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RECONNAISSANCE OF THE EFFECT OF LANDFILL LEACHATE ON THE WATER QUALITY OF MARSHALL BROOK, SOUTHWEST HARBOR, HANCOCK COUNTY, MAINE

Open-File Report 80-1120

Prepared in cooperation with the

WATER RESOURCES PROGRAM
OFFICE OF SCIENTIFIC STUDIES
NATIONAL PARK SERVICE
NORTH ATLANTIC REGION

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Boston, Massachusetts

1980

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

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CONVERSION FACTORS

The following table may be used to convert inch-pound units to International System Units (SI).

Multiply inch-pound units	By	To obtain SI Units
	Length	
mile (mi)	1.609	kilometer (km)
	Area	
acre	0.4047	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
cubic foot per second (ft^3/s)	28.32	liter per second (L/s)
gallon per minute (gal/min)	.06309	liter per second (L/s)

RECONNAISSANCE OF THE EFFECT OF LANDFILL LEACHATE ON THE WATER QUALITY OF MARSHALL BROOK, SOUTHWEST HARBOR, HANCOCK COUNTY, MAINE

By Bruce P. Hansen

ABSTRACT

A small stream (2.2 square miles drainage area) receiving leachate from a landfill was studied from August through November 1979 to determine the impact of the leachate on water quality. The presence of un-ionized ammonia, considered toxic to some aquatic vertebrates, was indicated in samples taken from sections of the stream affected by leachate. Some dissolved oxygen values did not meet the criteria for the protection of aquatic life. Many other dissolved constituents were present in elevated concentrations in the leachate-influenced reaches of the stream. Flow-data comparisons indicate that streamflow less than that observed will occur approximately 20 percent of the time. Leachate-affected stream conditions may deteriorate further during such low streamflow. Several areas with the potential for large sediment yields are present in the basin.

INTRODUCTION

This report presents the results of a reconnaissance of surface-water quality in the Marshall Brook basin in Southwest Harbor, Maine (fig. 1). The study was made by the U.S. Geological Survey in cooperation with the National Park Service.

Marshall Brook was once considered one of the best trout streams in the area. It has reportedly declined as a fishery because of impaired water quality resulting from a landfill. Because of the desire of the National Park Service to preserve the water quality in Acadia National Park, it asked the U.S. Geological Survey to assess the water quality of Marshall Brook, including the possible impact from the nearby landfill or other sources of contamination.

The cooperation and help of the National Park Service officials, State of Maine officials, and landowners in the study area are acknowledged.

Previous Investigations

Results of analysis by the Maine Health and Welfare Laboratory of water samples previously taken from the Marshall Brook area by the National Park Service and the MDEP (Maine Department of Environmental Protection, Bureau of Land Quality Control), were available. Information provided by Robert Farrell of the MDEP, from his study of the Worcester Landfill and its vicinity was very useful. Surficial deposits are shown on a map of the Mount Desert quadrangle by Borns (1974) and the bedrock formations are shown and discussed in a report by Chapman (1962).

Methods

Fieldwork lasted from August through November 1979 and included collection of water samples for chemical analysis, collection of biological samples for analysis of periphyton and benthic invertebrates, and measurement of stream discharge, specific conductance, and temperature. A reconnaissance of the geology and a ground survey to verify and delineate actual and potential sources of contamination were also made.

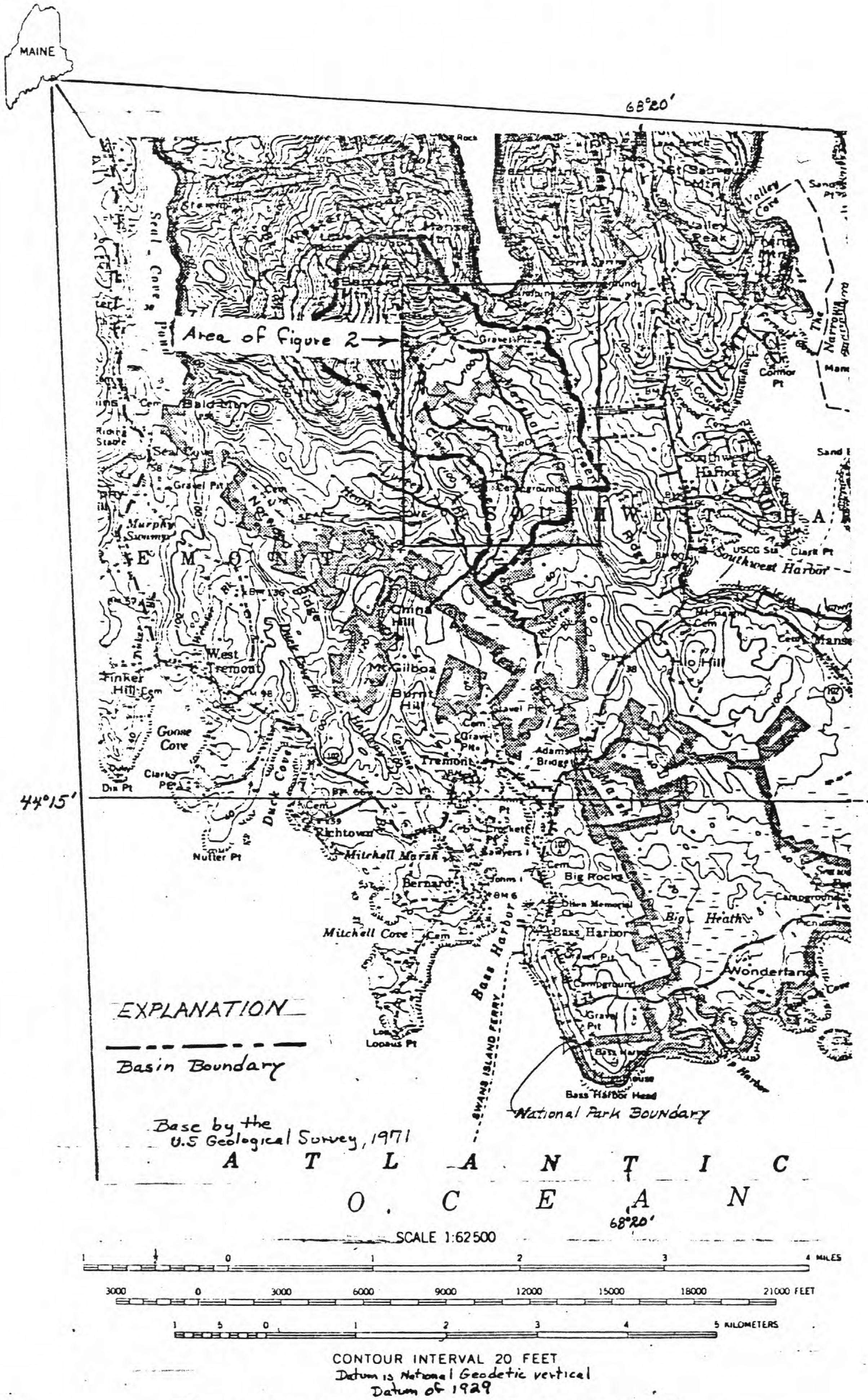

Figure 1.--Location of Marshall Brook basin

Samples of water for chemical analysis were collected at sites 1-5 (fig. 2) on Sept. 9, 1979, and Oct. 18, 1979. The samples were collected and analyzed by methods described by the Geological Survey (Skougstad and others, 1979).

Benthic invertebrate samples were collected and analyzed at sites 1-5 by methods suggested by the Geological Survey (Greeson and others, 1977). Jumbo multiplate samplers (artificial substrated) for benthic invertebrate colonization were secured to the streambeds in riffle areas on Sept. 11, 1979, and removed after 6 weeks.

Periphyton samples were collected at sites 1-5 using artificial substrates made of polyethylene. These were secured below water level and left for the same 6-week period as the benthic invertebrate samplers.

All chemical and biological samples were analyzed by the Geological Survey.

Measurements of stream discharge, dissolved oxygen, pH, temperature, and specific conductance were made at sites 1-5 when stream water samples were collected. Stream discharge, temperature, and specific conductance were also measured six additional times during the study at site 4. Specific conductance and temperature measurements were made at sites 2A, 2B, 2C, 2D, 4C, and 4D shown on figure 2, along Marshall Brook.

Basin Location and Characteristics

The Marshall Brook basin is on the southwest side of Mount Desert Island, Maine, in the town of Southwest Harbor. The basin heads on the southeast slope of Bernard Mountain and the southwest slope of Manset Mountain. This part of the basin is characterized by steep slopes and abundant areas of exposed bedrock. Runoff is rapid during precipitation, and base flows are low. Most of the stream below Mountain Road is characterized by low gradients, with many reaches of sluggish flow.

Streamflow is sustained through dry periods by ground-water discharge from unconsolidated surficial deposits of till and some ice-contact sand and gravel. These deposits are at least 30 feet thick in some of the morainal ridges. Marine deposits overlie these glacial deposits in low-lying areas and may constitute most of the unconsolidated material underlying the low, flat areas adjacent to the stream channels.

The basin is mostly forested, and about 27 percent of it is within Acadia National Park. That part outside the park contains several houses, a campground, several active and inactive gravel pits, and a landfill (figs. 1 and 2).

The landfill (area A, fig. 2) has been used to varying degrees since the mid-1930's, when it was first used as a dump for a Civilian Conservation Corps camp. According to estimates from a recent study (Mount Desert Island League of Towns, 1979), a total of about 6700 tons of refuse is being deposited each year at the landfill. Of this total, 3000 tons is deposited during the summer and the remaining 3700 tons during the rest of the year. This estimate includes a small amount of material deposited and burned in a different area. At present, the filled area is about 9.5 acres. The landfill rests on an original land surface that slopes gently to the south-southeast. The fill is thinnest near Mountain Road and thickest at the southeast face, where it is estimated to be 30 to 40 feet thick.

Leachate is generated by the reaction of air and water with the landfill during the downward percolation of precipitaton. This leachate emerges as seeps at the toe of the embankment on the south and southeast edges and flows into drainage ditches around the landfill. From the intersection of these ditches at the south end of the landfill, the leachate flows as a definable stream through a swampy area in which leachate-enriched ground water may also be discharging. The stream of leachate enters Marshall Brook at site 4E.

CHEMICAL QUALITY OF SURFACE WATER

Specific Conductance

Marshall Brook is a dynamic system whose constituents and characteristics are continually changing with time and location along its course. The water samples represent the conditions only at a single location at a specific time. The landfill leachate has a large influence on the water quality of Marshall Brook downstream from its discharge to the brook at site 4E. On

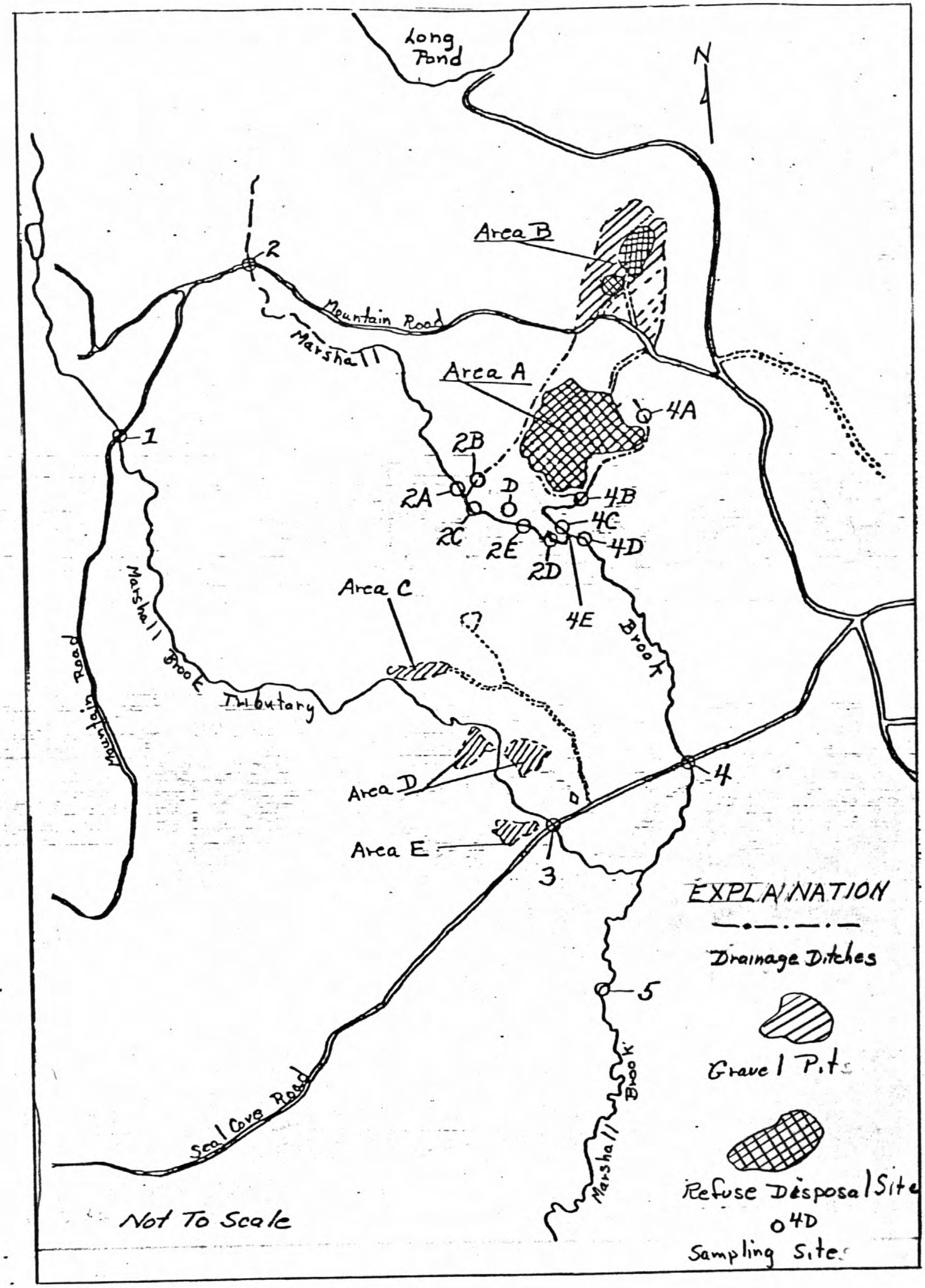

Figure 2.--Location of sampling sites and described areas, Marshall Brook basin, Southwest Harbor, Maine

September 25, the specific conductance (an index of dissolved-solids content) of the leachate discharge at site 4C, was 3200 umhos (micromhos) as compared with 71 umhos for Marshall Brook at site 2D just upstream (table 1). At site 4D just downstream from the discharge, the specific conductance was 780 umhos as a result of mixing. Specific conductance and thus dissolved-solids concentration decrease downstream from site 4E primarily due to dilution from ground water and tributary stream inflow and, to a much lesser degree, to precipitation of insoluble compounds formed by chemical reactions taking place in the stream, nutrient uptake by aquatic plants, and adsorption on streambed sediment.

Table 1.—Conductivity and temperature in Marshall Brook basin, September 25, 1979

Site No.	Time (EDT)	Temperature (°C)	Conductivity (umhos/cm at 25°C)	Site No.	Time (EDT)	Temperature (°C)	Conductivity (umhos/cm at 25°C)
2	1435	11.2	50	2D	1355	10.5	71
2A	1315	10	46	4C	1350	11.8	3200
2B	1300	14.9	138	4D	1400	10.9	780
2C	1320	10.1	59	4	1520	11.1	390
D	1330	10.2	240	1	1448	11.3	45
2E	1335	10.0	59	3	1511	10.4	43

Discharge and specific conductance measurements made at site 4 (table 2) indicate that as discharge decreases dissolved-solids concentration increases (fig. 3). This relation results from dilution of the relatively constant quantity of leachate by variable quantities of uncontaminated runoff. The maximum dissolved-solids concentration (215 mg/L) was measured on September 13, 1979.

Table 2.—Specific conductance, discharge, and temperature of Marshall Brook at Seal-Cove Road, Site 4, Southwest Harbor, Maine, 1979

Date	Time (EDT)	Discharge (ft^3/s)	Specific conductance (umhos/cm at 25°C)	Temperature (°C)	Date	Time (EDT)	Discharge (ft^3/s)	Specific conductance (umhos/cm at 25°C)	Temperature (°C)
9-13	0945	0.18	660	9.5	10-5	0856	—	105	12.5
9-28	1040	.25	545	10.5	10-18	0845	0.90	280	7.5
10-2	1700	4.13	82	14.2	10-23	0942	—	300	11.0
10-3	1400	2.57	123	14.2	10-24	1415	.58	315	14.0

Dissolved-solids concentrations in leachate-affected water can be expected to be greater at flows less than those observed during this study. Records for the nearest stream with continuous discharge measurements (Garland Brook near Mariaville, Maine, 31.3 miles north) show that the discharge on September 13 is equaled or exceeded 80 percent of the time. Because the antecedent precipitation conditions and the physical characteristics of the two basins are similar, the flow in Marshall Brook was probably in the same range of the flow duration. This indicates that approximately 20 percent of the time, the discharge of Marshall Brook at site 4 will probably be less than the 0.18 ft^3/s observed on September 13, 1979.

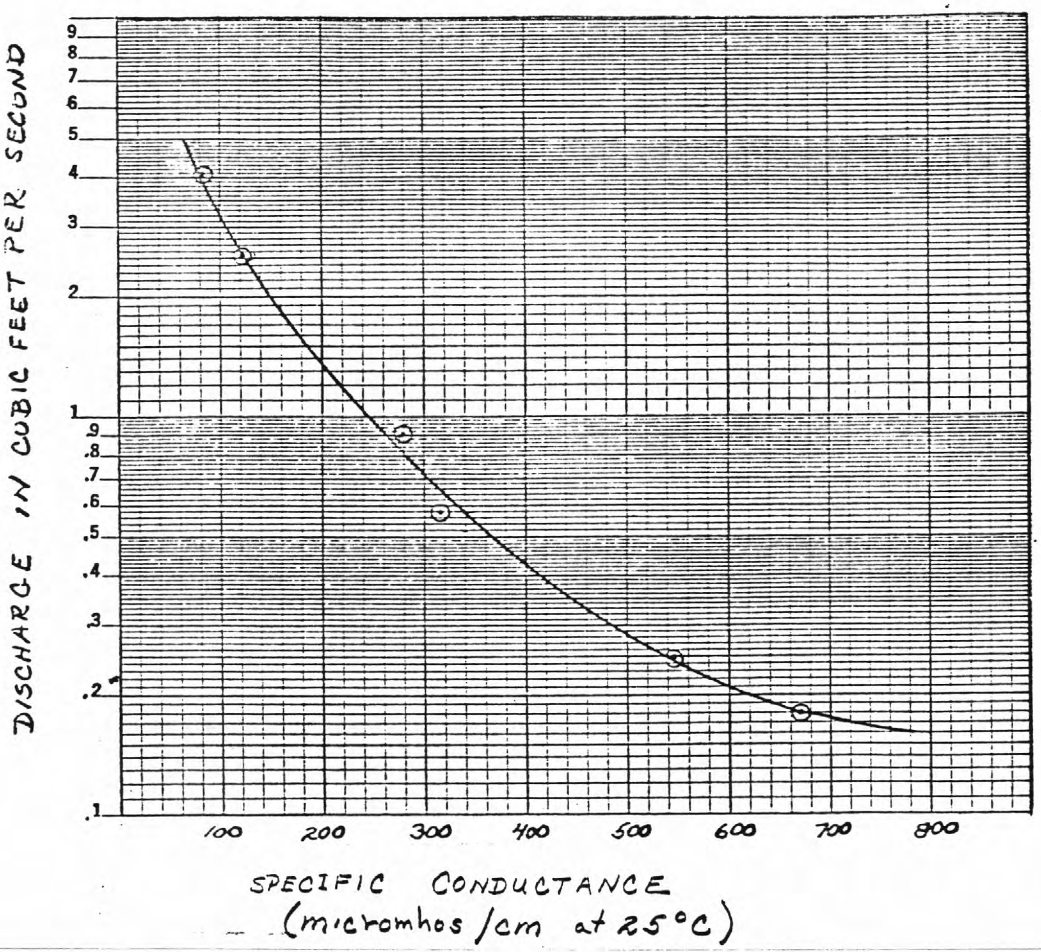

Figure 3.--Relationship between specific conductance and discharge in Marshall Brook at Seal Cove Road, Southwest Harbor, Maine, September-October 1979

A great number of other factors may affect the dissolved solids concentrations in the brook. Several examples are given below:

1. Seasonal variations in refuse deposition and climatic conditions will cause temporal variations in the volume and strength of the leachate being discharged, and

2. Long-term leachate concentrations are expected to continue to increase as long as the landfill remains active (U.S. Environmental Protection Agency, 1977).

Chemical Quality of Water Samples

Chemical quality of surface water, other than that in proximity to the landfill, ranged from that unaffected by leachate (sites 1-3) and having low (29-32 mg/L) dissolved-solids concentrations to leachate influenced (sites 4 and 5) with moderate (55-215 mg/L) dissolved-solids concentrations (table 3). Leachate-influenced water showed marked increases in many constituents.

Nitrogen levels were considerably elevated in water affected by leachate. Soluble nitrogen is increased by decomposition of organic matter in the landfill. Although the ammonium ion predominated at site 4, organic nitrogen and more stable oxygenated forms (nitrite and nitrate) were present in higher percentages at site 5. The un-ionized ammonia concentrations at sites 4 and 5 on September 13 were calculated to be approximately 0.82 and 0.03 mg/L. Un-ionized ammonia concentrations ranging from 0.88 to 0.39 mg/L are toxic to rainbow trout (Lloyd and Herbert, 1960; Lloyd, 1961; Lloyd and Orr, 1969; Herbert and Shurben, 1965; and Ball, 1967). The recommended limit of un-ionized ammonia safe for freshwater aquatic life is 0.02 mg/L (National Academy of Science and National Academy of Engineering, 1972).

The hardness of the unaffected water at sites 1, 2, and 3 was very low (6-9 mg/L) while it was moderately hard (82 mg/L) at site 4. The high carbonate hardness at site 4 results mainly from the increased amounts of dissolved calcium and magnesium.

Alkalinity, which is a measure of the capacity of a water to neutralize acids, was higher (110 mg/L) at site 4 than at sites 1, 2, 3, and 5 (2-4 mg/L). Aerobic decomposition of the organic matter in solid waste releases carbon dioxide, which, through a series of reactions, produces the bicarbonate ion, which is frequently a major anion in leachate. Because of the reversibility of the reaction-producing bicarbonate, it acts as a pH buffer. This reaction also results in a decrease in the hydrogen-ion concentration, producing a solution of high pH.

Other dissolved constituents, including sodium, potassium, chloride, silica, iron, manganese, magnesium, and phosphorus, have been found in higher concentrations in leachate-influenced water (tables 3 and 4).

A zinc concentration of 0.18 mg/L was found in one sample collected in 1976 at site 4B, just below the landfill. This concentration of zinc possibly may have toxic effects on some aquatic life (National Academy of Science and National Academy of Engineering, 1972, p. 182). Other trace constituents, including arsenic, cadmium, chromium, lead, mercury, and selenium, were not detected or were detected in very low concentrations (0-2 ug/L).

Dissolved Oxygen

Dissolved oxygen concentrations ranged from 3.6 mg/L at leachate-influenced site 4 to 10.9 mg/L at site 1, corresponding to 31 and 94 percent saturation, respectively. Fish require concentrations above 4 mg/L to survive, and this minimum is not met in at least the reach of Marshall Brook between sites 4 and 4E. Any reduction in the dissolved oxygen concentration of natural water may cause adverse effects on reproduction and growth of fish inhabiting those waters (National Academy of Science and National Academy of Engineering, 1972).

Table 3.--Chemical analyses of stream water, Marshall Brook and tributary, Southwest Harbor, Maine, 1979

(Site locations are shown in figure 2. Analyses for dissolved constituents are given in milligrams per liter except as indicated.)

Site numbers	1		2		3		4		5	
Dates	9-13	10-18	9-13	10-18	9-13	10-18	9-13	10-18	9-13	10-18
Discharge, (ft^3/s)	0.12	0.48	0.01	0.06	0.34	1.38	0.18	0.90	0.69	2.85
Temperature (°C)	13.5	9.0	13.5	9.5	10.5	7.5	9.5	7.5	10.5	8.5
Oxygen	8.9	10.9	8.8	9.9	7.6	9.9	3.6	6.6	8.1	8.8
Oxygen (percent saturation)	85	94	84	86	68	82	31	55	72	75
pH (units)	6.3	6.1	6.0	6.0	6.5	6.2	7.6	6.8	7.1	6.6
Specific conductivity (umho/cm at 25°C)	53	52	53	55	55	49	660	280	222	125
Nitrogen nitrite, NO_2 as N	.00	.00	.00	.00	.00	.00	.03	.01	.02	.00
Nitrogen nitrate, NO_3 as N	.02	.06	.02	.11	.02	.01	1.3	1.5	.98	.61
Nitrogen nitrite and nitrate as N	.02	.06	.02	.11	.02	.01	1.3	1.5	1.0	.61
Nitrogen ammonia as N	.03	.03	.03	.01	.05	.04	41	10	4.3	2.6
Nitrogen organic as N	.33	.59	.16	.08	.19	.38	.00	2.0	8.7	.80
Nitrogen ammonia and organic as N	.36	.62	.19	.09	.24	.42	40	12	13	3.4
Nitrogen, total as N	.38	.68	.21	.20	.26	.43	41	14	14	4.0
Phosphorus, ortho as P	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00
Phosphorus, total as P	.00	.00	.00	.01	.00	.01	.05	.03	.02	.01
Hardness, total as $CaCO_3$	8	8	6	6	9	8	82	36	30	18
Hardness, noncarbonate as $CaCO_3$	6	5	4	5	5	6	0	0	28	3
Calcium	2.3	2.0	1.5	1.5	2.4	1.9	19	9.1	7.2	4.5
Magnesium	.5	.7	.5	.6	.8	.7	8.4	3.2	2.9	1.7
Sodium	5.4	5.3	5.6	5.7	5.6	5.4	36	17	14	9.9
Potassium	.4	.3	.1	.2	.4	.3	20	6.6	5.6	2.3
Alkalinity as $CaCO_3$	2	3	2	1	4	2	110	36	2	15
Chloride	6.5	6.0	7.0	6.8	7.1	6.8	49	25	20	14
Sulfate	7.1	7.7	7.3	7.5	6.3	5.8	6.5	6.5	5.7	5.7
Silica	7.0	6.9	6.1	6.0	6.4	6.9	9.7	7.5	7.8	7.3
Iron (ug/L)	0	20	0	0	110	130	480	400	240	230
Arsenic (ug/L)	0	0	0	0	1	1	1	0	1	0
Cadmium (ug/L)	1	0	2	0	1	0	0	0	0	0
Lead (ug/L)	0	4	1	2	1	2	2	3	1	2
Mercury (ug/L)	.5	.1	.5	.1	.5	.2	.5	.1	.5	.1
Selenium (ug/L)	0	0	0	0	0	0	0	0	0	0
Dissolved solids	30	31	29	29	32	29	215	97	65	55

Table 4.--Miscellaneous chemical analyses of surface water in the Marshall Brook basin

Part A.--Analyses reported by the Maine Department of Environmental Protection, collected September 19, 1979.

Site	pH (units)	Specific Conductance (umhos/cm at 25°C)	TOC (ppm)[1]	Nitrate and nitrite as N (ppm)	Iron (ppm)	Manganese (ppm)
2B	6.7	100	5	0.19	0.42	0.034
2C	6.3	60	8	.07	1.4	.050
3	6.4	40	8	.04	.19	.012
4A	6.9	100	21	.06	1.4	.11
4B	7.1	1850	140	4.0	10	.70
4C	7.3	1800	78	5.9	13	.51
4	7.1	400	15	1.5	.19	.26

[1]The unit, parts per million, is approximately equal to milligrams per liter.

Part B.--Analyses reported by the Maine Health and Welfare Laboratory, samples collected by the National Park Service.

	Lower Marshall Brook	Upper Marshall Brook	Marshall Brook, site 4
Date collected----	June 1, 1974	June 1, 1974	June 29, 1974
Color (units)-----	80	5	165
Turbidity (units)-	5	0	8
Hardness as $CaCO_3$ (ppm)---	50	50	65
Nitrite (ppm)-----	.02	.02	.02
Nitrate (ppm)-----	1.0	1.0	1.0
Iron (ppm)--------	3.72	.2	2.88
Manganese (ppm)---	.11	--	.14
Copper (ppm)------	1	1	1
Chloride----------	28	10	50
Total coliform bacteria per 100 ml------	20	2	57

Part C.--Analyses reported by the Maine Department of Environmental Protection, collected July 8, 1976.

Site--------------	2B	4B
Calcium (ppm)-----	2	95
Magnesium (ppm)---	3	30
Chromium (ppm)----	.1	.1
Zinc (ppm)--------	.03	.18
Lead (ppm)--------	.4	.4
Iron (ppm)--------	1.3	32
Manganese (ppm)---	.3	2.3
Copper (ppm)------	.02	.02

Benthic Organisms

The invertebrate animals inhabiting the bottom of lakes and streams travel very little during their life span in water. Because most benthic invertebrates live several months, the composition of the benthic community reflects the prevailing environmental quality of the stream reach in which they are sampled. All other conditions being equal, samples from an unpolluted reach will show differences in abundance and kinds (greater diversity) compared with samples from a polluted reach. Benthic invertebrates are useful indicators of water quality because they are residents of the sampled reach and because their lives depend on the chemical and physical environment of the reach throughout their life span. Their absence in a stream of apparent good water quality may indicate transient or intermittent discharge of contaminants that may not be detected by periodic chemical sampling.

The benthic invertebrate samples taken in the Marshall Brook basin support the results of the chemical sampling, which indicates that discharging leachate affects the downstream biological community. The results of the analysis of the invertebrate samples (table 5) show that station 4 and to a lesser extent, station 5, which are in the affected reach, have small diversity indices, which reflect a small number of different taxa present and a large number of individuals in one taxon.

Certain precautions should be taken when evaluating the results of the benthic sampling. Although the level of taxonomic classification, method of collection, and season of the year were consistent, the physical habitat of each sampling location was somewhat different. Sampling locations were chosen in riffle areas of sand and gravel, but certain conditions at each site were different. The quantity of flow at each site was a function of its location. Site 2 is in a reach that possibly goes dry during some very low-flow periods. The reach near 4 and 5 generally has more fine bottom sediments than that near 1, 2, and 3. Also, more samples (2-5) need to be taken at each site (Wilhm, 1970). Wilhm and Dorris (1968) found that the diversity reached 95 percent of the asymptotic diversity (that value of diversity that essentially does not change with the addition of new samples) before five samples were collected. A comprehensive study of the affected reach by an aquatic biologist would be needed for a detailed assessment.

POTENTIAL SEDIMENT YIELD

All streams transport sediments eroded from the land. The quantity carried at any time depends on the rate of erosion which, in turn, relates to climate, vegetation, slope, and soil and rock properties. The sediment load also depends upon and generally increases with increased streamflow. The composition and quantity of sediment are important because of their effects on light penetration, temperature, availability of minerals for dissolution, transport of sorbed chemicals, and on the physical environment of aquatic biota. For example, the covering of plants and benthic animals with sediment as well as the blanketing of important habitats, such as spawning sites or surfaces to which some life forms attach themselves, can cause considerable changes in the aquatic ecosystems.

Human activities may alter the sediment regimen and may cause changes in sediment yield. Although no quantitative measurements of sediment discharge were made in the basin, those areas that have a potential for increased sediment discharge resulting from human activities are identified on the site location map (fig. 2) and are discussed below.

Area A: The landfill operation south of Mountain Road, which is the source of leachate entering Marshall Brook, also has about 10 acres of exposed cover material. The surface of this material is gently sloping at present, but grading operations are directed toward increasing the surface runoff in order to decrease infiltration and, thus, leachate generation. The steep slopes of the cover material at the edge of the landfill are highly susceptible to erosion. This entire area has a high potential for the discharge of large quantities of sediment, and that potential is likely to remain until a vegetal cover is established.

Table 5.--Benthic invertebrate identification, Marshall Brook basin, Southwest Harbor, Maine, September-October 1979

Organism name (Common name)	Station number				
	1	2	3	4	5
ANNELIDA					
HIRUDINEA (Leeches)					
Rhynchobdellida					5
Unknown order			1		16
OLIGOCHAETA (aquatic earthworms)					
Unknown order		1	26		
ARTHROPODA (Arthopods)					
CRUSTACEA					
Amphipoda (Scuds)			1		
INSECTA					
Coleoptera (Beetle)					
dytiscidae (predaceous diving beetle)				13	
Diptera					
ceratopogonidae (biting midges)					2
chironomidae (midges)	20	3	9	187	121
tipulidae (crane flies)					2
Ephemeroptera (may flies)			3		
Lepidoptera (lepidopterans)		1			
Plecoptera (stone flies)	29	3	12		23
Trichoptera (caddis flies)	2	5	3	2	
MOLLUSCA (Molluscs)					
BIVALVIA (Bivalves)					
Nuculoidea					
sphaeriidae (fingernail clams)					55
Schizodonta					
unionidae			4		
Total count	51	13	59	202	224
Diversity indices (based on actual counts)					
Phyllum	.0	.4	1.3	.0	1.2
Class	.0	.4	1.5	.0	1.3
Order	1.2	2.1	2.2	.4	1.7
Within Class Insecta	1.2	1.8	1.8	.4	.6

Area B: This area is a large sand and gravel pit, part of which is used for the disposal of burnable and metallic refuse. The topographic map indicates that this area is within the Marshall Brook basin, but the local removal of large volumes of material may have changed it to an area with little or no external surface drainage. If the surface drainage from this area flows to Marshall Brook, it could be a source of sediment. Spirit leveling of drainage features or observations of flow during high intensity precipitation would be needed to determine the direction of surface drainage.

Area C: This area is a large pit being used as a source of unconsolidated material. As of September 1979, at least part of this pit could drain to the Marshall Brook tributary, which flows along the west side of the pit. It is a potential source of moderate sediment yield. The potential for sediment discharge may change as pit geometry changes.

Area D: This area contains several small gravel pits associated with the Southwest Harbor Highway Department facility. Vegetal cover is returning, and the potential for sediment yield is small and will decline as vegetal cover is re-established.

Area E: This area is a small inactive gravel pit with closed surface drainage. No sediment can discharge from this area at the present time.

CONCLUSIONS

The discharge of leachate from the landfill site A modifies the chemical quality of Marshall Brook downstream from the discharge point. Samples of water from the affected sites were characterized by higher concentrations of some heavy metals and nitrogen. Concentrations of many other dissolved constituents were greater than those found in unaffected waters in the basin. Concentrations of un-ionized ammonia, considered toxic to some aquatic vertebrates, were indicated. Some dissolved oxygen values did not meet the criteria established for the protection of aquatic life.

Benthic invertebrate samples indicate that the benthic community is affected by the quality of the stream water. The present and long-term impacts of the leachate-influenced water on the aquatic community can be determined only by frequent and comprehensive sampling of the aquatic community.

Comparisons of flow data from Marshall Brook with a nearby stream with a long-term discharge record indicates that discharge in Marshall Brook at site 4 will be less than 0.18 ft^3/s about 20 percent of the time. The extremes of the actual flow regime and the range of dissolved constituent concentrations can be defined only by a comprehensive program of discharge measurement and chemical sampling.

Areas with the potential for the discharge of large quantities of sediment exist in the basin. Sediment yields and sources can be defined only by sampling and observation during intense or prolonged precipitation that maximizes overland runoff.

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