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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

27 Feb 95

MEMORANDUM FOR 28 SG/CEVR
ATTN: Mr. Dell Peterson
Twining Street, Suite 1
Ellsworth AFB SD 57706-5000

FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

SUBJECT: Completion of One-Year Bioventing Test, Building 102 and Area D Sites

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation projects at the Building 102 and Area D sites have been completed. For each site, Figure 1 provides general site information and Table 1 provides a summary of initial, six-month, and one-year fuel biodegradation rates measured at several monitoring points. Biodegradation rates at both sites have decreased by an order of magnitude over one year of bioventing. This is best explained by an overall reduction in contamination at both sites. Table 2 provides a summary of initial and final soil and soil gas sampling results for total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX). Based on results from your sites and 123 other sites currently under operation, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend its application throughout the Air Force and at other sites on your installation using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February, 1994. These are found in the "Tool Box" recently sent to your base.

The objective of the one-year sampling effort was not to collect the large number of samples required for statistical significance, but to show relative changes in TRPH and BTEX concentrations. Soil gas sampling results at Building 102 indicate more than an order of magnitude reduction in TVH, benzene, and toluene at VW, MPA-15, and MPC-15. TRPH concentrations significantly increased at VW-16. This increase in TRPH is attributable to soil variability. The initial and one-year soil samples could not be collected at monitoring points MPA, MPB, and MPC due to the presence of large cobbles and gravel in the subsurface.

Sampling results at Area D indicate a one order of magnitude reduction in BTEX concentrations at VW1-5, MPA-10, and MPB-10. TRPH concentrations significantly decreased at VW-1-5 and MPB-10, but increased at MPA-10. An increase in TRPH concentrations at MPA-10 could indicate a leak in the fuel lines adjacent to this monitoring point. Soil gas sampling results showed a reduction in TVH and BTEX at VW-1, VW-2, MPC-10, and MPA-14.

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Soil gas samples are similar to composite samples in that they are collected over a wider area. Thus, they provide a good indication of changes in soil gas profiles and volatile contaminant concentrations (see Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural Attenuation Potential, February 1994). Soil samples, on the other hand, are discrete point samples subject to large variabilities over small distances/soil types. Given this variability, coupled with known sampling and analytical variabilities, a large number of samples would have to be collected to conclusively determine "real" changes in soil contamination. Because of the limited number of samples, these results should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. In-situ respiration tests are considered to be better indicators of hydrocarbon remediation than limited soil sampling.

Sampling results indicate that a reduction in TRPH has taken place in the soils within the estimated 30-foot treatment radius of the pilot vent wells at the Building 102 site and the estimated 25-foot treatment radius at the Area D site. Due to the inherent variability of in-situ soil samples, TRPH sampling is inclusive at this time, but all other measurements indicate that fuel biodegradation is progressing at a significant rate.

AFCEE recommends that the bioventing pilot systems continue to operate at the Building 102 site until background respiration rates are approached. If additional source removal is required, system expansion to a full-scale bioventing system can be conducted through HQ AFCEE. We also recommend that the bioventing pilot systems continue to operate at the Area D site until the risk from BTEX has been determined through the Risk-Based Approach Initiative. If additional source removal is required, system expansion to a full-scale bioventing system can be conducted through the Risk-Based Approach Contract. Please contact Sam Taffinder, AFCEE/ERT, DSN 240-4366, COM 210-536-4366, to discuss the technical details for full-scale expansion.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. We strongly encourage its use over an arbitrary TPH standard. Within the AFCEE Risk-based Petroleum Hydrocarbon "Tool Box," the report entitled "Using Risk-based Standards will Shorten Cleanup Time at Petroleum Contaminated Sites" summarizes the BTEX/TPH issue and will assist you in negotiating for a BTEX cleanup standard. Our information indicates that South Dakota regulates to TPH clean-up levels, but this decision is made in conjunction with the results from a risk evaluation on a site-by-site basis. In conclusion, a risk-based approach will expedite site closure while reducing overall costs.

In general, quantitative destruction of BTEX will occur over a one- to two-year bioventing period. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TPH cleanup is chosen, the pilot and full-

scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted four to six months after background respiration rates are approached.

Because these are streamlined test and evaluation projects, our contract does not provide for additional reports to the base on pilot study results. The interim results report dated Feb 93 contains as-builts and initial data. This letter summarizes all data collected and provides the next step recommendations. AFCEE is no longer responsible for the operation, maintenance, or monitoring of bioventing systems. We are initiating a contract to extend monitoring at some sites beyond the initial one-year test. Monitoring will include soil gas and respiration tests to document hydrocarbon degradation, but may also include the collection of sufficient final soil samples to statistically demonstrate site cleanup. If you are interested, please call us.

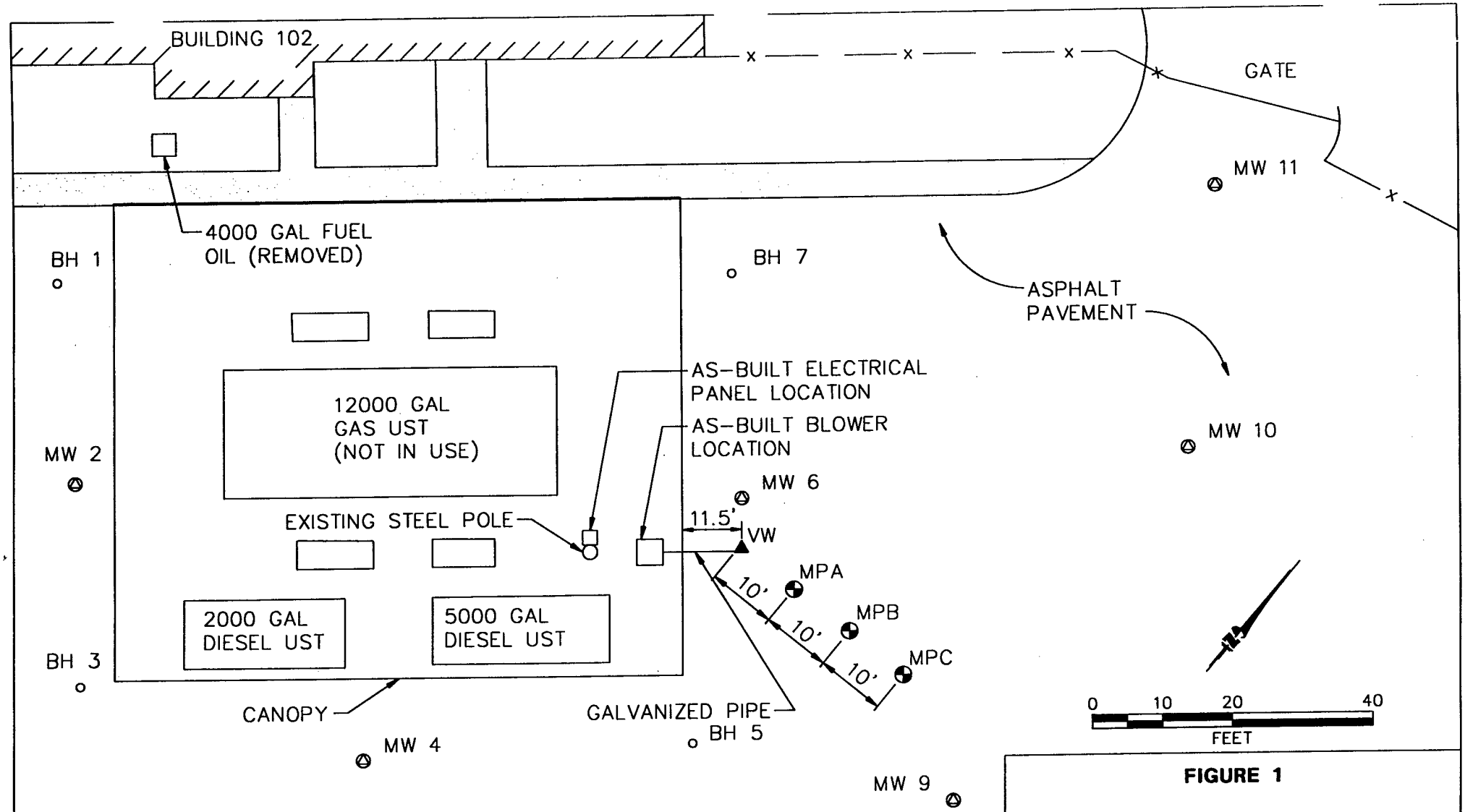
The blower and accessories are now base property and should continue to be used on this or other bioventing sites. Although current equipment is explosion proof, under no circumstances should it be used for soil vapor extraction unless appropriate explosion-proof wiring is provided. If the base does not want the keep the blower or if you have further questions, please contact us.

On behalf of the AFCEE/ERT staff, I would like to thank you for your support of these bioventing test and evaluation projects. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other DOD, government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. Building 102 Data
2. Area D Data
3. Survey

cc: HQ ACC/CEVR
AFCEE/ERD (Mr. Saulnier)
HQ USAF/CEVR
Engineering Science



LEGEND

MW 4 ⊙ EXISTING MONITORING WELL

BH 3 o PREVIOUS SOIL BORING LOCATION

VW ▲ VENT WELL

MPC ⊕ MONITORING POINT

FIGURE 1

AS-BUILT VENT WELL AND MONITORING POINT LOCATIONS BUILDING 102

Ellsworth AFB, South Dakota

ENGINEERING–SCIENCE, INC.
Denver, Colorado

ES

TABLE 1
BUILDING 102
RESPIRATION AND DEGRADATION RATES
ELLSWORTH AFB, SOUTH DAKOTA

Location–Depth	Initial			6–Month[b/]			1–Year[d/]		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW	0.00076	200	NS[c/]	NS	NS	NS	0.00011	20	NS
MPA–10	0.00046	100	14.3	0.000068	15	NS	0.000082	18	14.7
MPA–15	0.00045	100	12.5	0.00017	38	NS	0.000095	21	12.1
MPB–10	0.00043	96	NS	0.00007	16	NS	0.00009	20	NS
MPC–10	0.00053	120	NS	0.00018	40	NS	0.000071	16	NS
MPC–15	0.00073	160	NS	0.00031	69	NS	0.00011	25	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Assumes moisture content of the soil is average of initial and final moistures.
[c/] NS = Not sampled.
[d/] Blower was operating when test engineers arrived at site. Therefore, an area respiration test was performed rather than a point respiration test.

TABLE 2
BUILDING 102
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
ELLSWORTH AFB, SOUTH DAKOTA

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)					
	VW		MPA-15		MPC-15	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year
TVH (ppmv)	67,000	12	73,000	2,500	97,000	21
Benzene (ppmv)	340	< 0.002	230	< 0.097	400	< 0.002
Toluene (ppmv)	42	< 0.002	27	0.22	75	< 0.002
Ethylbenzene (ppmv)	8.4	< 0.002	3.4	20	8.3	0.016
Xylenes (ppmv)	45	0.011	24	96	48	0.031

	VW-16					
Soil Hydrocarbons[d/]	Initial[e/]	1-Year[f/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	11	651				
Benzene (mg/kg)	0.18	< 0.055				
Toluene (mg/kg)	0.60	< 0.055				
Ethylbenzene (mg/kg)	0.78	11				
Xylenes (mg/kg)	4.3	44				
Moisture (%)	7.2	9.8				

a/ TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume; TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
b/ Initial soil gas samples collected on 8/27/93.
c/ 1-Year soil gas samples collected on 9/24/94.
d/ Limited sample collection due to course gravel and cobbles in soil.
e/ Initial soil sample collected on 8/27/93.
f/ 1-Year soil sample collected on 8/29/94.

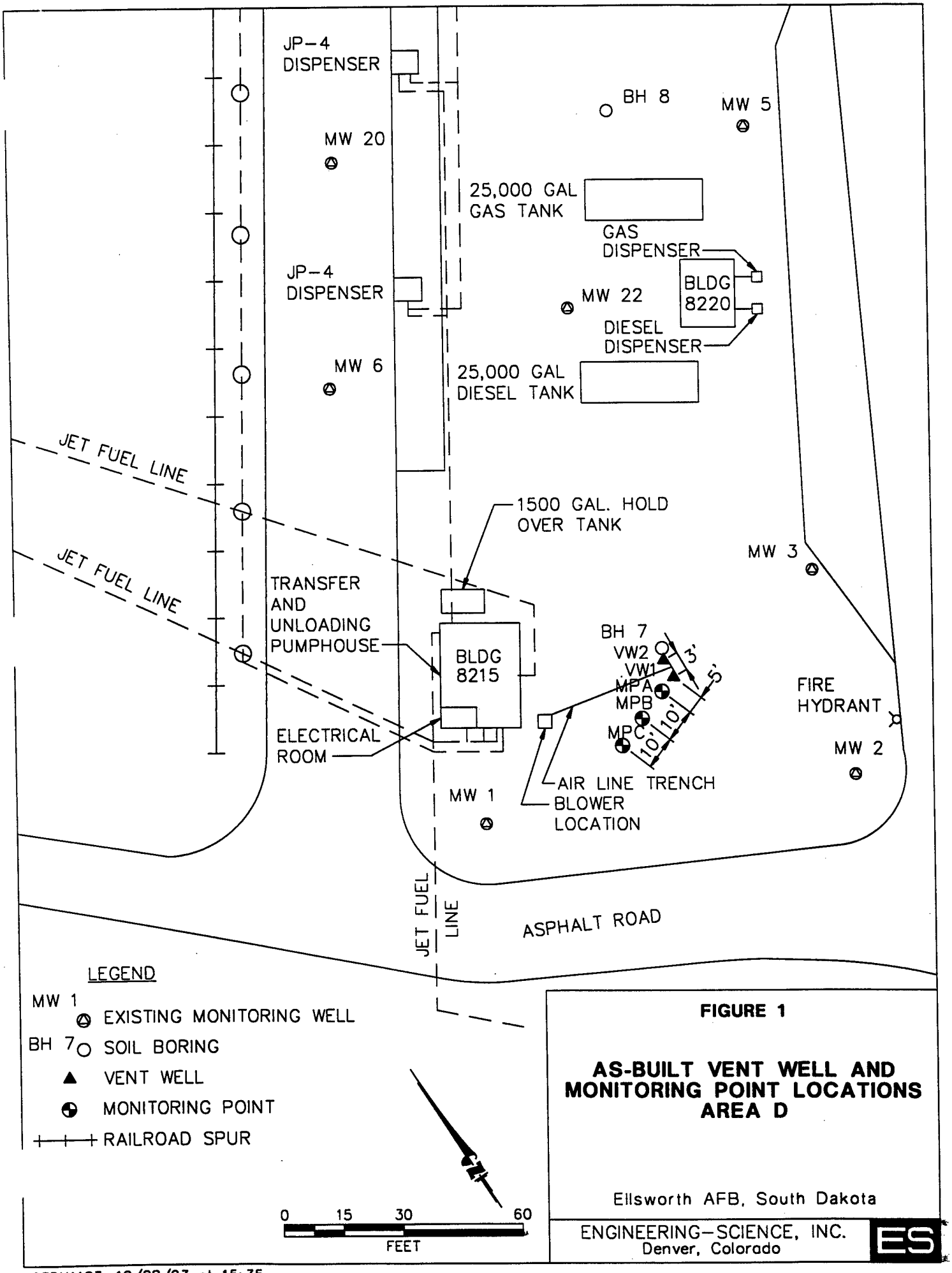


FIGURE 1

AS-BUILT VENT WELL AND MONITORING POINT LOCATIONS AREA D

Ellsworth AFB, South Dakota

ENGINEERING–SCIENCE, INC.
Denver, Colorado

ES

93DN1183, 10/28/93 at 15:35

TABLE 1
AREA D
RESPIRATION AND DEGRADATION RATES
ELLSWORTH AFB, SOUTH DAKOTA

Location–Depth	Initial			6–Month[b/]			1–Year		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW–1	0.017	1500	NS[c/]	NS	NS	NS	0.0004	4	NS
MPA–10	0.02	2700	NS	0.0002	27	NS	0.0007	100	NS
MPA–14	0.017	1500	11.5	0.0014	130	NS	0.0016	140	12.7
MPB–14	0.018	1600	NS	0.0018	160	NS	0.0022	200	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Assumes moisture content of the soil is average of initial and final moistures.
[c/] NS = Not sampled.

TABLE 2
AREA D
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
ELLSWORTH AFB, SOUTH DAKOTA

Analyte (Units)[a/]	Sample Location-Depth (feet below ground surface)							
	VW-1		VW-2		MPC-10		MPA-14	
Soil Gas Hydrocarbons	Initial[b/]	1-Year[c/]	Initial	1-Year	Initial	1-Year	Initial	1-Year
TVH (ppmv)	58000.00	5.70	650.00	82	13,000	340	68,000	2,700
Benzene (ppmv)	230.00	0.02	2.90	< 0.005	26	< .014	290	< .014
Toluene (ppmv)	18.00	0.05	< 0.056	< 0.005	11	< .014	22	< .014
Ethylbenzene (ppmv)	19.00	0.02	1.30	0.21	8.3	0.99	23	6.7
Xylenes (ppmv)	49.00	0.08	4.80	0.85	15	3.8	53	29

	VW1-5		MPA-10		MPB-10	
Soil Hydrocarbons	Initial[d/]	1-Year[e/]	Initial	1-Year	Initial	1-Year
TRPH (mg/kg)	840.00	177.00	3,310	5,100	4,340	3,040
Benzene (mg/kg)	6.4	< 0.063	15	< 0.058	3.2	0.19
Toluene (mg/kg)	13	< 0.063	10	< 0.058	3.7	< 0.059
Ethylbenzene (mg/kg)	53	< 0.063	40	3.7	17	1.7
Xylenes (mg/kg)	310	0.57	190	21	57	9
Moisture (%)	23	20	13	13.3	17	15.2

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b/] Initial soil gas samples collected on 8/26/93.
[c/] 1-Year soil gas samples collected on 8/23/94.
[d/] Initial soil samples collected on 8/24/93.
[e/] 1-Year soil samples collected on 8/28/94.