS1 and NP206. Most of the data show positive changes in water level between 1990-94 and 1995-99 at the 12 ground- and surface-water sites (table 3). Of the sites outside municipal well fields, negative differences occurred only at well F-179 in east-central Miami-Dade County for the average yearly October and high water levels and at well S-18 in northeastern Miami-Dade County for the average yearly October and low water levels.

A comparison of the water-level data between 1990-94 and 1995-99 indicates that negative differences also occurred at wells within municipal well fields. Negative differences were found at well G-1368A in the Hialeah-Miami Springs Well Field for average yearly May, high, and low water levels. Pumping was reduced at this well field from 1984 to 1992 owing to contamination of the supply wells; consequently, pumping was shifted to the Northwest Well Field during this period (Sonenshein and Koszalka, 1996). Most of the pumping eventually was shifted back to the Hialeah-Miami Springs Well Field in 1992. Negative differences also were found at well G-1074B in the Alexander Orr Well Field for average yearly October and high water levels and at well G-551 in the Southwest Well Field for the average yearly May, October, and low water levels.

Recurrence Water Levels

Statistical summaries were prepared for 5-, 10-, and 25-year recurrence water levels and associated 95-percent confidence limits at 58 wells in Miami-Dade County (table 4). The associated confidence limits indicate that there is a 95-percent probability that the true value lies between the lower and upper limits (table 4). The 5-, 10-, and 25-year recurrence water levels are those water levels that are: (1) likely to be exceeded only once every 5, 10, or 25 years, respectively, or (2) likely to be exceeded 20, 10, or 4 times, respectively in every 100 years.

Results indicate that the maximum 5-year recurrence water level was 8.5 feet at well G-968 along Levee 30 in north-central Miami-Dade County. The maximum 10- and 25-year recurrence water levels of 8.8 and 9.8 feet, respectively, occurred at well G-1363 east of Levee 31N in south-central Miami-Dade County. The minimum 5-, 10-, and 25-year recurrence water levels of 2.6, 2.7, and 2.9 feet, respectively, occurred at well G-3353 in south Miami-Dade County. The mean 5-, 10-, and 25-year recurrence water levels for all sites were 5.96, 6.38, and 6.91 feet, respectively.

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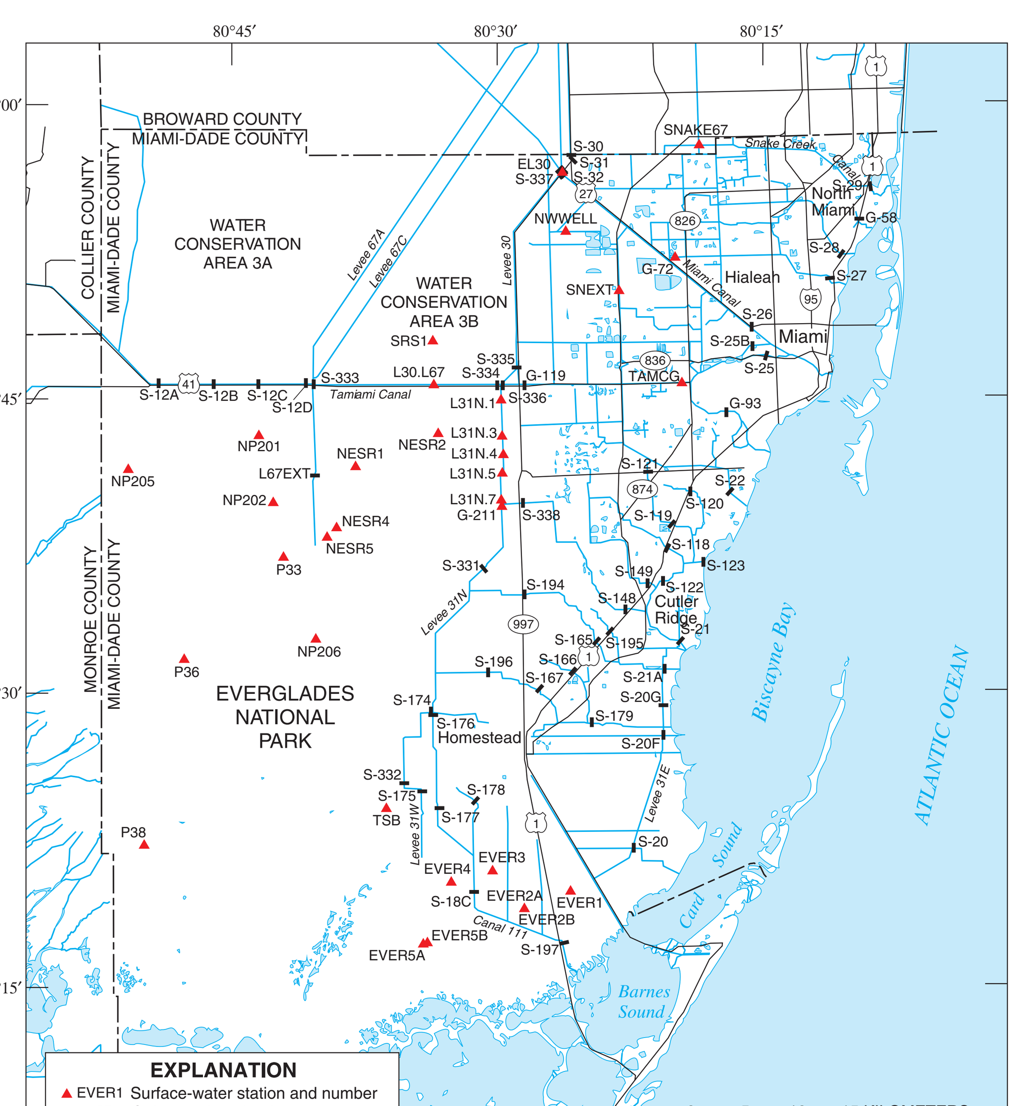


Figure 4. Location of surface-water stations and control structures in Miami-Dade County.

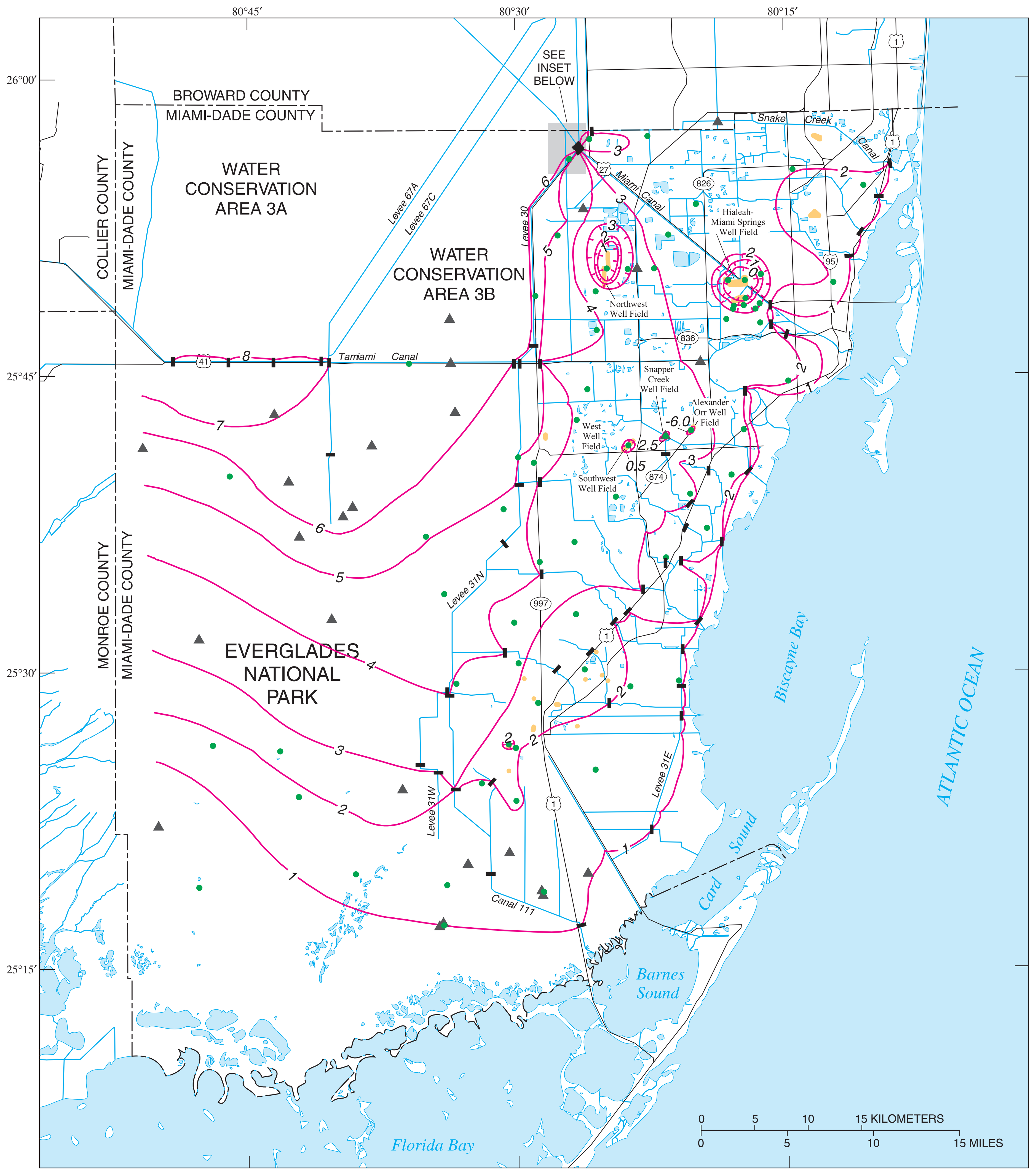
AVERAGE ALTITUDE OF THE WATER TABLE (1990-99) AND FREQUENCY ANALYSIS OF WATER LEVELS (1974-99) IN THE BISCAYNE AQUIFER, MIAMI-DADE COUNTY, FLORIDA

By
A.C. Lietz, Joann Dixon, and Michael Byrne
2002

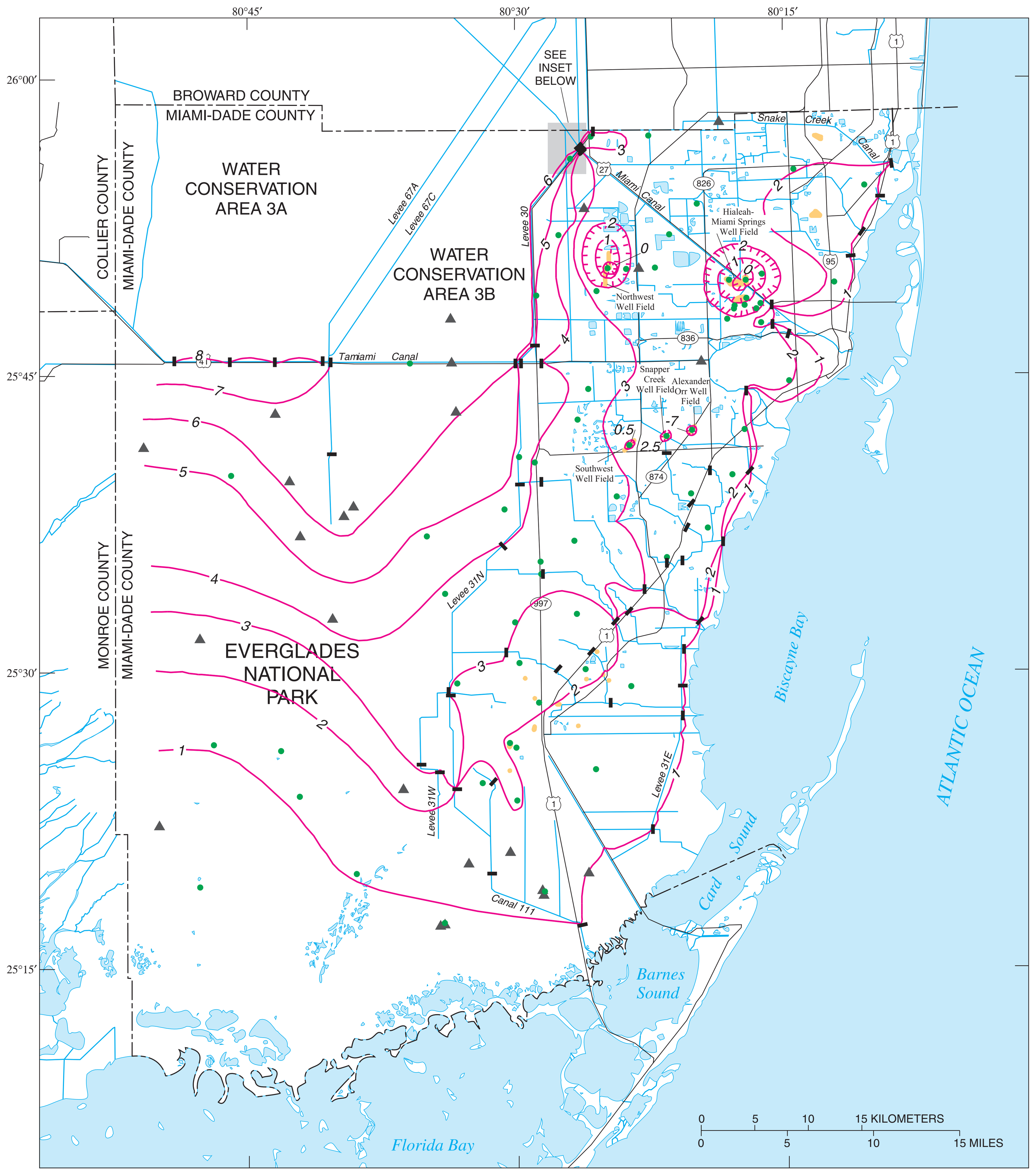
U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MIAMI-DADE COUNTY DEPARTMENT OF ENVIRONMENTAL RESOURCES MANAGEMENT

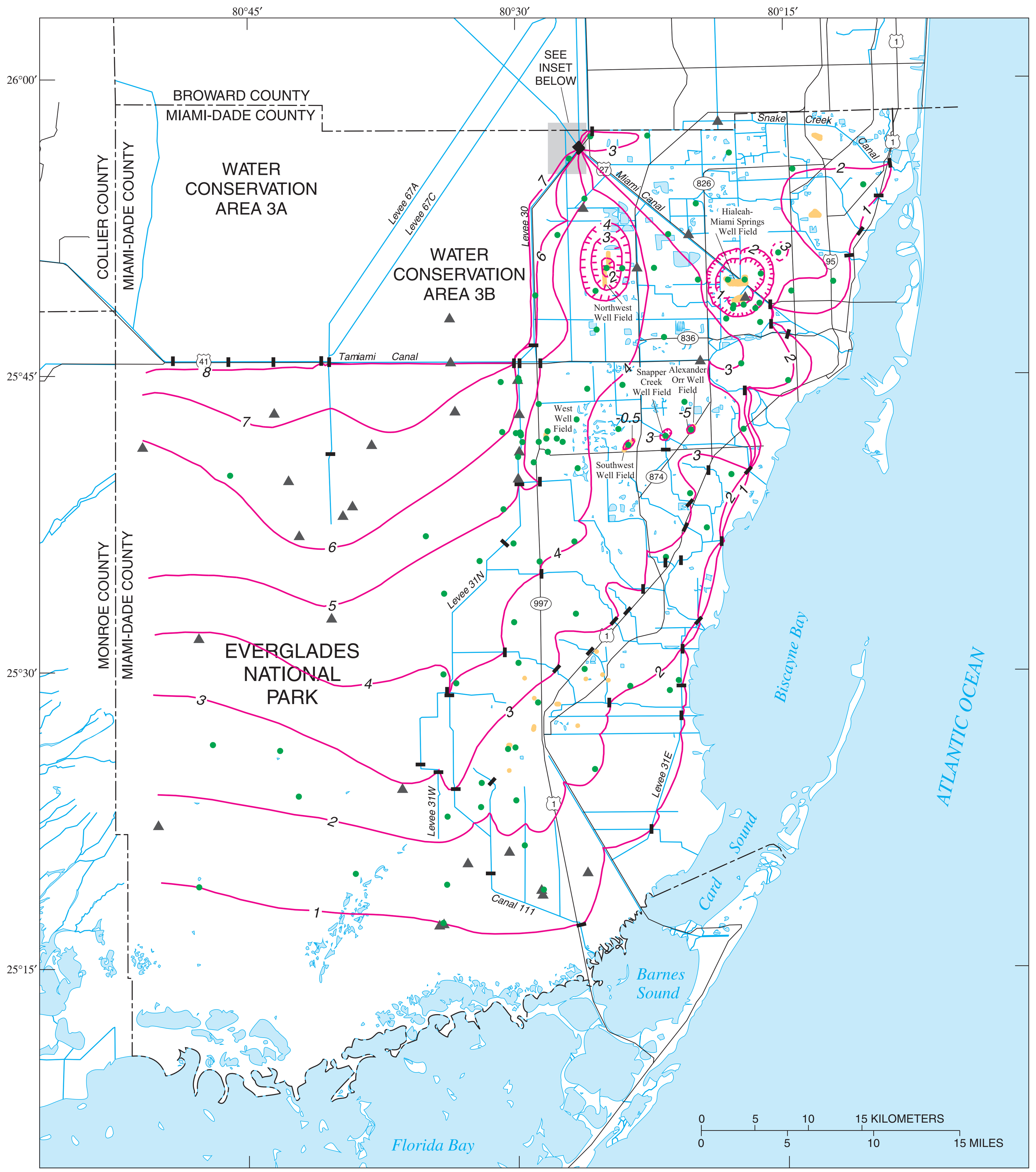
OPEN FILE REPORT 02-91
May water levels, plate 1 - SHEET 2 OF 6
Lietz, A. C., 2002, Average altitude of the water table (1990-99) and frequency analysis of water levels (1974-99) in the Biscayne aquifer, Miami-Dade County, Florida



AVERAGE MAY WATER LEVELS 1990-99



AVERAGE MAY WATER LEVELS 1990-94



AVERAGE MAY WATER LEVELS 1995-99

EXPLANATION

- WELL FIELD
- –2– WATER-TABLE CONTOUR--Shows altitude of water table. Hachures indicate depression. Dashed where approximately located. Contour interval 0.5 and 1 foot. Datum is sea level
- CANAL AND LEVEE
- GROUND-WATER WELL
- SURFACE-WATER STATION
- CONTROL STRUCTURE

INSET

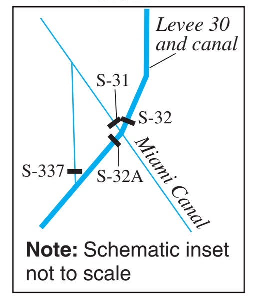


PLATE 1. MAPS SHOWING ALTITUDE OF THE WATER TABLE IN THE BISCAYNE AQUIFER, MIAMI-DADE COUNTY, FLORIDA, BASED ON AVERAGE YEARLY MAY WATER LEVELS FOR 1990-99, 1990-94, AND 1995-99

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2002

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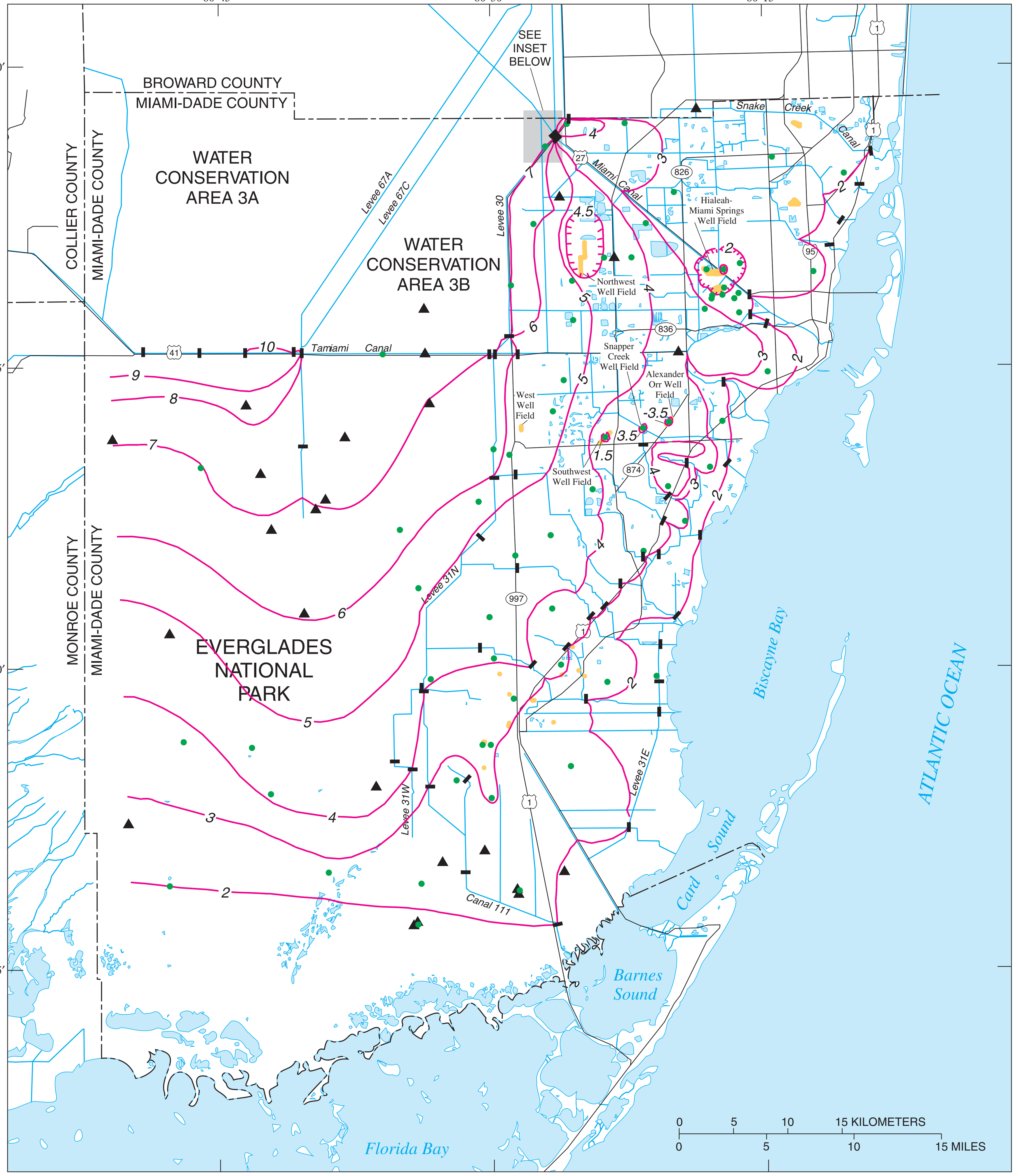
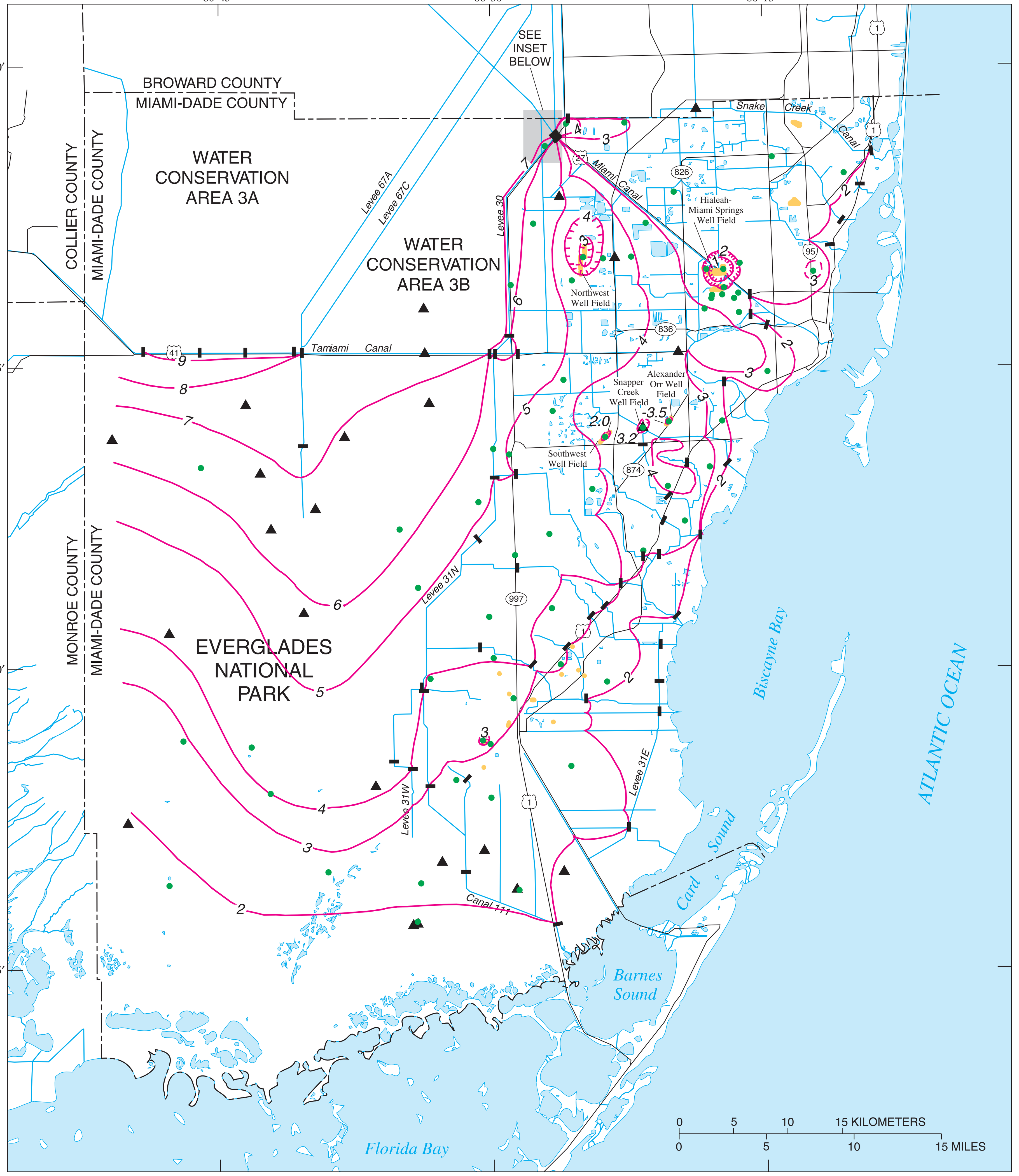
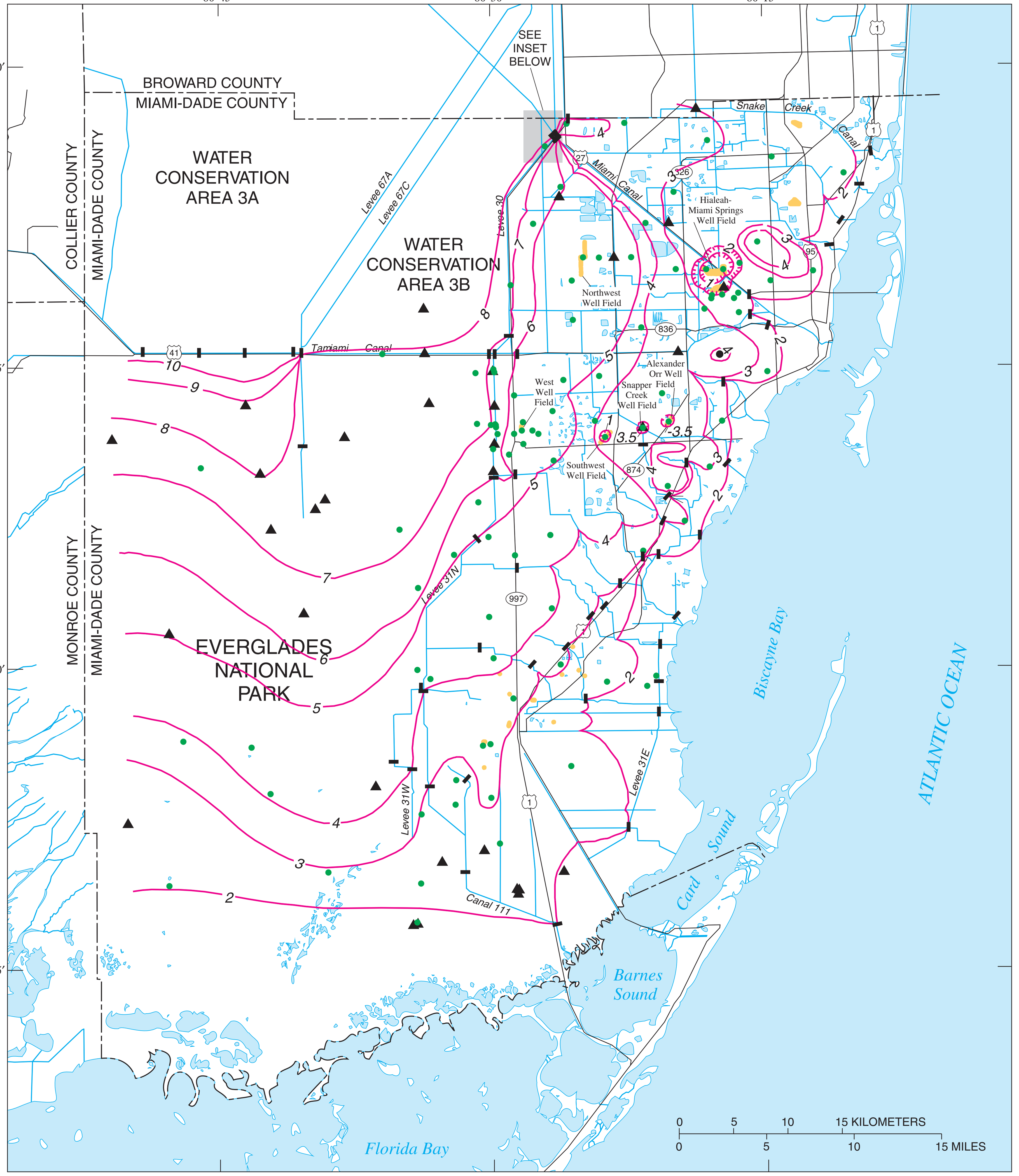
OPEN FILE REPORT 02-91
October water levels, plate 2 - SHEET 3 OF 6
Lietz, A. C., 2002, Average altitude of the water table (1990-99) and frequency analysis of water levels (1974-99) in the Biscayne aquifer, Miami-Dade County, Florida



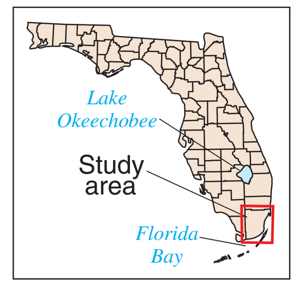
AVERAGE OCTOBER WATER LEVELS 1990-99



AVERAGE OCTOBER WATER LEVELS 1990-94



AVERAGE OCTOBER WATER LEVELS 1995-99



EXPLANATION

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- –2– WATER-TABLE CONTOUR--Shows altitude of water table. Hachures indicate depression. Dashed where approximately located. Contour interval 0.5 and 1 foot. Datum is sea level
- CANAL AND LEVEE
- GROUND-WATER WELL
- SURFACE-WATER STATION
- CONTROL STRUCTURE

INSET

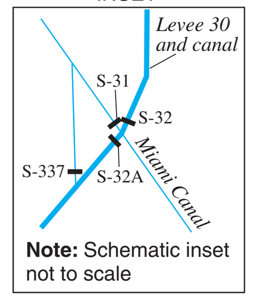

PLATE 2. MAPS SHOWING ALTITUDE OF THE WATER TABLE IN THE BISCAYNE AQUIFER, MIAMI-DADE COUNTY, FLORIDA, BASED ON AVERAGE YEARLY OCTOBER WATER LEVELS FOR 1990-99, 1990-94, AND 1995-99

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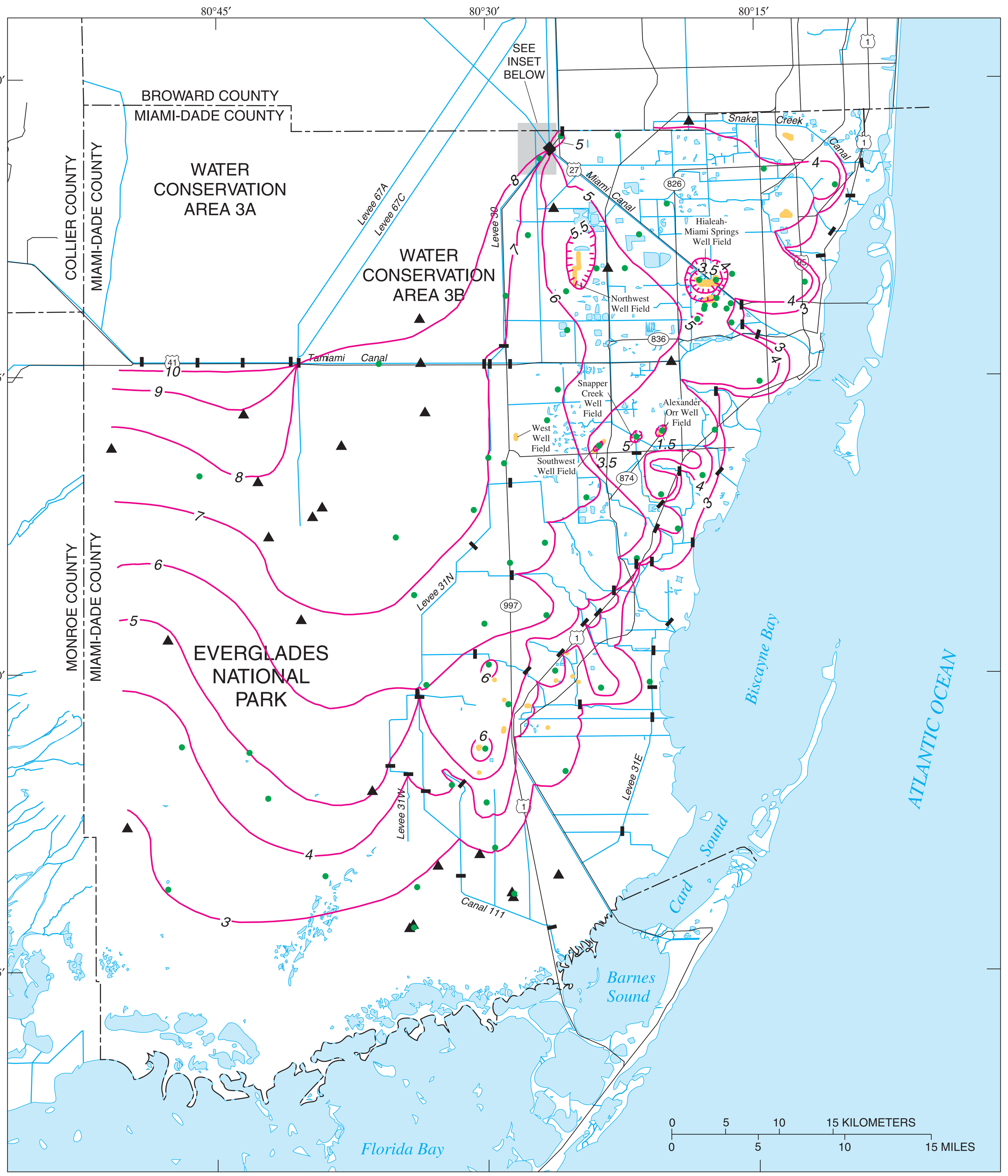
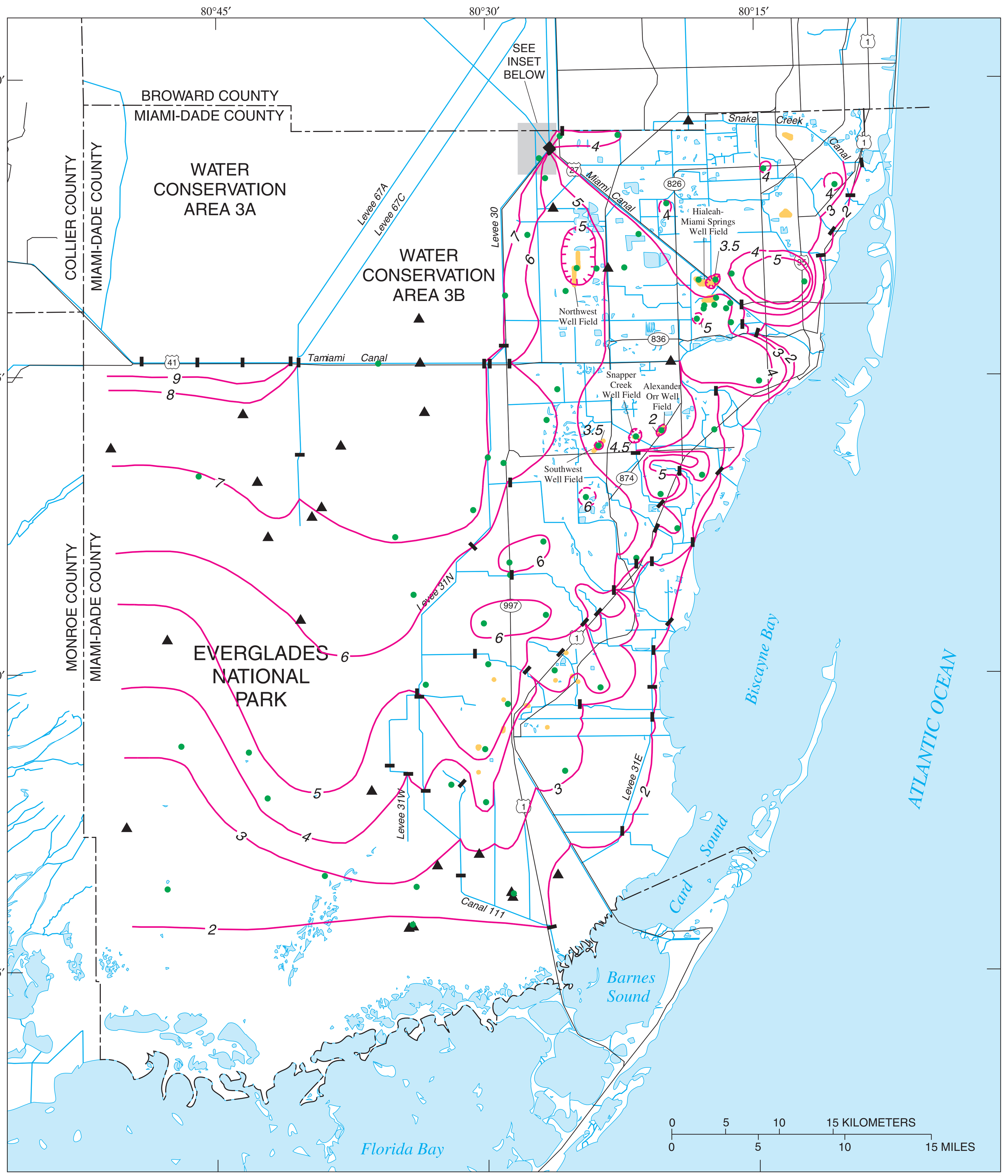
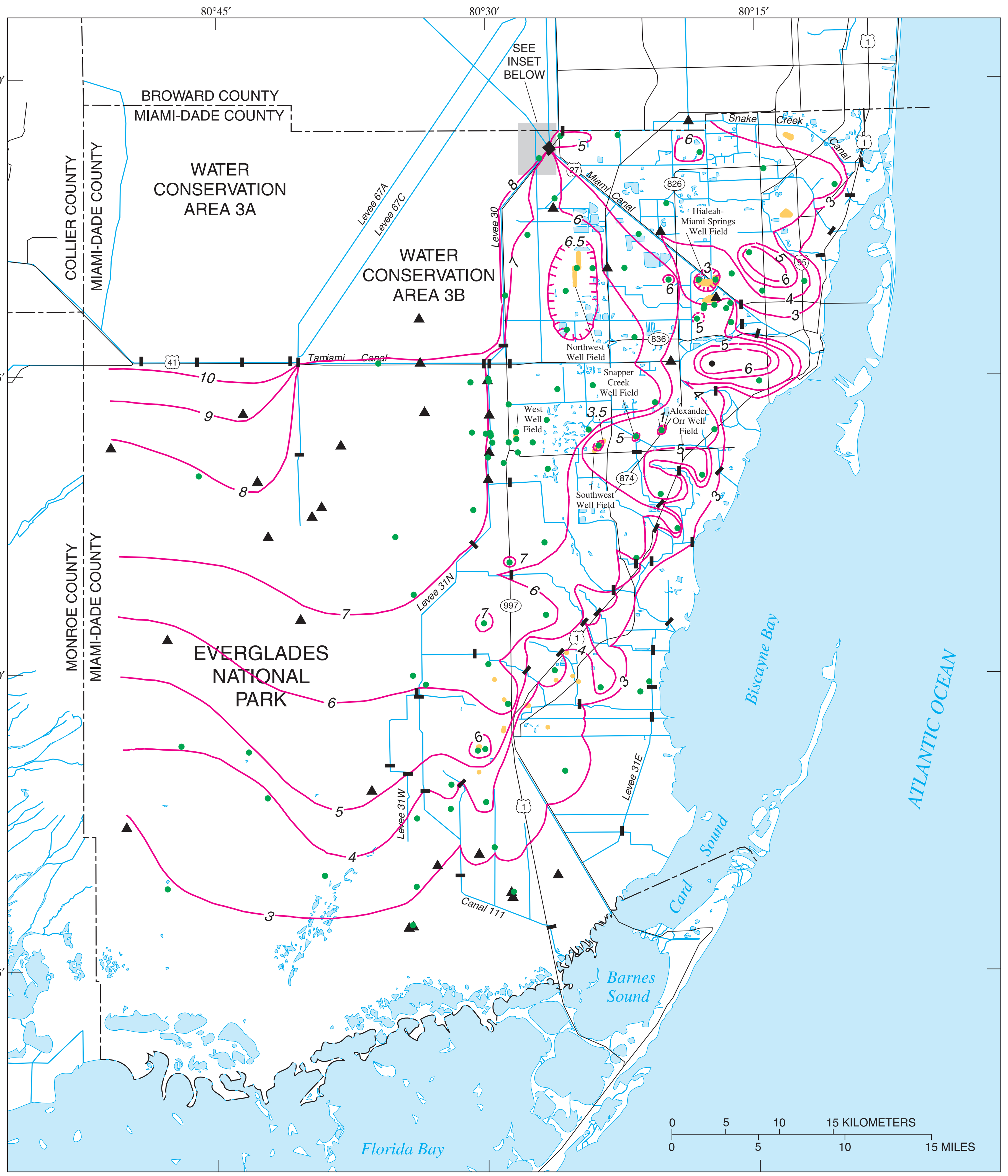


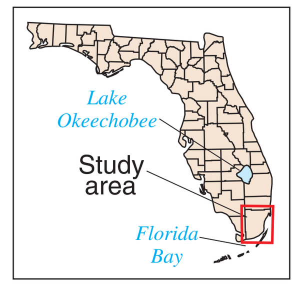
AVERAGE YEARLY HIGH WATER LEVELS 1990-99



AVERAGE YEARLY HIGH WATER LEVELS 1990-94



AVERAGE YEARLY HIGH WATER LEVELS 1995-99



EXPLANATION

- WELL FIELD
- –2– WATER-TABLE CONTOUR--Shows altitude of water table. Hachures indicate depression. Dashed where approximately located. Contour interval 0.5 and 1 foot. Datum is sea level
- CANAL AND LEVEE
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- SURFACE-WATER STATION
- CONTROL STRUCTURE

INSET

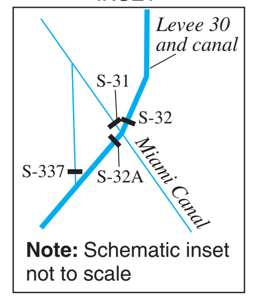

PLATE 3. MAPS SHOWING ALTITUDE OF THE WATER TABLE IN THE BISCAYNE AQUIFER, MIAMI-DADE COUNTY, FLORIDA, BASED ON AVERAGE YEARLY HIGH WATER LEVELS FOR 1990-99, 1990-94, AND 1995-99

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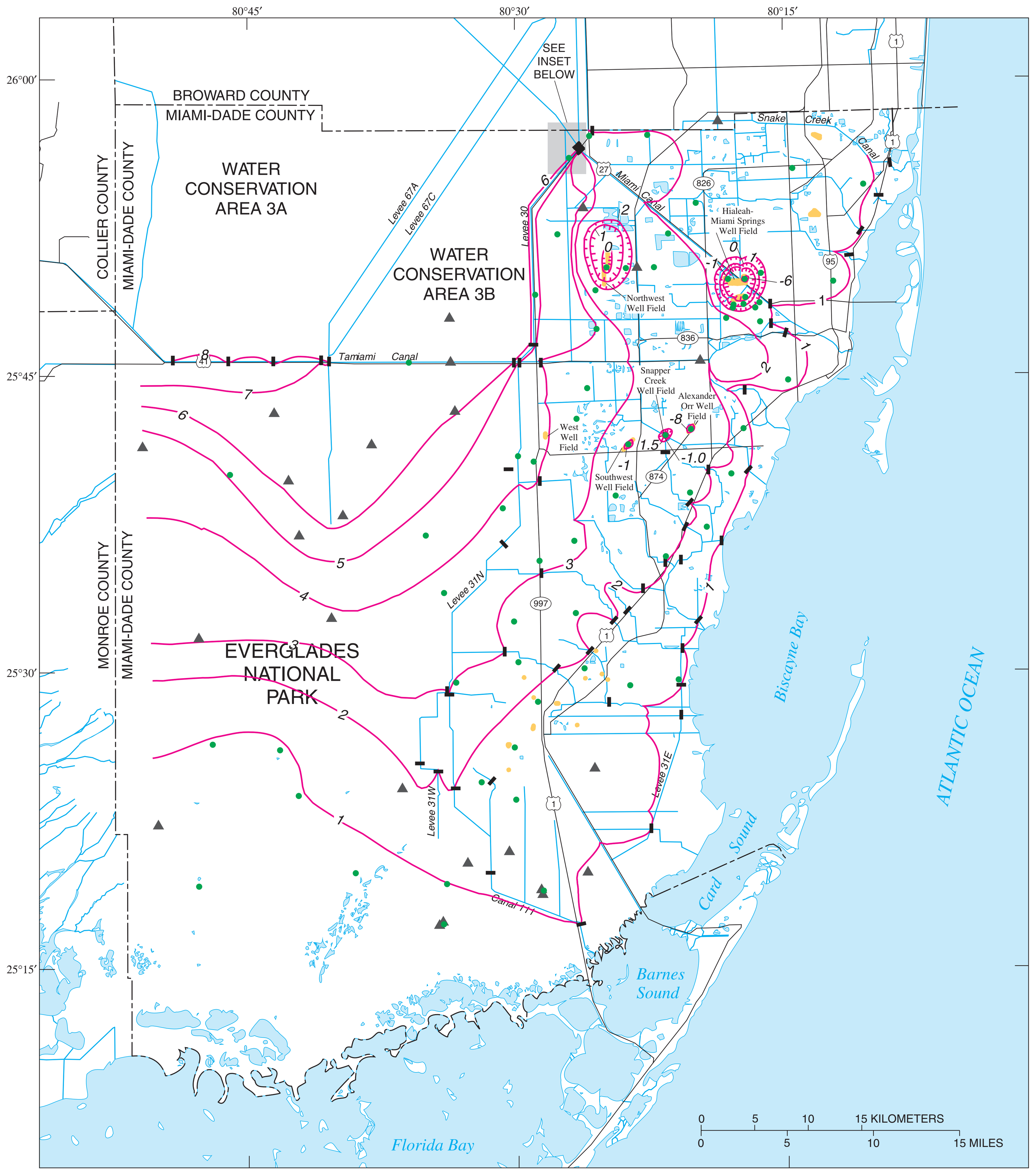
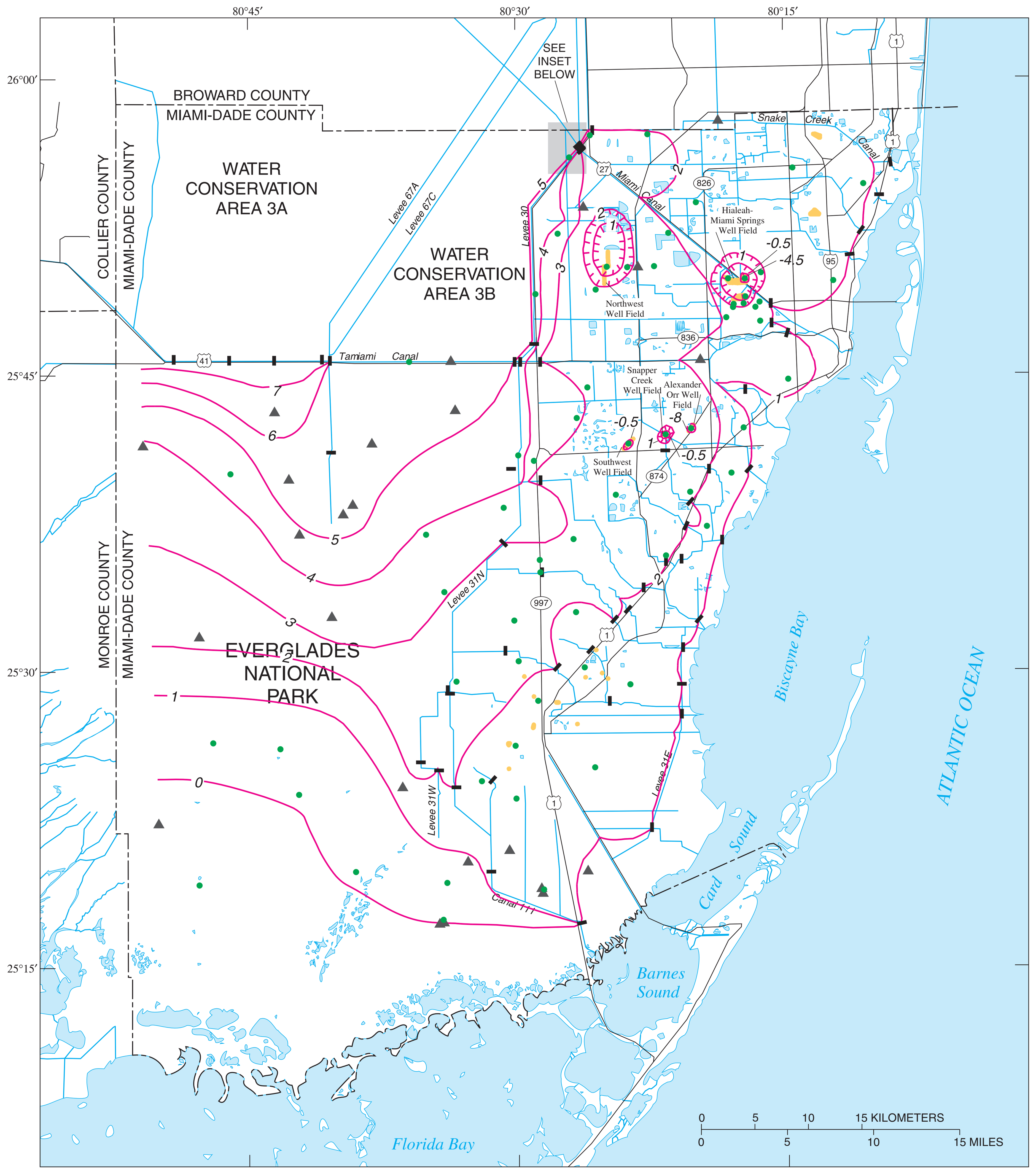
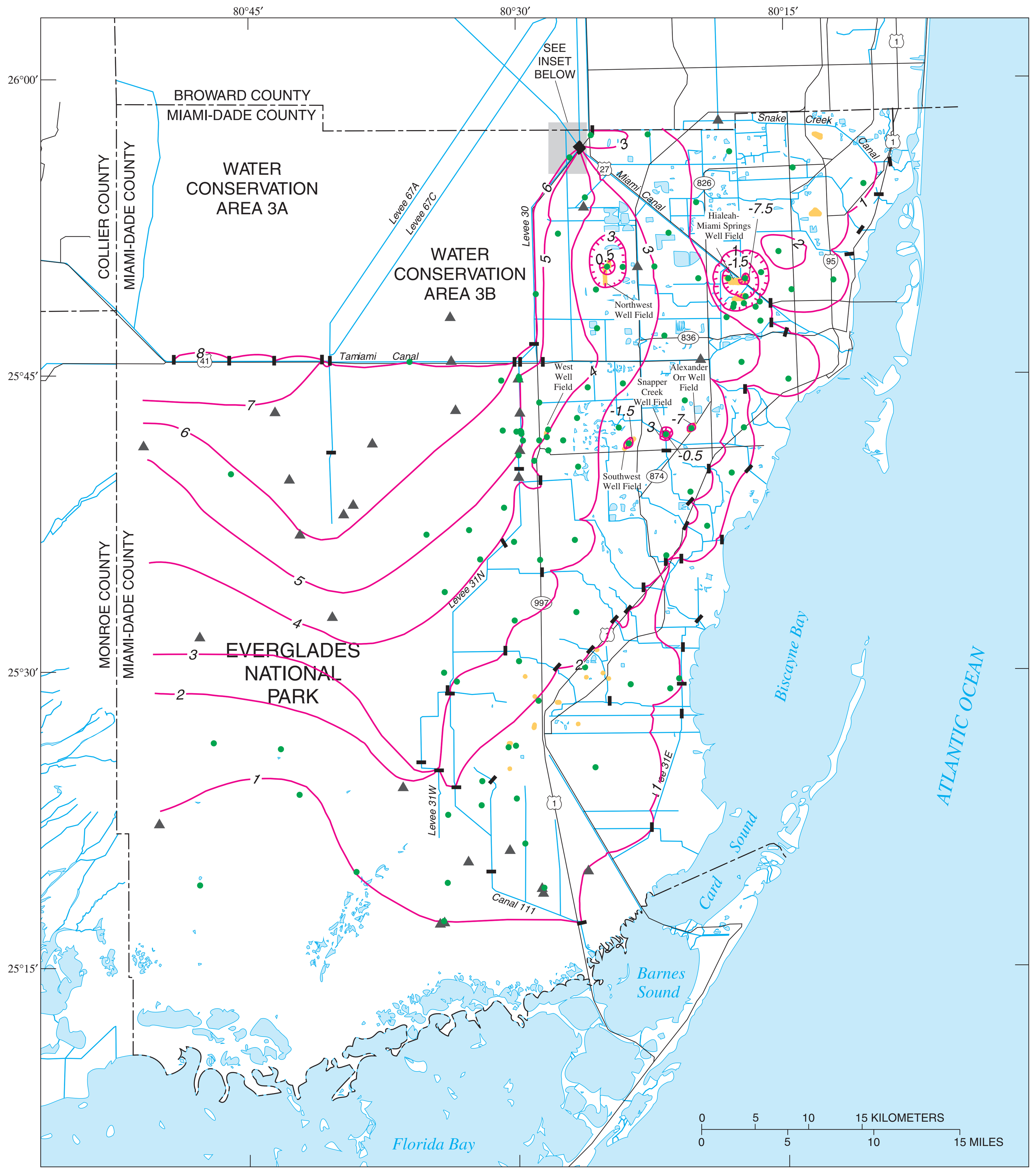


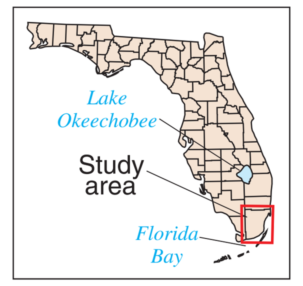
AVERAGE YEARLY LOW WATER LEVELS 1990-99



AVERAGE YEARLY LOW WATER LEVELS 1990-94



AVERAGE YEARLY LOW WATER LEVELS 1995-99



EXPLANATION

- WELL FIELD
- –2– WATER-TABLE CONTOUR--Shows altitude of water table. Hachures indicate depression. Dashed where approximately located. Contour interval 0.5 and 1 foot. Datum is sea level
- CANAL AND LEVEE
- GROUND-WATER WELL
- SURFACE-WATER STATION
- CONTROL STRUCTURE

INSET

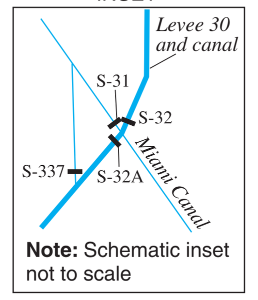


PLATE 4. MAPS SHOWING ALTITUDE OF THE WATER TABLE IN THE BISCAYNE AQUIFER, MIAMI-DADE COUNTY, FLORIDA, BASED ON AVERAGE YEARLY LOW WATER LEVELS FOR 1990-99, 1990-94, AND 1995-99

By
A.C. Lietz, Joann Dixon, and Michael Byrne
2002

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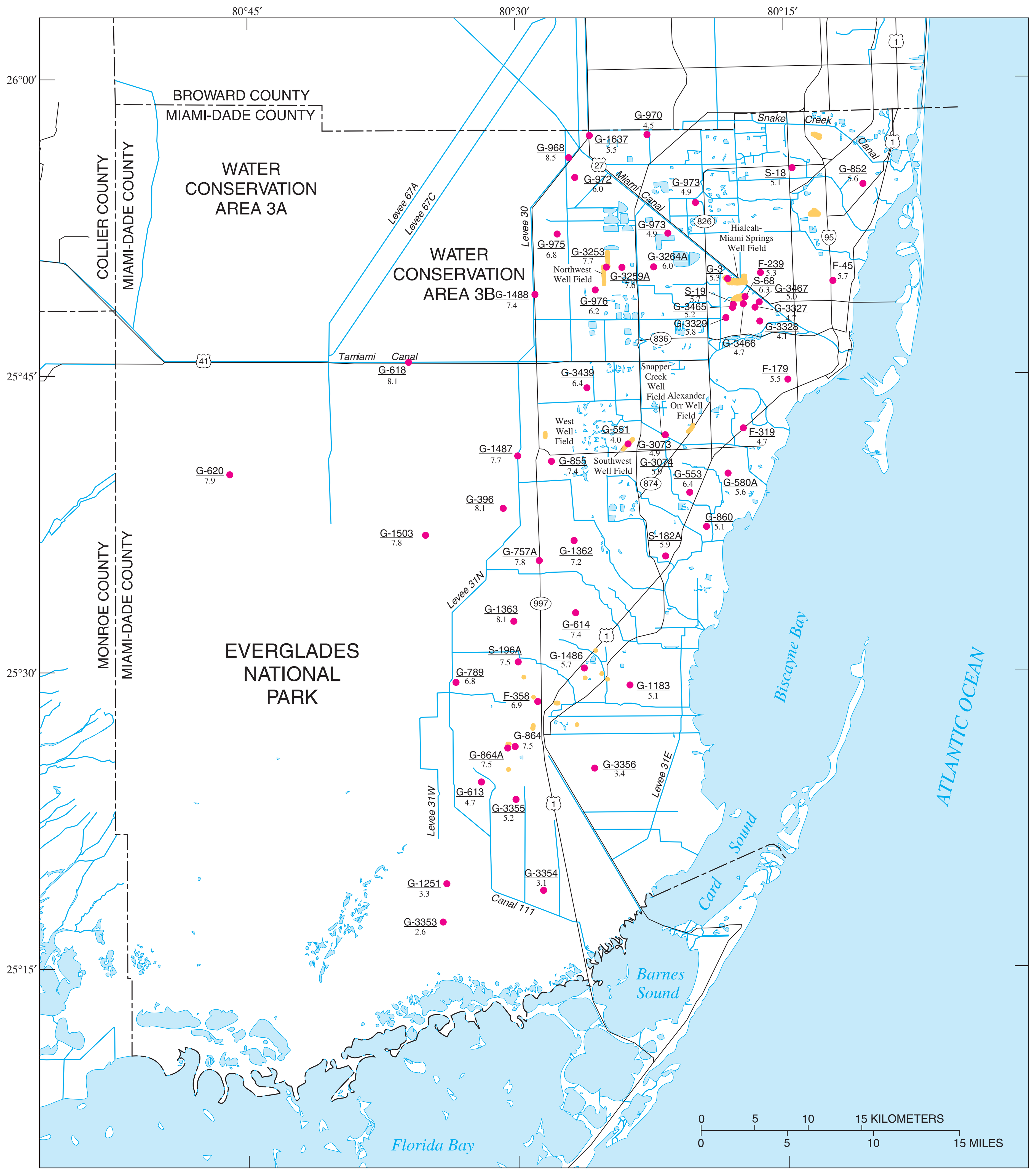
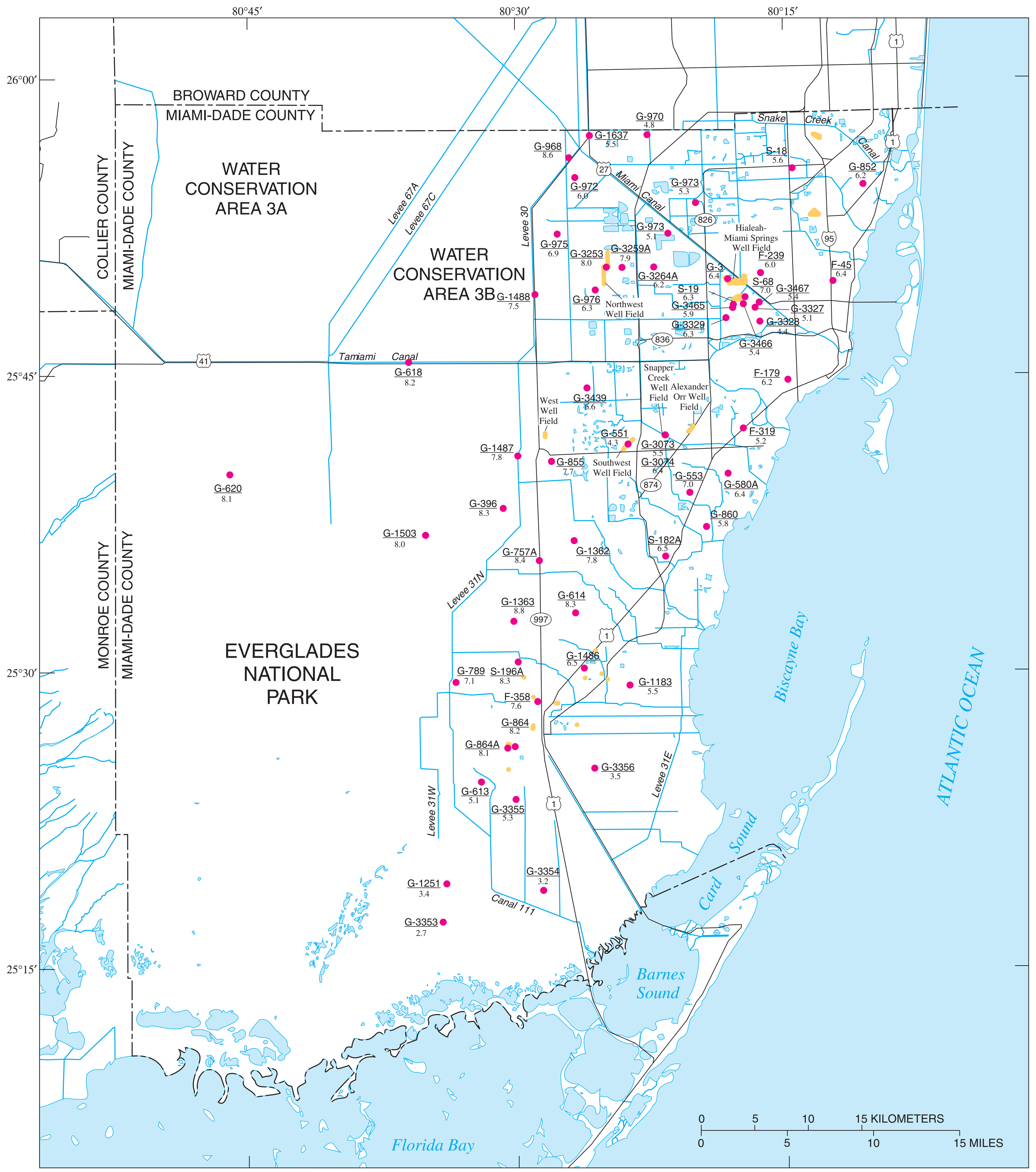
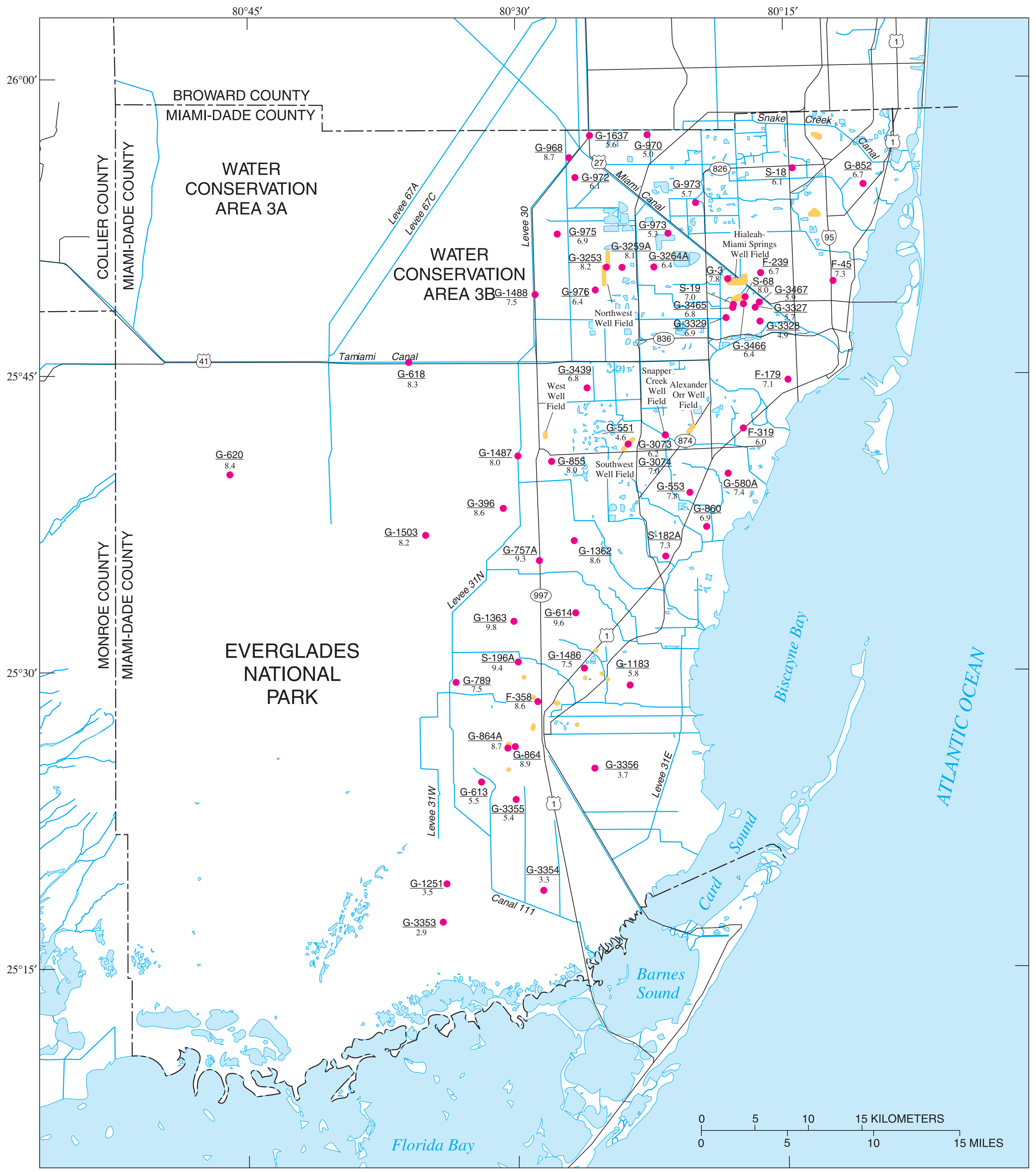
OPEN FILE REPORT 02-91
Recurrence water levels, plate 5 - SHEET 6 OF 6
Lietz, A. C., 2002, Average altitude of the water table (1990-99) and frequency analysis of water levels (1974-99) in the Biscayne aquifer, Miami-Dade County, Florida



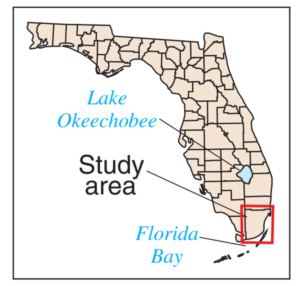
5-YEAR RECURRENCE WATER LEVELS



10-YEAR RECURRENCE WATER LEVELS



25-YEAR RECURRENCE WATER LEVELS



EXPLANATION

G-3353 2.7 GROUND-WATER WELL AND VALUE--Upper number is well identification. Lower number is water level in feet

WELL FIELD

PLATE 5. MAPS SHOWING RECURRENCE WATER LEVELS OF 5, 10, AND 25 YEARS IN MIAMI-DADE COUNTY, FLORIDA, 1974-99

By
A.C. Lietz, Joann Dixon, and Michael Byrne
2002