CONTAMINATION BY LANDFILL LEACHATE
SOUTH BISCAYNE BAY, FLORIDA

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In April 1987, four monitoring wells were drilled adjacent to a 46-m-high (150 ft) sanitary landfill near southern Biscayne Pay (Figures 1 and 2). The cored wells served two purposes: (1) they determined local stratigraphy and located the most permeable zone, and (2) they provided water samples for chemical analysis. Because surface and ground water flow is toward Biscayne Bay all four wells were drilled between the landfill and the Bay. Station A', consisted of one well drilled 30 m (100 ft) from the base of the landfill, and station A consisted of three wells approximately 150 m (500 ft) from the landfill (Fig. 2). The wells at station A consisted of one drilled to 1.5 m (5 ft), one to 4.5 m (15 ft), and one to 9.1 m (30 ft). The deep well was drilled first to determine depth to a regional, relatively impermeable unconformity called the Q3] (Perkins, 1977). The unconformity at station A consists of a 4-cm-thick (1.6 in), laminated calcrete crust like that presently forming on the surface of the Florida Keys (Multer and Hoffmeister, 1968; Robbin and Stipp, 1979; Shinn and Lidz, 1988). The Q3 horizon (Perkins, 1977) is located 5.1 m (17 ft) below land surface and approximately 4.5 m (15 ft) below mean sea level at site A. The dense, relatively impermeable calcrete layer caps a 40-cm-thick (16 in.), fine-grained freshwater limestone layer that is also relatively impermeable. Most significantly, the Q3 is overlain by a 40-cm-thick, highly porous and permeable zone containing leeched' interconnected porosity consisting of channels 1 to 2 cm in diameter. Permeability is so great that water circulation is lost when the zone is encountered by the drill bit.[1] This permeable zone occurs regionally, according to Perkins (1977), and has been found in all wells drilled in Florida Bay and Biscayne Bay by the USGS Fisher Island group. Monitoring wells were cased with 2.54-cm I.D. diameter (1 in.) PVC pipe. At station A, the pipe in the 1.5-m (5 ft) well is perforated between 1.2 and 1.5 m (4 and 5 ft), the 4.5-m (15 ft) well is perforated between 4 and 4.5 m (14 and 15 ft), and the 9.1-m 430 ft) well is perforated between 8.5 and 9.1 m (28 and 30 ft). At station A', 30 m (100 ft) from the landfill, the single well is also perforated between 4 and 4.5 m. The bottom end of all the PVC liners was left open.

All wells were cemented and sealed with Portland cement from the surface down to the perforated zones. Seven days after casing was set, 568 liters (150 gallons) of water were pumped from every well except the 1.5-m (5 ft) well, which was in such impermeable limestone that only a few liters could be removed. Water for chemical analysis was collected by lowering a 1-cm diameter (0.4 in) tygon tube to the perforated zone and pumping with a hand-operated EPA-recommended peristaltic pump. Samples were placed in sterilized vinegar bottles.

Chemical analysis

Water from the permeable zone above the unconformity at well A' (closest to the landfill) was greenish-yellow in color and had an extremely noxious odor much like a chemical solvent with a distinct H_2S and/or ammonia smell.

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[1] Fresh water was circulated through the drill pipe during drilling. Usually, the water flows up the annulus to the surface except when it is lost in a permeable formation.

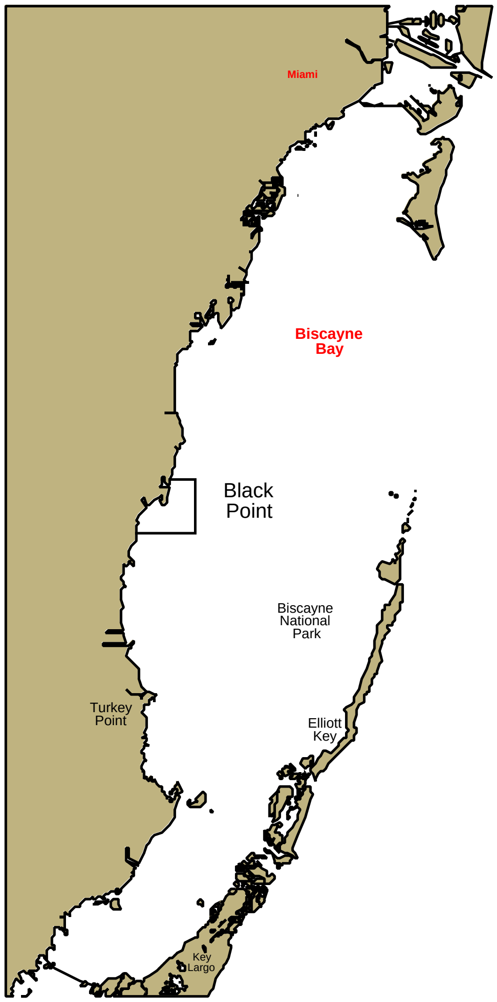

Figure 1. Map of southern Biscayne Bay showing location of Black Point study area.

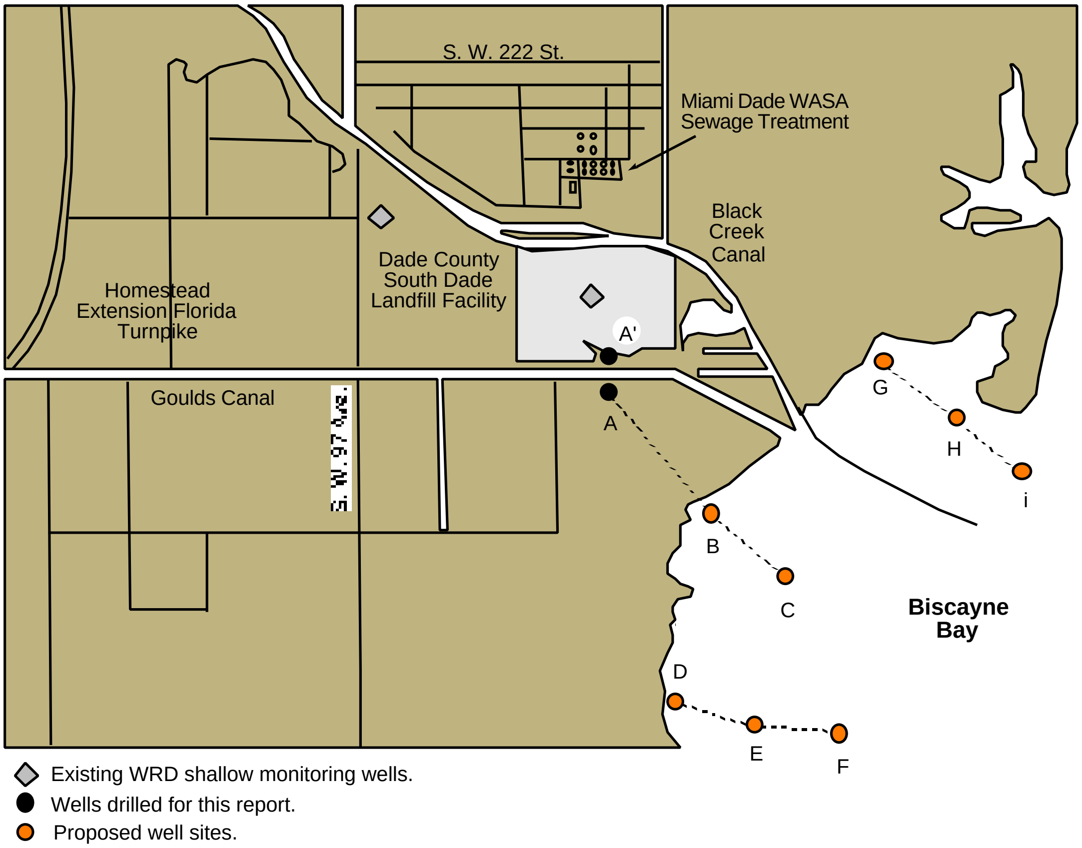

Figure 2. Detailed map of landfill area showing previous deep well, well stations A and A' drilled for this report, and proposed off shore wells.

Water from the 4.5-m (15 ft) well at station A 150 m (500 ft) from the landfill was clearer than that from well A' but had the same odor. Water from the 9.1-m (30 ft) well at station A (below the Q3 unconformity) was the clearest and had only a faint H_2S odor. All water samples were fresh according to field tests with an optical refractometer.

The results of chemical analyses are shown in Table 1.

DISCUSSION

The highest levels of the pesticides Lindane, Aldrin, o,p'-DDD, and Endosulfan, and the plasticizer dimethyl phthalate were found in the 4.5-m (15 ft) well at station A above the unconformity. In the 9.1-m (30 ft) well, only Aldrin, Endosulfan, and dimethyl phthalate were detected, and their concentration was about half that found in the 4.5-m (15 ft) well.

Surprisingly the discolored noxious smelling water from the 4.5-m (15 ft) well closest to the landfill did not contain detectable amounts of pesticides, and only a trace of the plasticizer dimethyl phthalate. Aliphatic and aromatic hydrocarbons were detectable in all wells with the least amount found in the 4.5-m (9.1 ft) well below the unconformity. Heavy-metal concentrations were not significant.

Using these chemicals as tracers, the analyses clearly show the confining effect of the Q3 unconformity and demonstrate the zone that should be monitored is between 4 and 5 m (14 and 17 ft) below the surface. We do not know why levels of pesticides are higher in the well farthest from the landfill but note that the two sites are separated by a 3-m-deep (10 ft) drainage canal. This canal (Goulds Canal) formerly drained agricultural lands to the west before being dammed to prevent contamination of Biscayne Bay. We also note that station A is on the same side of the canal as an abandoned private dump, where pesticides and other toxic wastes may have been discarded prior to establishment of the county-operated landfill. The county landfill is lined with fine-grained lime mud, locally called marl, which may impede downward percolation of leachate.

Bayward flow of both surface and subsurface water along the western margin of Biscayne Bay is well documented, and before draining of the Everglades in the 1920e and 1930s, drinkable water was collected in the Bay where it bubbled up through the porous limestone. There can be little doubt that during and after heavy rainfall, significant amounts of ground water flow out under and into Biscayne Bay. Figure 3 is a graphic model of how we think subsurface flow occurs.

RECOMMENDATIONS

Future subsurface monitoring should be targeted on the highly permeable zone above the Q3 unconformity. Existing monitoring wells placed below the Q3 unconformity, as were most of the wells presently being monitored as prescribed by the EPA, are not likely to detect contamination of ground water or enable determination of whether pollutants are entering Biscayne Bay. Some leakage of the Q3 unconformity undoubtedly occurs but during times of heavy rain flooding, major lateral flow will be above the unconformity. Such flow will undoubtedly enter the bay in a manner similar to that indicated in the model in Figure 3. To document this flow fully, wells should be established offshore in the permeable zone above the Q3 unconformity.

Sampling for contaminants should only be conducted following periods of heavy rainfall, rather than on a set schedule. A biological monitoring system should be established to determine effects if flow of contaminated water into the Bay is confirmed.

ACKNOWLEDGMENTS

We thank Harold Hudson and Jack Kindinger of the USGS Fisher Island Station for their expertise during drilling and setting of casing. We also thank Bradley G. Waller and Aaron Higer of the USGS Water Resources Division for encouragement and background information concerning hydrologic gradients. Sea Grant officers Donald Pybas and Bill Fox, and Richard Curry of Biscayne National Park provided encouragement throughout this pilot project. Barbara Lidz of the USGS Fisher Island Station aided in preparation of the data. Oiva Joensuu of Spectroanalytica, Inc. performed the trace metal analyses.

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Table 1.

Pesticides (ng/L)

Well	Lindane	Aldrin	o,p-DDD	Endosulfan
A-15	307.7	98.3	47.6	147.4
A-30	BDL	69.1	BDL	69.4
A`	BDL	BDL	BDL	BDL

Plasticizers (µg/L)

A-15	33.6
A-30	11.0
A’	1.5

Aliphatic hydrocarbons (µg/L)

	C-12	C-13	C-14	C-15	C-16	C-19	C-24
A-15	0.023	0.0203	0.008	BDL	BDL	0.181	0.582
A-30	BDL	BDL	BDL	BDL	BDL	0.038	0.52
A’	BDL	BDL	BDL	0.036	0.027	BDL	BDL

Aromatic hydrocarbons (µg/L)

	Acenaphthene	Fluorene
A-15	0.046	BDL
A-30	BDL	BDL
A’	0.054	0.412

Trace elements (mg/L)

	As	Cd	Cr	Cu	Fe	Pb	Sn	Hg
A-15	<0.01	<0.01	<0.01	<0.01	<0.2	<0.1	<0.5	<0.002
A-30	<0.01	<0.01	<0.01	<0.01	<0.2	<0.1	<0.5	<0.002
A’	<0.01	<0.01	<0.01	<0.01	<0.2	<0.1	<0.5	<0.002

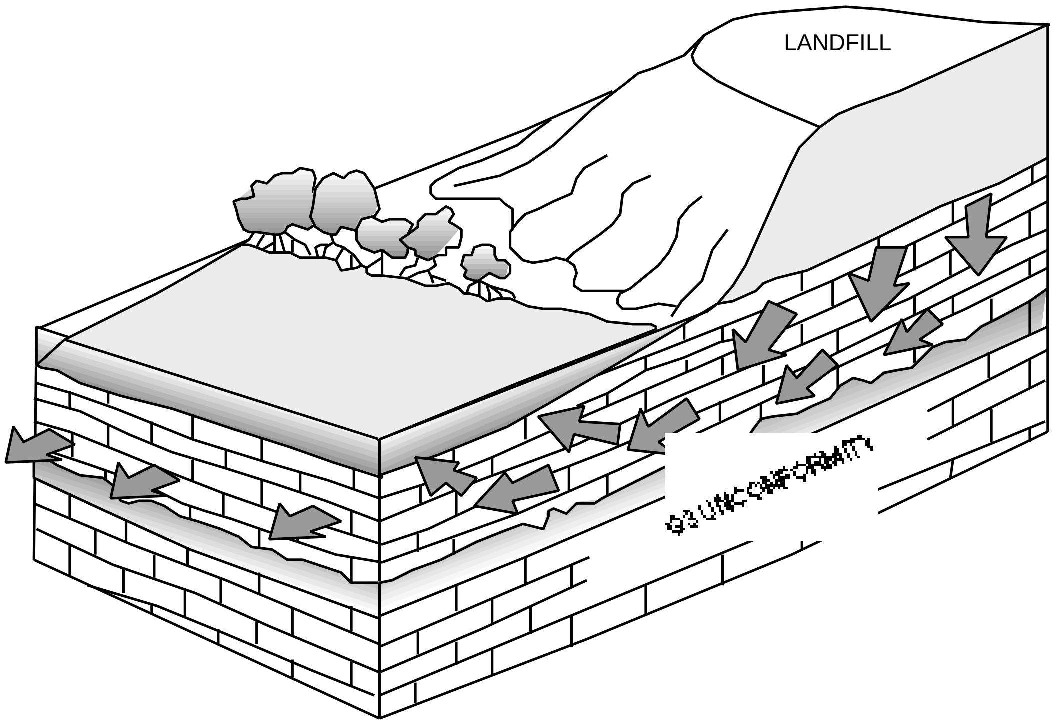

Figure 3. Schematic model of Black Point landfill area showing effect of Q3 unconformity on subsurface water flow