REPORT
EVALUATION OF POTENTIAL MIGRATION
FROM CONTAMINATED SOIL
TURKEY POINT POWER PLANT
TURKEY POINT, FLORIDA
FOR FLORIDA POWER & LIGHT COMPANY

JOB NO: 04598-127-26
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Dames & Moore
BOCA RATON, FLORIDA

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

REPORT
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INTRODUCTION

The purpose of this report is to provide an evaluation of the potential rate and direction of migration of radionuclides in the subsurface at the Turkey Point Power Plant and to assess the environmental impacts of permanent retention of the contaminated soils at the site.

The radionuclides were reportedly released to the subsurface in 1978 by a spill of radioactive water. A portion of the contaminated water entered a storm water drainage system and flowed to a drywell. FPL conducted an investigation to characterize the boundary of the contamination and to determine the level of radioactive contamination in the subsurface materials in the vicinity of the drywell. Subsequently, the area containing detectable subsurface radioactive activity was fenced off (Figure 1).

The site is located inside the southeast corner of the Radiation Controlled Area (RCA) at FPL's Turkey Point Power Plant. The RCA and areas surrounding the contamination area have been filled to an elevation of 17.5 feet above mean low water (MLW) (Figure 1). The remaining areas to the east and south outside of the Protected Area fence have been filled to an elevation of +7.5 feet MLW. The contaminated area elevation varies, but is less than +17.5 feet MLW as shown in Figure 1 (MLW plus 0.7 feet equals mean sea level).

Originally, the site consisted of approximately two feet of organic silty soils (locally referred to as muck) overlying the Biscayne aquifer limestone. The muck layer was excavated and removed from the area filled

to +17.5 feet MLW prior to constructing the +17.5 feet MLW filled pads. The muck within the contaminated area was excavated but not removed from the site. The contaminated area muck is presently stockpiled within the contaminated area fence. Demucking operations were not reported to have taken place in the +7.5 feet MLW fill areas.

METHOD OF INVESTIGATION

The investigation performed for the evaluation of the contamination involved sampling of subsurface materials, monitor well installations, ground water and canal water level monitoring, permeability tests, and cation exchange capacity testing of selected subsurface materials.

Eight monitor wells were installed in order to monitor ground water levels and run permeability tests. The locations of these wells are shown in Figure 1. Each well was installed in a hole drilled with a hollow-stem auger. During the drilling operation, soil samples were collected at the interface between the fill material and original ground surface by driving a standard split spoon sampler. The purpose of the sampling was to collect muck samples for cation exchange capacity testing. In areas where the site had been filled to an elevation of +17.5 feet MLW, the muck layer was absent and samples of the limestone at the top of the Biscayne aquifer were collected.

The monitor well installations are of a two-inch diameter schedule 40, PVC screen and gravel pack type construction. Figure 2 shows the construction of the monitor wells. Each well was installed to a depth of approximately three feet below the ground water table. The annulus between the screened portion of each well and the drilled hole is packed with Number 6/20 silica sand. The remainder of the annular space between the well casing and drilled hole is backfilled with fill augered from the borehole. A concrete pad is located at ground surface around each well.

Falling-head permeability tests were conducted in each monitor well after the wells were constructed and developed. The tests consist of filling the well casing with water and measuring the drop in water level over a period of time. All tests were conducted for a period of approximately 60 minutes, thus, saturating the area above the water table for calculation of permeability. The purpose of these tests was to calculate the mean permeability of the shallow subsurface materials at the top of the Biscayne aquifer.

Ground water levels in each well were measured during both high and low tide cycles. The well casing elevations were surveyed by FPL. These elevations and the measured ground water levels were used to calculate the elevation of the ground water surface in each well. In addition, canal water level elevations were measured and recorded during each of the ground water level monitoring periods. The water surface elevations were measured at the Intake Basin, Discharge Basin and East Canal (Figure 3). These ground water and surface water elevations were measured in order to evaluate the direction of ground water movement.

Organic muck samples collected from borings TP-1, TP-2, and TP-3 were analyzed to determine the cation exchange capacity (CEC) of the muck. The CEC is a measure of the ability of the soil to attenuate the migration of contaminants through the process of ionic exchange. Only muck samples were analyzed for CEC. Limestone samples collected from sites TP-4 through TP-8 were not analyzed. The limestone is crushed during sampling and must be further pulverized for this analysis, a process which makes additional ion exchange sites available as a result of increasing the surface area of the sample. Thus, the crushed limestone samples are not representative of the actual ion exchange capacity.

RESULTS OF INVESTIGATION

PERMEABILITY

Permeabilities calculated from the falling head permeability tests are shown in Table 1. These values provide a reasonable estimate of the

permeability of the composite subsurface materials in the interval from two feet above the water table to three feet below the water table.

The permeabilities range from 1.46×10^{-4} feet per minute (ft/min) to 9.46×10^{-4} ft/min. The average permeability based on the seven values shown on Table 1 is 3.90×10^{-4} ft/min. The permeability at TP-6 was not determined. After the placement of approximately 150 gallons of water in the TP-6 casing, a head of water could not be developed inside of the casing and the falling head test could not be conducted. This test result, however, indicates that the shallow subsurface materials at TP-6 are extremely permeable. The results of the seven other permeability tests are similar, thus indicating that the TP-6 permeability is anomalous. The calculated rates of ground water flow discussed later in this report do not, therefore, consider the TP-6 permeability.

WATER LEVELS

Ground water surface elevations determined from the eight wells and surface water elevations determined from the three canals are listed in Table 2. Water levels were measured near low tide on June 19, 1981 and near high tide on June 17, 1981. The water levels show the highest water surface elevation to have existed at well TP-1 on both tides while the lowest elevations are found in the Intake Basin. The high water levels in well TP-1 are probably due to the pond adjacent to the well. Although the ponds are presently dry, rainfall falling within the ponded areas will be retained and not allowed to runoff overland. The water table, therefore, becomes slightly mounded adjacent to the ponds.

It should also be noted that water levels in wells TP-4 and TP-6 are higher at low tide than at high tide. These conditions are probably due to a rainfall that occurred prior to the measurement of water levels on low tide. Similarly, the Intake Basin and East Canal high tide water levels are lower than the low tide water levels at the time of measurement. Rainfall and operation stages of the cooling canal system may be responsible for these variations.

The water surface elevations were used to construct a water table map. Figure 4 shows the water table elevation contours for both the high and low tide conditions. Water surface elevations in the East Canal, Discharge Basin, and Intake Basin are shown on Figure 3. The water table contours indicate the direction of ground water movement. During high tide conditions, ground water flows in a northeasterly direction through the contaminated area toward the Intake Basin. The flow direction changes during the low tide conditions to southeast and east. Since the Intake Basin water levels are the lowest water surface elevation, the Basin acts as a discharge boundary for ground water movement during both tide conditions.

HYDRAULIC GRADIENTS

Hydraulic gradients were calculated using the water table contour maps. The gradients are used as input into calculating the rate of ground water movement while the water table contour map is used to predict the direction of ground water flow. Four different hydraulic gradients were calculated and are listed in Table 3. The hydraulic gradient across the contaminated area is higher during high tide than during low tide. The gradient between the contaminated area and the Intake Basin, however, does not vary significantly over a tidal cycle.

RATES OF GROUND WATER FLOW

The hydraulic gradients, permeabilities, and water table contour map were used to calculate the rate and direction of ground water movement through the site area. Since the permeability data collected represents only the permeability of the limestone in the extreme upper section of the Biscayne aquifer, the calculated rates of ground water flow are representative ground water movement near the water table surface.

The calculated rates of ground water movement are shown on Table 4. The rate of ground water flow through the contaminated area varies from 3.7×10^{-3} feet per day (ft/day) to 4.7×10^{-4} ft/day between high and

low tide, respectively. Ground water is calculated to move from the contaminated area to the Intake Basin at an average rate of 7.4×10^{-3} ft/day. Although these rates appear to be low, the hydraulic gradients and permeabilities are also relatively low.

CATION EXCHANGE CAPACITY

In order to provide information for an assessment of the potential attenuation of radioactive contaminants by the organic muck, cation exchange capacity tests were run on muck samples from borings TP-1, TP-2, and TP-3. The results of these tests are listed in Table 5.

The cation exchange capacity (CEC) of the organic soils located near the top of the water table range from approximately 12 to 48 millequivalents per 100 grams of soil (meq/100 gm). These CEC's are high, equivalent to the CEC values of clay minerals such as illite and chlorite. As shown by the results of these tests, organic soils have a large capacity for ion exchange, thus, attenuation of cation contaminants.

EVALUATION OF RESULTS

The area contaminated was located and isolated by FPL. In order to assess the potential rate and direction of migration of the contaminated water, eight monitoring wells were installed. These wells were used to conduct permeability tests and measure water levels.

The results of the permeability tests and water level measurements indicate that ground water can travel from the contaminated area to the Intake Basin. The rate of movement is relatively slow, averaging approximately 7.4×10^{-3} feet per day. This rate represents the movement of ground water in the upper portion of the Biscayne aquifer near the water table surface. Water level variations resulting from variations in tide levels, rainfall, and operating stages in the Intake Basin will cause minor changes in the rate of ground water flow as hydraulic gradients change. The average rate of 7.4×10^{-3} feet per day, however, is believed to be representative of the flow rate.

The water level data indicates that the contaminated area is hydraulically isolated from areas outside of the cooling canal systems at Turkey Point. Low water levels measured in the Intake Basin and East Canal show that these surface water bodies act as discharge boundaries to ground water flow in the vicinity of the contaminated area. In particular, the water table contour map shows that ground water moving through the contaminated area will move in the direction of the Intake Basin, discharging over a long period of time into the Intake Basin and becoming part of the cooling canal system circulation.

Water samples collected in the contaminated area by FPL and analyzed for radioactivity revealed low levels of cobalt-60, cesium-134, and cesium-137. These levels were reportedly within limits for unrestricted areas according to 10 CFR Part 20, Appendix B. Contamination remained predominantly within the organic muck stockpiled in the contaminated area according to FPL.

The cation exchange capacity of the organic muck ranges from approximately 12 to 48 meq/100 gm. These high values indicate that the muck has a large capacity to attenuate the radionuclides through ion exchange. Even though a major portion of the muck has been removed in the immediate vicinity of the contaminated area, the organic muck still exists within the contaminated area and in surrounding areas. The rate of contaminant migration toward the Intake Basin near the water table surface should be further reduced as the contaminants are attenuated in the organic soils.

Over a period of time, the radionuclides contained within the organic soil above the water table in the contaminated area may be gradually released as rainfall percolates downward through the soil. Ground water levels rising and falling in response to seasonal and tidal variations, may allow the contaminants in the water to become repeatedly trapped and released from the soil above the water table but not above ground surface. These factors coupled with the relatively slow rate of ground water movement may cause the contaminants in the ground water to become

more dilute with time. The level of contamination reaching the Intake Basin should, therefore, be much lower than presently exists in the ground water. The dispersion and diffusion of the contaminants in the soil and ground water should considerably lower the concentration of radioactive nuclides through time.

Due to the slow movement of the ground water in the contaminated area and the expected reduction in concentations with time, the contamination is believed to pose no environmental threat to the ground water or surface water in the area. The capacity of the soil to attenuate the contaminants within and outside of the spill area and the slow movement of ground water should prevent significant migration of the contaminants. The contaminated area is hydraulically isolated from areas outside of the cooling canal system. If the contaminants eventually reach the canal system by seepage of ground waters into the Intake Basin, dilution of the contaminated ground waters with a significantly larger volume of canal water flow and physical decay of radioactive materials (several years) should reduce contaminant concentrations in the canal system to well below detectable limits.

In summary, the retention of the contaminated soil on site should not pose a negative environmental impact to water quality in the site area.

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Respectfully submitted,

DAMES & MOORE

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TABLE 1

RESULTS OF PERMEABILITY TESTS

Well	Average Permeability (K) (Feet Per Minute)	Average Permeability (K) (Centimeters Per Second)
TP-1	1.72×10^{-4}	8.74×10^{-5}
TP-2	5.84×10^{-4}	2.94×10^{-4}
TP-3	1.46×10^{-4}	7.42×10^{-5}
TP-4	4.96×10^{-4}	2.38×10^{-4}
TP-5	9.46×10^{-4}	4.81×10^{-4}
TP-6	NA	NA
TP-7	1.72×10^{-4}	8.74×10^{-5}
TP-8	2.38×10^{-4}	1.21×10^{-4}

NA = Not Available

TABLE 2
WATER SURFACE
ELEVATIONS

Well	Time	Casing Elevation (Ft. MSL)*	Water Level (FT. BTOC)**	Water Elevation (Ft. MSL)	Comments
TP-1	1225	+ 8.82	7.12	+1.70	Reading taken on 6-17-81 at high tide.
TP-2	1233	+10.44	9.40	+1.04	
TP-3	1239	+10.41	9.20	+1.21	
TP-4	1134	+21.02	20.00	+1.02	
TP-5	1139	+20.49	19.35	+1.14	
TP-6	1115	+17.83	16.79	+1.04	
TP-7	1107	+20.67	19.42	+1.25	
TP-8	1120	+22.35	21.11	+1.24	
East Canal	1244	NA	NA	-0.23	
Intake	1251	NA	NA	-0.46	
Discharge	1309	NA	NA	+1.38	
TP-1	0804	+ 8.82	7.16	+1.66	Reading taken on 6-19-81 at low tide.
TP-2	0807	+10.44	9.53	+0.91	
TP-3	0812	+10.41	9.38	+1.03	
TP-4	0750	+21.02	19.95	+1.07	
TP-5	0746	+20.49	19.45	+1.04	
TP-6	0730	+17.83	16.71	+1.12	
TP-7	0723	+20.67	19.58	+1.09	
TP-8	0734	+22.35	21.30	+1.05	
East Canal	0815	NA	NA	-0.14	
Intake	0822	NA	NA	-0.30	
Discharge	0839	NA	NA	+1.30	

* Feet Mean Sea Level

** Ft BTOC = Feet Below Top of Casing

TABLE 3

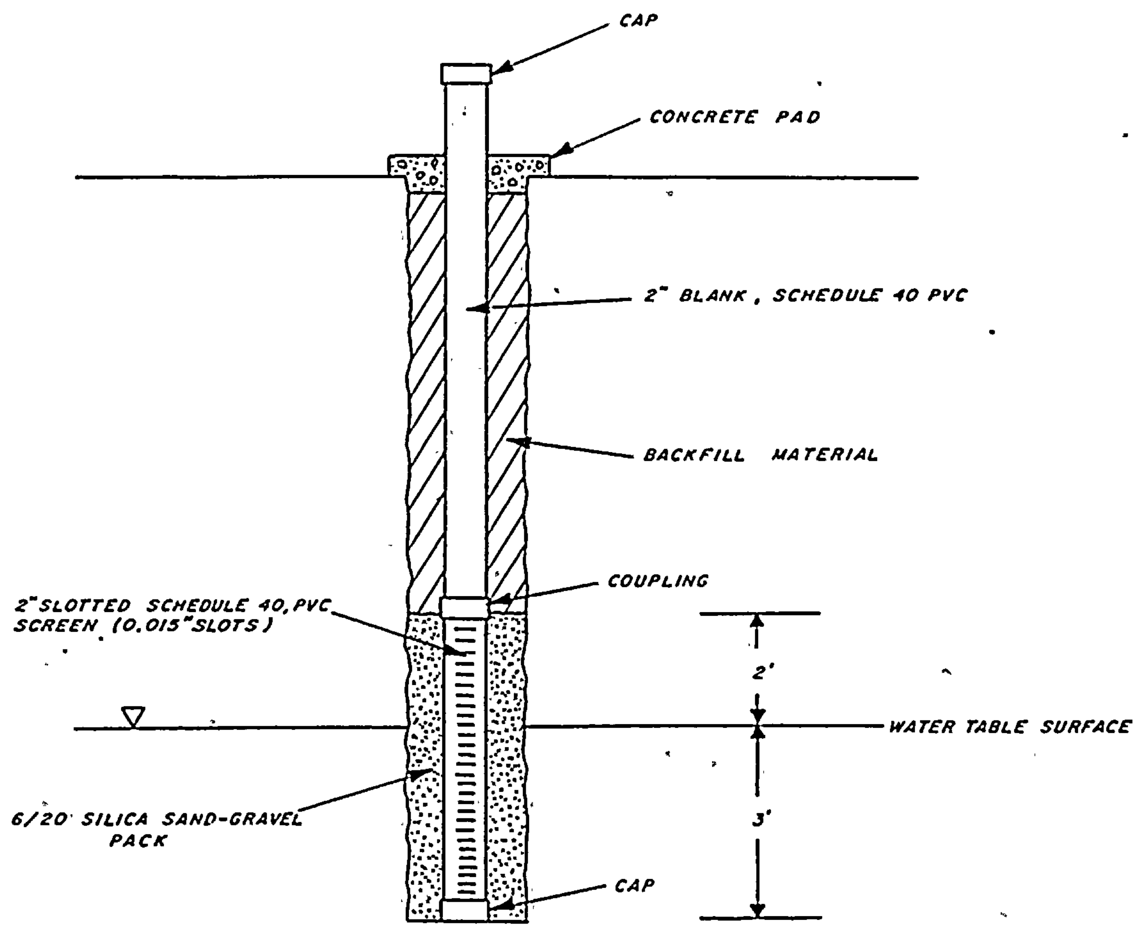
HYDRAULIC GRADIENTS

Hydraulic Gradient(i) Across Contaminated Area

High Tide	6-17-81	$i = 2.0\times10^{-3}$ (dimensionless)
Low Tide	6-19-81	$i = 2.4\times10^{-4}$

Hydraulic Gradient(i) Between Contaminated Area And Intake Basin

High Tide	6-17-81	$i = 4.1\times10^{-3}$
Low Tide	6-19-81	$i = 3.8\times10^{-3}$



NOT TO SCALE

GENERALIZED MONITOR WELL CONSTRUCTION

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LOCATION: TURKEY POINT, FLA.

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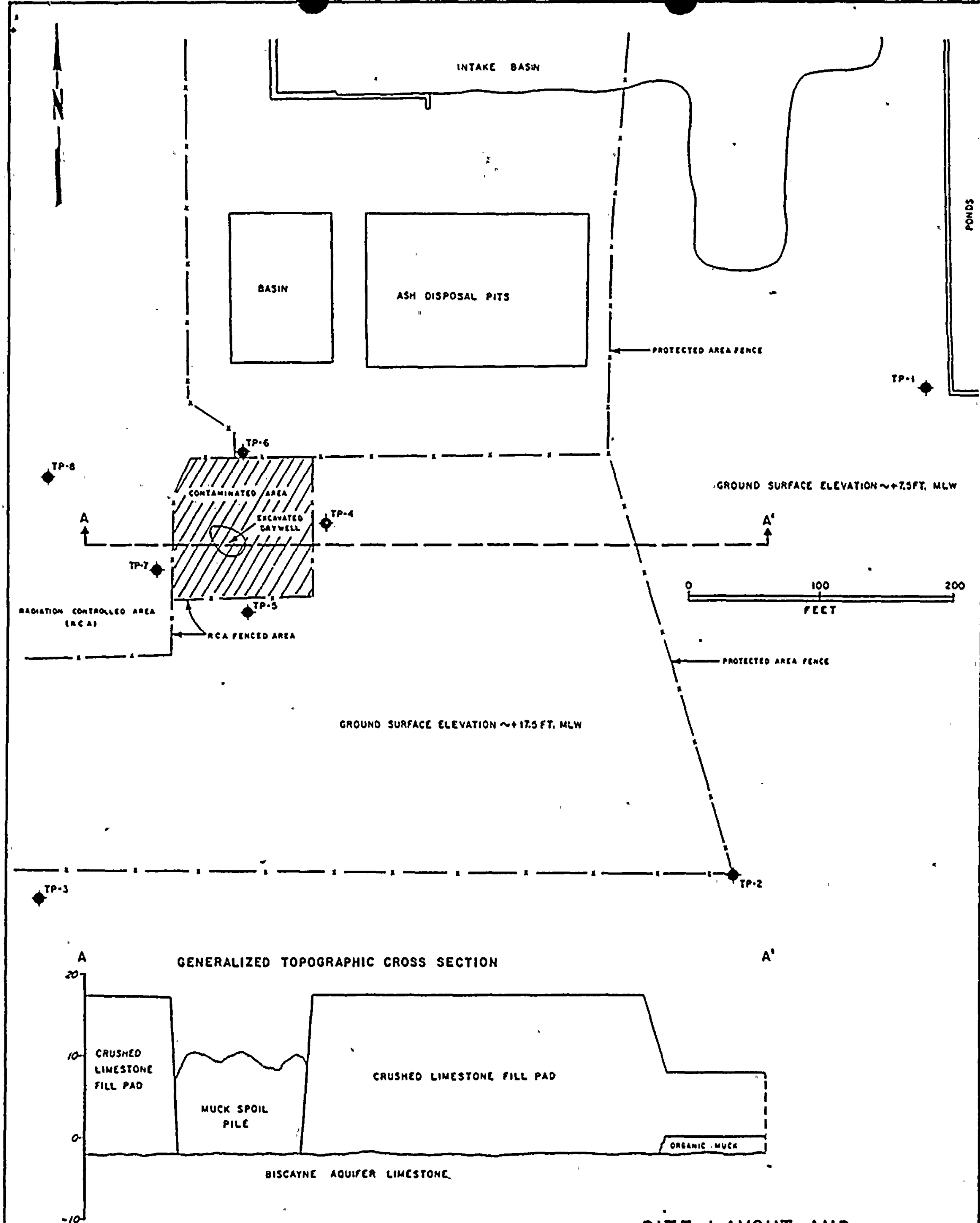
FIGURE 2

4598127 26(6/81)



SITE LAYOUT AND
MONITOR WELL LOCATIONS

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LOCATION: TURKEY POINT, FLA.

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FIGURE 1

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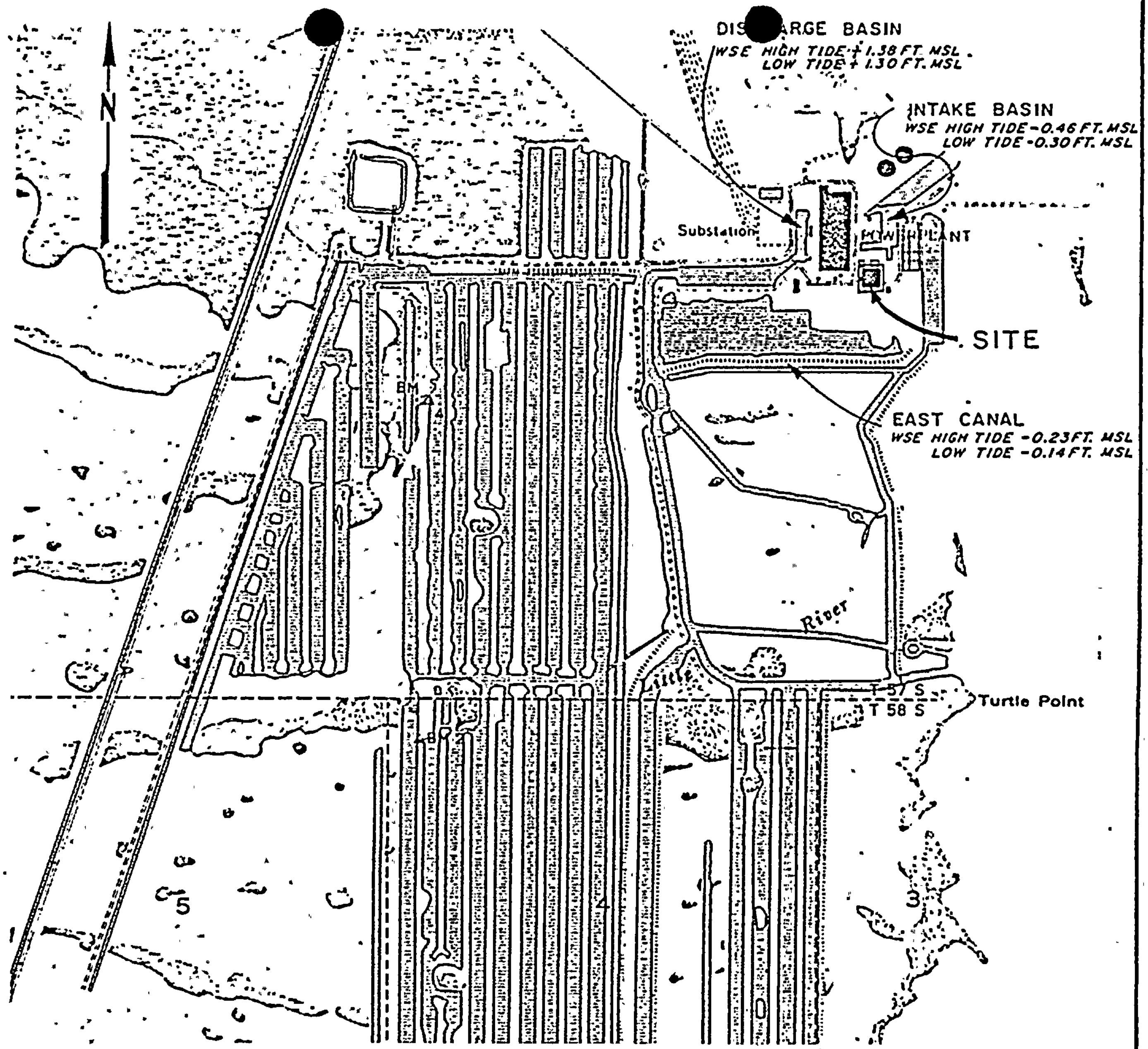

NOTE : WSE = WATER SURFACE ELEVATION
HIGH TIDE ON 6-17-81
LOW TIDE ON 6-19-81

SURFACE WATER ELEVATIONS

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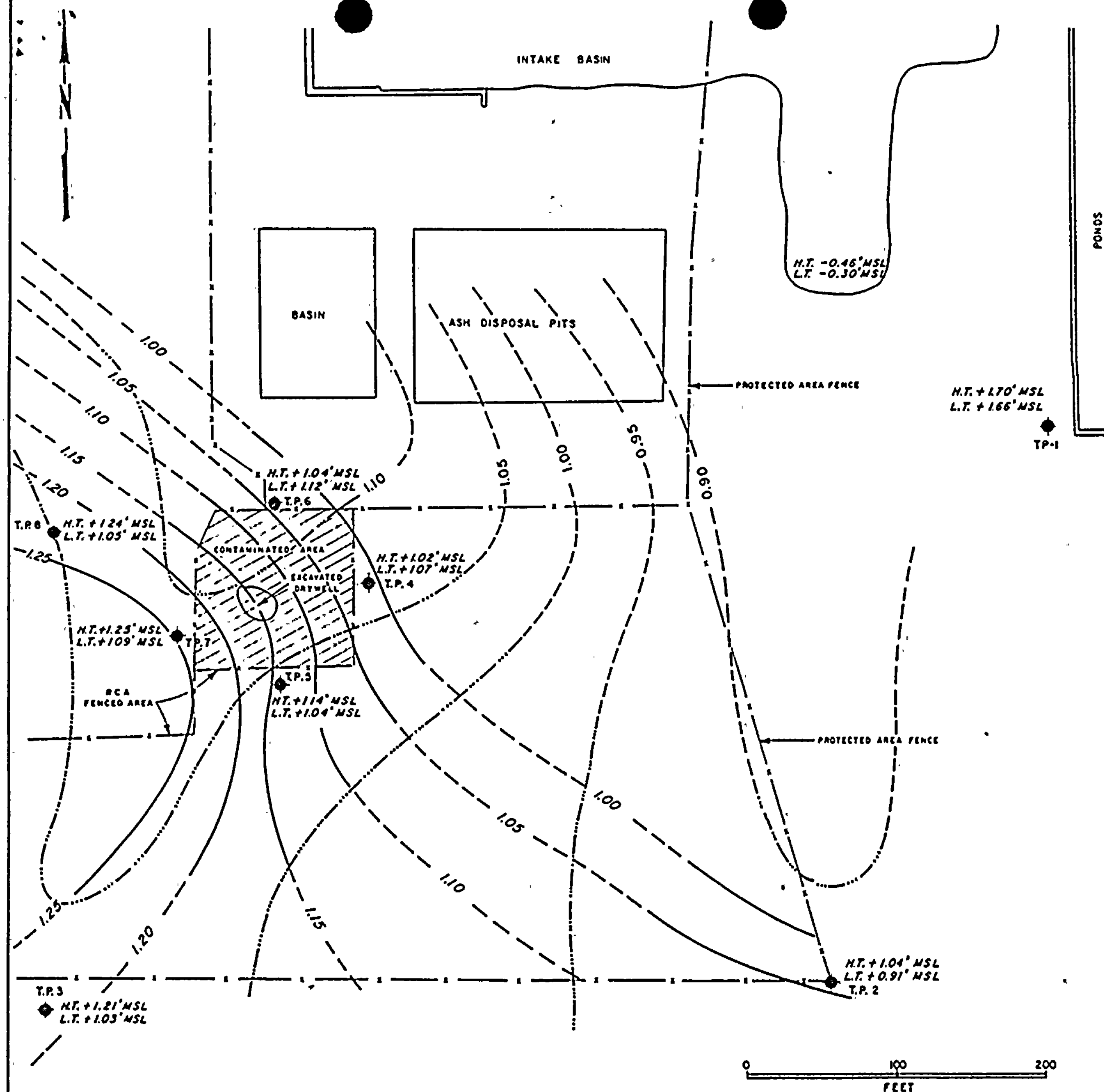
FIGURE 3

4598127 26 (6/81)

TABLE 4
RATES OF GROUND WATER MOVEMENT

	High Tide 6-17-81	Low Tide 6-19-81	Average
Rate through contaminated area	3.7×10^{-3} Ft/Day	4.7×10^{-4} Ft/Day	2.1×10^{-3} Ft/Day
Rate from contaminated area to Intake Basin	7.6×10^{-3} Ft/Day	7.2×10^{-3} Ft/Day	7.4×10^{-3} Ft/Day

Note: Rates are based on an assumed porosity of 30 percent, typical for Biscayne aquifer limestone.



KEY:

H.T. HIGH TIDE ON 6-17-81

L.T. LOW TIDE ON 6-19-81

100 ——— HIGH TIDE WATER TABLE ELEVATION CONTOURS IN FEET

100 ·········· LOW TIDE WATER TABLE ELEVATION CONTOURS IN FEET

NOTES:

CONTOUR INTERVAL = 0.05 FEET

MSL = MEAN SEA LEVEL

APPROXIMATE WHERE DASHED

WATER TABLE CONTOUR MAP

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LOCATION: TURKEY POINT, FLA.

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FIGURE 4

4598127 26(6/81)

TABLE 5
CATION EXCHANGE CAPACITY
TEST RESULTS

Boring Number	Depth Sampled (BGS)*	Cation Exchange Capacity (millequivalents per 100 grams of soil)
TP-1	8 - 9 1/2 Ft.	11.7
TP-2	8 - 9 1/2 Ft.	14.1
TP-3	8 - 9 1/2 Ft.	48.1

* BGS = Below Ground Surface