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INTERIM MEASURE WORK PLAN

FOR SWMU7
at
NAVAL STATION MAYPORT, FLORIDA

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ACRONYMS AND ABBREVIATIONS

bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
cfm	cubic foot (feet) per minute
F.A.C.	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
G&A	general and administration
GAC	granular activated carbon
gpd	gallon(s) per day
gpm	gallon(s) per minute
GW	groundwater
hp	horsepower
ID	identification
LNAPL	light, nonaqueous-phase liquid
MP	monitoring point
MW	monitoring well
NA	not applicable
NAS	Naval Air Station
NAVSTA	Naval Station
ND	not detected
NPDES	National Pollutant Discharge Elimination System
NT	not taken
O&M	operations and maintenance
OVA	organic vapor analyzer
OWS	oil/water separator
OWTP	Oily Waste Treatment Plant
PAH	polycyclic aromatic hydrocarbon
ppm	part(s) per million
ppmv	part(s) per million by volume
PVC	polyvinyl chloride
PWC	Public Works Center
RCRA	Resource Conservation and Recovery Act
SWMU	Solid Waste Management Unit

TPH	total petroleum hydrocarbon
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound
WWTP	Waste Water Treatment Plant

Section 1.0: INTRODUCTION

1.1 Scope. The scope of this project is to develop a interim measure design package for vacuum-enhanced free-product recovery (i.e., a bioslurper system) to remediate subsurface contamination identified in the area of Solid Waste Management Unit (SWMU) 7 of Naval Station (NAVSTA) Mayport. The primary objective in the design of the full-scale system is to recover free-floating product existing as light, nonaqueous-phase liquid (LNAPL), to the extent that less than 0.1 inch product thickness remains in any of the monitoring wells and that the lateral migration of LNAPL in the subsurface is minimized. Operational data collected by Battelle at other sites indicate that bioslurping is much more effective at recovering free product than are the other recovery technologies. Furthermore, the bioslurping technology allows for the simultaneous treatment of hydrocarbons in the vadose zone.

An initial 2-week pilot-scale test was performed at the site to determine if bioslurping would be effective in removing the free product at the SWMU7 area. Product recovery rates, soil-gas permeability test results, and in situ respiration data collected during pilot-scale testing will be used to establish the bioslurper system configuration for this site. The bioslurper system will be designed to recover free product from the areas where it has been observed during the recent site investigation activities conducted by ABB Environmental Services, Inc., and from the areas that are suspected to have free product. The system will consist of an off-gas treatment unit. The liquid extracted during the first month of full-scale operation will be discharged to the existing storage tanks and subsequently released to the Oily Waste Treatment Plant (OWTP). Concentrations in process water will be used to determine treatment thereafter.

Limited site characterization data collected during the pilot test indicate that free product may not be present in the sludge drying bed areas of SWMU7. Further characterization is recommended to verify the absence of free product in this area. Soil-gas data suggest that a bioventing system may be effective in reducing the total petroleum hydrocarbon (TPH) levels in vadose zone soils. If the Navy is interested in constructing a bioventing system, a pilot-scale bioventing treatability test should be conducted to establish the site-specific design parameters. If the pilot-test data indicate that the cleanup objectives can be met, a full-scale bioventing system can be designed and constructed for the sludge drying bed area. For the purpose of this work plan, approximately the Northern third of the sludge drying bed area will be included in the full-scale bioslurping design.

Battelle's involvement in a full-scale bioslurper system at NAVSTA Mayport includes the development of the interim measure work plan, engineering oversight and technical support during construction and operation activities within the available funding. Battelle has prepared an interim measure work plan for a full-scale bioslurper system and a cost estimate for activities associated with such a system. Battelle will also provide the Navy with an operations and maintenance manual.

1.2 Site Description. Information presented in this section of the report summarizes data from the following documents prepared for NAVSTA Mayport by ABB Environmental Services, Inc.: *RCRA Facility Investigation: Group II Solid Waste Management Units* (January 1996), *Corrective Action Program General Information Report* (July 1995), *RFI Report* (June 1995), and Draft Interim Measures Workplan (May 1994). These data are used to provide an overview of the state of contamination identified at NAVSTA Mayport and as engineering reference material for existing wells at the site.

NAVSTA Mayport is located on a peninsula in northeast Florida and lies approximately 12 miles northeast of Jacksonville. The complex is bounded by the Atlantic Ocean to the east and the St. Johns River to the north and west. The area is used primarily for industrial purposes. NAVSTA Mayport, occupying 3,401 acres, has been in existence since 1942. Current activities include support services for surface fleet and aircraft, including ship and aircraft repair and maintenance.

SWMU7 is made up of the OWTP Sludge Drying Beds (Figure 1). SWMU7 was constructed in 1979 and consists of four unlined sludge drying beds enclosed by earthen berms. The sludge drying beds received sludge from the OWTP clarifiers and bilge water from receiving Tanks 99 and 100. Records indicate that approximately 1,500 gallons of sludge were transferred to the drying beds on the average of twice per week until late 1994. The easternmost drying bed was excavated in 1989, at which time a lined, diked enclosure and three bilge water receiving tanks were constructed. SWMU6, located directly adjacent to SWMU7 on the west, served as a waste oil pit and sludge drying bed prior to the installation of SWMU7 in 1979.

The depth to groundwater at the site ranges from 8 to 14 ft below ground surface (bgs) or approximately 5 ft below the sludge drying beds. Reportedly, tidal influence accounts for a few tenths of a foot variation in the surficial aquifer; however, the influence of tides is negligible at distances greater than 400 ft from the St. Johns River. Tidal fluctuations could result in limited smearing of the floating free-phase hydrocarbon or its entrapment beneath the rising water table. Groundwater tends to flow north towards the St. Johns River at a horizontal rate of 0.19 to 0.24 ft/day (69 to 87 ft/yr). The horizontal gradient at the site ranges from 0.011 to 0.014 ft/ft and the hydraulic conductivity averages 3.7 ft/day.

The subsurface at the site is dredged fill material consisting primarily of fine sand with occasional shell fragments. The dredged material has been characterized as undifferentiated post-Hawthorn deposits. No confining unit of sufficient areal extent has been found at the site. A cross section of the area is seen in Figure 2.

Subsurface soil samples were collected during the 1993/1994 sampling events. The highest concentrations of hydrocarbon-related organic compounds were detected in boring MPT-08-MW03S. Maximum concentrations of benzene, toluene, and ethylbenzene at this location were 160, 170, and 1,500 mg/kg, respectively.

Monitoring wells and piezometers have been installed at various locations on the site (Figure 3). Some wells are screened across the water table, and others are screened in the intermediate zone of the surficial aquifer. Well construction details and soil boring logs of monitoring wells known to have contained free product at one time are found in Appendix A.

1.3 Site Characterization and Data Evaluation.

1.3.1 Soils. Soil (sludge) samples were collected from the sludge drying beds in 1993 and in 1994. In 1993, four soil samples and a duplicate were collected from the three sludge drying beds. Two of these samples were within the two easternmost sludge drying beds of SWMU7. In 1994, 18 samples and two duplicates were collected from the sludge drying beds. The 1994 samples were collected at two depths, 0 to 1 ft and 5 to 6 ft. Six of these samples and one duplicate were taken within the two easternmost drying beds. Samples were analyzed for volatiles, semivolatiles, pesticides and PCBs, and inorganic compounds. Volatile compounds detected in the samples included methylene chloride, acetone, carbon disulfide, 2-butanone, benzene, 2-hexanone, tetrachloroethene, toluene, ethylbenzene, xylenes, trichlorofluoro-methane, and isobutyl alcohol. Semivolatile compounds detected in the samples included naphthalene, 2-methylnaphthalene, acenaphthylene, dibenzofuran, fluorene, n-nitrosodiphenylamine, phenanthrene, anthracene, fluoranthene, pyrene, butylbenzylphthalate, benzo(a)anthracene, chrysene, bis(2-

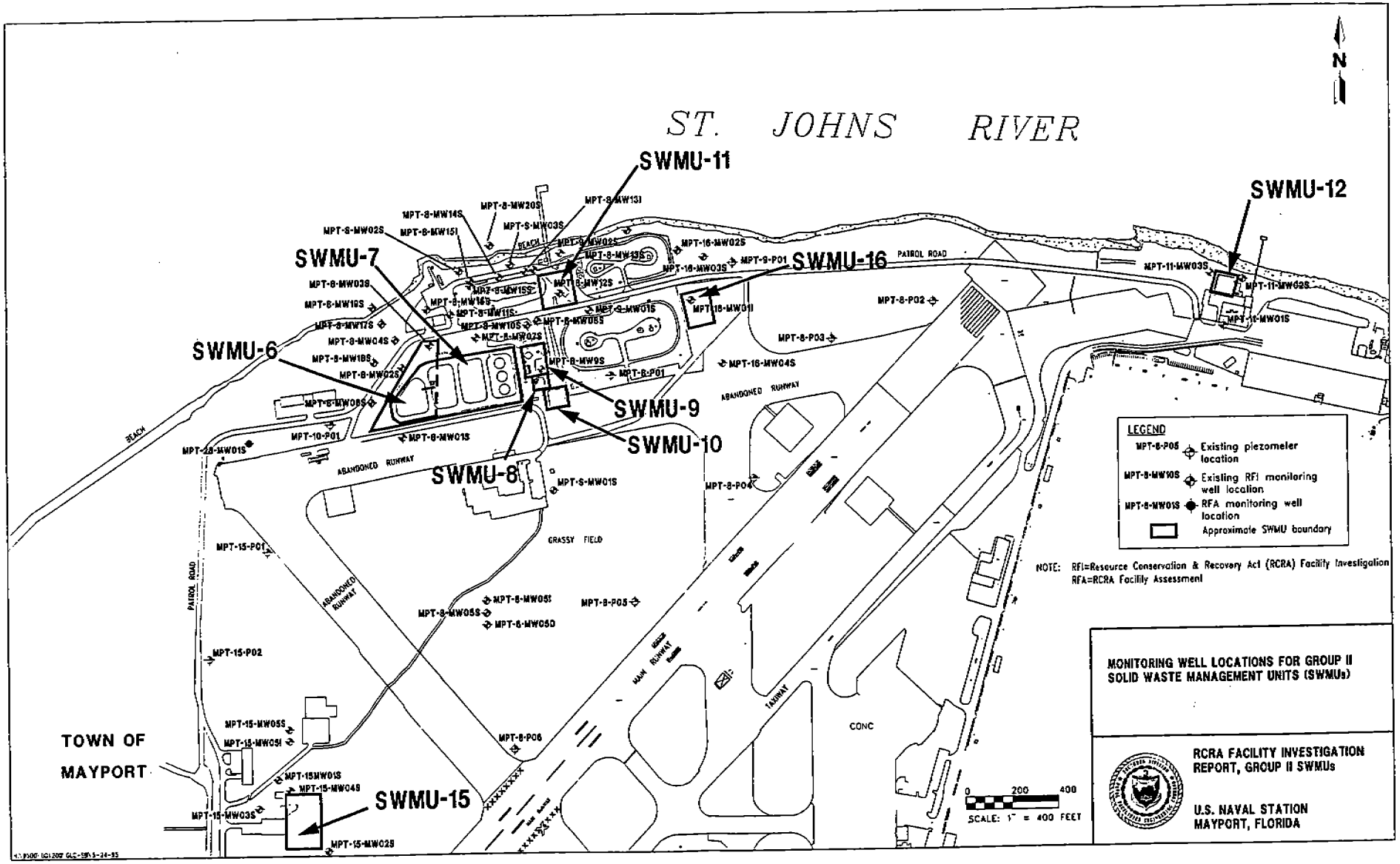


Figure 1. **Site Map of Solid Waste Management Units Including Monitoring Well Locations at NAVSTA Mayport**
(Source: ABB, 1996)

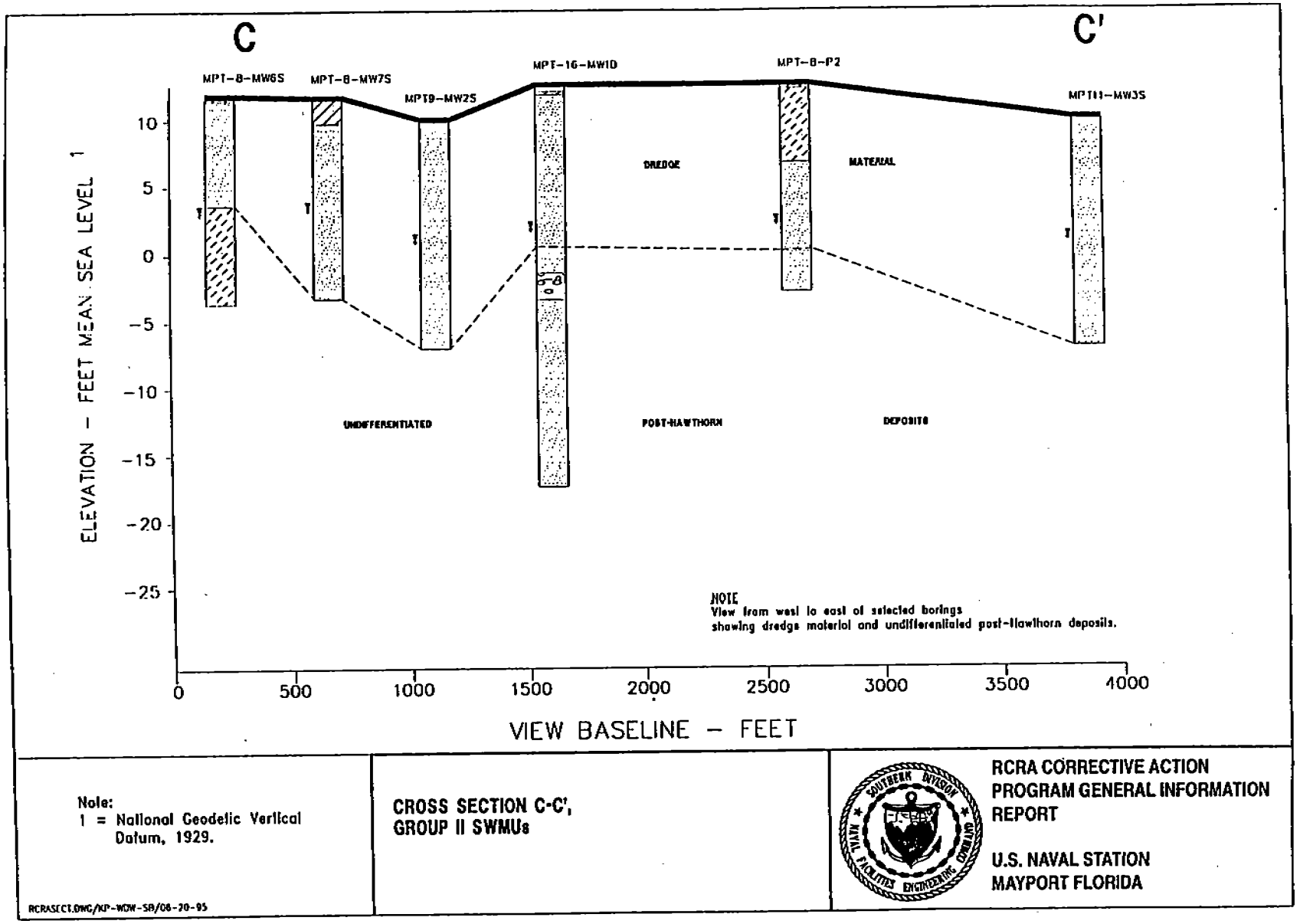


Figure 2. **Cross Section of Group II Solid Waste Management Units, NAVSTA Mayport**
(Source: ABB, 1995)

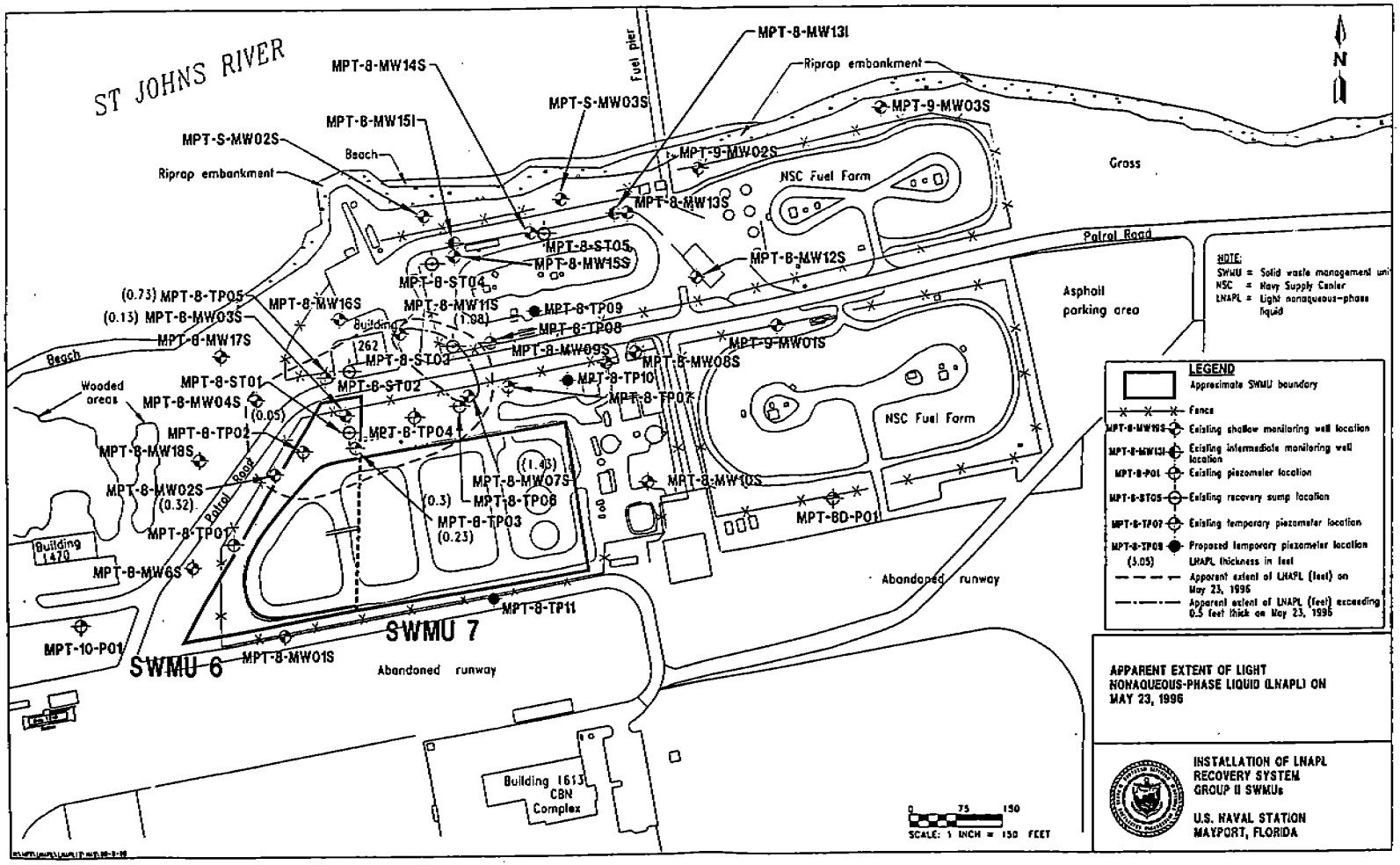


Figure 3. **Estimated Location of Free-Product Plume, NAVSTA Mayport** (Source: ABB, 1996)

ethylhexyl)phthalate, benzo(b)fluoranthene, and benzo(g,h,i)perylene. Pesticides detected included 4,4-DDE, 4,4-DDD, 4,4-DDT, and chlordane; however, these were present only in a small number of samples generally at very low concentrations. No PCBs were detected.

The detected concentrations of the various analytes were compared to several potentially applicable cleanup goals. These cleanup goals included the Florida Soil Cleanup Goals (April 5, 1995), United States Environmental Protection Agency (USEPA) Region III risk-based screening concentrations (February 9, 1995), and Soil Cleanup Target Levels for Direct Exposure (Industrial) developed by Dr. Stephen Roberts at University of Florida for the Florida Department of Environmental Protection (FDEP) (1996). The Soil Cleanup Target Levels are the concentrations calculated for direct exposure (direct contact with soil) for the industrial exposure scenario. These numbers have been calculated using a methodology similar to that used by USEPA Region IX but using parameter values applicable to Florida. Dr. Roberts anticipates that these or very similar numbers will be included in the Draft Petroleum Rule that is being reviewed by the FDEP. Dr. Roberts also indicated that the state is moving toward concentrations for individual compounds and away from numbers such as TPH, total benzene, toluene, ethylbenzene, and xylenes (BTEX), and total polycyclic aromatic hydrocarbon (PAH) (telephone conversation, October 10, 1996). The FDEP also suggested using an individual compound-based approach to determine cleanup needs/objectives for the Mayport site (personal communication, October 1, 1996).

The only constituents detected above these cleanup goals were benzo(a)anthracene and arsenic, which were each detected above the screening goals in only one sample. The cleanup goals for these constituents along with the detected concentrations exceeding the goals are shown in Table 1. Benzo(a)-anthracene was detected in only 2 out of 21 samples and only one sample was above the various screening levels (the other sample was 275 μg/kg). Only one of 8 sampling locations in the area of interest (SWMU7 - Sludge Drying Bed Area) was above the screening limit.

Table 1. Comparison of Contaminant Levels in the Sludge Drying Beds to Potentially Applicable Cleanup Goals

Contaminant (conc. units)	(a) Florida Soil Cleanup Goal[1]	(b) Risk-Based Screening Concentration[2]	(c) Soil Cleanup Target Level for Direct Exposure (Industrial)[3]	Concentration Detected	Sampling Location
Benzo(a)anthracene (μg/kg)	4,900	7,800	4,900	6,600	MPT-8-SL02
Arsenic (mg/kg)	3.0	3.3	3.7	10.6	MPT-8-SL02

[1] Value is from Florida Soil Cleanup Goals (April 5, 1995) (from Table 4-7, ABB, 1995b)

[2] U.S. EPA Region III risk-based screening concentrations (February 9, 1995). Concentrations for non-carcinogenic risks are adjusted to a hazard index of 0.1 (from Table 4-7, ABB, 1995b).

[3] Soil Cleanup Target Level is the concentration calculated for Direct Exposure (direct contact with soil) for the Industrial Exposure scenario. These target levels were calculated by Dr. Stephen Roberts, at Univ. of Florida for the Florida Department of the Environment (Roberts, 1996).

Arsenic was detected above background in 8 of 23 samples, but only 1 sample was above the goals given in Table 1. Arsenic levels ranged from 0.22 to 10.6 mg/kg. A 90% confidence interval based on the Student's t distribution was calculated for the mean arsenic level. There are two assumptions that must be met for the confidence interval to be accurate: each observation must be independent, and the arsenic levels must be normally distributed. The assumption of independence may not be valid in this study. Environmental variables, including contamination levels, often exhibit a spatial correlation. However, if mixing occurs in the drying beds, the observed levels may not be spatially correlated. Probability plots of the arsenic levels showed that they are not normally distributed. However, the logarithmic transformations of arsenic levels did appear to be normally distributed. Thus, confidence intervals obtained on logarithmically transformed arsenic levels will be more accurate. The confidence interval was calculated using data from all three drying beds. The following data transformations were applied before calculating the confidence interval:

- Duplicate samples were averaged
- Samples taken at the same location but at different depths were treated as separate samples
- One-half of the method detection limit was used for samples where arsenic was not detected
- The data was logarithmically transformed.

The 90% confidence interval calculated as a logarithmic transformation ranges from 0.45 to 0.91 mg/kg. Twenty-three samples were used to calculate the interval. The upper bound of the calculated confidence interval is below all of the cleanup goals for arsenic. In other words there is at least a 90% probability that the level of arsenic in the soil is below any of the cleanup goals. In addition, the interval indicates that the arsenic levels are statistically significantly greater than the background screening level of 0.9 mg/kg.

1.3.2 LNAPL. Floating free product as LNAPL has been measured at numerous wells existing at the site. Based on the more recent oil/water measurements (Table 2), the plume as identified by ABB in May 1996 is shown in Figure 3. Contour plots of previous free-product plumes delineated by ABB, as well as the original measurements taken by ABB, can be found in Appendix B. The free product may not be present in some of the area delineated in Figure 3. The amount of total recoverable LNAPL was estimated previously at approximately 43,000 to 90,000 gallons (ABB, 1994). Analyses of free-product samples indicate that the fuel most closely resembles weathered diesel fuel or mineral spirits and has a specific gravity of 0.8765 (ABB, 1996).

As an interim measure to remove LNAPL from the subsurface, a recovery system is present at the site. The system consists of five sumps containing total fluid pumps which recover LNAPL and water at a rate of approximately 1 gallon per minute (gpm) from each sump. The collected LNAPL and water are temporarily stored in two 20,000-gallon capacity tanks and subsequently discharged to the OWTP process for treatment and disposal.

1.4 Technology Description. Bioslurping is a technology application that teams vacuum-assisted free-product recovery with bioventing to simultaneously recover free product and remediate the vadose zone. Unlike other LNAPL recovery technologies, bioslurping systems treat two separate geologic media simultaneously. Bioslurping pumps are designed to extract free-phase fuel from the water table and to aerate vadose zone soils through soil-gas extraction. The systems also can be designed to achieve hydraulic control as is done with the conventional pump-and-treat technology. The bioslurper system

extracts groundwater, free product, and soil gas in one process stream using a single aboveground pump. Groundwater is separated from the free product, treated (when required), and discharged in accordance with local regulations. Free product is recovered and can be recycled. Soil-gas vapor is treated (when required) and discharged.

Table 2. Historical Groundwater and LNAPL Thickness Measurements in Treatment Area

Well ID	6/29/95		8/4/95		11/15/95		11/16/95		12/7/95		5/23/96	
	Depth to GW (ft)	LNAPL thick-ness (ft)	Depth to GW (ft)	LNAPL thick-ness (ft)	Depth to GW (ft)	LNAPL thick-ness (ft)	Depth to GW (ft)	LNAPL thick-ness (ft)	Depth to GW (ft)	LNAPL thick-ness (ft)	Depth to GW (ft)	LNAPL thick-ness (ft)
MPT-8-MW02S	11.38	0.17	11.71	0.0	11.84	0.50	12.37	0.70	NT	NT	12.62	0.32
MPT-8-MW03S	11.35	0.10	12.99	0.97	11.61	0.30	12.88	1.16	NT	NT	12.39	0.13
MPT-8-MW04S	9.48	0.0	10.24	0.0	9.61	0.0	10.20	0.0	NT	NT	10.55	0.05
MPT-8-MW07S	9.51	0.72	NT	NT	12.71	3.70	12.97	3.60	12.51	3.05	11.45	1.43
MPT-8-MW11S	9.83	0.68	10.72	1.02	10.01	0.79	10.75	1.18	10.12	0.74	10.91	1.08
MPT-8-MW15I	NT	NT	8.57	0.0	NT	NT	8.48	0.0	NT	NT	8.32	0.0
MPT-8-MW15S	7.89	0.0	8.42	0.0	7.94	0.0	8.40	0.0	NT	NT	8.75	0.0
MPT-8-ST01	NT	NT	NT	NT	10.71	0.02	10.80	0.08	NT	NT	NT	NT
MPT-8-ST02	NT	NT	13.11	0.0	12.06	0.03	12.36	0.05	NT	NT	NT	NT
MPT-8-ST03	NT	NT	NT	NT	12.82	0.0	12.92	0.0	NT	NT	NT	NT
MPT-8-ST04	NT	NT	NT	NT	9.82	0.0	10.20	0.0	NT	NT	NT	NT
MPT-8-TP02	7.92	0.02	8.74	0.0	8.12	0.15	8.56	0.19	8.27	0.02	NT	NT
MPT-8-TP03	10.55	0.05	11.23	0.02	11.07	0.44	11.55	0.57	11.65	0.44	11.99	0.23
MPT-8-TP04	12.80	0.38	13.56	0.64	12.92	0.47	13.69	0.92	NT	NT	13.85	0.45
MPT-8-TP05	12.60	0.17	13.27	0.10	12.49	0.03	12.99	0.02	12.80	0.01	14.11	0.73
MPT-8-TP06	13.75	0.52	14.00	0.23	13.87	0.62	14.11	0.50	13.67	0.03	14.47	0.30
MPT-8-TP07	9.85	0.45	10.27	0.32	10.85	0.0	NT	NT	10.85	0.0	NT	NT
MPT-8-TP08	10.95	0.01	12.01	0.0	10.76	0.29	10.95	0.23	11.60	0.0	12.44	0.0

NT = Not Taken

Source: ABB Environmental Services, Inc.

The bioslurping technology is unique because it uses elements of two separate remedial technologies, **free-product recovery** and **bioventing/soil vapor extraction**, to address two separate contaminant media.

1. **Free-product recovery** is the process of removing free-phase petroleum in liquid form from the capillary fringe. LNAPL recovery generally is accomplished by using either (a) a skimmer pump to pump out any fuel that passively enters a well, or (b) a dual-pump recovery system in which one pump lowers the water table and increases the fuel flow into the well (due to the gravity-induced gradient) and the second pump skims off the fuel.

2. **Bioventing and soil vapor extraction** are forced aeration processes that enhance the natural in situ biodegradation of petroleum contamination and the removal of volatile organic compound (VOC) from the vadose zone.

Both technologies, which are described in detail in Section 1.0 of the *Best Practices Manual for Bioslurping* (Battelle, 1996), are widely used in some form. Bioslurping combines elements of each to simultaneously recover free product and aerate the vadose zone soils. Conventional LNAPL recovery skimmer systems generally are inefficient for LNAPL recovery because they have little effect on free product outside the recovery well, so efficiency relies on the passive movement of fuel into the recovery well. Dual-pump LNAPL recovery systems increase recovery efficiency by drawing the water table down several feet to create a hydraulic gradient into the well. Although higher recovery rates are achieved, creation and maintenance of the hydraulic gradient can require extraction of large volumes of groundwater that must be treated prior to discharge. In addition, lowering the water table may serve only to trap much of the free product in the newly exposed vadose zone so that it reappears when the water table returns to its normal level.

Bioslurping may improve free-product recovery efficiency without requiring the extraction of large quantities of groundwater. The bioslurper system pulls a vacuum of up to 20 inches of mercury on the recovery well to create a pressure gradient to promote movement of fuel into the well. Bioslurping treats the vadose zone by increasing the oxygen levels in the unsaturated soils through soil-gas extraction. The slurping action of the bioslurper system cycles between recovering liquid (free product and/or groundwater) and recovering soil gas. When free-product removal activities are complete at a site, the bioslurper system is easily converted to a conventional bioventing system to complete remediation of the vadose zone soils.

Bioslurping systems are designed to minimize environmental discharges of groundwater and soil gas. As is done in bioventing, bioslurper systems can be designed and operated to extract soil gas at a low rate to reduce volatilization of contaminants. In some instances, the volatile discharge from the bioslurper can be kept below treatment action levels without treatment. The slurping action of a bioslurping system greatly reduces the volume of groundwater that must be extracted compared to conventional LNAPL recovery systems, thus greatly reducing groundwater treatment costs. Figure 4 illustrates the differences between conventional dual-pump LNAPL recovery and bioslurping.

Nonaqueous-phase liquids that are less dense than water move downward through the vadose zone and accumulate at and above the water table. Generally, the vertical interval containing the accumulated LNAPL also contains some air and water. Near the top of the LNAPL zone, both water and LNAPL contents are low and most of the pore space is occupied by air. LNAPL contents usually are greatest toward the center of the LNAPL zone and decline to zero at the bottom where the pore space is fully occupied by water.

A significant feature of the slurping process is the induced air flow toward the well, which is believed to increase LNAPL flow to the well. The pressure gradient created in the air phase causes a driving force on the LNAPL that is similar to the hydraulic gradient created with the dual-pump recovery system. Also of importance is the fact that the air flow created by the vacuum actually enhances the LNAPL content around the well. That is, the LNAPL tends to accumulate around the well. For these reasons, bioslurping has the potential for removing more LNAPL and at greater rates than do other pumping technologies.

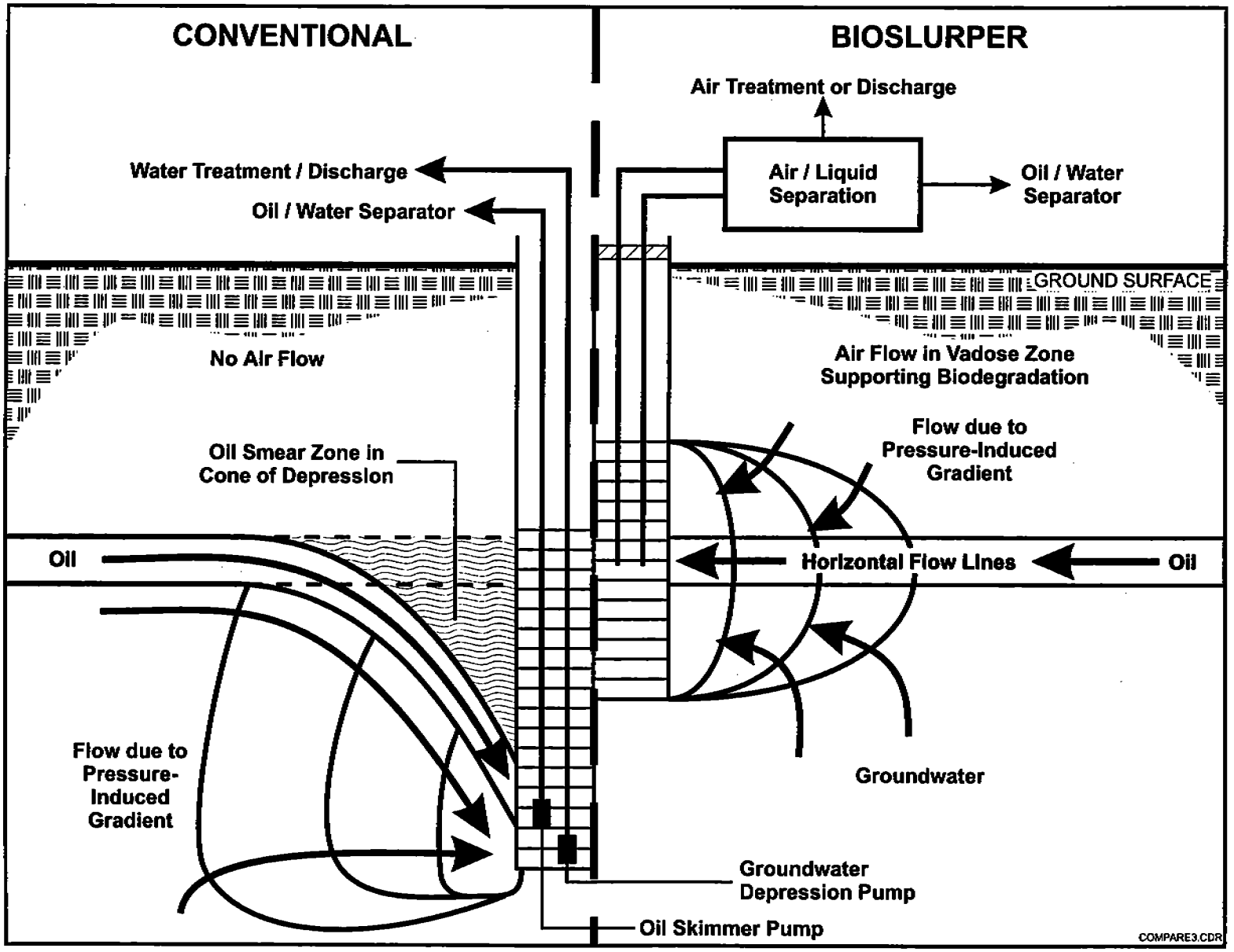


Figure 4. Comparison of Conventional LNAPL Recovery and Bioslurping

Section 2.0: PILOT-SCALE BIOSLURPER TEST

2.1 Test Methodology. The field activities at SWMU7 consisted of a 2-week-long pilot-scale test to evaluate the recoverability of LNAPL from existing site recovery wells using the bioslurper technology. Battelle evaluated site-specific data received from the Navy and addressed site-specific variables before beginning field activities. The field program involved installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. Baildown tests were performed and oil/water measurements were taken to identify a suitable extraction well. Soil-gas monitoring points were installed prior to startup of the bioslurper system.

Bioslurper testing was conducted to allow for the observation of the effect of varying system vacuum on LNAPL and water recovery rates. The sequence of testing involved operational periods conducted at low (7 inches water), medium (14 inches water), and high (20 inches water) vacuums. Bioslurping was conducted at each of these vacuum levels with drop tube placement at the oil/water interface. In addition, a bioslurper pump test was conducted in drawdown mode. This pump test was conducted under a vacuum; however, the drop tube was placed 30 inches below the oil/water interface. The full range of pump tests was conducted at monitoring well MPT-8-MW07S in the following sequence: approximately 7 hours in the low-vacuum mode, approximately 67 hours in the high-vacuum mode, 70 hours in the drawdown mode, an additional 22 hours in the low-vacuum mode, and 66 hours in the medium-vacuum mode. Following activities at monitoring well MPT-8-MW07S, a bioslurper pump test at very low vacuum was conducted at monitoring well MPT-8-MW11S for approximately 22 hours to determine the well's potential for free-product recovery. Recovery results are discussed in Section 2.5.

Measurements of the extracted soil-gas composition, free-product thickness, and groundwater level were made during bioslurper activities. In addition, aqueous discharge and vapor discharge samples were collected during various operational periods. The amounts of extracted free product, groundwater, and soil gas were quantified over time.

Battelle conducted in situ respiration tests to establish vadose zone hydrocarbon biodegradation rates and performed vacuum radius-of-influence tests at each vacuum to aid in determining the optimum well spacing for full-scale system design. Detailed procedures for specific field activities are described in the *Best Practices Manual for Bioslurping* (Battelle, 1996).

In addition to the bioslurper pilot-scale testing performed at SWMU7, Battelle performed some field investigation activities inside the sludge drying bed area. Two monitoring wells were installed. A headspace analysis for TPH was performed on the resulting soil cuttings to help determine the degree of petroleum contamination in the soil. The wells were monitored for the presence of free product. Three additional monitoring points were installed inside the sludge drying bed area. These points were used to measure the change in oxygen, carbon dioxide, and TPH concentrations in the subsurface. The results of these activities are presented in Section 2.11.

2.2 System Setup. The pilot-scale bioslurper system is a trailer-mounted unit consisting of an extraction manifold, a liquid ring pump, a gravity oil/water separator (OWS), a 225-gallon surge tank, and an activated carbon treatment system for off-gas. Figure 5 shows a schematic diagram of bioslurper process flow.

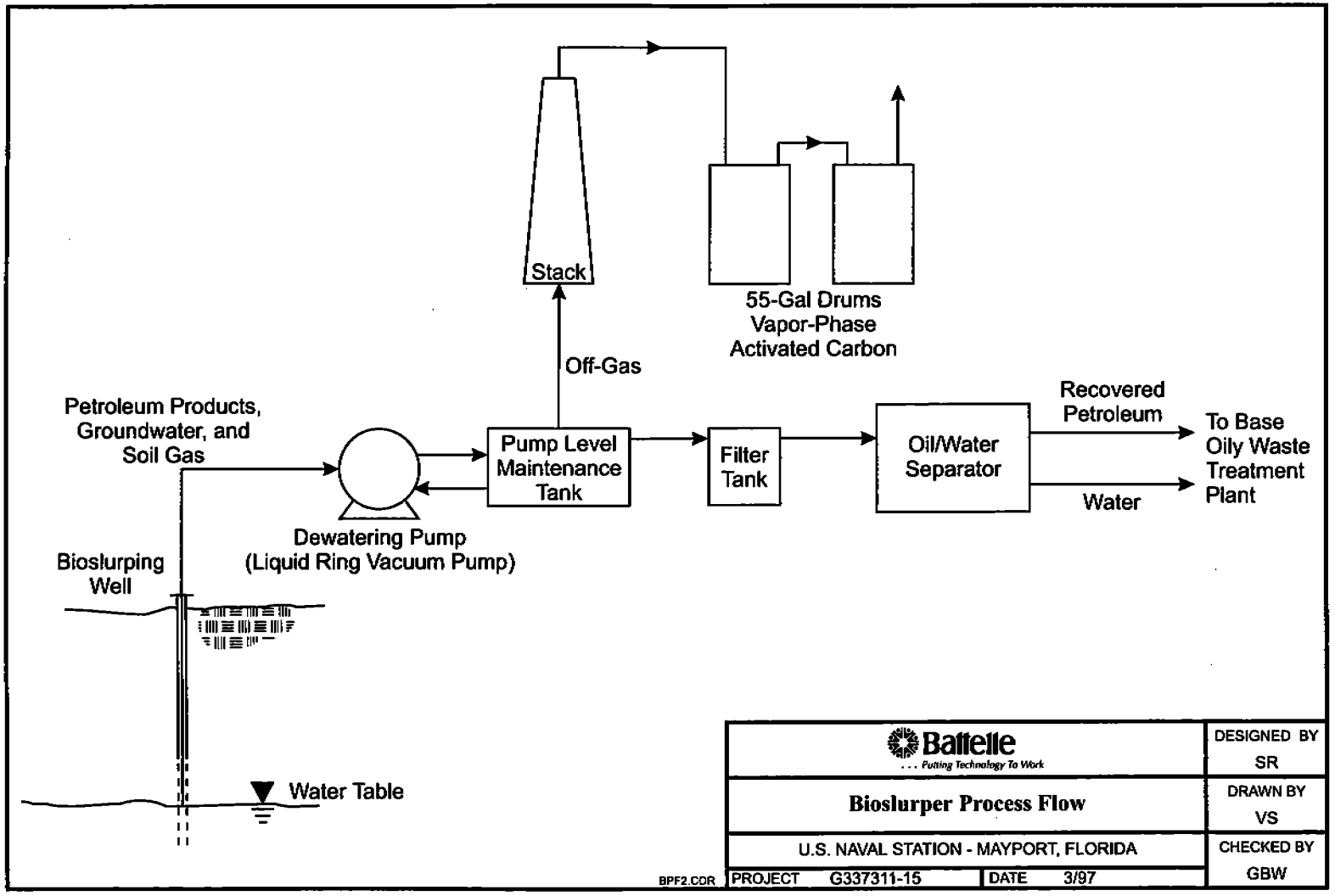


Figure 5. Bioslurper Process Flow

A 7.5-hp Atlantic Fluidics Model A100 liquid ring pump was used for all pilot testing. LNAPL was separated from the aqueous phase by passing the liquid discharge stream through a gravity OWS (Megator Corp. Model #S-1-A-1.5, or equivalent) with 10 gpm flow capacity. Extracted groundwater was allowed to gravity-drain into a 225-gallon surge tank located adjacent to the OWS. The tank was equipped with a float switch to shut down all power prior to tank overflow. Recovered LNAPL was quantified and recombined with the wires inside the 225-gallon surge tank. An additional pump was used to direct extracted groundwater and LNAPL to the NAVSTA-supplied 40,000-gallon-capacity temporary storage system.

A heavy emulsion, which can significantly affect the performance of the bioslurper system, tends to form during pumping operations at SWMU7. To address this concern, a centrifugal separator (CINC, Model V-5) was installed and operated in addition to the gravity-feed OWS. The unit was placed upstream of the liquid ring pump to determine its ability to break up emulsions and separate the LNAPL from the aqueous streams.

The vapor discharge treatment system consisted of two 200-lb gas-phase activated carbon canisters plumbed in series to the bioslurper vapor discharge stack. A pressure gauge was placed on the vapor discharge stack, and vapor sampling ports were placed before and after the two carbon canisters. The discharge stack from the liquid ring pump was fitted with a pitot tube flow indicator.

Three soil-gas monitoring points were installed to measure pressure and soil-gas concentrations. Monitoring points MPA, MPB, and MPC are located in a straight line directly east of bioslurping well MPT-8-MW07S at respective distances of 10, 20, and 30 feet. Screened intervals were placed at depths of 4.0, 6.0, and 8.5 feet in each monitoring point.

2.3 Soil Contamination. Four soil samples were collected during the installation of monitoring point MPC and were taken at depths of 6-6.5, 7-7.5, 8-8.5, and 9-9.5 feet bgs. The soil samples were contained in brass sleeves, placed in an insulated cooler, and shipped with chain-of-custody records to a qualified laboratory.

Table 3 shows the concentrations of TPH and BTEX measured in soil samples collected in the vicinity of SWMU7. TPH concentrations ranged from 150 to 4,900 mg/kg with concentrations at the higher end of the spectrum being found at deeper depths. With the exception of toluene, concentrations of individual BTEX components were not found above the respective detection limits. The laboratory analytical report is provided in Appendix C.

Concentrations in soil samples collected by Battelle are considerably lower than concentrations reported by ABB from a 1994 sampling. The difference could be explained in part by the occurrence of biodegradation and also by the smearing that results from fluctuations in water-table elevations.

2.4 Oil/Water Measurements and Baildown Test Results. Initial depths to LNAPL and to groundwater were measured at existing wells using an oil/water interface probe. Free-product thickness ranged from 0.01 to 1.56 ft with the greatest thicknesses being measured at MPT-8-MW07S and MPT-8-MW11S (Table 4). These measurements were used to determine which wells would be selected for baildown testing.

Table 3. TPH and BTEX Concentrations in Soil Samples Collected from SWMU7, NAVSTA Mayport

Parameter	Concentration (mg/kg)			
	MPC (6-6.5 ft bgs)	MPC (7-7.5 ft bgs)	MPC (8-8.5 ft bgs)	MPC (9-9.5 ft bgs)
TPH (as diesel)	150	4,300	2,100	4,900
Benzene	ND	ND	ND	ND
Toluene	0.017	0.23	0.18	ND
Ethylbenzene	ND	ND	ND	ND
Xylenes	ND	ND	ND	ND

ND = not detected.

Table 4. Initial LNAPL/Groundwater Measurements, June 1996, Navsta Mayport

Well ID	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
MW02S	12.28	12.06	0.22
MW03S	12.33	12.24	0.09
MW07S	11.30	9.74	1.56
MW08S	9.52	—	—
MW09S	8.90	8.89	0.01
MW10S	9.11	—	—
MW11S	11.2	9.91	1.29
MW15S	9.87	—	—
TP04	11.79	11.62	0.17

Baildown tests were conducted at monitoring wells MPT-8-MW07S and MPT-8-MW11S. After initial depths to LNAPL and groundwater were measured, LNAPL was removed from the wells with a Teflon™ bailer until the LNAPL thickness could no longer be reduced. The volume of LNAPL removed from each well was recorded. The increase in the thickness of the floating LNAPL layer was monitored over time. The thickness measurements were converted to volumes by multiplying the measurements by the cross-sectional area of the monitoring well.

By 27 hours after bailing MPT-8-MO7S, the LNAPL had recovered to approximately 42% of its initial thickness. Monitoring well MPT-8-MW11S had a higher recovery, where product thickness recovered to approximately 47% of its initial level after only a 7-hour test period. The volumetric change of LNAPL in each of the wells is presented in Figure 6. The point on each plot at 0 minute represents the volume of LNAPL inside each well immediately after bailing down the well. Note that the initial slope (in gal/min) of the recovery curve for well MPT-8-MW11S is greater than that of MPT-8-MW07S, indicating a greater initial recovery rate. Although monitoring well MPT-8-MW11S showed greater recovery, monitoring well MPT-8-MW07S was chosen for the full range of bioslurper pump tests due to site logistics. Following the activities at MPT-8-MW07S, a short, low-vacuum pump test was conducted at MPT-8-MW11S.

Groundwater and oil levels were monitored in MPT-8-TP07 throughout the duration of bioslurper testing (Table 5). This monitoring point is approximately 40 ft from the bioslurper extraction well.

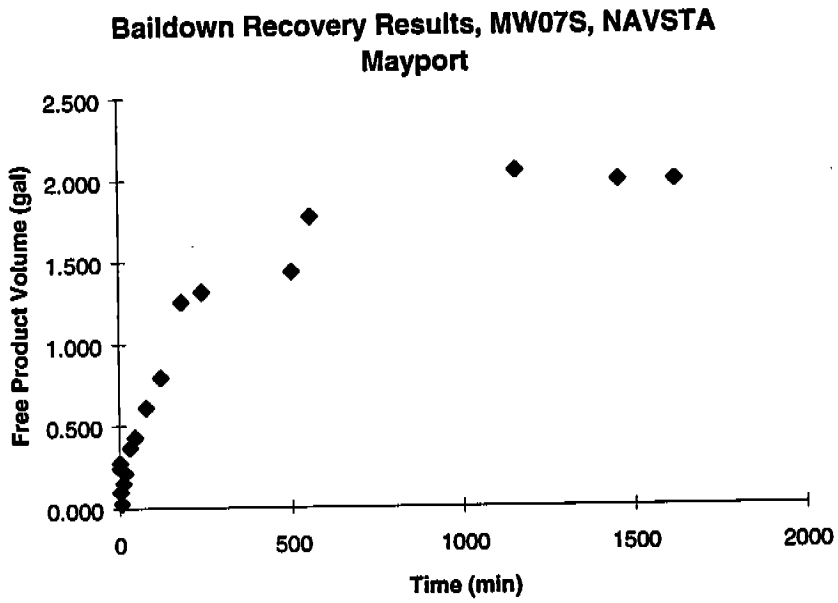
Measurements were taken to determine the effect of bioslurper operation on water-table elevations and fuel thickness. Oil/water measurements were taken at MPT-8-MW11S as a background point to determine what variations in elevation resulted from tidal influence.

Table 5. Oil/Water Measurements in MPT-8-TP07, NAVSTA Mayport

Measurement Data	Depth to Groundwater (ft)[a]	Depth to LNAPL (ft)[a]	LNAPL Thickness (ft)
7/8/96 - 1215	12.15	11.60	0.55
7/10/96 - 0855	11.84	11.72	0.12
7/11/96 - 1820	11.58	11.41	0.17
7/12/96 - 0820	11.38	11.21	0.17
7/13/96 - 0833	11.48	11.24	0.24
7/14/96 - 0845	11.75	11.51	0.24
7/16/96 - 0730	12.22	12.03	0.19
7/17/96 - 1100	12.25	12.01	0.24
7/17/96 - 1915	12.29	12.21	0.08
7/18/96 - 0745	11.67	11.53	0.14
7/19/96 - 0751	12.39	12.36	0.03
7/20/96 - 0821	12.70	12.68	0.02

[1] = Below top of casing.

Results show a general increase in the depth to the water table at MPT-8-TP07, with the most noticeable difference seen to correspond with the operation of the bioslurper in drawdown mode. The



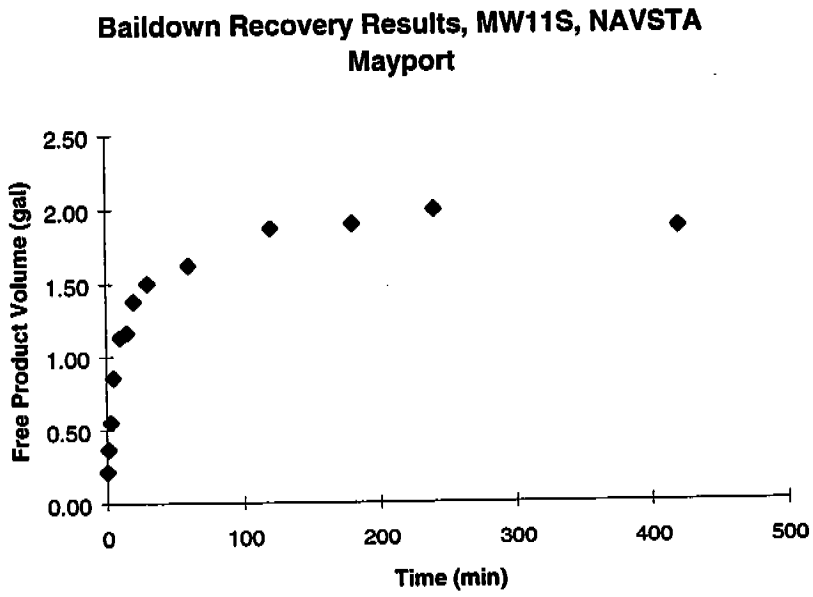


Figure 6. Baildown Test Results, NAVSTA Mayport

background point MPT-8-MW11S also showed increasing depth to the water table. The drop in water-table elevation corresponded to increased fuel thicknesses measured in the well.

2.5 LNAPL and Groundwater Recovery Results. Bioslurper testing was conducted at low-, medium-, and high-vacuum modes and in drawdown mode at monitoring well MPT-8-MW07S. Respective vacuums for the various pump tests were 7, 14, and 20 in. of water. Details of the operational parameters can be found in Appendix D.

Groundwater recovery was seen to increase with greater wellhead vacuums. Groundwater recovery rates at low, medium, and high vacuums were 342 gal/day, 630 gal/day, and 1,161 gal/day, respectively (Table 6). A graphical presentation showing the relationship between groundwater recovery and wellhead vacuum is shown in Figure 7. As is typical, an even greater groundwater recovery rate of 2,084 gal/day was observed during the bioslurper pump test in drawdown mode. Total groundwater recovery during each of the operational modes can also be found in Table 6.

Table 6. Bioslurper Pump Test Results at MPT-8-MW07S, NAVSTA Mayport

Recovery Rate (gal/day)	Low Vacuum 7" H_2O		Medium Vacuum 14" H_2O		High Vacuum 20" H_2O		Drawdown Mode 44" H_2O	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
Day 1	Sheen	343	Sheen	700	Sheen	1,186	Sheen	2,132
Day 2	Sheen	342	Sheen	641	Sheen	1,171	Sheen	2,067
Day 3	NA	NA	Sheen	566	Sheen	1,096	Sheen	2,057
Average	Sheen	342	Sheen	864	Sheen	1,151	Sheen	2,085
Total Recovery (gal)	Sheen	685	Sheen	2,592	Sheen	3,453	Sheen	6,256

NA = Not applicable.

LNAPL recovery throughout the sequence of bioslurper pump tests at MPT-8-MW07S was too small to accurately quantify; however, recovery improved slightly with increased wellhead vacuum and when operating in drawdown configuration. The recovered product was predominantly a dark-colored foamy emulsion. It is believed that oil present as a sheen was absorbed by iron precipitates formed after the water exited from the ring pump. Greater quantities of this oily substance were observed while operating in the drawdown mode.

Following bioslurper activities at monitoring well MPT-8-MW07S, a bioslurper pump test at very low vacuum was conducted at monitoring well MPT-8-MW11S for a duration of approximately 22 hours. Average recovery rates were 1.2 gal/day for LNAPL and 1,577 gal/day for groundwater (Table 7). A total of 1.1 gal of LNAPL and 1,465 gal of groundwater were collected throughout the duration of the bioslurper pump test at MPT-8-MW11S. Complete operational data can be found in Appendix D.

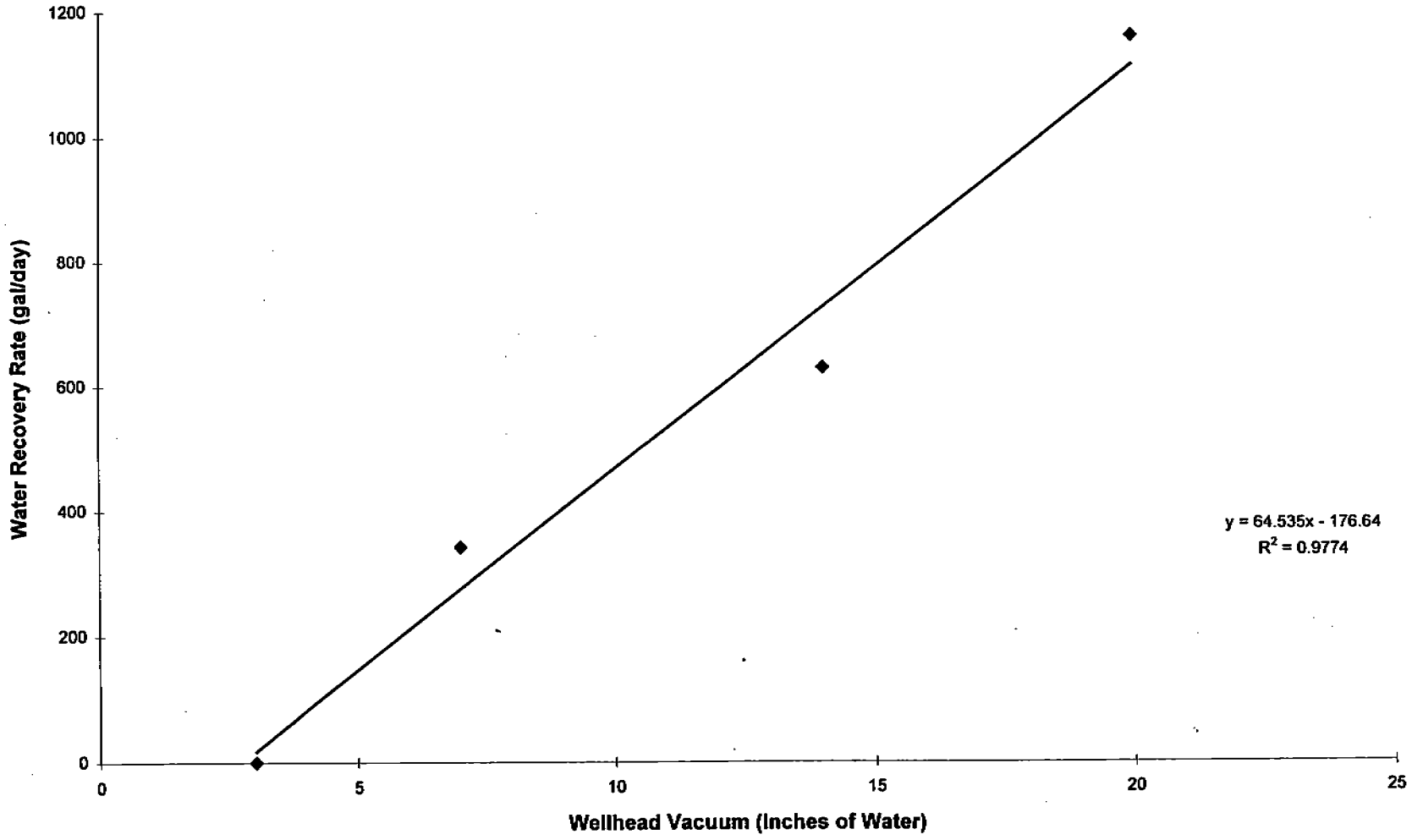
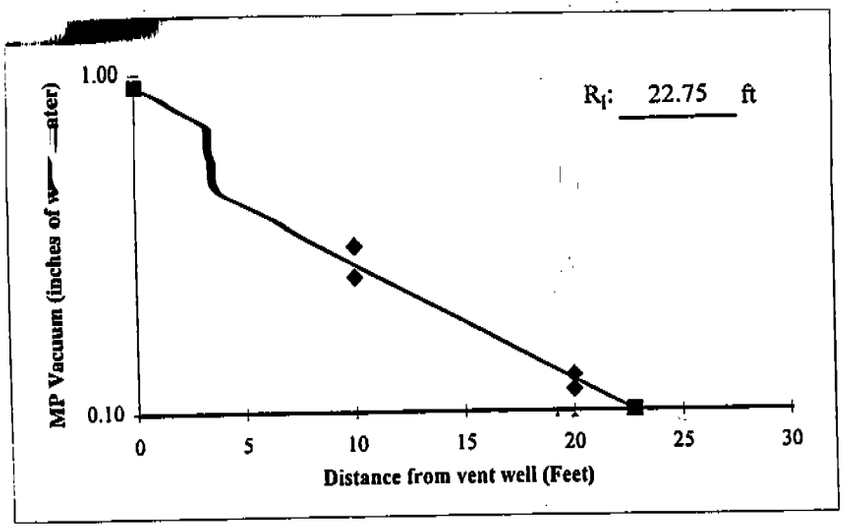
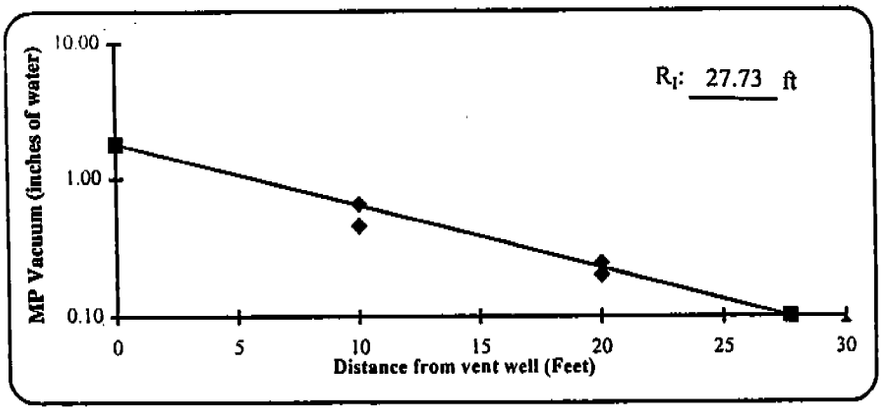


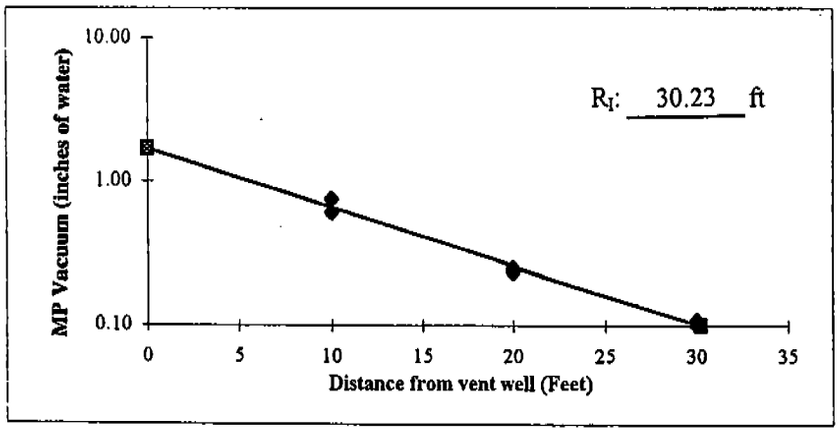
Figure 7. **Liquid Recovery as a Function of Wellhead Vacuum at MPT-8-MW07, NAVSTA Mayport**



Low Vacuum



Medium Vacuum



High Vacuum

Figure 8. **Radius of Influence During the Low-, Medium-, and High-Vacuum Bioslurper Pump Tests at MPT-8-MW07S**

- Experience at other sites shows, vacuum-enhanced free-product recovery to be more efficient than the conventional skimming or drawdown techniques. At this site, however, free-product recovery with the bioslurper is relatively low (i.e., 1.1 gpd) indicating that the recoverable free product in the areas of the wells tested is low.

- The vacuum-enhanced bioslurper system is not required to be operated in the drawdown mode, because the increase in LNAPL recovery is not significant compared to the increase in water recovery.

- The radius of influence at the site is approximately 30 ft under high vacuum conditions.

- In situ respiration rates range from 2.8 to 3.6 μg TPH per kg soil per day.

- Low groundwater extraction rates caused high temperatures to be observed in the seal water tank. An air-cooled heat exchanger could be used to decrease the temperature and minimize the volatilization of hydrocarbons into the off-gas stream.

In the design of a full-scale system, Battelle has based its bioslurper treatment area on previous delineations of the LNAPL plume and excluded areas where free product has not been measured.

2.12.2 Sludge Drying Beds. It may not be necessary to implement bioslurping in the sludge drying beds at SWMU7. Data collected from two piezometers in the northern portion of the beds indicate that free product may not be present. However, further characterization of the area is needed to confirm its absence. Battelle installed three soil-gas monitoring points in the sludge drying bed area. Although a respiration test was not performed, soil-gas samples collected from the monitoring points indicated biodegradation was occurring. In approximately 5 days after air injection, the oxygen concentrations measured at the soil-gas monitoring points dropped from as high as 20% to as low as 0.5%. In the same time period, carbon dioxide concentrations increased from as low as 1% to as high as 14%. Based on these initial results, it may be more cost effective to remediate the sludge drying beds using bioventing rather than bioslurping technology.

A bioventing system can be designed and implemented in areas having contamination above acceptable regulatory levels to reduce both the PAH and the TPH levels in the soil. Bioventing is a relatively low-cost in situ technology that has been proven to be effective at remediating petroleum-contaminated sites. However, prior to installing a full-scale bioventing system in the sludge drying beds, additional information such as the soil-gas radius of influence should be determined. Although the radius of influence and biodegradation rates were determined for soils located beyond the sludge drying bed area during pilot-scale bioslurper testing, these values cannot be used to accurately design a bioventing system inside the drying beds. The fact that the groundwater table elevation is significantly higher in the sludge drying bed area potentially could affect the radius of influence. It is recommended that these important design parameters be addressed prior to designing and installing a full-scale system.

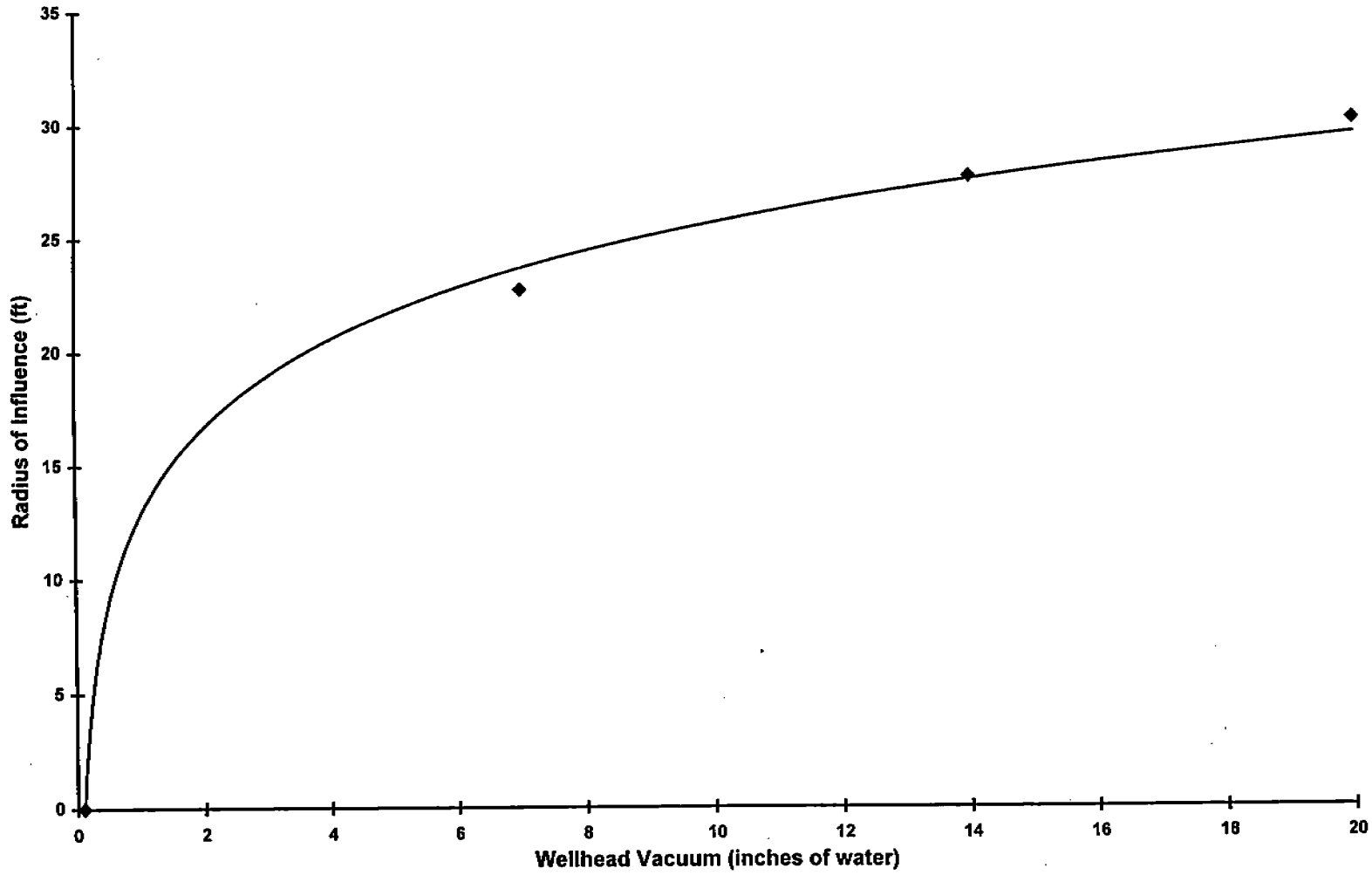


Figure 9. Correlation Between Radius of Influence and Wellhead Vacuum

Table 8. In Situ Respiration Results at NAVSTA Mayport

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg-day)
MPA-6'	0.17	2.8
MPA-8.5'	0.17	2.8
MPB-8.5'	0.22	3.6
MPC-6.5'	0.19	3.2

2.8 Vapor Discharge. Off-gas samples from the bioslurper system were collected during each of the bioslurper pump tests. The bioslurper system was operated at high, medium, and low vacuums and in drawdown mode at monitoring well MPT-8-MW07S and at very low vacuum only at monitoring well MPT-8-MW11S. One sample was collected directly from the bioslurper stack during each of these operational periods. In addition, one sample was collected following treatment with activated carbon. Pretreatment concentrations in off-gas at MPT-8-MW07S ranged from 75 to 250 ppmv for TPH and were less than 3.0 ppmv for combined BTEX. Off-gas concentrations were higher at MPT-8-MW11S with 1,600 ppmv for TPH and 22.9 ppmv for combined BTEX. The results of the off-gas analyses are presented in Table 9.

Off-gas discharge rates during the various operational periods at both wells were calculated based on flowrates from the bioslurper stack and on TPH and BTEX concentrations in the off-gas. The maximum loading was found to be less than 14 lb/day for TPH and less than 1.0 lb/day for BTEX. The expected daily vapor loading for TPH and BTEX during each operational period is shown in Table 10.

The off-gas concentrations may be higher than normally would be expected due to unnecessarily high temperatures in the seal water tank. Elevated seal water temperatures could result in increased volatilization of recovered free product present inside the tank, which would result in vapor concentrations unrepresentative of expected concentrations.

2.9 Groundwater Discharge. Five groundwater samples were collected during the series of bioslurper pump tests at SWMU7. Aqueous discharge samples were collected from the outlet of the oil/water separator (OWS) during each of the bioslurper pump tests. These operational periods include high-, medium-, and low-vacuum modes and a drawdown mode at monitoring well MPT-8-MW07S and a very-low-vacuum mode at monitoring well MPT-8-MW11S. All samples were analyzed for BTEX and TPH. Samples to be analyzed for BTEX were collected in 40-mL septa vials containing HCl preservative, and samples to be analyzed for TPH were collected in 2-L glass jars with no preservative. BTEX concentrations in all aqueous samples were less than detection limits, and TPH concentrations ranged from 3.9 to 23 mg/L (Table 11). The highest TPH concentration was found in the sample collected from MPT-8-MW11S (Mayport 5).

Table 9. Off-Gas Analyses

Sample ID	Sample Date	Bioslurper Model of Operation	Benzene (ppmv)	Toluene (ppmv)	Ethyl-benzene (ppmv)	Total Xylenes (ppmv)	TPH (ppmv)
Stack Pre-Carbon 1	7/10/96	Well MW07S; low-range vacuum; drop tube set at interface	0.16	0.61	0.17	0.87	75
Stack Pre-Carbon 2	7/12/96	Well MW07S; high-range vacuum; drop tube set at interface	0.19	0.68	0.25	0.97	96
Stack Pre-Carbon 3	7/15/96	Well MW07S; drop tube set 30 inches beneath interface	0.17	0.44	0.44	1.4	210
Stack Pre-Carbon 4	7/19/96	Well MW07S; mid-range vacuum; drop tube set at interface	0.24	0.46	0.58	1.6	250
Stack Pre-Carbon 5	7/22/96	Well MW11S; drop tube set at interface	1.3	2.3	7.3	12	1,600
Stack Post-Carbon 1	7/22/96	Well MW11S; drop tube set at interface; after carbon treatment	0.046	0.29	0.044	0.18	56

Table 10. Off-Gas Mass Loading[a]

Sample ID	Sample Date	Flowrate (scfm)	BTEX Loading (lb/day)	TPH Loading (lb/day)
Stack Pre-Carbon 1	7/10/96	31	0.021	1.4
Stack Pre-Carbon 2	7/12/96	33	0.026	1.8
Stack Pre-Carbon 3	7/15/96	30	0.028	3.8
Stack Pre-Carbon 4	7/19/96	34	0.038	4.9
Stack Pre-Carbon 5	7/22/96	15	0.132	13.5

[a] Regulatory requirements mandate that the off-gas loading be less than 15 lb/day.

Groundwater TPH mass loading during the various operational periods at both wells was calculated based on average groundwater flowrates and the TPH concentration in the aqueous discharge. The TPH loadings are presented in Table 12. The BTEX loading was not calculated because the BTEX concentrations in the groundwater were below laboratory detection limits.

2.10 Centrifugal Separator Evaluation. During the pilot-scale testing of the bioslurper system at NAVSTA Mayport, a centrifugal separator unit was tested in an attempt to reduce emulsification of the free product. The separator, manufactured by CINC Corp., was installed between the extraction well and the liquid ring pump to remove fuel from the influent stream prior to reaching the liquid ring pump. The separator rotor turns at high speed, separating liquids of differing specific gravities. By varying the weir sizes and manipulating the speed of the rotor, the system can be optimized to discharge fuels from one port and water from another. The system was installed to maintain a constant vacuum across the influent line, the centrifugal separator, and the tanks plumbed to the separator outlet ports. The fuel outlet drained into a pair of 30-gallon pressure cylinders designed to allow recovered product to be drained from the second cylinder while maintaining a vacuum across the rest of the system. The water outlet emptied into a vacuum-tight 55-gallon equalization drum, which was connected to the liquid ring pump.

The centrifugal separator system was not successful at this site. Some fuel escaped through the water discharge, allowing emulsification to occur. The manufacturer's representatives were unable to consistently prevent water from flowing through the fuel discharge port. In addition, the separator operation may have been impeded by iron oxides precipitating out of the water and encrusting the inner surfaces of the equipment. Following a period of unsuccessful operation, the centrifugal separator was shut down and bypassed.

2.11 Sludge Drying Bed Investigations. Battelle installed two 2-inch-diameter piezometers in SWMU7 using a hollow-stem auger drill rig. These piezometers were labeled MW1 and MW2. MW1 was installed in the northern portion of the central drying bed and MW2 was installed in the northern portion of the easternmost drying bed (Figure 10). Both wells were located within the free-product plume, which is delineated by the dashed line in Figure 10. Each piezometer was installed to a depth of 13 feet bgs and was screened from 3 to 13 feet bgs. The piezometer completion drawings are included in Appendix A of this document.

Table 11. Extracted Groundwater Analyses

Sample ID	Sample Date	Bioslurper Model of Operation	Benzene (mg/L)	Toluene (mg/L)	Ethyl-benzene (mg/L)	Total Xylenes (mg/L)	TPH (mg/L)
Mayport 1	7/12/96	Well MW07S; low-range vacuum; drop tube set at interface	<0.0050	<0.0050	<0.0050	<0.0050	7.3
Mayport 2	7/14/96	Well MW07S; high-range vacuum; drop tube set at interface	<0.0050	<0.0050	<0.0050	<0.0050	3.9
Mayport 3	7/15/96	Well MW07S; drop tube set 30 inches beneath interface	<0.0050	<0.0050	<0.0050	<0.0050	14
Mayport 4	7/19/96	Well MW07S; mid-range vacuum; drop tube set at interface	<0.0050	<0.0050	<0.0050	<0.0050	7.6
Mayport 5	7/22/96	Well MW11S; very low-range vacuum; drop tube set at interface	<0.0050	<0.0050	<0.0050	<0.0050	23

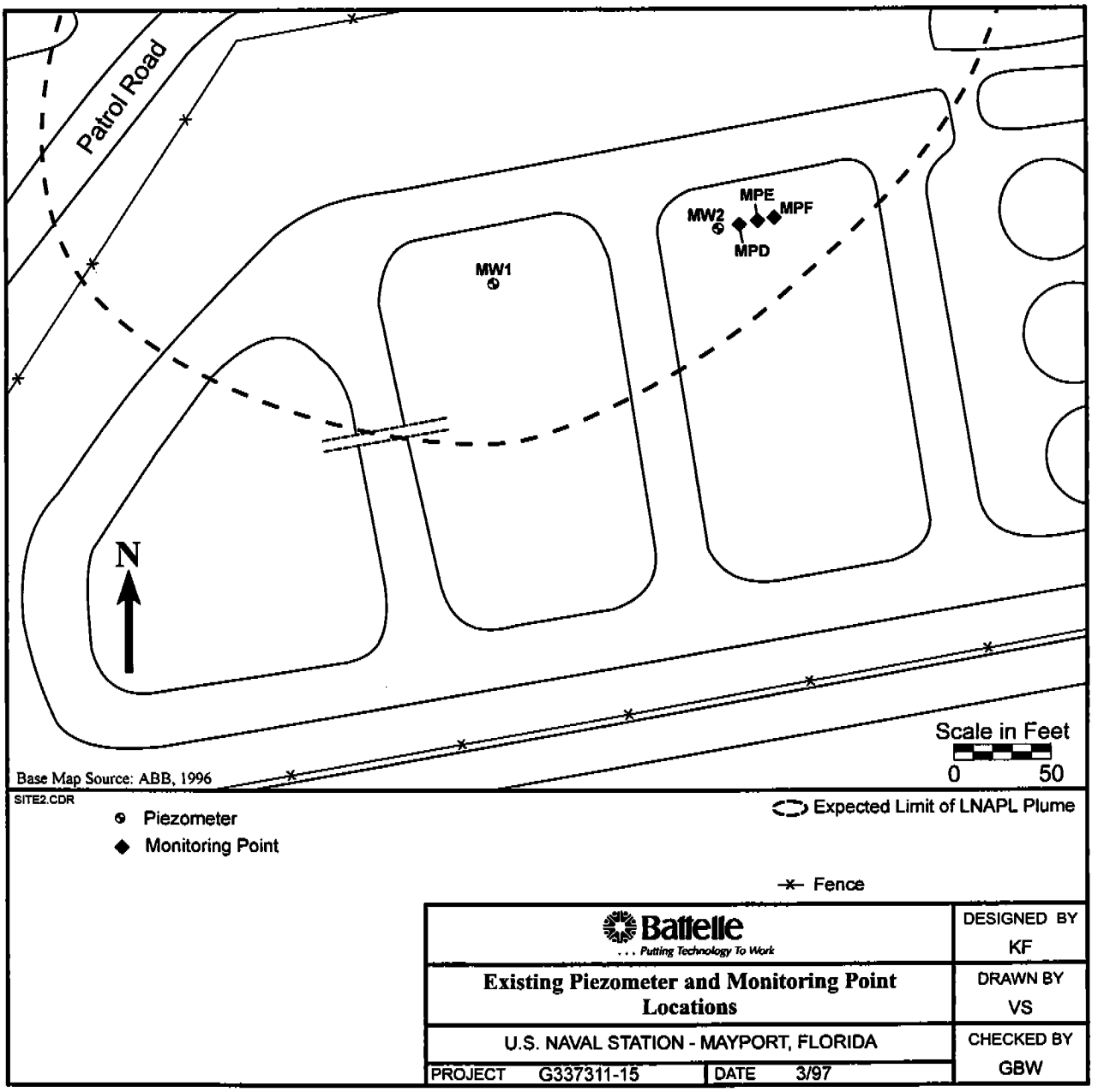


Figure 10. Existing Piezometer and Monitoring Point Locations

Table 12. Groundwater TPH Mass Loadings

Sample ID	Sample Date	Flowrate (gal/day)	TPH Loading (lb/day)
Mayport 1	7/12/96	343	0.021
Mayport 2	7/14/96	1161	0.038
Mayport 3	7/15/96	2084	0.243
Mayport 4	7/19/96	630	0.040
Mayport 5	7/22/96	1577	0.303

During the installation of the piezometers, a split spoon was used to collect soil samples at depths of about 1 to 9 feet bgs. The soil samples were dark gray in color and had a petroleum odor. A headspace analysis was performed on the soil samples in accordance with the method specified in the FDEP *Guidelines for Assessment of Remediation of Petroleum Contaminated Soil* (FDEP, 1994b). The method requires each sample to be placed in a 16-oz jar and to be half-filled with the sample and covered with foil. Within 5 minutes of obtaining the sample or bringing the soil sample to a temperature between 20°C and 30°C, the gas in the headspace above the soil is analyzed using an organic vapor analyzer (OVA). The samples were analyzed both with and without a charcoal filter that is designed to adsorb organic vapors other than methane. The reading due to petroleum volatile organic vapors is obtained by subtracting the filtered reading from the unfiltered reading. The results are presented in Table 13.

Table 13. Headspace Analysis Results

Sample Location	Sample Depth (ft bgs)	Hydrocarbon Concentration (ppm)
MW1	0-2	105
	2-4	140
	4-6	80
MW2	0-1	0
	1-2	4
	2-3	120
	3-4	95
	4-5	580

In addition to installing the piezometers, three soil-gas monitoring points were installed using a 3-inch-diameter bucket auger. The monitoring points, designated as MPD, MPE, and MPF, were placed 10, 20, and 30 feet east of MW2, respectively. Each monitoring point contains one 1-inch-diameter by 6-inch-long suction filter screen filled with gravel and placed about 3 feet bgs. Nylon tubing was connected to each filter screen. The tubing was extended to the surface and attached to a quick-connect coupler. The monitoring point was packed with a 12-inch-thick sand pack. The interval between the sand pack and the surface was sealed with bentonite.

MW1 and MW2 were monitored over a 1-week period. During this time, free product was not observed in either piezometer. Groundwater elevation measurements ranged from 5.3 to 5.5 feet bgs in MW1 and from 4.5 to 4.8 feet bgs in MW2. Groundwater samples removed from the well had a yellow tint. There was no hydrocarbon odor associated with these samples.

Soil gas was analyzed for oxygen, carbon dioxide, and TPH concentrations in the previously installed soil-gas monitoring points. The results are presented in Table 14. The decrease in oxygen concentrations and increase in carbon dioxide concentrations with time indicate potential aerobic microbial biodegradation activity at these locations.

Table 14. Soil-Gas Analysis at SWMU7

Monitoring Point	Parameter	7/18/96	7/19/96	7/19/96	7/21/96	7/23/96
MPD	O_2 (%) CO_2 (%) TPH (ppm)	18 1.5 160	18 3.5 300	20 1 230	5 11 800	11 6.5 200
MPE	O_2 (%) CO_2 (%) TPH (ppm)	17 2.5 200	18.5 3 280	19 1.8 180	6 10 2000	2 13 1000
MPF	O_2 (%) CO_2 (%) TPH (ppm)	17 2.5 380	20 1.5 200	18 2.8 320	8 8.5 940	0.5 14 2000

2.12 Discussion of Pilot-Scale Test Results

2.12.1 Bioslurping. Bioslurper pilot-scale testing at NAVSTA Mayport consisted of free-product recovery at monitoring wells MPT-8-MW07S and MPT-8-MW11S. The highest fuel recovery was seen at MPT-8-MW11S, with a rate of approximately 1.2 gallons per day (gpd). Groundwater was recovered at a rate of approximately 1,577 gpd. Pilot-scale testing at MPT-8-MW07S revealed increased recovery at higher wellhead vacuums. Respective groundwater recovery rates at wellhead vacuums of 7, 14, and 20 in. of water were 342, 630, and 1,161 gpd. Groundwater recovery during the bioslurper drawdown mode increased to over 2,000 gpd. LNAPL recovery throughout the sequence of bioslurper pump tests at MPT-8-MW07S was minimal; however, recovery improved slightly with increased wellhead vacuum and in drawdown configuration. The fuel was difficult to quantify because it was predominantly in the form of a dark-colored foamy emulsion.

Based on the higher fuel recovery obtained at MPT-8-MW11S, bioslurping would be an appropriate remediation technology for subsurface hydrocarbon contamination north of the sludge drying beds at NAVSTA Mayport. However, the frequent fluctuation in groundwater elevation resulting in changes in free-product thicknesses can significantly affect both LNAPL and groundwater recovery rates. The following conclusions were made based on the results of the pilot-scale testing:

- Experience at other sites shows, vacuum-enhanced free-product recovery to be more efficient than the conventional skimming or drawdown techniques. At this site, however, free-product recovery with the bioslurper is relatively low (i.e., 1.1 gpd) indicating that the recoverable free product in the areas of the wells tested is low.

- The vacuum-enhanced bioslurper system is not required to be operated in the drawdown mode, because the increase in LNAPL recovery is not significant compared to the increase in water recovery.

- The radius of influence at the site is approximately 30 ft under high vacuum conditions.

- In situ respiration rates range from 2.8 to 3.6 μg TPH per kg soil per day.

- Low groundwater extraction rates caused high temperatures to be observed in the seal water tank. An air-cooled heat exchanger could be used to decrease the temperature and minimize the volatilization of hydrocarbons into the off-gas stream.

In the design of a full-scale system, Battelle has based its bioslurper treatment area on previous delineations of the LNAPL plume and excluded areas where free product has not been measured.

2.12.2 Sludge Drying Beds. It may not be necessary to implement bioslurping in the sludge drying beds at SWMU7. Data collected from two piezometers in the northern portion of the beds indicate that free product may not be present. However, further characterization of the area is needed to confirm its absence. Battelle installed three soil-gas monitoring points in the sludge drying bed area. Although a respiration test was not performed, soil-gas samples collected from the monitoring points indicated biodegradation was occurring. In approximately 5 days after air injection, the oxygen concentrations measured at the soil-gas monitoring points dropped from as high as 20% to as low as 0.5%. In the same time period, carbon dioxide concentrations increased from as low as 1% to as high as 14%. Based on these initial results, it may be more cost effective to remediate the sludge drying beds using bioventing rather than bioslurping technology.

A bioventing system can be designed and implemented in areas having contamination above acceptable regulatory levels to reduce both the PAH and the TPH levels in the soil. Bioventing is a relatively low-cost in situ technology that has been proven to be effective at remediating petroleum-contaminated sites. However, prior to installing a full-scale bioventing system in the sludge drying beds, additional information such as the soil-gas radius of influence should be determined. Although the radius of influence and biodegradation rates were determined for soils located beyond the sludge drying bed area during pilot-scale bioslurper testing, these values cannot be used to accurately design a bioventing system inside the drying beds. The fact that the groundwater table elevation is significantly higher in the sludge drying bed area potentially could affect the radius of influence. It is recommended that these important design parameters be addressed prior to designing and installing a full-scale system.

Section 3.0 FULL-SCALE DESIGN APPROACH

The objective of this design is to provide treatment systems to remove a portion of the free-phase petroleum contamination from the soils in the vicinity of SWMU7 at NAVSTA Mayport and to reduce the PAH and TPH concentrations in the soil located inside the sludge drying beds. Results of the pilot study indicate that bioslurping is a viable method of recovering free-phase petroleum products from the capillary fringe and water table. The operation of the bioslurper treatment system will aerate the subsurface soils, stimulating soil-indigenous microorganisms to aerobically metabolize fuel hydrocarbons in the vadose zone (bioventing).

Historical site characterization data indicate that the free-phase product plume has moved outside of the sludge drying bed area. During pilot-scale testing, two piezometers were installed inside two of the drying beds. No evidence of free product was found. During full-scale implementation, additional wells will be installed. If free product is observed inside the wells, the wells will be incorporated into the full-scale bioslurper process. However, if free product is not observed, a bioventing system will be installed inside the sludge drying bed area and will be used to degrade the PAHs and TPH present in the soil. The treatment area at SWMU7 is shown in Figure 11; it is based on a series of contour plots provided by ABB Environmental Services. Copies of these plots are provided in Appendix A.

3.1 Bioslurper Design Approach. Bioslurper extraction wells will be installed in a manner to effectively treat the region depicted in Figure 11. The exact location of each well will be determined using the radius of influence measured during pilot testing as well as the presence of underground utilities. The wells will be monitored for free product. A portable bioslurper system will be used to pump from each well for 1 to 2 hours to facilitate the migration of free product into the well. If greater than 0.1 inch of product thickness is observed in a well, or if free product is extracted from a well during the pump test, the well will be finished and a protective casing will be installed around it (Section 4.1.1). Subsurface polyvinyl chloride (PVC) pipe will be used to plumb the well to the vacuum extraction system. The free product and water generated during the pump test will be discharged to the base 20,000-gallon temporary storage facility and subsequently discharged to the base OWTP. The off-gas generated will be treated using two 200-lb drums of activated carbon placed in series.

If free product is detected in the wells that are installed in the sludge drying beds, a subsurface extraction manifold will be used to plumb these wells to the rest of the bioslurper extraction system. If free product is not detected, the wells will be used as injection wells for bioventing. The bioventing design approach is discussed in detail in Section 3.2.

The primary site-specific parameters that determine the design of the full-scale bioslurper system are shown in Table 15. Sections 3.1.1 through 3.1.4 describe the influence of each parameter on the full-scale design.

3.1.1 Well Spacing. Spacing of wells is important to ensure optimizing free-product recovery and supplying oxygen-rich air for enhanced in situ biodegradation of fuel hydrocarbons in the vadose zone. The design, placement, and installation of the multiple bioslurper wells are the most critical factors in achieving successful remediation. The desired well spacing is determined from the radius of influence that was measured during the pilot-scale test. The radius of influence is the measurement of the distance at which one bioslurper well will aerate the contaminated soils and mobilize free product and groundwater. By accurately calculating the radius of influence during pilot-scale testing to optimize the number and spacing of extraction wells, the full-scale costs can be minimized.

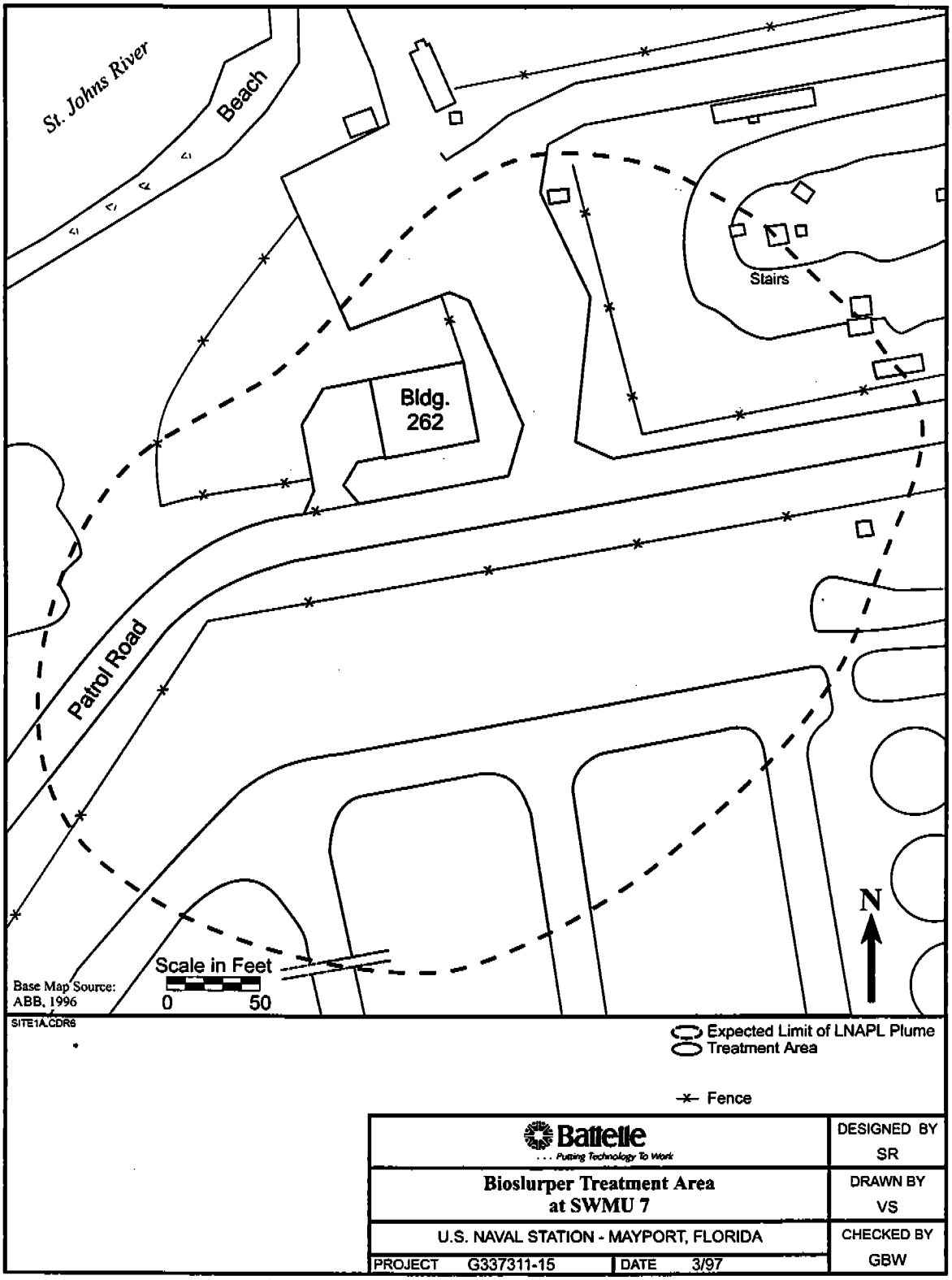


Figure 11. Bioslurper Treatment Area at SWMU 7

Table 15. Bioslurper System Design Variables

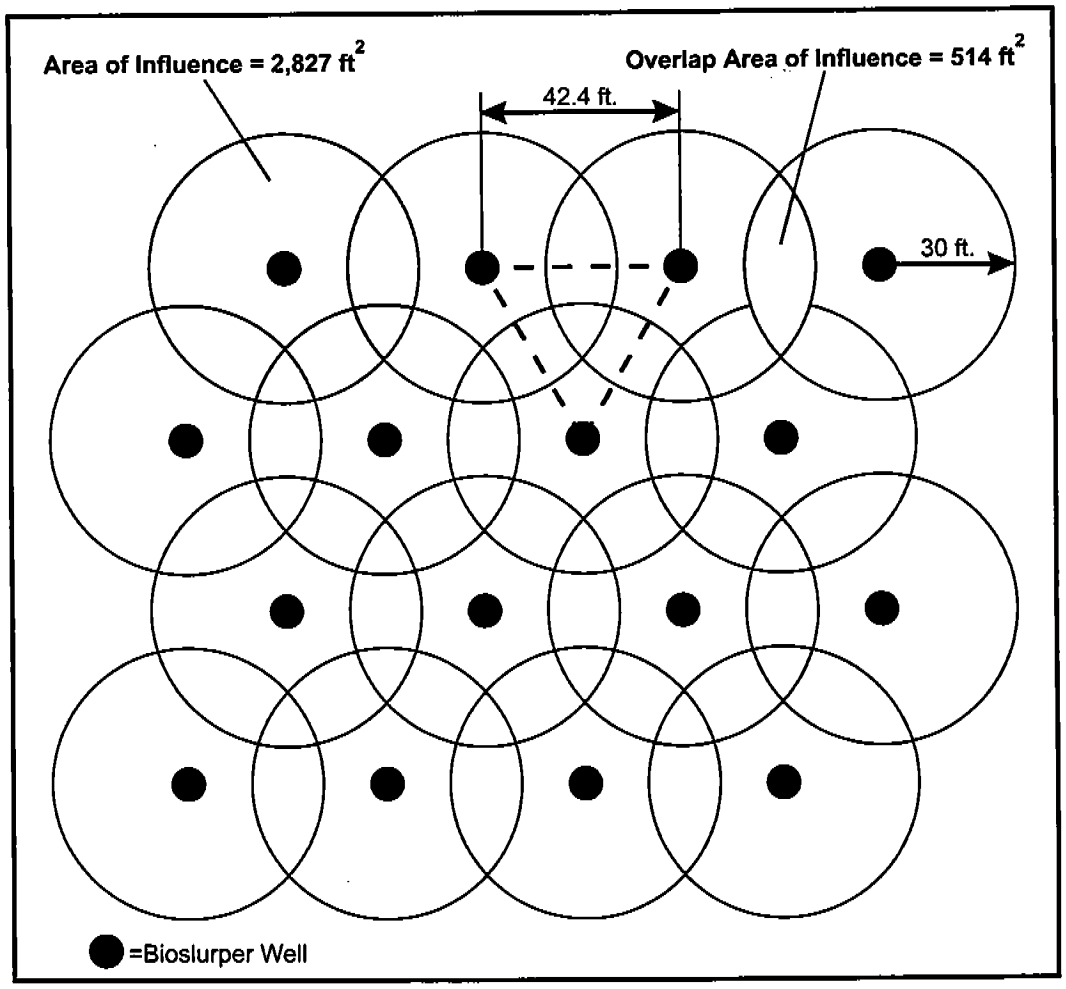
Influence on Design	Site-Specific Parameters
Well spacing	Radius of influence
Ring pump sizing	LNAPL and water extraction rates
Off-gas treatment	Hydrocarbon loading in off-gas
Water treatment	Hydrocarbon loading in water
Bioventing feasibility	Soil permeability; biodegradation rates

The radii of influence measured during the pilot-scale test were 23, 27.5, and 30 ft at wellhead vacuums of 7, 14, and 20 in. of water, respectively (Section 2.6). For the full-scale system, it is assumed that a radius of influence of 30 ft can be achieved by maintaining the vacuum at each wellhead at 20 in. of water. The wells will be installed in a triangular formation as depicted in Figure 12. The spacing arrangement resulting in overlapping zones of influence is recommended to avoid inactive zones and provide a safety margin. Using this spacing arrangement with a 30-foot radius of influence and a 17.6-foot overlap between the centers of the radii of influence of any two wells, the total distance between any two wells will be 42.4 feet. Using this radius of influence, a total of 70 extraction wells will be required: 32 wells on the north side of Patrol Road, 30 on the south side of Patrol Road (outside of the sludge drying beds), and 8 inside the sludge drying beds (Section 4.1.1).

3.1.2 Liquid Ring Pump Sizing. The size of the liquid ring pump depends primarily on the wellhead vacuum and air flowrate required to draw free-phase product into the extraction well and up to the surface. A general rule of thumb is to use between ⅓ and ⅔ horsepower (hp) for each extraction well. Because bioslurping is a relatively new technology, it has not yet been understood fully how well the pilot-scale flow data correlate to a full-scale system. However, based on Battelle's database that includes more than 25 pilot-scale test sites, it is apparent that LNAPL/water flow can be maintained with air flowrates as low as 3 cubic feet per minute (cfm) and wellhead vacuums as low as 0.7 in. water.

The pilot-scale test was performed using a 7.5-hp liquid ring pump and one extraction well. During pilot testing, significant fluid flow was observed at vacuums as low as 1 in. of water in an extraction well. The soil-gas flowrate induced by the pump while extracting from 1 well was about 32 cfm, or about 45% of the pump capacity at 20 in. Hg vacuum at the pump suction. This reduced gas flowrate is a result of the significant pressure drop created by the extraction well and associated piping. The large pressure drop between the pump suction and the well is due to the small diameter of the slurper tube. The small diameter is required to provide a sufficient velocity to lift the liquids. As more wells are added to the extraction system, the soil-gas velocity at each well decreases, resulting in less pressure drop. Therefore, the pump capacity will increase significantly when multiple wells are used.

The full-scale system will incorporate two liquid ring pumps. Site logistics and the area of contamination require two pumps. Assuming that 4 to 5 cfm of soil-gas flow is required to generate LNAPL/water flow and that one ring pump will extract from 32 wells and the other will extract from 38 wells (Section 4.1.1), the total required airflow for one pump would be between 128 and 160 cfm and the required airflow from the other would be 152 to 190 cfm. An Atlantic Fluidics 20-hp liquid ring pump



Battelle ... Putting Technology To Work		DESIGNED BY SR
Recommended Extraction Well Layout		DRAWN BY VS
U.S. NAVAL STATION - MAYPORT, FLORIDA		CHECKED BY GBW
ZONES3.CDR PROJECT G337311-15	DATE 3/97	

Figure 12. Recommended Extraction Well Layout

can generate 280 cfm. Assuming a 45% pump capacity as calculated from the pilot-scale data, a 20-hp pump could generate approximately 126 cfm of gas flow. In a multiple-well application, the capacity of each pump will be much greater than the 45% seen during pilot testing. Therefore, it is recommended that two 20-hp ring pumps be used for the bioslurping system, one on the north side of Patrol Road and the other on the south side.

3.1.3 Off-Gas Treatment. The full-scale off-gas treatment system is designed based on site-specific regulatory requirements and the hydrocarbon concentrations found in the stack gas during pilot-scale testing. Regulatory requirements demand that hydrocarbons discharged to the atmosphere should not exceed 15 lb/day. During pilot-scale testing, the concentration of total hydrocarbons in the stack gas ranged from about 75 to 250 ppmv (1.4 to 4.9 lb/day) while extracting from well MPT-8-MW07S. The hydrocarbon concentrations gradually increased during the pilot-scale test. This trend coincided with an increase in the liquid ring pump seal water temperature. Because the water extraction flowrate was low (less then 1 gpm), the seal water recycled through the ring pump frequently, increasing its temperature. Temperatures as high as 160°F were recorded in the seal water tank. The hydrocarbon concentration in the off-gas on the north side of Patrol Road (extracting from well MPT-8-MW11S) was 1,600 ppmv (13.5 lb/day). This unexpectedly high off-gas concentration likely was the result of the unusually high fluid temperature in the seal water tank. The free-product recovery rate was significant (approximately 1.2 gpd) while extracting from this well. At elevated seal water temperatures, a greater portion of the recovered free product present inside the seal water tank would volatilize, resulting in vapor concentrations unrepresentative of what would have been observed if the ring pump had been operating within its normal temperature range. Therefore, this reading was excluded from the daily carbon loading design calculations. The design includes a heat exchanger to avoid this problem.

The recommended treatment method for the off-gas stream is carbon adsorption. An estimate of carbon usage was made assuming the hydrocarbon concentration in the off-gas will be a maximum of 250 ppm. If off-gas is extracted from 70 extraction wells at 5 cfm per well, the total off-gas flowrate would be 350 cfm. Based on carbon loading data supplied by Sher-Fran Corporation (included with the equipment literature in Appendix F), approximately 23 lb of carbon would be required to treat 100,000 ft^3 per day. At 350 cfm, a 2,000-lb charge of carbon would last 17 days if exposed to a 250-ppm hydrocarbon concentration. This estimate assumes that the inlet gas stream is dry and has an inlet temperature of 77°F. These are optimum conditions for adsorption. As either temperature or relative humidity increases, the adsorption capacity of the carbon decreases. Keeping the process gas between 40 and 50% relative humidity optimizes the adsorption capacity with respect to both humidity and temperature. It is recommended that the full-scale bioslurper system use a dehumidifier to reduce the relative humidity of the off-gas into this range.

An alternative off-gas treatment method would be to use a thermal or catalytic oxidizer. Manufacturer's literature for a thermal oxidizer is found in Appendix F. The cost advantages of a thermal or catalytic oxidizer are the lower operating costs and the lack of disposal cost for waste material that is incurred with carbon treatment. However, the capital cost of an oxidizer can exceed $50,000 and will require purchase of supplemental fuel. It is cost-effective to use a thermal or catalytic oxidizer if the hydrocarbon concentrations in the off-gas are excessively high or treatment is expected to continue over a duration of years. At SWMU7, the concentrations of hydrocarbons in the off-gas are relatively low. It is believed that, with the proper liquid ring pump seal water temperature, the hydrocarbon concentration in the off-gas may be less than 100 ppm during full-scale remediation. After the first 1 to 3 months of operation, the concentration is expected to decrease enough to allow discharge of the off-gas directly to the

atmosphere without treatment. Hence, it would not be cost-effective to purchase a thermal or catalytic oxidizer.

3.1.4 Water Treatment Options. There are three options for treating the process water generated during operation: (1) discharge to a storm sewer, which would require a National Pollutant Discharge Elimination System (NPDES) permit; (2) pretreat the water to meet the requirements specified by the NAVSTA Mayport Waste Water Treatment Plant (WWTP) and discharge to the WWTP; or (3) discharge the oil/water to the base OWTP. The first option is not recommended because extensive treatment would have to be performed prior to discharging the water to the environment. Additional analyses of the full-scale aqueous discharge (flowrate and contaminant concentrations) should be performed prior to implementing the second treatment option. Both of the first two options are capital cost intensive, especially if the bioslurper system is required only for a short time.

This design assumes that the discharge water will be pumped to and temporarily stored in the two 20,000-gal storage tanks currently being used in the existing treatment process at SWMU7. The water subsequently will be pumped and treated at the base OWTP. Because the oil and water will not need to be separated and treated on site, both capital and maintenance costs will be low. The disadvantage is a high operating cost. Beginning in the 1997 fiscal year, the OWTP treatment cost increased to $32.14 per 1,000 gal of fluids treated. However, it is still recommended that the process water be discharged to the OWTP for at least the first month of operation. During this time, the water quality should be evaluated and the discharge volume quantified. If it is deemed more economical to discharge to the base WWTP (i.e., the second option), additional equipment (separator, clarifier, carbon, etc.) should be procured and installed. The required equipment will be determined based on the contaminant loading in the bioslurper discharge water as well as the WWTP influent requirements.

3.2 Bioventing Design Approach. A bioventing system will be used to remediate the soils inside the sludge drying bed area if free product is not detected in any of the wells. The bioventing system is intended to remediate any existing vadose zone contamination. The bioventing design activities will include a soil-gas survey, soil sampling and analysis, and a soil-gas permeability test. The results of these activities will be used to field-design the full-scale bioventing system. Each activity is discussed below.

3.2.1 Soil-Gas Survey. A soil-gas survey will be conducted to determine what portion of the sludge drying beds is oxygen-limited and indicate the locations of the most contaminated soils. The survey also will give some indication of the microbial activity that is occurring in the sludge drying beds. A probe will be driven into the soil to various depths to analyze for oxygen, carbon dioxide, and TPH using field instruments.

3.2.2 Soil Sampling. Ten soil samples will be collected from each of the two easternmost sludge drying beds. The samples will be analyzed for PAHs and TPH. The results of this sampling will be used to establish a baseline for future sampling events. The next sampling event will be conducted after bioventing the drying beds for 6 months.

3.2.3 Permeability Testing. In order to determine the optimal spacing for the bioventing wells, a permeability test must be performed. The permeability test will be performed by extracting air from well MW2 and monitoring pressure changes in monitoring points MPD, MPE, and MPF. Results of the permeability test will be used to determine the soil gas permeability and the bioventing radius of influence.

The bioventing radius of influence is the lateral distance air can be moved physically. In practice, the radius of influence is the maximum distance from a vent well where pressure change can be measured. Usually, 0.1 in. of water is the cutoff pressure. Past experience indicates that when the test protocol is followed, the radius of influence is larger than the measured radius of influence thus making the pressure radius of influence a reasonable conservative method for estimating the true radius of influence.

In general, the soil permeability must be sufficiently high to allow movement of oxygen from the vent well in a reasonable time frame (1 to 10 days). If such a flowrate cannot be achieved, oxygen cannot be supplied at a rate to match its demand. If either the soil-gas permeability or the radius of influence is high (>0.01 darcy or radius of influence greater than the screened interval of the vent well), then this is a good indicator that bioventing is feasible at the site and that it is appropriate to proceed with a full-scale design. If either the soil-gas permeability or radius of influence is low (permeability <0.01 darcy or radius of influence less than the screened interval of the vent well), bioventing may not be feasible. In this situation, it is necessary to evaluate the cost-effectiveness of bioventing over other alternative technologies for site remediation. The cost of installing a bioventing system at a low-permeability site will be driven primarily by the need to install more vent wells, use a blower with a greater delivery pressure, or install horizontal wells.

Section 4.0 FULL-SCALE SYSTEM DESIGN

4.1 Bioslurping System. The full-scale bioslurping system designed for SWMU7 at NAVSTA Mayport consists of extraction wells, monitoring points, and associated treatment and disposal equipment. Two bioslurping extraction systems are recommended. One extraction system will be located north of Patrol Road behind Building 262; the other will be located approximately south of Patrol Road and just north of the Sludge Drying Bed Area.

The tanks and pumps for both extraction systems will be installed on a concrete pad. The major items of equipment on the pads are a manifold to link several extraction wells, an equalizing tank, a liquid ring pump, a heat exchanger, and a seal water reservoir. It is recommended that all equipment be explosion-proof, meeting the requirements for Class I, Division I, Groups C and D, because of the possibility that flammable gases or vapors may be present in the air in quantities sufficient to produce explosive or ignitible mixtures under normal operating conditions. The liquid ring pump should be insulated if it creates excessive noise and disturbance for the employees at Building 262.

The extraction equipment will generate both gas and liquid wastestreams. The treatment equipment for the resulting liquid discharge includes transfer pumps and an oil/water surge tank at each site location. This remedial design assumes that the discharged liquid (oil and water) will be pumped into the two existing 20,000-gallon double-walled storage tanks to be subsequently discharged to the base OWTP. The 20,000-gallon tanks currently are being used to store oil/water generated by the existing treatment system. They are fixed units with subsurface plumbing to the base OWTP.

The treatment equipment for the off-gas stream consists of a dehumidifier, two containers of vapor-phase-activated carbon placed in series, and an induced-draft blower. The condensate for the dehumidifier will be transported to the oil/water surge tank. The off-gas treatment equipment will be placed with the system located behind Building 262; more contamination is anticipated in that region, compared with the area south of Patrol Road. The off-gas from the system located south of Patrol Road will be pumped through subsurface pipes to the treatment system on the northern pad. A drawing of the extraction and treatment equipment is shown in Figure 13. A list of the process and treatment equipment is presented in Table 16. If after 1 month of monitoring off-gas the TPH levels are below the regulatory requirement of 15 lb/day, off-gas treatment should be discontinued.

Utility supply lines known to be in the zone of remediation include electrical, oily water, sanitary, and water (including fire suppression). These are illustrated in Figure 14. Depths below the ground surface are not known. The locations of these utilities were taken and adapted from the Naval Air Station (NAS) Jacksonville and NAVSTA Mayport Utility Mapping CD-Rom (Navy PWC Jacksonville, 1995). Figure 14 should not be used to determine the exact location of utilities. A survey must be performed to determine the proximity to existing utilities before drilling or trenching begins. The locations of new wells, manifolds, and process equipment should be displaced by the amount necessary to avoid interference with existing utilities.

4.1.1 Extraction Wells. A bioslurper well must allow for extraction of free product, groundwater, and soil gas from the subsurface; the creation of a pressure/vacuum gradient for enhanced fluid recovery; and increasing the subsurface oxygen levels as measured by in situ aeration testing. Based on the results of the pilot-scale bioslurper test, a 2-in.-diameter well provides sufficient soil-gas and liquid flow. The radius of influence was determined to be as great as 30 ft, and soil-gas oxygen concentrations equilibrated to ambient levels during operation of the pilot-scale bioslurper system.

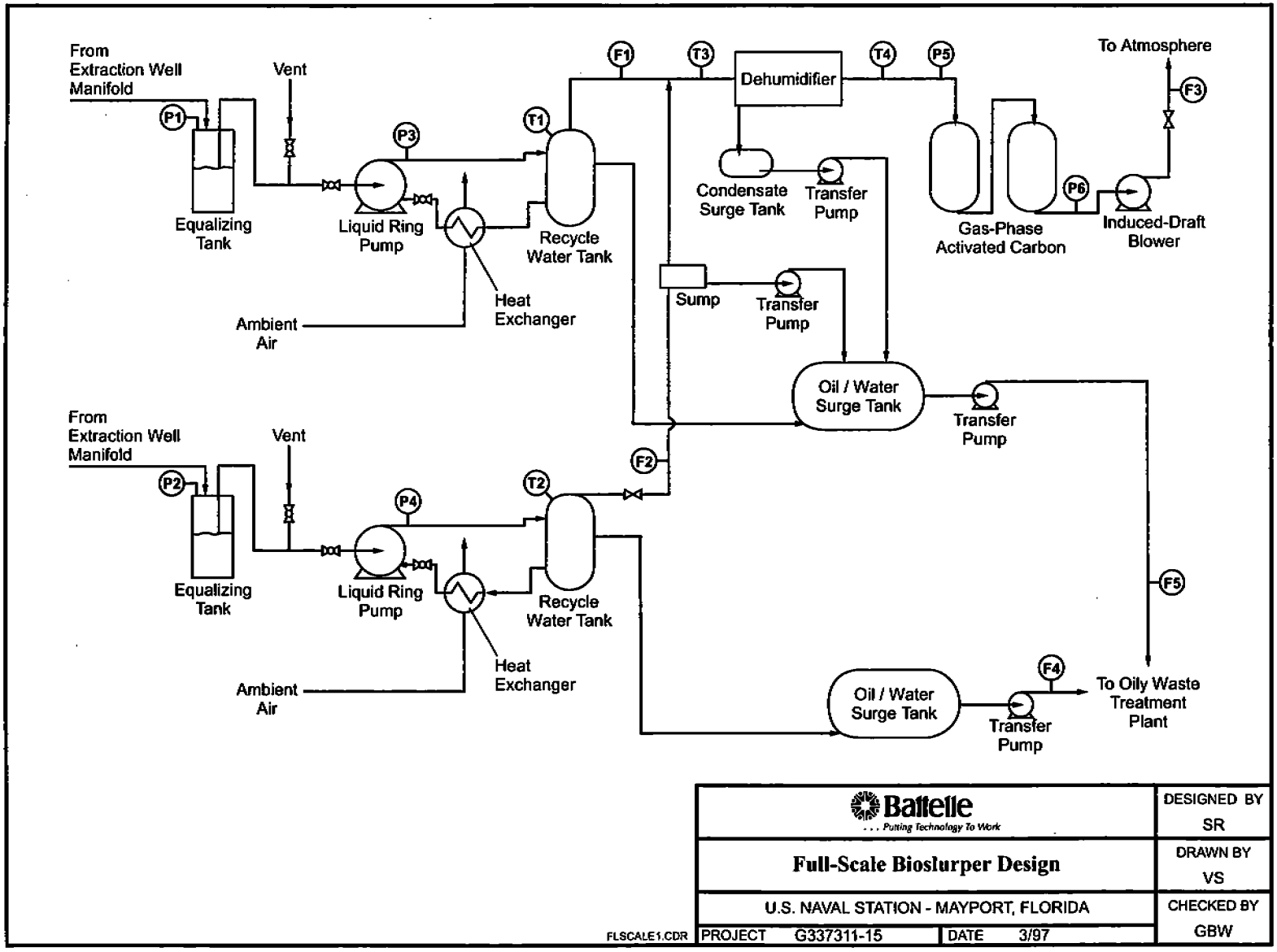


Figure 13. Full-Scale Bioslurper Design

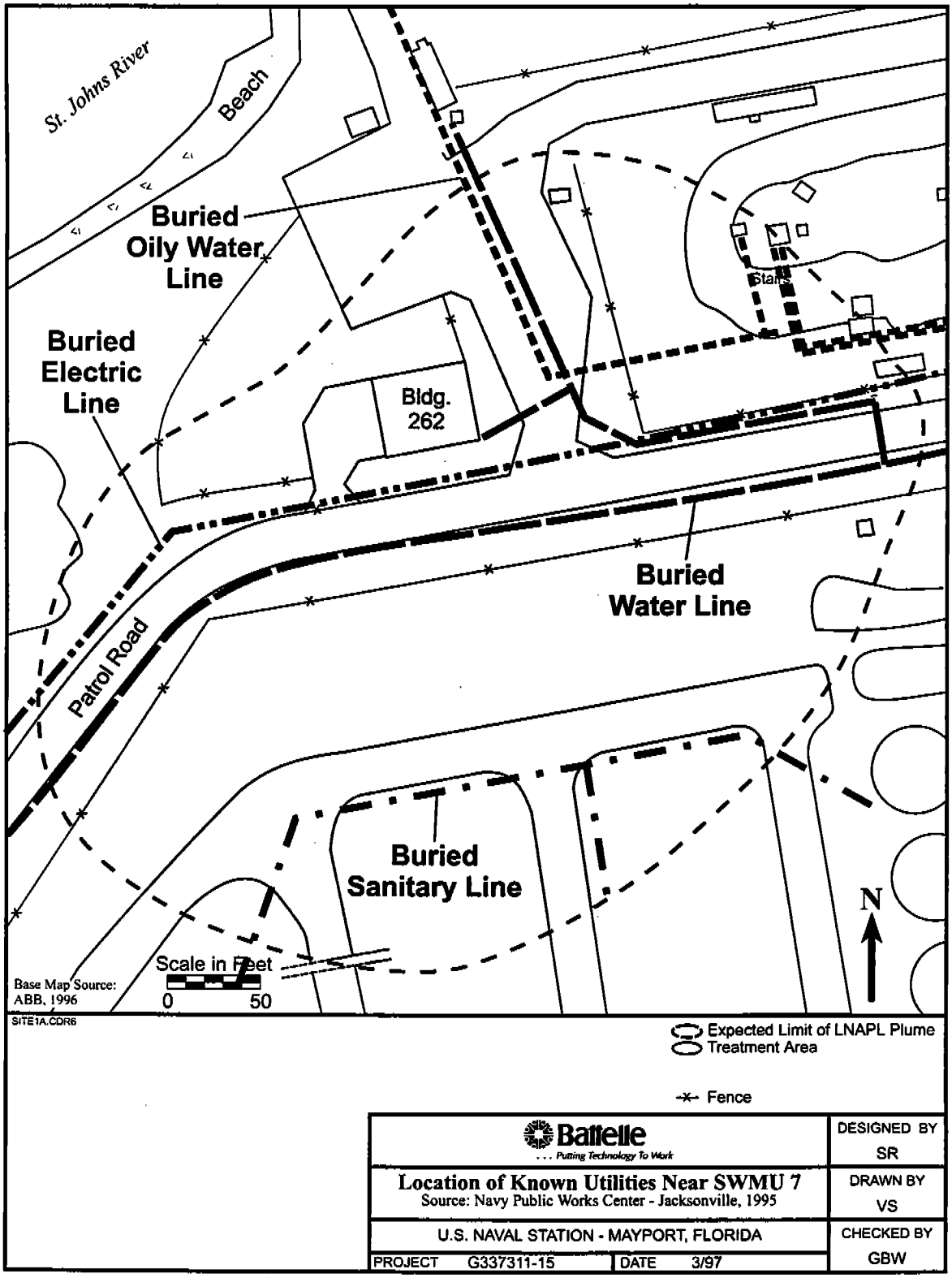


Figure 14. Location of Known Utilities Near SWMU 7

Table 16. Bioslurper Extraction and Treatment Equipment

Item	Quantity	Manufacturer/Distributor	Model Number
Equalizing tank	2	Columbus Steel Drum Co.	UN1A2
Liquid ring pumps	2	Atlantic Fluidics, Inc.	A300
Heat exchanger	2	Thermal Transfer Products	AA-100-11
Seal water tank	2	Atlantic Fluidics, Inc.	NA
Oil/water surge tank	2	McMaster-Carr	3696K77
Oil/water transfer pump (3/4-hp)	2	ARO	650709-C
Water transfer pump (1/3-hp)	2	ARO	650709-C
Dehumidifier	1	TEK Engineering Co., Inc.	NA
2,000-lb-capacity activated carbon canisters	2	Sher-Fran Corp.	SFV-2000
Induced-draft blower	1	Gast Manufacturing Corp.	R7100R-50
Condensate surge tank	1	McMaster-Carr	3764K22

A planimeter was used to approximate the cross-sectional area of the treatment zone. Based on these measurements, the treatment area is estimated to be 141,000 ft^2. Using a radius of influence of 30 ft with a triangular arrangement having a 17.6-ft overlap between the centers of radii of influence of any two wells, the total distance between any two wells will be 42.3 ft. Based on this radius of influence, the treatment area will require approximately 70 extraction wells, including 32 on the north side of patrol road, 30 on the south side (outside of the sludge drying beds), and 8 inside the sludge drying beds. Each well will treat an area of about 2,827 ft^2; (514 ft^2 of which will be overlapped/treated by an adjacent well). The full-scale design incorporates 11 of the existing wells/piezometers already installed within the area of the plume; 59 new wells will need to be installed. The recommended locations are shown in Figure 15. As a result of incorporating the existing wells into the extraction system, not all of the wells are spaced exactly 42.3 ft apart. In addition, it was not practical to design the system with wells placed in the Patrol Road subbase or the Building 262. For these reasons, it was necessary to offset some wells; therefore, some areas of the site will have slightly more or less overlap between overlap/treatment areas. A survey will be performed to determine the exact locations of underground utilities prior to installing the wells. A typical extraction well construction diagram is shown in Figure 16.

4.1.2 Soil-Gas Monitoring Points. Soil-gas monitoring points are used for pressure measurements and soil-gas sampling. The monitoring points are used to determine if nearby extraction wells are sufficiently aerating the soil. In addition, the monitoring points can be used to measure the change in the biodegradation rate over time. These parameters are determined by measuring the in situ soil-gas pressures and the oxygen, carbon dioxide, and TPH concentrations in the soil.

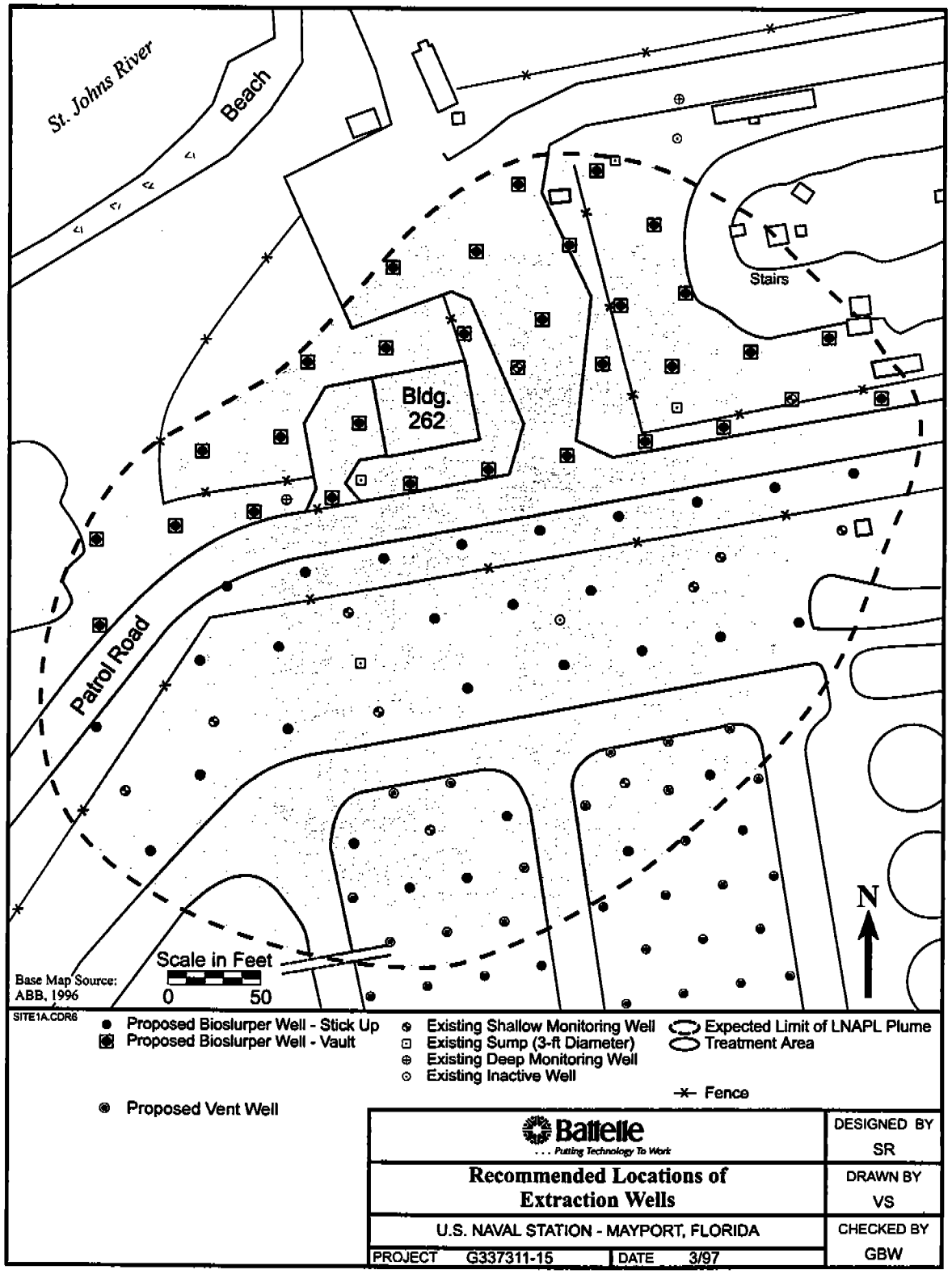


Figure 15. Recommended Locations of Extraction Wells

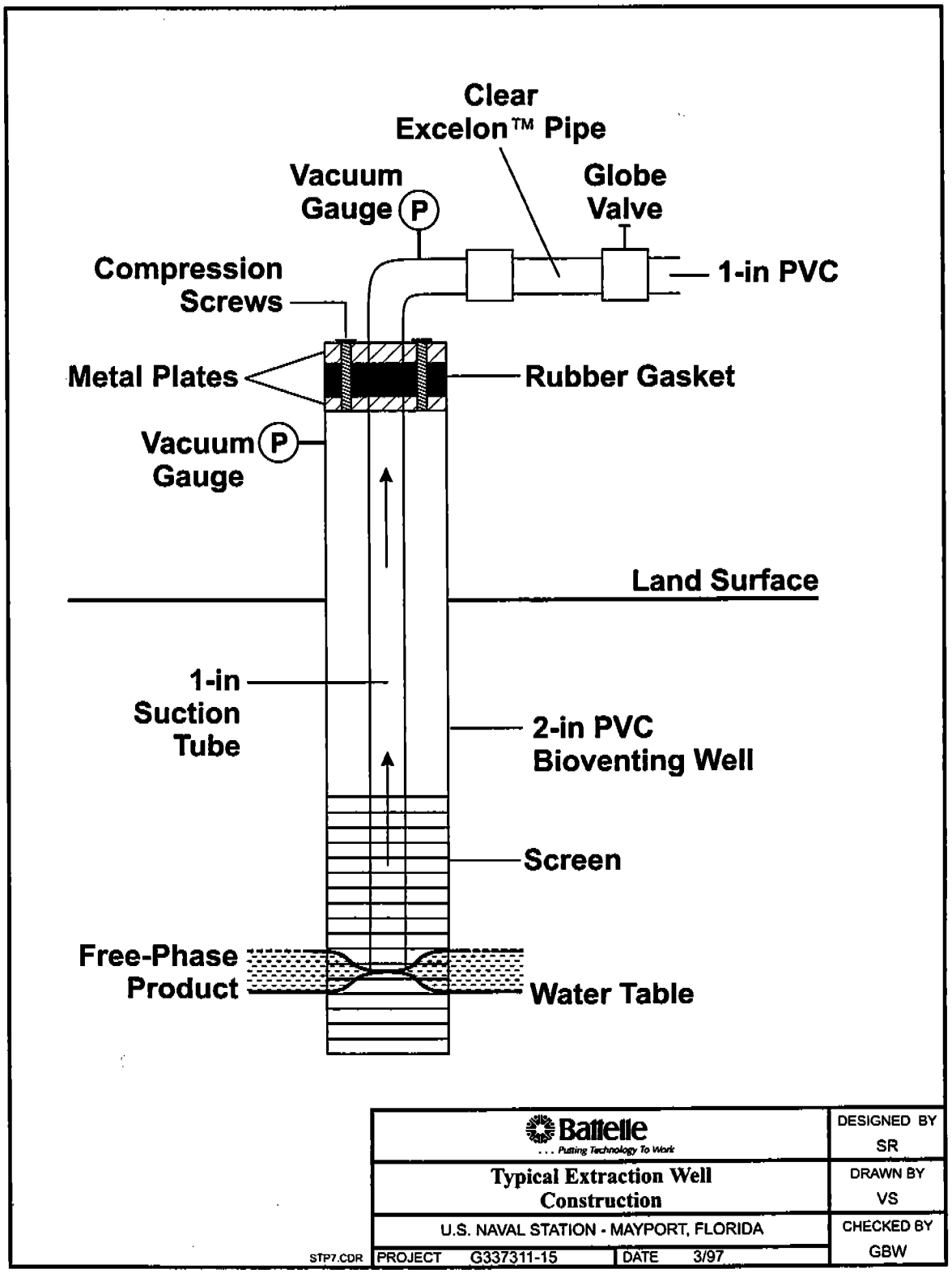


Figure 16. Typical Extraction Well Construction Diagram

Monitoring points typically are installed with screened intervals at three to six depths. However, at NAVSTA Mayport it is recommended that they be installed at only one to three depths because of the relatively shallow water table. Three monitoring wells were installed outside the Sludge Drying Bed Area during pilot-scale testing with points at depths of 4, 6, and 8.5 ft bgs. Three additional monitoring wells were installed inside the sludge drying beds with points at a single depth of approximately 3 ft bgs. However, water was found in the monitoring point at 8.5 ft bgs for the full-scale system.. Therefore, monitoring points inside the Sludge Drying Bed Area should be located at 3 ft bgs and monitoring points outside the drying beds should be at depths of 4, 6, and 8 ft bgs. The monitoring points should be positioned to allow monitoring of the in situ changes in soil-gas composition caused by the bioslurper system.

It is recommended that the majority of the monitoring points be positioned within the radius of influence of the bioslurper system and that two or three points be placed outside the zone of influence as background points. It is most efficient if the points are placed between a set of four wells and/or in highly contaminated soils within the free-product plume. It is recommended that a total of 57 monitoring points be installed in the treatment area, including the six points that were installed during pilot testing. Recommended locations are shown in Figure 17. A typical monitoring point construction diagram is shown in Figure 18.

4.1.3 Extraction Equipment

4.1.3.1 Manifold. A central manifold is used to connect the extraction wells to the process equipment. Two manifolds are required at SWMU7; each is dedicated to an extraction system. The manifold is designed to maximize the flow velocity of the fluids. It should be constructed of schedule 80 PVC pipe and should be placed between 24 to 30 in. bgs. The diameter of the manifold must be constructed larger as it nears the ring pump to accommodate the flow from all of the wells and to maintain the flow velocity. Based on the pilot-scale test, a 1-in.-diameter pipe is large enough to support flow from one well. In general, the remaining manifold piping was sized by taking the square root of the number of extraction wells it needed to support and rounding to the nearest pipe size. The layout of the manifold and associated pipe sizing are illustrated in Figure 19. A conceptual illustration of the recommended way to couple the manifold piping to the liquid ring pump for each extraction system is presented in Figure 20.

The manifold piping was located to avoid the utilities shown in Figure 14. With the exception of a buried water line near Patrol Road and a buried sanitary line in the sludge drying bed area, no utility lines are located in the treatment area on the south side of Patrol Road (Navy PWC Jacksonville, 1995). However, two utility lines cross through the site at various locations on the north side of Patrol Road. The 3-in.-diameter manifold pipe laid from the bioslurper trailer to the wells in the northeastern portion of the site will cross an oily water line and a water line. It will be necessary to locate this pipe either above or below the existing utilities. Other lines may cross or be in very close proximity to other utilities. Therefore, a survey must be performed to determine the proximity of the manifold lines to existing utilities before drilling or trenching begins.

It is recommended that butterfly valves be placed in line at various locations of the manifold. These valves are useful if it is desired to decrease or turn off the vacuum to a series of extraction wells. For instance, while optimizing system performance, it may be determined that greater product recovery and less water and vapor recovery is obtained by pulling from one group of extraction wells while letting another group re-equilibrate after extraction. Also, some areas of the site may be remediated faster than others. The valves to these areas could be closed, thereby minimizing the volume of extracted water that must be treated. It is recommended that the butterfly valves be placed at the same depth below ground

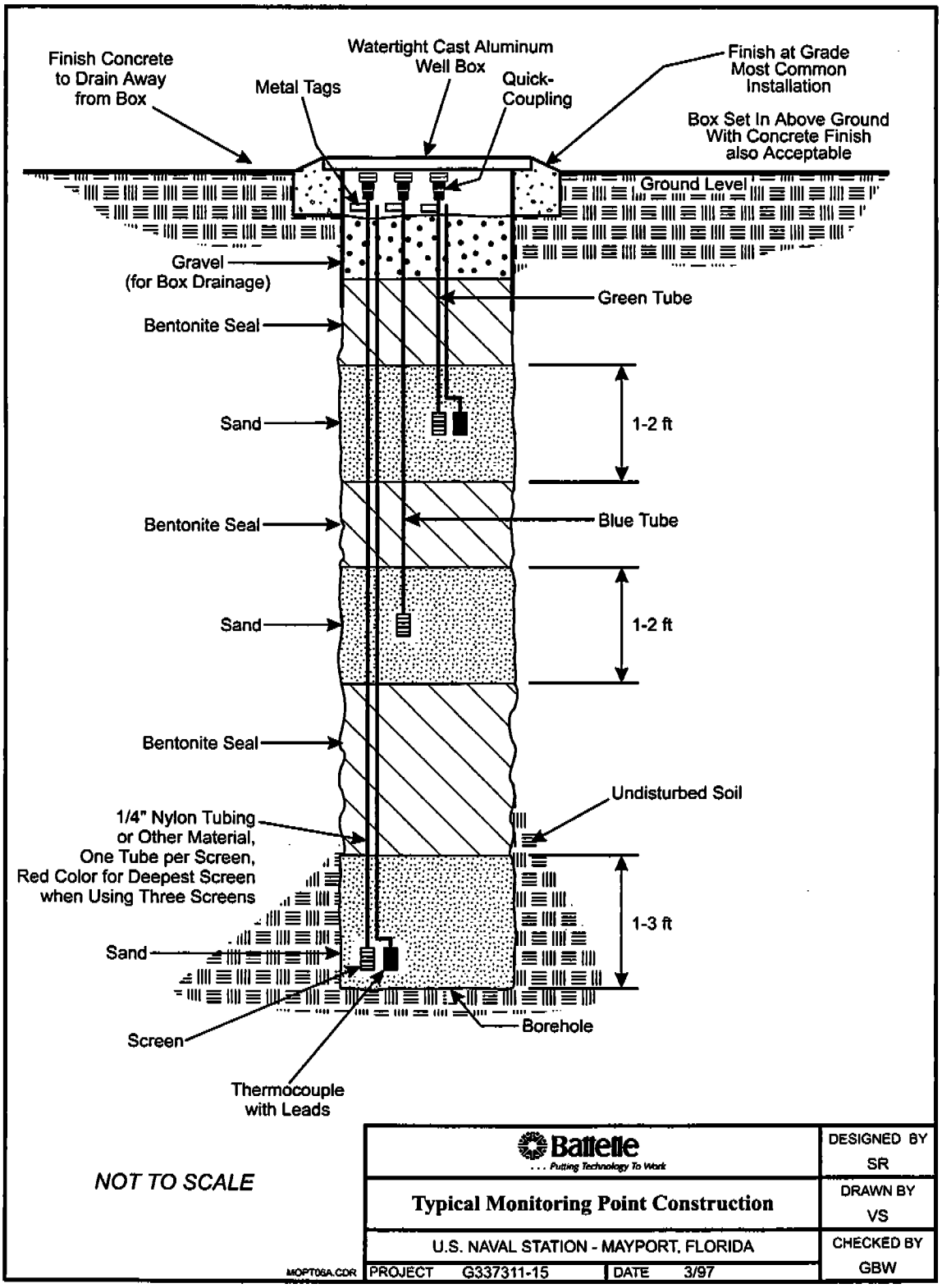
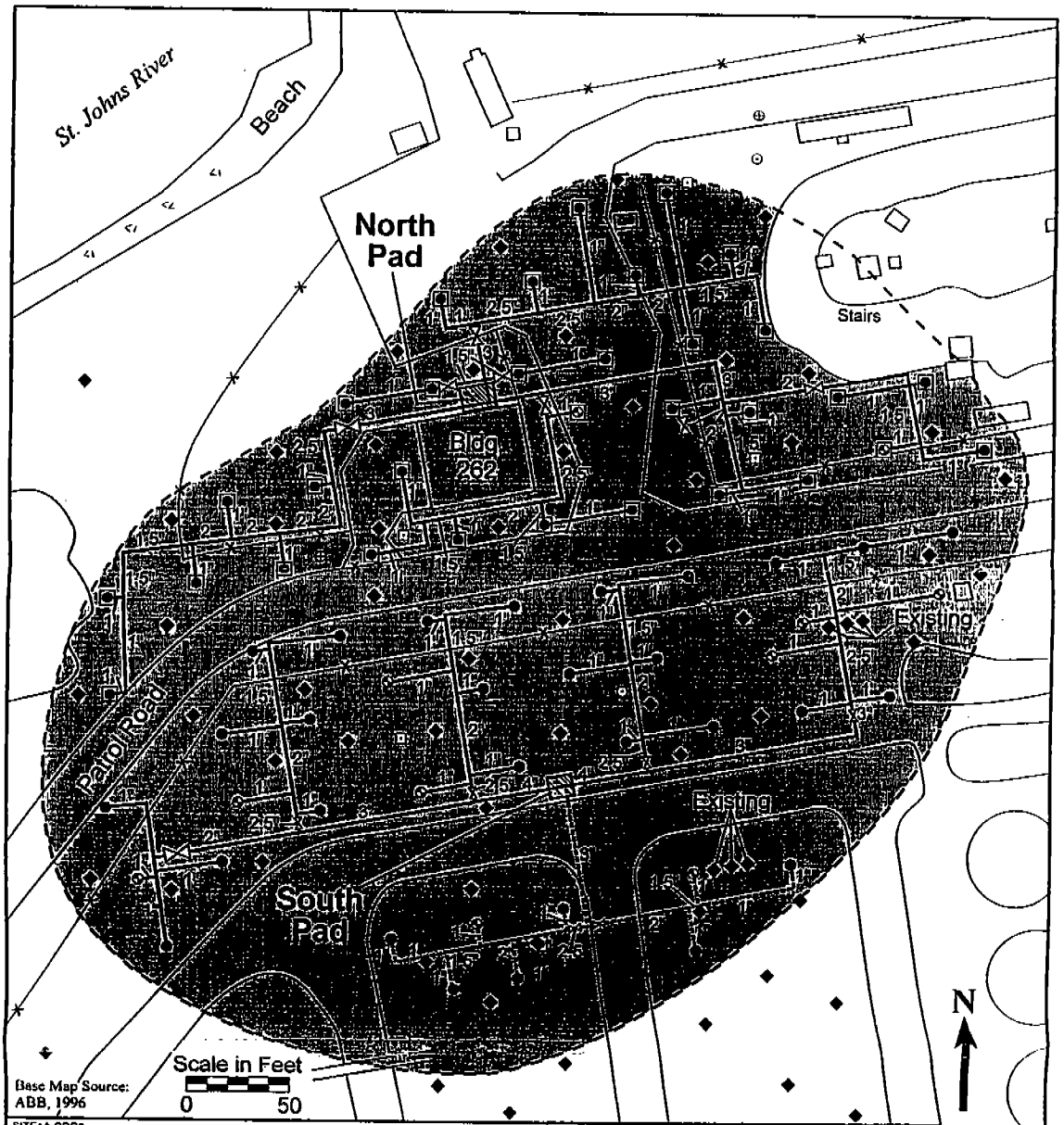


Figure 18. Typical Monitoring Point Construction Diagram



SITE1A.CDR6

- Proposed Bioslurper Well - Stick Up
- Proposed Bioslurper Well - Vault
- Proposed Monitoring Point
- 2" Bioslurper System Piping
- 2" Bioslurper System Piping (install only if LNAPL present)
- Existing Shallow Monitoring Well
- Existing Sump (3-ft Diameter)
- Existing Deep Monitoring Well
- Existing Inactive Well
- Expected Limit of LNAPL Plume
- Treatment Area
- Equipment Pad
- Fence

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Conceptual Manifold Layout

U.S. NAVAL STATION - MAYPORT, FLORIDA

PROJECT G337311-14 | DATE 10/96

Designed by
Stephen H. Rosansky
Project Engineer
Enviromental Restoration Department
Signed

Drawn by
Victor J. Saylor
Lead Technical Illustrator
Enviromental Restoration Department
Signed

Checked by
Shelley B. Gisclar, P.E.
President
Geotechnical Professional Associates, Inc.
Signed

Figure 19. Conceptual Manifold Layout

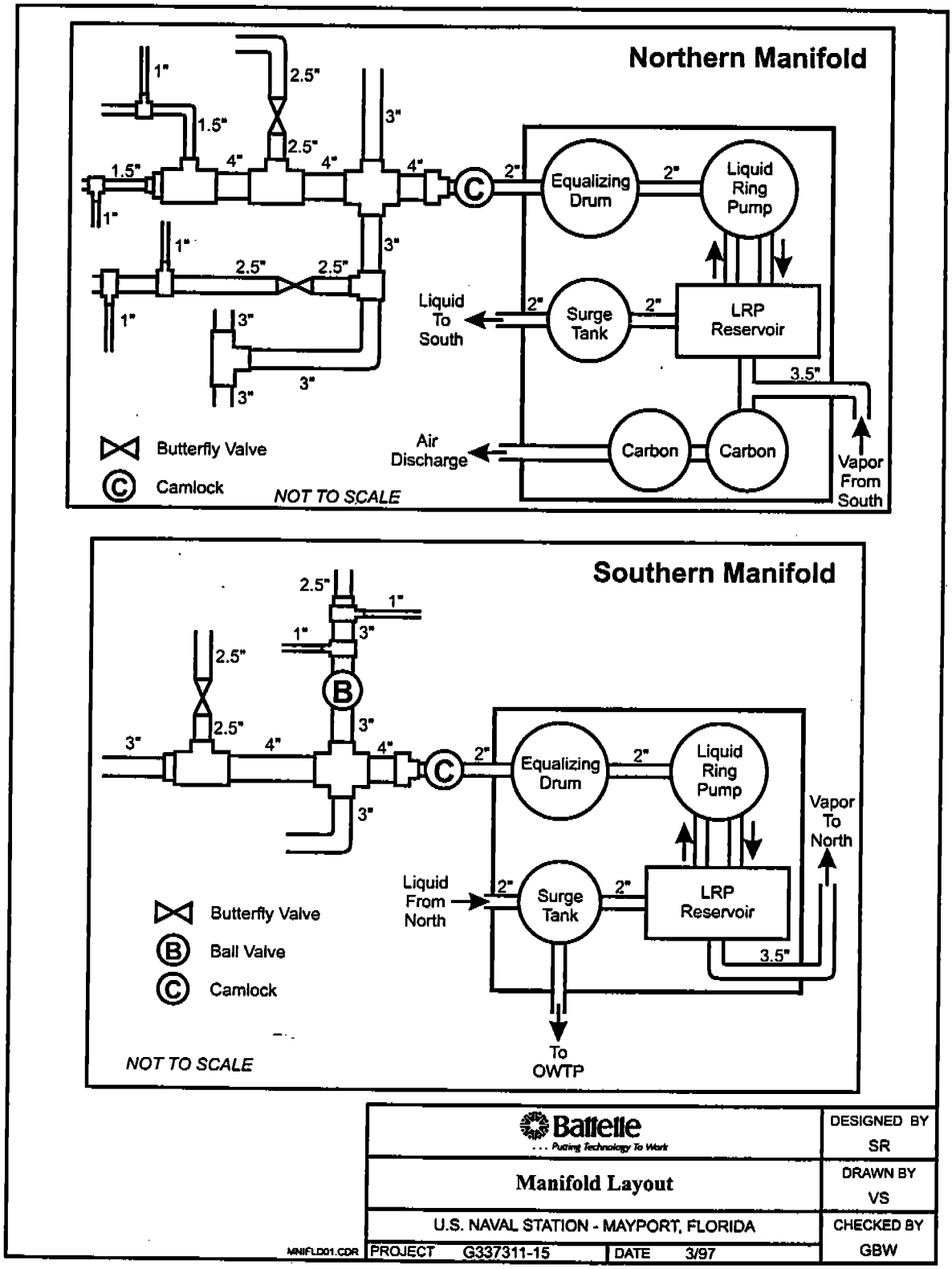

Figure 20. Manifold Layout

surface as the manifold piping. Therefore, vaults will be required to contain the valves. A 24-in.-wide by 24-in.-long by 24- to 30-in.-deep vault should be adequate. The recommended locations of the valves are shown in Figure 19. The diameter of each valve should correspond to the size of the manifold pipe that will be plumbed to it. Six valves are recommended for the northern manifold and five are recommended for the southern manifold.

The manifold design (Figure 19) assumes that all 70 extraction wells will be plumbed into the extraction manifold and will be utilized. However, some of the wells (and surrounding soils) likely will not contain free product; therefore, they should not be incorporated into the manifold. The wells that do contain free product will be identified prior to installing the extraction manifold. A 1- to 2-hour vacuum-enhanced pump test will be performed at each well to identify the presence of free product. If free product is not present or cannot be extracted from a well, the well will not be installed. The construction and size of the extraction manifold will be designed based on the number of extraction wells that actually will be installed.

4.1.3.2 Equalizing Tank. To minimize the possibility of subjecting the liquid ring pump to a large slug of water, an equalizing tank is recommended. This tank should consist of a heavy-gauge, removable-lid 55-gal drum, with a minimum of 2-in.-diameter openings for the connection to the manifold and liquid ring pump. The drum must withstand the maximum vacuum that can be created by the liquid ring pump (about 28 in. Hg) without imploding. The lid must have two 2-in.-diameter holes to accommodate the inlet and outlet streams. A ¾-in.-diameter hole may be used for a vacuum gauge. A 2-in.-diameter tank bulkhead fitting that is threaded on either end must be placed in the lid for the outlet plumbing. A 2-in.-diameter by 18-in.-long piece of schedule 40 PVC pipe is threaded into the side of the fitting facing the inside of the drum. The openings on the outside of the drum can be fitted with standard 2-in.-diameter camlock fittings.

4.1.3.3 Liquid Ring Pump. A liquid ring pump is recommended for bioslurping because of its ability to accept a wide range of proportions of liquid and gas inflow, while maintaining a relatively high vacuum in the range of 20 to 28 in. of mercury. Such pumps are available in a range of airflow capacities with explosion-proof motors and wiring from Atlantic Fluidics, Inc. (South Norwalk, CT). Based on the number of existing and recommended wells, two 20-hp liquid ring pumps are recommended. One for the installation north of Patrol Road near Building 262 and one for the installation south of Patrol Road adjacent to SWMU7.

An integral seal water reservoir is recommended for the liquid ring pump to ensure reliable sealing and thus maintain fluid flow. This reservoir should be equipped with both high-level and low-level float switches to shut down the pump-motor should the level of liquid reach off-normal extremes. A reservoir having these features is included with the Atlantic Fluidics liquid ring pump, with both pump and reservoir mounted on a steel base plate. The fluid streams leaving this reservoir are liquid and gas. The gas stream contaminated with petroleum vapors exits through the top of the reservoir. The liquid stream, consisting of oil/water, gravity flows out of the reservoir through a side port.

A heat exchanger is recommended for cooling the seal water returning to the pump and for disspating energy applied to the fluid stream so that the heat does not damage equipment components, including wiring. An air-cooled heat exchanger that has been used successfully in a bioslurper installation can be obtained from Thermal Transfer Products (Racine, WI). The manufacturer recommends a model AA-100-11 for use with the 20-hp ring pump to cool the ring pump recycle water from 150°F to about 100°F. These heat exchangers can be equipped with explosion-proof motors to meet the requirements of a

Class I, Division I, Group C and D environment. Manufacturers' data for both the liquid ring pump and heat exchanger are provided in Appendix F.

4.1.4 Liquid Process Equipment

4.1.4.1 Transfer Pumps. Positive-displacement pumps driven with explosion-proof motors or compressed air are recommended to move liquids between the dehumidifier and the oil/water surge tank and for emptying the oil/water surge tank, because a suction lift capability has been found necessary in most installations. The suction lift of 10 in. Hg should be adequate to provide a 10-gpm flowrate at a backpressure of 50-ft head of water. Two ¾-hp pumps are recommended for transferring oil/water from the oil/water surge tanks to the 20,000-gal temporary storage facility; ⅓-hp pumps are recommended for transferring the dehumidifier condensate and the sump water to the oil/water surge tank located on the northern pad. Either a pneumatic ARO Model 650709-C (preferred) or the electric Fill-Rite Model 700B with optional nickel-plated internal wetted parts is recommended. So that these pumps are not run dry, it is recommended that they be controlled from liquid level switches, turning on the pumps when the liquid rises to a high-level switch, and turning them off when liquid falls below a low-level switch. It is intended that the air compressor currently being used to power the existing recovery system be used to power the ARO pneumatic pumps. Explosion-proof electrical components and wiring are recommended for the electric pumps.

4.1.4.2 Surge Tanks. A double-wall tank for holding the oil and water recovered from the extraction wells is recommended. This tank should include features that will disclose leakage in the inner tank without the chance of an environmentally hazardous spill. A capacity of 480 gal is recommended, such as the tank available from McMaster-Carr, Part No. 3696K77. A Madison Company M5600 switch distributed by W. W. Grainger is recommended for the high-level float switch. A horizontal polyethylene tank is recommended to store and transfer the condensate generated by the dehumidifier. The recommended tank is available from McMaster-Carr, Part No. 3764K22.

4.1.5 Gaseous Treatment Equipment.

4.1.5.1 Dehumidifier. The purpose of the dehumidifier is to remove excess moisture from the gaseous stream so that the activated carbon is not rendered ineffective by a liquid coating. Preferably, the air entering the activated carbon containers should be between 40% and 50% relative humidity. Partial reheating of the air stream is a preferred feature of this dehumidifier for energy conservation. The recommended equipment is offered by TEK Engineering Co., Inc. (Atlanta, GA). TEK Engineering has a 6-hp Refrigeration Reheat dehumidifier with dry precooler. Off-gas entering the unit at 270 cfm and 100°F will leave the unit at 45% humidity and 80°F. Design calculations performed by TEK are included in Appendix F along with their equipment literature.

4.1.5.2 Vapor-Phase Activated Carbon. It is recommended that 2 containers of vapor-phase GAC be placed in a series configuration for treatment of the bioslurper off-gas. To allow operation for a significant time period, 2,000-lb containers are recommended, such as those available from Sher-Fran Corporation (Plantsville, CT) SFV-2000. The adsorber is constructed from carbon steel with epoxy internal coatings and PVC internals. The manufacturer's literature is presented in Appendix F. If the off-gas production remains below 15 lb per day during the first month of full-scale operation, the Florida Department of Environmental Protection will allow discharge directly to the atmosphere without treatment with activated carbon.

4.1.5.3 Induced-Draft Blower. The induced-draft blower is necessary to motivate the gaseous stream against the pressure drop in the carbon containers and the dehumidifier. This blower is usually located downstream of the gaseous stream so that the dehumidifier need not be constructed to withstand the high internal pressure equal to the pressure drop across the carbon containers. Although this blower should be conveying gas free of petroleum vapors, it still should be of nonsparking construction and driven with an explosion-proof electric motor. Gast Manufacturing Corporation (Benton Harbor, MI) offers high-pressure blowers suitable for this application. The blower should be equipped with an internal temperature switch to open the circuit to the motor starter in the event of elevated temperatures. A 10-hp blower should be adequate.

4.1.6 Annunciator Panel. An annunciator panel is recommended to diagnose any off-normal condition that causes the liquid ring pump to shut down. The panel should allow the operator to quickly determine the cause of a system shutdown. The panel should include indicating lights to determine a shutdown caused by loss of power, motor overcurrent, motor overtemperature, low liquid level in the seal water reservoir, high liquid level in the seal water reservoir, high liquid level in the oil/water surge tank, or high liquid level in the 20,000-gallon temporary storage tanks. A timer also may be included to track the total hours of system operation.

4.1.7 Discussion of Equipment Layout. The conceptual layout of the extraction and treatment equipment components for the installation adjacent to Building 262 is shown in Figure 21. Criteria leading to this arrangement choice include minimization of piping runs, access to service points on equipment components, and provision for gravity drainage of liquid lines, while minimizing the land area of the concrete pad recommended for mounting the equipment. The system should rest on a concrete pad 17 ft long by 12 ft wide. The pad will contain an equalizing drum, a liquid ring pump and heat exchanger, oil/water surge tank, and the vapor treatment system.

The conceptual layout of the extraction equipment components for the installation adjacent to SWMU7 is shown in Figure 22. This pad should be 11 ft long by 10 ft wide. It is recommended that a vapor treatment system not be included on this pad. The off-gas stream generated by this system may be pumped under Patrol Road from the liquid pump reservoir to the gas treatment portion of the installation adjacent to Building 262. This will reduce capital cost by eliminating a second dehumidifier, two additional carbon canisters, and a second induced-draft blower. The off-gas transfer piping should be constructed out of 3.5-inch-diameter schedule 80 PVC. Preferably, the pipe should be pitched with the low end nearest to Building 262, so that condensate in the gaseous stream will collect north of the road. It will be necessary to pump out the condensate from the pipe carrying the gaseous stream, so a sump with a 1/3 hp transfer pump and float switches is recommended (ARO 650709-C). The sump could be made by excavating the soil beneath the low point in the piping and installing a tee and short length of piping (in a vertical axis) and cap below this tee to form the sump. The continuing gaseous stream should be connected to another tee above the first tee. The uppermost run connection of this second tee should be plugged to allow for installation of float switches and the suction tube of the transfer pump. The transfer pump should be located adjacent to this sump. The discharge plumbing is illustrated in Figure 23.

This design assumes that the oil/water discharge from the surge tank on each pad must be transferred to the 20,000-gallon storage tank facility and subsequently discharged to the base OWTP. It is recommended that the surge tank used with the system located adjacent to Building 262 be plumbed subsurface beneath Patrol Road using a PVC line. Aboveground galvanized plumbing would be sufficient for plumbing the discharge from the surge tank located near SWMU7 because of its near proximity to the pad housing the 20,000-gallon holding tanks. The discharge plumbing is illustrated in Figure 22.

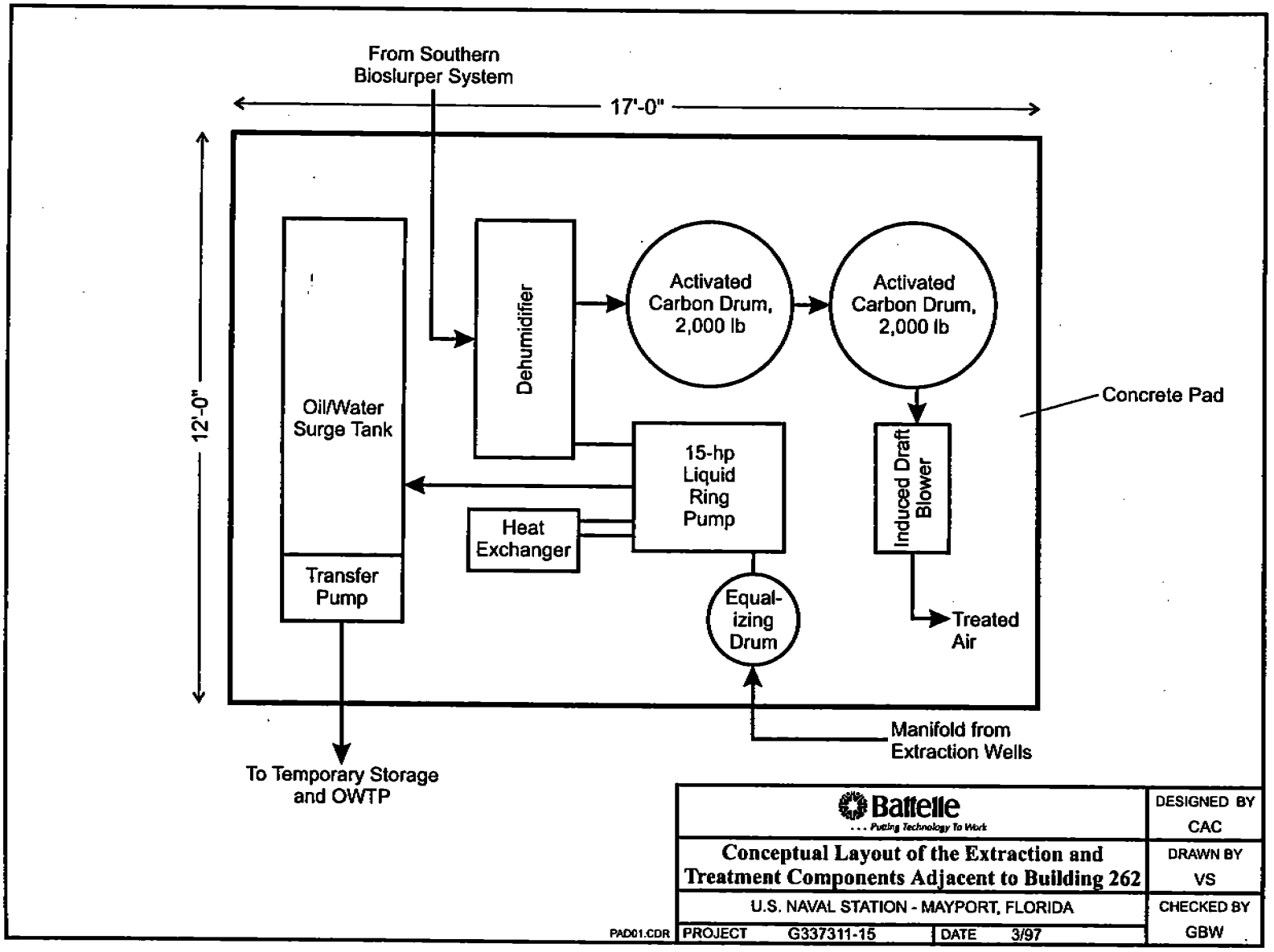

Figure 21. Conceptual Layout of the Extraction and Treatment Components Adjacent to Building 262

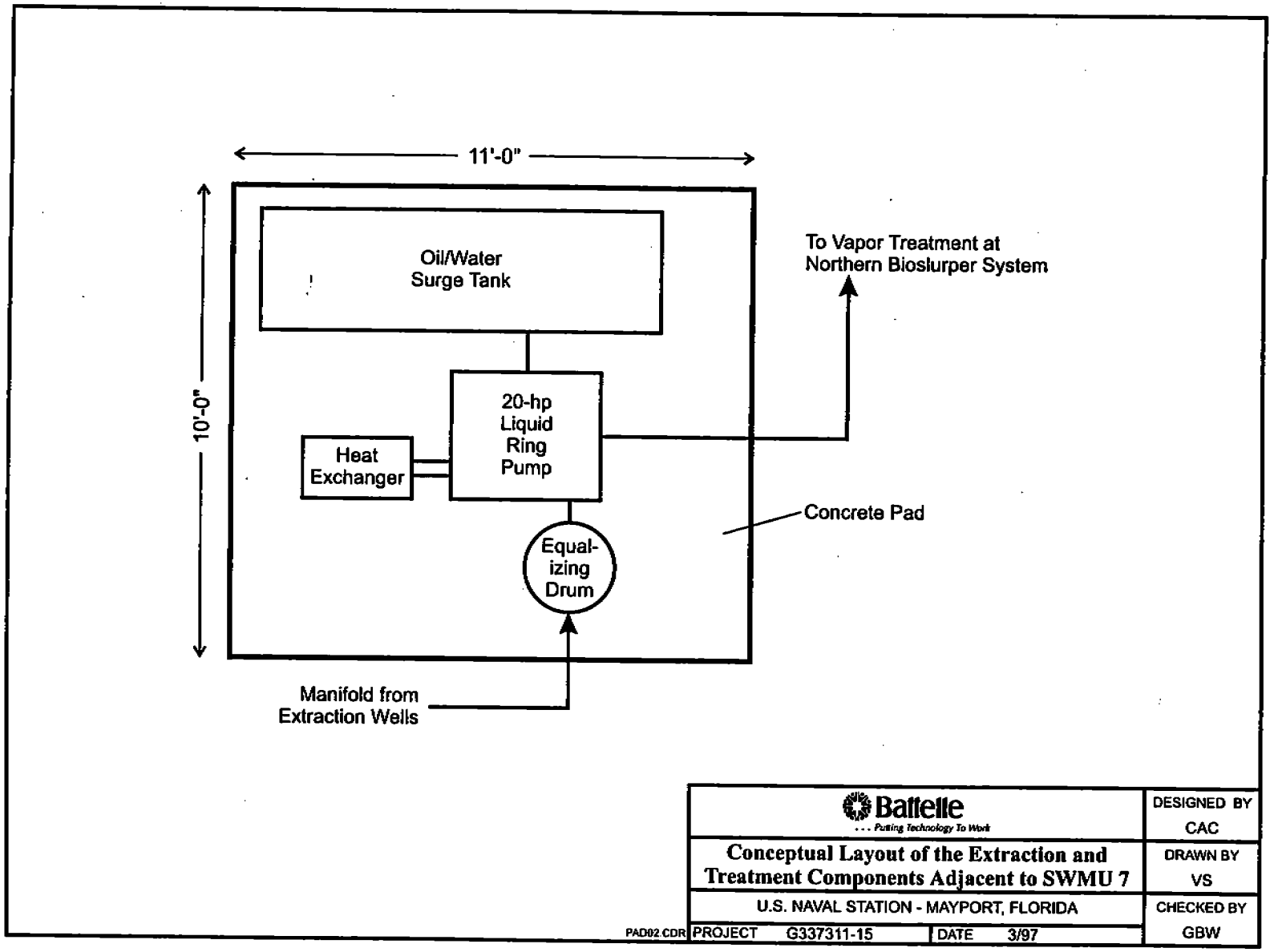

Figure 22. Conceptual Layout of the Extraction and Treatment Components Adjacent to SWMU 7

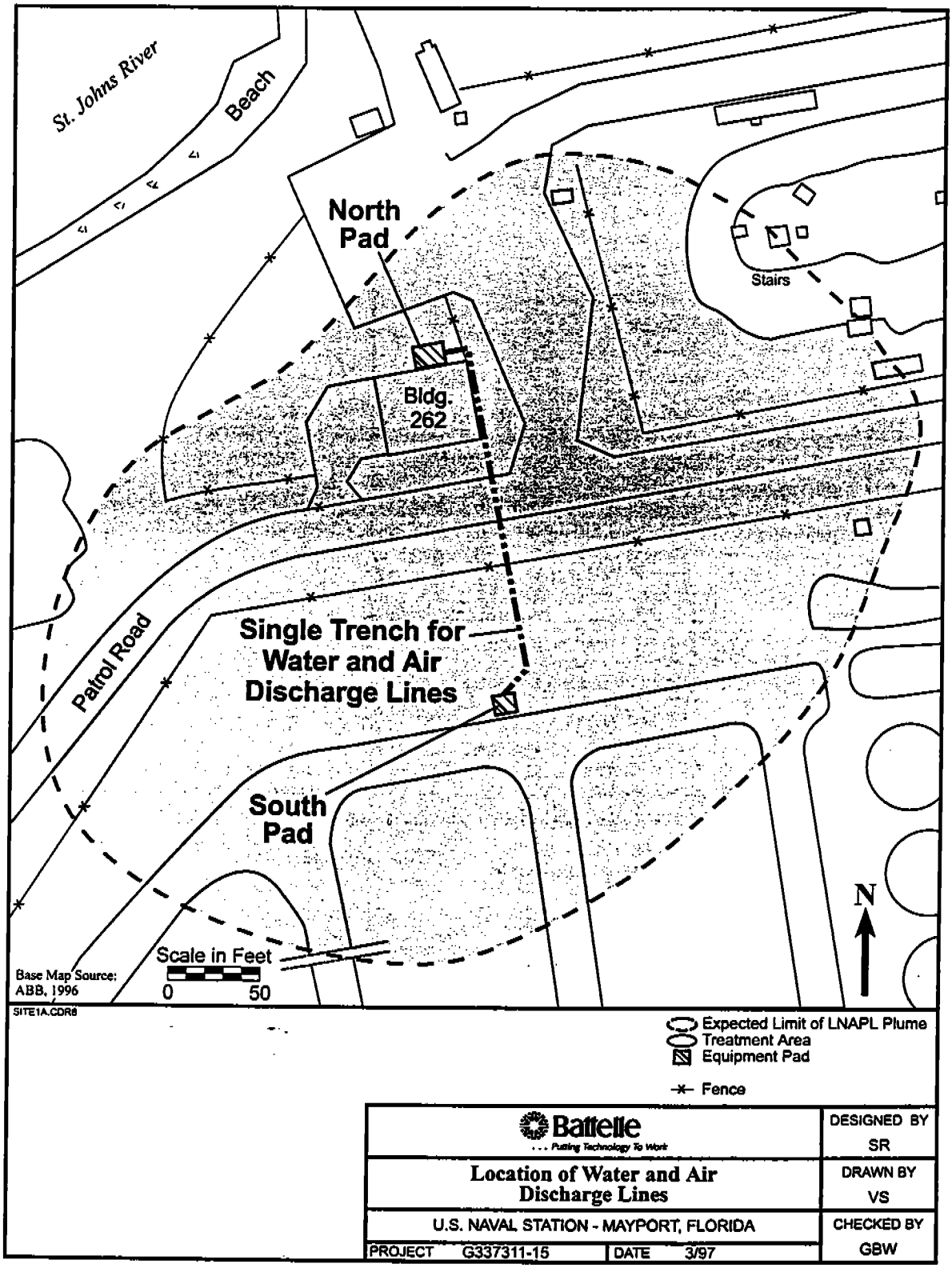

Figure 23. Location of Water and Air Discharge Lines

The relative heights of each piece of equipment with respect to one another must be considered to ensure that the bioslurper system operates properly. For instance, it is necessary to gravity-drain fluids from the liquid ring pump seal water reservoir and the oil/water storage tank. The liquid stream from the seal water tank must enter into the bottom of the oil/water surge tank to ensure that the soil-gas vapor inside the seal water tank flows out of the stack and does not enter the surge tank. Therefore, the outlet of the seal water tank must be placed above the highest level at which fluids will be contained in the surge tank. If the recommended surge tank is used (Table 16), having a height of 36 inches, and fluids are allowed to fill to 30 inches from the top, then the outlet of the seal water tank must be raised at least 30 inches off the concrete pad. The heat exchanger coils also must be slightly beneath the seal water reservoir so that the coils will fill with water when the seal water tank is primed. If air is present in the coils, the ring pump will not be able to recirculate the water through the heat exchanger from the seal water tank. Gravity drainage also is necessary from the dehumidifier to the condensate surge tank.

4.1.8 Utility Requirements. The electrical power requirements that will be needed to operate the full-scale bioslurper system are shown in Table 17. A water supply will be required to prime the equalizing tank, heat exchanger, and oil/water separator. It is estimated that 30 gallons will be required for each reservoir. Water will also be needed to periodically flush/clean system components.

Table 17. Electrical Requirements to Operate a Full-Scale Bioslurper System

Equipment	Phases	Voltage (V)	Amperage (amps)	Distribution Circuit Required
North Pad (near Bldg 262)				
20-hp Liquid Ring Pump	3	230/460	52/26	150/70
Heat Exchanger	3	230/460	1.3/0.65	15
¾-hp Transfer Pump	1	120	13.8	40
⅓-hp Transfer Pump	1	120	7.2	20
⅓-hp Transfer Pump	1	120	7.2	20
Dehumidifier (6-hp compressor, 1-hp pump, and two ½-hp fans)	3	230/460	25.6/12.8	70/30
10-hp Blower	3	230/460	24/12	70/30
Instrumentation	1	120	NA	20
South Pad (near SWMU7)				
20-hp Liquid Ring Pump	3	230/460	52/26	150/70
Heat Exchanger	3	230/460	1.3/0.65	15
¾-hp Transfer Pump	1	120	13.8	40
Instrumentation	1	120	NA	20

NA - Not available. Amperage dependent on the various meters and instrumentation that are used simultaneously. A circuit should be dedicated for this use only.

4.2 Full-Scale Bioventing System Design. A conceptual design for a bioventing system to be installed inside the sludge drying bed area has been developed for cost estimating purposes. Bioventing will be implemented if no free product exists in the sludge drying beds. For conceptual design purposes, it is assumed that no free-product exists in the beds. This design is believed to be a conservation design. It is based on the sludge drying bed investigation activities performed during bioslurper pilot testing (Section 2.11). This design does not incorporate site-specific data generated from bioventing pilot-scale tests. The bioventing testing described in Section 3.2 will be performed prior to installing the full-scale system. Assumptions and preliminary calculations associated with the conceptual design of the full-scale bioventing system are presented in this section.

4.2.1 Soil Aeration. It is assumed that the bioventing system will operate in an air injection mode due to the absence of nearby structures and the lower operating costs. Reduced operating costs result from not treating the off-gas that is generated when operating in an extraction mode. The air injection flowrate must be calculated for design purposes. The flowrate required to operate the bioventing system is dependent on the oxygen demand of the indigenous microorganisms. Oxygen demand is determined from maximum oxygen utilization rates measured during an in situ respiration test. Equation 1 is used to estimate the required air flowrate:

$$Q = \frac{k_o V \theta_a}{(20.9\% - 5\%) \times 60 \frac{\text{min}}{hr}} \tag{1}$$

where:
Q = flowrate (ft^3/min)
k_o = oxygen utilization rate (%/hr)
V = volume of contaminated soil (ft^3)
θ_a = gas-filled porosity (fraction)

The oxygen utilization rate, volume of contaminated soil, and gas-filled porosity have not been determined inside the sludge drying beds; therefore, space values have been approximated based on both past experience and what was learned about the site from the bioslurping pilot test. The oxygen utilization rates obtained during the bioslurping pilot test ranged from 0.170 to 0.215%/hr. A rate of 0.20%/hr was chosen as a reasonable approximation. The volume of contaminated soil was estimated by multiplying the sludge drying bed surface area times the depth to the groundwater (approximately 4 feet). The gas-filled porosity was estimated at 0.25 based on previous experience. Using these assumptions, the required flowrate, Q, was calculated to be 8.4 cfm. Table 18 summarizes the assumptions and resulting flowrate.

Table 18. Estimated Values for Determining Flowrate

Parameter	Value
k_o = oxygen utilization rate (%/hr)	0.20
V = volume of contaminated soil (ft^3)	160,000
θ_a = gas-filled porosity (fraction)	0.25
Q = flowrate (ft^3/min)	8.4

4.2.2 Well Placement. An estimate was made for the radius of influence to determine the number of vent wells required and the appropriate spacing between the wells. During the bioslurping pilot test performed outside the sludge drying bed area, a radius of influence of 30 feet was achieved at an extraction pressure of 20 inches of H_2O. The radius of influence in the sludge drying beds will be less than that observed outside of the beds due to the decreased depth to the groundwater table. In addition, based on the lithology data collected during the installation of piezometers MW1 and MW2, air could channel through the soil, thereby further limiting the radius of influence. If necessary, the radius of influence may be increased by placing an impermeable plastic liner on top of the soil surrounding the vent wells. For this design, it is assumed that the sludge drying bed area will have a radius of influence of 25 feet. The resulting area of influence of each vent well will be about 1,963 ft^2. A more representative radius of influence will be determined by performing a permeability test in the drying beds prior to installing the full-scale bioventing system (Section 3.2.3).

The wells will be installed in a formation similar to the one shown in Figure 12. Using a radius of influence of 25 feet, the wells would be spaced approximately 35.4 feet apart. The layout of the vent wells for the conceptual bioventing system is shown in Figure 24. The circles surrounding each vent well represent the assumed 25-foot radius of influence.

Based on the assumed 25-foot radius of influence and a contaminated area of 40,000 ft^2, 48 vent wells, will be required to adequately aerate the two easternmost sludge drying bed areas. Included in the 48 vent wells are 2 existing monitoring wells (MW1 and MW2) and 6 proposed bioslurper wells. This conceptual design assumes free product is not present in SWMU 7 and the proposed bioslurper wells installed in this area are converted to bioventing wells. To effectively monitor this conceptual bioventing process, 22 soil-gas monitoring points will be required, including the 3 existing monitoring points (MPA, MPB, & MPC). Because of the shallow groundwater table, each monitoring point will be screened at only one depth (3.0 to 3.5 ft bgs). A conceptual drawing showing the placement of the vent wells and monitoring points is presented in Figure 25.

4.2.3 Equipment. A blower is the only piece of equipment that is required for a bioventing system operating in an injection mode. Using the air injection flowrate of 8.4 cfm (Section 4.2.1) and 48 vent wells (Section 4.2.2), one 2.0-hp regenerative blower will effectively aerate both of the easternmost sludge drying bed areas. Gast manufactures a single-phase 2.0-hp regenerative blower that can deliver a maximum of 100 cfm of air at 50 inches of H_2O. This size blower will service all 48 wells. The manufacturer's literature for a 2.0-hp Gast regenerative blower is presented in Appendix F.

4.2.4 Injection Manifold. There is no traffic (vehicular or pedestrian) inside the sludge drying bed area; therefore, the manifold piping that connects the blower to the vent wells will be placed aboveground. The conceptual blower location and piping layout design is illustrated in Figure 26. Approximately 1,500 feet of 1-inch schedule 40 PVC pipe will be required to construct the injection manifold.

4.2.5 Utility Requirements. Electric service is the only utility required to operate the bioventing system. The electrical requirements for the bioventing system include a single-phase, 120/240-volt, 70/30-amp distribution circuit to operate the 2.0-hp blower and a single-phase, 120-volt, 20-amp distribution circuit to operate analytical instruments, lights, and hand-held power tools.

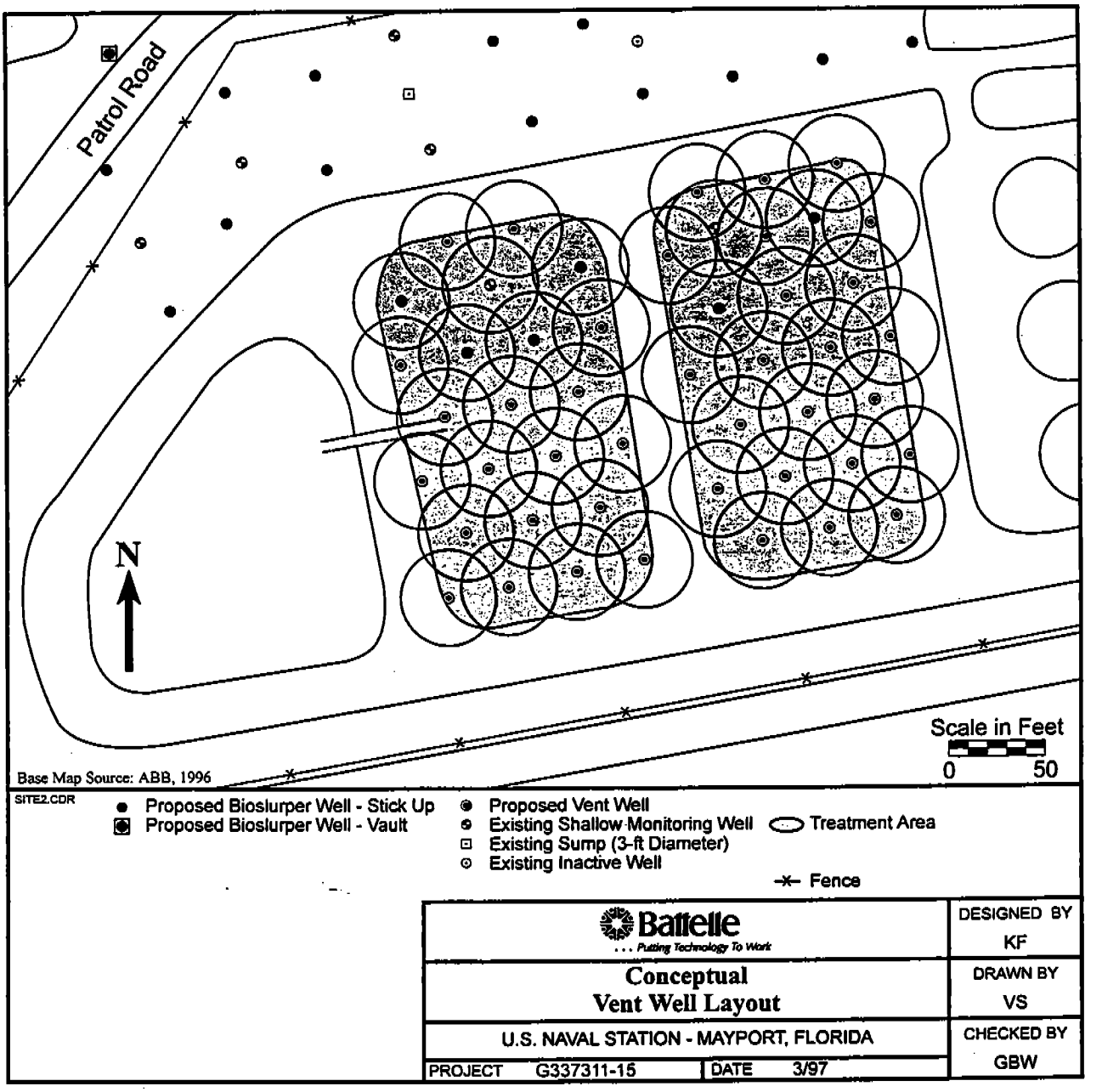

Figure 24. Conceptual Vent Well Layout

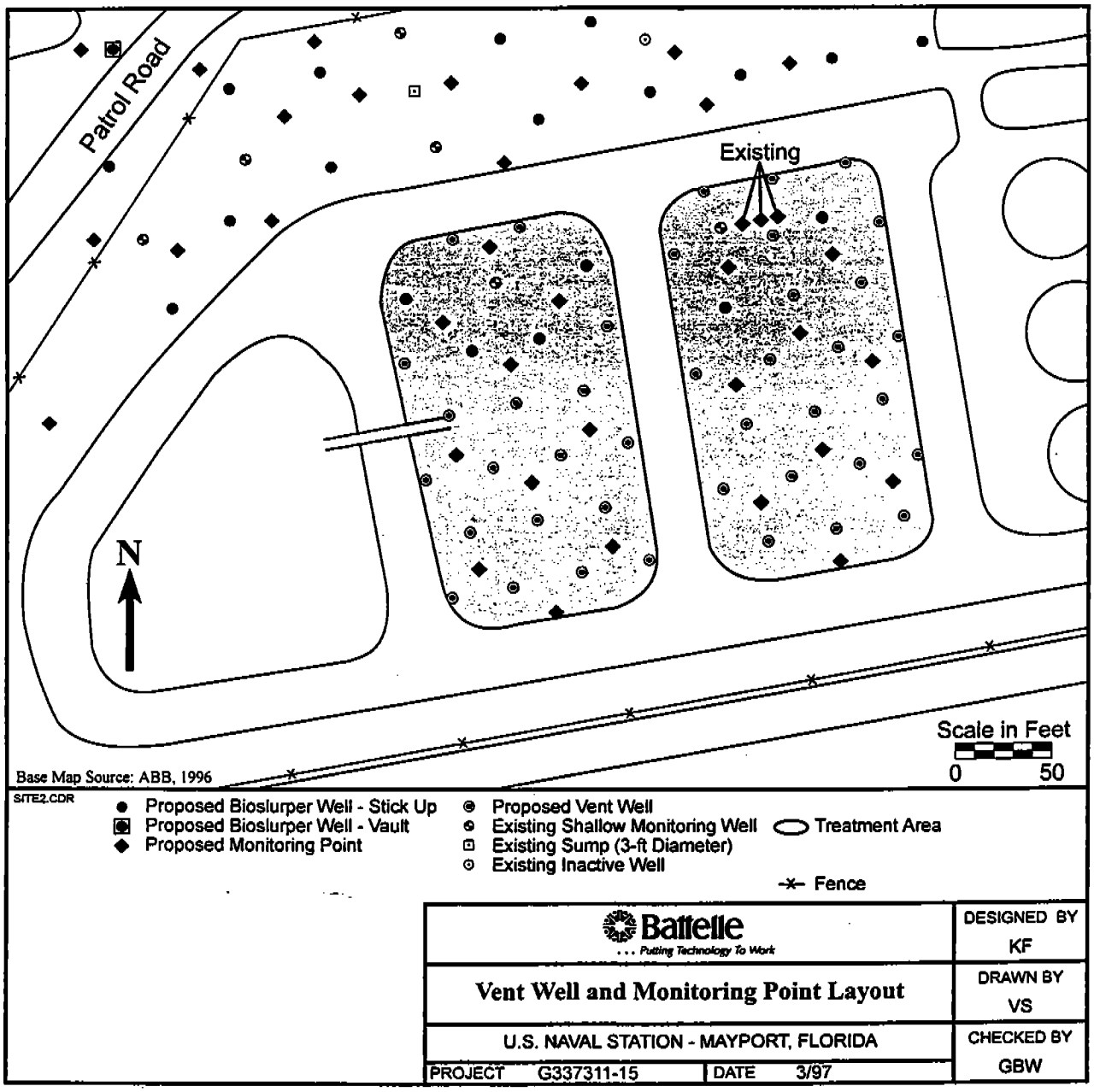

Figure 25. Vent Well and Monitoring Point Layout

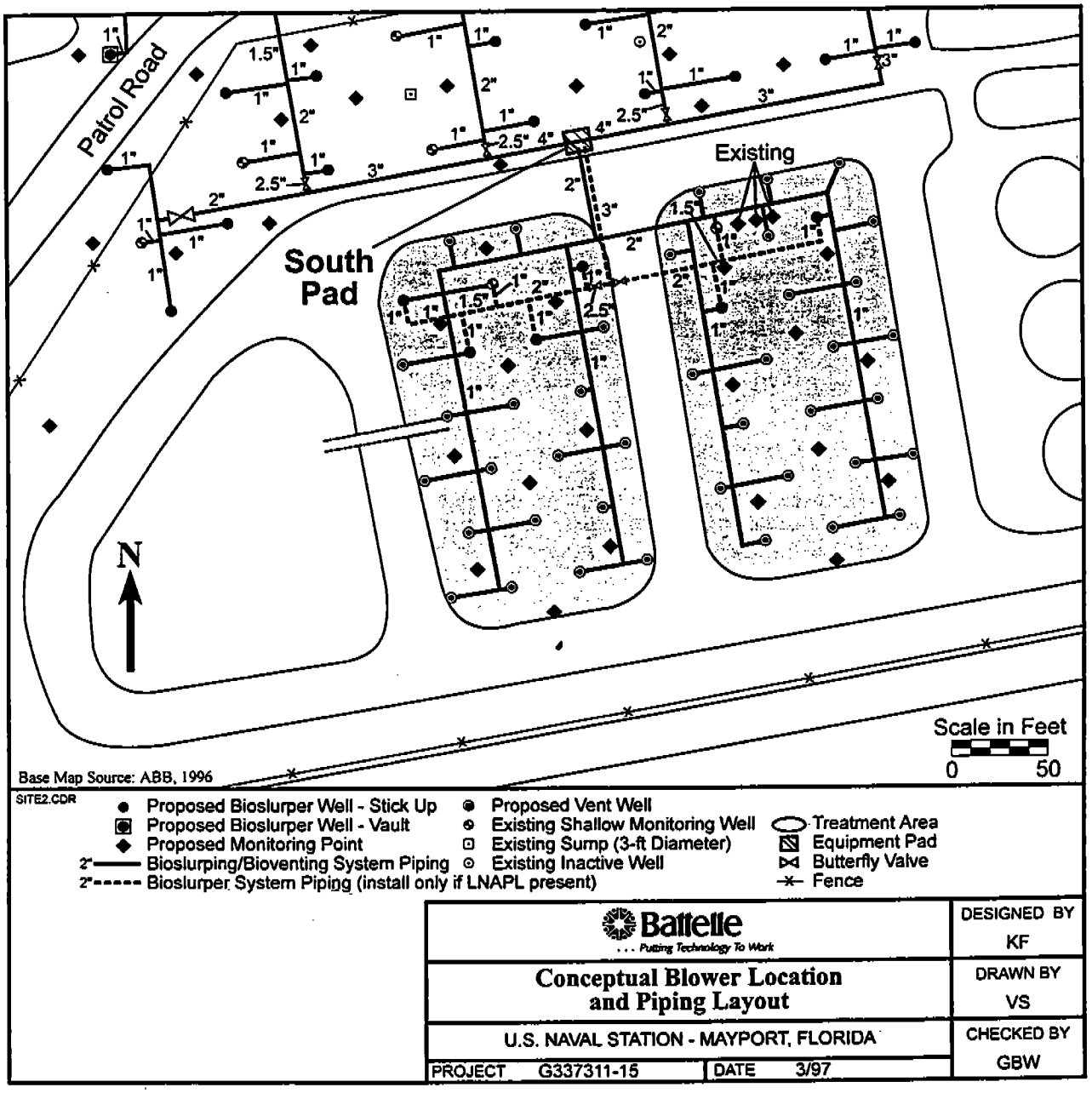

Figure 26. Conceptual Blower Location and Piping Layout

Section 5.0: PERMITTING REQUIREMENTS

The *Revised Guidance on Air Emissions from Petroleum Cleanup Sites* (FDEP, 1996) assumes that air emissions sources associated with petroleum cleanup sites will be temporary in nature. Provided that the cleanup is projected to last less than 5 years, as is the case for NAVSTA Mayport, it is not necessary to obtain an air permit. Only in cases where site cleanup duration is estimated to last longer than 5 years, would it be necessary to obtain either an air permit or an exemption under the provisions of Chapter 62-4 Florida Administrative Code (F.A.C.). As with any other remedial technology, cleanup times are difficult to accurately estimate; however, it is expected that removal of recoverable free product at SWMU7 can be achieved within 6 to 12 months. If necessary, remediation can be expedited by installing additional extraction wells.

Vapor discharge may not exceed 15 pounds per day of VOCs, which can be determined by direct measurement of the air stream. Vapor treatment will be required for the first 30 days of bioslurper operation. Recovered vapors (pretreatment) must be collected and analyzed at the end of 30 days. Analytical reports and the air flowrate will be used to calculate vapor discharge in pounds per day. Vapor treatment may be discontinued at this time if recovered VOCs do not exceed 15 lb/day. Due to bioslurper operation at low flowrates and a contamination of heavier, less- volatile fuels, vapor treatment may not be necessary after the initial 30-day treatment period.

The St. Johns River Water Management District does not require a permit for the installation of wells less than 6 inches in diameter, provided they will not be used as a potable water source. Based on conversation with regulatory officials, the city of Mayport (or Jacksonville) does not require a construction permit for bioslurper installations. It was also indicated that the bioslurper wells would not require a consumptive use permit on the basis that the wells have a diameter of less than 6 inches and water will be extracted only from the surficial aquifer (Gisclar, 1996, personal communication). Exemption from a consumptive use permit also requires that the combined withdrawal from all the bioslurper wells shall not exceed 100,000 gallons per day (Mitchell, 1997, faxed communication). Estimated groundwater withdrawals are more than an order-of-magnitude less than this requirement.

Soil cuttings removed during the installation of extraction wells and monitoring points may be placed in the sludge drying beds, which are already known to contain contaminated soils. If this is not an acceptable method of disposal, soil cuttings should be placed in 55-gallon drums and disposed of in accordance with regulatory requirements.

Section 6.0: MONITORING AND SAMPLING REQUIREMENTS

6.1 Bioslurping System. During operation of the full-scale bioslurper system, it is recommended that the bioslurper process be monitored on a regular basis. Operation of the bioslurper system will start with a shakedown test, during which all components are checked to ensure that they are operating properly and that there are no leaks in the system. Components that must be checked include valves, pressure/vacuum gauges, all extraction equipment, flowmeters, emergency shutoff switches, and the vapor treatment system.

Following system shakedown, the baseline data for the site will be collected. These data include the LNAPL thickness and depth to the groundwater table at each bioslurper well as well as oxygen, carbon dioxide, and TPH measurements from each soil-gas monitoring point. The system may then be started. It must be monitored closely for 2 to 4 weeks to determine the most effective operating configuration.

Monitoring consists of reading and recording the values of the various temperature, pressure, and flow gauges as well as collecting and analyzing samples for hydrocarbon constituents. Table 19 lists the bioslurper operational parameters and the recommended frequency at which they should be monitored. The frequency of the measurement or analysis is determined on the basis of data needs. In some cases, as in the case of vapor discharge, the monitoring recommendations are based on the requirements of the Florida Department of Environmental Protection. In other cases, the recommendations are based on Battelle's prior experience in operating full-scale bioslurper systems. Additional monitoring information, procedures, equipment, and data interpretation used for the above analyses/ measurements will be included in the Operations and Maintenance Manual for the Full-Scale Bioslurper System at NAVSTA Mayport, Florida.

An important parameter that must be monitored closely is the LNAPL recovery. When the LNAPL extraction rate decreases, the system will be shut down and the rate of LNAPL recovery into the bioslurper wells will be measured. As the quantity of recoverable LNAPL in the subsurface decreases, the rate of recovery into the wells will decrease. As the LNAPL thickness equilibrates, LNAPL levels will be measured to evaluate if the bioslurper system operation should be modified. For example, bioslurper treatment will be continued at wells with high recovery rates and/or comparatively high LNAPL, whereas treatment at wells with no LNAPL may be discontinued.

6.2 Bioventing System. Bioventing systems are very simple, with minimal mechanical and electrical parts. If the system is operated in the injection mode, a simple visual system check to ensure that the blower is operating within its intended flowrate, pressure, and temperature ranges is required. Ten soil samples will be collected and analyzed for PAHs and TPH to establish baseline contaminant levels. Baseline soil-gas measurements including oxygen, carbon dioxide, and TPH will be taken from the monitoring points prior to startup of the full-scale system. Periodic soil-gas monitoring will be conducted to ensure that the site is well-oxygenated. The remaining part of this section describes the various monitoring and sampling activities that will be performed with regard to the bioventing system. These activities are summarized in Table 20.

6.2.1 Soil-Gas Monitoring. Collection of soil-gas samples before, during, and after injecting air is important to determine the effectiveness of a bioventing system. Soil-gas measurements will be taken during air permeability testing and respiration testing. Soil-gas samples also will be collected on a monthly basis while operating the bioventing system to ensure that the soils are sufficiently aerated. Samples will be collected with a soil-gas sampling pump system. Oxygen and carbon dioxide concentrations in the soil gas are measured with a direct-reading GasTech 3250X O_2/CO_2 detector (or

Table 19. Full-Scale Bioslurper Monitoring and Sampling Parameters

Activity	Recommended Frequency
System shakedown	Prior to startup
Baseline oil/water level data and soil-gas concentrations	Prior to startup
Routine system monitoring and site inspection (i.e., process vacuums, flowrates, temperatures, etc.)[a]	A minimum of 2 to 3 times a week during the first month of operation; weekly thereafter
Vapor discharge flowrate	Weekly
Vapor discharge sampling for laboratory analysis of TPH and BTEX	Weekly for first 4 weeks; monthly thereafter at discretion of FDEP
Vapor discharge monitoring with field instrumentation	Weekly
Aqueous and LNAPL discharge volumes and rates	Weekly
Aqueous discharge stream sampling for laboratory analysis of TPH, BTEX, PAH, and etals	Monitor weekly during the first 2 months of operation to determine if it is more economical to treat water and discharge to WWTP or to discharge water to OWTP without treatment; monthly for the next 4 months; and quarterly thereafter at discretion of FDEP
LNAPL levels and recovery rates in wells[b]	Monthly for 3 to 6 months; quarterly thereafter[c]
Aeration monitoring[c]	Monthly[c]
Respiration monitoring[d]	Quarterly first year and semiannually thereafter[a]

(a) Routine system monitoring and site inspection duties will be included as part of the Operations and Maintenance Manual.

(b) LNAPL levels and recovery rates into the wells are used to indicate the degree of removal of LNAPL. As more LNAPL is removed, the resulting levels are less and the recovery rate is slower. This monitoring test must be performed with the system off. It may be performed more or less frequently based on observed change in the LNAPL recovery rate during bioslurper operation.

(C) Aeration monitoring is performed with the bioslurper on. Soil-gas concentrations in the monitoring points are measured to determine if the subsurface process is being aerated by the bioslurper process.

(d) Respiration monitoring is performed with the bioslurper system off to determine the change in the biodegradation rate over time.

equivalent detector). Concentrations of TPH are measured with a direct-reading GasTech GT105 total petroleum hydrocarbon (TPH) detector (or similar detector).

6.2.2 In Situ Respiration Testing. Following startup of the bioventing system, in situ respiration tests should be conducted quarterly for the first year and annually thereafter. In situ respiration tests consist of turning off the injection blower and measuring the change in oxygen, carbon dioxide, and TPH levels in the soil. Typically, measurement will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours depending on the rate at which the oxygen is utilized. If oxygen uptake is rapid, more frequent monitoring will be required. If it is slower, less frequent readings are acceptable. Procedures for performing an in situ respiration test can be found in the *Principles and Practices of Bioventing Volume II: Bioventing Design* (Battelle, 1995)

Table 20. Full-Scale Bioventing Monitoring and Sampling Parameters

Activity	Recommended Frequency
Baseline soil sampling	Prior to installing full-scale system
Soil-gas sampling	Baseline prior to startup; monthly thereafter
Respiration test	Quarterly for first year; annually thereafter
Soil sampling and analysis	Semiannually
Routine system monitoring and site inspection (i.e., blower flowrate, pressure, temperature, etc,)	Weekly

Section 7.0: CLOSURE REQUIREMENTS

Cleanup criteria at the site, according to Florida State regulatory requirements, mandate that free product in excess of 0.1 inch thickness be removed from the water table. It is, however, stated in the Petroleum Contamination Site Cleanup Criteria that free-product recovery shall be deemed complete when free product has been removed to the maximum extent practicable (FDEP, 1994a).

Based on a 1.2 gal/day recovery rate at MPT-8-MW11S, a full-scale system consisting of 70 extraction wells potentially would extract 84 gal/day. Wells located in areas containing large amounts of free product may recover more than the 1.2 gal/day average; however, there also may be wells where little or no free product is present. If free product is not present or has a thickness of less than 0.1 inch, it should be monitored to ensure that the product thickness does not increase. If at some time the free-product thickness in a well increases beyond 0.1 inch, it should be reincorporated into the extraction system. When product thicknesses are measured, the system should be shut down and the wells allowed to fully recover before taking readings.

The length of time for remediation using the bioslurper technology is difficult to estimate, but it is expected to be considerably shorter than the time required for remediation by conventional technologies. The LNAPL thickness and recovery data collected during the operation of the system should be evaluated frequently to decide what areas served by the bioslurper wells have been effectively remediated, so that some wells can be closed and the extraction can be limited to those wells with residual LNAPL. If necessary, remediation can be expedited by installing additional extraction wells. After removing the free-product, additional time may be required to biodegrade hydrocarbon contamination present in the vadose zone. The bioslurper extraction wells have been designed so that they can be easily converted to a bioventing system.

Biodegradation of hydrocarbons in the vadose zone in the sludge drying beds can be monitored by performing in-situ respiration testing. Soil samples should be collected periodically and analyzed for the constituents of concern. Based on historical site data benzo(a)anthracene is the primary contaminant of concern that may be present at levels greater than the cleanup criteria (Section 1.3). The extent and methodology of soil sampling necessary for site closure will be coordinated with the FDEP.

Section 8.0: BIOSLURPER COST ESTIMATE

8.1 Bioslurper Cost Estimate. The installation and operation of a full-scale bioslurper system at the SWMU7 Sludge Drying Bed area at NAVSTA Mayport is cost-effective compared to the costs of other remediation technologies. The estimate includes both installation, and operations and maintenance (O&M) costs. The installation costs include labor and material costs associated with installing the monitoring points, the monitoring wells, and the subsurface manifold; purchasing and installing the process equipment; and performing electrical installation. The O&M costs include the labor and materials required to conduct operations and maintenance, power to operate the bioslurper system components, and disposal and discharge costs required to remove recovered fuel and extracted water. A cost for contingency (10%) is also included in the event that unforeseeable circumstances arise that may add to the total project cost. Estimated labor costs assume the burden of general and administration (G&A), overhead, and fee charges. However, because each contracting company applies these charges to different categories of project costs at different rates, application of these costs should be computed according to contractor-specific methods.

Costs not included in this estimate are documentation, site closure, and additional design costs. These costs will be determined by both Florida regulatory agency requirements and the contractor's prior experience with designing and installing full-scale bioslurper systems. These costs also do not include travel or per diem expenses.

The total cost to install the full-scale bioslurper system is $231,000. It is estimated that the annual O&M cost will be about $257,500. The O&M cost assumes that carbon treatment will be required throughout the duration of the project and that 5 gal/min of water will be discharged to the NAVSTA OWTP. However, because the free product at SWMU7 is not very volatile and the allowable hydrocarbon release is as high as 15 lb/day, it is possible that carbon treatment could be discontinued after 1 to 3 months of operation to potentially decrease the annual O&M cost by as much as $90,000. The annual cost of treating the oil/water discharge is estimated to be $84,000. This assumes that the discharge oil/water will be sent to the NAVSTA OWTP at a cost of $32.14/1,000 gal of water treated. (However, if analysis of the discharge stream indicates that the water may be sent to the NAVSTA WWTP with minimal treatment, it may be deemed more economical to separate the oil and water streams and discharge the water to the base WWTP. Alternative water treatment and disposal options should be evaluated following the installation of the full-scale system based on water quality and quantity.) Assuming a 10% contingency, the total project cost during installation and the first year of operation is about $537,000. The remainder of this section describes the individual activities and associated costs that comprise these values.

8.1.1 Materials and Installation Labor Costs

8.1.1.1 Monitoring Wells and Monitoring Points. Material and labor costs to install the monitoring points and monitoring wells are shown in Table 21. Material costs are estimated to be about $20,000 and labor costs are estimated to be $57,600. These costs assume that 59 extraction wells and 51 monitoring points will be installed. Labor costs include a quote for drillers to drill, install, and develop the wells and to drill and install the monitoring points. The drilling labor includes the installation of the flush-mount well covers but does not include the installation of the vaults. It is estimated that approximately 10 yd^3 of soil cuttings will be generated during drilling operations, requiring treatment and disposal. It is recommended that a technician be present to install the vaults as well as to assemble the monitoring point components. In addition, it is recommended that a geologist be present on site to supervise the drilling and log the monitoring wells and points. It is estimated that this activity will require 3 weeks to perform.

Table 21. Monitoring Well and Monitoring Point Installation Costs

Cost Type	Item	Unit	Cost	Quantity	Total	Vendor
Materials	Suction strainer	ea	$7	145	$1,015	Grainger
	Quick-connect female x tube	ea	$12.10	145	$1,755	Forberg Scientific
	Quick-connect protector	ea	$5.01	145	$727	Forberg Scientific
	Nylon tubing	ft	$0.39	1250	$488	Cole-Parmer
	Flush-mounts 8 x 12	ea	$50	32	$2,550	Global Drilling
	Brass tags	ea	$1.30	145	$189	Seton
	Thermocouple wire	roll	$59	3	$177	Cole-Parmer
	Aquarium gravel	50-lb bag	$14.99	3	$45	Byerly's Aquarium Supply
	Bentonite chips	50-lb bag	$10.16	50	$508	Unitek
	Concrete mix	80-lb bag	$3.35	350	$1,173	Columbus Builders Supply
	2x2x2 ft vaults	ea	$250	32	$8,000	Global Drilling
	Well seals 2x1	ea	$14.41	59	$850	Boundary Waters
	Cuttings barrels	ea	$45	40	$1,800	Williams Earth Science
	Drilling consumables	lump sum	$350	1	$350	Williams Earth Science
	Monitoring well permits	lump sum	$350	1	$350	Williams Earth Science
	Total materials:				**$19,974**	
Labor	Driller mobilization	ea	$850	1	$850	Williams Earth Science
	Monitoring well installation[a]	ft	$35	885	$30,975	Williams Earth Science
	Hollow-stem auger boring	ft	$9.50	383	$3,639	Williams Earth Science
	Development time	hr	$130	26	$3,380	Williams Earth Science
	Standby time	hr	$110	5	$550	Williams Earth Science
	Difficult access time	hr	$130	5	$650	Williams Earth Science
	Decontamination time	hr	$130	22	$2,860	Williams Earth Science
	Soil cuttings - loading and hauling	yd^3	$22	10	$220	Means Estimating Guide
	Soil cuttings - treatment and disposal	yd^3	$150	10	15200	Engineering Estimate
	Geologist	hr	$60	130	$7,800	Primary Contractor
	Technician	hr	$40	130	$5,200	Primary Contractor
	Total labor:				**$57,624**	
Total Monitoring Well Installation Cost					**$77,598**	

(a) Includes PVC pipe, screen, and sand.

Table 22. Extraction Manifold Installation Costs

Cost Type	Item	Unit	Cost	Quantity	Total	Vendor
Materials	PVC pipe	total	$3,500	total	$3,500	Engineering Estimate
	Transporter tank truck hose	ft	$3.16	250	$790	Fournier Rubber
	Clear Excelon™ pipe	ft	$2.04	100	$204	U.S. Plastics
	Butterfly valves	total	$1,450	total	$1,450	Corro-Flo
	PVC globe valves	ea	$30	70	$2,100	Corro-Flo
	Misc. PVC valves and fittings	total	$1,000	total	$1,000	Engineering estimate
	PVC primer	qt	$9.94	20	$199	U.S. Plastics
	PVC cement	qt	$12.84	20	$257	U.S. Plastics
	Total materials:				**$9,500**	
Labor	Trenching and resurfacing	ft	$7	3,430	$24,010	Geotechnical Professional Associates estimate
	Utility trenching	ft	$25	50	$1,250	Geotechnical Professional Associates estimate
	Technician	hr	$40	40	$1,600	Primary Contractor
	Total labor:				**$26,860**	
Total Extraction Manifold Cost:					**$36,360**	

Table 23. Full-Scale Bioslurper Equipment Procurement and Installation Costs

Cost Type	Item	Unit	Cost	Quantity	Total	Vendor
Process Equipment	20-hp liquid ring pump	ea	$11,719	2	$23,438	Atlantic Fluidics
	Equalizing drum	ea	$35	2	$70	Columbus Steel Drum
	Oil/water surge tank	ea	$1,825	2	$3,650	McMaster-Carr
	Condensate surge tank	ea	$227	1	$227	McMaster-Carr
	Fill-Rite electric transfer pump or ARO pneumatic transfer pump	ea	$533	4	$2,132	Grainger (price is for metered Fill-Rite, Grainger # 7P073)
	Air compressor (if ARO pumps are chosen)	ea	$320	1	$320	Grainger
	Heat exchanger (50 cfm)	ea	$725	1	$725	Thermal Transfer Products
	Heat exchanger (100 cfm)	ea	$980	1	$980	Thermal Transfer Products
	Carbon container	ea	$3,450	2	$6,900	Sher-Fran
	Dehumidifier	ea	$15,650	1	$15,650	TEK Engineering
	Induced-draft blower	ea	$2,425	1	$2,425	Gas
	Total process equipment:				**$56,517**	
Instrumentation	Annunciator panel[a]	ea	$1,700	2	$3,400	In-house estimate, including assembly labor
	Pitot tube	ea	$220	2	$440	W.R. Frew
	Oil/water interface probe	ea	$2,000	1	$2,000	ORS
	Helium detector	ea	$4,500	1	$4,500	Mark Products
	GasTech O_2/CO_2 meter	ea	$3,700	1	$3,700	Control Analytics
	TraceTechtor TPH meter	ea	$2,100	1	$2,100	GasTech
	Fluke digital thermometer	ea	$180	1	$180	Meter Masters
	Magnehelic gauges	ea	$51	36	$1,836	Grainger
	Vacuum gauges	ea	$20	6	$120	Cole-Parmer
	Total instrumentation:				**$18,276**	

Table 23. Full-Scale Bioslurper Equipment Procurement and Installation Cost (Continued)

Cost Type	Item	Unit	Cost	Quantity	Total	Vendor
Hardware	Liquid-level switches	ea	$39	4	$156	Grainger
	Quick-connect female x pipe	ea	$11.88	6	$72	Forberg Scientific
	Quick-connect protectors	ea	$5.01	6	$31	Forberg Scientific
	3-inch galvanized pipe	ft	$4.15	50	$208	Pipe-Valves
	2-inch galvanized pipe	ft	$2.02	50	$101	Pipe-Valves
	Misc. camlock fittings	total	$1,000	total	$1,000	Plumbing Supply
	Misc. hardware	total	$500	total	$500	Hardware Store
	Total hardware:				**$2,068**	
Shipping	Total materials	total	10%	total	**$7,686**	
Misc.	Concrete pads[a]	sq. ft.	$325	6	$1,950	Means Building Construction Cost Data 1995
Labor	Engineer	hr	$60	240	$14,400	Primary Contractor
	Technician	hr	$40	240	$9,600	Primary Contractor
	Total misc. and labor:				**$25,950**	
Total Full-Scale Procurement and Installation Costs					**$110,497**	

(a) Includes labor to construct.

8.1.2.2 Power. Table 24 lists the primary system components that require electrical power along with the estimated annual power cost. Components requiring minimal amounts of power such as the annunciator panel and monitoring instrumentation are not included. The total estimated cost for electricity to operate the bioslurper system is estimated to be $38,758. The power cost was calculated by estimating the length of time each piece of equipment would operate on a yearly basis. Power is assumed to cost $0.10/kW-hr.

8.1.2.3 Sampling and Analytical. Analytical costs are shown in Table 25. It is assumed that the labor required to perform the sampling is included in the routine operations and maintenance labor specified in Section 9.2.1. The total analytical cost is $8,900. This estimate assumes that 45 off-gas samples and 18 water samples (for 16 water analyses) will be collected and analyzed annually. The exact number of required samples will be determined by regulatory requirements. Also, if carbon treatment can be discontinued after the first 1 to 3 months of operation, the number of required off-gas samples may be reduced.

8.1.2.4 Disposal and Discharge. Two primary wastestreams will be generated during operation of the full-scale bioslurper system. These include disposal of spent activated carbon and discharge of the oil/water extracted during full-scale operation. The spent activated carbon can be disposed of for $0.90/lb (Sher-Fran Corporation). Based on the carbon usage of 2,000 lb in 17 days as assumed in Section 3.1.3, the annual disposal cost for the activated carbon would be $43,800.

Table 24. Full-Scale Bioslurper Power Requirements

Process Equipment	Quantity	Work (hp)	Operating Time (hr/day)	Annual Electrical Power Cost ($/year)
Liquid ring pump	2	20	24	$26,130
Dehumidifier	1	6	24	$3,919
Transfer pumps	2	3/4	12	$490
Transfer pumps	2	1/3	3	$54
Air compressor[a]	1	4	12	$1,306
Induced-draft blower	1	10	24	$6,532
Heat exchanger	2	1/4	24	$327
Total Annual Power Cost:				**$38,758**

(a) Optional item - to be used with ARO pneumatic pumps.

Table 25. Sampling and Analytical Costs

Cost Type	Medium	Analysis	Cost	Quantity	Total	Vendor
Analysis	Off-gas	TO-3 for TPH and BTEX	$140	45	$6,300	Air Toxics
	Water	8015 TPH as diesel	$100	8	$800	Quality Analytical Labs
	Water	8240 BTEX	$225	8	$1,800	Quality Analytical Labs
Total Analytical Cost:					**$8,900**	

Again, it is expected that carbon treatment can be discontinued after 1 to 3 months of operation; hence, carbon disposal costs potentially could be as low as $3,600 to $10,800.

It is assumed that the oil/water discharge from the bioslurper system will be treated by the NAVSTA OWTP, at the rate of $32.14/1000 gal of water treated. Assuming that the combined water discharge rate from the two bioslurper pumps is 5 gal/min, a total of 2,628,000 gal would be collected in the course of 1 year's operation. At $32.14/1000 gallons, the cost for discharge in 1 year would be $84,464. During the first month of operation, analysis of the discharge stream should be performed to determine if it would be more economical to pretreat the water and discharge it to the NAVSTA WWTP.

8.1.3 Contingency. It is reasonable to expect that unforeseeable circumstances will arise in any long-term remediation project that may add to the total project cost. Health and safety issues, vandalism, regulatory delays, and equipment manufacturing errors are only some examples of factors that can add cost to a well-planned project. To cover these costs, a contingency factor of 10% is assumed, which amounts to $46,400 of contingency funds.

8.2 Bioventing Cost Estimate. The estimated cost for full-scale installation and 1 year of operation and maintenance has been determined based on the available site information and the proposed conceptual design. The cost is estimated to be $ 93,600. This cost estimate assumes the two easternmost sludge drying beds will be biovented and that no free-product is present. Installation costs for the full-scale system include labor and materials needed to install 41 additional vent wells, 19 additional soil-gas monitoring points, a 2.0-hp blower, and approximately 1,500 feet of 1-inch schedule 40 PVC piping. Annual O&M costs include materials and labor to conduct routine operation of the bioventing system and perform soil analysis as well as the power requirements needed to operate the blower. A contingency cost of 10% also is included to account for unforeseeable circumstances that may add to the total cost of the system. Estimated labor costs include general and administration charges, overhead, and fee charges. It is also assumed that the purchase of all meters, detectors, probes, and Magnehelic™ gauges is accounted for in the full-scale bioslurping design. Because each contracting company applies these charges to different categories of project costs at different rates, application of these costs should be computed according to contractor-specific methods.

Documentation preparation, site closure, and design costs are not included in this estimate. These costs will be determined by both Florida regulatory agency requirements and the contractor's experience with designing and installing full-scale bioventing systems. Also, the cost estimate does not include travel or per diem expenses.

8.2.1 Bioventing System-Installation Costs. The cost to install the full scale bioventing system is estimated to be $57,000. This includes costs for the installation of the vent wells, soil-gas monitoring points, and blower system as well as soil analysis to determine baseline concentrations. Table 26 presents the costs associated with each aspect of the bioventing system installation.

Table 26. Full-Scale Bioventing System Installation Costs

Cost Type	Item	Unit	Cost	Quantit	Cost	Vendor/source
Vent Well Installation	Driller mobilization/demobilization	mile	$ 3.00	100	$ 300.00	Layne Env Services
	Driller travel	crew hr	$ 60.00	2	$ 120.00	Layne Env Services
	Driller per diem, per crew	crew day	$ 140.00	5	$ 700.00	Layne Env Services
	Driller charge rate (labor & equip)	hour	$ 210.00	40	$ 8,400.00	Layne Env Services
	Soil-cuttings disposal	yd^3	$ 172.00	3	$ 516.00	Estimate
	Misc. safety	set	$ 500.00	3	$ 1,500.00	Estimate
	Shipping	ea	$ 50.00	12	$ 600.00	Estimate
	Bentonite chips (assumed 0.75 ft3)	bag	$ 10.16	50	$ 508.00	Unitek
	Plastic cable ties 8 in long	100/bag	$ 6.00	2	$ 12.00	Instrmnt Lab Estimt
	PVC 2-in. sch 40 screen 5 ft	ea	$ 12.25	41	$ 502.25	Boundary Waters
	PVC 2-in. sch 40 casing 5 ft	ea	$ 7.75	41	$ 317.75	Boundary Waters
	Ball valve, 2-in.	ea	$ 20.74	41	$ 850.34	Pipe Valves
	Quikrete ready mix, 80-lb bags	ea	$ 3.69	41	$ 151.29	Columbus Hardware
	Silica sand, ft^3/bag	bag	$ 11.86	31	$ 367.66	Unitek
	Std brass valve tags 1.5-in. natural	ea (1-99)	$ 1.30	41	$ 53.30	Seton
	Labor - Engineer	hr	$ 60.00	40	$ 2,400.00	Estimate
	Labor - Technician	hr	$ 40.00	40	$ 1,600.00	Estimate
	Vent Well Installation Total				**$ 18,898.59**	
Soil-Gas Monitoring Point Installation	Driller per diem, per crew	crew day	$ 140.00	2	$ 280.00	Layne Env Services
	Driller charge rate (labor & equip.)	hour	$ 210.00	16	$ 3,360.00	Layne Env Services
	Soil-cuttings disposal	yd3	$ 172.00	2	$ 344.00	Estimate
	Misc. safety	set	$ 500.00	3	$ 1,500.00	Estimate
	Shipping	ea	$ 50.00	12	$ 600.00	Estimate
	Al flush-mount well cover (8-in solid)	ea	$ 98.42	19	$ 1,869.98	Global Drilling
	Bentonite chips (assumed 0.75 ft^3)	bag	$ 10.16	4	$ 40.64	Unitek
	Quikrete ready mix, 80-lb bags	ea	$ 3.69	19	$ 70.11	Columbus Hardware
	Silica sand (assumed 3/4 ft^3)	bag	$ 11.86	1	$ 11.86	Unitek
	Mini male thermocouple plug	ea	$ 3.18	15	$ 47.70	Instrmnt Lab Estimt
	Thermocouple wire (type K) 125 ft	roll	$ 62.83	1	$ 62.83	L.H. Marshall
	MPT male connector 3/8-in. X 1/4-in. tube	ea	$ 1.31	19	$ 24.89	NewAge Industries
	Nylon tubing 1/4-in.	50 ft pk	$ 19.25	5	$ 96.25	Cole-Parmer
	Plastic cable ties 8 in long	100/bag	$ 6.00	7	$ 42.00	Instrmnt Lab Estimt
	Qck-cnct F X 1/4 in tube 4Z-Q4CN-BBP	ea	$ 12.10	19	$ 229.90	Forberg Scientific
	Qck-cnct protector CP-Q4C-BB	ea	$ 5.01	19	$ 95.19	Forberg Scientific
	Std brass valve tags 1.5-in. natural	ea	$ 1.30	19	$ 24.70	Seton
	Suction strainer (monitoring pt) 3/4 in	ea	$ 6.72	19	$ 127.68	Grainger
	Gravel for suction screen 50 lb	bag	$ 20.00	2	$ 40.00	Estimate
	Labor - Engineer	hr	$ 60.00	16	$ 960.00	Estimate
	Labor - Technician	hr	$ 40.00	16	$ 640.00	Estimate
	Soil-Gas Monitoring Point Installation Total				**$ 10,467.73**	
Blower System Installation	2.0-hp explosion-proof regenerative blower	ea	$ 1,019.15	1	$ 1,019.15	Isaacs
	Blower inlet filter with filter cover	ea	$ 115.00	1	$ 115.00	Grainger
	Electrical parts/set-up	total	$ 200.00	1	$ 200.00	Estimate
	Miscellaneous PVC piping, fittings, etc.	ea	$ 400.00	1	$ 400.00	U.S. Plastics
	Magnehelic gauge 0 - 10 in H_2O	ea	$ 47.00	1	$ 47.00	Dwyer
	Magnehelic gauge 0 - 100 in H_2O	ea	$ 49.00	1	$ 49.00	Dwyer
	Anemometer, hot wire	ea	$ 795.00	1	$ 795.00	TSI Inc
	Trenching Costs	ft	$ 25.00	500	$ 12,500.00	DirtGo Inc.
	PVC cement	quart	$ 12.32	5	$ 61.60	U.S. Plastics
	PVC primer	quart	$ 9.56	5	$ 47.80	U.S. Plastics
	PVC 1-in. sch 40 pipe	20 ft	$ 23.48	100	$ 2,348.00	U.S. Plastics
	Labor - Engineer	hr	$ 60.00	24	$ 1,440.00	Estimate

Table 26. Full-Scale Bioventing System Installation Costs (Continued)

Cost Type	Item	Unit	Cost	Quantit	Cost	Vendor/source
	Labor - Technician	hr	$ 40.00	24	$ 960.00	Estimate
	Blower System Installation Total				**$ 19,982.55**	
Soil Analysis	VOC Analysis	each	$ 390.00	10	$ 3,900.00	Lancaster
	PAH Analysis	each	$ 225.00	10	$ 2,250.00	Lancaster
	Labor - Engineer	hr	$ 60.00	10	$ 600.00	Estimate
	Labor - Technician	hr	$ 40.00	10	$ 400.00	Estimate
	Soil Analysis Total				**$ 7,150.00**	
Total Installation Costs:					**$57,000.00**	

8.2.2 Bioventing System Operation Costs. One year of operation and maintenance costs for the full-scale conceptual bioventing system are estimated to be $29,000. Included in the operation costs are two soil analysis sampling events to be performed every 6 months of operation. Also, power cost was calculated by estimating the length of time the blower would operate in a year and multiplying by a unit cost of $0.10/kW-hr. Table 27 presents the cost breakdown for O&M during one year of operation.

Table 27. Operation and Maintenance Costs.

Cost Type	Item	Unit	Unit Cost	Quantity	Cost	Vendor/source
Operation and Maintenance	Filter cover replacement	ea	$ 13.75	5	$ 68.75	Grainger
	Carbon dioxide, size s3 10%	ea	$ 124.00	4	$ 496.00	Scott Specialty
	Hexane, size s3 4,800 in air	ea	$ 124.00	4	$ 496.00	Scott Specialty
	Oxygen, size s3 10% balance	ea	$ 124.00	4	$ 496.00	Scott Specialty
	Tedlar bags	10/box	$ 82.00	6	$ 492.00	SKC
	Std. brass valve tags 1.5 in	ea	$ 1.30	60	$ 78.00	Seton
	Miscellaneous replacement	ea	$ 1,000.00	1	$ 1,000.00	Estimate
	Power for 2.0-hp Blower	kW-h	$ 0.10	13065	$ 1,306.47	Estimate
	Labor - Engineer	hr	$ 60.00	100	$ 6,000.00	Estimate
	Labor - Technician	hr	$ 40.00	100	$ 4,000.00	Estimate
Soil Analysis	VOC Analysis	each	$	20	$ 7,800.00	Lancaster
	PAH Analysis	each	$	20	$ 4,500.00	Lancaster
	Labor - Engineer	hr	$	20	$ 1200.00	Estimate
	Labor - Technician	hr	$	20	$ 800.00	Estimate
	Soil Analysis Total				$ 14,300.00	
Total Operation and Maintenance:					$ 28,733.22	

8.2.3 Contingency. In order to allow for unforeseeable circumstances and the nature of a conceptual design cost estimate, a 10% contingency is added to the total estimated total costs. The estimated contingency costs for the full-scale bioventing system installation and operation is estimated to be $ 8,600.

Section 9: REFERENCES

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APPENDIX A

WELL CONSTRUCTION DETAIL AND SOIL BORING LOGS

TITLE: Mayport Naval Station, Mayport, Fl.		**LOG of WELL:** MPT-8-MW2S	**BORING NO.** MPT-8-2
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 5097-04
CONTRACTOR: MONITOR TESTING		**DATE STARTED:** 9/17/87	**COMPLTD:** 9/17/87
METHOD: H.S.A.	**CASE SIZE:** 2"	**SCREEN INT.:** 5-17' ?	**PROTECTION LEVEL:** D
TOC ELEV.: 14.00 FT.	**MONITOR INST.:** Hnu	**TOT DPTH:** 15.0FT.	**DPTH TO ▽** 9.50 FT.
LOGGED BY: M. C. Diblin	**WELL DEVELOPMENT DATE:** 9/17/87		**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN
		SS1	2.0/2'		Sand-fine to medium, tan, few shell fragments, dry, bottom/ tan to grey, many shells		SP	13,20,22,38
5		SS2	1.7/2'		Sand-same as above, dark brown on the top, light grey at the bottom			17,21,30,58
	YES	SS3	1.1/2'		Sand-same as above			12,13,20,22
10		SS4	1.1/2'		Sand-fine to medium, grey, shells and fragments, grading to fine sand			8,9,13,19
15		SS5	2.0/2'		Sand-same as abov, light grey, with many shells			4,7,9,13
20								
25								
30								

WELL DATA

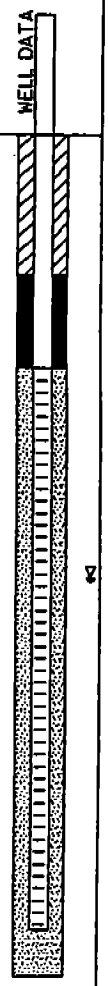

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Mayport Naval Station, Mayport, Fl.	**LOG of WELL:** MPT-8-MW3S	**BORING NO.** MPT-8-3
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM		**PROJECT NO:** 5097-04
CONTRACTOR: MONITOR TESTING	**DATE STARTED:** 9/16/87	**COMPLTD:** 9/16/87
METHOD: H.S.A.	**CASE SIZE:** 2" / **SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 14.10 FT.	**MONITOR INST.:** Hnu / **TOT DPTH:** 15.0FT.	**DPTH TO ∇** 9.50 FT.
LOGGED BY: M. C. Dilbin	**WELL DEVELOPMENT DATE:** 9/16/87	**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN
		SS1	1.4/2'		Sand-fine to medium, light tan, shell fragments, dry		SP	7,13,20,29
5		SS2	1.1/2'		Sand-same as above, interbedded with dark brown shells			13,14,18,7
	YES	SS3	1.8/2'		Sand-same as above, some dark brown Sand-top (0.5')/ fine, tan, shells, middle (0.5-0.55')/ blue shells bottom/ fine to medium, graded to light grey, shells			10,10,12,8
10		SS4	1.4/2'		Sand-fine to medium, grey, shells and fragments, grading to fine sand			17,17,15,7
15		SS5	2.0/2'		Sand-same as abov, many shells and fragments			17,21,21,37
20								
25								
30								

WELL DATA

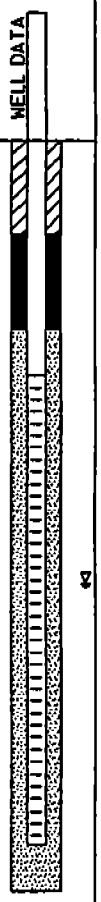

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Mayport Naval Station, Mayport, Fl.		**LOG of WELL:** MPT-8-MW7S	**BORING NO.** MPT-8-MW7S
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 7533-84
CONTRACTOR: GROUNDWATER PROTECTION, INC.		**DATE STARTED:** 1/18/93	**COMPLTD:** 1/18/93
METHOD: H.S.A.	**CASE SIZE:** 2"	**SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 11.73 FT.	**MONITOR INST.:** F.I.D.	**TOT DPTH:** 15.5FT.	**DPTH TO ∇** 8.38 FT.
LOGGED BY: Felix Alzk	**WELL DEVELOPMENT DATE:** 2/1/93		**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN
	MPT8 MS07-2	X	100%	0.0	ORGANIC SOIL - dark brown, loamy, w/ some shell fragments		OL	4,8,8,10
							SP	
5			75%	0.0	SAND - fine, tan, shelly (approx. 30%), moist			4,11,8,15
	MPT8 MS07-9	X	100%	3000	SAND - medium to fine, dark gray, shelly w/ hydrocarbon odor			21,20,18,25*
10								
15					Boring Terminated at 15.5 feet			
20					*Use of non-standard 3" split-spoon for sample recovery is reflected in the higher blow counts at these depths			
25								
30								

WELL DATA

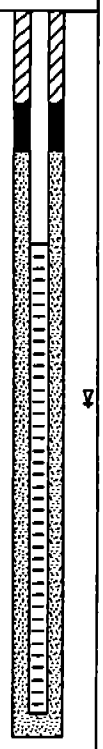

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Naval Station Mayport, Mayport, FL		**LOG of WELL:** MPT-8-MW11S	**BORING NO.** MPT-8-MW11S
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 8533-04
CONTRACTOR: LAYNE ENVIRONMENTAL SERVICES, INC.		**DATE STARTED:** 07/28/94	**COMPLTD:** 07/28/94
METHOD: 4.25" HSA	**CASE SIZE:** 2"	**SCREEN INT.:** 5-15 FT.	**PROTECTION LEVEL:** D
TOC ELEV.: 11.48 FT.	**MONITOR INST.:** FID	**TOT DPTH:** 15.5FT.	**DPTH TO ∇** FT.
LOGGED BY: P. Craine	**WELL DEVELOPMENT DATE:** 08/05/94		**SITE:** 8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
				0	Silty Sand-fine to medium, with shell fragments.		SM	Posthole	
5			1/2		Silty Sand-fine, gray, with trace of shell fragments.			11,8,7,8	
10			0.8/2	250	Silty Sand-fine, tan to gray with shell fragments.			3,4,6,8	
15			1/2	30	Silty Sand-fine to medium, brown to dark gray with trace of shell fragments.			2,1,1,1	
					TOTAL DEPTH OF BORING = 15.5' BLS				
20									

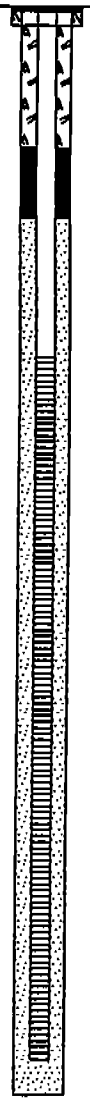

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Mayport Naval Station, Mayport, FL		**LOG of WELL:** MPT-8-P2	**BORING NO.** MPT-8-P2
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 7533-84
CONTRACTOR: GROUNDWATER PROTECTION, INC.		**DATE STARTED:** 1/17/93	**COMPLTD:** 1/17/93
METHOD: H.S.A.	**CASE SIZE:** 2"	**SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 12.70 FT.	**MONITOR INST.:** N.A.	**TOT DPTH:** 15.5FT.	**DPTH TO ∇** 10.24 FT.
LOGGED BY: Larry Smith	**WELL DEVELOPMENT DATE:** N.A.		**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
					ORGANIC SOIL - dark brown, loamy (top 8")		OL		
							SM	Post-Hole	
5			70%		SAND - medium to fine, silty, tan to gray, laminated			8,8,5,8	
							SP		
10			50%		SAND - coarse to fine, laminated w/ shell stringers			5,15,18,13	∇
15									
					Boring Terminated at 15.5 feet				
20									
25									
30									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Mayport Naval Station, Mayport, FL		**LOG of WELL:** MPT-8-P3	**BORING NO.** MPT-8-P3
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 7533-84
CONTRACTOR: GROUNDWATER PROTECTION, INC.		**DATE STARTED:** 1/17/93	**COMPLTD:** 1/17/93
METHOD: H.S.A.	**CASE SIZE:** 2"	**SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 13.17 FT.	**MONITOR INST.:** N.A.	**TOT DPTH:** 15.5FT.	**DPTH TO ▽** 10.52 FT.
LOGGED BY: Felix Rizk	**WELL DEVELOPMENT DATE:** N.A.		**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN	WELL DATA
					ORGANIC SOIL - dark brown, loamy (top 4")		OL		
					SAND - coarse to fine, well-graded,tan, compacted		SP	Post-Hole	
5			70%		SAND - medium to fine, silty, tan, w/ shell fragments		SM	13,21,14,12	
10			60%		SAND - medium to fine, silty, tan			10,9,9,23	▽
15					Boring Terminated at 15.5 feet				
20									
25									
30									

 ABB ENVIRONMENTAL SERVICES, INC.

TITLE: Mayport Naval Station, Mayport, Fl.		**LOG of WELL:** MPT-8-P6	**BORING NO.** MPT-8-P6
CLIENT: SOUTHERN DIVISION, NAVFACENGCOM			**PROJECT NO:** 7533-84
CONTRACTOR: GROUNDWATER PROTECTION, INC.		**DATE STARTED:** 1/18/93	**COMPLTD:** 1/18/93
METHOD: H.S.A.	**CASE SIZE:** 2"	**SCREEN INT.:** 5-15'	**PROTECTION LEVEL:** D
TOC ELEV.: 14.87 FT.	**MONITOR INST.:** N.A.	**TOT DPTH:** 15.5FT.	**DPTH TO ∇** 7.72 FT.
LOGGED BY: Felix Rizk	**WELL DEVELOPMENT DATE:** N.A.		**SITE:** #8

DEPTH FT.	LABORATORY SAMPLE ID.	SAMPLE	RECOVERY	HEADSPACE (ppm)	SOIL/ROCK DESCRIPTION AND COMMENTS	LITHOLOGIC SYMBOL	SOIL CLASS	BLOWS/6-IN
					ORGANIC SOIL - dark brown, loamy (top 6") over		OL	
					SAND - fine, tan , w/ shell fragments		SP	
					SAND - fine, tan, moist			
5								
					Same as above			
10								
					SAND - fine, light gray, wet			
					SAND - fine, silty, dark gray, wet		SM	
					SILT - black, wet		ML	
15					SAND - fine, dark gray, wet		SP	
					Boring Terminated at 15.5 feet			
					Lithologic descriptions from drill cuttings			
20								
25								
30								

WELL DATA

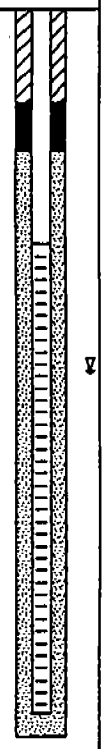

 ABB ENVIRONMENTAL SERVICES, INC.

APPENDIX B

FREE PRODUCT MEASUREMENTS AND PLUME DELINEATIONS

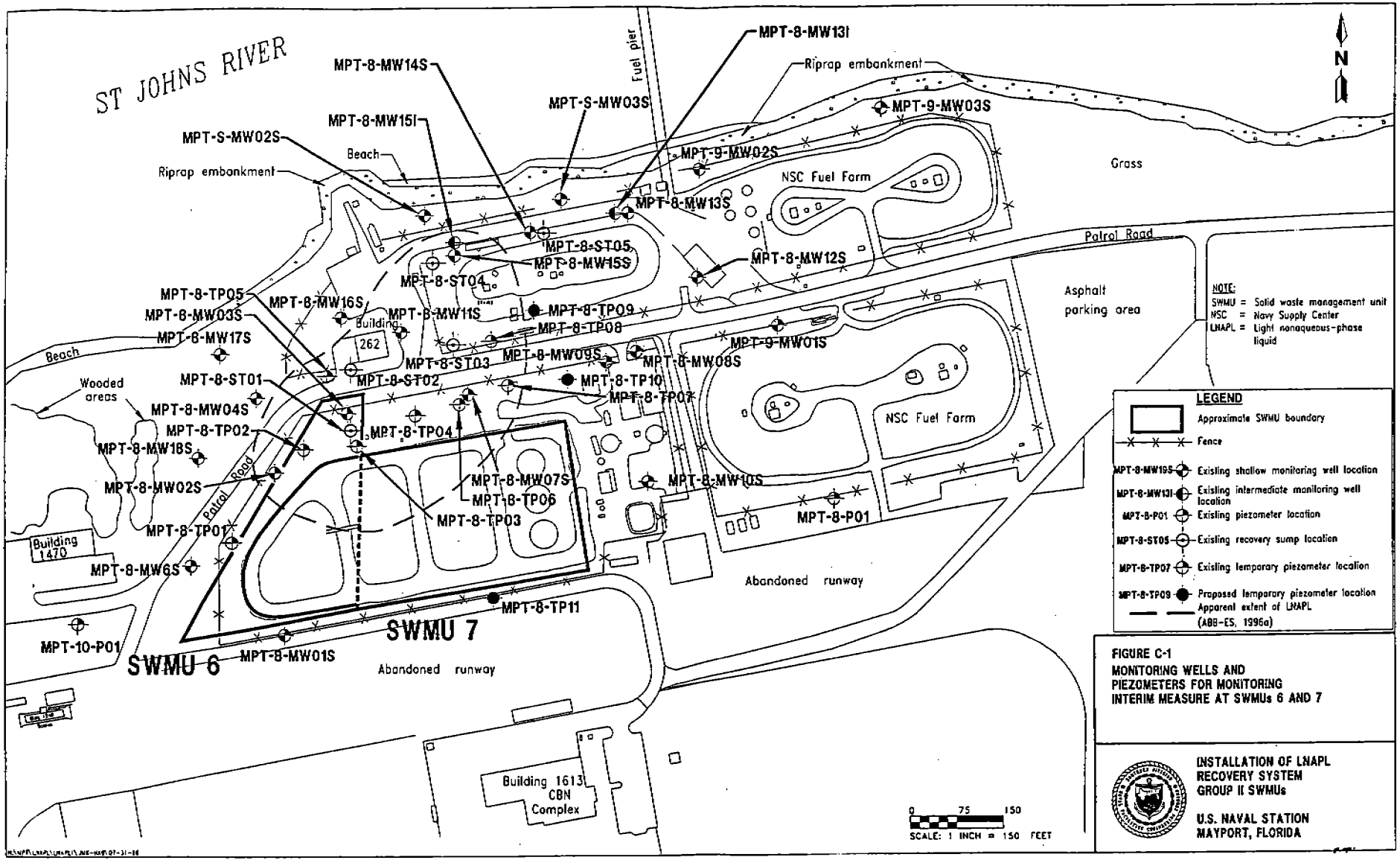

FIGURE C-1
MONITORING WELLS AND PIEZOMETERS FOR MONITORING INTERIM MEASURE AT SWMUs 6 AND 7

INSTALLATION OF LNAPL RECOVERY SYSTEM GROUP II SWMUs

U.S. NAVAL STATION MAYPORT, FLORIDA

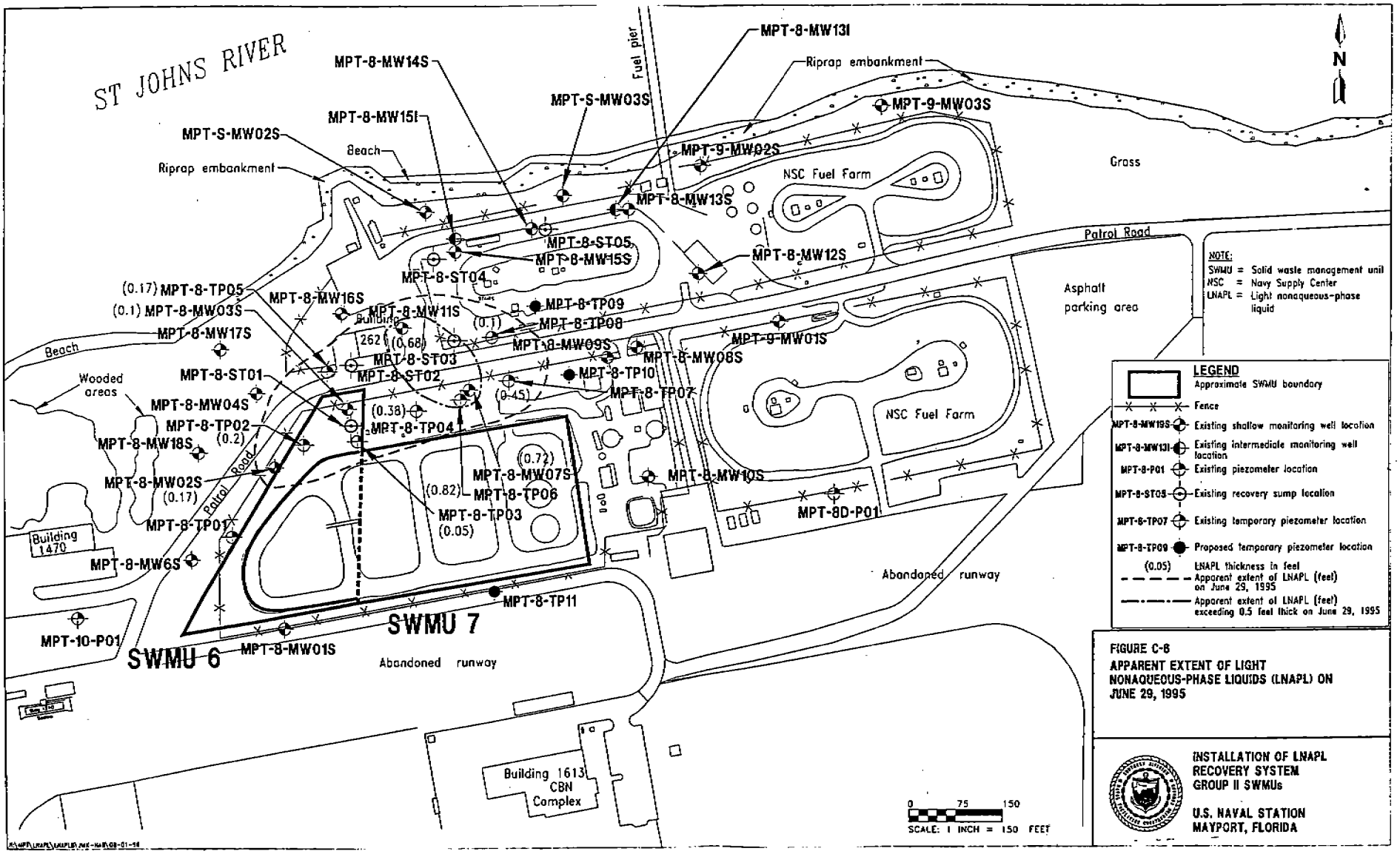

FIGURE C-8
APPARENT EXTENT OF LIGHT NONAQUEOUS-PHASE LIQUIDS (LNAPL) ON JUNE 29, 1995

INSTALLATION OF LNAPL RECOVERY SYSTEM
GROUP II SWMUs

U.S. NAVAL STATION
MAYPORT, FLORIDA

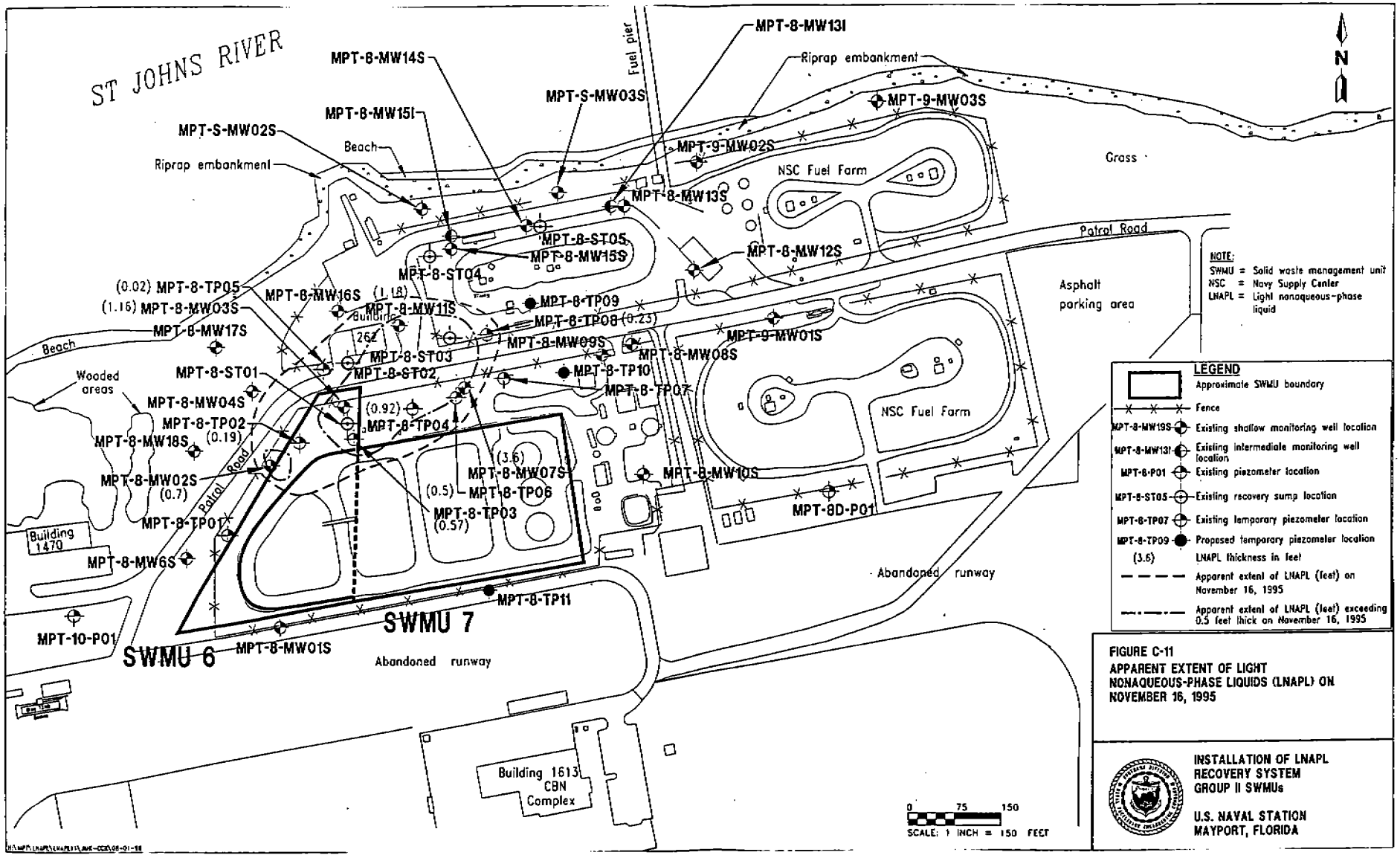

FIGURE C-11
APPARENT EXTENT OF LIGHT NONAQUEOUS-PHASE LIQUIDS (LNAPL) ON NOVEMBER 16, 1995

INSTALLATION OF LNAPL RECOVERY SYSTEM GROUP II SWMUs

U.S. NAVAL STATION MAYPORT, FLORIDA

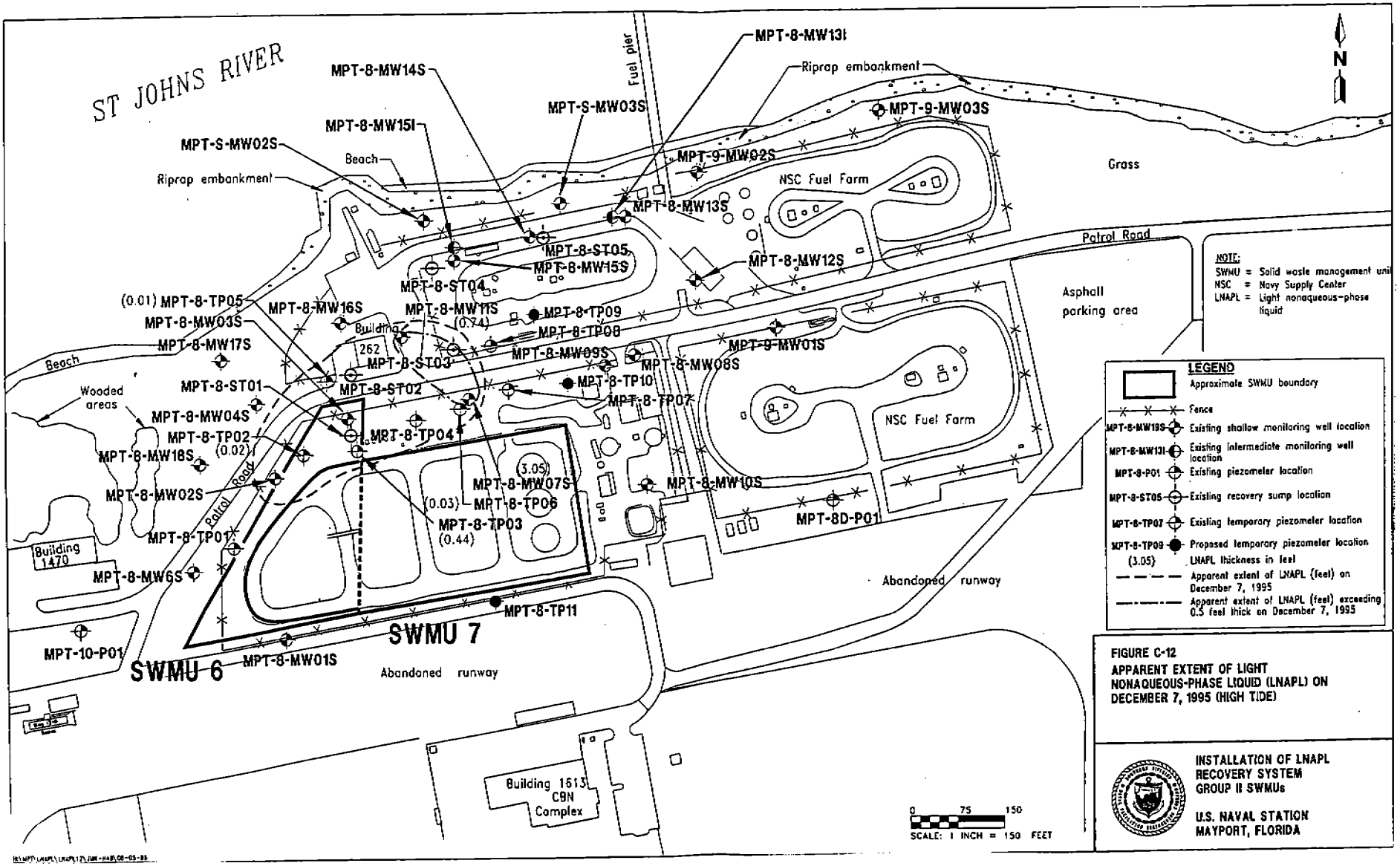

FIGURE C-12
APPARENT EXTENT OF LIGHT NONAQUEOUS-PHASE LIQUID (LNAPL) ON DECEMBER 7, 1995 (HIGH TIDE)

INSTALLATION OF LNAPL RECOVERY SYSTEM
GROUP II SWMUs

U.S. NAVAL STATION
MAYPORT, FLORIDA

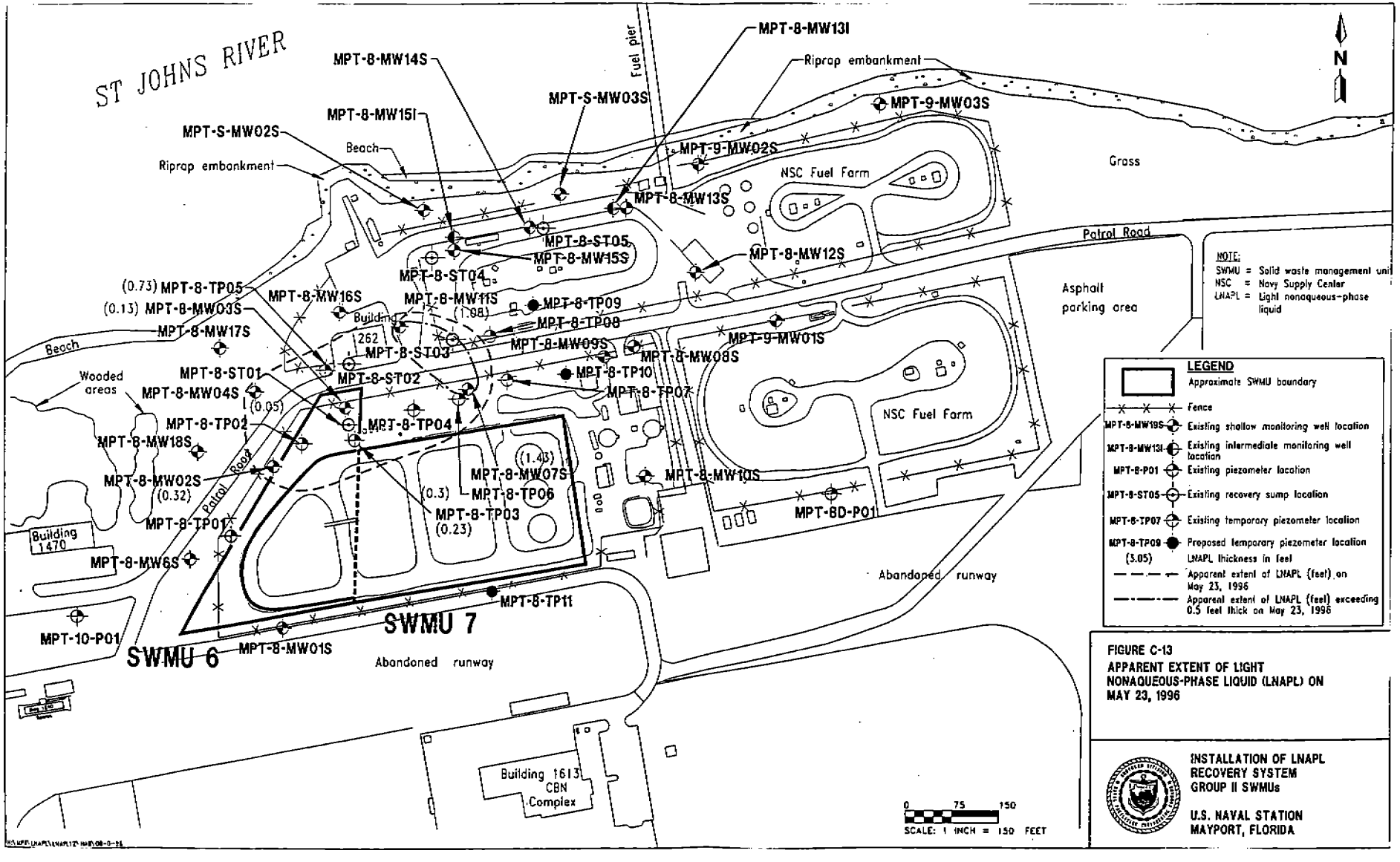

FIGURE C-13
APPARENT EXTENT OF LIGHT NONAQUEOUS-PHASE LIQUID (LNAPL) ON MAY 23, 1996

INSTALLATION OF LNAPL RECOVERY SYSTEM
GROUP II SWMUs

U.S. NAVAL STATION
MAYPORT, FLORIDA

DRAFT

Table 1
Estimated Groundwater Elevation and Apparent LNAPL Thickness on June 29, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-MW01S	2204730.6	366284.7	10.19	8.21	--	--	1.98
MPT-8-MW02S	2204968.2	366261.8	13.93	11.38	11.19	0.17	2.72
MPT-8-MW03S	2205069.4	366363.4	13.72	11.35	11.24	0.10	2.47
MPT-8-MW04S	2205098.3	366255	11.9	9.48	--	--	2.42
MPT-8-MW06S	2204828.9	366149.2	11.57	6.76	--	--	4.81
MPT-8-MW07S	2205103.2	366601.4	11.73	9.51	8.68	0.72	2.94
MPT-8-MW08S	2205160.8	366882.7	13.12	8.95	--	--	4.17
MPT-8-MW09S	2204961.3	366890.1	12.55	9.16	--	--	3.39
MPT-8-MW10S	2205154.0	366823.9	13.11	5.00	--	--	8.11
MPT-8-MW11S	2205203.6	366493.3	11.46	9.83	9.05	0.68	2.31
MPT-8-MW12S	2205289.8	366963.9	12.93	10.60	--	--	2.33
MPT-8-MW13S	2205390.0	366852.9	11.33	9.03	--	--	2.30
MPT-8-MW14S	2205362.1	366701.2	10.72	8.55	--	--	2.17
MPT-8-MW15S	2205227.2	366393.5	10.03	7.89	--	--	2.14
MPT-8-MW16S	2205227.2	366393.5	10.03	7.99	--	--	2.04
MPT-8-MW17S	2205125.4	366229.5	10.89	8.43	--	--	2.46

DRAFT

Table 1
Estimated Groundwater Elevation and Apparent LNAPL Thickness on June 29, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-MW18S	2205001.9	366161.4	8.8	6.20	--	--	2.60
MPT-8-TP01	2204912.6	366232.1	12.15	7.11	--	--	5.04
MPT-8-TP02	2205010.7	366304.9	10.61	7.92	7.90	0.02	2.71
MPT-8-TP03	2205026.6	366405.2	13.45	10.55	10.49	0.05	2.95
MPT-8-TP04	2205084.4	366462.3	14.88	12.80	12.36	0.38	2.46
MPT-8-TP05	2205153.2	366412.4	14.87	12.60	12.40	0.17	2.44
MPT-8-TP06	2205191.7	366617.4	15.66	13.75	13.15	0.52	2.43
MPT-8-TP07	2205099.1	366561.5	14.34	9.85	9.33	0.45	4.94
MPT-8-TP08	2205114.0	366661.6	14.65	10.95	10.94	0.01	3.71
MPT-9-MW01S	2205218.8	367081.4	14.42	12.00	--	--	2.42
MPT-9-MW02S	2205465.4	367012.3	13.39	11.21	--	--	2.18
MPT-9-MW03S	2205507.6	367183	11.53	9.49	--	--	2.04

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Table 1
Estimated Groundwater Elevation and Apparent LNAPL Thickness on June 29, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

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Table 2
Estimated Groundwater Elevation and Apparent LNAPL Thickness on August 4, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL	Elevation of Groundwater (feet, NGVD[4])
MPT-8-MW01S	2204730.6	366234.7	10.19	9.18	--	--	1.01
MPT-8-MW02S	2204968.2	366261.8	13.93	11.71	--	--	2.22
MPT-8-MW03S	2205069.4	366363.4	13.72	12.99	11.88	0.97	1.70
MPT-8-MW04S	2205098.3	366255.0	11.9	10.24	--	--	1.66
MPT-8-MW06S	2204828.9	366149.2	11.57	7.50	--	--	4.07
MPT-8-MW08S	2205160.8	366882.7	13.12	9.10	--	--	4.02
MPT-8-MW09S	2204961.3	366890.1	12.55	9.61	--	--	2.94
MPT-8-MW10S	2205154.0	366823.9	13.11	5.98	--	--	7.13
MPT-8-MW11S	2205203.6	366493.3	11.46	10.72	9.55	1.02	1.76
MPT-8-MW12S	2205289.8	366969.9	12.93	11.07	--	--	1.86
MPT-8-MW13I	2205390.0	366852.9	11.33	10.12	--	--	1.21
MPT-8-MW13S	2205390.0	366852.9	11.33	9.72	--	--	1.61
MPT-8-MW14S	2205362.1	366701.2	10.72	9.14	--	--	1.58
MPT-8-MW15I	2205346.6	366578.6	9.96	8.57	--	--	1.39
MPT-8-MW15S	2205227.2	366393.5	10.03	8.42	--	--	1.61
MPT-8-MW16S	2205227.2	366393.5	10.03	8.73	--	--	1.30
MPT-8-MW17S	2205125.4	366229.5	10.89	9.37	--	--	1.52

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Table 2
Estimated Groundwater Elevation and Apparent LNAPL Thickness on August 4, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL	Elevation of Groundwater (feet, NGVD[4])
MPT-8-MW18S	2205001.9	366161.4	8.8	6.72	--	--	2.08
MPT-8-TP01	2204912.6	366232.1	12.15	7.70	--	--	4.45
MPT-8-TP02	2205010.7	366304.9	10.61	8.74	--	--	1.87
MPT-8-TP03	2205026.6	366405.2	13.45	11.23	11.21	0.02	2.24
MPT-8-TP04	2205084.4	366462.3	14.88	13.56	12.82	0.64	1.96
MPT-8-TP05	2205153.2	366412.4	14.87	13.27	13.15	0.10	1.70
MPT-8-TP06	2205191.7	366617.4	15.66	14.00	13.73	0.23	1.89
MPT-8-TP07	2205099.1	366561.5	14.34	10.27	9.90	0.32	4.39
MPT-8-TP08	2205114.0	366661.6	14.65	12.01	--	--	2.64
MPT-9-MW01S	2205218.8	367081.4	14.42	12.36	--	--	2.06
MPT-9-MW02S	2205465.4	367012.3	13.39	12.04	--	--	1.35
MPT-9-MW03S	2205507.6	367183.0	11.53	10.38	--	--	1.15
MPT-S-MW03S	2205411.6	366783.9	11.9	10.25	--	--	1.65
MPT-8-ST02	2205239.2	366750.2	14.34	13.11	--	--	1.23
MPT-8-ST05	2205209.0	366869.7	13.46	15.04	--	--	-1.58

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Table 2
Estimated Groundwater Elevation and Apparent LNAPL Thickness on August 4, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL	Elevation of Groundwater (feet, NGVD[4])
	North	East					

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

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Table 3
Estimated Groundwater Elevation and Apparent LNAPL Thickness on August 8, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
MPT-8-MW01S	2204730.6	366284.7	10.19	9.24	--	--	0.95
MPT-8-MW04S	2205098.3	366255.0	11.9	9.78	--	--	2.12
MPT-8-MW06S	2204828.9	366149.2	11.57	7.80	--	--	3.77
MPT-8-MW08S	2205160.8	366882.7	13.12	9.34	--	--	3.78
MPT-8-MW09S	2204961.3	366890.1	12.55	9.84	--	--	2.71
MPT-8-MW10S	2205154.0	366823.9	13.11	6.12	--	--	6.99
MPT-8-MW12S	2205289.8	366969.9	12.93	11.08	--	--	1.85
MPT-8-MW13I	2205390.0	366852.9	11.33	9.51	--	--	1.82
MPT-8-MW13S	2205390.0	366852.9	11.33	9.36	--	--	1.97
MPT-8-MW14S	2205362.1	366701.2	10.72	8.88	--	--	1.84
MPT-8-MW15I	2205346.6	366578.6	9.96	8.10	--	--	1.86
MPT-8-MW15S	2205227.2	366393.5	10.03	8.25	--	--	1.78
MPT-8-MW16S	2205227.2	366393.5	10.03	8.38	--	--	1.65
MPT-8-MW17S	2205125.4	366229.5	10.89	8.60	--	--	2.29
MPT-8-MW18S	2205001.9	366161.4	8.8	6.73	--	--	2.07
MPT-8-TP01	2204912.6	366232.1	12.15	7.95	--	--	4.20

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Table 3
Estimated Groundwater Elevation and Apparent LNAPL Thickness on August 8, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-TP03	2205026.6	366405.2	13.45	11.37	11.27	0.09	2.17
MPT-9-MW01S	2205218.8	367081.4	14.42	12.50	--	--	1.92
MPT-9-MW02S	2205465.4	367012.3	13.39	11.32	--	--	2.07
MPT-9-MW03S	2205507.6	367183.0	11.53	9.58	--	--	1.95
MPT-9-P01S	2205413.6	367665.5	12.22	10.15	--	--	2.07

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

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Table 4
Estimated Groundwater Elevation and Apparent LNAPL Thickness on November 15, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
MPT-8-MW01S	2204730.6	366284.7	10.19	8.40	--	--	1.79
MPT-8-MW02S	2204968.2	366261.8	13.93	11.84	11.27	0.50	2.59
MPT-8-MW03S	2205069.4	366363.4	13.72	11.61	11.26	0.30	2.41
MPT-8-MW04S	2205098.3	366255.0	11.9	9.61	--	--	2.29
MPT-8-MW06S	2204828.9	366149.2	11.57	7.44	--	--	4.13
MPT-8-MW07S	2205103.2	366601.4	11.73	12.71	8.46	3.70	2.72
MPT-8-MW08S	2205160.8	366882.7	13.12	8.41	--	--	4.71
MPT-8-MW09S	2204961.3	366890.1	12.55	8.96	--	--	3.59
MPT-8-MW10S	2205154.0	366823.9	13.11	4.75	--	--	8.36
MPT-8-MW11S	2205203.6	366493.3	11.46	10.01	9.10	0.79	2.24
MPT-8-MW12S	2205289.8	366969.9	12.93	10.62	--	--	2.31
MPT-8-MW13S	2205390.0	366852.9	11.33	9.07	--	--	2.26
MPT-8-MW14S	2205362.1	366701.2	10.72	8.58	--	--	2.14
MPT-8-MW15S	2205227.2	366393.5	10.03	7.94	--	--	2.09
MPT-8-MW16S	2205227.2	366393.5	10.03	8.03	--	--	2.00
MPT-8-MW17S	2205125.4	366229.5	10.89	8.57	--	--	2.32

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Table 4
Estimated Groundwater Elevation and Apparent LNAPL Thickness on November 15, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-MW18S	2205001.9	366161.4	8.8	6.41	--	--	2.39
MPT-8-TP01	2204912.6	366232.1	12.15	7.61	--	--	4.54
MPT-8-TP02	2205010.7	366304.9	10.61	8.12	7.95	0.15	2.64
MPT-8-TP03	2205026.6	366405.2	13.45	11.07	10.57	0.44	2.82
MPT-8-TP04	2205084.4	366462.3	14.88	12.92	12.38	0.47	2.43
MPT-8-TP05	2205153.2	366412.4	14.87	12.49	12.45	0.03	2.41
MPT-8-TP06	2205191.7	366617.4	15.66	13.87	13.16	0.62	2.41
MPT-8-TP07	2205099.1	366561.5	14.34	10.85	--	--	3.49
MPT-8-TP08	2205114.0	366661.6	14.65	10.76	10.43	0.29	4.18
MPT-9-MW01S	2205218.8	367081.4	14.42	12.04	--	--	2.38
MPT-9-MW02S	2205465.4	367012.3	13.39	11.29	--	--	2.10
MPT-9-MW03S	2205507.6	367183.0	11.53	9.59	--	--	1.94
MPT-9-P01S	2205413.6	367665.5	12.22	9.98	--	--	2.24
MPT-8-ST01	2205329.5	366695.2	13.06	10.71	10.69	0.02	2.37
MPT-8-ST02	2205239.2	366750.2	14.34	12.06	12.02	0.03	2.31
MPT-8-ST03	2205082.7	366687.2	15.12	12.82	--	--	2.30

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Table 4
Estimated Groundwater Elevation and Apparent LNAPL Thickness on November 15, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-ST04	2205037.6	366818.3	11.91	9.82	--	--	2.09
MPT-8-ST05	2205209.0	366869.7	13.46	11.42	--	--	2.04

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

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Table 5
Estimated Groundwater Elevation and Apparent LNAPL Thickness on November 16, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
MPT-8-MW01S	2204730.6	366284.7	10.19	8.48	--	--	1.71
MPT-8-MW02S	2204968.2	366261.8	13.93	12.37	11.57	0.70	2.26
MPT-8-MW03S	2205069.4	366363.4	13.72	12.88	11.55	1.16	2.00
MPT-8-MW04S	2205098.3	366255.0	11.9	10.20	--	--	1.70
MPT-8-MW06S	2204828.9	366149.2	11.57	7.57	--	--	4.00
MPT-8-MW07S	2205103.2	366601.4	11.73	12.97	8.83	3.60	2.36
MPT-8-MW08S	2205160.8	366882.7	13.12	8.46	--	--	4.66
MPT-8-MW09S	2204961.3	366890.1	12.55	9.15	--	--	3.40
MPT-8-MW10S	2205154.0	366823.9	13.11	4.82	--	--	8.29
MPT-8-MW11S	2205203.6	366493.3	11.46	10.75	9.39	1.18	1.89
MPT-8-MW12S	2205289.8	366969.9	12.93	10.97	--	--	1.96
MPT-8-MW13I	2205390.0	366852.9	11.33	9.94	--	--	1.39
MPT-8-MW13S	2205390.0	366852.9	11.33	9.68	--	--	1.65
MPT-8-MW14S	2205362.1	366701.2	10.72	9.11	--	--	1.61
MPT-8-MW15I	2205346.6	366578.6	9.96	8.48	--	--	1.48
MPT-8-MW15S	2205227.2	366393.5	10.03	8.40	--	--	1.63

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Table 5
Estimated Groundwater Elevation and Apparent LNAPL Thickness on November 16, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
MPT-8-MW16S	2205227.2	366393.5	10.03	8.68	--	--	1.35
MPT-8-MW17S	2205125.4	366229.5	10.89	9.44	--	--	1.45
MPT-8-MW18S	2205001.9	366161.4	8.8	6.65	--	--	2.15
MPT-8-TP01	2204912.6	366232.1	12.15	7.68	--	--	4.47
MPT-8-TP02	2205010.7	366304.9	10.61	8.56	8.34	0.19	2.24
MPT-8-TP03	2205026.6	366405.2	13.45	11.55	10.89	0.57	2.47
MPT-8-TP04	2205084.4	366462.3	14.88	13.69	12.63	0.92	2.11
MPT-8-TP05	2205153.2	366412.4	14.87	12.99	12.97	0.02	1.90
MPT-8-TP06	2205191.7	366617.4	15.66	14.11	13.53	0.50	2.05
MPT-8-TP08	2205114.0	366661.6	14.65	10.95	10.69	0.23	3.93
MPT-9-MW01S	2205218.8	367081.4	14.42	12.19	--	--	2.23
MPT-9-MW02S	2205465.4	367012.3	13.39	12.06	--	--	1.33
MPT-9-MW03S	2205507.6	367183.0	11.53	10.40	--	--	1.13
MPT-S-MW03S	2205411.6	366783.9	11.9	10.36	--	--	1.54
MPT-8-ST01	2205329.5	366695.2	13.06	10.80	10.71	0.08	2.34
MPT-8-ST02	2205239.2	366750.2	14.34	12.36	12.30	0.05	2.03

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Table 5
Estimated Groundwater Elevation and Apparent LNAPL Thickness on November 16, 1995

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-ST03	2205082.7	366687.2	15.12	12.92	--	--	2.20
MPT-8-ST04	2205037.6	366818.3	11.91	10.20	--	--	1.71
MPT-8-ST05	2205209.0	366869.7	13.46	11.61	--	--	1.85

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

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Table 6
Estimated Groundwater Elevation and Apparent LNAPL Thickness on December 7, 1995; 0841 hours (high tide)

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-8-MW07S	2205103.2	366601.4	11.73	12.51	9.00	3.05	2.27
MPT-8-MW11S	2205203.6	366493.3	11.46	10.12	9.27	0.74	2.08
MPT-8-MW16S	2205227.2	366393.5	10.03	8.22	--	--	1.81
MPT-8-MW17S	2205125.4	366229.5	10.89	8.76	--	--	2.13
MPT-8-TP01	2204912.6	366232.1	12.15	8.02	--	--	4.13
MPT-8-TP02	2205010.7	366304.9	10.61	8.27	8.25	0.02	2.36
MPT-8-TP03	2205026.6	366405.2	13.45	11.65	11.15	0.44	2.24
MPT-8-TP05	2205153.2	366412.4	14.87	12.80	12.79	0.01	2.08
MPT-8-TP06	2205191.7	366617.4	15.66	13.67	13.64	0.03	2.02
MPT-8-TP07	2205099.1	366561.5	14.34	10.85	--	--	3.49
MPT-8-TP08	2205114.0	366661.6	14.65	11.60	--	--	3.05

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

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Table 7
Estimated Groundwater Elevation and Apparent LNAPL Thickness on December 7, 1995 at 1442 hours (low tide)

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1] North	Coordinate[1] East	Measuring Point Elevation (feet, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwter (feet, NGVD[4])
MPT-8-MW07S	2205103.2	366601.4	11.73	12.65	9.3	2.91	1.99
MPT-8-MW11S	2205203.6	366493.3	11.46	11	9.62	1.20	1.66
MPT-8-MW16S	2205227.2	366393.5	10.03	8.85	--	--	1.18
MPT-8-MW17S	2205125.4	366229.5	10.89	9.42	--	--	1.47
MPT-8-TP01	2204912.6	366232.1	12.15	8.02	--	--	4.13
MPT-8-TP02	2205010.7	366304.9	10.61	8.5	--	--	2.11
MPT-8-TP03	2205026.6	366405.2	13.45	11.85	11.2	0.57	2.17
MPT-8-TP05	2205153.2	366412.4	14.87	13.25	--	--	1.62
MPT-8-TP06	2205191.7	366617.4	15.66	14.03	13.85	0.16	1.79
MPT-8-TP07	2205099.1	366561.5	14.34	10.88	--	--	3.46
MPT-8-TP08	2205114.0	366661.6	14.65	11.78	--	--	2.87

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

DRAFT

Table 8
Estimated Groundwater Elevation and Apparent LNAPL Thickness on May 23, 1996

U.S. Naval Station
Mayport, Florida

Location Identifier	Coordinate[1]		Measuring Point Elevation (ft, NGVD[2])	Depth to Groundwater (feet)	Depth to LNAPL (feet)	Apparent Thickness[3] of LNAPL (feet)	Elevation of Groundwater (feet, NGVD[4])
	North	East					
MPT-16-MW02S	2205468.0	367483.2	10.65	9.75	9.15	0.52	1.42
MPT-16-MW03S	2205439.1	367599.1	11.19	9.98	--	--	1.21
MPT-S-MW01S	2206144.0	368038.0	14.59	4.41	--	--	10.18
MPT-S-MW03S	2205411.6	366783.9	11.9	10.69	--	--	1.21

Notes: [1] = State Plane Coordinate System, 1983.
[2] = Elevation relative to the National Geodetic Vertical Datum (NGVD) of 1929. (NGVD, 1929).
[3] = Thickness is the difference between the depth to the light nonaqueous phase liquid (LNAPL) and depth to the groundwater level multiplied by a specific gravity of 0.87 (ABB-ES, 1994).
[4] = Where LNAPL is present, the groundwater elevation relative to the NGVD of 1929 includes the thickness of the LNAPL.

LNAPL = light nonaqueous phase liquid
-- = LNAPL not determined to be present, therefore, LNAPL thickness not determined.

APPENDIX C

LABORATORY ANALYTICAL REPORTS

WORK ORDER #: 9607223

Work Order Summary

CLIENT: Mr. Chris Coonfare
Battelle Memorial Institute
505 King Avenue
Columbus, OH 43201

BILL TO: Same

PHONE: 614-424-5481
FAX: 614-424-3667
DATE RECEIVED: 7/23/96
DATE COMPLETED:

INVOICE #
P.O. # 121606
PROJECT # G337311-13 MAYPORT
AMOUNT$: $1,055.06

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	Stack Pre-Carbon 1	TO-3	3.5 "Hg	$156.25
02A	Stack Pre-Carbon 2	TO-3	1.5 "Hg	$156.25
03A	Stack Pre-Carbon 3	TO-3	1.0 "Hg	$156.25
04A	Stack Pre-Carbon 4	TO-3	1.0 "Hg	$156.25
05A	Stack Pre-Carbon 5	TO-3	1.5 "Hg	$156.25
06A	Post-Carbon 1	TO-3	1.0 "Hg	$156.25
07A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter Summa Canister Preparation (6) @ $15.00 each.	$90.00
	Shipping (7/3/96)	$27.56

PRELIMINARY

LAB NARRATIVE:
A 25% surcharge is applied for 48 hour turnaround time.

CERTIFIED BY: Melissa E. Mgo/s for Laboratory Director

DATE: 7-25-96

AIR TOXICS LTD.

SAMPLE NAME: Stack Pre-Carbon 1
ID#: 9607223-01A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6072315 Date of Collection: 7/10/96
Dil. Factor: 5.72 Date of Analysis: 7/23/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.006	0.019	0.16	0.52
Toluene	0.006	0.022	0.61	2.3
Ethyl Benzene	0.006	0.025	0.17	0.75
Total Xylenes	0.006	0.025	0.87	3.8

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6072315 Date of Collection: 7/10/96
Dil. Factor: 5.72 Date of Analysis: 7/23/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.057	0.37	75	490
C2 - C4** Hydrocarbons	0.057	0.10	0.12	0.22

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Stack Pre-Carbon 2
ID#: 9607223-02A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6072316 Date of Collection: 7/12/96
Dil. Factor: 4.70 Date of Analysis: 7/23/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.005	0.015	0.19	0.62
Toluene	0.005	0.018	0.68	2.6
Ethyl Benzene	0.005	0.021	0.25	1.1
Total Xylenes	0.005	0.021	0.97	4.3

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6072316 Date of Collection: 7/12/96
Dil. Factor: 4.70 Date of Analysis: 7/23/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.047	0.30	96	620
C2 - C4** Hydrocarbons	0.047	0.086	0.24	0.44

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Stack Pre-Carbon 3
ID#: 9607223-03A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6072408 Date of Collection: 7/15/96
Dil. Factor: 7.46 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.007	0.024	0.17	0.55
Toluene	0.007	0.029	0.44	1.7
Ethyl Benzene	0.007	0.033	0.44	1.9
Total Xylenes	0.007	0.033	1.4	6.2

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6072408 Date of Collection: 7/15/96
Dil. Factor: 7.46 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.075	0.48	210	1400
C2 - C4** Hydrocarbons	0.075	0.14	0.33	0.60

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Stack Pre-Carbon 4
ID#: 9607223-04A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/FID

File Name: 6072409 Date of Collection: 7/19/96
Dil. Factor: 8.71 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.009	0.028	0.24	0.78
Toluene	0.009	0.033	0.46	1.8
Ethyl Benzene	0.009	0.038	0.58	2.6
Total Xylenes	0.009	0.038	1.6	7.1

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6072409 Date of Collection: 7/19/96
Dil. Factor: 8.71 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.087	0.56	250	1600
C2 - C4** Hydrocarbons	0.087	0.16	0.35	0.64

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Stack Pre-Carbon 5
ID#: 9607223-05A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6072410 Date of Collection: 7/22/96
Dil. Factor: 88.8 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.089	0.29	1.3	4.2
Toluene	0.089	0.34	2.3	8.8
Ethyl Benzene	0.089	0.39	7.3	32
Total Xylenes	0.089	0.39	12	53

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6072410 Date of Collection: 7/22/96
Dil. Factor: 88.8 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.89	5.8	1600	10000
C2 - C4** Hydrocarbons	0.89	1.6	17	31

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Post-Carbon 1
ID#: 9607223-06A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/PID

File Name: 60712411 Date of Collection: 7/19/96
Dil. Factor: 5.22 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.005	0.017	0.046	0.15
Toluene	0.005	0.020	0.29	1.1
Ethyl Benzene	0.005	0.023	0.044	0.19
Total Xylenes	0.005	0.023	0.18	0.79

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 60712411 Date of Collection: 7/19/96
Dil. Factor: 5.22 Date of Analysis: 7/24/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.052	0.34	56	360
C2 - C4** Hydrocarbons	0.052	0.095	0.17	0.31

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter Summa Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank
ID#: 960723-07A

EPA METHOD TO-3
(Aromatic Volatile Organics in Air)

GC/FID

File Name: 6072313 Date of Collection: NA
Dil. Factor: 1.00 Date of Analysis: 7/23/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name: 6072313 Date of Collection: NA
Dil. Factor: 1.00 Date of Analysis: 7/23/96

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)
**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

Report of Analytical Results

Client Sample ID: MATPORTA
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/19/96 (Friday)
Date Received: 07/24/96 (Wednesday)
Date Extracted: 07/24/96 (Wednesday)
Date Analyzed: 07/24/96 (Wednesday)

Lab Reference No: R8883
Lab Sample ID: R8883C01

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	7.4	mg/L	0.50
Decanane-$$	629-97-0	76	%rec	

(3679)

Report of Analytical Results

Client Sample ID: MATPORT5
Sample Description: GRAB
Sample Matrix: water
Dilution: 5.00

Date Collected: 07/22/96 (Monday)
Date Received: 07/24/96 (Wednesday)
Date Extracted: 07/24/96 (Wednesday)
Date Analyzed: 07/25/96 (Thursday)

Lab Reference No: R8683
Lab Sample ID: R8683002

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	23	mg/L	2.3
Decosane-SS	629-97-0	88	%rec	

(5679)

6

Report of Analytical Results

Client Sample ID: MAYPORT4
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/19/96 (Friday)
Date Received: 07/24/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/24/96 (Wednesday)

Lab Reference No: R6883
Lab Sample ID: R6883001

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	N/A	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	102	%rec	
Bromofluorobenzene - SS	460-00-4	100	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	99	%rec	

(5678)

Report of Analytical Results

Client Sample ID: MAYPORT5
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/22/96 (Monday)
Date Received: 07/24/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/24/96 (Wednesday)

Lab Reference No: RB883
Lab Sample ID: RB883002

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	N/A	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	100	%rec	
Bromofluorobenzene - SS	460-00-4	105	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	104	%rec	

(5678)

Report of Analytical Results

Client Sample ID: TRIPBLANK
Sample Description: None
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/22/96 (Monday)
Date Received: 07/24/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/25/96 (Thursday)

Lab Reference No: R8883
Lab Sample ID: R8883003

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	N/A	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	102	%rec	
Bromofluorobenzene - SS	460-00-4	97	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	91	%rec	

(5678)

Report of Analytical Results

Client Sample ID: MAYPORT1
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/12/96 (Friday)
Date Received: 07/17/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/18/96 (Thursday)

Lab Reference No: R8851
Lab Sample ID: R8851001

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
NS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	1330-20-7	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	101	%rec	
Bromofluorobenzene - SS	460-00-4	99	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	105	%rec	

(3674)

Report of Analytical Results

Client Sample ID: MATPORT1
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/12/96 (Friday)
Date Received: 07/17/96 (Wednesday)
Date Extracted: 07/18/96 (Thursday)
Date Analyzed: 07/19/96 (Friday)

Lab Reference No: R8051
Lab Sample ID: R8051001

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	7.3	mg/L	0.50
Decanoic Acid	629-97-0	75	%rec	

(5676)

Report of Analytical Results

Client Sample ID: MAYPCRT2
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/14/96 (Sunday)
Date Received: 07/17/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/18/96 (Thursday)

Lab Reference No: R8251
Lab Sample ID: R8251002

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	1330-20-7	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	103	%rec	
Bromofluorobenzene - SS	460-00-4	102	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	105	%rec	

(5674)

Report of Analytical Results

Client Sample ID: MAYPORT2
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/14/96 (Sunday)
Date Received: 07/17/96 (Wednesday)
Date Extracted: 07/18/96 (Thursday)
Date Analyzed: 07/19/96 (Friday)

Lab Reference No: R8851
Lab Sample ID: R8851002

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	3.9	mg/L	0.50
Docosane-S8	629-97-0	82	%rec	

(5676)

Report of Analytical Results

Client Sample ID: NAYPORT3
Sample Description: GRAB
Sample Matrix: Water
Dilution: 1.00

Date Collected: 07/15/96 (Monday)
Date Received: 07/17/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/18/96 (Thursday)

Lab Reference No: N8851
Lab Sample ID: N8851003

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
NS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	1330-20-7	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	105	%rec	
Bromofluorobenzene - SS	460-00-4	99	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	108	%rec	

(5674)

Report of Analytical Results

Client Sample ID: MAYPORT3
Sample Description: GRAB
Sample Matrix: Water
Dilution: 2.00

Date Collected: 07/15/96 (Monday)
Date Received: 07/17/96 (Wednesday)
Date Extracted: 07/18/96 (Thursday)
Date Analyzed: 07/19/96 (Friday)

Lab Reference No: H8851
Lab Sample ID: H8851003

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	14	mg/L	1.0
Decosane-RS	629-97-0	70	%rec	

(5676)

Report of Analytical Results

Client Sample ID: M0718W01-BLK
Sample Description: None
Sample Matrix: Water
Dilution: 1.00

Date Collected: None
Date Received: None
Date Extracted: None
Date Analyzed: 07/18/96 (Thursday)

Lab Reference No: LABQC
Lab Sample ID: M0718W01-BLK

Analytical Parameter	CAS or Stored Number	Result	Units	Reporting Level
NS VOLATILES				
Benzene	71-43-2	5 U	ug/L	5
Toluene	108-88-3	5 U	ug/L	5
Ethylbenzene	100-41-4	5 U	ug/L	5
Xylene (total)	1330-20-7	5 U	ug/L	5
Toluene-d8 - SS	2037-26-5	103	%rec	
Bromofluorobenzene - SS	460-00-4	98	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	98	%rec	

(5474)

Report of Analytical Results

Client Sample ID: DWB10718
Sample Description: None
Sample Matrix: Water
Dilution: 1.00

Date Collected: None
Date Received: None
Date Extracted: 07/18/96 (Thursday)
Date Analyzed: 07/18/96 (Thursday)

Lab Reference No: LABOC
Lab Sample ID: DWB10718

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	0.50 U	mg/L	0.50
Docosane-SS	629-97-0	83	%rec	

(3676)

Report of Analytical Results

Client Sample ID: M0718W01-LCS
Sample Description: None
Sample Matrix: Water
Dilution: 1.00

Date Collected: None
Date Received: None
Date Extracted: None
Date Analyzed: 07/18/96 (Thursday)

Lab Reference No: LABQC
Lab Sample ID: M0718W01-LCS

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	92	%rec	
Toluene	108-88-3	98	%rec	
Toluene-d8 - SS	2037-26-5	102	%rec	
Bromofluorobenzene - SS	460-00-4	98	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	95	%rec	

(5674)

GC TPH DIESEL
Lab Reference No./SDG: R8851
Page 2

CASE NARRATIVE
Addendum

Sample Information

LAB SAMPLE ID	CLIENT SAMPLE ID	SAMPLE MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	SAMPLE pH[1]
R8851001	MAYPORT1	WATER	07/12/96	07/18/96	07/19/96	N/A
R8851002	MAYPORT2	WATER	07/14/96	07/18/96	07/19/96	N/A
R8851003	MAYPORT3	WATER	07/15/96	07/18/96	07/19/96	N/A
DWB10718	DWB10718	WATER	N/A	07/18/96	07/18/96	N/A

[1] Applies to samples designated for purgeable VOA analysis only.
1

Quality Analytical Laboratories Inc.
5090 Caterpillar Road,
Redding, CA 96003-1417
916 244-5227
Fax No. 916 244-4109

Report of Analytical Results

Client Sample ID: NPC 6-6.5
Sample Description: None
Sample Matrix: Soil
Dilution: 1.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/05/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/06/96 (Saturday)

Lab Reference No: 98804
Lab Sample ID: R9804001

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	6 U	ug/Kg	6
Toluene	108-88-3	17	ug/Kg	6
Ethylbenzene	100-41-4	6 U	ug/Kg	6
Xylene (total)	N/A	6 U	ug/Kg	6
Toluene-d8 - SS	2037-26-5	101	%rec	
Bromofluorobenzene - SS	460-00-4	108	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	110	%rec	

(5875)

Report of Analytical Results

Client Sample ID: MPC 6-6.5
Sample Description: None
Sample Matrix: Soil
Dilution: 5.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: 07/08/96 (Monday)
Date Analyzed: 07/15/96 (Monday)

Lab Reference No: R8804
Lab Sample ID: R8804001

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	150	mg/Kg	50
Docosane-SS	629-97-0	67	%rec	

(5831)

Report of Analytical Results

Client Sample ID: MPC 7-7.5
Sample Description: None
Sample Matrix: Soil
Dilution: 125.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/07/96 (Sunday)

Lab Reference No: RB804
Lab Sample ID: RB804002

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
NS VOLATILES				
Benzene	71-43-2	680 U	ug/Kg	680
Toluene	108-88-3	230 J	ug/Kg	680
Ethylbenzene	100-41-4	680 U	ug/Kg	680
Xylene (total)	N/A	680 U	ug/Kg	680
Toluene-d8 - SS	2037-26-5	100	%rec	
Bromofluorobenzene - SS	460-00-4	107	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	117	%rec	

(5879)

Report of Analytical Results

Client Sample ID: MPC 7-7.5
Sample Description: None
Sample Matrix: Soil
Dilution: 50.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: 07/08/96 (Monday)
Date Analyzed: 07/16/96 (Tuesday)

Lab Reference No: R8804
Lab Sample ID: R8804002

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	4300	mg/Kg	500
Docosane-SS	629-97-0	ND	%rec	

(5831)

Report of Analytical Results

Client Sample ID: MPC 8-8.5
Sample Description: None
Sample Matrix: Soil
Dilution: 125.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/07/96 (Sunday)

Lab Reference No: R8804
Lab Sample ID: R8804003

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	720 U	ug/Kg	720
Toluene	108-88-3	180 J	ug/Kg	720
Ethylbenzene	100-41-4	720 U	ug/Kg	720
Xylene (total)	N/A	720 U	ug/Kg	720
Toluene-d8 - SS	2037-26-5	100	%rec	
Bromofluorobenzene - SS	460-00-4	107	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	119	%rec	

(5875)

Report of Analytical Results

Client Sample ID: MPC B-8.5
Sample Description: None
Sample Matrix: Soil
Dilution: 50.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: 07/08/96 (Monday)
Date Analyzed: 07/16/96 (Tuesday)

Lab Reference No: R8804
Lab Sample ID: R8804003

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	2100	mg/Kg	500
Docosane-SS	629-97-0	N.D	%rec	

(5831)

Report of Analytical Results

Client Sample ID: MPC 9-9.5
Sample Description: None
Sample Matrix: Soil
Dilution: 125.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: None
Date Analyzed: 07/07/96 (Sunday)

Lab Reference No: RB804
Lab Sample ID: RB804004

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	780 U	ug/Kg	780
Toluene	108-88-3	780 U	ug/Kg	780
Ethylbenzene	100-41-4	780 U	ug/Kg	780
Xylene (total)	N/A	780 U	ug/Kg	780
Toluene-d8 - SS	2037-26-5	101	%rec	
Bromofluorobenzene - SS	460-00-4	112	%rec	
1,2-Dichloroethane-d4 - SS	17060-07-0	123	%rec	

(5875)

Report of Analytical Results

Client Sample ID: MPC 9-9.5
Sample Description: None
Sample Matrix: Soil
Dilution: 50.00

Date Collected: 06/26/96 (Wednesday)
Date Received: 07/03/96 (Wednesday)
Date Extracted: 07/08/96 (Monday)
Date Analyzed: 07/16/96 (Tuesday)

Lab Reference No: R8804
Lab Sample ID: R8804034

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	4900	mg/Kg	500
Decosane-S5	629-97-0	N D	%rec	

(5831)

Report of Analytical Results

Client Sample ID: DSB10708
Sample Description: None
Sample Matrix: Soil
Dilution: 1.00

Date Collected: None
Date Received: None
Date Extracted: 07/08/96 (Monday)
Date Analyzed: 07/14/96 (Sunday)

Lab Reference No: LABQC
Lab Sample ID: DSB10708

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
GC SEMI-VOLATILES				
TPH-Diesel	N/A	10 U	mg/Kg	10
Decosane-SS	629-97-0	82	%rec	

(5831)

Report of Analytical Results

Client Sample ID: M0706S01-BLK
Sample Description: None
Sample Matrix: Soil
Dilution: 1.00

Date Collected: None
Date Received: None
Date Extracted: None
Date Analyzed: 07/06/96 (Saturday)

Lab Reference No: LA86C
Lab Sample ID: M0706S01-BLK

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
NS VOLATILES				
Benzene	71-43-2	5 U	ug/Kg	5
Toluene	108-88-3	5 U	ug/Kg	5
Ethylbenzene	100-41-4	5 U	ug/Kg	5
Xylene (total)	1330-20-7	5 U	ug/Kg	5
Toluene-d8 - SS	N/A	104	%rec	
Bromofluorobenzene - SS	N/A	100	%rec	
1,2-Dichloroethane-d4 - SS	N/A	95	%rec	

(5875)

Report of Analytical Results

Client Sample ID: M0707M01-BLK
Sample Description: None
Sample Matrix: Soil
Dilution: 1.00

Date Collected: None
Date Received: None
Date Extracted: None
Date Analyzed: 07/07/96 (Sunday)

Lab Reference No: LABQC
Lab Sample ID: M0707M01-BLK

Analytical Parameter	CAS or Storet Number	Result	Units	Reporting Level
MS VOLATILES				
Benzene	71-43-2	5 U	ug/Kg	5
Toluene	108-88-3	5 U	ug/Kg	5
Ethylbenzene	100-41-4	5 U	ug/Kg	5
Xylene (total)	1330-20-7	5 U	ug/Kg	5
Toluene-d8 - SS	N/A	102	%rec	
Bromofluorobenzene - SS	N/A	98	%rec	
1,2-Dichloroethane-d4 - SS	N/A	107	%rec	

(5875)

GC TPH DIESEL
Lab Reference No./SDG: RB804
Page 2

CASE NARRATIVE
Addendum

Sample Information

LAB SAMPLE ID	CLIENT SAMPLE ID	SAMPLE MATRIX	DATE SAMPLED	DATE EXTRACTED	DATE ANALYZED	SAMPLE DR[1]
RB804001	MPC 6-6.5	SOIL	06/26/96	07/08/96	07/15/96	N/A
RB804002	MPC 7-7.5	SOIL	06/26/96	07/08/96	07/16/96	N/A
RB804003	MPC 8-8.5	SOIL	06/26/96	07/08/96	07/16/96	N/A
RB804004	MPC 9-9.5	SOIL	06/26/96	07/08/96	07/16/96	N/A
DSB10708	DSB10708	SOIL	N/A	07/08/96	07/14/96	N/A

[1] Applies to samples designated for purgeable VOA analysis only.

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Redding, CA 96003-1412
916 244-5227
Fax No. 916 244-4109

APPENDIX D

OPERATIONAL DATA

Operational Data for MPT-8-MW07S, NAVSTA Mayport - July 10-21

Date	Time	Hour meter	LRP Vac (in. Hg)	LRP Temp °F	Water Total (gal)	Surge Tank Volume (gal)	Well Head Vac (in. H_2O)	Stack Pressure (in. H_2O)	Stack Flow (scfm)	Ambient Temp °F	CINC RPM	Fuel	Stack Concentration O_2 (%)	CO_2 (%)	TPH (ppmv)
7/10/96	0845	5.90	23		551	180	7				1500	0			
7/10/96	0945	6.90	22		682	100	7	0.075	30		1500	0			
7/10/96	1140	8.85	21		682	110	8				1450	sheen			
7/10/96	1425	11.62	21		682	135	7				1600	sheen			
7/10/96	1600	13.30	Shut down		682	155									
7/11/96	1415	13.30			1018	160	20			80	1450				
7/11/96	1445	13.80	20		1018		20	0.07	30			sheen			
7/11/96	1515	14.30	20		1018	195		0.07	30			sheen			
7/11/96	1815	17.40	21		1240	110	20	0.07	30			sheen			
7/12/96	0815	31.40	21	106.6	1972	100	20	0.07	30	77.2		sheen			
7/12/96	0925												17	ND	ND
7/12/96	1400												18	5	1200
7/12/96	1600	39.00	21	111.6	2308	140	19	0.08	30	88.6	1640	very little			
7/13/96	0830	55.70	21	108.6	3147	135	19	0.07	30	82.8	1640	very little	17.5	5.5	48
7/13/96	1900	66.20	21	109.2	3635	140	18	0.07	30	79.2	1460				
7/14/96	0845	79.80	20	109.4	4268	130	20	0.08	30	83.6	1460		18.5	3.5	65
7/14/96	1000	81.00	-shut down, switch to drawdown (set tube 30" below interface)												
7/14/96	1030	-restart in drawdown			4268	180									
7/14/96	1100	81.60	23	104.4	4319	180	14	0.06		86.2					
7/14/96	1900	89.60	23	97.6	4967	200	14	0.09		82		more	18.5	4	1000
7/15/96	0800	102.60	23	98.6	6200	150	14	0.07	30	82.4		increase	19	4	1000
7/15/96	1710	111.10	22	103	6933	160	15	0.08	30	88					
7/16/96	0730	126.10	23	98.4	8214	160	15	0.09	32	82.4			18.5	3.5	1000
7/16/96	1655	134.80	22	101.6	8932	180	15	0.09	32	84			17	5	1000
7/17/96	0744	150.00	23	98.2	10177	185	15	0.06	27	82			17	3.5	1000
7/17/96	0915	151.20			10353							0.5-1 gal			
7/17/96	1100	151.20			10534										
7/17/96	1330	153.60	23	147	10534	120	7	0.06-0.07	30	91		foam			
7/17/96	1915	159.50	23	147.8	10534	160	7	0.03	15	85.2			16	3.5	600
7/18/96	0745	172.00	22	143	10686	150	7	0.03	15	78		little	17	3.5	500
7/18/96	0850	173.10			10686	160									
7/18/96	1420	173.10										8 oz			

Operational Data for MPT-8-MW07S, NAVSTA Mayport - July 10-21

Date	Time	Hour meter	LRP Vac (in. Hg)	LRP Temp °F	Water Total (gal)	Surge Tank Volume (gal)	Well Head Vac (in. H_2O)	Stack Pressure (in. H_2O)	Stack Flow (scfm)	Ambient Temp °F	CINC RPM	Fuel	Stack Concentration O_2 (%)	CO_2 (%)	TPH (ppmv)
7/18/96	1450	173.70	20.5	125	10686	180	14	0.07	30	91.6		little			
7/18/96	1800	176.90	20.5	125.4	10847	130	14	0.08	30	86.8			16	3	600
7/19/96	0751	190.80	21	119.2	11162	200	14	0.09		78			17.5	3.5	650
7/19/96	1525	198.30	20	127.2	11476	110	14	0.02		93					
7/20/96	0821	215.20	20	120.2	11854	160	14	0.06		80.2			17	3.3	400
7/20/96	1830	225.40	20	128	12099	150	14	0.075		92					
7/21/96	0900	238.70	20	121	12408	160	14	0.07		80.6					

Operational Data for MPT-8-MW11S, NAVSTA Mayport - July 21-24

Date	Time	Hour meter	LRP Vac (in. Hg)	LRP Temp °F	Water Total (gal)	Surge Tank Volume (gal)	Well Head Vac (in. H_2O)	Stack Pressure (in. H_2O)	Stack Flow (scfm)	Ambient Temp °F	CINC RPM	Fuel	Stack Concentration O_2 (%)	CO_2 (%)	TPH (ppmv)
7/21/96	1236	238.70			12571	below tube	8								
7/21/96	1330	239.70	25	95	12572	150	8	0.03		95					
7/21/96	1400	240.20	- surge tank reaches high-level mark, automatically shutting off LRP, transfer pump having difficulty, flowrate at approx. 0.7 gpm												
7/21/96	1440				12606	220		- generator shut down							
7/21/96	1640		-restart transfer pump, flowrate still at .7 gpm												
7/21/96	2030	240.20			12766	110	4	- surge tank draining, restart LRP							
7/21/96	2100						0.5								
7/21/96	2355	243.70	20	137	12837	110	0.5			81					
7/22/96	710	245.80	- bioslurper shutdown												
7/22/96	0950	245.80	25		13054	100	1	- restart bioslurper							
7/22/96	1145	247.80	26.5	110	13123	170	1	0.02		95.6					
7/22/96	1240	248.70			13142	190									
7/22/96	1450	251.00	20	154	13222	140	0.05			95					
7/22/96	1635	252.70	22	141	13283	115	2			96					
7/22/96	1900	255.20	- LRP shutdown, generator stopped for refueling												
7/22/96	1935				13377	220		- restart generator							
7/22/96	2250	255.20			13490	140	1								
7/22/96	2330	255.90	26	96	13513	150	1			85					
7/23/96		257.00			13720	100									
7/23/96	0820		- restart bioslurper												
7/23/96	0900	257.60	26	102	13737	130	1			85					
7/23/96	1045	259.40	26	107	13794	190	1			88					
7/23/96	1215	261.00	17	159	13846	190	0			97			20	1	250
7/23/96	1300	261.80	- system shutdown												

APPENDIX E

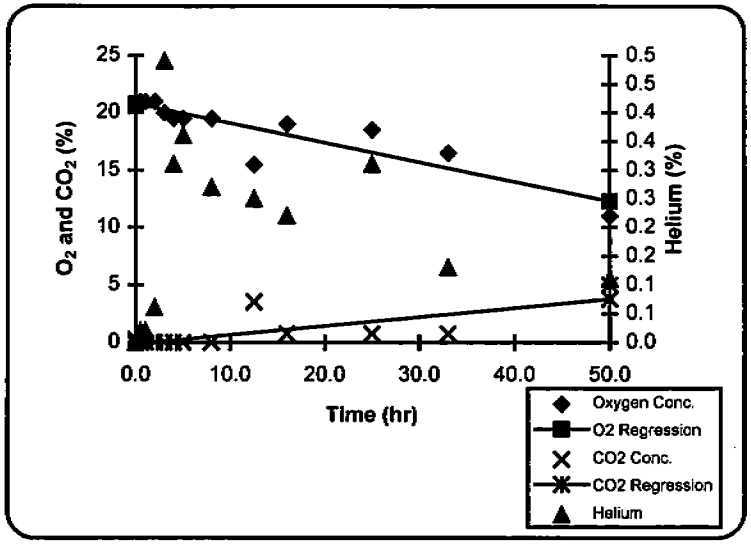
IN SITU RESPIRATION DATA

In Situ Respiration Tests: Data Analysis

Date: 7/25/96 **Site Name:** Mayport

Monitoring Point: MP-A-6' **Depth of MP (ft):** 6'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
7/22/96 7:15	0.0	21.00	0.25	0.00
7/22/96 7:45	0.5	21.00	0.00	0.02
7/22/96 8:15	1.0	21.00	0.00	0.02
7/22/96 9:15	2.0	21.00	0.00	0.06
7/22/96 10:15	3.0	20.00	0.00	0.49
7/22/96 11:15	4.0	19.50	0.00	0.31
7/22/96 12:15	5.0	19.50	0.00	0.36
7/22/96 15:15	8.0	19.50	0.00	0.27
7/22/96 19:45	12.5	15.50	3.50	0.25
7/22/96 23:15	16.0	19.00	0.75	0.22
7/23/96 8:15	25.0	18.50	0.75	0.31
7/23/96 16:15	33.0	16.50	0.75	0.13
7/24/96 9:15	50.0	11.00	5.00	0.11



Biodegradation Rate (mg/kg/day)

2.804

O_2 Utilization Rate

Ko	0.003 %/min
	0.170 %/hr
	4.072 %/day

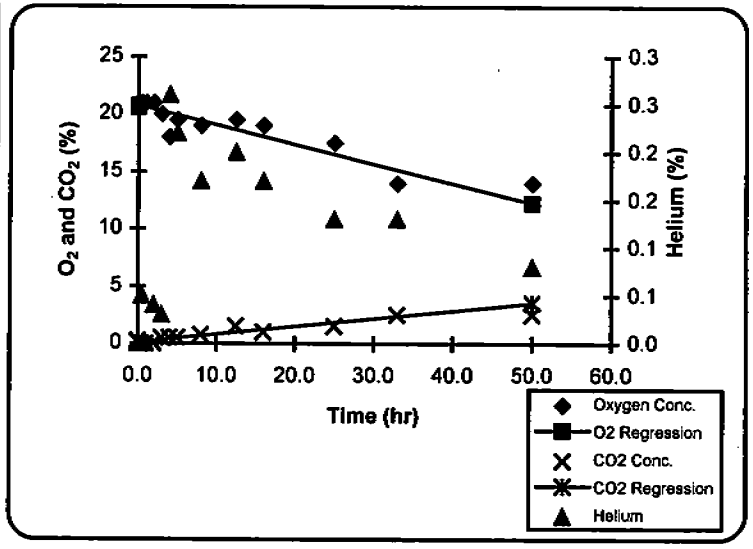
Regression Lines	O_2	CO_2
Slope	-0.1697	0.0770
Intercept	20.7804	-0.1019
Determination Coef.	0.8050	0.5548
No. of Data Points.	13	13

In Situ Respiration Tests: Data Analysis

Date: 7/25/96 **Site Name:** Mayport

Monitoring Point: MP- A-8.5' **Depth of MP (ft):** 8.5'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
7/22/96 7:15	0.0	21.00	0.25	0.00
7/22/96 7:45	0.5	21.00	0.00	0.05
7/22/96 8:15	1.0	21.00	0.00	0.00
7/22/96 9:15	2.0	21.00	0.00	0.04
7/22/96 10:15	3.0	20.00	0.50	0.03
7/22/96 11:15	4.0	18.00	0.50	0.26
7/22/96 12:15	5.0	19.50	0.50	0.22
7/22/96 15:15	8.0	19.00	0.75	0.17
7/22/96 19:45	12.5	19.50	1.50	0.20
7/22/96 23:15	16.0	19.00	1.00	0.17
7/23/96 8:15	25.0	17.50	1.50	0.13
7/23/96 16:15	33.0	14.00	2.50	0.13
7/24/96 9:15	50.0	14.00	2.50	0.08



Biodegradation Rate (mg/kg/day)

2.815

O_2 Utilization Rate

Ko	0.003 %/min
	0.170 %/hr
	4.087 %/day

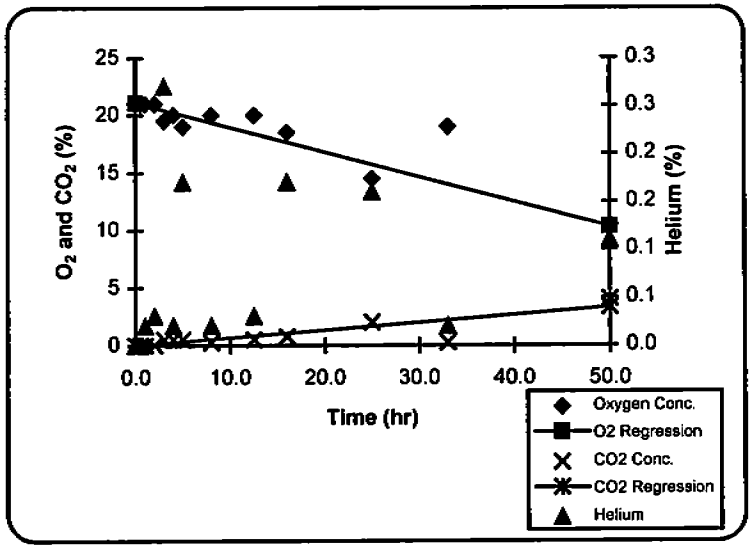
Regression Lines	O_2	CO_2
Slope	-0.1703	0.0681
Intercept	20.7692	0.1258
Determination Coef.	0.7931	0.9000
No. of Data Points.	12	12

In Situ Respiration Tests: Data Analysis

Date: 7/25/96 **Site Name:** Mayport

Monitoring Point: MP-B-8.5' **Depth of MP (ft):** 8.5'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
7/22/96 7:15	0.0	21.00	0.00	0.00
7/22/96 7:45	0.5	21.00	0.00	0.00
7/22/96 8:15	1.0	21.00	0.00	0.02
7/22/96 9:15	2.0	21.00	0.00	0.03
7/22/96 10:15	3.0	19.50	0.50	0.27
7/22/96 11:15	4.0	20.00	0.50	0.02
7/22/96 12:15	5.0	19.00	0.50	0.17
7/22/96 15:15	8.0	20.00	0.25	0.02
7/22/96 19:45	12.5	20.00	0.50	0.03
7/22/96 23:15	16.0	18.50	0.75	0.17
7/23/96 8:15	25.0	14.50	2.00	0.16
7/23/96 16:15	33.0	19.00	0.25	0.02
7/24/96 9:15	50.0	10.50	4.00	0.11



Regression Lines	O_2	CO_2
Slope	-0.2154	0.0668
Intercept	21.0986	-0.0131
Determination Coef.	0.7977	0.8220
No. of Data Points.	11	11

Biodegradation Rate (mg/kg/day)

3.560

O_2 Utilization Rate

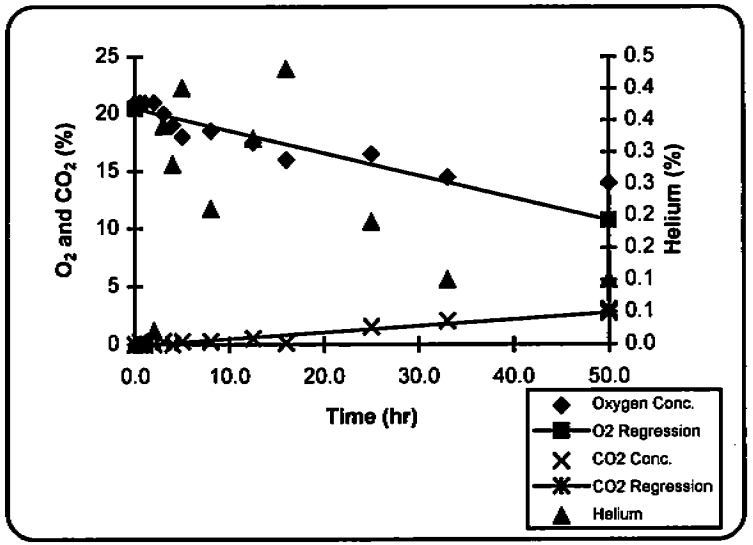
Ko	0.004 %/min
	0.215 %/hr
	5.169 %/day

In Situ Respiration Tests: Data Analysis

Date: 7/25/96 **Site Name:** Mayport

Monitoring Point: MP-C-6.5' **Depth of MP (ft):** 6.5'

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
7/22/96 7:15	0.0	21.00	0.00	0.00
7/22/96 7:45	0.5	21.00	0.25	0.00
7/22/96 8:15	1.0	21.00	0.00	0.00
7/22/96 9:15	2.0	21.00	0.00	0.02
7/22/96 10:15	3.0	20.00	0.25	0.34
7/22/96 11:15	4.0	19.00	0.00	0.28
7/22/96 12:15	5.0	18.00	0.25	0.40
7/22/96 15:15	8.0	18.50	0.25	0.21
7/22/96 19:45	12.5	17.50	0.50	0.32
7/22/96 23:15	16.0	16.00	0.10	0.43
7/23/96 8:15	25.0	16.50	1.50	0.19
7/23/96 16:15	33.0	14.50	2.00	0.10
7/24/96 9:15	50.0	14.00	3.00	0.10



Biodegradation Rate (mg/kg/day)

3.208

O_2 Utilization Rate

Ko	0.003 %/min
	0.194 %/hr
	4.657 %/day

Regression Lines	O_2	CO_2
Slope	-0.1941	0.0556
Intercept	20.4455	-0.0842
Determination Coef.	0.8523	0.8313
No. of Data Points.	12	12

APPENDIX F

MANUFACTURER'S LITERATURE

LIQUID RING PUMP

1.0 GENERAL DESCRIPTION - FLUID VAC® SYSTEM

Fluid-Vac liquid ring vacuum pumps are designed to operate over the full vacuum range from 0 - 28" Hg. Because of the unique axial flow design the pumps operate at constant horsepower throughout the full vacuum range. They are designed to handle groundwater as well as extracted vapor, and so Fluid-Vac pumps are used extensively for dual phase extraction of liquids and gases. Inlet separator tanks, required by competing vacuum pumps, are not necessary on Fluid-Vac systems.

Atlantic Fluidics soil venting vacuum pump packaged units consist of a Fluid-Vac liquid ring vacuum pump, close coupled to motor, seal water reservoir tank with gauge glass, electrical motor controller, inlet strainer, low water shut off switch, water make up valve, seal water flow control valve, and interconnecting piping and wiring, fully mounted and assembled on steel baseplate. Dual phase extraction systems include a centrifugal transfer pump, float switches for operating the transfer pump, piping, and wiring to electrical controller. The system described above is illustrated in Figure 1.

OPERATION - VAPOR EXTRACTION

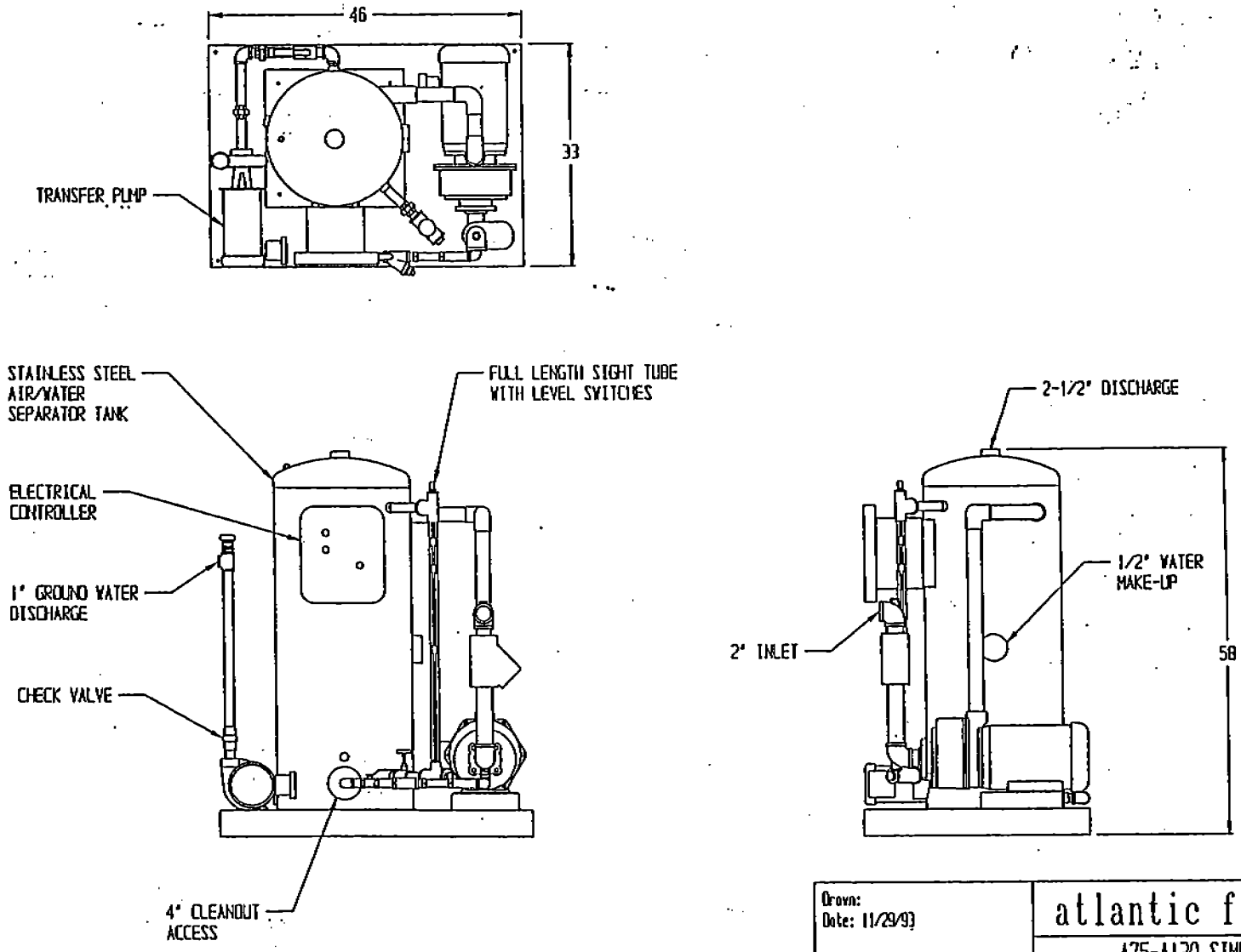
The liquid ring vacuum pump suction is connected to the soil venting wells and its function is to extract vapors from contaminated soil. The vacuum pump utilizes water for its pumping action. A description of the vacuum pump is provided in the attached brochure.

In operation, the vacuum pump extracts vapors from the soil, and the vapors and seal water are discharged to the water reservoir tank. There, water and vapor are separated, and the vapor is vented to atmosphere or piped to incinerators or activated charcoal adsorbers. The water is recirculated from the bottom of the tank to the vacuum pump inlet, thus providing a closed loop seal water system. A gauge glass is provided on the tank to indicate water level.

The vacuum pump system is designed to operate unattended continuously, 24 hours per day, 365 days per year. It can operate in a vacuum range of 0-28" Hg vacuum. Vacuum in the suction lines can be adjusted by means of air bleed valves or vacuum relief valves.

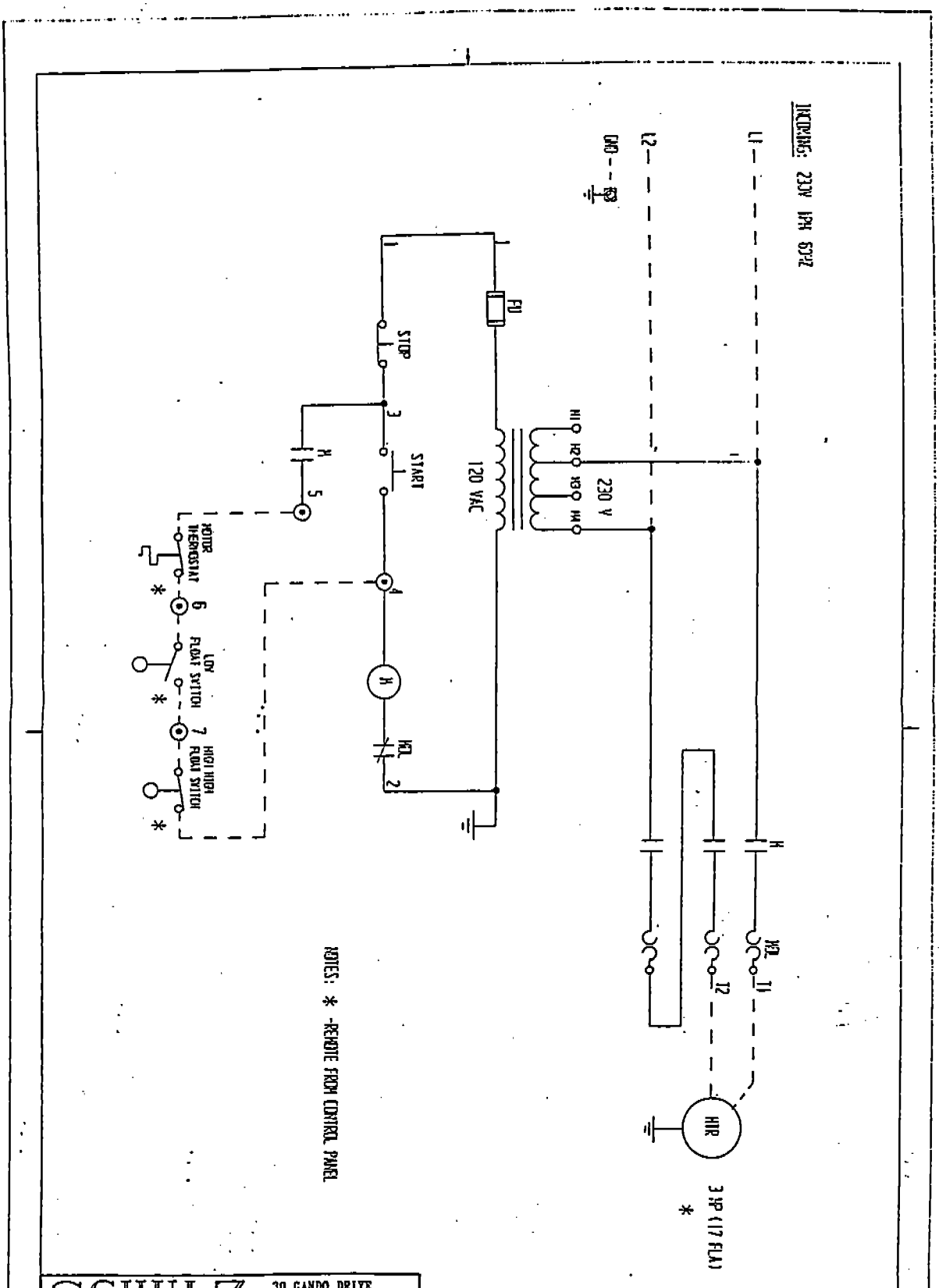
The electrical control consists of a motor starter with push button on/off switch and a float switch. The function of the float switch is to shut down the vacuum pump when seal water is depleted from the tank. Since there are evaporation losses the seal water must be replenished periodically. A fresh water supply pipe or hose may be piped to the 1/2" connection on the float valve. If pressurized water is not available the tank must be filled periodically by hand.

A Y strainer is provided on the vacuum pump suction. Its function is to prevent particulate matter from entering the pump. It should be checked periodically and cleared of collected debris. Normally, some sediment will pass through the inlet



Drawn: Date: 11/29/93	atlantic fluidics, inc.
	A75-A130 SIMPLEX DUAL EXTRACTION SOIL REMEDIATION PACKAGE
	SIZE B · FSCM NO. · DWG NO. B997-A100-22 · REV C
	SCALE 1:16 · CAD FILE NO: 997-102C · SHEET 1 of 1

FIG. 1

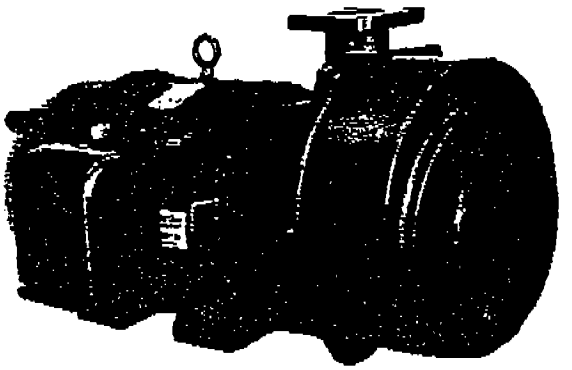

INCOMING: 230V 1PH 60HZ
L1
L2
GND
FU
STOP
START
120 VAC
230 V
H1
H2
H3
H4
M
5
6
7
MOTOR THERMOSTAT
LOW FLOAT SWITCH
HIGH HIGH FLOAT SWITCH
HOL
T1
T2
HOR
3 HP (17 FLA)
NOTES: * -REMOTE FROM CONTROL PANEL
SCHULZ ELECTRIC CO.
30 GANDO DRIVE
NEW HAVEN CT. 06513
TEL: (203)562-5811
#19058 BATTELLE
CUSTOMER:
ATLANTIC FLUIDICS
PROJECT: N-7 3 HP CONTROLLER 230 V 1 PH.
REVISION
DESCRIPTION
DATE
APPROVED
SO #: 7553-23
DWG BY: J. GRAVELINE
APP BY: J. KOVERDOVICH
DWG NO. 95058B01
DATE: 8/15/95
SCALE
SIZE B
REV
SHEET 1 OF 1

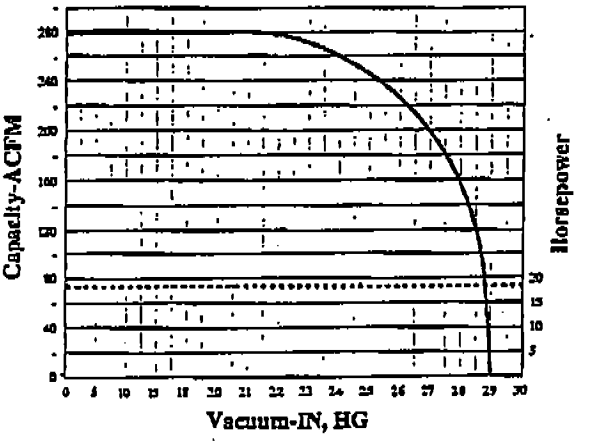
Model A300

Liquid Ring Vacuum Pump

Features:

- ***Axial flow design provides highest vacuum of any single stage liquid ring pump***
- ***Power requirements are constant over full vacuum range***
- ***Outstanding liquid handling capacity***
- ***Compact close coupled design***
- ***100% American***



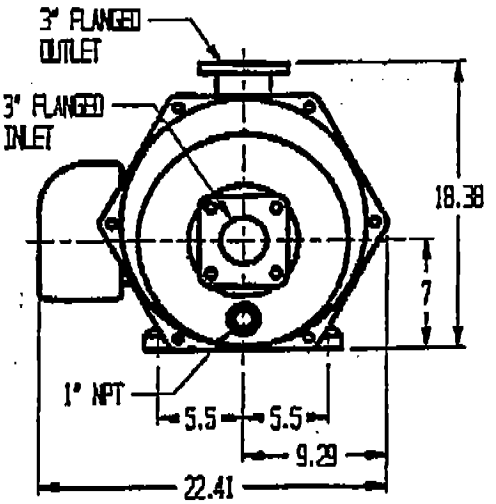


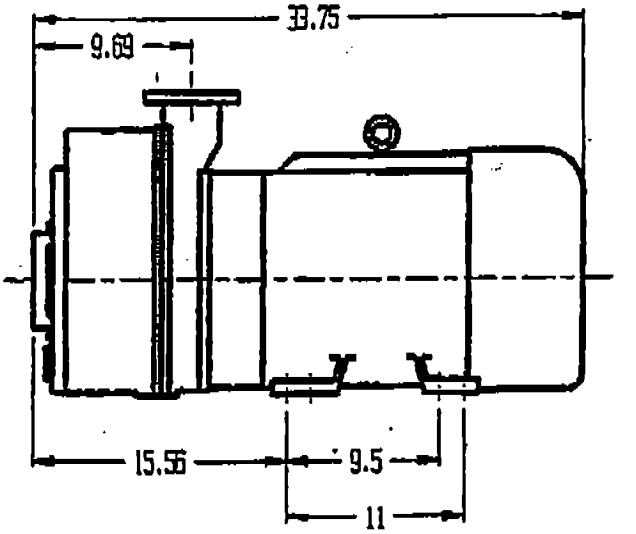
WATER CONSUMPTION

0-10" Hg. – 6 GPM
10-25" Hg. – 8 GPM
Over 25" Hg. – 10 GPM

NOTES:

Performance corrected for 60° F seal water and 30 in. barometer.



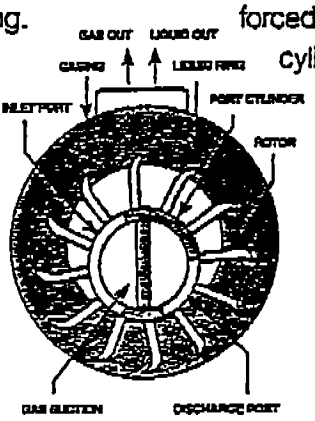


atlantic fluidics, inc.
21 South Street, South Norwalk, CT 06854
(203) 853-7315 FAX (203) 866-8218

Printed in U.S.A.

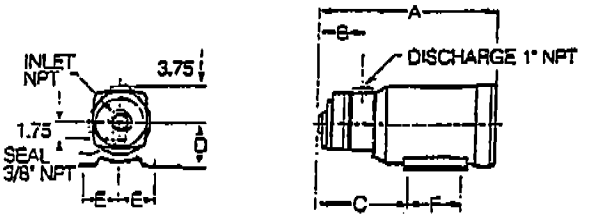
Principle of Operation

The Fluid-Vac® vacuum pump consists of a shrouded rotor rotating freely within an eccentric casing. There is no metal-to-metal contact between the rotor and the casing. Centrifugal force acting on liquid within the pump causes the liquid to form a ring inside the casing. A fixed port cylinder concentric with the rotor directs the gas into the suction ports. Gas is trapped between the blades by the liquid pistons formed by centrifugal force as the liquid recedes from the port cylinder. It is trapped at the point of maximum eccentricity and is then compressed by the liquid ring as it is forced radially inward toward the central port cylinder. After each revolution the compressed gas and accompanying liquid are discharged.

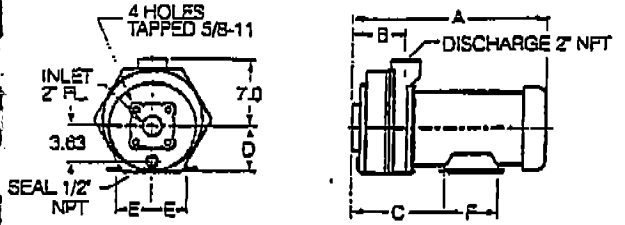


During the pumping cycle the gas is in intimate contact with the sealing liquid and compression is nearly isothermal. When handling saturated vapor-gas mixtures the liquid ring acts as a condenser, greatly increasing the effective capacity of the pump.

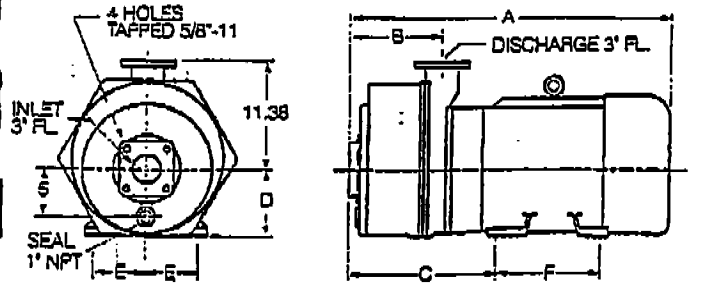
Dimensions



MODEL	FRAME	INLET	A	B	C	D	E	F
A5	56J	3/4	13.9	2.9	6.7	3.5	2.44	3.0
A10	145TCZ	1	16.3	3.6	8.0	3.5	2.75	5.0
A15	145TCZ	1	16.7	4.0	8.3	3.5	2.75	5.0
A20	182CZ	1	18.5	4.6	9.6	4.5	2.75	5.5



MODEL	FRAME	INLET	A	B	C	D	E	F
A75	184TCZ	2	20.2	5.8	9.8	4.50	3.75	5.5
A100	213TCZ	2	23.1	7.1	12.1	5.25	4.25	7.0
A130	215TCZ	2	25.3	8.1	13.1	5.25	4.25	7.0



MODEL	FRAME	INLET	A	B	C	D	E	E'
A200	284TYZ	3	32.4	8.3	14.2	7.0	5.50	11.0
A300	284TYZ	3	33.7	9.7	15.6	7.0	5.50	11.0

All dimensions are in inches. Dimensions are based on 3-phase TEFC motors (except A5: 3-phase ODP). Dimensions are accurate at time of printing and are subject to change without notice; consult factory for up to date information.

Features

Rugged Simplified Construction
All components are designed for 24 hour per day continuous service under the most demanding industrial conditions.

High Vacuum Characteristics
Exclusive axial flow design permits efficient operation in the full vacuum range from 0 to 29 inches of mercury (760-25 Torr).

Vibrationless Operation
No special foundations required.

Low Maintenance
No metal-to-metal contact between rotating and stationary elements.

Environmentally Clean
No oil used for lubrication or sealing. No oil vapor discharge to atmosphere.

Advanced Design
Employs mechanical seal and O-ring gaskets for zero leakage.

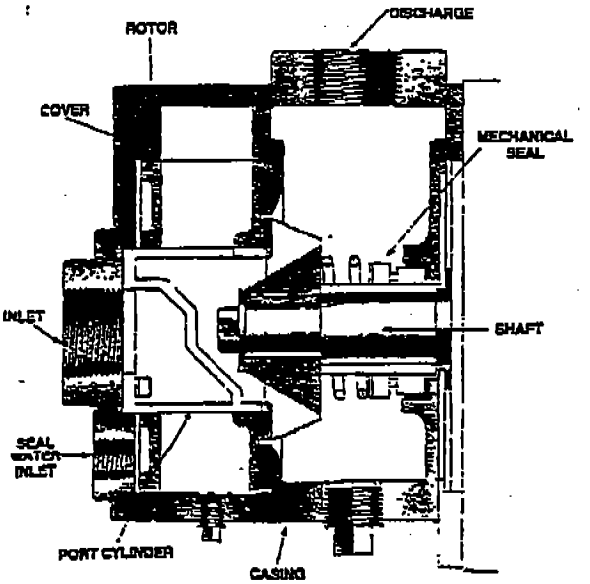
Constant power
Power requirements are constant over the full vacuum range. Non-overloading.

Performance

Model	HP	Capacity (CFM) at Vacuum (in Hg)							Weight (lb.) approx
		5	10	15	20	25	27	28	
3450 RPM									
A5	1	10	10	10	10	10	8	5	45
A10	1-1/2	15	15	15	15	15	13	10	55
A15	2	22	22	22	22	20	16	13	60
A20	3	34	34	34	34	32	26	18	80
1725 RPM									
A75	5	72	72	74	74	72	65	45	180
A100	7-1/2	100	102	102	102	100	86	60	195
A130	10	125	125	125	125	118	95	65	250
1160 RPM									
A200	15	230	230	230	230	220	190	135	560
A300	20	280	280	280	280	245	200	160	600

Dry air performance data based on service liquid water at 60°F. Barometric Pressure-Sea Level-29.92" Hg.

Construction



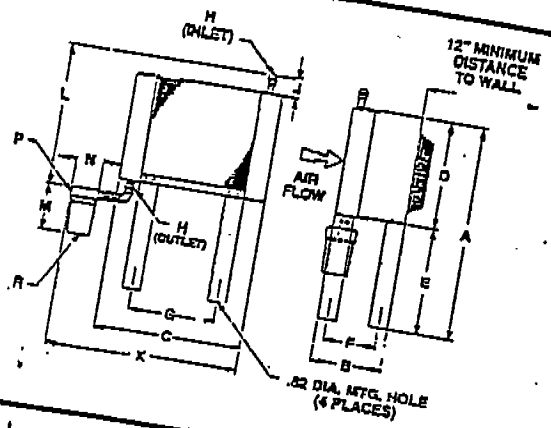
® Fluid-Vac is a registered trademark of Atlantic Fluidics, Inc.

HEAT EXCHANGER

TRANSFER PUMPS

AA SERIES

Thermal Transfer Products
Racine WI



DIMENSIONS

Model	A	B	C	D Approx	E	F	G	H NPT	J	"K" Approx	"L" Approx	M	OPTIONAL SEPARATOR N	P NPT	R	RECOMMENDED OPTIONAL SEPARATOR MODEL NUMBER
AA-25	46.50	14.75	30.50	22.50	24.00	10.75	19.09	1.00	4.00	41.12	34.50	10.00	4.62	1	¼	S-100M or AD
AA-50																
AA-65																
AA-80																
AA-100																
AA-120			43.50					1.50			38.00					
AA-150										54.12						
AA-200	49.50						22.09			54.20	37.10	12.10	4.70	1		S-200M
AA-300	55.50		47.63	25.50							38.60					
			51.68	31.50			38.09	2.00		58.33	40.60			1½		S-300M
										62.38	49.60					

*Dimension will vary depending on the separator model used and the piping between the separator and cooler.

CAPACITY SELECTION CHART MAX. SCFM @ 5, 10, 15 and 20°F Approach

INLET TEMP. °F	150				200				250				300				350				RECOMMENDED OPTIONAL SEPARATOR MODEL NUMBER
APPROACH TEMP. °F	5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20	5	10	15	20	
AA-35	25	42	58	73	18	31	43	53	15	25	35	44	13	22	30	37	11	19	26	32	S-100M or AD
AA-50	34	58	79	99	25	43	59	74	21	36	50	62	18	31	42	52	16	27	38	47	
AA-65	42	73	99	125	32	55	77	95	27	47	65	81	24	41	57	71	22	37	52	65	
AA-80	50	87	118	150	40	69	94	117	34	59	80	100	30	52	71	89	28	47	65	82	
AA-100	60	102	140	177	48	81	112	140	43	73	100	124	38	64	87	110	34	58	81	100	
AA-120	81	138	190	235	61	105	142	177	51	87	120	150	43	73	102	127	40	69	94	116	
AA-150	92	160	220	270	73	125	172	216	63	110	150	187	55	95	130	160	50	85	120	146	S-200M
AA-200	160	275	380	425*	120	207	285	355	100	175	240	300	84	145	204	250	78	135	185	231	S-300M
AA-300	184	318	440	480*	145	250	345	430	125	217	300	375	110	190	257	320	100	175	240	300	

*Indications are based on 80 to 125 PSIG operating pressures.
*Capacity drop, less than 3 psi.
*Capacity restricted by pressure drop, actual thermal capacities are higher.
*Unit must be properly installed between the compressor and aftercooler to validate warranty.

ELECTRIC MOTOR & FAN DATA

Fan CFM	Motor H.P.	Standard Motor (ODP) Voltage	Standard Motor (ODP) Full Load Amps/Motor	Optional Motor (TEFC) Voltage	Optional Motor (TEFC) Full Load Amps/Motor	Optional Motor (TEFC) Voltage	Optional Motor (TEFC) Full Load Amps/Motor	Approximate Shipping Weight (lbs.)
1300	¼	115/1/60	7.2	115/208 230/1/60	5/2.5-2.5	208-230/ 460/3/60	1.4-1.3/.65	110
1500								120
1500	¼ (2)							140
1700								145
2000								200
2700								300

*Custom Frame. Equipped with Thermal Overload. Optional Motor(s) = 1725 RPM, Nema 48 Frame, No Thermal Overload.
*Are approximate and may vary because of motor brand. Actual ratings are on motor nameplate.

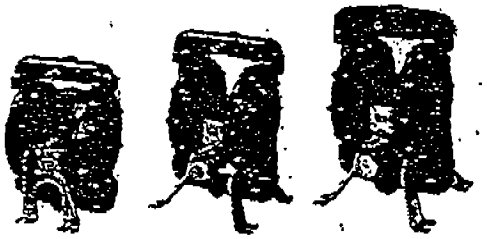
NOTE: We reserve the right to make reasonable design changes without notice.

U.L. Listed Fuel Transfer Pumps

These Aro Diaphragm Pumps have been designed specifically for dispensing petroleum-based fuel. These pumps meet UL-79 specification, code and are compatible with:

- GASOLINE
- AVIATION FUEL
- DIESEL FUEL
- FUEL OIL
- KEROSENE
- UNLEADED FUEL

Used for high-volume transfer, bulk-unloading or fueling applications. To meet UL-79 specification, a pressure relief valve opens and bleeds off excess pressure. The relief valve can be plumbed to return the bleed-off fuel to the storage container.



1-inch 1-1/2 -inch 2-inch

Air Connectors Not Included.

Performance Specifications

	1-inch	1-1/2-inch	2-inch
RATIO:	1:1	1:1	1:1
MAXIMUM G.P.M. (Liters):	29 (110)	75 (284)	105 (397)
AIR INLET:	1/4-inch NPT(F)	1/2-inch NPT(F)	1/2-inch NPT(F)
FLUID INLET:	1-inch NPT(F)	1-1/2-inch NPT(F)	2-inch NPT(F)
FLUID OUTLET:	1-inch NPT(F)	1-1/2-inch NPT(F)	2-inch NPT(F)
MAX. OPERATING PRESSURE PSI (bar):	50 (3.4)	50 (3.4)	50 (3.4)
SUSPENDED SOLIDS MAX. DIA. IN. (mm):	1/8-inch (3.2)	1/4-inch (6.4)	1/4-inch (6.4)
WEIGHT - LBS. (Kg):	18.5 (8.4)	44 (20.0)	46 (20.9)

Dimensional Data

See 1-inch, 1-1/2-inch, and 2-inch (ports) metallic pump dimensional data on pages 10, 11, and 12.

Model / Material Selection

	MODEL	FLUID INLET/OUTLET PORT SIZE	SEAT CONSTRUCTION	BALL CONSTRUCTION	DIAPHRAGM & O-RING CONSTRUCTION
→	650709-C	1-inch NPT	Kynar®	Acetal	Buna N
Unleaded	650717-C	1-inch NPT	Kynar	Acetal	Viton®
	650710-C	1-1/2-inch NPT	Kynar	Acetal	Buna N
Unleaded	650718-C	1-1/2-inch NPT	Kynar	Acetal	Viton
	650711-C	2-inch NPT	Kynar	Acetal	Buna N
Unleaded	650719-C	2-inch NPT	Kynar	Acetal	Viton

Viton Diaphragms are recommended for use with unleaded fuels.

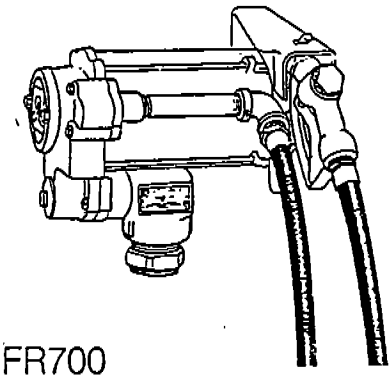
Pump System Technology

FILL-RITE

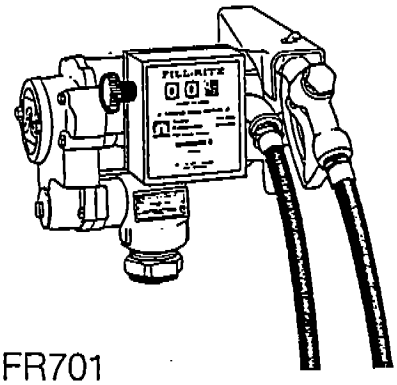
Parts and Technical Service Guide

SERIES 700B PUMP

For models: FR700, FR700R, FR701, FR701R, FR720, FR721, FR730, & FR731



Model FR700

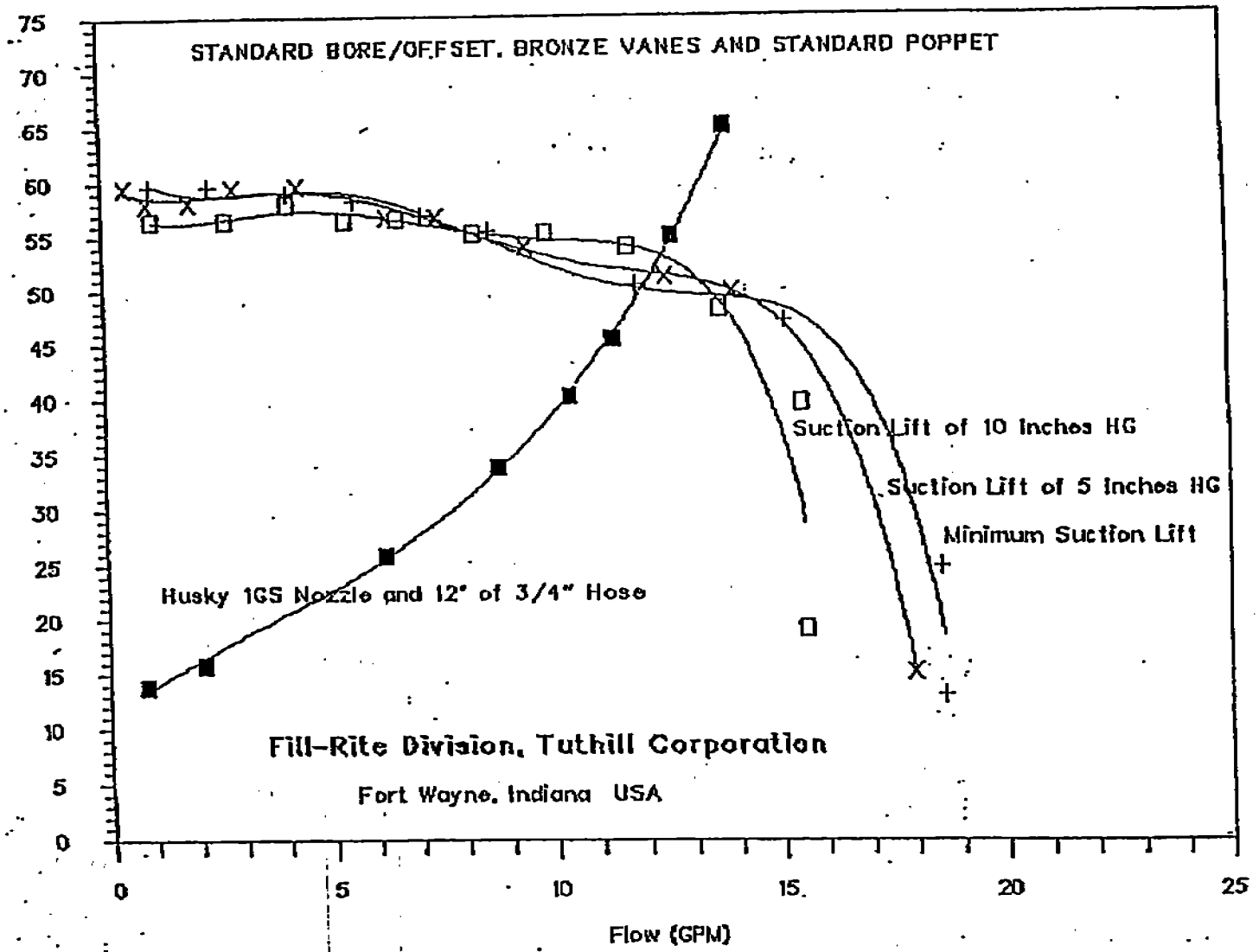


Model FR701

OUTSTANDING FEATURES

- Up to 18 GPM / 69 LPM
- UL listed pump and motor
- Full 1/3 HP 115 VAC-60Hz motor, optional 220/240 VAC-50/60Hz
- Thermal overload protector
- Heavy duty double pole switch
- Integral check valve
- Built-in bypass valve

700B Economy Pump Characterization

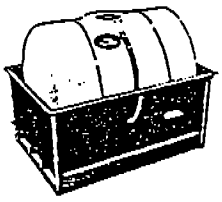


As a Function of Varying Inlet Vacuum

SURGE TANKS

Portable Storage Tanks

Skid-Mount Polyethylene Tanks

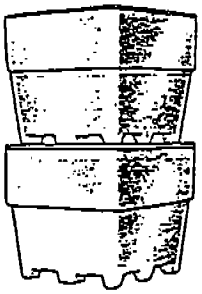


Durable tanks come with a sturdy steel skid for quick, easy transport with a forklift. Skids have two-way forklift entry. Tanks are made of seamless linear polyethylene that complies with FDA regulations for handling food and potable water. They can also be used for storing herbicides, insecticides, liquid fertilizer, and other chemicals. Tanks won't rust, corrode, or delaminate. They're ultraviolet stabilized and resistant to many corrosive chemicals. The translucent walls and a molded-in gallon scale make it easy to determine the liquid level. All models have a threaded fill cap with an EPDM gasket. A recessed sump is molded into the tank floor for drainage. Maximum operating temperature is 140° F.

Round-bottom tanks have a 1½" ball valve drain. Flat bottom tanks are loaf-shaped for a low center of gravity and greater stability. Tanks have a threaded vent plug and a 2" outlet drain fitting.

Cap., Gal.	Dimensions Lg. × Wd. × Ht.	Tank Bottom	Fill Cap	No.	NET EACH
110	49" × 32" × 37"	Round	6"	3664K16	$594.23
150	66" × 32" × 38"	Round	6"	3664K17	649.09
200	75" × 36" × 42"	Round	6"	3664K18	745.45
210	50" × 46" × 40"	Flat	6"	3664K11	796.75
300	77" × 41" × 49"	Round	6"	3664K19	840.00
300	50" × 46" × 49"	Flat	6"	3664K12	918.46
400	78" × 45" × 49"	Round	6"	3664K21	927.59
500	81" × 52" × 57"	Round	6"	3664K22	981.97
500	50" × 46" × 79"	Flat	6"	3664K13	1109.23
800	80" × 72" × 54"	Flat	12"	3664K14	1323.08
1200	80" × 72" × 71"	Flat	12"	3664K15	1423.08

Stackable Polyethylene Bulk Storage Bins



If you need a tank that can be used for over-the-road shipping as well as in-plant handling, these fit the bill. Great for storing liquid and dry-flowable materials. Tanks are FDA and USDA approved, and feature seamless, one-piece construction that's easy to keep clean. Tapered design allows nesting when tanks are empty to save floor space. Tanks allow four-way forklift entry and are stackable two high when used with the optional ¼" thick stacking lids (sold separately below). Dust covers are also available to keep tank contents free of contaminants. Capacity is 2000 lbs. Temperature range is −40° to 150° F.

Tanks are available in single- and double-wall styles. Walls are ¼" thick. Double-wall tanks have two ¼" thick walls for added strength and secondary containment.

Capacity Cu. Ft.	Gal.	Dimensions Lg. × Wd. × Ht.	Tanks No.	Tanks NET EACH	Stacking Covers No.	Stacking Covers NET EACH	Dust Covers No.	Dust Covers NET EACH
SINGLE-WALL TANKS								
30	225	50" × 42" × 36"	3674K11	$427.14	3674K16	$152.25	3674K17	$124.54
34	250	50" × 42" × 39"	3674K12	450.00	3674K16	152.25	3674K17	124.54
39	290	50" × 42" × 45"	3674K13	482.86	3674K16	152.25	3674K17	124.54
48	360	50" × 42" × 52"	3674K14	527.14	3674K16	152.25	3674K17	124.54
53	400	50" × 42" × 55"	3674K15	551.43	3674K16	152.25	3674K17	124.54
DOUBLE-WALL TANKS								
30	225	50" × 42" × 36"	3674K21	544.29	3674K23	152.25	3674K25	124.55
35	260	52" × 44" × 42"	3674K22	634.29	3674K24	152.25	3674K26	124.55

Polyethylene Bulk Storage Hoppers

Versatile hoppers handle a wide variety of materials—from foods and chemicals to powders, granulars, and tablets. FDA-approved linear polyethylene construction is easy to maintain. Hoppers have a removable top for easy loading. Top also allows them to be stacked two high.

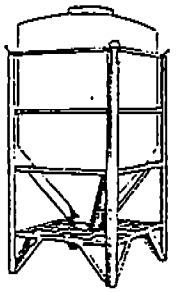
Maximum operating temperature is 150° F.

The 18 and 20 cu. ft. models have a 25° side angle discharge and a 6" opening with screw cap. Base permits two-way forklift entry.

The 35 cu. ft. model has 45° bottom discharge with a 13½" opening and a slide gate valve. Hopper permits four-way forklift entry.

Capacity Cu. Ft.	Lbs.	Dimensions Lg. × Wd. × Ht.	No.	NET EACH
18	1000	40" × 48" × 38"	3782K21	$697.66
20	1200	40" × 48" × 40½"	3782K22	724.09
35	1200	44" × 44" × 50"	3782K23	1215.71

Stackable Polyethylene Bulk Storage Hoppers

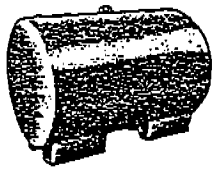


These heavy-duty hoppers made of FDA-approved seamless, linear polyethylene have a slick, nonadhering surface and a 60° slope for unimpeded flow of liquids and solids. Ideal for storage, transport, and dispensing. Hoppers have a 16" top-loading manhole with a raised-lip fill opening and snap-on cover. Top has a vent and cap; bottom has a fast-opening valve.

Hoppers have white translucent walls so you can see material level. A steel stand with a blue epoxy coating is included with each hopper. Stand allows four-way forklift entry. Hoppers are available to store either liquids or solids. Maximum operating temperature is 140° F.

Capacity Cu. Ft.	Gal.	Dimensions Lg. × Wd. × Ht.	Solid Storage Hopper w/8" Butterfly Valve No.	Solid Storage NET EACH	Liquid Storage Hopper w/2" Ball Valve No.	Liquid Storage NET EACH
24.5	183	39" × 39" × 60"	3697K5	$1869.09	3697K25	$1636.36
35	260	44" × 44" × 66"	3697K6	1860.00	3697K26	1710.91
54	400	44" × 44" × 86"	3697K7	2060.00	3697K27	1938.33

Skid-Mount Steel Tanks



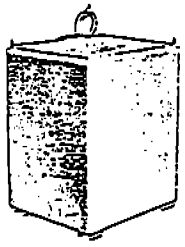
Store fuel and waste oil in these steel tanks with lifting lugs and a high-visibility red enamel overcoat. Tanks are available in light-duty and heavy-duty models.

Light-duty tanks have a 1" drain. Skid runners are 2" × 2" × ¼" angle iron.

Heavy-duty tanks have welded legs that allow forklift entry. Drain is ¾". These tanks are pressure tested and meet UL 142 specifications.

Cap., Gal.	Dimensions Dia. × Lg.	Wall Thick.	Vent Fittings	No.	NET EACH
LIGHT-DUTY TANKS					
300	38" × 60"	14 ga.	3-2", 1-1½"	37415K61	$296.58
560	48" × 72"	12 ga.	4-2"	37415K62	497.22
1000	48" × 144"	12 ga.	3-2", 1-3"	37415K63	993.43
HEAVY-DUTY TANKS					
300	38" × 60"	12 ga.	4-2"	37415K71	543.86
560	48" × 72"	12 ga.	3-2", 1-4"	37415K72	684.21
1000	64" × 72"	10 ga.	3-2", 1-4"	37415K73	1076.92
1500	64" × 108"	7 ga.	3-2", 1-6"	37415K74	1478.87

Double-Walled Waste and Oil Storage Tanks



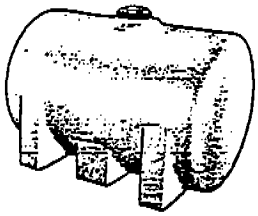
Environmentally safe, vented, transportable tanks are perfect for storing waste oil, solvents, antifreeze, and most products that require double-wall containment. UL-listed tanks have a 6" fill opening with a locking hinged cap and strainer, plus two 2" bungs and a 2" side drain. A ½" diameter side pipe with rod lets you check for leaks in the interior tank.

Tanks are made of welded steel painted safety red with channels on the bottom for two-way forklift entry.

Cap., Gal.	Wall Thick.	Dimensions Lg. × Wd. × Ht.	No.	NET EACH
120	12 ga.	26" × 30" × 36"	3696K71	$692.86
240	12 ga.	52" × 30" × 36"	3696K73	978.57
360	12 ga.	77" × 30" × 36"	3696K75	1271.43
480	10 ga.	102" × 30" × 36"	3696K77	1824.32

Storage Tanks

Free-Standing Horizontal Polyethylene Tanks



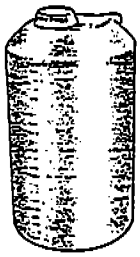
Forget about saddles, stands, and cradles—these tanks stand on their own! Horizontal tanks have molded legs so you can mount them on a flat surface without any additional support.

Tanks are available in natural high-density polyethylene that meets FDA regulations for food and potable water applications, and in cross-linked high-density polyethylene that's ultraviolet-stabilized for outdoor use.

Both styles have gallon and liter graduations. Maximum operating temperature is 150° F. Wall thickness is ¼". Natural color.

Cap., Gal.	Dimensions Lg. × Wd. × Ht.	Fill Opening	Linear Polyethylene No.	Linear Polyethylene NET EACH	Cross-Linked Polyethylene No.	Cross-Linked Polyethylene NET EACH
60	38½" × 23" × 24½"	6"	3764K11	$116.67	3764K21	$146.36
125	49" × 30" × 30¾"	10"	3764K12	180.65	3764K22	227.27
230	51½" × 38" × 38¾"	10"	3764K13	215.17	3764K23	273.68
300	71½" × 38" × 38¾"	10"	3764K14	237.70	3764K24	309.32
500	75" × 48" × 48¼"	10"	3764K15	349.52	3764K25	463.93

Vertical Polyethylene Storage Tanks



Save floor space with these rotationally-molded, polyethylene tanks that you store vertically. Tanks are more lightweight and less expensive than fiberglass and stainless steel tanks.

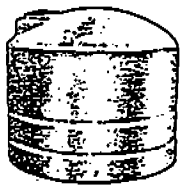
One-piece seamless units have gallon and liter graduations Translucent walls let you see liquid levels. Top head has flats for fitting installations. Tanks provide excellent low-temperature impact resistance and are ultraviolet-stabilized for outdoor use.

30 to 100 gallon tanks are molded of linear polyethylene and have a screw-on fill cap with an EPDM gasket. Top bung is 2" buttress thread. HDPE resin complies with FDA 177.1520 for food service use. Operating temperature range is −94° to +150° F. Color is translucent white.

300 to 1100 gallon tanks are molded of cross-linked polyethylene for superior strength, stress-crack resistance, and corrosive chemical resistance. Lever-lock tank cover simplifies manway opening and closing. Operating temperature range is −180° to 150° F. Color is translucent gray.

Cap. Gal.	Dimensions Dia. × Ht.	Wall Thick.	Fill Opening	No.	NET EACH
30	18" × 36¾"	.188"	6¼"	38555K31	$98.11
55	22" × 39½"	.250"	6¼"	38555K32	120.75
100	28½" × 51¼"	.250"	6¼"	38555K33	270.91
300	35" × 80"	.220"	16"	38555K34	496.15
550	48" × 84"	.250"	16"	38555K35	685.71
850	64" × 74"	.280"	16"	38555K36	921.43
1100	64" × 93"	.370"	16"	38555K37	942.86

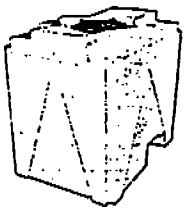
Reinforced Polyethylene Storage Tanks



Reinforcing cylindrical ribs make these tanks extra rigid to minimize bulge even with the heaviest liquids. Tanks are made from rotationally-molded linear polyethylene treated with ultraviolet stabilizers to prevent deterioration caused by exposure to sunlight. Chemical-resistant polyethylene won't rust or corrode, and won't delaminate or wick like fiberglass can. Resins comply with FDA regulations for food and potable water applications. Walls are translucent white, so no sight gauge is needed to determine liquid levels. Operating temperature is 140° F. Tanks have a coarse-threaded fill well, gallon graduations, and a 2" adapter fitting, except Nos. 3662K16 and K18, which have a 1½" fitting.

Cap., Gal.	Dimensions Dia. × Ht.	Fill Opening	No.	NET EACH
125	29" × 47"	10"	3662K18	$236.36
165	31" × 59"	6"	3662K16	262.50
300	46" × 49"	15"	3662K17	324.56
525	46¼" × 79"	15"	3662K11	406.78
1100	80" × 63"	15"	3662K12	634.62
1600	90" × 66"	15"	3662K13	754.55

Polyethylene Dike Tank



•With Optional Stackable Frame

More than just a tank, more than just a secondary containment vessel—it's a tank within a tank. System consists of a 110-gallon interior tank and a 160-gallon exterior dike. The tank has a 10" diameter screw-on lid and three 2" NPT fittings. A 1" high wall keeps leaks and spills from running down the side of the tank. There are two flat areas on the top for mounting pumps.

Tank is 29½" wide × 39½" long × 37" high. The dike is designed to easily accommodate the tank. It measures 29½" wide × 39½" long × 33¼" high. Both the tank and dike are made of ¼" thick polyethylene. Operating temperature is 140° F. Tanks can be stacked up to three high using the optional steel frame sold separately below. Frame permits four-way forklift entry and has a black enamel finish.

Description	No.	NET EACH
Tank/Dike System	3762K55	$494.37
Stackable Frame	3762K77	207.69

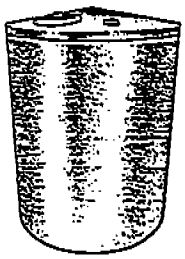
Secondary-Containment Polyethylene Basins

One-piece molded basins provide an effective barrier between your storage tank and the environment. They're designed to answer growing concerns over contamination from hazardous chemical spills and leaks. Linear polyethylene construction resists impact and ultraviolet rays—excellent for outdoor use. Maximum service temperature is 140° F.

Basin capacity is approximately 110% of maximum tank capacity. Color is translucent white.

Cap., Gal.	Approx. Max. Recommended Tank Size, Gal.	Dimensions	No.	NET EACH
ROUND BASINS				
605	550	82" Dia. × 30" Ht.	3737K11	$478.97
935	850	84" Dia. × 46" Ht.	3737K12	621.72
SQUARE BASINS				
1100	1000	84" Sq. × 48" Ht.	3737K15	980.31
1650	1500	84" Sq. × 60" Ht.	3737K16	1092.00

Double-Wall Polyethylene Tanks



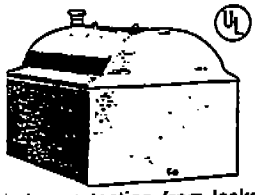
Seamless, corrosion-resistant tanks are double-walled for maximum leak protection—the perfect solution for chemical and hazardous material storage. One-piece unit consists of an inner and outer tank. The outer tank capacity is approximately 110% of inner tank capacity.

Linear polyethylene construction complies with FDA regulation 177.1520. Polyethylene has great structural rigidity, excellent chemical- and impact-resistance, plus it's UV stabilized for outdoor use. Maximum service temperature is 140° F.

Top of tank has an 8" manhole and a 1" vent. Color is translucent white.

Cap., Gal.	Dimensions Dia. × Ht.	No.	NET EACH
100	35" × 39"	3741K1	$476.07
200	41" × 52"	3741K2	608.31
500	50" × 58"	3741K3	1353.43

Secondary-Containment Steel Tanks

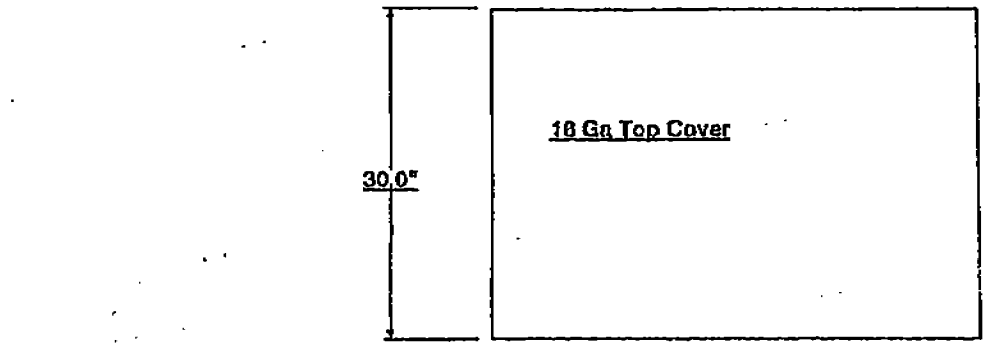


Above-ground storage tanks may be used indoors and out to protect against leaks and ruptures. These units combine round or obround storage tanks with rectangular secondary containment tanks for extra protection from leaks. Ideal for storing motor fuel, heating and waste oil, and lubricants. The containment tanks are designed to hold 110% of the storage tank capacity. They also feature weatherproof flashing to keep rain water and other debris out of the containment sections.

Tanks have a 1½" threaded pipe drain opening and are heavy-gauge carbon steel and coated with rust-resistant primer and beige-colored enamel. Tanks meet UL 142 standards for above-ground storage.

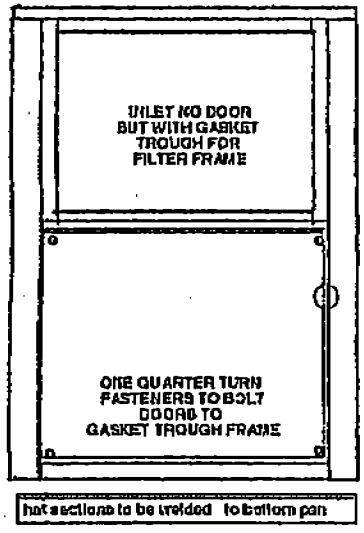
Cap., Gal.	Dimensions Lg. × Wd. × Ht.	Wall Thick.	Fill Openings	No.	NET EACH
150	56" × 38" × 33"	12 ga.	4-2"	3658K51	$1078.56
270	68" × 46" × 39"	12 ga.	1-4", 3-2"	3658K55	1348.20
525	84" × 54" × 50"	12 ga.	1-4", 3-2"	3658K53	1807.59
1000	84" × 72" × 68"	10 ga.	1-6", 3-2"	3658K54	2846.21

DEHUMIDIFIER

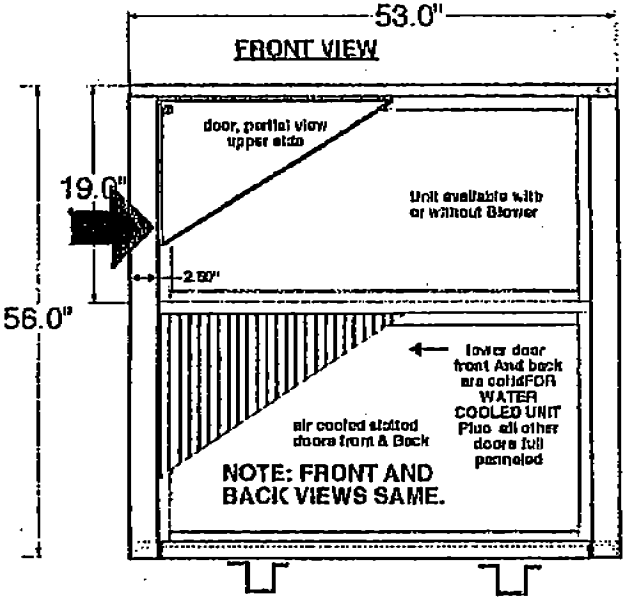


Material :- as shown
Doors, 16 Ga Paint Grip
Corner Posts, Four (4) , 14 Ga P.G.
Mid Pan 12 Ga P.G., welded to 4 posts
Bottom Pan 12 Ga P.G.

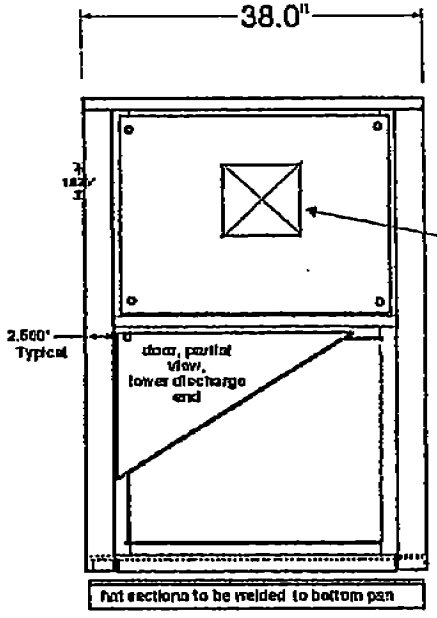
PAINT: PHOSPHATIZE, PRIME AND PAINT WITH outdoor POLANE EPOXY , PRECISION TAN



LEFT VIEW

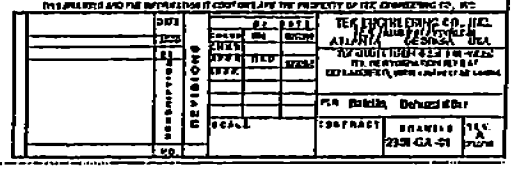


12 Ga Bottom Pan



RIGHT VIEW

TEK ENGINEERING CO INC, ATLANTA, GA 8/02/96



	A	B	C	D	E	F
1	Airflow	270	scfm	O.K. / program 8/20/93		
2	Pressure	0	PSIG			
3	Inlet Temp	100	°F	Change cells in this box only		
4	Inlet RH	99	%			
5	Outlet Temp	50	°F		CASE 4	
6	Outlet RH	100	%			
7						
8	Dry air movement	1218.04511	lbm/hr			
9	Moisture removed	42.522928	lbm/hr			
10		297660.496	gr/hr			
11	Total heat	61827.7181	btu/hr	5.1523	tons	45°F Suct.
12	Sensible heat	14616.5414	btu/hr			Tons
13	Latent heat	47211.1767	btu/hr			
14	SHR	0.23640758				
36	*Inlet Values*					
41	W	0.04254125	lbm/lbm	humidity ratio		
42	gr/lb Mass	297.788778	gr./lbm			
46	v	15.07	ft3/lbm	specific volume		
47	h	71.03	btu/lbm	enthalpy		
49	Dewpoint	99.63	°F			
72						
73	*Outlet Values*					
78	W	0.00763046	lbm/lbm	humidity ratio		
79	gr/lb mass	53.4131855	gr/lbm			
83	v	13.01	ft3/lbm	specific volume		
84	h	20.27	btu/lbm	enthalpy		
86	Dewpoint	50.06	°F			
87	*values per pound of dry air*					
88	One DX & One Reheat Coil with air precooled by Water coil					
89	with Pump & Remote Dry Cooler (Glycol Water					
90	NOTE: MUST precool air from Ring vac. Pump to 100°Fusing ducted coil with remote air cooled					
91	Dry cooler with Pump (glycol 40% solution)					
92						
93	CFM	270				Reheat°F
94	°FDB	100.00	73	50		79.4
95	%R.H.	99	96%	100		30
96	Enthalpy, BTU/LB	71.03	EC1 63.97 DX 1	20.27	EC2	
97						
98	Enthalpy	H1	H2	H3		
99						
100						
101	(EAT-LDP)*.60 EFF		29.4		Reheat	
102	(LDPT+C102)		79.4			
103	CFM*4.5*H1EAT		86295.50			
104	CFM*1.08*C114		8,573.04			
105	(C104-C105)/45000		63.97			Air cooled unit
106	DX1 LOAD, BTUH		53,100.11	4.43	Tons @ 35°F	6HP Compr.
107					for 45°F D.Pt also attainable.	
108	100CFM needs 3HP Compr @28°F Suction with 100°f Sat'd inlet (precooled by coil and remote dry coole					
109	150 CFM needs 4HP @28°F Suction with 100°F Sat'd Inlet(precooled by Coil and remote dry cooler.					
110	230 CFM Needs a 6 HP @28°F Suction with 100°F Sat'd Inlet					
111	precooled by a coil and remote dry cooler w/ a recirc'g pump with glycol-water solution closed circuit					
112						

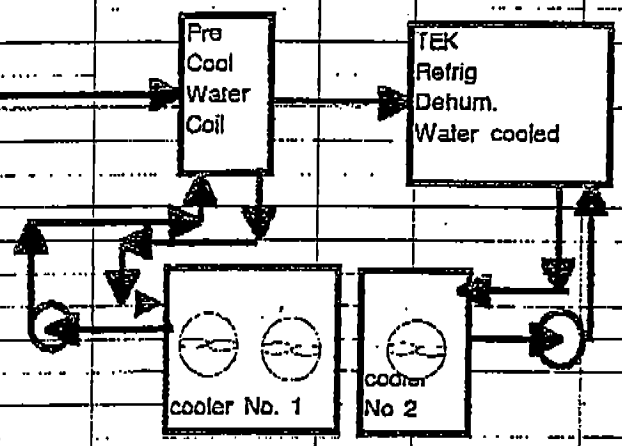
	A	B	C	D	E	F
113						
114						
115	Case I , 100 CFM air flow(8/02/96)					
116	TEK 3HP Air Cooled Refrigeration Reheat Dehumidifier, Model RRDH-3-100-230-1-60ACEC					
117	Estimating price $7,000.00					
118	Coil and Pump and Air cooled Dry Cooler :-estg price , $3950.00 to precool air from 140°F to 100°F satd					
119	Case 2-150 CFMair flow(8/02/96)					
120	TEK -4HP Air Cooled RRDH unit, $8,900.00					
121	Coil, Pump Dry Cooler Price :- $4600.00					
122	Case 3-230 CFM Air Flow(8/02/96)					
123	TEK 6 HP RRDH Dehumidifier $9,900.00					
124	Coil, Pump, Dry Cooler $5750.00					
125	Case 4-270 CFM Air Flow(8/13/96)					
126	TEK 6HP RRDH Dehumidifier, $9,900.00 a D.Pt of +45°F is attainable with this compressor.					
127	Copil, Pump, Dry Cooler $5750.00					
128	TEK was specified for a Chevron job by Camp Dresser & Mckee Boston ,MA for a job at Cape Cod in 1985					
129	TEK SOLD A DEHUMIDIFIER & CARBON TOWER (A 500 CFM ADSORPTION TOWER)TO PROVIDE ULTRA					
130	FILTERED OUTSIDEAIR TO A CONTROL ROOM IN A FERTILIZER PLANT (AMMONIA PRODUCTS) IN 1994					
131	TOWER LIFE 12 MONTHS PER CHARGE OF CARBON.					
132	Note a water cooled Dehumidifier may be used by using a larger Dry Cooler and providing another 20 GPM					
133	of Glycol water for easier year round operation of the Dehumididifer. ; This adds about $2,000.00					
134	to the price of the Dry Cooler.					
139						
140						
141						
142						
170						
171						
172						

Precool 140°F Air to 100°F from Vac Pump TEK Engineering Co Atlanta, GA

	A	B	C	D	E	F
1	Airflow	270	scfm	O.K. / program 8/20/93		
2	Pressure	0	PSIG			
3	Inlet Temp	140	°F	Change cells in this box only		
4	Inlet RH	100	%			
5	Outlet Temp	100	°F		Precool VAC Pump &	
6	Outlet RH	100	%		Cool Water Cooled Condenser.	
7						
8	Dry air movement	1218.04511	lbm/hr			
9	Moisture removed	133.284169	lbm/hr			
10		932989.326	gr/hr			
11	Total heat	162322.914	btu/hr	13.53	tons	cooling
12	Sensible heat	11693.2331	btu/hr			
13	Latent heat	150629.681	btu/hr			
14	SHR	0.07203686				
29						
30						
31	*Input*					
32	Temp	140	°F			
33	RH	100	%			
34	Pressure	0	psig			
35						
36	*Inlet Values*					
41	W	0.15242535	lbm/lbm	humidity ratio		
42		1066.97742	gr./lbm			
46	v	18.82	ft3/lbm	specific volume		
47	h	204.80	btu/lbm	enthalpy		
49	Dewpoint	140.02	°F			
72						
73	*Outlet Values*					
78	W	0.04300067	lbm/lbm	humidity ratio		
79		301.004702	gr/lbm			
83	v	15.09	ft3/lbm	specific volume		
84	h	71.53	btu/lbm	enthalpy		
88	Dewpoint	99.96	°F			
87	*values per pound of dry air*					
88						
89						
90						
91						
92						
93						
94						
95						
96						
97						
98						
99						
100						

Precool 140°F Air to 100°F from Vac Pump TEK Engineering Co Atlanta, GA

	A	B	C	D	E	F
101						
102	Precool outlet from Vac Pump with Cooling coil & Dry Cooler					
103	CFM	270				
104	EAT, °F	140				
105	Inlet Rh	100				
106	LAT,°F	100				
107	Outlet R.H.	100				
108						
109						
110						
111						
112	VACPump					
113						
114						
115						
116						
117						
118						
119						
120						
121						
122						
123	Cooler No 1 load	162,322BTUH	14 ton Cooler			
124	Cooler No. 2	90,000 BTUH	6 Ton x 1.25			
125	TWO COOLERS, One to precoolEAT, & other for cooled condenserusing Glycol Water 40%.					
126			TwoPumps required			
127						



VAPOR-PHASE ACTIVATED CARBON

VAPOR PHASE ACTIVATED CARBON

Vapor Phase Coconut Carbon

GRADE: **SHER-FRAN VP1-COC**

DESCRIPTION: High quality granular activated carbon produced to tight specifications from selected grades of Coconut shell. Specifically designed for vapor phase applications.

SPECIFICATIONS:

Mesh Size U.S. (Sieve Series)	4x8
Iodine Number:	1150 mg/g minimum
Bulk Density:	0.50 - 0.52 gm/cc
Moisture as Packed:	3% maximum
Hardness:	98% minimum
Ash Content:	3% maximum

STANDARD PACKAGING: Fifty-five (55) pound polyline polypropylene bags, fiber drums, and 1,000 pound supersacks.

SHER-FRAN® CORPORATION
459 Marion Avenue • P.O. Box 596 • Plantsville, Connecticut 06479 • Tel: 860/628-8684 • Fax: 860/621-7528

VAPOR PHASE ACTIVATED CARBON

Vapor Phase Coal Carbon

GRADE: **SHER-FRAN VP1-COL**

DESCRIPTION: High quality granular activated carbon produced to tight specifications from selected grades of coal. Specifically designed for vapor phase applications.

SPECIFICATIONS:

Mesh Size U.S. (Sieve Series)	4x6, 4x8
Iodine Number:	1100 mg/g minimum
Bulk Density:	0.44 - 0.46 gm/cc
Moisture as Packed:	3% maximum
Hardness:	98% minimum

STANDARD PACKAGING: Fifty-five (55) pound polyline polypropylene bags, fiber drums, and 1,000 pound supersacks.

SHER-FRAN® CORPORATION
459 Marion Avenue • P.O. Box 596 • Plantsville, Connecticut 06479 • Tel: 860/628-8684 • Fax: 860/621-7528

VAPOR CARBON ADSORPTION SYSTEMS

Vapor Phase Adsorbers

MODEL:	**SFV-2000**	
DIMENSIONS:	*Diameter:*	*48"*
	Overall Height:	*92"*
CONNECTIONS:	*Inlet:*	3" NPT side
	Outlet:	3" NPT side
	Drain	1" on bottom
DESIGN FEATURES:		
	OPERATING PRESSURE:	15 psi maximum
	CARBON:	Virgin 4x8 coconut shell
	IODINE NUMBER:	1150
	CARBON WEIGHT:	2,000 lbs.
	ADSORBER:	Carbon Steel with epoxy internal coatings. PVC internals. DOT rated.
MAXIMUM FLOW (cfm):	800	
SHIPPING WEIGHT:	3,000 lbs.	

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8/7/96 10:28 AM

VAPOR PHASE CARBON USAGE ESTIMATE
CARBTROL® Corporation

PROJECT: Battelle

FLOW IN CFM: 270.00
FLOW IN CFD: 388800.00

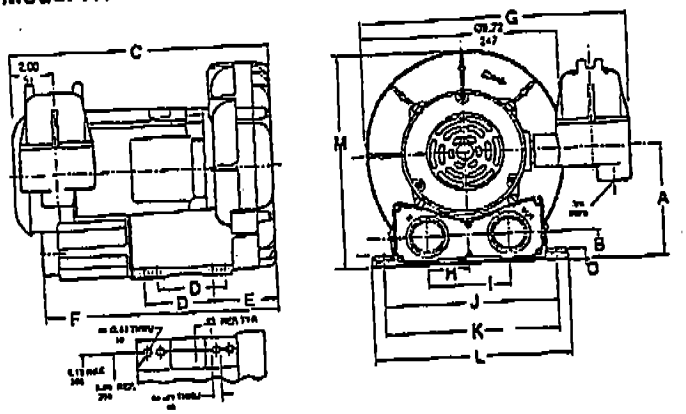
PERFORMANCE:

CONTAMINANT	CONC(ppmv)	#CONT /DAY	#CARBON /DAY	#CONT /100,000cf	#CARBON /100,000cf
Benzene	0.24	0.02	0.27	0.00	0.07
Toluene	0.46	0.04	0.28	0.01	0.07
Ethylbenzene	0.58	0.06	0.39	0.02	0.10
Xylene	1.6	0.17	0.94	0.04	0.24
TPH (as Benzene)	250	19.43	90.93	5.00	23.39
TOTALS	252.88	19.72	92.81	5.07	23.87

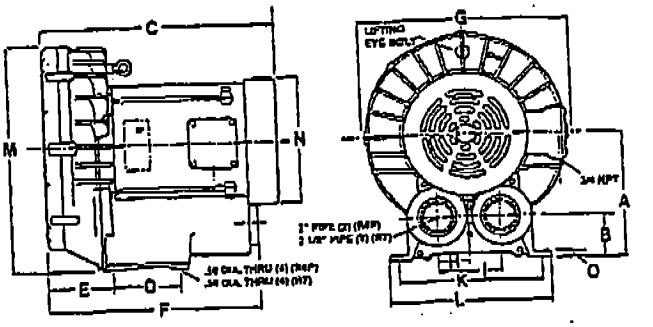
INDUCED-DRAFT BLOWER

SOIL VAPOR EXTRACTION PUMPS – REGENERATIVE BLOWERS

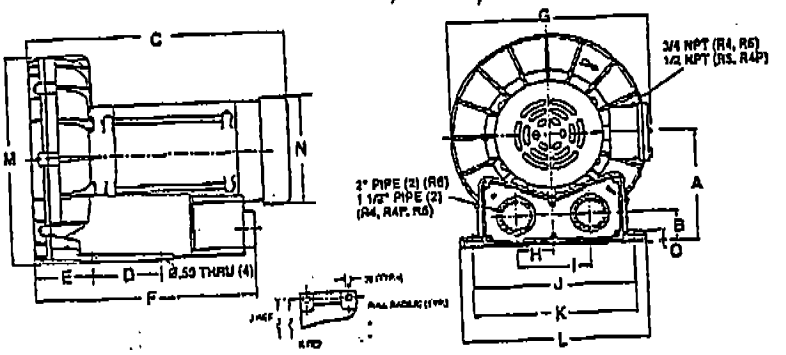
Model R3



Models R6P, R7



Models R4, R4P, R5, R6



Product Dimensions Metric (mm) / U.S. Imperial (inches)

Model	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
R3105N-50	131	35	310	83	80	281	324	49	99	205	206	238	258	-	13
	5.17	1.37	12.20	3.25	3.03	11.06	12.75	1.94	3.88	8.06	8.12	9.38	10.15	-	.53
R4110N-50	157	43	389	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	15.30	3.75	2.85	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4310P-50	157	43	356	95	72	316	313	50	101	225	227	254	293	175	11
	6.18	1.68	14.03	3.75	2.84	12.44	12.31	1.98	3.96	8.86	8.93	10.00	11.73	6.88	.44
R4P115N-50	177	47	442	114	83	354	338	60	121	260	262	298	346	175	15
	6.98	1.84	17.41	4.50	3.25	13.93	13.31	2.38	4.75	10.25	10.31	11.75	13.6	6.88	.60
R5125Q-50	178	46	445	114	91	361	344	60	121	260	262	298	350	173	15
	7.00	1.82	17.50	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	6.81	.59
R5325R-50	178	46	423	114	91	361	344	60	121	260	262	298	350	183	15
	7.00	1.82	16.66	4.50	3.58	14.22	13.56	2.38	4.75	10.25	10.31	11.75	13.78	7.19	.59
R6130Q-50	197	49	511	140	98	404	389	62	125	289	290	329	391	217	13
	7.75	1.94	20.13	5.50	3.85	15.89	15.30	2.46	4.92	11.38	11.42	12.96	15.38	8.56	.52
R6340R-50	197	49	478	140	98	404	385	62	125	289	290	329	390	217	13
	7.75	1.94	18.82	5.50	3.85	15.89	15.17	2.46	4.92	11.38	11.42	12.96	15.34	8.56	.52
R6P155Q-50	248	80	602	140	137	438	428	64	127	-	290	325	463	257	13
	9.77	3.15	23.7	5.51	5.39	17.25	16.87	2.50	5.00	-	11.42	12.80	18.21	10.12	.50
R6P355R-50	248	80	554	140	137	438	428	64	127	-	290	325	463	257	13
	9.77	3.15	21.80	5.51	5.39	17.25	16.87	2.50	5.00	-	11.42	12.80	18.21	10.12	.50
R7100R-50	274	92	577	216	212	545	457	100	200	-	375	410	509	257	14
	10.79	3.64	22.72	8.50	8.33	21.46	18.00	3.94	7.88	-	14.76	16.14	20.02	10.12	.56

Notice: Specifications subject to change without notice.

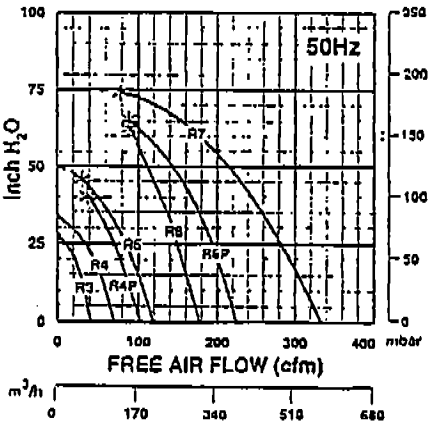
SOIL VAPOR EXTRACTION PUMPS – REGENERATIVE BLOWERS

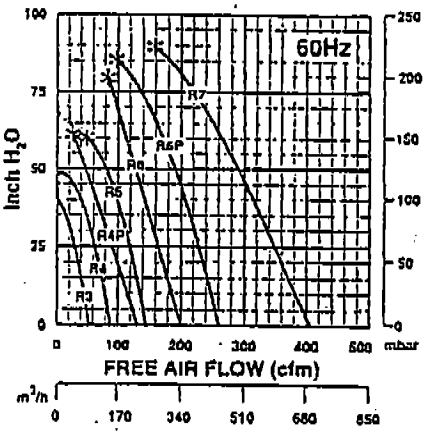
Product Specifications

Model Number	Motor Specifications Phase	Hz	Voltages	HP	Full Load Amps	Max Vac "H_2O	Max Vac mbar	Max Pressure "H_2O	Max Pressure mbar	Max Flow cfm	Max Flow m³h	Net. Wt. lbs	Net. Wt. kg
R3105N-50	Single	50	110/220-240	.33	3-8/1.9-2.0	28	70	31	77	43	73	52	24
		60	115/208-230	0.5	5.2/2.9-2.6	40	100	43	107	53	90		
R4110N-50	Single	50	110/220-240	0.6	9.2/5.2-4.6	35	87	38	95	74	126	60	28
		60	115/208-230	1.0	11.4/6.2-5.6	48	120	51	127	92	156		
R4310P-50	Three	50	220/380	0.6	3.2/1.6	35	87	38	95	74	126	58	27
		60	208-230/460	1.0	3.4-3.3/1.65	48	120	51	127	92	156		
R4P115N-50	Single	50	110/220-240	1.0	15.2/7.6-6	40	100	45	112	112	190	79	36
		60	115/208-230	1.5	18.2/9.7-9.1	60	149	65	162	133	226		
R5125Q-50	Single	60	115/230	2.0	25/12.5	60	149	55	137	160	272	77	35
R5325R-50	Three	50	190-220/380-415	1.5	5.0-4.4/2.5-2.6	47	117	50	125	133	226	75	34
		60	208-230/460	2.0	6.0-5.6/2.8	60	149	65	162	160	272		
R6130Q-50	Single	50	220-240	2.5	14.7-13.5	65	162	75	187	182	309	129	59
		60	230	3.0	16.3	70	174	60	149	215	365		
R6340R-50	Three	50	190-220/380-415	3.0	14.4-13.4/7.2-6.8	65	162	75	187	180	306	112	51
		60	208-230/460	4.0	13-12/6	80	199	100	249	215	365		
R6P155Q-50	Single	50	220-240	4.0	20.8-19.1	65	162	80	199	235	399	243	110
		60	230	5.5	29.9	85	212	95	237	280	476		
R6P355R-50	Three	50	190-220/380-415	4.5	14.9-11/7.45-5.8	65	162	80	199	232	394	233	105
		60	208-230/460	6.0	20-18/9	85	212	100	249	280	476		
R7100R-50	Three	50	190-220/380-415	8.0	20.8-18.9/10.4-9.5	72	179	80	199	350	595	297	134
		60	208-230/460	10.0	26.5-24/12	90	224	90	224	420	714		

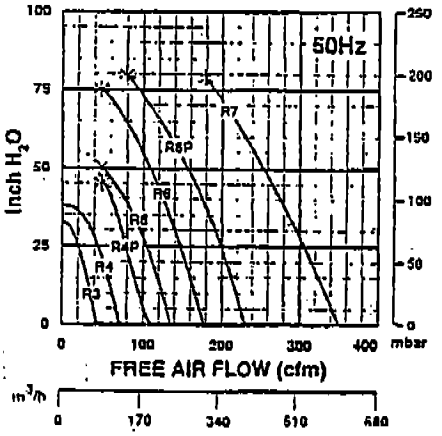
NOTICE: Performance specifications subject to change without notice.

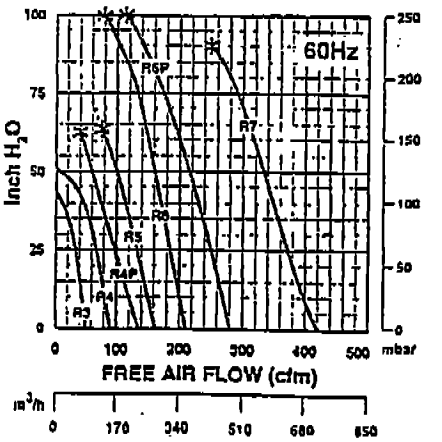
VACUUM





PRESSURE





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THERMAL OXIDIZER

EPG COMPANIES

Manufacturer of Solutions to Environmental Pollution Problems

September 3, 1996

Mr. Jerry Tompkins
Battelle
505 King Avenue
Columbus, OH 43201

Re: Thermal Oxidizer quote

Dear Jerry:

EPG Companies Inc. is pleased to offer the following proposal for your vapor extraction and off-gas treatment equipment needs.

To eliminate contaminants in a vapor stream with a destruction rate efficiency of 99+%, we recommend an EPG Oxidair™ thermal oxidizer with ceramic venturi-jet high efficiency burner. The thermal oxidizer shall include the fume mixing chamber, auxiliary fuel supply piping, draft air fan, and easy to operate process controls.

The EPG Oxidair™ Model EH 100 is offered for your flow of 80 SCFM which is capable of burning a maximum fume flow of 100 SCFM with a maximum heating value of 157,200 BTUH. The maximum fuel consumption at 80 SCFM with no fume stream concentrations is 90,547 cubic feet of natural gas per month(approximate cost of $425.00) operating in the thermal mode, or 35,572 cubic feet of natural gas per month(approximate cost of $170.00) operating with the addition of the catalytic module.

The thermal oxidizer shall operate at 1400°F with a residence time of 0.5 seconds. The process operating temperature shall be controlled by a digital temperature controller receiving signal from a type "K" thermocouple for temperature sensing. The Honeywell Series 7800 Burner controller contains a first out annunciator with contacts that assist in operation.

Corporate Offices
19900 County Road 81 ◆ Maple Grove, MN 55311

Mailing Address
P.O. Box 410 ◆ Rogers, MN 55374

612-424-2613 ◆ 800-443-7426 ◆ FAX 612-493-4812

Equipment Specifications for an EPG Oxidair™ Model EH Thermal Oxidizer

1. Oxidair™ burner features include:

   - Ceramic venturi-jet tile -- design accelerates the flow through the burner and thereby eliminates the possibility of flash back. The burner shall be a cast and fired ceramic material which will not breakdown or erode from harsh chemicals.

   - Windbox -- Controls the ratio of combustion air brought through and around the ignition tube which regulates the air/fuel ratio. The windbox shall be manually adjustable.

   - Ignition tube -- Contains the flame to produce a higher destruction efficiency and reduce the production of NO_X and CO. The ignition tube shall be lined with a low specific heat castable refractory.

   This unique burner design uses the oxygen and heating value from the fume stream reducing the amount of makeup air needed. The result is a typical fuel savings of 30% over competitive thermal oxidizers.

2. Draft air fan:

   The draft air fan shall supply supplemental air into the combustion chamber for the purge cycle and startup. The draft air inlet shall be equipped with an automatic modulating damper.

3. Cylindrical casted combustion chamber:

   The combustion chamber shall be cylindrical to eliminate dead air spots and to maximize the mixing of fumes and heat of combustion. The cylindrical design also allows for a monolithically cast liner which eliminates hot spots and increases refractory life. A low specific heat, lightweight insulation shall be used for its excellent durability and high insulating value.

4. Control Panel:

   A NEMA 4 enclosure shall house the Honeywell programmable burner process controller with flame strength indicator, high temperature limit controller, strip chart recorder, purge timer, alarm silencing push-button, indicator lights to show operating conditions, burner start push-button, ignition transformer, fan motor starter, motor load fuses, step down transformer (if required), terminal strips, and control circuit fuses.

5. Factory Mutual equivalent natural gas or propane pipe train:

   The auxiliary full pipe train shall include a safety shutoff valve, automatic modulating gas flow control valve, high and low gas pressure switches, pressure gauge, manual isolating valves, pilot gas regulator, and pilot solenoid shutoff valve. All interconnecting piping mounted on the unit shall be supplied, and all control items shall be fully wired.

6. Fume pipe train:

   The fume piping train shall include a safety shutoff solenoid valve, fume pressure switch, and pressure gauges.

Installation

The EPG Oxidair™ Model EH 100 thermal oxidizer will need at least the following items to be supplied by others:

1. Suitable structural support for the thermal oxidizer.

2. Connection of all utilities to the thermal oxidizer system terminal points, including 230 Volt, single phase (or as specified by customer), 60 Hz power and natural gas (or propane) regulated at 5 PSIG.

3. Ducting to the thermal oxidizer.

4. Any permits, such as air pollution control approvals, building permits, and any other regulatory documents that may be required.

5. All testing required for regulatory permits.

6. Installation and start up of the thermal oxidizer (or with recommended EPG assistance; see Rate Table, Bulletin 3120c).

The thermal oxidizer would be built and tested at EPG's manufacturing facility. After testing is finished the thermal oxidizer shall be disassembled only as necessary for shipment.

Two(2) sets of operations and maintenance manuals shall be provided and will include the following: parts list, general arrangement drawings, operations and maintenance instructions, and installation instructions.

Approval drawings including an equipment layout drawing, process diagram, piping and instrumentation schematic, and an electrical schematic can be submitted within two(2) weeks after receipt and acceptance of your purchase order. Testing can take place within eight(8) weeks after receipt of approved drawings and shipment can take place two(2) weeks after testing. If a shorter time schedule is desired, it can be provided upon request depending on the schedule of existing orders. Additional funds may be required for the overtime needed to meet the shortened schedule.

1 ea.	**EPG Oxidair™ Model EH 100** thermal oxidizer, horizontal skid mount. Includes burner, fume mixing chamber, exhaust stack, auxiliary fuel fume stream pipe trains, draft air fan, vapor extraction blower package(based on 80 SCFM at 25" W.C. vacuum) with CS-16b condensate separator, high level shut off switch, dilution air valve, vacuum relief valve, piping, and controls.	**$ 27,760.00**

Options:

1 ea.	**EPG Oxidair™ Model EH 100T** thermal oxidizer, trailer mounted. Includes burner, fume mixing chamber, exhaust stack, auxiliary fuel fume stream pipe trains, draft air fan, vapor extraction blower package(based on 80 SCFM at 25" W.C. vacuum) with CS-16b condensate separator, high level shut off switch, dilution air valve, vacuum relief valve, piping, and controls.	**$ 30,385.00**
1 ea.	**Catalytic Module**, to convert to catalytic oxidizer with 98%+ efficiency at an operating temperature of ~550°F, with a maximum auxiliary fuel consumption of 49,406 BTUH. Maximum VOC concentration at 80 SCFM without dilution air is up to 25% LEL or approximately 2,000 ppmV. With no known contaminants, the precious metal catalyst has an expected life of three to five years.	**$ 3,590.00**

Thank you for allowing us to quote on this project. All prices quoted are based on information supplied for bidding and our interpretation of that information along with our recommendations and/or changes for fabrication. Prices are subject to review and possible adjustment for any changes made that deviate from our outline given.

All prices are quoted F.O.B. our dock in Maple Grove, Minnesota. Standard terms of payment are net thirty(30) days from date of invoice subject to credit approval. If you have any questions or would like to place an order, please call me at (800) 443-7426.

Sincerely,
EPG Companies Inc.

Jim Bailey

Jim Bailey
Applications Specialist

Enclosures: EH 100 Thermal Oxidizer Specification, Bulletin 3125
EPG Drawing 1645
EPG Drawing 1842
Rate Table, Bulletin 3120c
Terms of Sale, Bulletin 3400b
Limited Warranty, Bulletin 0200c

STANDARD SPECIFICATION
EPG OXIDAIR™ MODEL EH 100 THERMAL OXIDIZER

1. OVERVIEW

A. This is a specification for a horizontal forced draft fume thermal oxidizer for destroying hydrocarbon vapors.

B. The standard unit consists of a high efficiency venturi jet burner system, combustion chamber, exhaust stack, pipe trains for auxiliary fuel and fume stream, draft air fan, and easy to operate process controls.

2. SPECIFICATIONS

A. 100 SCFM maximum fume flow with a maximum heating value of 157,200 BTUH.

B. 1400°F operating temperature with 0.5 second residence time.

C. Destruction rate in excess of 99.9%

D. Auxiliary burner turndown range of 4:1.

E. Vapor concentrations may vary from 0% LEL through and above the explosive range (100% LEL).

F. Carbon steel construction with internal insulation.

G. Factory Mutual style pipe train for natural gas or LPG which branches to provide fuel to the pilot as well as to the multi-burner system.

H. Factory Mutual style pipe train for hydrocarbon vapors.

I. The unit shall be pre-piped, wired and tested before shipping.

3. GENERAL OPERATION

A. The fumes enter a distribution plenum. The air which is carrying the fumes will be used as the oxygen supply for the combustion process, eliminating the need for outside combustion air. A unique venturi multi-jet burner system is used which eliminates the possibility of flashing back. It can be turned down, without hazard, until the fire is extinguished, and then readily re-ignited from the pilot. The burner produces a large cross-sectional area flame pattern for efficient mixing with the fumes, which minimizes fume bypass.

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B. The combustion safeguard pilot is easily and safely applied because the pilot becomes, in effect, another burner jet. The combustion chamber is insulated by a low specific heat, lightweight, insulating, castable refractory which is molded to an engineered contour for the most intimate mixing of the combustion gases and the cold fumes. In addition, an arrangement of mixing baffles is supplied so that optimum fuel gas/air/fume mixing is obtained which results in minimum operating temperature for economical fuel requirements. When specified, the inlet plenum is insulated to further conserve heat and eliminate condensation of fumes. The refractory is encased in a circular steel shell for maximum strength. The shell is structurally supported, with its centerline matching the blower centerline.

4. MAJOR COMPONENTS

A. Horizontal insulated cylindrical casing, with sight ports and lifting lugs.

B. Draft air inlet plenum with automatic modulating damper.

C. Gas burner with a gas-electric igniter pilot. The venturi multi-jet burner design promotes intimate mixing of fuel and combustion air, which results in complete combustion and maximum heat release.

D. A U.L. listed, hinged, weather-resistant control panel enclosure shall contain the temperature indicating controller, high/low temperature limits, ultraviolet combustion safeguard system, alarm silencing push-button, operating lights to show normal operation, ignition push-button system, ignition transformer, draft air control, enable and disable circuit for fume blower, terminal strips, control circuit fuse, and nameplates.

E. Auxiliary fuel pipe train, including safety shutoff valve, automatic modulating gas flow control valve, high and low gas pressure switches, pressure gauge, manual isolating valves, pilot gas regulator, pilot solenoid shutoff valve and pressure taps. All interconnecting piping mounted on the unit will be supplied, and all control items will be fully wired.

F. Fume pipe train including pressure gauge, automatic shutoff valve, low vapor pressure switch, and manual valves.

G. Operating manuals (2) shall include a set of drawings, equipment maintenance requirements and component specifications.

5. COMBUSTION SAFEGUARD SYSTEM

A. An EPG nozzle-mixing type burner is used which eliminates the possibility of flash back. It can be turned down, without hazard, until the fire is extinguished and then readily re-ignited from the pilot. The oxidizer reaches operating temperature in approximately ten(10) minutes from a cold start.

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B. An electronic controller, with thermocouple burnout safeguard, shall modulate a throttling electric motor-driven gas flow control valve to hold the incineration temperature at the set point. Should the temperature control system fail, a temperature limit will protect the oxidizer by activating both the fume and the main burner gas safety shutoff valves.

C. In order to assure that the burner is not operating unless it is burning normally and the start-up sequence has been properly followed, combustion safe-guard relay with UV flame monitor will be supplied. The combustion safeguard relay is interlocked to the high and low gas pressure switches, high temperature limit, and alarm.

D. A Factory Mutual approved main gas safety shut-off valve and pilot solenoid will be installed in the gas lines to automatically shut off the main gas and pilot gas in an alarm condition. An audible alarm shall be annunciated and an alarm light will be activated..

E. A U.L. listed NEMA 4 enclosure shall be supplied which will contain the electrical controls, including the control transformer for converting supply power to control power, operating lights to show normal operation, flame-rectification combustion safeguard system, fan motor starter, starting push-button, gas pilot ignition push-button system, audible alarm with silencing push-button, temperature recorder, terminal strips, control circuit fuse, and nameplates.

6. OPERATING ECONOMY

A. The Oxidair™ units are able to achieve low operating costs for the following reasons:

1. EPG will assist the customer in designing the fume gathering system so that only the optimum amount of air will be incinerated.
2. The auxiliary fuel valve and draft air damper shall automatically modulate as vapor concentrations change so that the entire heating value of the fume stream is utilized.
3. Operating temperature shall be controlled at the lowest permissible level with the smallest differential to minimize the amount of auxiliary fuel required.
4. When the fume stream contains a minimum of 16% oxygen, it shall be used as the source of combustion air for the burner and incineration process, eliminating the need for additional heat absorbing outside combustion air.
5. Shall not require LEL or O_2 sensors for safe operation which eliminates time spent cleaning and calibrating sensors.

7. ASSEMBLY AND TESTING

A. The unit will be completely assembled and tested in our plant. The unit shall be finished with a heavy coat of high temperature synthetic enamel. It will be partially disassembled for shipping to the site for installation to be completed by others.

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B. All field work will be done by others. Written instructions concerning proper operation of the equipment shall be furnished.

8. INSTALLATION

The Oxidair™ units will need at least the following items to be supplied by others:

A. Suitable flat, level, stable foundation.

B. Connection of all utilities to the thermal oxidizer system terminal points, including appropriate electrical power and pressure regulated natural gas or LPG (to be determined at time of purchase) to the burner mounted on the thermal oxidizer.

C. Connection of fume blower control circuitry to the N.C. enable/disable contacts in the thermal oxidizer control panel.

D. Any permits, air pollution control approvals, and any other regulatory documents which may be required.

E. Installation of the thermal oxidizer system.

F. Installation engineering and supervision.

G. Start up (or with recommended EPG assistance; see Rate Table, Bulletin 3120b).

H. Air pollution compliance testing.

9. OPTIONAL EQUIPMENT

A. Trailer mounted.

B. Extended combustion chamber to increase residence time.

C. Heat exchanger.

D. Catalytic modules.

E. Flame arrestor.

F. Fume blower.

G. Condensate separator.

H. Autodialers or telemetry systems.

Note: Custom designs such as special controls and physical arrangements, can be provided upon request.

10. AIR POLLUTION GUARANTEE

A. We guarantee the destruction of all hydrocarbon materials to comply with the requirements of the local air pollution control authority as of the date of our proposal.

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11. DELIVERY

Approval drawings including and equipment layout drawing, process diagram, piping, and instrumentation schematic, and an electrical schematic, can be submitted within two(2) weeks after receipt of your purchase order. Testing can take place within eight(8) weeks after receipt and acceptance of approved drawings and shipment can take place two(2) weeks after testing. If a shorter time schedule is desired, it can be provided upon request depending on the schedule of existing orders. Additional funds may be required for the overtime needed to meet the shortened schedule.

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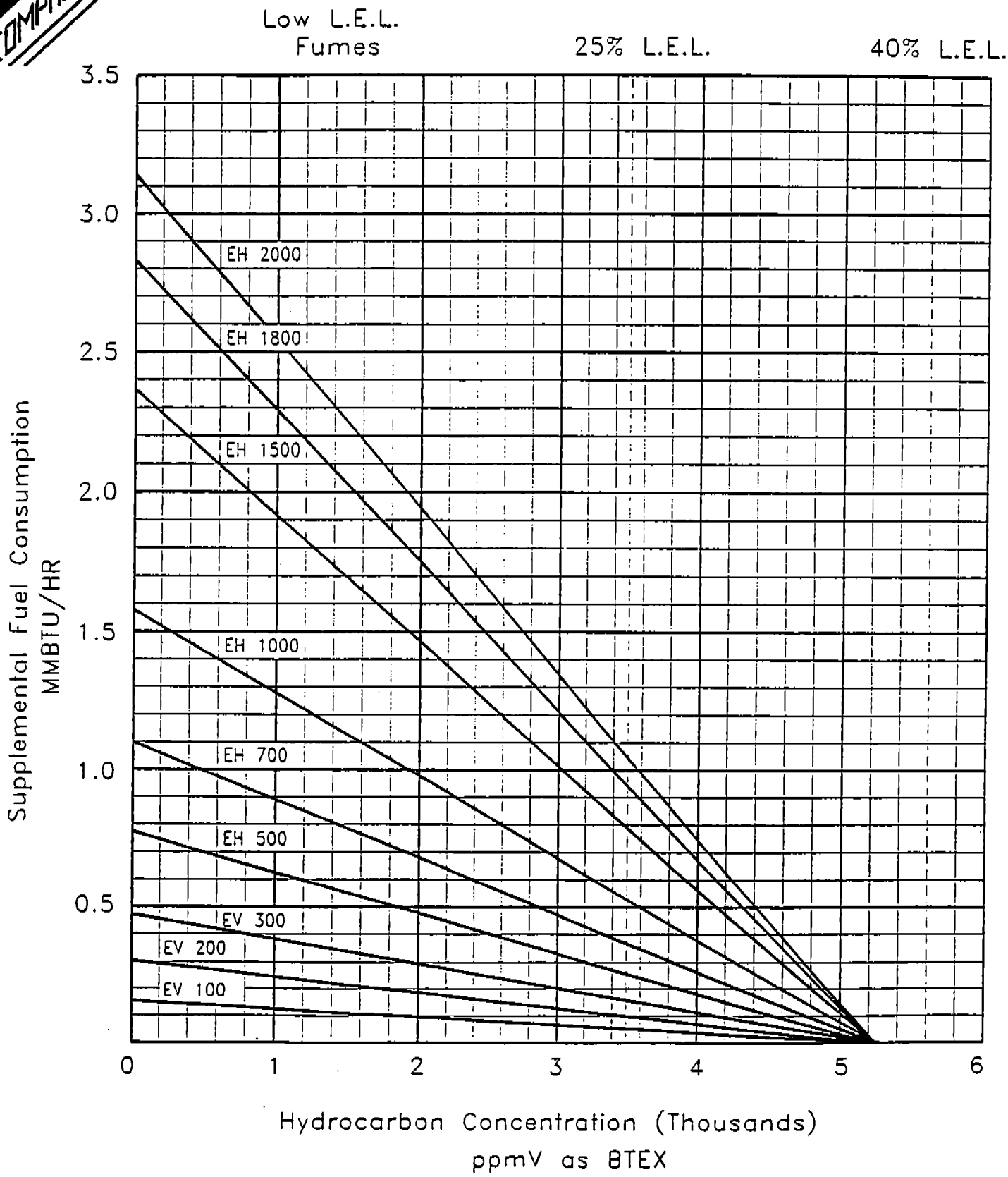
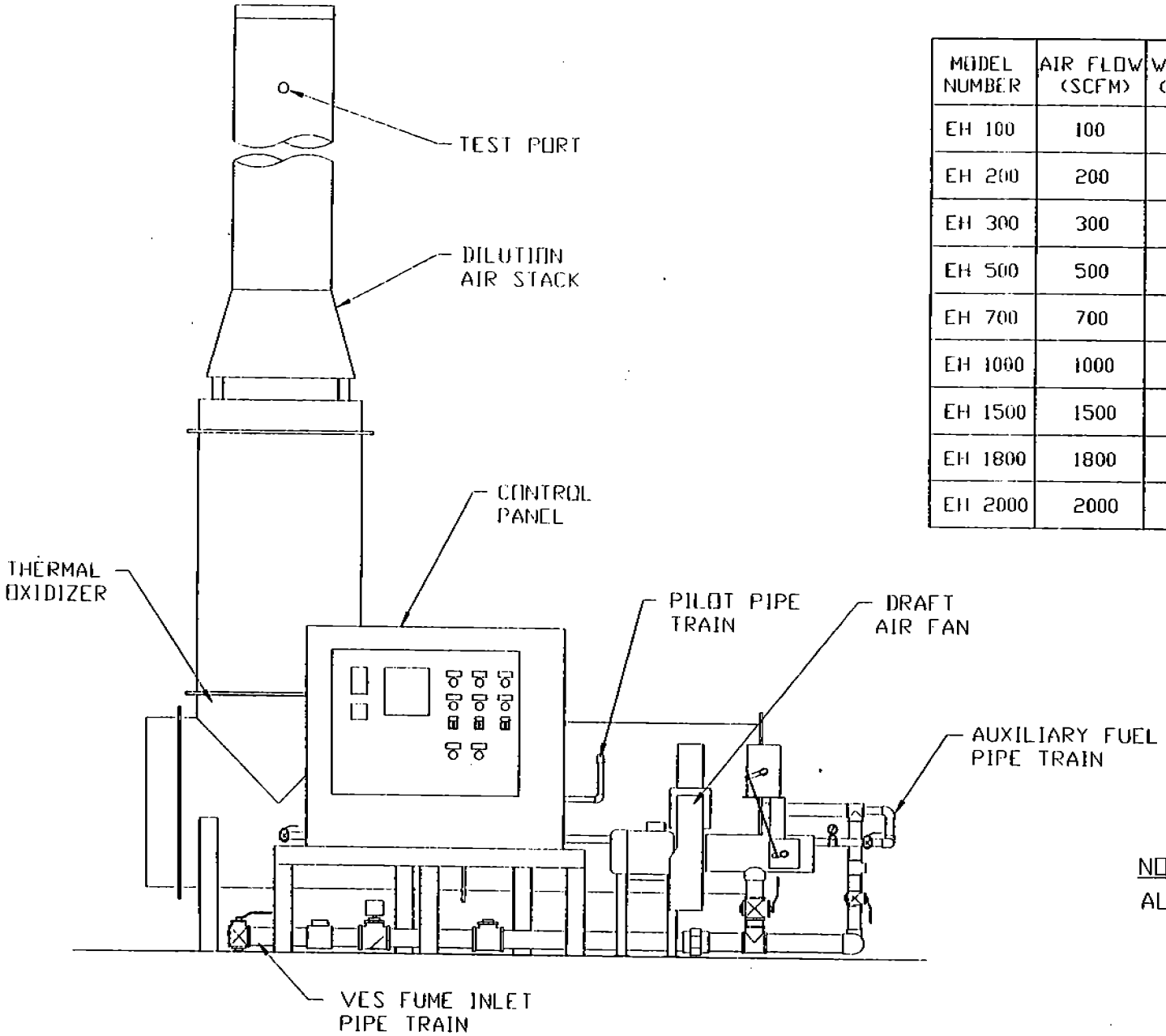
EPG COMPANIES

OXIDAIR™ THERMAL OXIDIZER

0395



This curve is based on an operating temperature of 1400°F. The catalytic oxidizer will require approximately 60% less fuel.



MODEL NUMBER	AIR FLOW (SCFM)	WEIGHT (LBS.)	DIMENSIONS		
			LENGTH	WIDTH	HEIGHT
EH 100	100	1300	10'-0"	4'-6"	12'-0"
EH 200	200	1500	10'-0"	4'-6"	12'-0"
EH 300	300	2000	10'-9"	4'-10"	12'-8"
EH 500	500	3200	10'-9"	4'-10"	12'-8"
EH 700	700	3600	11'-3"	5'-0"	13'-8"
EH 1000	1000	4500	12'-0"	6'-0"	13'-8"
EH 1500	1500	5500	13'-6"	6'-9"	14'-6"
EH 1800	1800	6600	13'-6"	7'-6"	14'-6"
EH 2000	2000	7000	13'-6"	7'-6"	14'-6"

NOTE:

ALL WEIGHTS AND DIMENSIONS ARE APPROXIMATE.

* NOTICE *
THIS DRAWING IS A PROPERTY OF EPG COMPANIES FOR REFERENCE ONLY.

EPG COMPANIES

EPG OXIDAIR™ THERMAL OXIDIZER

DRAWN BY C.A.S.	SCALE NONE	MATERIAL
CHK'D	DATE 05-19-95	DRAWING NO. 1842
TRACED	APP'D	

RATE TABLE

LABOR CHARGES:	PER HOUR*	PER DAY
Principal Engineer	$200.00	$1,600.00
"A" Engineer	125.00	1,000.00
"B" Engineer	100.00	800.00
Programming	85.00	680.00
Drafting	55.00	440.00
Purchasing	50.00	400.00
Clerical	40.00	320.00
SERVICE OR TESTING:		
Start-up, Senior Test Technician, Installation Supervisor	85.00	680.00
"A" Mechanic	65.00	520.00
Shop Labor	55.00	440.00

NOTES:

1. All work to be done during normal working hours.
* 2. Rates 1.5 times those shown for:
   A. Hours in excess of eight(8), but not more than twelve(12) hours per day (Monday through Friday).
   B. Saturday work (up to eight hours).
   C. Sunday work if worked in lieu of Saturday at our option.
* 3. Rates 2.0 times those shown above will apply for:
   A. All holidays.
   B. Sundays, except as excluded above.
   C. Hours in excess of twelve(12) per day (Monday through Friday).
   D. Hours in excess of eight(8) for Saturday work.
4. All field rates are based on portal to portal time.
5. Travel time charged at straight time.
6. Minimum labor charge is four(4) hours.

TRAVEL AND PER DIEM:

Mileage	$ .45/mile
Commercial transportation/car rental	Cost + 10%
Per diem (lodging and subsistence only)	$100.00 per day minimum, not less than cost + 10%

TEST INSTRUMENT: $125.00 per day

EQUIPMENT RENTAL: Cost + 25%

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TERMS OF SALE

All sales of equipment are expressly conditioned upon the terms set forth below. Buyer's acceptance of these terms shall be presumed from the buyers acceptance of all or any part of the goods or services ordered. No addition or modification of these terms shall be binding upon EPG Companies (EPG) unless agreed to by EPG in writing. If a purchase order or other correspondence contains terms or conditions contrary to the terms contained here, EPG's acceptance of any order shall not be construed as assent to any additional terms and conditions, nor will that constitute a waiver by EPG of any of the terms contained here.

1. Until all sums due are paid in full, buyer hereby grants to EPG a security interest in and to the property described herein.

2. Should buyer fail to make any payment when due or fail to fulfill any promise or condition herein, all sums payable shall be, at EPG's option and without notice, immediately due and payable. EPG may take possession of the property and for that purpose may enter any premises where the property may be and remove the same thereby terminating all buyer's right and may retain all payments received as liquidated damages, or EPG may enforce any other remedy allowed by law.

3. In the event of default, buyer agrees to pay all costs incurred by EPG, including reasonable attorney fees, to secure payment of the amounts due or collection of the properties identified.

4. No credit will be allowed for goods returned without our written permission. There will be a 20% restocking charge for items accepted for credit; items to be returned to Seller's plant, transportation prepaid and subject to inspection.

5. Payment terms are as follows:
   Rental equipment - due upon receipt of invoice
   Services calls and system startups - due upon receipt of invoice
   Freight charges - Net 10 days from date of invoice
   All other billings - Net 30 days from date of invoice

   A service charge of 1.5% per month may be added to all accounts not paid within thirty(30) days of the invoice date. All payments must be made in U. S. dollars.

6. EPG shall not be liable for any production delay resulting in whole or in part from acts of God, labor disruptions, shortages, inability to procure product, supplies, or raw materials, severe weather conditions, or any other circumstances or cause beyond the control of EPG. In no case shall EPG be liable for any consequential or special damages arising from any delay in delivery.

7. Acceptance of any order is subject to credit approval and acceptance of order by EPG. If Buyer fails to comply with these terms and conditions of sale or if Buyer's credit becomes unsatisfactory to EPG at its sole discretion, EPG reserves the right to terminate credit arrangement upon notice to Buyer without liability to EPG.

8. Buyer shall be responsible for payment of any or all state or local taxes directly to the taxing authority, although EPG will collect state and local taxes for shipments made to locations in Minnesota.

9. Deliveries are F.O.B. Maple Grove, MN. Quoted prices do not include freight. Title and risk of loss shall pass to Buyer upon tender of the products by EPG to a common carrier. In absence of specific written instruction from Buyer, EPG will select the common carrier, but EPG shall not incur any liability in connection with shipment. Buyer shall be responsible for any freight charge. If the products are shipped freight prepaid, Buyer shall pay EPG the freight and handling charge, which will be shown as a separate item on the invoice. Payment terms on freight charges are *net 10 days*.

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LIMITED WARRANTY

This agreement shall be deemed to have been entered into in the State of Minnesota, and shall be construed in accordance with the laws of the State of Minnesota, including Minnesota's enactment of the Uniform Commercial Code. Buyer hereby stipulates and agrees that Hennepin County, Minnesota shall be the proper jurisdiction for adjudicating all claims and controversies arising from this agreement.

Products manufactured by EPG Companies Inc. are warranted for a period of 12 months from date of installation or eighteen(18) months from date of manufacture* to be free from defects of materials and workmanship. It is expressly agreed that the exclusive remedy under this warranty is limited solely to the repair or replacement, at the sole discretion of EPG, of the part that failed. The cost of labor for any field repairs is not covered by this warranty. EPG Companies will not be liable for any damage or wear due to abnormal conditions or improper installation.

Products not manufactured by EPG Companies Inc. are covered by the original manufacturer's warranty, which EPG Companies passes through to the purchaser. Warranty determination will be made by the actual manufacturer.

To have a defective part repaired or replaced, you must return the defective product to EPG Companies. Please call (800) 762-8418 or (612) 424-2613 to obtain a Return Goods Authorization (RGA) number. Send defective product (freight prepaid) with RGA #, description of installation, installation data and failure date to EPG Companies Inc., 19900 County Rd. 81, Maple Grove, MN 55311.

EPG Companies will not be held liable for any incidental or consequential damages, losses or expenses incurred from installation, use or any other reason. THERE ARE NO OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING IMPLIED WARRANTIES OF EITHER FITNESS FOR A PARTICULAR PURPOSE OR OF MERCHANTABILITY, WHICH EXTEND BEYOND THOSE SPECIFICALLY LISTED HERE.

If equipment is to be stored for a period greater than six months, proper storage precautions must be taken if the warranty is to be maintained. Please call EPG Companies for specific requirements regarding product storage.

The following is a partial list of items which will void the warranty:

- Opening of a motor for any reason.
- Using undersized electrical wire.
- Making unauthorized circuit changes. Please call EPG Companies before making any changes.
- Operating a three phase submersible motor from single phase power through a phase converter unless 3-leg ambient-compensated quick trip overload protectors are used and complete details are sent in writing to EPG Companies.

* To qualify for the delayed installation warranty you must contact EPG Companies Inc., at (800) 762-8418 or (612) 424-2613 within 60 days of purchase.

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SUBSTANCES THAT INFLUENCE CATALYST ACTIVITY

TYPE OF INHIBITORS	EFFECT
Fast Acting Inhibitors Phosphorus, Bismuth, Lead, Arsenic, Antimony, Mercury	Irreversible reduction of catalyst activity at rate dependent on concentration and temperature.
Slow Acting Inhibitors Iron, Tin, Silicon	Irreversible reduction of catalyst activity. Higher concentrations than those of fast acting catalyst inhibitors may be tolerated.
Reversible Inhibitors Sulfur, Halogens, Zinc	Reversible surface coating of catalyst active area at rate dependent on concentration and temperature.
Surface Maskers Organic Solids	Reversible surface coating of catalyst active area. Removed by increasing catalyst temperature.
Surface Eroders and Maskers Inert Particulate	Surface coating of catalyst active area. Also erosion of catalyst surface at rate dependent on particle size, grain loading and gas stream velocity.

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THERMAL OXIDIZERS

Fume Stream Characteristics	Operations Recommendations
High concentrations of VOCs and high oxygen content.	Dilution of VOCs may be required.
High concentrations of VOCs and low oxygen content.	Dilution air required for supplemental oxygen (~16% minimum). Further dilution of VOCs may also be required.
Low concentrations of VOCs and high oxygen content.	Addition of catalytic module recommended for longer term projects. Consider the use of carbon or direct discharge if applicable.
Low concentrations of VOCs and low oxygen content.	Dilution air required for supplemental oxygen (~16% minimum). Addition of catalytic module recommended for longer term projects. Consider the use of carbon or direct discharge if applicable.

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COMPARISON OF VARIOUS METHODS FOR OFF-GAS TREATMENT

METHOD	ADVANTAGES	DISADVANTAGES
CARBON ABSORPTION	- Can be energy efficient with high fume flow rates and low organic concentration. - Possibility of recovering valuable wastes. - Low maintenance.	- Disposal/regeneration of spent carbon is expensive. - Cannot acheive high removal effiency. - Limited to flows with low concentrations of contaminants.
CATALYTIC OXIDATION	- Ducts and catalysts usually the only maintenance. - Heat recovery possible. - Theoretically lower operating temperature under ideal conditions where fume constituents have similar characteristics and can react completely.	- High equipment costs. - Replacement catalyst costs can be as much as the price of a thermal oxidizer. - Catalysts are not able to handle all the constituents found in a complex fume due to its selectivity. - When heat recovery equipment is used, comparatively large exchange surfaces are required due to lower temperature differentials. - SO_2 in fume oxidized to SO_3 which must be scrubbed with caustic. - High pressure drop across catalyst increases energy costs.
EPG OXIDAIR™ THERMAL OXIDATION	- Provides a final solution to the problem. - No carbon or catalysts to dispose of. - Economical heat recovery possible. - Oxidation completion not affected by hydrocarbon vapor particle size. - Rich hydrocarbon fumes safely accommodated, and can be almost self-incinerating reducing fuel requirements to practically nil. - Fumes containing 16% or more 0_2 can be used as the source of fuel combustion air saving up to 30% of fuel requirements. - Incineration temperature readily adjustable to minimum required for complete destruction. - Minimum maintenance since there are no fouling or further disposal problems.	- Inorganic materials not destroyed. - Fumes with a dew point above 120°F should be cooled, and condensed moisture separated, to minimize fuel cost. - Increased auxiliary fuel usage for low L.E.L. fume streams.

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approximately 10,000 SCF of air is required for every gallon of solvent evaporated. To mine the minimum safe exhaust rate the following formula may be used:

$$\text{haust SCFM} = \frac{\text{GPH} \times 10{,}000}{60}$$

Where: GPH is the actual evaporation of solvent expressed as gallons per hour.

en the solvent concentration is known in PPM, the following conversion table may be used:

- %	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0
er 10,000 SCF	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0
M (Gasoline)	350	700	1,050	1,400	1,750	2,100	2,450	2,800	3,150	3,500
(Methane)	1,250	2,500	3,750	5,000	6,250	7,500	8,750	10,000	11,250	12,500

AT REQUIREMENTS

The heat required to raise the temperature of a known volume of air can be determined from the following formula:

$$\text{TUH} = \text{SCFM} \times (t_2 - t_1) \times 1.1$$

Where: t_2 is the final temperature in ° F.
t_1 is the initial temperature in ° F.

BASIC HEATING DATA

- 1 BTU (British Thermal Unit) = heat required to raise 1 lb. of water 1°F
- Specific heat of water = 1 BTU
- Specific heat of air = 0.24 BTU
- 1 cubic foot of air @ 32°F = 0.085 lb.
- 1 cubic foot of air @ 60°F = 0.075 lb.
- 1 BTU will heat 1 cubic foot of air 55°F
- 1 gallon (U.S.) of water = 8.33 lbs.
- 1 gallon (U.S.) of water = 231 cubic inches @ 39.2°F
- 1 cubic foot of water = 7.48 gallons
- 1 cubic foot of water = 62.418 lbs. @ 39.2°F
- Natural gas = 18,000 BTU/lb. or 1,000 BTU/ft³
- Propane = 21,500 BTU/lb. or 2,500 BTU/ft³
- Gasoline = 17,857 BTU/lb. or 4,921 BTU/ft³
- 1 gallon of LP gas = 36.6 ft³
- 1 gallon of LP gas = 4.25 lbs
- 1 gallon of gasoline = 125,000 BTU
- 1 gallon of propane = 91,375 BTU

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