FINAL SUBMITTAL
SANITARY LANDFILL SITE STUDY
NAVAL AIR STATION
ALAMEDA, CALIFORNIA
CONTRACT N62474-76-C-7543
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A Report Prepared For

Commanding Officer
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I INTRODUCTION

This report constitutes the final submittal of the results of the study undertaken by Harding-Lawson Associates (HLA) for the Western Division Naval Facilities Engineering Command (WESTNAVFACENGCOM) at the Alameda Naval Air Station Sanitary Landfill. This study is authorized by WESTNAVFACENGCOM Contract N62474-76-C-7543.

The purpose of the study is to review the landfill site performance relative to compliance with State and Federal regulatory guidelines; to evaluate the possible migration of landfill gases to adjacent areas; and evaluate the seepage of subsurface water into San Francisco Bay. The study includes recommendations for alternative measures, both short and long term, to correct deficiencies if and as required.

The scope of work included drilling test borings, installing observation wells, monitoring water quality and gas generation, laboratory testing, and analyses of the data obtained. The scope also included presentation of an interim operation plan for the disposal site through September 1977 and various long term plans including continued operation by the Navy, continued operation by a private contractor and closure of the site.

II SUMMARY

1. The purposes of the study are to review the landfill site performance relative to compliance with State and Federal regulatory guidelines; to evaluate the possible migration of landfill gases to adjacent areas; and to evaluate the seepage of subsurface water into San Francisco Bay and develop recommendations for alternative measures, both short and long term, to correct deficiencies if and as required.

2. The two major areas where compliance is in question are adequacy of cover material and leachate seepage from the site.

3. The actual cover thickness is not known over the entire site but it is estimated that about one-third the landfill lacks the required 12 inches of intermediate cover. This represents a deficiency of approximately 94,000 cubic yards of material.

4. A relatively small amount of water (about 700 to 1,300 gallons per day) is seeping from the site. It is slightly contaminated but is not significantly lower in quality than that of the adjacent bay. Therefore, unless required by regulatory agencies, it is recommended that the seepage not be corrected at this time.

5. Several alternative methods of stopping seepage are presented in case the regulatory agencies require it. The recommended method is a subsurface drain around the north and east perimeter of the landfill which will cause the flow to reverse from the perimeter. The collected subsurface water can be sprayed onto the landfill or disposed of at a sewage treatment plant.

6. Methane gas is being generated in the landfill. Most of it is venting vertically and adjacent structures appear to be unaffected by lateral migration at this time. When impervious cover is placed over the site perimeter, gas vents will be needed along the north and east boundaries. It is possible to combine this requirement with the perimeter drain.

7. Three options for landfill operations that were studied include:

   a. Navy Operated Landfill

      To continue operations, adequate intermediate cover should be placed and the area method of landfill construction should be utilized. Equipment and personnel can be reduced.

   b. Contractor Operated Landfill

      Adequate intermediate cover should be placed and a long-term operating plan should be developed by the Navy for the contractor to follow.

   c. Close The Landfill

      Closure will require placement of final cover over the site and planting. Gas control measures will be required and a site closure plan developed for the regulatory agencies.

8. Capital Cost Estimates

   a. Navy Operated Landfill

1.	Seepage repairs, if required	$71,000 to 780,000
2.	Placement of intermediate cover	$47,000

   b. Contractor Operated Landfill

      1. Seepage and cover placement costs are the same

   c. Close The Landfill

1.	Seepage repairs, if required	$71,000 to 780,000
2.	Place final cover	$140,000
3.	Install gas migration barrier	$63,000
4.	Plant grass and shrubs	$19,000 to $25,000
5.	Total	$293,000 to $1,008,000

9. Estimated Operating Cost Per Year

a. Navy Operated Landfill

1. Current costs $166,000

2. Costs after placement of cover $128,000

b. Contractor Operated Costs

1. Costs assuming cover has been placed $167,000

c. Close The Landfill

1. The only annual costs would be if seepage repair alternative 6 were selected and installed; it would cost about $5,000 per year.

III LANDFILL DESCRIPTION AND CURRENT OPERATIONS

A. Site Description and History

Prior to 1925, the U.S. Naval Air Station at Alameda was an area of tidal marsh and sloughs. It is underlain by bay mud which is a soft, gray silty clay containing minor amounts of sand and shells. The bay mud tends to become firmer with depth. Sand and clay fill were placed over the mud during the period 1925 to 1929. According to work by the California Division of Mines and Geology (Ref. 1), the bottom of the younger bay mud is as deep as 80 to 90 feet and the top of bedrock varies from a depth of 300 to 400 feet. According to a report (Ref. 2), filling began in 1956 with construction of the sea wall on the south and west sides and hydraulic placement of 15 to 20 feet of sand fill.

The landfill site occupies approximately 110 acres at the southwest corner of the Air Station, as shown on the Vicinity Map included on the Plot Plan, Plate 1. It has been divided into three areas designated A, B and C on the Plot Plan. After initial filling, clayey and sandy dredge spoil was added in Areas B and C. The sanitary landfill has been confined to Areas A and B. The present grade ranges from about Elevation 108.2 (elevations are in feet relative to the Alameda Naval Air Station Datum*) at Boring 6** to about 120 near the southeast corner; some sand stockpiles in the latter area are higher than Elevation 135.

* Alameda Naval Air Station Datum equals Mean Lower Low Water Datum + 101.2 feet.

** Boring locations are included on Plate 1.

Brief descriptions of the three areas are presented below.

1. Area A

Since 1958, this 51-acre area has received refuse fill and wastes from the Naval Air Station, Alameda, its ships and other Navy bases in the area. Only in recent years has the operation been limited to disposing of refuse from the Naval Air Station and its tenant commands. Filling operations were recently completed.

2. Area B

This 13-acre area was originally used for disposal of dredge spoil material as discussed in Paragraph 3 below. Subsequently, the area was used for disposal of refuse. Refuse is currently being placed as fill in the southeast portion of the area.

3. Area C

Area C (46 acres) and Area B were diked and used for the disposal of spoil from dredging operations. Records of the dredging operations at the Air Station (Ref. 3) show that about 360,000 cubic yards of spoils were deposited in 1970 and another 155,000 cubic yards in 1973. Most of it came from the pier areas, turning basin and entrance channel.

B. Landfill Operations

1. Fill Placement and Cover Materials

Former landfill operations consisted of (1) excavating about 20 feet of hydraulic sand fill; (2) filling the excavation with waste materials and excavated sand; and (3) covering the fill with the remaining sand.

The current operation of the landfill is confined to the southeast portion of Area B. A trench is excavated to just above the ground-water surface (depth of five to six feet) and the excavated material is stockpiled for future cover. Waste material is deposited at the working face of the excavation and is spread and compacted with bulldozers. The cover material, which consists of on-site dredge slurry sands and bay mud, is collected by dragline and front-end loader, hauled and deposited by a scraper and spread and track-rolled by bulldozers.

Initial inspections of the filling operations by HLA personnel indicated that insufficient material was used to cover the debris. This deficiency has been corrected by obtaining sufficient cover material from Area C.

It has been reported recently that birds have been a problem to aircraft using the runways adjacent to the landfill. The birds are probably attracted by the refuse exposed during filling, a common occurrence at many landfills close to the Bay.

The Air Station is a Federal facility subject to Public Law 94580, the Resources Conservation and Recovery Act of 1976, which requires that Federal facilities comply with all local and state solid waste regulations. In compliance with this law, the Navy Public Works Center, San Francisco Bay (PWC SFRAN) has applied for an operating permit from the Alameda County Health Services Agency for the NAS Alameda Sanitary Landfill.

2. Refuse and Cover Quantities

Table 1 presents the refuse quantities received at the site. Quantities are based on a weight survey conducted by WESTNAVFACENGCOM in April 1976 (Ref. 4).

Table 1

Refuse Quantities Received At
The Sanitary Landfill

Facility	Tonnage/Day
Naval Air Station Alameda	18.5
Naval Air Rework Facility	5.5
Ships	12.5
Total	36.5

Notes:

95 percent of refuse is dry trash; the remainder is wet garbage

Separation of recyclable refuse materials will offset normal solid waste quantity increases

4.5 tons/day of wet garbage from base residences is disposed of elsewhere

An analysis of the dredge spoil pond in Area C indicates that the quantities of sand and mud shown in Table 2 are available for cover material. Detailed calculations are presented in Appendix D.

WESTNAVFACENGCOM commissioned a topographic survey of the NAS Alameda Landfill. The resultant topographic map is presented on Plate E1 in Appendix E.

Table 2

Estimated Cumulative Summary of
Available Cover Material
(cubic yards)

Bottom Elevation	Mud	Sand	Total
108.5	180,000	55,000	235,000
108.0	200,000	70,000	270,000
107.5	215,000	85,000	300,000

3. Men and Equipment

Three men operate the site on a five and one-half day per week schedule. The on-site equipment includes two bulldozers, a crane which can be operated as a dragline, a scraper, a loader, a motor grader and a water truck.

IV INVESTIGATION

A. Test Borings

Subsurface conditions were explored during October and November 1976 by drilling 16 test borings at the locations shown on Plate 1. Borings 1 through 6 were drilled with a truck-mounted rotary wash drill rig and Borings 7 through 12 were drilled with a truck-mounted continuous flight auger. Borings 13 through 16 were drilled with hand auger equipment and ranged up to 10 feet in depth. Ten of the 12 borings drilled with truck-mounted equipment varied in depth from 25 to 37 feet below existing grade; the other two were 44 and 68 feet deep to fully penetrate the bay mud.

In March of 1977, authorization was granted to drill three additional test borings (17, 18 and 19) with truck-mounted hollow-stem auger drilling equipment. They ranged in depth from 25 to 30 feet below existing grade. Test Boring 20 was drilled on October 6, 1977, using hand auger drilling equipment to a depth of 10 feet.

An HLA engineer directed the test boring operations, logged the soils and refuse encountered, and obtained representative samples of the soils for visual classification and laboratory testing. The boring logs are presented on Plates 2 through 19. The results of laboratory tests to determine moisture content, dry density and soil classification characteristics are included on the boring logs. The soil classification system used and the method of presenting laboratory test data on the logs are explained on Plate 20. Compaction test data are presented on Plate 21.

B. Observation Wells

On completion of each boring, Test Borings 1 through 13 and 17 through 20 were converted to observation wells for monitoring water levels, and obtaining water and gas samples for qualitative testing. A three-inch-diameter perforated plastic pipe surrounded with pea gravel was installed in each boring. Borings 1 through 11, 17 and 18 were used for both gas and water monitoring. Boring 13 was used to obtain water levels. Borings 12 and 19 were used for gas sampling only and Boring 20 for water sampling only. Borings 14, 15 and 16 were not used for monitoring and have been backfilled.

Water levels in the observation wells were measured periodically either by lowering a weighted tape measure or by using a battery powered electronic probe.

C. Water Quality Sampling and Testing

Observation well waters were periodically sampled for qualitative testing. A day prior to sampling, the observation wells were pumped so the water sampled was relatively fresh inflow. The sampler is a two-inch-diameter plastic pipe, 2 feet long, with a flap valve at the bottom. It was lowered into each well to a few feet below the ground-water level, permitted to fill, retrieved and the contents transferred to a one gallon glass bottle. The bottles were delivered to LFE Environmental Laboratory in Richmond for water chemical analyses performed in accordance with Environmental Protection Agency (EPA) and State of California requirements. The components that were selected for quantity and quality testing are those that the Regional Water Quality Control Board has required in similar evaluations. The results are presented in Section V and discussed in Section VII.

D. Gas Sampling and Testing

Gas samples were obtained from observation wells and ammunition magazines and tested by LFE Environmental Laboratory using two methods. The first is a field test using a small meter to detect the presence of combustible gases (methane) expressed as a percent of the "lower combustible limit". The second method uses a small vacuum pump to collect samples in plastic bags. The bagged samples were analyzed in the laboratory by gas chromatography. The results of all tests are presented in Section V and discussed in Section VII.

V MONITORING PROGRAM

A. Water Levels

Water level readings were obtained in the 17 observation wells on several dates at different times during the tidal cycle. The data are presented in Table 3.

B. Water Quality

Water samples were taken from selected points in November 1976 and in March, July and October of 1977 as shown on Table 4. Wells 10 and 20, which are outside the sanitary fill area were sampled as background references. Samples of bay water adjacent to Well 5 were taken at high and low tide in April and July 1977 to provide additional background references. The results of all analyses are presented in Table 4.

Two previously existing wells on the Air Station located about 3600 and 8300 feet northeast of the landfill are referred to as the Pan American and Army wells, respectively. The Pan American well is inoperative but the Army well water is used for landscape irrigation. A report (Ref. 5) has been prepared on the feasibility of reactivating the Pan American well.

C. Gas

Gas samples from the observation wells and magazines were taken on March 27, 1977. Bag samples obtained from Wells 5 and 9 as described in Section IV were subjected to gas chromatography tests for oxygen, nitrogen, carbon dioxide and five hydrocarbons including

Table 3

	Column 1 - Bay Waters						Column 2 - Perimeter Wells									
	Low Tide		High Tide		Bay Averages		Well #1				Well #2			Well #3	Well #4	
Parameters Analyzed (Units)	3/77	7/77	3/77	7/77	3/77	7/77	11/76	3/77	7/77	10/77	11/76	3/77	7/77	11/76	11/76	3/77
Oil and grease (mg/l)	5.5	0.73	7.40	0.73	6.45	0.73	2.2	8.5	3.27	3.8	11	8.3	1.47	11	1.6	8.2
Sulfide (mg/l)	< 0.02	0.01	< 0.02	0.01	< 0.02	0.01	3.0	12	6.6	< 0.01	0.10	0.026	0.02	0.27	3.3	1.1
Total Hardness (mg $CaCO_3$/l)	5,800	6,100	5,600	6,100	5,700	6,100	3,700	2,000	3,300	2,200	5,500	5,300	5,600	5,200	3,500	6,200
Total Dissolved Solids (mg/l)	3,500	39,000	34,000	30,000	18,750	34,500	--	11,000	15,000	13,000	--	2,800	26,000	--	--	16,000
Calcium (mg/l)	300	300	310	300	305	300	380	110	240	200	620	370	560	560	260	140
Chloride (mg/l)	18,000	19,000	13,000	19,000	15,500	19,000	3,100	5,200	7,400	6,300	13,000	14,000	14,000	12,000	16,000	8,000
COD (mg/l)(1)	1,500	2,200	270	1,900	885	2,050	240	140	460	400	140	1,000	1,400	200	290	230
pH	8.4	8.3	8.4	8.2	8.4	8.2	6.7	7.3	8.1	7.5	6.7	7.6	8.1	6.6	7.1	7.7
Iron (mg/l)	1.6	0.15	0.34	0.07	0.97	0.11	51	32	10	51	70	20	0.34	200	14	3.6
Magnesium (mg/l)	1,100	1,200	1,100	1,200	1,100	1,200	820	330	550	440	560	950	890	600	350	460
Nitrate Nitrogen (mg N/l)	0.55	0.21	0.25	0.40	0.4	0.34	0.22	0.25	1.7	2.8	0.42	3.9	2.9	0.54	0.01	0.25
Potassium (mg/l)	420	270	410	270	415	270	340	260	140	98	300	340	170	220	290	310
Sodium (mg/l)	10,000	6,200	9,200	780	9,600	3,490	4,000	5,700	2,000	3,300	15,000	8,000	4,200	8,000	4,000	5,500
Sulfate (mg/l)	2,500	3,200	2,100	2,700	2,300	2,950	1,600	380	1,600	460	2,000	13,000	1,400	1,100	660	68
Mercury (μg/l)	< 1	< 1.0	< 1	< 1.0	< 1	< 1.0	< 1.0	< 1.0	1.3	1	2	< 1.0	3.4	< 1.0	6	< 1.0
Lead (mg/l)	0.36	< 0.02	0.34	< 0.04	0.35	< 0.03	0.22	0.16	0.16	0.37	0.25	0.36	< 0.04	0.37	0.65	0.16
Total Phosphate (mg P/l)	0.22	0.18	0.18	0.16	0.20	0.17	1.6	1.8	5.7	1.8	0.20	0.45	2.0	0.10	0.95	1.3
Total Kjeldahl Nitrogen (mg N/l)	1.40	1.7	2.80	6.9	2.1	4.3	5.8	9.6	18	15	10	0.80	2.4	5.2	0.43	29
Total Chromium (mg/l)	0.02	0.03	0.06	0.03	0.04	0.03	0.12	0.02	0.26	0.32	0.25	< 0.01	0.05	0.42	1.0	< 0.01
Cadmium (mg/l)	0.038	< 0.01	0.028	< 0.01	0.033	< 0.01	0.02	0.014	0.04	0.01	0.28	0.052	< 0.01	0.12	0.08	0.016
Turbidity (JTU)(2)	14	28	1.30	2.6	7.65	2.7	15	74	500	6.1	42	150	150	15	12	24
[illegible]	750	750	770	750	760	750	--	270	600	500	--	920	750	--	--	350

Table 4. WATER QUALITY TEST RESULTS

	Well #4			Well #5				Column 3 – Interior Wells Well #6			Well #7				Well #8	Well #9	Well #11	
	11/76	3/77	7/77	11/76	3/77	7/77	10/77	11/76	3/77	10/77	11/76	3/77	7/77	10/77	11/76	11/76	3/77	7/77
	1.6	8.2	3.27	2.0	6.8	7.34	4.6	2.8	7.2	4.9	9.7	7.9	2.80	6.2	16	11	11	5.80
7	3.3	1.1	1.0	< 0.08	0.061	0.01	< 0.01	2.5	< 0.02	< 0.01	4.9	2.1	0.40	< 0.01	< 0.08	0.08	0.49	0.28
	3,500	6,200	3,700	4,300	1,600	1.800	1,700	2,500	1,300	4,500	3,400	2,800	3,400	5,300	1,200	1,500	1,500	1,700
	--	16,000	17,000	--	9,700	10,000	11,000	--	7,200	6,700	--	16,000	13,000	18,000	--	--	8,300	8,800
	260	140	150	180	86	110	160	500	110	110	380	160	160	220	600	410	250	110
	16,000	8,000	9,000	6,200	5,000	5,300	5,300	7,100	3,700	3,200	12,000	8,400	14,000	7,700	4,200	5,600	4,000	4,400
	290	230	600	400	3,100	690	540	220	240	150	220	72	280	410	130	42	220	540
	7.1	7.7	8.0	6.6	7.2	7.9	7.3	7.2	7.7	7.7	6.9	7.6	8.6	7.6	6.9	6.6	7.4	8.3
	14	3.6	0.40	3.6	2.6	1.7	190	13	6.6	7.5	22	8.0	0.90	9.7	30	41	32	32
	350	460	470	460	180	290	300	240	180	180	350	480	410	520	100	130	860	250
	0.01	0.25	0.59	0.25	0.38	0.99	1.4	0.01	1.4	0.75	0.40	1.6	1.3	1.7	0.42	0.42	0.40	1.4
	290	310	160	310	220	130	100	130	134	43	220	200	110	86	140	190	270	120
	4,000	5,500	2,400	5,500	1,000	1,000	3,000	2,000	1,800	1,800	4,000	5,200	1,600	4,300	1,300	1,000	3,800	1,000
	660	68	228	68	60	< 2.0	< 10	340	160	160	960	700	500	520	78	10	24	64
	6	< 1.0	1.3	< 1.0	< 1.0	< 1.0	< 0.5	< 1.0	< 1.0	< 0.5	2	< 1.0	< 1.0	< 0.5	< 1.0	< 1.0	< 1	1.0
	0.65	0.16	< 0.04	0.35	0.16	0.4	0.32	0.20	0.12	0.28	0.62	0.19	0.52	0.39	0.10	0.12	0.25	< 0.04
	0.95	1.3	1.3	0.18	0.75	1.6	0.9	2.8	1.2	1.0	0.34	0.51	1.6	0.75	0.26	0.40	0.43	0.44
	0.43	29	18	46	28	69	100	10	1.6	8.2	18	1.8	3.2	12	19	51	33	61
	1.0	< 0.01	0.03	0.10	< 0.01	0.20	0.11	0.08	< 0.01	0.11	0.45	< 0.02	0.04	0.11	0.12	< 0.01	0.04	0.03
	0.08	0.016	0.01	0.18	0.019	0.46	0.024	0.13	0.014	0.009	0.03	0.025	0.01	0.011	0.14	0.32	0.015	< 0.01
	12	24	27	15	42	60	290	8	37	0.83	18	32	67	3.3	10	50	74	100

	Column 3 - Interior Wells													Column 4 - Outside Wells*				
	Well #7				Well #8	Well #9	Well #11		Well #17		Well #18				Well #10			Well #20
	11/76	3/77	7/77	10/77	11/76	11/76	3/77	7/77	3/77	10/77	3/77	7/77	10/77	11/76	3/77	7/77	10/77	10/77
	9.7	7.9	2.80	6.2	16	11	11	5.80	8.4	11	8.9	4.67	6.3	12	6.9	0.67	12	8.8
1	4.9	2.1	0.40	< 0.01	< 0.08	0.08	0.49	0.28	0.061	< 0.01	0.045	< 0.01	0.04	< 0.08	< 0.02	0.03	< 0.01	< 0.01
	3,400	2,800	3,400	5,300	1,200	1,500	1,500	1,700	1,600	982	3,500	2,300	2,300	540	28	160	300	130
	--	16,000	13,000	18,000	--	--	8,300	8,800	9,800	10,000	21,000	13,000	16,000	--	840	500	3,500	320
	380	160	160	220	600	410	250	110	85	130	180	60	150	390	1	11	45	33
	12,000	8,400	14,000	7,700	4,200	5,600	4,000	4,400	5,100	5,000	12,000	7,400	8,200	400	210	120	47	22
	220	72	280	410	130	42	220	540	270	315	870	450	455	43	110	170	136	52
	6.9	7.6	8.6	7.6	6.9	6.6	7.4	8.3	7.2	7.4	7.5	8.0	7.6	8.0	7.7	8.0	7.6	7.7
	22	8.0	0.90	9.7	30	41	32	32	34	16	30	1.2	21	370	290	400	470	330
	350	480	410	520	100	130	860	250	260	270	650	160	380	16	67	130	32	30
5	0.40	1.6	1.3	1.7	0.42	0.42	0.40	1.4	0.50	1.4	0.40	1.1	1.6	0.20	6.4	1.2	28	21
	220	200	110	86	140	190	270	120	340	87	400	160	12	17	84	11	1.4	1.6
	4,000	5,200	1,600	4,300	1,300	1,000	3,800	1,000	3,700	2,800	7,000	1,300	4,400	240	84	55	65	50
	960	700	500	520	78	10	24	64	2.8	< 10	32	5.6	< 10	50	0.05	34	26	98
	2	< 1.0	< 1.0	< 0.5	< 1.0	< 1.0	< 1	1.0	< 1.0	< 0.5	< 1.0	1.0	3.3	< 1.0	< 1.0	2.6	8.2	1
3	0.62	0.19	0.52	0.39	0.10	0.12	0.25	< 0.04	0.16	0.30	0.22	0.05	0.38	0.20	0.28	0.18	0.51	0.32
	0.34	0.51	1.6	0.75	0.26	0.40	0.43	0.44	0.51	1.0	1.3	0.40	0.7	0.40	0.10	9.7	2.9	1.9
	18	1.8	3.2	12	19	51	33	61	11	110	104	110	240	3.0	2.0	8.8	9.8	5.0
	0.45	< 0.02	0.04	0.11	0.12	< 0.01	0.04	0.03	< 0.01	0.11	0.02	0.02	0.12	0.90	0.66	1.5	1.56	0.90
9	0.03	0.025	0.01	0.011	0.14	0.32	0.015	< 0.01	0.019	0.08	0.018	< 0.01	0.08	0.73	0.028	0.02	0.34	< 0.005
	18	32	67	3.3	10	50	74	100	77	21	55	86	7.2	35	1,650	3,800	1.2	1.8
	--	400	400	550	--	--	250	270	210	320	450	150	370	--	2.5	27	110	82

Observation Well (boring) D a t e,

	Elevation*		11/9/76		11/15/76		12/3/76		12/17/76			3/10/77	3/16/77		3/21/77	3/22/
Number	Top of Pipe	Ground Surface	1200 to 1330	1600 to 1650	1045 to 1130	1430 to 1505	1415 to 1515	1530 to 1630	0845 to 1600	1325 to 1345	1517 to 1545	1400 to 1530	0900 to 0945	1330 to 1350	1330 to 1600	09 tc 13
1	116.5	115.5	105.2	105.5	105.3	105.3	105.7	105.3	105.9	105.6	105.2	---	105.8	---	105.9	105
2	114.4	113.4	105.4	105.4	105.4	105.4	105.4	---	105.4	105.4	105.4	104.8	105.2	---	105.1	105
3	112.2	111.4	105.3	105.2	105.2	105.2	105.3	105.2	105.5	105.1	105.1	104.9	105.0	---	104.6	104
4	110.4	110.7	108.2	105.5	105.9	105.9	103.8	103.5	108.4	103.7	103.1	---	---	---	105.7	105
5	109.8	110.1	106.6	105.9	105.6	105.6	105.1	104.9	106.8	104.9	104.5	106.7	106.8	105.8	---	105
6	108.1	108.2	106.2	106.2	106.2	106.2	106.2	---	106.2	---	106.2	106.8	---	107.1	107.1	107
7	109.2	109.9	106.2	106.2	106.2	106.2	106.2	---	106.2	---	106.2	106.7	---	107.7	106.7	106
8	114.8	114.0	106.6	106.6	106.6	106.6	106.7	---	106.7	---	106.6	107.8	107.2	---	---	---
9	114.3	113.8	107.3	107.3	107.3	107.3	107.3	---	107.3	---	107.3	108.1	107.9	---	---	108
10	111.9	112.0	108.0	108.0	108.0	108.0	---	---	108.0	---	108.0	---	---	---	109.5	109
11	112.6	112.5	---	---	---	---	106.3	---	106.3	---	106.3	106.5	---	106.7	106.6	106
12	113.1	113.0	---	---	---	---	106.2	---	106.2	---	106.2	106.4	---	106.5	106.9	106
13	109.0	109.5	---	---	106.0	106.0	---	---	105.7	---	105.7	108.7	---	---	---	109
17	111.7	110.3	Borings installed 3/16/77										No initial readings taken		105.2	106
18	111.8	110.0													104.9	106
19	110.4	109.8													105.3	106
20	115.3	114.5	Boring installed 10/6/77													
Bay Tide	---	---	107.9	104.9	103.9	104.4	104.1	103.1	108.2	102.4	101.4	104.9	107.2	103.4	105.8	vari
High Tide	---	---	107.9 at 1230		106.1 at 1800		107.7 at 0930		108.3 at 0815			106.1 at 1645	107.5 at 0945		106.7 at 1330	106. 141
Low Tide	---	---	100.9 at 1930		103.5 at 1230		101.2 at 1615		100.7 at 1530			101.2 at 0945	101.0 at 1615		102.5 at 1900	101. 07
Rainfall since last reading (in.)			0		1.07		0		0			3.93	1.42		0	0
Cumulative rainfall (in.)			0		1.07		1.07		1.07			5.00	6.42		6.42	6.

*All elevations are in feet, based on the Alameda Naval Air Station Datum

...ate, Time, Reading and Tide

7	3/22/77	4/4/77				4/7/77							4/13/77	4/18...			
50	0945 to 1330	0745 to 1000	1000 to 1315	1320 to 1430	1430 to 1440	0800 to 0950	0950 to 1040	1050 to 1110	1150 to 1240	1250 to 1310	1350 to 1410	1450 to 1550	1230 to 1400	1000 to 1045	1100 to 1115	1130 to 1145	1200 to 1250
9	105.7	103.2	103.7	104.2	---	104.4	104.4	---	104.9	104.6	104.7	104.8	---	104.2	104.7	104.7	104.8
.1	105.0	103.9	103.9	---	---	105.0	105.0	---	105.0	---	---	105.0	---	---	---	---	---
6	104.6	103.3	103.6	103.7	---	104.1	104.1	---	104.1	---	---	104.1	---	104.0	---	---	104.4
.7	105.7	103.9	106.8	105.7	---	103.2	103.2	103.4	104.1	105.1	106.2	106.4	---	104.8	105.7	106.1	106.4
	105.2	104.0	106.0	106.7	106.3	105.4	104.2	104.7	105.3	105.8	106.2	106.3	105.2	---	106.1	106.2	106.3
	107.1	106.9	106.9	---	---	106.8	---	---	106.8	---	---	106.8	106.8	---	---	---	---
	106.7	106.5	106.5	---	---	106.6	---	---	106.6	---	---	106.6	---	---	---	---	---
	---	106.4	106.4	---	---	107.3	---	---	107.3	---	---	107.3	---	---	---	---	---
	108.1	---	---	---	---	108.0	---	---	108.0	---	---	108.0	---	---	---	---	---
	109.6	---	---	---	---	109.1	---	---	---	---	109.1	---	---	---	---	---	---
	106.6	106.5	106.5	---	---	106.7	---	---	106.7	---	---	106.7	---	---	---	---	---
	106.7	106.5	106.2	106.3	---	106.6	---	---	106.6	---	---	106.6	---	---	---	---	---
	109.3	---	---	---	---	109.0	---	---	109.0	---	---	109.0	---	---	---	---	---
	106.4	104.6	105.3	105.2	105.3	106.4	106.4	106.4	106.4	106.4	106.4	106.4	106.2	106.3	---	---	106.3
	106.4	105.4	---	105.3	105.3	106.4	106.4	106.4	106.4	106.4	106.4	106.4	106.2	106.3	---	---	106.3
	106.3	105.2	105.3	105.4	105.4	106.3	106.3	106.3	106.3	106.3	106.3	106.3	106.2	106.3	---	---	106.3
5.8	varies	103.7	105.9	106.2	105.7	100.8	102.2	102.7	104.0	104.5	105.4	105.8	102.7	104.6	105.0	105.4	106.1
.7 at 330	106.4 at 1415	107.1 at 1245				106.7 at 1530							106.7 at 0845	106.5 a			
at	101.7 at 0745	101.0 at 0600; 102.1 at 1800				100.4 at 0830							101.4 at 1445	101.2 at 0600;			
	0	0.49				0							0				
.42	6.42	6.91				6.91							6.91	6			

4/7/77						4/13/77	4/18/77								7/15/77	10/14/77
0950 to 1040	1050 to 1110	1150 to 1240	1250 to 1310	1350 to 1410	1450 to 1550	1230 to 1400	1000 to 1045	1100 to 1115	1130 to 1145	1200 to 1250	1300 to 1315	1330 to 1345	1400 to 1415	1430 to 1445	0930 to 1100	1000 to 1115
104.4	---	104.9	104.6	104.7	104.8	---	104.2	104.7	104.7	104.8	105.0	105.0	105.1	105.0	104.2	104.5
105.0	---	105.0	---	---	105.0	---	---	---	---	---	---	---	---	---	104.7	105.0
104.1	---	104.1	---	---	104.1	---	104.0	---	---	104.4	---	---	---	104.3	104.4	104.7
103.2	103.4	104.1	105.1	106.2	106.4	---	104.8	105.7	106.1	106.4	106.5	106.4	106.1	105.1	103.6	106.6
104.2	104.7	105.3	105.8	106.2	106.3	105.2	---	106.1	106.2	106.3	106.3	106.3	106.2	106.2	104.8	105.8
---	---	106.8	---	---	106.8	106.8	---	---	---	---	---	---	---	---	106.1	106.0
---	---	106.6	---	---	106.6	---	---	---	---	---	---	---	---	---	106.0	106.0
---	---	107.3	---	---	107.3	---	---	---	---	---	---	---	---	---	106.4	106.0
---	---	108.0	---	---	108.0	---	---	---	---	---	---	---	---	---	107.3	107.0
---	---	---	---	109.1	---	---	---	---	---	---	---	---	---	---	107.9	107.5
---	---	106.7	---	---	106.7	---	---	---	---	---	---	---	---	---	105.9	105.9
---	---	106.6	---	---	106.6	---	---	---	---	---	---	---	---	---	105.8	105.7
---	---	109.0	---	---	109.0	---	---	---	---	---	---	---	---	---	---	---
106.4	106.4	106.4	106.4	106.4	106.4	106.2	106.3	---	---	106.3	---	---	---	106.3	105.8	105.8
106.4	106.4	106.4	106.4	106.4	106.4	106.2	106.3	---	---	106.3	---	---	---	106.3	105.8	105.8
106.3	106.3	106.3	106.3	106.3	106.3	106.2	106.3	---	---	106.3	---	---	---	106.3	105.8	105.8
																108.5
102.2	102.7	104.0	104.5	105.4	105.8	102.7	104.6	105.0	105.4	106.1	106.5	106.1	105.8	105.4	104.0	105.6
106.7 at 1530						106.7 at 0845	106.5 at 1300								105.8 at 1345	107.4 at 1345
100.4 at 0830						101.4 at 1445	101.2 at 0600; 102.9 at 1745								100.7 at 0630	102.8 at 0715
0						0	0								66	.89
6.91						6.91	6.91								7.57	8.46

methane. The results of these analyses are presented in Table 5. Samples from the other selected wells were tested for oxygen, nitrogen, carbon dioxide and methane only. The results of these analyses are presented in Table 6. The presence of combustible gases was checked in the field in all except Wells 13 and 20 and some magazines using a gas meter; the results are presented in Table 7.

Table 5

Gas Chromatographic Analysis Results for Observation Wells 5 and 9

	Concentration by Volume							
	Oxygen (O_2) %	Nitrogen (N_2) %	Carbon Dioxide (CO_2) %	Methane (CH_4) %	Ethane (C_2H_6) ppm	Propane (C_3H_8) ppm	Butane (C_4H_{10}) ppm	Pentane (C_5H_{12}) ppm
Well 5	3.2	70.0	19.0	8.3	2.4	39	1	1
Well 9	15.0	67.0	8.2	8.3	2.0	40	1	1

Table 6

Reduced Gas Chromatographic Analysis Results

Location	Concentration (% by Volume)			
	Oxygen (O_2)	Nitrogen (N_2)	Carbon Dioxide (CO_2)	Methane (CH_4)
Well 1	20	75	3.2	0.54
Well 4	18	73	1.2	1.3
Well 6	21	76	0.07	1.6
Well 10	21	77	0.05	0.01
Well 11	8.4	80	12.5	0.5
Well 12	10	45	17.0	27.3
Well 17	15	77	6.0	0.10
Well 18	21	76	.21	.24
Magazine 57	20	74	.05	.01
Magazine 353	22	77	.05	.01

Table 7

Combustible Gas Meter Results

	Percentage of Methane By Volume
Well 1	>3.40
Well 2	negative*
Well 3	negative
Well 4	1.30
Well 5	1.10
Well 6	0.40
Well 7	negative
Well 8	negative
Well 9	>3.40
Well 10	negative
Well 11	0.70
Well 12	>3.40
Well 17	0.02
Well 18	0.20
Well 19	negative
Magazine 56	negative
Magazine 57	negative
Magazine 58	negative
Magazine 353	negative

3.4% is the maximum the meter can measure when converted to methane concentrations.

* Means no gas measured.

VI SUBSURFACE CONDITIONS

A 1973 report (Ref. 2) indicates that the initial fill placement behind the perimeter sea wall at the landfill consisted of hydraulic sand fill. Additional sand fill has been placed in Area A and mixed with sanitary landfill debris materials since 1958. In Areas B and C, about 5 feet of dredged spoil, consisting of silty and sandy soil, was placed directly over the initial sand fill. Additionally, about 3 to 10 feet of hydraulically placed bay mud slurry was placed in Area C which was diked off. Area B contains some stockpiles of sandy soils 10 to 15 feet high.

Based on HLA borings, the average subsurface condition for each area is summarized below.

Depth Below Ground Surface, feet	Areas A and B
0 - 20	Sand and refuse fill
20 - 50	Soft bay silt deposit (bay mud)
	Area C
0 - 5	Bay mud fill (dredge slurry)
5 - 10	Clay and sand fill (dredge slurry)
10 - 30	Sand fill
30 - 50	Soft bay deposit (bay mud)

In Borings 2 and 6, the bay mud below the lower sand fill layer extended 44 and 63 feet below existing grade, respectively. Firm sandy soil was encountered below the bay mud.

VII DISCUSSION AND CONCLUSIONS

A. Compliance With State and Federal Guidelines

The Environmental Protection Agency's 40 CFR 241 Guidelines for Land Disposal of Solid Waste and the State of California's California Administrative Code, Title 14, Division 7, Chapter 3, Article 7, were used as standards for evaluating the operation of the Air Station landfill. Both regulations were written for application to new facilities; however, existing sites are expected to operate in compliance with them. The analysis of compliance is presented in Appendix C on Table C-1 for the Federal guidelines and Table C-2 for the State guidelines.

The two major areas where compliance is in question are inadequate intermediate cover material and leachate seepage from the site.

B. Cover Material

The current Federal Solid Waste Disposal Guidelines require 12 inches of intermediate cover and 24 inches of final cover. New State (RWQCB) regulations requiring 12 inches of intermediate cover and 36 inches of final cover have been adopted. The sand and bay mud slurry available from the slurry pond are suitable for cover material.

When obtaining cover material from the slurry pond, it should be removed in a manner that promotes drainage of the slurry pond toward the center of the south side (away from the landfill).

This will prevent ponding and minimize surface water contributions to the subsurface water.

The actual thickness of existing intermediate cover over the site is unknown and should be determined by drilling shallow test borings or pits. It is estimated that about one-third of the landfill lacks adequate intermediate cover thickness. Further, the cover soils are very pervious. If the landfill is to continue, whether contractor or Navy operated, adequate intermediate cover should be placed over the 58 acres of the site that have been filled. About 94,000 cubic yards of cover material will be required. This would leave about 205,000 cubic yards of cover or enough for 34 years of operation. The intermediate cover quantity estimate includes a 50 percent increase to fill in low spots and to provide slope for drainage. This amount of material is available in the slurry pond above Elevation 108.5.

If the site is to be closed, a final cover of three feet will be required. The existing and future intermediate cover can be included as part of the required thickness. Considering the existing cover, about 280,000 cubic yards of material will be needed. It can be obtained from the slurry pond without excavating below Elevation 107.5. Excavations below Elevation 107.2 (approximate Mean Higher High water elevation) will require a Corps of Engineers permit.

C. Perimeter Seepage

The water levels in some of the observation wells near the sea wall perimeter fluctuate up to two to three feet corresponding with tidal variations which indicates relatively high permeability of the sea wall. This is especially so in the vicinities of Wells 4 and 5 which were close to the sea wall. The water surface elevation in wells distant from the sea wall are nearly the same as each other, are higher than the perimeter wells, and show no tidal influence. The difference in water elevation between the interior wells and the perimeter wells shows that the subsurface water is flowing from the northeast corner toward the Bay at the south and west perimeter.

Flow net analyses of the subsurface conditions shown by cross sections A-A and B-B, Plate 22, indicate that seepage would be about 0.3 gallons per foot of sea wall per day at the terminus of the sections. The seepage through Area C (between Wells 2 and 4) would be about half this amount because of the decreased permeability of the subsurface soils and flatter hydraulic gradient. Accordingly, the total seepage is estimated to be on the order of 700 to 1,300 gallons/day. Calculations for these estimates are presented in Appendix A.

D. Water Quality

1. Usable Ground-Water Protection

Usable ground-water aquifers in the area are artesian and are located in the lower sections of the Alameda formation (Ref. 5). They are protected from intermingling with the landfill subsurface water by the relatively impervious upper portions of the Alameda formation and the layer of impervious bay mud between the fill and the formation (see Refs. 1 and 6).

2. Precipitation

Precipitation data for the period of this study is presented in Table 3. Very low rainfall for the year prior to and the year of the study has had the effect of lowering the subsurface water level which may tend to increase its contaminant concentrations. However, shallow subsurface water will continue to flow through the site, dilute the concentrations and probably prevent contaminant values from rising.

Normal seasonal rainfall would raise the water level due to infiltration through the pervious landfill cover. As the water percolates through the refuse, it picks up contaminants and mixes with the water. The pollutant uptake of the percolating surface waters will probably offset any dilution effects and the contaminant levels will remain nearly the same.

An impervious soil cover cap over the site will minimize rainfall infiltration and create a similar effect to the recent dry spell. After many years of subsurface water flowing through the site, the contaminant levels should decrease.

3. Standards

LFE Environmental Laboratory assisted HLA in seeking published water quality standards related to the Air Station landfill and San Francisco Bay, but none were found. The Regional Water Quality Control Board (RWQCB) has jurisdiction over water quality at landfills. Its staff indicates that sites are analyzed on a case by case basis and that there are no specific guidelines for water quality.

4. Test Results

To provide a basis for evaluating the quality of water samples obtained from within the landfill, samples were tested from the Bay waters west of Well 5. Observation Wells 10 and 20, located inland of the landfill, also were analyzed to determine the general quality of the subsurface water on the Air Station side of the landfill. This method of comparing landfill sample results to Bay and adjacent ground water is not used directly by the RWQCB but provides a basis for comparisons.

As shown on Table 4, the analyses have been broken down into several groups of wells by their proximity at the landfill. The average qualities of the Bay water for March and July 1977 were used as a base line for comparing the perimeter, interior, and outside well analyses, as discussed below.

a. Perimeter Wells (Table 4, Column 2)

Approximately 30 percent of the water quality components tested were in greater concentration in the perimeter wells than in the base line samples. These include sulfide, iron, nitrate nitrogen, lead, total phosphate, total Kjeldahl nitrogen, total chromium and turbidity.

b. Interior Wells (Table 4, Column 3)

About 50 percent of the water quality components tested were in greater concentration in the interior wells than in the base line samples. These include oil and grease, sulfide, iron, nitrate nitrogen, lead, total phosphate, total Kjeldahl nitrogen, calcium and turbidity.

c. Outside Wells (Table 4, Column 4)

About 50 percent of the water quality components tested were in greater concentration in the outside wells than in the base line samples. These include oil and grease, sulfide, iron, nitrate nitrogen, mercury, lead, total phosphate, total Kjeldahl nitrogen, total chromium, cadmium and turbidity.

Based on an overall analysis of the test results, landfill characteristics, flow rates and seepage characteristics, the following conclusions are made:

1. The subsurface water generally flows across the site from the north and east boundaries in a south and west direction.

2. Well 20 indicates the general quality of subsurface water adjacent to the landfill and is considered to be unaffected by the landfill. It is brackish and while 50 percent of the tested components had results higher than the Bay water, many of the values were lower and probably would not be considered polluting.

3. Well 10 also indicates the general ground water quality. The parameter concentrations are generally a little higher than Well 20, indicating the landfill may be contributing to the higher values. The hydraulic gradient throughout the study has been from Well 10 toward the landfill which would prevent contamination. However, in the past during periods of high rainfall, the relatively pervious landfill has probably absorbed water faster than the surrounding areas that are mostly sealed and paved. This may have created a temporary reversal of the gradient which could cause pollutants to migrate eastward temporarily.

   Also, the low flow rates through the site may allow some of the pollutants to disperse easterly to areas of lower concentrations.

It is believed Well 20 is too far east to have been affected by these phenomena.

4. Subsurface water within the landfill contains higher contaminant levels in 50 percent of the components than the base line and some of the concentrations are probably high enough to be considered polluting.

5. Calculations based on the permeability and hydraulic gradient in the landfill show that at the edge of the refuse fill area near the sea wall (about 1800 feet) about 0.3 gallons of subsurface water per day per foot of sea wall seeps from the site. Along the border between the slurry pond and the sea wall (3100 feet) the longer drainage path and lower permeabilities reduce the seepage by about one-half.

6. The leachate seeping from the landfill mixes rapidly with Bay waters in the vicinity of the sea wall and contributes some contaminants to it. These amounts are presented in Appendix A.

7. The relatively small flow from the landfill is mixed and diluted with the very large volume of Bay water that flows in and out of the tidal zone in the sea wall. Because of the dilution, the contribution of contaminants from the landfill cannot be detected in the test results of the Bay water.

In summary, this study shows that a small amount of water flows from the landfill into San Francisco Bay. The water quality tests indicate that polluting materials are present in the water but the concentrations are not significantly greater than those found in the Bay waters adjacent to the site. The small subsurface flow and the low concentrations result in the discharge of extremely small quantities of contaminants into the Bay each day (see Appendix A). It is believed that the flow is insignificant and that repairs to the sea wall are unwarranted.

As previously mentioned, PWC SFRAN is applying to the Alameda County Health Services Agency for an operating permit on the NAS Alameda Landfill. Because this permitting agency has just been established, the data on the site is being forwarded to the State Solid Waste Management Board (SWMB) for review. The SWMB will consult with the RWQCB regarding the seepage problem and can be expected to follow its recommendations. Generally, the RWQCB prohibits discharge of any polluted water into waters of the State; however, it looks at each landfill on a case by case basis to determine if the seepage can be tolerated.

E. Gas

Gas samples from Observation Wells 5 and 9 were subjected to complete gas chromatographic analysis. The test results in Table 5 indicate that the only flammable gas present in sufficient quantities to warrant analysis is methane. The other hydrocarbons for which tests were performed are too scarce to be of concern. The oxygen to nitrogen ratio found in Well 9 is close to that found in ambient air (1 to 4) and the sample may have been diluted by air. This would lower the methane reading. Air dilution also may be a factor in the results shown on Table 6 for Well 1 since the field check indicated that greater amounts of methane were present.

The low methane readings in Well 10 indicate that migration of the gas beyond the landfill to the east is negligible. The results of tests on Well 6 samples show that small amounts of methane may be migrating to the north but the test on samples obtained in nearby Magazine 353 showed a negligible gas concentration. The Magazine 57 and 353 readings may reflect both the effects of ventilation and the ability of the concrete floor slab to retard upward gas migration into the building. Due to the readings it appears that methane migrating to the ammunition storage area is not a problem at this time.

Methane is combustible when found in concentrations varying between 5.3 and 15 percent in air. The data in Table 7 indicate that methane is present in quantities approaching combustible amounts in Wells 1, 5 and 9. Concentrations in Well 12 are above the combustible limit. Due to rapid dilution with air as the methane escapes, the chance for combustion is very low. The remainder of the wells show either no methane presence or concentrations inadequate for combustion.

Methane gas generated at landfills is suitable for use as a fuel. However, due to the relatively shallow refuse fill thickness, lack of high organic content and high ground-water table, it is doubtful that this landfill generates sufficient quantities of gas to be economically recovered.

The results of gas monitoring are summarized as follows:

1. The landfill is generating methane and in some of the borings it is in combustible concentrations.

2. Insignificant concentrations were found in the magazines which are well ventilated.

3. Carbon dioxide generated by the landfill is probably increasing the hardness and lowering the pH of water in the fill.

F. Correction of Perimeter Sea Wall Seepage

If the State or Federal agencies require that seepage be stopped, there are several alternatives for decreasing the flow from the landfill adjacent to the Bay. They include: (1) chemical grouting; (2) sheet piling; (3) a trench with compacted earth backfill; (4) a slurry trench; (5) an impervious membrane; and (6) subdrain trenches to reverse flow of subsurface water. A description and the advantages and disadvantages and typical sections of the repair alternatives are presented in Appendix B.

Cost estimates using 1977 dollars are presented in Table 8 for the various methods. The estimates have been prepared for the approximate current cost of applying Alternatives 1 through 5 to about 2600* feet of the perimeter in Areas A and C where refuse fill has been placed. The recommended repair areas are shown on Plate B1 in Appendix B. Alternative 6 would be installed along the north and east boundaries to intercept flow from this direction and to flatten or reverse the flow gradient toward the sea wall. The Alternative 6 estimate provides for about 2700 feet of interceptor trench averaging 10 feet deep, two collection points, and the equipment to spray the collected water onto the landfill. The location of the repair alternatives is shown schematically on Plate B1 in Appendix B.

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* 2600 feet includes 1600 feet of repair near Wells 4 and 5 plus 200 feet on each end for a safety factor and 200 feet of repair near Well 1 plus 200 feet on each end.

Table 8. Cost Estimates for Seepage Prevention

Alternative	Cost Range Estimates On Per Foot Basis	Per Foot Cost Range Used	Capital Cost Range (For 2,600-Foot Sea Wall)
1	$220/foot cost recommended range $150 to $250	$175 to $275	$455,000 to $715,000
2	$250 to $300	$250 to $300	$650,000 to $780,000
3	$250 to $300	$250 to $300	$650,000 to $780,000
4A	$6 to $10/square foot or $150 to $250/foot	$200 to $250	$520,000 to $650,000
4B	$100 to $150	$100 to $150	$260,000 to $390,000
5	Lump sum figure	$150 to $170	$390,000 to $442,000
6*	$20 to $25 for collectors disposal system (sprinklers and pumps)	$20 to $25 $17,000	$ 71,000 to $ 85,000

* Alternative 6 is based on 2700 linear feet of trench and an estimated yearly operating cost of $5000. The first five alternatives have no yearly operating costs.

G. Current Landfill Operating Costs

The cost data below for the current landfill operations have been supplied by the Public Works Center (PWC), San Francisco (Ref. 11), and have been confirmed (Ref. 12) for their applicability at the time of this report.

Landfill Personnel - 3 heavy equipment operators

Salaries @ $8.05/hr x 2080 hrs/yr x 3 men =	$ 50,232
Fringe benefits @ $2.88/hr x 2080 hrs/yr x 3 men =	17,983
Overhead @ $5.75/hr x 2080 hrs x 3 men =	35,880
TOTAL PERSONNEL COSTS	$104,095

Landfill Equipment - Leased on monthly basis including fuel and maintenance

Item	Cost Per Month	Yearly Cost
2 crawler tractors	$1,900	$ 22,800
1 crawler crane	745	8,940
1 motor grader	680	8,160
1 front end loader	680	8,160
1 tug and scraper	680	8,160
1 water truck	475	5,700
TOTAL EQUIPMENT COSTS		$ 61,920
TOTAL - PERSONNEL AND EQUIPMENT		$166,015

H. Future Operating Costs

The options under consideration for future site use are: (1) PWC will continue the current landfill operations; (2) have an outside contractor operate the landfill and possibly accept Air Station household refuse; and (3) close the site. The recommendations for implementing these options are presented in Section VIII.

Options 1 and 2 require placement of about 94,000 cubic yards of intermediate cover. The PWC would place the cover in conjunction with normal filling and cover operations if the first option is selected. It would take about one year and cost approximately $47,000 ($0.50 per cubic yard) to finish. The cost estimate calculations are presented in Appendix D. Under Option 2, the contractor would place the intermediate cover and the cost would be about the same. However, with several pieces of equipment, the work could be performed in a couple of months.

The cost of seepage repair, if required, is in addition to the cost estimates that follow. All estimates are based on 1976 costs.

1. Option 1 - Continue Current Landfill Operations

For the first year of continued operations, the personnel costs would be the same as presented in Section G above. The three operators would be used to operate the landfill and spread and compact intermediate cover. One tractor, the front end loader and the crane with dragline would be eliminated. The second tractor and the grader would be needed occasionally. This would reduce the yearly equipment costs from about $62,000 to about

$27,000 and first year costs including placement of intermediate cover would be about $131,000.

After cover placement, the landfill operations would be changed to two operators and one gatekeeper, as discussed in Section VIII.

Estimates of operating costs for the second and succeeding years are:

<u>Landfill Personnel</u> - 2 operators and 1 gatekeeper

Salaries @ $8.05/hr x 2080 hrs/yr x 2 men =	$ 33,488
$6.50/hr x 2080 hrs/yr x 1 man =	13,520
Fringe benefits @ $2.88/hr x 2080 hrs/yr x 3 men =	17,983
Overhead @ $5.75/hr x 2080 hrs/yr x 3 men =	35,880
TOTAL PERSONNEL COSTS	$100,871

<u>Landfill Equipment</u> - Leased on monthly basis including fuel and maintenance

Item	Cost Per Month	Yearly Cost
Crawler tractor	$950	$ 11,400
Tug and scraper	680	8,160
Water truck	475	5,700
Tractor (1 month/year)	950	950
Grader (1 month/year)	680	680
TOTAL EQUIPMENT COSTS		$ 26,890
TOTAL - PERSONNEL AND EQUIPMENT		$127,761

2. Option 2 - Outside Contractor Operates Landfill

The cost estimate for an outside contractor depends upon his method of operation. Variables include the type and cost of equipment and the number of people required. The estimate below is based on information obtained from commercial landfill and equipment operators. Their consensus is that two operators but no gatekeeper would be required unless specified in the contract. They probably would use the equipment listed below.

The estimated cost below is equivalent to the second year costs of Option 1. A cost of about $47,000 for placing intermediate cover would have to be added to obtain the first year cost.

Personnel Costs (Reference 11)

Salaries @ $7.17/hr x 2080 hrs/yr x 2 men =	$ 29,827
Fringe benefits @ $0.86/hr x 2080 hrs/yr x 2 men =	3,578
Total Direct Labor Costs	33,405
Administration Costs = 10% direct labor costs	3,340
Profit - 5% of direct labor and administration costs	1,837
TOTAL PERSONNEL COSTS	$ 38,582

Equipment Costs (Reference 15) includes maintenance, overhead and profit

1 crawler tractor - $20/hr x 2080 hrs/yr =	$ 41,600
1 self-loading scraper - $30/hr x 2080 hrs/yr =	62,400
1 water truck - $10/hr x 2080 hrs/yr =	20,800
1 grader (1 month/year) - $20/hr x 160 hrs/month =	3,200
TOTAL EQUIPMENT COST	$128,000
TOTAL - PERSONNEL AND EQUIPMENT	$166,582

Comparison of Options 1 and 2 costs show that the contractor's labor requirements and expenses are lower; however, his equipment costs are much higher because he includes depreciation and replacement costs. Because the Public Works Center does not pay directly for equipment acquisition, amortization is not included in the costs charged to customers. Other factors involved in the difference in costs are contractor's profits and the fact that the Navy labor and equipment costs are based on rates several years old.

3. Option 3 - Close the Landfill

To close the landfill would require covering the site with three feet of compacted soil cover obtained from the slurry pond. Slightly less may be required if further investigation shows the cover to be thicker than estimated. It is estimated that using landfill personnel, their two dozers and scraper, it would cost about $140,000 ($.50 per cubic yard) to place the required 280,000 cubic yards. It would require nearly two years to complete with existing equipment because the slurry pond is inoperable during the rainy months. The cost is about the same that an outside contractor would charge but by using several pieces of more efficient equipment he could probably do it in four to six months.

In order to minimize erosion by wind and rain, the surface should be seeded with fast-growing grasses or shrubs; it is estimated that this will cost $19,000 to $25,000 (Ref. 13).

When the site is covered it will be necessary to install the gas venting system described in Section VIII, D. It is a trench about 3 feet wide, 6 to 8 feet deep, and 4200 feet long with vertical perforated plastic pipe vents at 100-foot intervals. Installation costs are estimated to be $15 per foot or a total cost of $63,000.

To close the site by covering, planting and installing the gas venting system would cost a total of about $225,000. If seepage repair Alternative 6 is required and selected, the gas venting system could be incorporated in the same trench which would provide cost savings of about $40,000 (see Appendix D).

A maintenance program after site closure, as discussed in Section VIII, C, should be implemented. The cost would be minimal and would not be affected by installation of seepage repair Alternatives 1 through 5. Repair Alternative 6 would require an annual maintenance cost of about $5,000.

VIII RECOMMENDATIONS

A. Control of Subsurface Water

If seepage must be controlled, the subdrain collector system (Alternative 6) is recommended as the least expensive method. This approach is not only suitable to the degree of severity of the problem (potential or existing) but it provides flexibility in that it can be adapted to future site use and regulatory requirements. The low cost of the subdrain system would reflect little in unused investment if it were no longer needed. On the other hand, if regulatory requirements were to become more stringent or if water quality problems were to increase because of changed conditions or site use, the subdrain system could be conveniently and economically expanded or supplemented.

B. Immediate Operational Procedures

Criteria for the operation of the landfill during the period of this study have been developed by HLA working with Naval Air Station personnel and are as follows:

1. Trench method for disposal of waste materials should continue in the area of current operations with the following modifications. These modifications are illustrated on Plate 23.

   a. Excavation should be limited to a minimum depth of two feet above subsurface water level. The current water level is about Elevation 105 (NAS Datum).

   b. Trench width should be limited to the minimum width allowable for efficient equipment operation (approximately 20 feet).

c. The working trench length should be limited to about 200 feet.

d. Excavated soil should be stockpiled adjacent to the excavation where it will be available for cover.

e. The active working area should be kept to the minimum width of about 20 feet and a length of about 100 feet until that portion of the trench is filled.

f. Refuse should be deposited at the head of the working face portion of the trench. The material should be placed in the excavation at a maximum thickness of 18 inches and compacted with a minimum of 10 dozer passes. Additional layers could be placed during the day's operation as required.

g. At the end of the day's operation, a minimum of 6 inches of compacted soil or excavated sand from the trench should be placed over the working surface.

h. When the trench has been filled to an elevation close to the adjacent ground surface, 12 inches of intermediate soil cover should be compacted in-place. This cover material should consist of sand and a minimum of 50 percent dredged bay mud slurry. The material can be obtained from the existing dredged slurry pond.

i. The soil cover surface of new landfill areas should be sloped at a minimum of three percent toward the Bay, where possible, to promote surface drainage and minimize infiltration. This will require the refuse fill to increase in height slightly toward the center of the landfill.

2. Public Works Center, San Francisco Bay shall be responsible for performing the trench excavation and cover, stockpiling of cover material (sand and bay mud slurry), compaction of wastes, road grading, record keeping, policing, and dust control at the sanitary landfill.

3. The area surrounding the landfill working face should be policed at least once weekly for loose and blowing refuse. If this is not an effective control, more frequent policing may be required. Alternatively, portable litter fences could be placed close to the working area to collect blowing refuse.

C. Future Operational Procedures

As discussed in Section VII, G, the options for future site use under consideration are: (1) continue the current landfill operations; (2) have an outside contractor operate the landfill and possibly accept air station household refuse; and (3) close the site. The cost estimates for these options are also presented in Section VII, H. Calculations for cover requirements and site life are presented in Appendix D. The recommendations for implementing the options are presented below. If Options 1 or 2 are selected the Navy should develop a long-term operational plan using the recommendations of this report.

1. Option 1 - Continue Current Landfill Operations

Assuming the landfill remains open, then intermediate cover should be placed over the site, as discussed in Section VII, B. This will require about 94,000 cubic yards of material at a ratio of about 60 percent dried bay mud and 40 percent sand. The soils should be spread, moisture conditioned as required and compacted to 85 percent relative compaction.* Placement of the intermediate cover should begin immediately in addition to the

* Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density of the same material, as determined by the ASTM D1557-70(C) test method.

normal activities of the site. Using existing manpower and equipment, except for the loader and dragline, it is estimated that it will require about a year to place the cover.

A grading plan should be developed to provide adequate drainage of the site. The use of "mounding" areas and directing surface water into drainage swales for removal from the site should be considered. Existing slopes should be used as much as possible. Consultation with RWQCB should be pursued to reduce the required drainage slope from three to two percent.

The trench method of landfill construction is currently being used but should be changed to the area method before the refuse trenches encroach on the slurry pond. The area method would in effect start a second layer on the site which can be started at any location and progress in any direction the operator of the site chooses. However, it is best to work logically from one corner of the site toward another corner.

The area method, as shown on Plate 23, consists of placing the solid wastes in 24-inch layers and compacting them in an area about 50 by 100 to 150 feet in plan dimension. At the end of each days operation, 6 inches of compacted soil should be placed over the refuse. This process forms a cell. Cells should be placed on top of each other until the desired height is reached. Then 12 inches of intermediate cover should be placed over the top and an adjacent set of cells started. Within 15 months after an area is completed, an additional two feet of soil should be placed to achieve the required total of 36 inches for final cover. Generally, the height of the fill should correspond to that required to achieve a final grading and drainage plan. The additional layer, including final cover, should not exceed 12 feet in height and side slopes should not be constructed steeper than three horizontal to one vertical (3:1). The fill should be kept at least 100 feet behind the sea wall to prevent stability problems from occurring.

Existing personnel are adequate for continuing the operations and spreading the intermediate cover material. Once the cover has been placed, the personnel should be changed to two equipment operators and a gatekeeper who will be adequate to operate the site and place the final cover as the fill progresses.

The equipment necessary to operate the site includes the tug and scraper to haul the cover material, a crawler tractor to spread and compact the refuse and cover soils and a water truck for dust control and fire suppression. The grader would only be needed a few times a year to maintain the roads. The front end loader and crawler crane should not be needed.

The gatekeeper should be responsible for record keeping including number and types of loads plus their weight and yardage; loads should be checked by him to be sure they are acceptable materials. He should also keep track of equipment maintenance and prevent unauthorized people from entering the site.

The work week should be changed from 5-1/2 days to 5 days. Arrangements in collection should be made to avoid use of the landfill on the weekends. Closing the site on the weekend will discourage unauthorized dumping and scavenging.

Gas venting will take place through the intermediate cover material. Whenever the fill and final soil cover approach the north and east boundaries the gas prevention measures discussed in Section VIII-D below should be installed to prevent migration of gases toward the ammunition storage areas.

By placing a 12-foot-thick layer of refuse and soil (which would cause no clearance problems with the runways), the site can receive about 820,000 cubic yards more of refuse which will give a site life of 34 years. If specialized landfill equipment were purchased, average densities of the refuse compacted in place could increase from 800 to 1200 pounds per cubic yard, increasing the site life to 51 years. Since 34 years is more than adequate, the expense of the equipment necessary to achieve higher densities is not warranted.

At a refuse to soil ratio of 4:1, 204,900 cubic yards of cover material would be required regardless of in-place densities. This amount is available without lowering the slurry pond below Elevation 107.5.

2. <u>Option 2 - Outside Contractor Operates Landfill</u>

The cost comparison between current and private contractor operation of the site are presented in Section VII, G. If this option is selected, the bidding contractors should be required to submit an operational plan for the site which complies with local, state and federal regulations applicable at the time, the recommendations presented for Option 1, and a long-term operational plan prepared by the Navy. These plans along with the cost estimates should be considered in the selection process.

For the contractors to prepare their plans and cost estimates, certain operational decisions would have to be made by the Navy. These include whether or not the contractor should place the intermediate cover, install the gas venting system or install the seepage control measures.

If the outside contractor were to accept the 23 tons per week of housing refuse, it is estimated that the site life would be reduced to 30 years at existing densities. At increased densities, as discussed in Option 1, the site life would be reduced from 51 to 46 years.

3. Option 3 - Close The Landfill

A site closure plan, as required by Alameda County and the CRWQCB, should be prepared and submitted for approval. Correction of perimeter seepage should be performed if required by the regulatory agencies. Gas venting should be provided as described in Section VIII, D, below.

Closing the site would require that about 58 acres* be covered with three feet of final soil cover. Using a ratio of 75 percent dry mud slurry and 25 percent sand, about 280,000 cubic yards of material would be required to meet the state permeability requirement of 1×10^{-6} centimeters per second for the top foot. A larger percentage of sand can be used for the remaining thickness. Adequate cover material is available above Elevation 107.5.

* Excluding the dredge slurry pond.

The material should be mixed, moisture conditioned to near optimum moisture content, and compacted to 90 percent relative compaction.

The final grading plan should be developed so that the site drains from the interior toward the exterior at two or three percent depending upon RWQCB requirements. Instead of returning the surface water to the bay, it could be directed into the trench for Alternative 6, if it is constructed. The amount of surface runoff and its effect on the evaporation rate will have to be considered in the final design to determine if this is feasible.

This will leave about 18,000 cubic yards of extra cover material that will accommodate about 2-1/2 years of filling at current rates. This could keep the site open while the final cover is placed.

A landscape contractor should be consulted in selecting plants that can tolerate the high salt content of the cover materials. It may be desirable to delay planting a year or two to allow rainfall to leach out the salts.

Once the site is closed, a maintenance program of periodic site inspections should be implemented. The inspections should include checking for cover material erosion, presence of sinkholes, surface drainage and gas venting systems. Deficiencies should be repaired immediately. The Alameda County Health Services Agency will also inspect the landfill.

D. Gas Control Measures

When the landfill is covered with impervious soils there will be less vertical ventilation of methane gas than occurs now and the tendency for the gas to migrate laterally toward the magazines will increase accordingly. To prevent gas movement outside the refuse fill area, vertical collectors should be provided around the north and east perimeters for a length of about 4200 feet, as shown on the Plot Plan in Appendix B. The collectors should consist of 2-foot-wide trenches excavated to a depth of 6 to 10 feet (down to the water table) and backfilled to within 2 feet of the surface with crushed rock. The top 2 feet should be compacted with impervious soils to prevent surface water infiltration. Vent the gas to the atmosphere through vertical risers of perforated plastic pipe installed at 100-foot intervals.

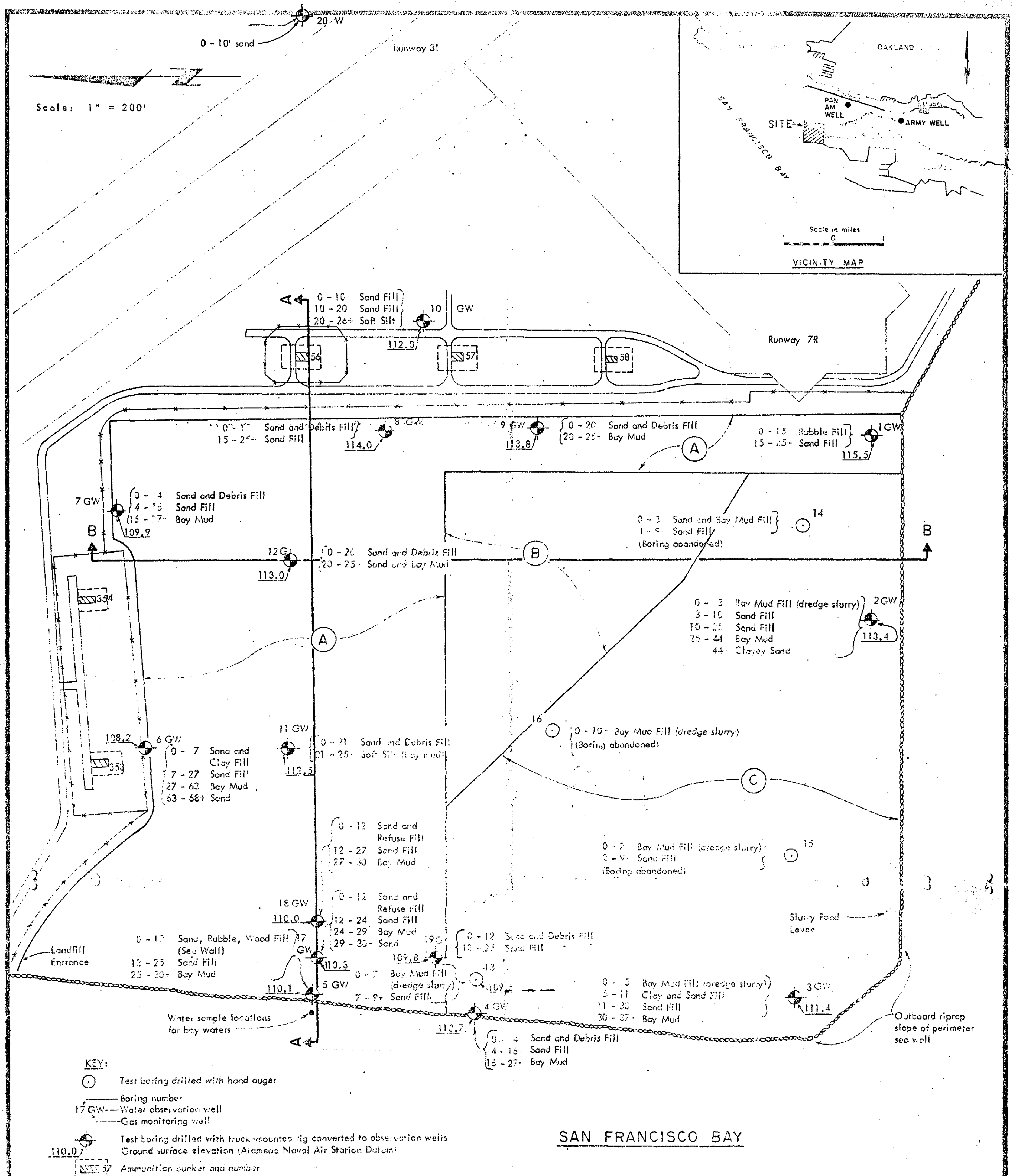
If methane readings in the magazines outside the landfill increase then the gas barrier should be installed.

If it is decided to install seepage repair Alternative 6, the subdrain collector system, it can be used for gas ventilation by installing the plastic pipe vents. The trench would have to be extended to the entire length of the north and east sides.

E. Slurry Pond Drainage

To provide drainage from the slurry pond a sump with drain pipe should be installed near the center of the south perimeter. The pipe should be an 18-inch-diameter steel drain pipe with tide gate and should be placed from the sump through the sea wall. The invert of the drain pipe should be at Elevation 107.5, the lowest recommended elevation for the bottom of the pond.

IX ILLUSTRATIONS



Reference: General Development Map, Naval Air Station, Alameda, by Naval Facilities Engineering Command, undated

Job No. 2176,030.01
Designed ALS
Drawn GES
Checked
Approved
Date
Scale 1" = 200'

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PLOT PLAN

SANITARY LANDFILL SITE
ALAMEDA NAVAL AIR STATION

Alameda California

PLATE

1

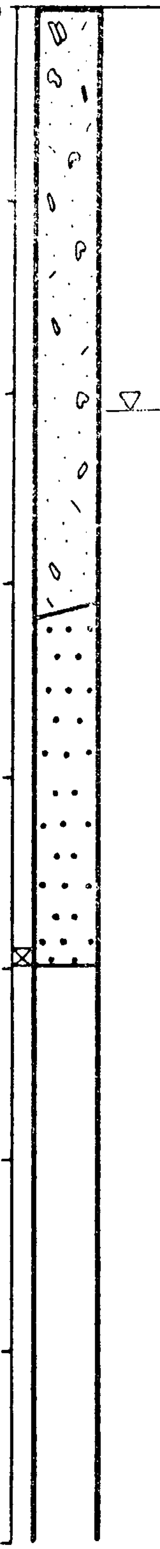
48

LOG OF BORING 1

Equipment: 6" Flight Auger

Elevation: 115.5* feet Date: 10/29/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description	
			0		BROWN SILTY SAND (SM) loose to medium dense, moist, with debris	Refuse Fill
			5			
			10		water level 4/18/77	
			15		BROWN SAND (SP) loose, saturated,	Hydraulic Fill
			20			
			25	⊠		
			30			
			35			
			40			



*Reference: Topo, NAS Alameda Sanitary Dump Facility, 1975, by M. B. Cristi

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Job No. 2176,030.01 Appr: JCD Date 5/20/77

LOG OF BORING 1

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 2

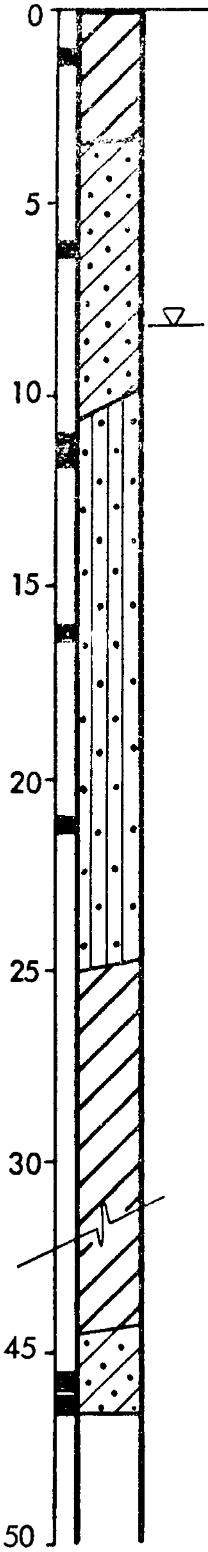
LOG OF BORING 2

Equipment: 5" Rotary Wash

Elevation: 113.4 feet Date: 10/26/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
			0		BROWN-BLACK CLAY (CH) very soft, moist
					LIGHT BROWN CLAYEY SAND (SC) loose, saturated
			5		
	22.9	94			
					water level 4/7/77
			10		GRAY SILTY SAND (SM) loose, saturated
			15		
			20		
			25		GRAY SILTY CLAY (CH) very soft, saturated, (bay mud)
			30		
			45		LIGHT BROWN CLAYEY SAND (SC) medium dense, saturated
	17.6	113			
			50		

Hydraulic Fill (0 to 25 ft)



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LOG OF BORING 2

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 3

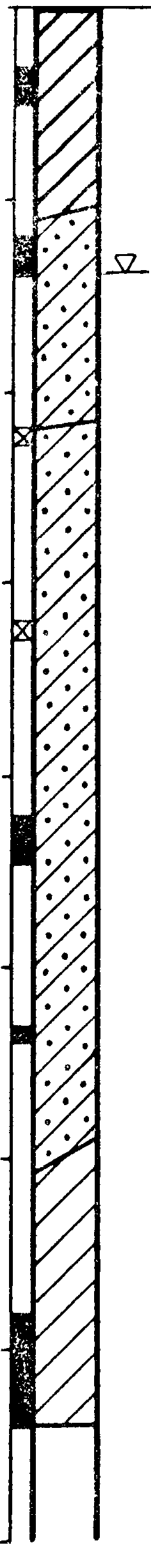
LOG OF BORING 3

Equipment 5" Rotary Wash

Elevation 111.4 feet Date 10/25/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)
97% passing No. 200 sieve	64.7	59	~2
	23.6	99	~27

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40



BROWN-GRAY CLAY (CH)
very soft, saturated

LIGHT GRAY CLAYEY SAND (SC)
medium dense, saturated
water level 4/18/77

LIGHT GRAY-BROWN CLAYEY SAND
(SC) - very loose, saturated

GRAY SILTY CLAY (CL)
very soft, saturated, (bay mud)

Hydraulic Fill

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LOG OF BORING 3

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 4

LOG OF BORING 4

Equipment: 5" Rotary Wash

Elevation: 110.7 feet Date: 10/21/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)
13% passing No. 200 sieve	18.5	104	

Depth (ft)	Description	
0	LIGHT BROWN CLAYEY SAND (SC) loose, dry, with debris	Refuse Fill
4	DARK GRAY SILTY SAND (SM) medium dense, saturated, with concrete rubble; water level 4/18/77	Hydraulic & Sea Wall Fill
20	DARK GRAY CLAY (CH) soft, saturated, (bay mud)	

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40

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LOG OF BORING 4

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 5

LOG OF BORING 5

Shear Strength (lbs/sq ft)

Equipment 5" Rotary Wash

Elevation 110.1 Date 10/20/76

Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description	
5.0	122	0		BROWN SILTY SANDY GRAVEL (GM) medium dense, dry	Refuse Fill
				BLACK SILTY SAND (SM) loose, moist, with debris	
				water level 4/18/77	
		5			
		10			
				DARK GRAY SILTY SAND (SM) loose, saturated	Hydraulic Fill
		15			
		20			
32.7	84				
		25		BLACK CLAY (CH) very soft, saturated, (bay mud)	
		30			
		35			
		40			

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LOG OF BORING 5

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 6

LOG OF BORING 6

Equipment 5" Rotary Wash
Elevation 108.2 feet Date 10/21/76

Depth (ft)	Description
0	DARK GRAY SILTY SAND (SM) loose, saturated, with rock fragments — water level 4/7/77
4	BLACK SANDY CLAY (CL) very soft, saturated
7	DARK GRAY SILTY SAND (SM) very loose, saturated
15	LIGHT BROWN SILTY SAND (SM) loose, saturated
27	GRAY SILTY CLAY (CH) very soft, saturated, with shells, (bay mud)

Hydraulic Fill (0–26.5 ft)

Columns: Shear Strength (lbs/sq ft); Moisture Content (%); Dry Density (pcf); Depth (ft); Sample

(Continuation of Log)

Depth (ft)	Description
40	GRAY SILTY CLAY (CH) (continued)
63	GRAY SILTY SAND (SM) medium dense, saturated

Depth scale 0–80 ft.

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Job No 2176,030.01 Appr. JCD Date 5/20/77

LOG OF BORING 6
Sanitary Landfill Site
Alameda Naval Air Station

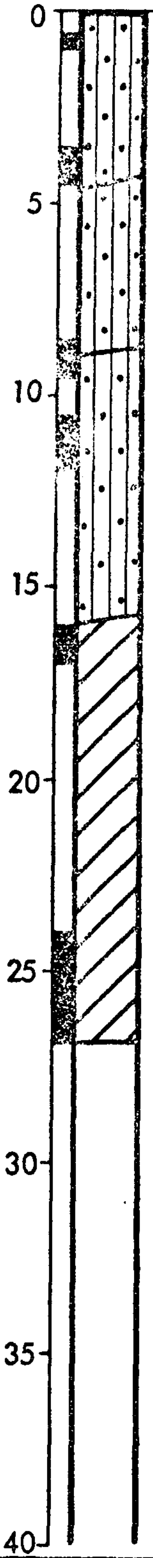
PLATE 7

LOG OF BORING 7

Equipment 5" Rotary Wash

Elevation 109.9 feet Date 10/25/76

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample



Depth (ft)	Description	Unit
0	LIGHT BROWN SILTY SAND (SM) loose, with debris water level 4/7/77	Refuse Fill
~4	GRAY SILTY SAND (SM) loose, saturated	Hydraulic Fill
~9	LIGHT BROWN SILTY SAND (SM) loose, saturated	Hydraulic Fill
~16	LIGHT GRAY CLAY (CH) very soft, saturated, (bay mud)	

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Job No. 2176,030.01 Appr: JG Date 5/10/77

LOG OF BORING 7

Sanitary Landfill Site
Alameda Naval Air Station

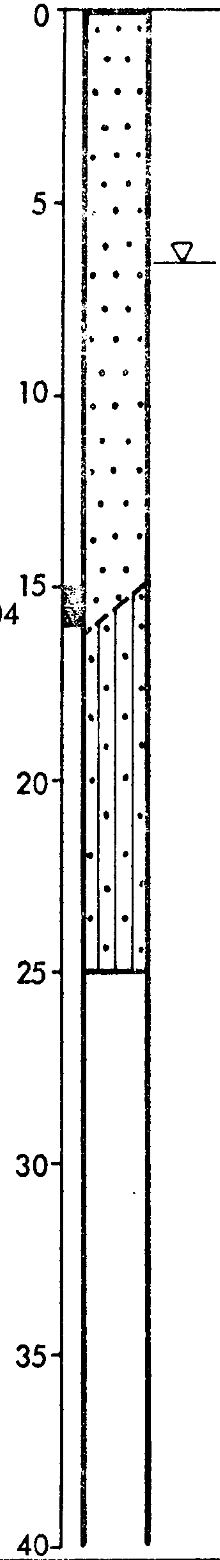
PLATE 8

LOG OF BORING 8

Equipment 8" Hollow Auger

Elevation 114.0 feet Date 10/29/77

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample



Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Description
		0	BROWN SAND (SP) medium dense, moist, with debris
		~6.5	∇ water level 4/7/77
19.2	104	15	DARK GRAY SILTY SAND (SM) loose, saturated

Refuse Fill (0–15 ft)

Hydraulic Fill (15–25 ft)

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Consulting Engineers and Geologists

Job No. 2176,030.01 Appr: JCD Date 5/20/77

LOG OF BORING 8

Sanitary Landfill Site
Alameda Naval Air Station

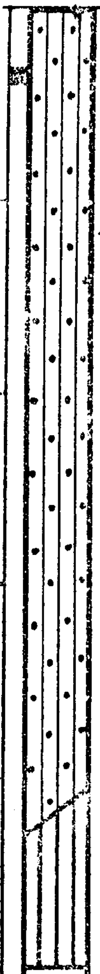
PLATE 9

LOG OF BORING 9

Equipment: 6" Flight Auger

Elevation: 113.8 feet   Date: 10/29/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample



Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40

0 ft — BROWN SILTY SAND (SM)
loose to medium dense, moist, with debris

water level 4/7/77

Refuse Fill (0 to about 20 ft)

About 20 ft — DARK GRAY CLAYEY SILT (MH)
soft to medium stiff, saturated, (bay mud)

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›b No. 2176,030.01   Appr: JCD   Date 5/20/77

LOG OF BORING 9

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 10

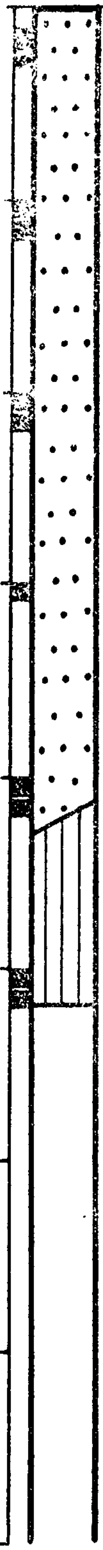
LOG OF BORING 10

Equipment 8" Hollow Auger

Elevation 112.0 feet Date 10/28/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Description
			0	LIGHT BROWN SAND (SP) medium dense, moist, with silt lenses; water level 4/7/77
	20.3	104	5	
			10	
5.7% passing No. 200 sieve	21.4	100	15	
			20	DARK GRAY SANDY SILT (ML) medium stiff, saturated
			25	
			30	
			35	
			40	

Hydraulic Fill (0 to about 21 ft)



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LOG OF BORING 10

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 11

LOG OF BORING 11

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Equipment 6" Flight Auger

Elevation 112.5 feet Date 10/29/77

Depth (ft): 0, 5, 10, 15, 20, 25, 30, 35, 40

BROWN SILTY SAND (SM)
loose to medium dense, with debris

water level 4/7/77

Refuse Fill

DARK BLUE-GRAY SILTY SAND (SM)
loose, saturated

BLUE-GRAY CLAYEY SILT (MH)
medium stiff, saturated, with lenses of silty sand

Hydraulic Fill

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LOG OF BORING 11

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 12

LOG OF BORING 12

Equipment 6" Flight Auger

Elevation 113.0 feet Date 10/29/76

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
			0		BROWN SILTY SAND (SM) loose, moist, with debris
			5		water level 4/7/77
			10		Refuse Fill (0 to about 19 ft)
			15		
			20	X	DARK GRAY CLAYEY SILT (MH) medium stiff, saturated, (bay mud)
				X	DARK GRAY SILTY SAND (SM) loose, saturated
			25		
			30		
			35		
			40		

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LOG OF BORING 12

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 13

LOG OF BORING 13

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Equipment: Hand Auger

Elevation: 109.5 feet Date: 11/9/76

82.3% passing No. 200 sieve

Depth scale: 0, 5, 10, 15

BROWN CLAYEY SILT (MH)
stiff, dry, (desiccated bay mud)
becoming soft, moist at 3'
water level 4/7/77

DARK GRAY SILTY SAND (SM)
loose, saturated, (fill)

Hydraulic Fill

LOG OF BORING 14

Equipment: Hand Auger

Elevation: 113.3 feet Date: 11/9/76

15% passing No. 200 sieve

Depth scale: 0, 5, 10, 15

BROWN SAND (SP)
loose, moist, with organic matter

GRAY-BLACK SILT (MH)
soft, saturated

BROWN SAND (SP)
loose, moist
becoming wetter at 6'

Hydraulic Fill

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›b No. 2176,030.01 Appr: JCD Date 5/20/77

LOG OF BORINGS 13&14

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 14

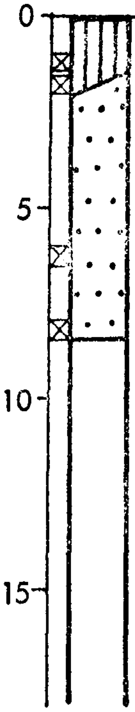
N34547

LOG OF BORING 15

Shear Strength (lbs/sq ft) | Moisture Content (%) | Dry Density (pcf) | Depth (ft) | Sample

Equipment: Hand Auger

Elevation: 113.9 feet   Date: 11/16/76



LIGHT BROWN SILT (MH)
medium stiff, dry, (desiccated bay mud)

LIGHT BROWN SAND (SP)
medium dense, dry

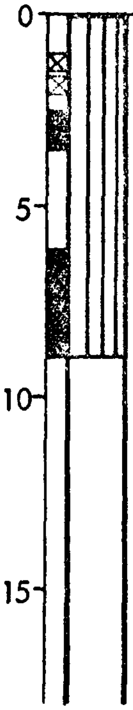
wet at 8'

Hydraulic Fill

LOG OF BORING 16

Equipment: Hand Auger

Elevation: 109.3 feet   Date: 11/16/76



95.4% passing No. 200 sieve

BROWN SILT (MH)
soft to medium dense, moist, (desiccated bay mud)
becoming softer at 4'

Hydraulic Fill

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LOG OF BORINGS 15&16

Sanitary Landfill Site
Alameda Naval Air Station

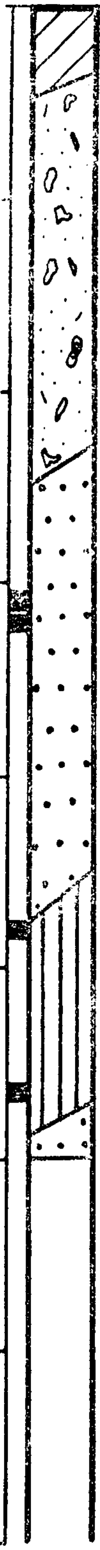
PLATE 15

LOG OF BORING 17

Equipment: 9" Hollow Auger

Elevation: 110.3 feet | Date: 3/16/77

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
			0		BROWN SANDY CLAY (CL) medium stiff, wet, with organic matter
					DEBRIS FILL loose water level 4/18/77
			5		
			10		
					BLACK SAND (SP) loose, saturated
	20.2	106	15		
			20		
					BLUE-GRAY CLAYEY SILT (MH) soft, saturated, (bay mud)
			25		
					BROWN SAND (SP) loose, saturated
			30		
			35		
			40		



Refuse Fill (0 to about 11.5 ft)

Hydraulic Fill (about 11.5 to 22.5 ft)

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LOG OF BORING 17

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 16

LOG OF BORING 18

Equipment: 9" Hollow Auger
Elevation: 110 feet Date: 3/16/77

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description	
			0		BROWN SANDY CLAY (CL) medium stiff, wet, with debris	Refuse Fill
					DEBRIS FILL loose	
					water level 4/18/77	
			5			
			10			
15.0% passing No. 200 sieve	20.9	107			BLACK SILTY SAND (SM) loose, saturated	Hydraulic Fill
			15			
			20			
			25			
					DARK GRAY CLAYEY SILT (MH) soft, saturated, (bay mud)	
			30			
			35			
			40			

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LOG OF BORING 18
Sanitary Landfill Site
Alameda Naval Air Station

PLATE 17

LOG OF BORING 19

Equipment 9" Hollow Auger

Elevation 109.8 feet Date 3/16/77

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
			0		BROWN SANDY CLAY (CL) medium stiff, wet
					DEBRIS FILL loose, saturated
					▽ water level 4/18/77
			5		
			10		
					BLACK SILTY SAND (SM) loose, saturated, with layers of sandy silt
	44.6	75	15		
			20		
			25		
			30		
			35		
			40		

Refuse Fill (0 to approx. 11.5 ft)

Hydraulic Fill (approx. 11.5 to 24.5 ft)

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LOG OF BORING 19

Sanitary Landfill Site
Alameda Naval Air Station

PLATE 18

LOG OF BORING 20

Equipment: Hand Auger
Elevation: 114.5 feet   Date: 10/6/77

Shear Strength (lbs/sq ft)	Moisture Content (%)	Dry Density (pcf)	Depth (ft)	Sample	Description
			0		BROWN SAND (SP) medium dense, dry
					becomes moist at 2'
					becomes wet at 4'
			5		▽ water level 10/6/77
			10		
			15		
			20		
			25		
			30		
			35		
			40		

Hydraulic Fill (0 to approx. 9 ft)

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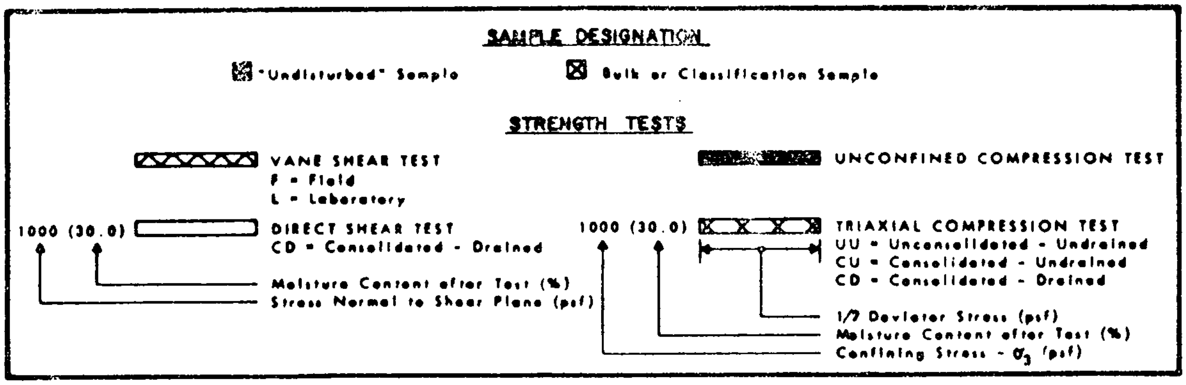
LOG OF BORING 20
Sanitary Landfill Site
Alameda Naval Air Station

PLATE 19

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS (MORE THAN HALF IS LARGER THAN #200 SIEVE)	GRAVELS — MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE SIZE	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES
			GP	POORLY GRADED GRAVELS, GRAVEL - SAND MIXTURES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, POORLY GRADED GRAVEL - SAND - SILT MIXTURES
			GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL - SAND - CLAY MIXTURES
	SANDS — MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE SIZE	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL GRADED SANDS, GRAVELLY SANDS
			SP	POORLY GRADED SANDS, GRAVELLY SANDS
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, POORLY GRADED SAND - SILT MIXTURES
			SC	CLAYEY SANDS, POORLY GRADED SAND - CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN HALF IS SMALLER THAN #200 SIEVE)	SILTS AND CLAYS — LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC CLAYS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS — LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACIOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS			Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS

UNIFIED SOIL CLASSIFICATION SYSTEM



KEY TO TEST DATA

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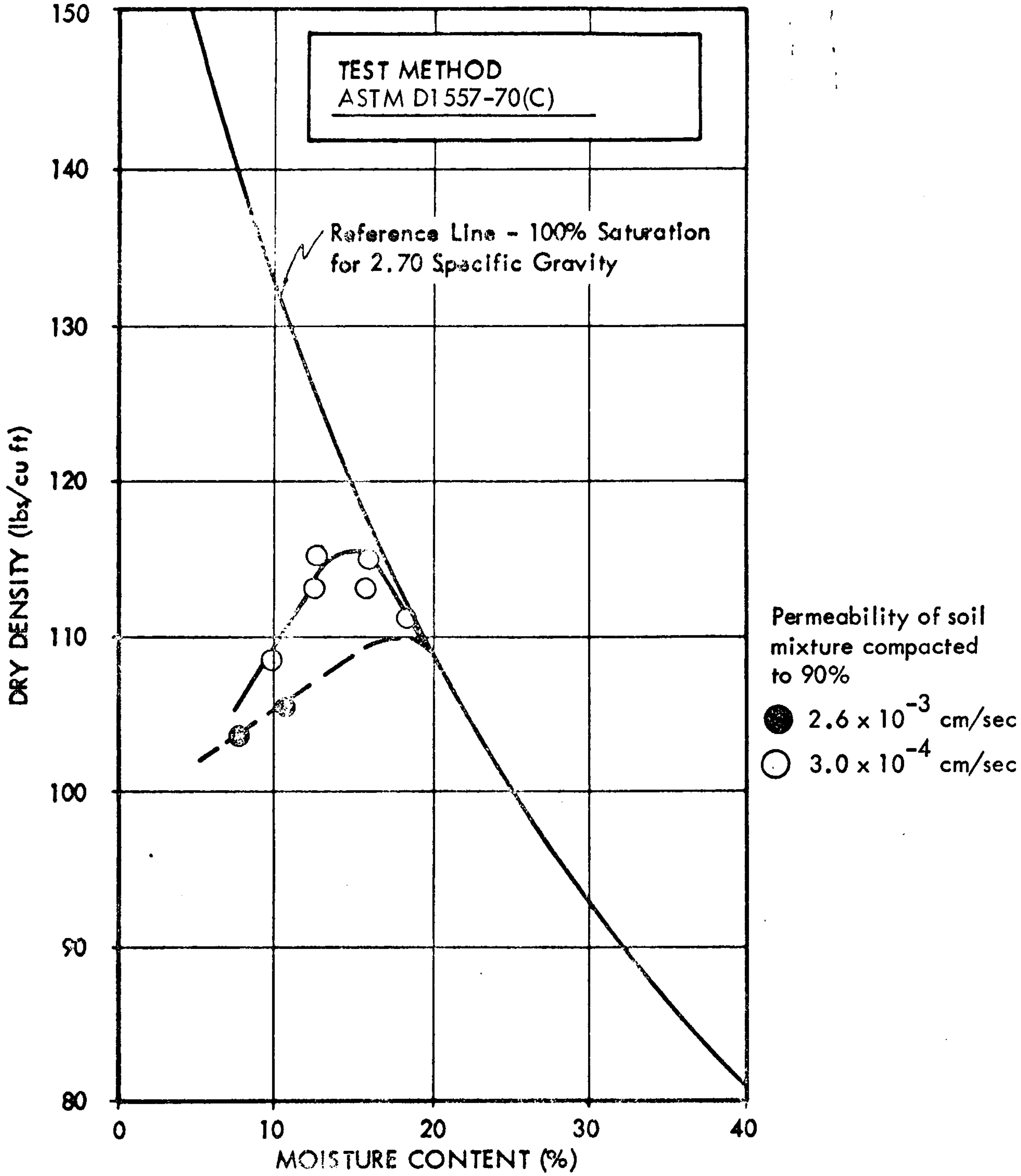
SOIL CLASSIFICATION CHART AND KEY TO TEST DATA
Alameda Naval Air Station

PLATE 20

N02470



Symbol	Sample Source	Classification	Optimum Moisture (%)	Maximum Dry Density (pcf)
--◌--	Dredged slurry pond	50% Sand, 50% Bay Mud (CH)	18.0	110
—○—	Dredged slurry pond	70% Sand, 30% Bay Mud (CH)	15.0	116

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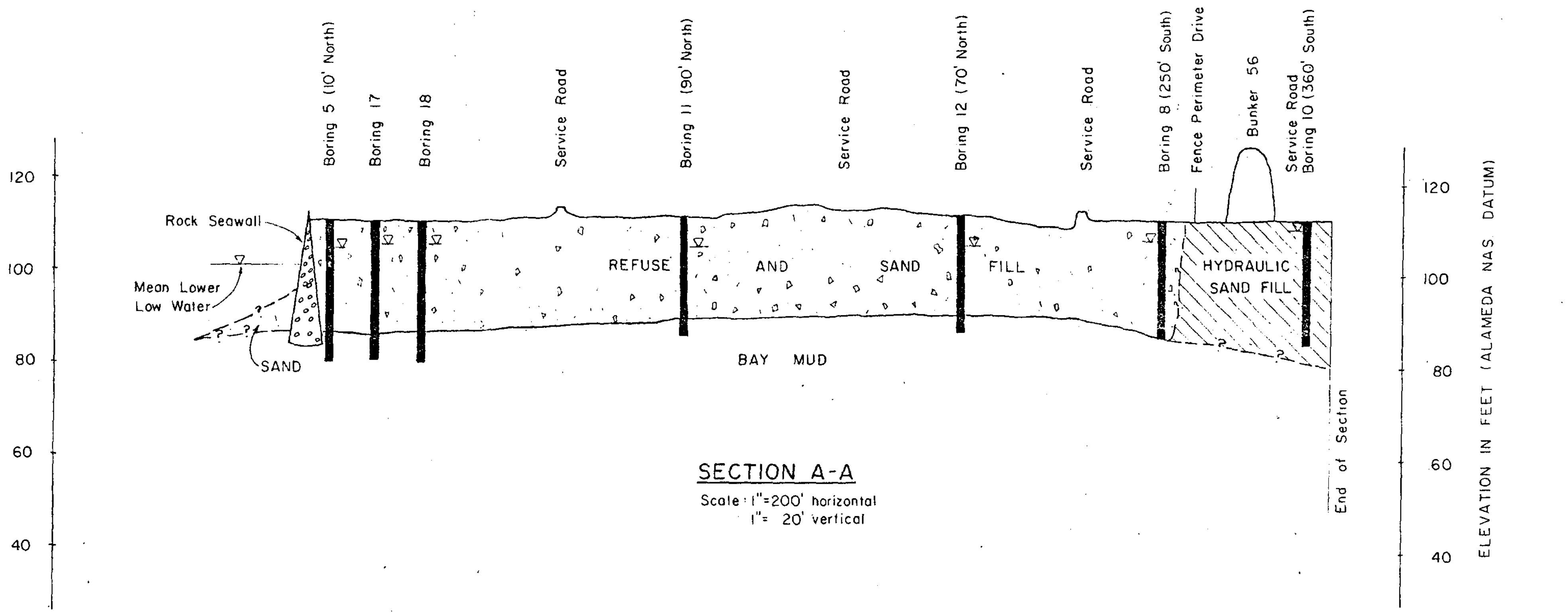
COMPACTION TEST DATA

Sanitary Landfill Site
Alameda Naval Air Station

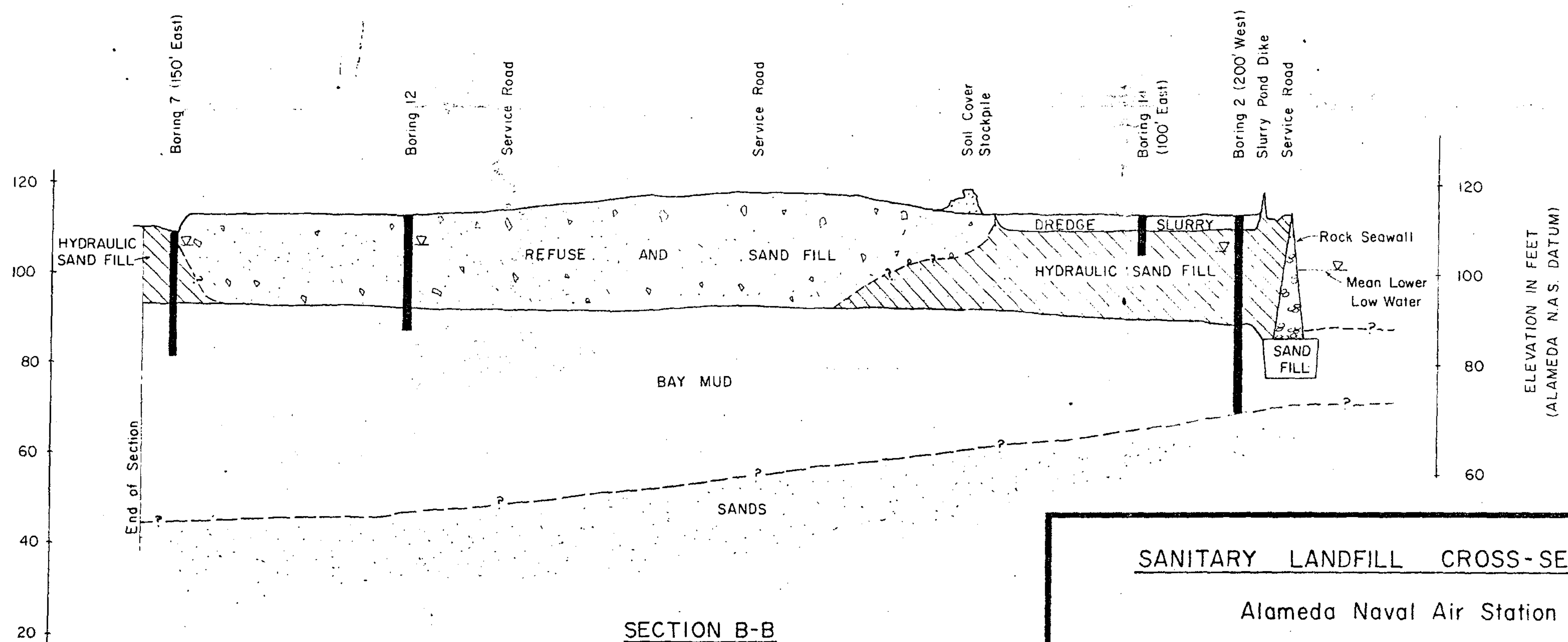
PLATE
21

N30336



SECTION A-A

Scale: 1"=200' horizontal
1"= 20' vertical



SECTION B-B

Scale: 1"=200' horizontal
1"= 20' vertical

* Alameda Naval Air Station Datum equals Mean Lower Low Water + 101.2 Feet

SANITARY LANDFILL CROSS-SECTIONS

Alameda Naval Air Station

Alameda, California

Job No. 2176,030.01
Designed JCD
Drawn GR
Checked JCD
Approved LEL
Date 4/7/77
Scale as shown

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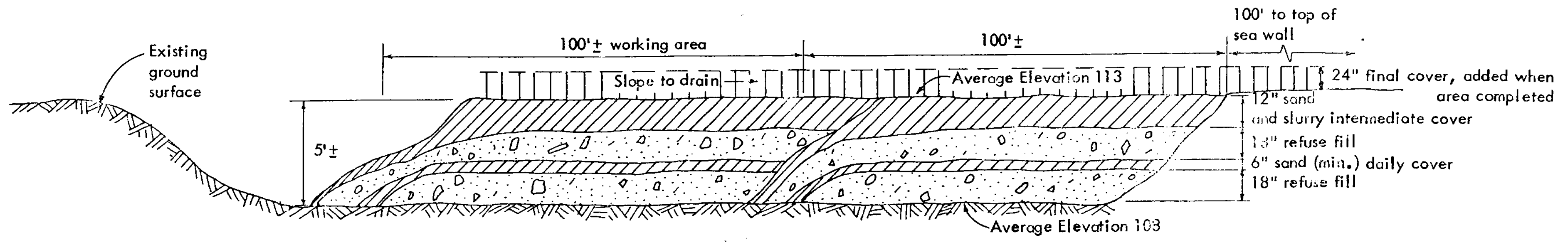
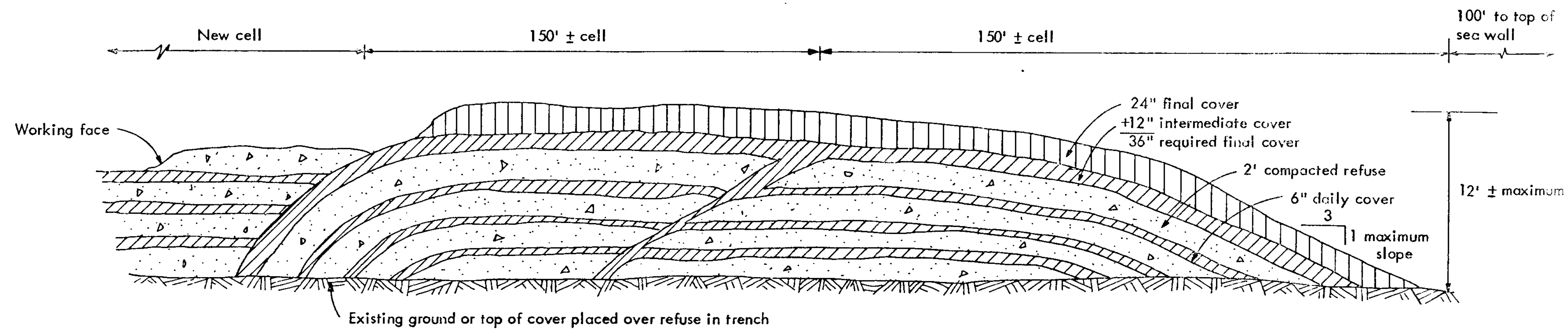
PLATE

22



TRENCH METHOD

Not to Scale



AREA METHOD

Not to Scale

HARDING - LAWSON ASSOCIATES *Consulting Engineers and Geologists* Job No. 2176,030.01 Appr: JD Date 11/21/77	SOLID WASTE DISPOSAL METHODS TYPICAL CROSS SECTIONS Sanitary Landfill Site Alameda Naval Air Station Alameda, California	PLATE 23

Appendix A

LANDFILL SEEPAGE RATE ANALYSIS AND QUANTITIES OF CHEMICAL CONSTITUENTS DISCHARGED INTO SAN FRANCISCO BAY

SUBSURFACE WATER FLOW RATE ANALYSIS

Subsurface water levels in many of the observation wells within the landfill have been monitored for about a year. The data obtained from this program indicate that there are two different types of flow occurring within the landfill. The first is a relatively rapid exchange of bay water along the south and west sides as the tide rises and falls. Second, water is continually flowing southwesterly through the site toward the Bay at a relatively constant rate, unaffected by tidal variations.

The flow rate from the interior of the landfill is small, as indicated by the slight downward slope of the water table across the site. As it flows through the site, it contacts the refuse and leaches out various contaminates.

As the contaminated subsurface water approaches the perimeter of the landfill, it is mixed with Bay water and drained away during falling tides. We estimate that the zone of mixing extends 100 to 150 feet into the landfill since beyond this region water levels show no tidal variations. Therefore, contaminates are discharged into the Bay at a rate dependent upon the flow through the interior of the landfill.

Several factors influence the flow rate occurring in the landfill: the permeability of the material, the area through which flow is taking place, and the hydraulic gradient or driving force that is causing flow.

The permeability (k) of the landfill debris is highly variable. However, our investigation indicates that a relatively clean, fine sand zone exists between the sea wall and the refuse fill. The sand limits the maximum flow rate because its permeability is less than the refuse fill. A value of 0.01 centimeters/second (cm/sec) was used for the sand in the analyses. This value is typical of a fast-draining, fine sand.

The hydraulic gradient (i) or slope of water table varies within the site. Using the water level in Well 9 (the highest water level) as a starting point, hydraulic gradients range from 0.0009 to 0.0028 feet/foot (ft/ft) and an average value of 0.0015 ft/ft was selected. However, since this average value was calculated using extreme differences in water elevations, it is probably higher than the true average gradient for the site. Consequently, 0.001 ft/ft was assumed for the final analyses.

The area through which flow is taking place (A) also varies throughout the site and was considered to be restricted to the porous material bounded by the upper surface of the water table and the virtually impermeable underlying bay mud. The test borings indicate that on the average in the interior of the landfill, the water table is approximately 14-1/2 feet above the bay mud layer. Consequently, a flow area of 14-1/2 square feet/foot was used in the analyses.

Since the conditions under which flow is taking place are relatively simple, the equation q = kiA was used to calculate the flow rate through the site. In the equation, "q" represents the flow per foot of discharge surface. The resulting flow, after the required unit conversions have been made, was approximately 0.3 gallons per day per foot of levee (gpd/ft). The calculations are presented below. The flow rate through the slurry pond in the southwest corner of the site was estimated to be significantly less due to the relatively low permeability of the slurry and longer flow path. Based on engineering judgment and experience, it was assumed that no more than one-half of the landfill value or 0.15 gpd/ft was flowing through this area.

The length of discharge face around the site was determined to be approximately 4900 feet, 3100 feet of which is next to the dredged slurry pond and 1800 feet along the refuse filled area. The resulting total discharge from the landfill was calculated to be approximately 1,005 gpd. Considering the uncertainties in the assumptions and judgments, we estimate the actual total discharge to be between 700 and 1,300 gpd. This range of flow rates and the average chemical concentrations obtained from the water quality tests were used to estimate pollutant discharge quantities.

Flow Rate Calculations

Taken between Borings 9 and 11 as typical.

Change in elevation = 108.0 - 106.7 = 1.3 feet

Length between borings = 1300 feet

Average refuse fill thickness = 14.6 feet

Flow Rate q = kiA

where k = 0.001 cm/sec (assumed) = .118 ft/hour

i = 1.3 ft/1300 ft = 0.001 ft/ft

A = 14.6 ft x 1 ft = 14.6 ft^2/ft levee

therefore q = .118 ft/hr (0.001) ft/ft (14.6) ft^2/ft = 0.0017 ft^3/ft/hr

= 0.0017 ft^3/ft/hr x 24 hrs/day = 0.041 ft^3/day/ft

= 0.041 ft^3/day/ft x 7.49 gal/ft^3 $\approx$ 0.3 gal/day/ft

Flow rate for refuse fill perimeter

0.3 gal/day/ft x 1800 ft = 540 gal/day

Flow rate for slurry pond perimeter

0.15 gal/day/ft x 3100 ft = 465 gal/day

Total flow rate = 540 + 465 = 1,005 gal/day

Use range of 700 to 1,300 gal/day

QUANTITIES OF CHEMICAL CONSTITUENTS DISCHARGED INTO SAN FRANCISCO BAY

To evaluate the amount of pollution the landfill is contributing to San Francisco Bay, it was decided to determine what increase in pollutants above the average of the Bay water is attributable to the landfill. Therefore, the average of the Bay water concentration was subtracted from a high and low range value for seven components that exceeded the Bay averages.

The calculations for the components presented below are on the following pages.

Discharge From Landfill*

Component	Quantity (pounds per day)
Oil and grease	0.01 to 0.06
Sulfide	0.002 to 0.02
Iron	0.05 to 0.25
Nitrate nitrogen	0 to 0.010
Lead	0 to 0.002
Total phosphate	0.002 to 0.012
Total Kjeldahl nitrogen	0.06 to 0.90

* Quantities in excess of background levels

Chemical Constituent Discharge Calculations

Flow rates:

1. Flow rate from site at refuse area is 0.3 gallons/day/foot, length = 1800 feet
   1800 x 0.3 = 540 gallons/day

2. Flow rate from site at slurry pond is 1-1/2 gallons/day, length = 3100 feet
   3100 x 0.15 = 465 gallons/day

Conversion Factor: $\frac{mg}{l} = \frac{g}{1000\ l} \cdot \frac{lb}{454\ g} \cdot \frac{3.79\ l}{gallon}$

$$\frac{mg}{l} = 8.35 \times 10^{-6}\ \#/gallon$$

Concentration Values
(Taken From Table 3)

Parameter	Interior Wells (1) Low	Interior Wells (1) High	Bay (2) Average	Increase Above Bay Average Low	Increase Above Bay Average High	Total Range (3)
Oil and grease	5.0	11.0	4.0	1.0	7.0	0.01 - 0.06
Sulfide	0.4	2.1	0.2	0.2	1.9	0.002 - 0.02
Iron	6.0	30	0.5	5.5	29.5	0.05 - 0.25
Nitrate nitrogen	0.4	1.6	0.4	0	1.2	0 - 0.010
Lead	0.2	0.4	0.2	0	0.2	0 - 0.002
Total phosphate	0.4	1.6	0.2	0.2	1.4	0.002 - 0.012
Total Kjeldahl nitrogen	10	110	3.0	7.0	107	0.06 - 0.90

(1) High and low value with extremes disregarded
(2) Average Bay water
(3) Pounds per day

<u>Landfill Contribution</u>: seepage from that portion of the sea wall adjacent to refuse fill areas
pounds/day = (concentration)$(8.35 \times 10^{-6})(0.3)(1800) = 0.0045$

Component		Low value		High value
Oil and grease	=	1.0 x 0.0045 = 0.0045 lbs/day	;	7.0 x 0.0045 = 0.032 lbs/day
Sulfide	=	0.2 x 0.0045 = 0.0009	;	1.9 x 0.0045 = 0.009
Iron	=	5.5 x 0.0045 = 0.025	;	29.5 x 0.0045 = 0.133
Nitrate nitrogen	=	0	;	1.2 x 0.0045 = 0.0054
Lead	=	0	;	0.2 x 0.0045 = 0.0009
Total phosphate	=	0.2 x 0.0045 = 0.0009	;	1.4 x 0.0045 = 0.0063
Total Kjeldahl nitrogen	=	7.0 x 0.0045 = 0.032	;	107 x 0.0045 = 0.482

<u>Slurry Pond Contribution</u>: seepage from that portion of the sea wall adjacent to the slurry pond
pounds/day = (concentration)$(8.35 \times 10^{-6})(0.15)(3100) = 0.0039$

Component		Low value		High value
Oil and grease	=	1.0 x 0.0039 = 0.0039	;	7.0 x 0.0039 = 0.027
Sulfide	=	0.2 x 0.0039 = 0.0008	;	1.9 x 0.0039 = 0.0074
Iron	=	5.5 x 0.0039 = 0.021	;	29.5 x 0.0039 = 0.115
Nitrate nitrogen	=	0	;	1.2 x 0.0039 = 0.0047
Lead	=	0	;	0.2 x 0.0039 = 0.0008
Total phosphate	=	0.2 x 0.0039 = 0.0008	;	1.4 x 0.0039 = 0.0055
Total Kjeldahl nitrogen	=	7.0 x 0.0039 = 0.027	;	107 x 0.0039 = 0.417

See table on previous page for totals.

Appendix B

PERIMETER SEEPAGE CONTROL MEASURES

APPENDIX B

PERIMETER SEEPAGE CONTROL MEASURES

A discussion of the seepage control measures is presented below. The areas where the various alternatives would apply are shown on the Plot Plan, Plate B-1 and a typical section for each is shown on Plates B-2 through B-4.

1. Chemical Grouting

Chemical grout could be introduced through drill holes to fill voids and decrease the permeability of the sea wall. This would require two-inch-diameter holes drilled through the perimeter sea wall approximately 20 to 25 feet deep and spaced about 5 feet apart. Portland cement grout or chemical grout, consisting of a cementing material and a reagent, would be pumped into the holes under pressure and forced into the voids before hardening to form an impervious seal.

Advantages	Disadvantages
1. Repairs can be located directly in the perimeter sea wall making use of the existing structure	1. Difficulty in controlling placement of the grout (quantities may be excessive or may not reach areas desired)
	2. Drilling through the rock sea wall may be difficult
	3. Cost may be relatively high and can vary greatly

2. Steel Sheet Piles

Interlocking steel sheet piles could be driven through the fill and debris behind the sea wall well into the underlying soils to provide a relatively watertight barrier. Piles at least 25 to 30 feet in length would be required.

Advantages	Disadvantages
1. Repair requires no excavation or relocation of existing landfill material	1. Unprotected piles may be susceptible to corrosion from sea water and from contaminates within the fill. Epoxy or some other type of pile coating may be required.
2. Provides a barrier unaffected by site settlement	2. Driving sheet piles through refuse and debris filled areas may be difficult. Interlocks may be damaged during the driving with the result that an impervious seal will not be obtained in some places.
	3. Very high cost

3. Trench With Compacted Earth Backfill

This method would consist of excavating a trench about 25 feet deep through the trash fill just inside the sea wall. The trench would have sloping sides and be about 5 feet wide at the bottom and 55 feet wide at the top. The excavated trash would be relocated on the site, and the trench would be backfilled immediately with compacted soils to form an impervious barrier.

Advantages	Disadvantages
1. Conventional earthmoving equipment can be used	1. May require imported material to be used for the impervious backfill
2. Provides a barrier that can tolerate settlement	2. Large excavation would be required behind existing perimeter sea wall
	3. Best suited for repair of long continuous lengths

4. Would require trench dewatering

5. Sands may not be stable after the excavation is dewatered

4. Slurry Trench

A trench approximately 3 to 5 feet wide and 20 feet deep would be excavated just inside the sea wall and backfilled with either bay mud dredged slurry or a mixture of water, cement and bentonite. If dredged material were used, it would require at least two applications to allow solids to separate from the liquid. This would require the trench to be open for a relatively long period of time and necessitate some shoring. The bentonite slurry would be mixed on site and the trench could be backfilled immediately with less risk of caving so shoring would not be required.

4A. Dredged Slurry Alternative

Advantages

1. Fine-grained maintenance dredging material could be used
2. Would provide a flexible impervious barrier
3. A relatively small amount of excavation is required

Disadvantages

1. Timing and location of a dredging project with suitable dredge spoil would affect the feasibility
2. Best suited to repair long continuous lengths
3. Would require an overflow system to handle decant water at one end of the trench
4. May require some shoring

4B. Cement Bentonite Alternative

Advantages

1. A relatively small amount of excavation is required
2. Provides a barrier that can tolerate settlement
3. Requires a minimum amount of excavation
4. One of the least costly methods
5. Independent of dredging schedule

Disadvantages

1. Relatively high mobilization cost
2. Requires specialized construction equipment and techniques

5. Impervious Membrane

This method would involve excavating a trench approximately 3 to 5 feet wide and 20 feet deep just inside the perimeter sea wall. The trenched refuse should stand vertically for a short period of time which eliminates the need for shoring. A tough impervious membrane would be supported from the surface and extend the full depth of the excavated trench. The void between the trench and the impervious membrane would be backfilled with sand to protect the membrane and support it within the trench.

Advantages

1. Provides a barrier that can tolerate settlement
2. Requires no special construction equipment or techniques

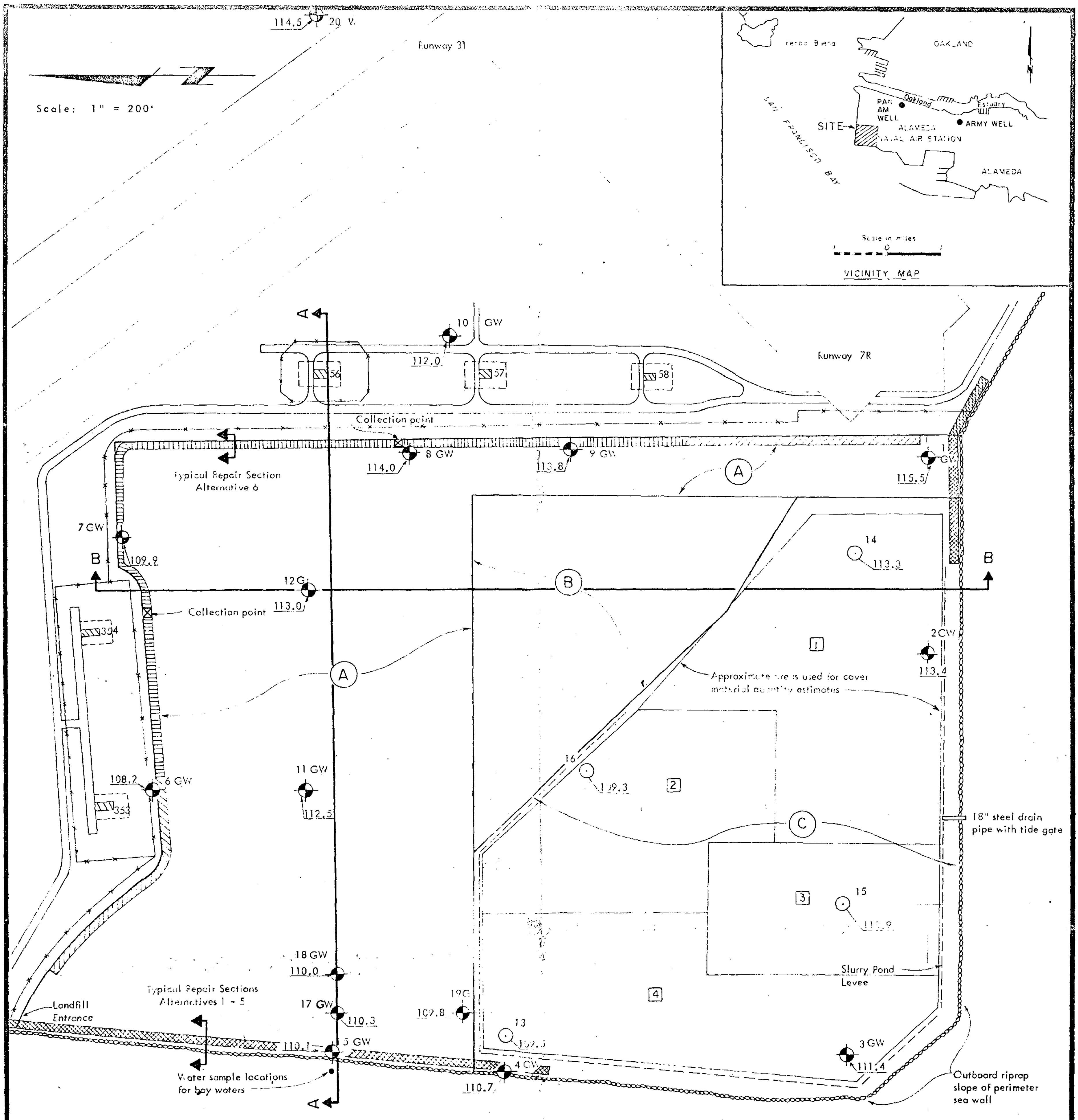
Disadvantages

1. Membrane must be protected against puncture during installation
2. Imported soil and/or clean on-site sand will be required for backfill between membrane and trench walls

6. Subdrain Collector System

An alternative method would consist of installing a system of subdrain trenches leading subsurface water to two collection sumps. Water would be collected and removed at a rate sufficient to reverse the subsurface flow gradient from the sea wall back toward the north and east perimeters of the landfill. The collected water (approximately 700 to 1,300 gallons per day) would be contaminated and could not be disposed of directly into the Bay. It could be disposed of either by sprinkling on the landfill surface or at a treatment plant; sprinkling would be the preferred method due to its low annual cost. Most of the water would evaporate and aeration would reduce the contaminant levels. The remaining water would percolate through the cover and be recycled. While this system is the only one that requires maintenance the cost would be minimal and it could be performed by existing Air Station maintenance crews.

Advantages	Disadvantages
1. Short construction time	1. May provide a temporary remedy only depending on feasibility of connecting to a disposal facility or incorporating continued disposal into ultimate site use
2. Lower cost	2. Will require some maintenance of pumping and sprinkling equipment on a perpetual basis
3. Might be discontinued if water quality improves with time	3. Disposal of collected water at a sewage treatment plant may be expensive



KEY:

- ○ Test boring drilled with hand auger
- 17 GW — Boring number; Water observation well; Gas monitoring well
- Test boring drilled with truck-mounted rig converted to observation wells
- 110.0 Ground surface elevation (Alameda Naval Air Station Datum)
- 57 Ammunition magazine and number

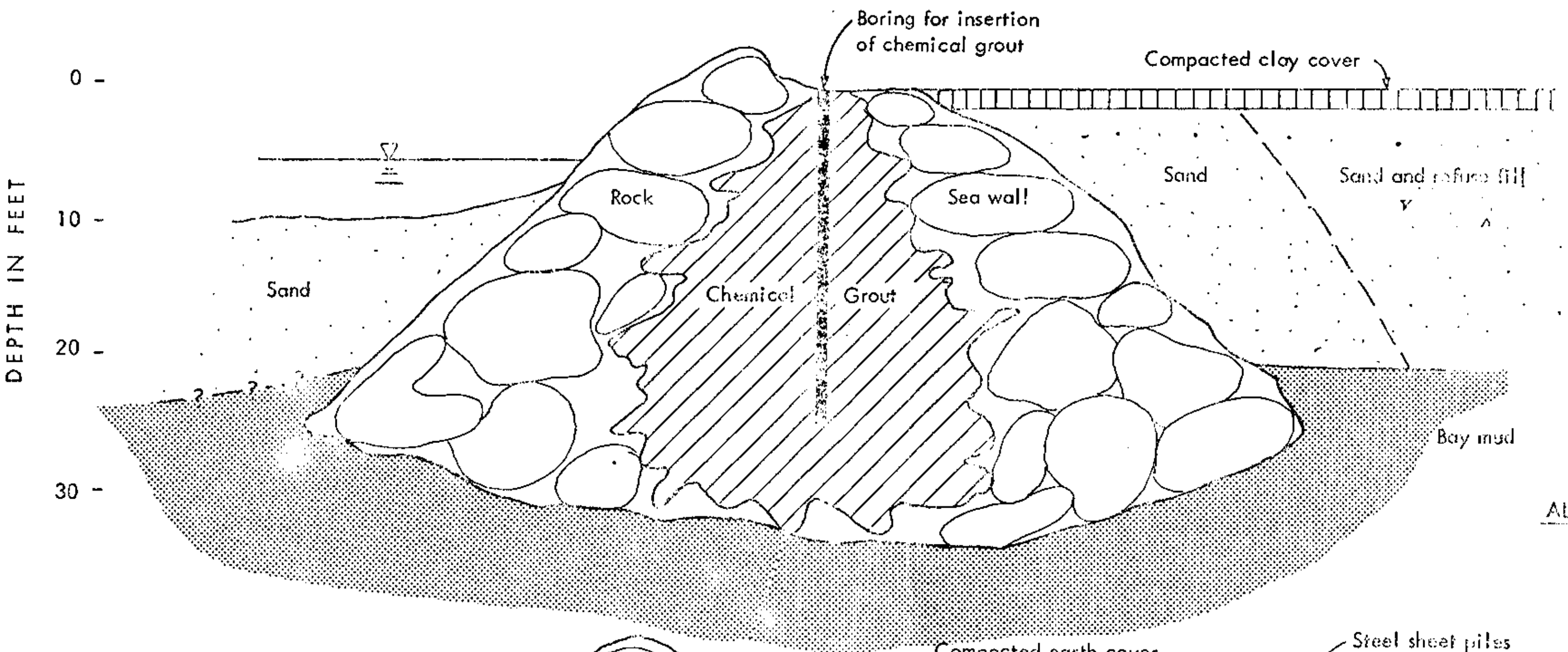
REPAIR ALTERNATIVES KEY

- Alternatives 1 - 5
- Alternative 6
- Gas venting System (can be combined with Alternative 6)

SAN FRANCISCO BAY

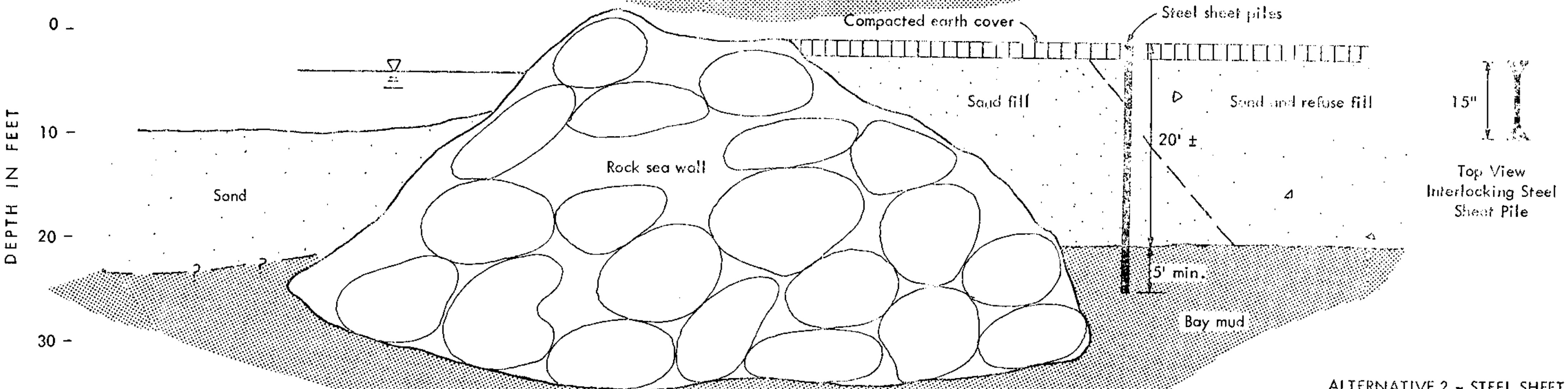
Reference: General Development Map, Naval Air Station, Alameda, by Naval Facilities Engineering Command, undated

Job No. 2176,030.01 Designed ALB Drawn GER Checked LEL Approved Date 12/17/76 Scale 1" = 200'	HARDING - LAWSON ASSOCIATES *Consulting Engineers and Geologists*	PLOT PLAN - REPAIR ALTERNATIVE LOCATIONS SANITARY LANDFILL SITE ALAMEDA NAVAL AIR STATION Alameda California	PLATE B-1



ALTERNATIVE 1 - CHEMICAL GROUTING

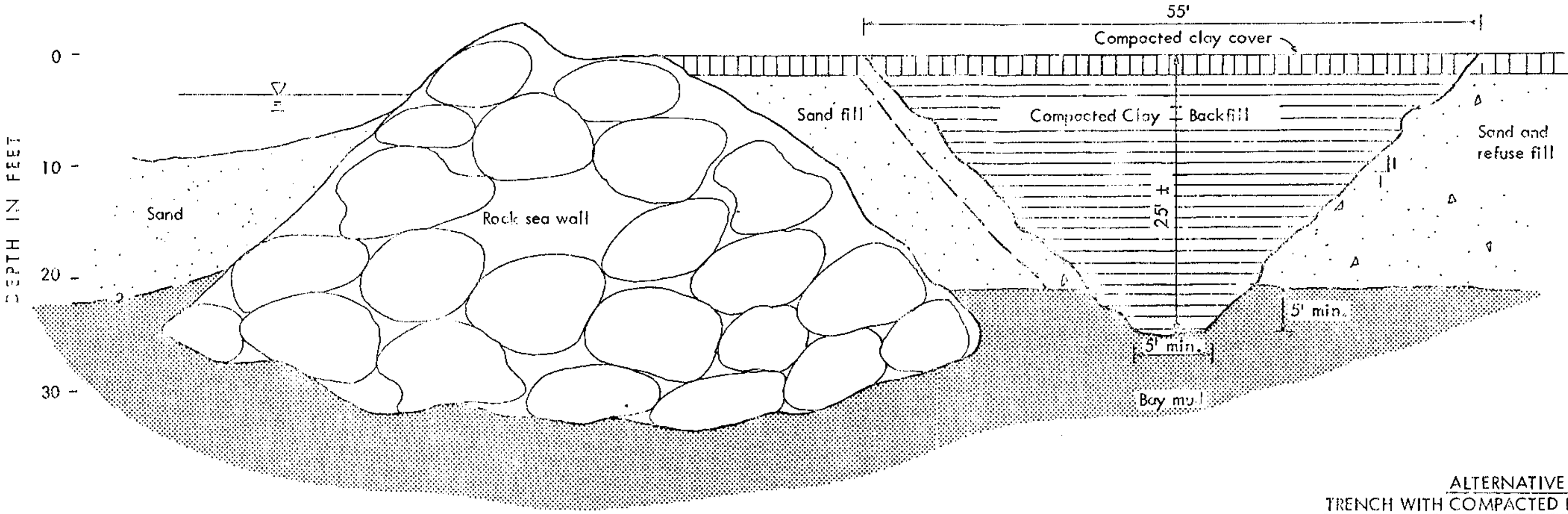
Scale: 1" = 10' Horizontal & Vertical



ALTERNATIVE 2 - STEEL SHEET PILES

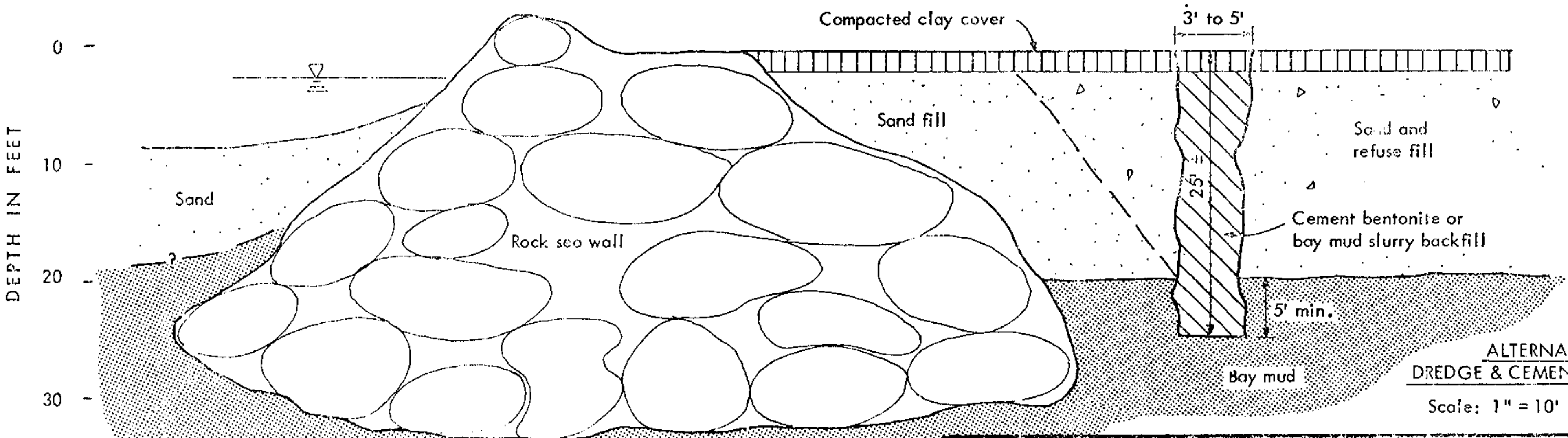
Scale: 1" = 10' Horizontal & Vertical

HARDING - LAWSON ASSOCIATES *Consulting Engineers and Geologists* Job No. 2176,030.01 Appr. MB Date 11/21/77	TYPICAL REPAIR CROSS SECTIONS Sanitary Landfill Site Alameda Naval Air Station Alameda, California	PLATE B2



ALTERNATIVE 3
TRENCH WITH COMPACTED EARTH BACKFILL

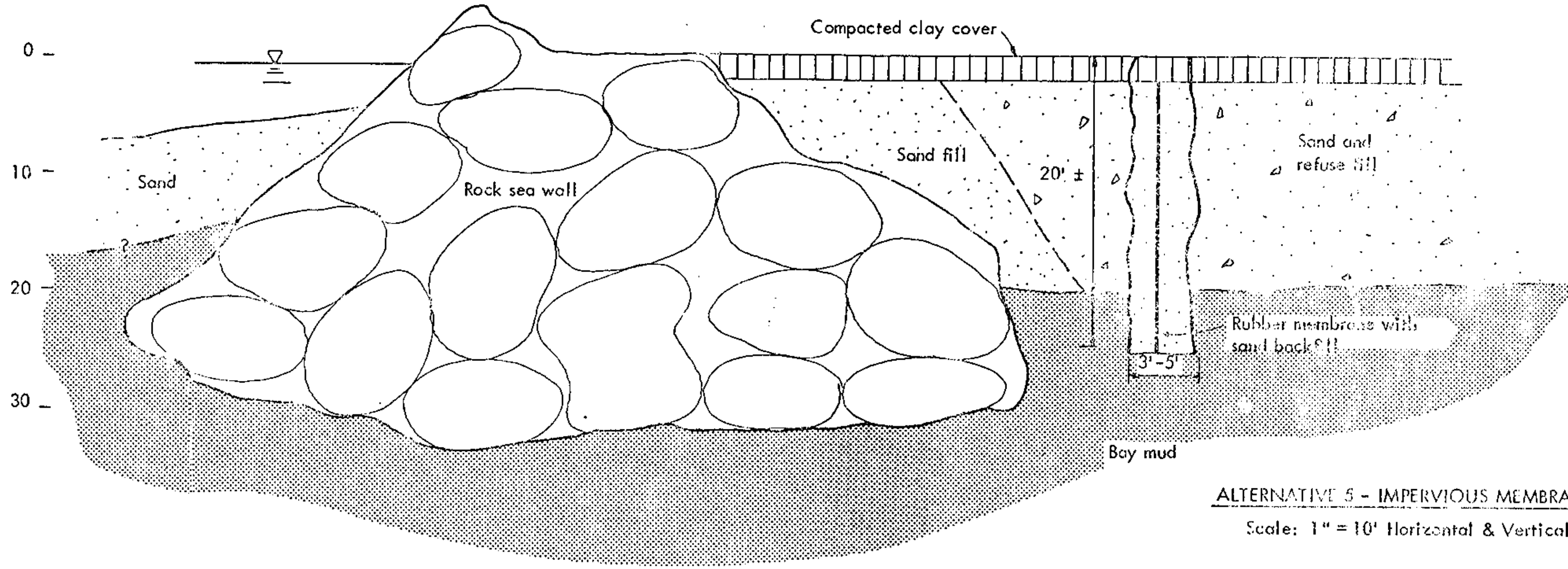
Scale: 1" = 10' Horizontal & Vertical



ALTERNATIVES 4A & 4B
DREDGE & CEMENT BENTONITE SLURRY

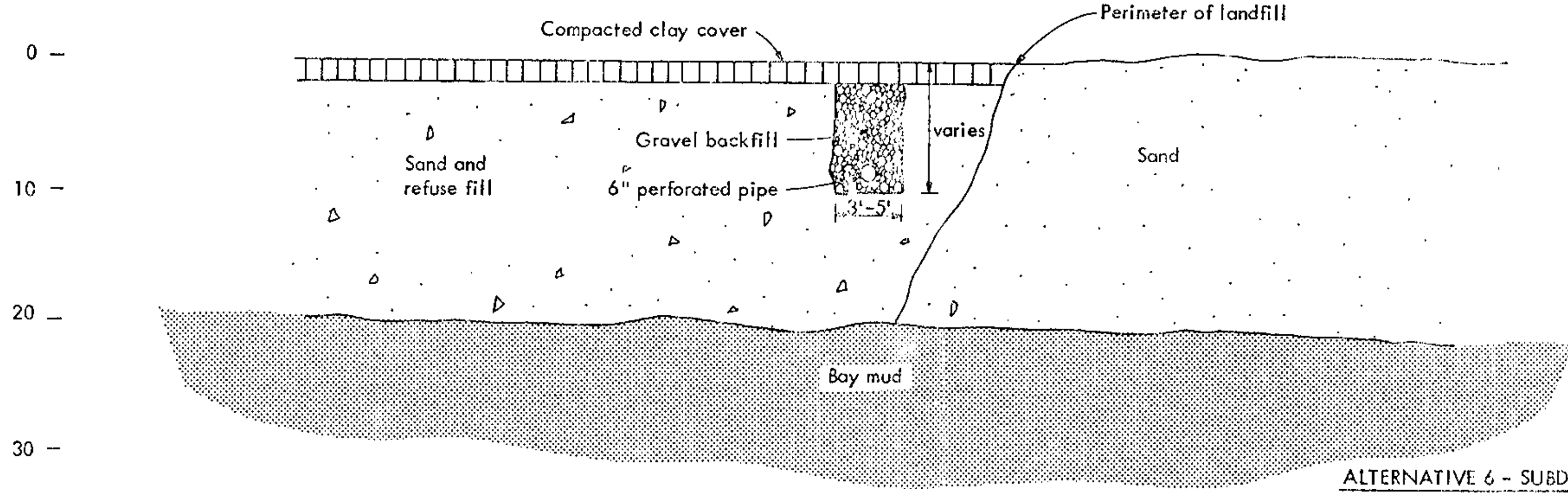
Scale: 1" = 10' Horizontal & Vertical

HARDING-LAWSON ASSOCIATES *Consulting Engineers and Geologists*	TYPICAL REPAIR CROSS SECTIONS	PLATE
Job No. 2176,030.01 Appr: JB Date 11/21/77	Sanitary Landfill Site Alameda Naval Air Station Alameda, California	B3



ALTERNATIVE 5 - IMPERVIOUS MEMBRANE

Scale: 1" = 10' Horizontal & Vertical



ALTERNATIVE 6 - SUBDRAIN COLLECTOR

Scale: 1" = 10' Horizontal & Vertical

HARDING - LAWSON ASSOCIATES *Consulting Engineers and Geologists*	TYPICAL REPAIR CROSS SECTIONS Sanitary Landfill Site Alameda Naval Air Station	PLATE

Appendix C

FEDERAL AND STATE SOLID WASTE REGULATION COMPLIANCE SUMMARY

APPENDIX C

Table C-1. FEDERAL SOLID WASTE REGULATION COMPLIANCE SUMMARY

Section No. and Subject		Landfill Compliance	Remarks and Measures Required to Obtain Compliance
241.200	Solid Wastes Accepted	Yes	While the site appears to be in compliance, the landfill foreman should be supplied a list of wastes that are acceptable so continued compliance can be achieved. See Plate C4 for a list of acceptable wastes.
241.201	Solid Wastes Excluded	Yes	
241.202	Site Selection	N/A	The site fails many site selection criteria. This report provides mitigating measures for these problems.
241.203	Design	N/A	The landfill is an existing operation and has no specific design. A Landfill Operation Plan incorporating local, State and Federal regulations and the recommendations of this report should be made.
241.204	Water Quality	No	Water quality problems of surface drainage and leachate are addressed in this report.
241.205	Air Quality	Yes	
241.206	Gas Control	No	Gas control measures are addressed in this report.
241.207	Vectors	Yes	Vectors do not appear to be a problem at the landfill.
241.208	Aesthetics	No	The site should be policed more often and/or portable litter fences utilized.
241.209	Cover Material	Yes/No	The site lacks adequate intermediate cover; daily cover operations are adequate. This subject is discussed in the report.
241.210	Compaction	Yes	For the size of the operation, compaction is adequate.
241.211	Safety	No	Site safety operations are inadequate. Corrective measures should include but not be limited to equipment (roll-over protection, seat belts, backup warnings), personnel (hard hats, safety shoes, safety glasses) and fire extinguishers should be on each piece of equipment. Asbestos wastes must be containerized or in plastic bags and covered immediately. Respirators should be worn by equipment operators. A complete safety program for the site should be designed as part of the Landfill Operations Plan.
241.212	Records	No	Record keeping procedures should be established and utilized to include type and volume of refuse, operational problems, environmental factors of gas, leachate, vectors, dust and litter.

Note: For detailed discussion of each subject matter, refer to the Environmental Protection Agency's "40 CRF 241, Guidelines for Land Disposal of Solid Waste"

HARDING-LAWSON ASSOCIATES
Consulting Engineers and Geologists

Job No. 2176,030.01 Appr:_____ Date 2/16/78

FEDERAL SOLID WASTE REGULATION COMPLIANCE SUMMARY

Alameda Naval Air Station
Alameda, California

PLATE
C1

Table C-2. STATE SOLID WASTE REGULATION COMPLIANCE SUMMARY

Section No. and Subject	Landfill Compliance	Remarks and Measures Required to Obtain Compliance
17601 - 17603 General	Yes	
17606 - 17608 Disposal Site Approval	Yes	The Public Works Center, San Francisco Bay, is in the process of obtaining the permits and providing the information as required by these sections.
17616 - 17617 Disposal Site Information	Yes	
17626 - 17629 Disposal Site Design	N/A	*Applies to design of new facilities.*
17636 - 17639 Disposal Site Records	No	Record keeping procedures should be established and utilized as required by these sections.
17646 - 17649 Disposal Site Personnel	No	Personnel require more training regarding safety, emergencies and environmental controls.
17656 - 17660 Disposal Site Improvements	Yes/No	*Site access and internal roads are adequate.* Site security requires improvement to prevent unauthorized dumping and salvaging. The site requires improved identification and entry signs.
17666 - 17670 Disposal Site Health and Safety	No	The site needs adequate communications facilities to obtain compliance.
Disposal Site Operations		
17676 Confined Unloading	Yes	
17677 Spreading and Compacting	Yes	
17678 Slopes and Cuts	Yes	
17679 Final Site Face	Yes	
17680 Stockpiling	Yes	
17681 Available Cover Material	Yes	
17682 Cover	Yes	
17683 Spreading	N/A	
17684 Intermediate Cover	No	The site lacks adequate intermediate cover. This subject is discussed in the report.
17685 Final Cover	No	The site lacks adequate final cover. This subject is discussed in the report.
17686 Scavenging	Yes	Apparently isolated scavenging has taken place but the landfill is basically in compliance.
17687 Scavenging Permitted	Yes	
17688 Volume Reduction and Energy Recovery	Yes	
17689 Processing Area	Yes	
17690 Storage of Salvage	Yes	

Note: For detailed discussion of each subject matter, refer to the State of California Administrative Code, Title 14, Article 7, Disposal Site Standards

HARDING - LAWSON ASSOCIATES Consulting Engineers and Geologists	STATE SOLID WASTE REGULATION COMPLIANCE SUMMARY	PLATE
Job No. 2176,030.01 Appr. Date 10/6/77	Alameda Naval Air Station Alameda, California	[illegible]

Table C-2. STATE SOLID WASTE REGULATION COMPLIANCE SUMMARY (continued)

Section No. and Subject	Landfill Compliance	Remarks and Measures Required to Obtain Compliance
17691 Removal	Yes	
17692 Non-salvageable Items	Yes	
Disposal Site Controls		
17701 Nuisance Control	Yes	
17702 Animal Feeding	Yes	
17703 Fire Control	Yes	
17704 Leachate Control	No	This subject is discussed in the report.
17705 Gas Control	No	This subject is discussed in the report.
17706 Dust Control	Yes	
17707 Vector and Bird Control	Yes	Birds are present at the site; current operations keep these to a minimum; however, birds present an aviation safety problem.
17708 Drainage and Erosion Control	No	Site drainage is inadequate. This subject is discussed in the report.
17709 Contact with Water	Yes	Previous operations caused refuse to come in contact with subsurface water. Current procedures are in compliance.
17710 Grading of Fill Surfaces	No	This subject is discussed in the report.
17711 Litter Control	No	The site should be policed more often and/or portable litter fences utilized.
17712 Noise Control	Yes	
17713 Odor Control	Yes	
17714 Traffic Control	Yes	
17715 Ponded Liquid	N/A	
Disposal Site Equipment		
17726 and 17727	Yes	
Disposal Site Maintenance		
17731 - 17735	Yes	Once the landfill is brought up to standards for cover, drainage, etc. then a site maintenance program should be implemented.
17741 - 17744 Disposal Site Special Wastes	Yes	The site does not handle these types of wastes.
17751 Periodic Site Review	No	This may or may not be required depending upon future use of the disposal site.

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Job No. 2176,030.01 Appr: [illegible] Date 10/6/77

STATE SOLID WASTE REGULATION COMPLIANCE SUMMARY
Alameda Naval Air Station
Alameda, California

PLATE [illegible]

Table C-3. ACCEPTABLE ITEMS FOR DISPOSAL AT NAS ALAMEDA SANITARY LANDFILL

a. Asbestos and cement.

b. Asphalt and tar.

c. Carbon black.

d. Cooked ships' garbage.

e. Crude lime and calcium carbonates.

f. Domestic refuse. Delivered only by contractor.

g. Dry cell batteries other than mercury.

h. Dry paint skins or drained paint sludges, except those containing lead, mercury or chromium.

i. Dry trash.

j. Glass.

k. Grease trap pumpings.

l. Light bulbs and tubes, other than flourescent, mercury vapor, or neon replaced by service contractor.

m. Metal cans or drums. Holes must be punched in sides and container crushed. All containers which once held chemicals, pesticides, flammables, or potentially harmful material must be emptied, holes punched in the sides, and covers removed. Aerosol cans must not be punctured.

n. Metal scraps.

o. Photographic film after processing through silver recovery unit.

p. Rubber, leather, nylon and teflon.

q. Stone, concrete and sand.

r. Wood and building demolition waste.

s. Wood piling will be accepted from NAS Alameda only.

Reference: NASALAMEDAINST 11350.2G memo dated 1 February 1973.

HARDING-LAWSON ASSOCIATES Consulting Engineers and Geologists Job No. 2176,030.01 Appr: JCD Date 2/16/78	ACCEPTABLE ITEMS FOR DISPOSAL Alameda Naval Air Station Alameda, California	PLATE C4

APPENDIX D

Appendix D

REFUSE, COVER MATERIAL, AND SITE LIFE CALCULATIONS

REFUSE, COVER MATERIAL, AND SITE LIFE CALCULATIONS

1. Assumptions

   1. 200 tons/week delivered to site (see below)
   2. Light compaction of refuse achieves densities of 800 pounds/cubic yard in place
   3. Refuse to soil cover ratio of 4:1 (Ref. 7)
   4. Additional refuse lifts will average 12 feet
   5. 58 acres of site has received refuse fill

2. Refuse delivered to the site (Ref. 3)

   NARF = 5.5 tons/day
   Station = 18.7
   Ships = 12.5

   36.7 tons/day x 5 days/week = 184 tons/week

3. In-place yardage/year - soil and refuse

   Refuse - $\frac{\text{184 tons/week x 2000 pounds/ton}}{\text{800 pounds/cubic yard}}$ = 460 cubic yards/week

   460 cubic yards/week x 52 weeks/year =

   23,920 cubic yards/year

   Soil - 23,920 cubic yards/year @ 4:1 refuse to soil ratio = 5,980 cubic yards/year of soil or 29,900 cubic yards total

4. Yearly acreage

   $\frac{\text{29,900 cubic yards/year x 27 cubic feet/cubic yard}}{\text{12 feet*}}$ = 67,275 square feet/year

   $\frac{\text{67,275 square feet/year}}{\text{43,560 square feet/acre}}$ = 1.5 acres/year

   or for Areas A and part of Area B (58 acres) it will take

   $\frac{58}{1.5}$ = 38.7 years to cover the site

* See Section 7(g) of this Appendix.

5. <u>Volume of slurry pond</u>
(Areas refer to parts of the slurry pond that were selected on the basis of average soil conditions indicated in the test borings. These areas are shown on Plate B1.)

Area 1 - average elevation = 113; average mud = 3 feet;
area = 528,000 square feet

Volume mud = $\frac{\text{3 feet} \times \text{528,000 square feet}}{\text{27 cubic feet/cubic yard}}$ = 58,700 cubic yards

Volume sand to 108.5 = 1.5 x 528,000/27 = 29,300 cubic yards
108.0 = 2 x 528,000/27 = 39,100 cubic yards
107.5 = 2.5 x 528,000/27 = 48,900 cubic yards

Area 2 - average elevation = 111; average mud = 10 feet;
area = 405,000 square feet

Volume mud to 108.5 = 2.5 x 405,000/27 = 37,500 cubic yards
108.0 = 3.0 x 405,000/27 = 45,000 cubic yards
107.5 = 3.5 x 405,000/27 = 52,500 cubic yards

(No sand to Elevation 107.5)

Area 3 - average elevation = 113; average mud = 2 feet;
area = 264,000 square feet

Volume mud = 2 x 264,000/27 = 19,600

Volume sand to 108.5 = 2.5 x 264,000/27 = 24,400 cubic yards
108.0 = 3.0 x 264,000/27 = 29,300 cubic yards
107.5 = 3.5 x 264,000/27 = 34,200 cubic yards

Area 4 - average elevation = 111.5; average mud = 6 feet;
area = 574,000 square feet

Volume mud to 108.5 = 3.0 x 574,000/27 = 63,800 cubic yards
108.0 = 3.5 x 574,000/27 = 74,400 cubic yards
107.5 = 4.0 x 547,000/27 = 85,000 cubic yards

(No sand to Elevation 107.5)

Summary - Cover Material Available*
(cubic yards)

Elevation	Mud	Sand	Total	Percent Mud
108.5	179,600	53,700	233,300	77
108.0	197,700	68,400	266,100	74
107.5	215,800	83,100	298,900	72

* Totals in Table 2 are rounded off.

6. Cover material requirements

a. Close existing site - 58 acres @ 3 feet cover

$$\frac{58 \text{ acres} \times 43{,}560 \text{ square feet/acre} \times 3 \text{ feet}}{27 \text{ cubic feet/cubic yard}} = 281{,}000 \text{ cubic yards required}$$

ratio of 75% mud to 25% sand = 210,800 cubic yards mud
= 70,200 cubic yards sand

This would require removing almost all mud to depth of 107.5 but site could be closed using available cover material. The bottom 12 to 18 inches could use a ratio closer to that of the intermediate cover.

Excess = 215,800 − 210,800 = 5,000 cubic yards mud; 83,100 − 70,200 = 12,900 cubic yards sand

or 17,900 cubic yards total @ 4:1 = 71,600 cubic yards of refuse can be placed while the cover is being placed. This will take about 2-1/2 years at current rate.

b. Continued operations - intermediate cover: 58 acres, 12 inches cover: assume partly covered so 8 inches will suffice; add 50 percent for shaping

$$\left[\frac{58 \text{ acres} \times 43{,}560 \text{ square feet/acre} \times .67 \text{ foot}}{27 \text{ cubic feet/cubic yard}}\right] 1.5 =$$

94,000 cubic yards

Ratio of 60% mud, 40% sand = 56,400 mud and 37,600 sand

Adequate material is available above Elevation 108.5

c. Cover available after intermediate cover placed

mud remaining (Elevation 107.5) = 215,800 - 56,400 =		159,400 cubic yards
sand remaining (Elevation 107.5) = 83,100 - 37,600 =		45,500 cubic yards
	Total	204,900 cubic yards

7. Site life

204,900 cubic yards cover available after intermediate cover

a. Volume of refuse

with 4:1 refuse to cover ratio (will provide for final cover):

refuse = 204,900 x 4 = 819,600 cubic yards refuse

increase for housing @ 23 tons/week

$$\frac{\text{23 tons/week x 2000 pounds/ton}}{\text{800 pounds/cubic yard}} = \text{58 cubic yards/week x 52 =}$$

3016 cubic yards/year + 754 cubic yards of cover/year = 3770

b. Total volume at site

volume of refuse	=	819,600 cubic yards
soil @ 4:1 ratio	=	204,900 cubic yards
Total		1,024,500 cubic yards

c. Site life at existing densities and volume

$$\frac{\text{1,024,500 cubic yards total}}{\text{29,900 cubic yards/year}} = \text{34 years}$$

d. Site life at existing densities and increased volume for housing refuse

$$\frac{\text{1,024,500 cubic yards total}}{\text{33,670 cubic yards/year}} = \text{30 years}$$

e. Increase compaction to achieve densities of 1200 pounds/cubic yard

$$\text{current} = \frac{184 \text{ tons/week} \times 2000 \text{ pounds/ton}}{1200 \text{ pounds/cubic yard}} = 307 \text{ cubic yards/week}$$

307 cubic yards/week x 52 weeks = 15,964 cubic yards/year

15,964 x .25 = 3991 cubic yards soil/year = 19,955 total

$$\text{current + housing} = \frac{207 \text{ tons/week} \times 2000 \text{ pounds/ton}}{1200 \text{ pounds/cubic yard}} =$$

345 cubic yards/week x 52 weeks = 17,940 cubic yards/year

17,940 x .25 = 4485 cubic yards soil/year = 22,475 total

f. Site life at increased densities

$$\text{current} = \frac{1{,}024{,}500 \text{ cubic yards total}}{19{,}955 \text{ cubic yards/year}} = 51 \text{ years}$$

$$\text{current + housing} = \frac{1{,}024{,}500 \text{ cubic yards total}}{22{,}425 \text{ cubic yards/year}} = 46 \text{ years}$$

Note: Site capacity will be reduced if refuse to soil cover ratio increases from 4:1

g. Height of refuse fill and cover material

Site volume;	intermediate cover	=	94,000 cubic yards
	refuse	=	819,600 cubic yards
	soil	=	204,900 cubic yards
	Total		1,118,500 cubic yards

58 acres x 43,560 square feet/acre x 1 foot = 2,526,500 cubic ft.

$$\frac{2{,}526{,}500 \text{ cubic feet}}{27 \text{ cubic feet/cubic yard}} = 93{,}570 \text{ cubic yards/foot of height across fill}$$

$$\text{height} = \frac{1{,}118{,}500 \text{ cubic yards total}}{93{,}570 \text{ cubic yards/foot}} = 12 \text{ feet}$$

8. Site closure cost estimate

a. Assumptions

1. PWC equipment to be used including one 20 cubic yard scraper, 1 dozer to push scraper in slurry pond and 1 dozer to spread and compact cover

2. 10 minute average turn around time for scraper

3. Slurry pond workable 8 months out of the year

b. Time required

1 load/10 minutes = 6 loads/hour = 48 loads/day

48 loads/day x 20 cubic yards/load = 960 cubic yards/day

$$\frac{\text{281,000 cubic yards of cover}}{\text{960 cubic yards/day}} = \frac{\text{293 days}}{\text{5 days/week}} = \text{58 weeks}$$

$$\frac{\text{58 weeks}}{\text{4 weeks/month}} = \text{14.5 months}$$

@ 8 months/year working time it will require 1.8 years to complete the job

c. Cost estimate

Equipment:

2 dozers @ $950/month x 14.5 months =	$ 13,775
1 scraper @ $680/month x 14.5 months =	9,860
Total Equipment Cost =	$ 23,635

Personnel:

Salaries = $8.05/hr x 2320 hrs x 3 men =	$ 56,028
Fringe benefits = $2.88/hr x 2320 hrs x 3 men =	20,045
Overhead = $5.75/hr x 2320 hrs x 3 men =	40,020
Total Personnel Cost =	$116,093
Total Cost - Personnel & Equipment	$139,729

$$\text{Cost per cubic yard} = \frac{\$140,000}{\text{281,000 cubic yards}} = \$0.50\text{/cubic yard}$$

d. Seeding

Seeding with salt-tolerant grasses and shrubs

Estimated cost of .75 to 1 cent/square foot over 58 acres (Ref. 13)

58 acres x 43,560 square feet/acre =
2,526,480 square feet x 1¢/square foot ≈ $25,000
2,526,480 square feet x .75¢/square foot ≈ $19,000

9. Placement of intermediate cover cost estimate

The cost for the PWC to place the cover would be included as part of the normal operating expense. The unit cost of $0.50 per cubic yard developed from the above section is applicable.

It would cost an outside contractor about the same unit cost as the PWC to place the cover. Therefore, the cost would be:

$0.50/cubic yard x 94,000 cubic yards = $47,000

10. Alternative 6 cost estimate breakdown

This is for a fully automated collection, pumping and spraying operation using movable sprinklers to reduce infiltration. Reference 21 is the source of the sprinkler and pump data.

a. Trenching - 2700 ft @ $20 to $25/ft = $54,000 to $67,500
(unshored and includes sumps)

b. Irrigation - movable pipe system

400 ft with sprinklers	=	$12,000
pipeline - sumps to irrigation 600 ft @ $5/ft installed	=	3,000
2 pumps @ $1000 each installed	=	2,000
Total		$17,000

c. Yearly costs

Maintenance @ 1% capital cost	=	$ 1,200
Operating costs @ $20/month	=	240
Inspections 1/2 man-day/week @ $120/man-day	=	3,120
Total		$ 5,060

11. Cost of combining Alternative 6 with gas venting system

Cost of Alternative 6 from Table 8 is $69,000 to $83,000 for 2,700 feet of trench.

Total cost of gas trench is 4200 feet x $15/foot = $63,000

Additional gas trench cost if Alternative 6 is installed is 4200 feet - 2700 feet = 1500 feet x $15/foot = $22,500

Cost savings = $63,000 - $22,500 = $40,500

Total cost of Alternative 6 and gas trench is $91,500 to $105,500

Appendix E

TOPOGRAPHIC MAP

APPENDIX E


RUNWAY
TAXIWAY
ROCK SEA WALL
SAN FRANCISCO BAY
Job No. 2176.030 01   Date 2/28/77
Topographic Map
Alameda NAS
Alameda, CA
Plate
E1

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