



INSTALLATION RESTORATION PROGRAM

AD-A196 074

PHASE II - CONFIRMATION/QUANTIFICATION

STAGE 1

FINAL REPORT FOR

IOWA AIR NATIONAL GUARD

Des Moines Municipal Airport
Des Moines, Iowa 50321

The Air National Guard Support Center,
Andrews AFB, Maryland. 20831

PREPARED FOR
UNITED STATES AIR FORCE
OCCUPATIONAL AND ENVIRONMENTAL LABORATORY (USAFOEHL)
BROOKS AIR FORCE BASE, TEXAS 78235

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Soil and water samples were collected for chemical analyses from unconsolidated loess and glacial till surficial materials at 4 sites on the Des Moines Air National Guard Base. Analyses of samples used gas chromatograph-flame ionization detector (GC-FID) scans on all samples and gas chromatograph-mass spectrometer (GC-MS) on selected samples. Interpretation was based on correlation of GC-FID scan retention time peaks between field sites and samples of known contaminated material or wastes. Results of GC-MS indicate the presence of acenapthene, phenenthrene, pyrene, 1,2-dichlorobenzene, fluoranthene, butylbenzylphthalate, aliphatic hydrocarbons, naphthalenes, cyclohexanes, benzenes, and other organic substances in on or more of the samples. GC-MS analyses indicate the presence of priority pollutants in excess of detection limit concentrations at each site.			
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Iowa Air National Guard
Des Moines Municipal Airport
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The Air National Guard Support Center
Andrews AFB, Maryland 20331

February 1986

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PREFACE

The purpose of this investigation was to determine if contamination has occurred in soils or water immediately adjacent to four sites on the Iowa Air National Guard Base where known contaminants were disposed of or leaked from storage areas. No attempt has been made to determine the areal extent or rate of movement of any suspected contamination within the context of this investigation. Estimates of the probable direction of movement have been made.

This work was performed under the authority of the United States Air Force, Occupational and Environmental Health Laboratory (USAFOEHL), contract number OEH-4-006.

Project chief of this investigation was Robert C. Buchmiller. Technical support was provided by the Iowa District, Central Region, and Headquarters staff of the U.S. Geological Survey, Water Resources Division. Most chemical analyses were performed by the U.S. Geological Survey Central Laboratory, Arvada, Colorado. All drilling operations were performed by Patzig Testing Laboratories Inc. of Des Moines, Iowa.

Appreciation is extended to Milt Butzke and the staff of Patzig Testing Laboratories for their knowledge and assistance in drilling test holes and installing monitoring wells for the project. The assistance and cooperation provided by TSGT Terry Greenfield and SRA Jeff Hamilton of the Iowa Air National Guard also is greatly appreciated.

All work was conducted between July 30, 1984 and January 31, 1986. Major George New, Technical Services Division, USAF Occupational and Environmental Health Laboratory was the technical monitor for this investigation.

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I. Executive Summary

I. EXECUTIVE SUMMARY

Introduction

The Installation Restoration Program (IRP) process consists of four main phases. They are: Phase I-Problem Identification/Records Search, Phase II-Problem Confirmation and Quantification, Phase III-Technology Base Development, and Phase IV-Corrective Action. This report presents the results of an IRP Phase II, Stage 1 Problem Confirmation investigation at the Iowa Air National Guard Base, Des Moines, Iowa. Four sites where disposal of wastes or leakage of stored materials occurred were studied. These sites are: 1) Vehicle Maintenance Fuel Tank (VFT), located at the south end of the vehicle maintenance facility, 2) Vehicle Maintenance Fuel Tank Excavation Material disposal area (FTE), located in the empty field south of the Base hospital, 3) Old Fire Training Area (OFTA), located beneath the concrete pad at the Noise Suppressor and Power-Check Pad, and 4) New Fire Training Area and North Runway Drain (NFTA), located near the end of runway 12L-30R and near the intersection of Watrous Avenue and 42nd Street SW. Figure 1 shows the locations of the sites and monitoring wells drilled during this investigation and estimates of the probable direction of movement of contaminants at each site.

Soil and water samples were collected from three monitoring wells surrounding and adjacent to each of the four sites. Wells VFT-1, VFT-2, and VFT-3 were installed at the Vehicle Maintenance Fuel Tank site. Based on topographic analysis and water levels observed in the wells at this site, well VFT-1 appears to be on the down-gradient side of the site. Well FTE-1 was drilled on the up-gradient side of the Vehicle Maintenance Fuel Tank Excavation Material site. Two wells, FTE-2 and FTE-3, were drilled topographically down gradient from this site. Water levels measured during the project indicate a shallow ground-water gradient in the direction of the topographic gradient at FTE. The old Fire Training Area (FTA) includes wells OFTA-1, OFTA-2, and OFTA-3. Gradients in the area of this site are uncertain because well OFTA-2 was dry during most of the field activity. Wells NFTA-2 and NFTA-3 were drilled topographically down gradient of the new FTA. Water levels measured at the new FTA site do not indicate the same gradient direction as the land surface, however the land surface gradient probably has a dominant effect on shallow ground-water gradients at this site. Refer to the ENVIRONMENTAL SETTING, Hydrogeology section for a more thorough discussion of hydrogeology on the Base.

Forty-one soil samples were collected during the drilling of the 12 monitoring wells. One water sample was obtained from each monitoring well. One water sample

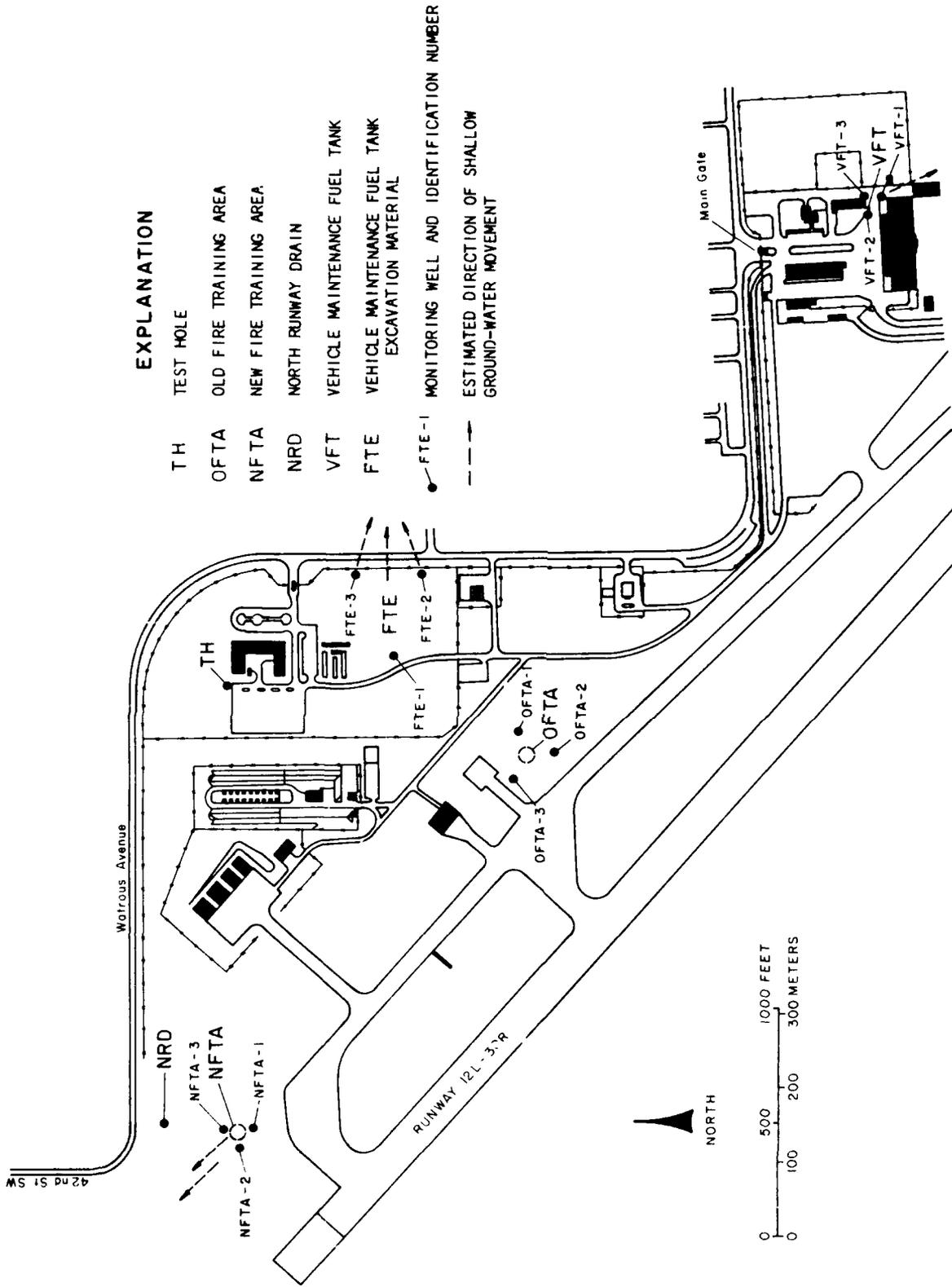


Figure 1.---Map of IRP Phase II, Stage 1 sites and monitoring wells installed at Iowa Air National Guard Base, Des Moines, Iowa

and one soil sample also were collected at the North Runway Drain (NRD), which is down gradient of the new FTA.

Physical and chemical analyses were performed on the samples. Soil samples were analyzed for particle-size, total recoverable lead, total recoverable oil and grease, and organic compounds by gas chromatograph-flame ionization detector (GC-FID) scans. Water samples were analyzed for total recoverable lead, total organic carbon (TOC), total organic halide (TOX), volatile organic compounds (VOC), total recoverable oil and grease, and organic substances by gas chromatograph-flame ionization detector (GC-FID) scans. Selected soil and water samples were analyzed by gas chromatograph-mass spectrometer (GC-MS) for identification of organic substances. All chemical samples, except TOX, were analyzed by the United States Geological Survey, Water Resources Division's Central Laboratory. TOX was analyzed for by Rocky Mountain Analytical Laboratory, Arvada, Colorado.¹

Values for lead in water samples ranged from less than 0.001 to 0.250 milligrams per liter (mg/L). Oil and grease values for water samples ranged from less than 1 to 23 milligrams per liter (mg/L). Values for TOC in water samples ranged from 0.9 to 140 mg/L. TOX analyses were performed on eight water samples. Values ranged from 33 to 83 micrograms chloride per liter.

Results for soil oil and grease analyses were inconclusive. Values for soil oil and grease samples ranged from less than 1 to 1 microgram per gram ($\mu\text{g/g}$). Total lead values in soil samples ranged from less than 10 to 30 $\mu\text{g/g}$.

Gas chromatograph-mass spectrometer (GC-MS) analyses were performed on seven soil samples and five water samples to help determine specific chemical substances associated with the sample. Priority pollutants that were identified are as follows. Phenol was detected in four of the soil samples, one of which was from each of the four sites investigated during the project. Values of phenol ranged from 0.025 to 0.105 $\mu\text{g/g}$. Phenol also was detected in a sample of aggregated Base industrial wastes. Butylbenzylphthalate was detected in soil samples from each of the fire training areas. The concentration of butylbenzylphthalate was 0.0057 and 0.0713 $\mu\text{g/g}$ at the old FTA and new FTA respectively. Butylbenzylphthalate also was detected in an aggregate sample of Base industrial wastes. The substances acenaphthene (3.7 $\mu\text{g/L}$) in a water sample and 1,2-dichlorobenzene (0.026 $\mu\text{g/g}$) in a soil sample were detected at the VFT. Pyrene was detected in a soil sample from FTE (0.034 $\mu\text{g/g}$) and in a water sample from VFT (0.6 $\mu\text{g/L}$). Pyrene was detected

¹ Use of the firm name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey

in a surface soil sample from the burn pit at new FTA at a concentration of 0.593 µg/g. The substance phenanthrene occurred in a water sample at VFT (2.4 µg/L) and a soil sample at FTE (0.020 µg/g). Fluoranthene occurred in only one soil sample at FTE (0.030 µg/g). Two volatile organic compounds were detected in water samples. They were benzene at VFT-2 and tetrachloroethene at FTE-2 at concentrations of 6.3 and 15 µg/L respectively.

Findings

Results of the GC-FID scans and GC-MS analyses indicate the presence of organic substances in nearly every soil and water sample. GC-MS was used to identify substances detected in selected samples. Priority pollutants were identified based on comparison of analytical results with reagent-grade reference samples. Other substances were tentatively identified based on mass spectra data contained in computerized libraries. Refer to page IV-5 and Appendix E for a more thorough discussion of analytical methods. Some of these may be naturally occurring substances, however the GC-FID scans on samples from various sites had peaks with retention times that were the same as those found in samples of known wastes or waste contaminated materials. One or more priority pollutants were detected at each site. Results of the investigation are summarized by site below.

Vehicle Maintenance Fuel Tank

Oil contamination was detectable by sight and smell in samples from each of the monitoring wells at the Vehicle Maintenance Fuel Tank (VFT) site. Benzenes (0.22 to 4.03 µg/L), naphthalenes (1.25 to 15.27 µg/L), indene (1.19 to 12.06 µg/L), and aliphatic hydrocarbons (2.19 to 49.55 µg/L) were tentatively identified by GC-MS in a water sample. Benzenes (0.0109 to 0.3341 µg/g), naphthalenes (0.0155 to 0.0200 µg/g), cyclohexanes (0.0176 to 0.0599 µg/g), and aliphatic hydrocarbons (0.0116 to 1.073 µg/g) were tentatively identified by GC-MS in soil samples from this site. The priority pollutants acenaphthene (3.7 µg/L), phenanthrene (2.4 µg/L), and pyrene (0.6 µg/L) were detected in a water sample from well VFT-1. Phenol (0.041 µg/g) and 1,2-dichlorobenzene (0.026 µg/g) were present in a soil sample from VFT-1 at a depth of 9 feet. TOC for the water samples from this site ranged from 63 to 80 mg/L. Total lead in water samples for this site ranged from 0.006 to 0.250 mg/L. Well VFT-1 and VFT-2 had the largest concentrations of lead when compared with all other water samples collected. The volatile priority pollutant benzene was detected by GC-MS in a water sample from

VFT-2 at a concentration of 6.3 $\mu\text{g/L}$. Fluids recovered during drilling operations at this site separated into an oil and a water layer upon settling. It was not possible to determine if fluids in the soils are present in separate layers.

Vehicle Maintenance Fuel Tank Excavation Material

The priority pollutants fluoranthene (0.030 $\mu\text{g/g}$), phenanthrene (0.020 $\mu\text{g/g}$), and pyrene (0.034 $\mu\text{g/g}$) were detected in a soil sample from FTE-1 at a depth of 2 feet. The soil at this depth was determined at the time of drilling to be the original soil at the site, not fill material. The priority pollutant tetrachloroethene (15.0 $\mu\text{g/L}$) was detected in a water sample from well FTE-2 at the Vehicle Maintenance Fuel Tank Excavation Material (FTE) site. There was not enough water present in FTE-3 to run the analysis for tetrachloroethene on the water sample from this well. TOC values for this site ranged from 30 to 140 mg/L . The 140 mg/L value for FTE-1 was the largest TOC value from all water samples collected during this investigation and is most likely due to the decaying vegetation that was buried by fill placed at this location. Some of the substances, particularly tetrachloroethene, do not appear to be directly related to the disposal of excavation material from the vehicle maintenance fuel tank and may be due to disturbances that this site has been exposed to or migration of contaminants from nearby sources.

New Fire Training Area

The new Fire Training Area shows evidence of contamination of soil and water samples. GC-MS identified the priority pollutants phenol (0.053 $\mu\text{g/g}$) and butylbenzylphthalate (0.071 $\mu\text{g/g}$) in soil samples from wells NFTA-1 and NFTA-2 respectively. Phenol and butylbenzylphthalate were detected in an aggregate sample of wastes from the Base's industrial operations. GC-MS tentatively identified 1,4-dimethylbenzene (2.74 $\mu\text{g/L}$) and aliphatic hydrocarbons ranging from 0.38 to 0.44 $\mu\text{g/L}$ in a water sample from this site. Aliphatic hydrocarbons ranging from 0.0242 to 0.0951 $\mu\text{g/g}$ also were tentatively identified in soil samples at this site. Analysis of GC-FID scan retention-time data indicates the presence of substances in samples from wells NFTA-2 and NFTA-3 that correlate with similar retention-time peaks detected in a sample of the aggregated Base industrial waste and a surface soil sample from the new FTA burn pit. Identification of the substances producing these peaks is not possible at this time. TOC values in water samples from NFTA-2 and NFTA-3, on the down-gradient side of the burn pit, were

larger than TOC values in NFTA-1, up gradient of the burn pit, and larger than values for the NRD, down gradient of the site.

Old Fire Training Area

Phenol (0.105 $\mu\text{g/g}$) and butylbenzylphthalate (0.006 $\mu\text{g/g}$) were detected by GC-MS in a soil sample from well OFTA-1 at a depth of 9 feet. GC-MS tentatively identified the following substances and estimated concentrations in water samples: ethylbenzene (0.43 to 0.53 $\mu\text{g/L}$), 1,2-dimethylbenzene (0.61 to 11.30 $\mu\text{g/L}$), and aliphatic hydrocarbons (0.58-1.58 $\mu\text{g/L}$). Benzothiazole (0.0417 $\mu\text{g/g}$) and aliphatic hydrocarbons (0.0112 to 0.4574 $\mu\text{g/g}$) were tentatively identified in soil samples at the site. Analysis of GC-FID scan retention-time data indicates a correlation of retention-time peaks for a soil sample from OFTA-2 at a depth of 29 feet with several retention-time peaks detected in a sample of aggregate Base industrial waste. Identification of the substances producing these peaks is not possible at this time. The TOC value for OFTA-2 (7.0 mg/L) was about three times larger than the TOC values for the other monitoring wells at this site.

Conclusions

Interpretations of the results of the chemical and physical analyses of soil and water samples are the basis for conclusions reached concerning the four identified disposal or spill sites. Some of the interpretation is based on correlation of GC-FID scan retention-time peaks found in known wastes or disposal sites with similar retention-time peaks found in the soil and water samples.

The presence of organic substances and some degree of contamination can not be ruled out at each of the four sites studied. With the exception of the Vehicle Maintenance Fuel Tank site, most organic substances occur in small concentrations, less than 1 mg/L. At these concentrations it is difficult to determine whether the substance is a naturally occurring organic, a ubiquitous environmental contaminant, or a contaminant due to Base disposal activities. The soil materials that the substances were found in are not likely to be used for local water supplies. Preliminary examination of the soil materials indicates that movement of water, solutes, and other liquids through the loess and glacial till will be slow because of the large clay content of these soils. The particle-size analyses for soil samples collected during the investigation is believed to not reflect the true

nature of the soil particles. Refer to page III-3 for additional discussion. A faster rate of movement may be found in localized sand deposits. These sand deposits occur at random depths and their areal extent is not known. The sand deposits do not appear to be continuous, even among closely spaced wells. Refer to page III-3 for a more thorough discussion on hydrogeology. Because of the slow movement of water and contaminants, if present, out of surficial materials, it is theorized that concentrations of organics introduced to surface runoff would be less than concentrations detected in samples during Phase II, Stage 1, because of the increasing role of dispersion and dilution factors with distance from the source.

Petroleum products or hydrocarbons are present at the Vehicle Maintenance Fuel Tank Site. Among these substances are several priority pollutants. This site had evidence of the most concentrated contamination of the four sites studied. It is not known if the movement of the contamination is occurring as a solvent front or is dispersing with dilution. It is beyond the technical data of this investigation to determine the extent, and rate of movement of this contamination. The direction of movement has tentatively been estimated to be towards the south.

Conclusive evidence of fuel contamination from the Vehicle Maintenance Fuel Tank (VFT) was not found at the Vehicle Maintenance Fuel Tank Excavation Material disposal site, however, the presence of tetrachloroethene in one well at this site indicates that a potential may exist for unexpected contamination from an unknown source. It is not possible at this time to determine what proportion of the organic substances identified at this site are due to the fill material removed during the excavation of the Vehicle Maintenance Fuel Tank. The amount of material disposed of and the incorporation of this material with the other fill material at this site has probably dispersed the measureable amounts of organics due to the Vehicle Maintenance Fuel Tank to near background levels. The concentrations oil and grease in soil and water samples were similar to concentrations found in samples from other areas of the Base where some degree of contamination is present. The same is true of soil lead concentrations at this site. In addition to potential contamination from the disposed excavation material, the concentrations of organic substances, including priority pollutants and benzene compounds, found at this site are potentially the result of the chemical quality of the fill material as has resulted from the disturbances, such as heavy equipment training, that this site has been subjected to or due to migration of substances down gradient from nearby fuel handling areas. The natural decomposition of vegetation buried by fill material placed at this site can be expected to produce a variety of organic substances as well.

The source of the tetrachloroethene needs to be found and the potential for contamination from this source assessed. The occurrence of this volatile man-made organic may indicate the presence of a potentially important source of contamination on the Base. During the sampling of this site redundant samples were collected for the VOC analysis that detects tetrachloroethene. The duplicate sample for well FTE-2 verified the existance of tetrachloroethene in water from this well. Inadvertent contamination of the sample has been ruled out because there was no exposure of this sample to tetrachloroethene during sampling.

The two fire training areas under investigation appear to have contaminated areas beyond where materials were disposed. The new Fire Training Area contained evidence of contamination in soil and water samples, particularly in the monitoring wells that are on the apparent down-gradient side of the burn pit. The ground-water seep which is referred to as the North Runway Drain did not produce evidence of contamination during the dry hydrologic conditions present while sampling. The old Fire Training Area appears to have less evidence of contamination. This may be misleading for several reasons: 1) the exact location of the old burn pit was not known, therefore the actual spatial relationship of the monitoring wells to the disposal site is not known, 2) gradients in the area may not be as great or apparent as those at the new Fire Training Area, making interception of mobilized materials from the unknown location more difficult, 3) the monitoring well that appears to be intercepting mobilized substances, in this case OFTA-2, may by chance be located in very tight materials which may not reflect the movement of organic substances adequately. And lastly, 4) because the old and new burn pits were operated in the same manner and used for the disposal of similar materials, it is likely that if contamination of adjacent materials is occurring in one fire training area it may also be occurring in the other one.

Recommendations

1. There appears to be no immediate threat to area public water supplies from the four sites investigated. A long-term monitoring program is recommended to detect changes in water quality at each site and trends in water quality due to past disposal practices at the Base. Monitoring efforts may be designed from the information collected during this investigation and utilize some of the monitoring wells installed at the sites. It is not possible to determine at this time if chemical and hydrologic conditions will be reproducible in the monitoring wells at the old Fire Training Area because the monitoring wells have been moved due to construction of additional Base facilities at this site.

2. The source of the tetrachloroethene at the Vehicle Maintenance Fuel Tank Excavation Material disposal site needs to be identified. Additional investigation surrounding the tetrachloroethene source, if located, is recommended to determine the extent and magnitude of any contamination from this source. The method to determine the extent is by taking water samples from open holes as described in detail in the Recommendations section of this report.

3. Because of the apparent large concentration of heating oil in the soils and water surrounding the Vehicle Maintenance Fuel Tank, a Phase II, Stage 2 study is recommended to determine the extent, rate of movement and direction of movement of this fuel. The method to determine the extent is by taking water samples from open holes as described in detail in the Recommendations section of this report.

4. It is recommended that fire training exercises on the Base be discontinued until a facility to prevent the surface runoff of disposal residues is constructed. Evidence of surface runoff having occurred from the new Fire Training Area was noticed during this investigation. Although no data exists concerning the chemical quality of prior runoff events, concerns should be equally divided between surface water contamination due to the burn pit and ground water contamination from the burn pit as was investigated in this study. A liner should be installed in any newly constructed burn pit to further minimize potential ground water contamination from the burn pit.

Recommendations are summarized in Table 1.

According to U.S. Air Force IRP rating criteria, the four sites may be classified as Category II sites (Table 2). Category II are sites "requiring additional monitoring or work to quantify or further assess the extent of current or future contamination".

Table 1.--Summary of Recommendations for IRP Phase II, Stage 1 Iowa Air National Guard Base (Iowa ANG), Des Moines, Iowa

SITE	RECOMMENDED ACTION	RATIONALE
1. Vehicle Maintenance Fuel Tank	Long-term monitoring Phase II, Stage 2 study	Concentrated fuel residues present at the site
2. Vehicle Maintenance Fuel Tank Excavation Material	Determine the source of tetrachloroethene	Unexpected presence of tetrachloroethene in water sample
3. Old Fire Training Area	Long-term monitoring	Potential source of contamination
4. New Fire Training Area	Long-term monitoring Construct facility to minimize impact of fire training exercises on surface and ground water	Potential source of contamination

Table 2.--IRP Site Recommendation Categories for Phase II, Stage 1, Iowa Air National Guard Base (Iowa ANG), Des Moines, Iowa

No.	Site	Recommendation Category	Rationale
1.	VFT	II	Presence of organic compounds
2.	FTE	II	Presence of organic compounds
3.	OFTA	II	Presence of organic compounds
4.	NFTA	II	Presence of organic compounds

II. Introduction

II. INTRODUCTION

Under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and Executive Order 12316, the U.S. Air Force has developed a program to comply with hazardous-waste regulations at its installations. This program, the Installation Restoration Program (IRP), has objectives designed to identify and evaluate potential problems caused by past handling or disposal of toxic or hazardous materials at Air Force facilities and ultimately to control the movement of any of these materials into areas where health and property could be endangered.

The IRP consists of a series of phases designed to achieve the above stated objectives, with implementation of each succeeding phase dependent on the results of preceding phases. Phase I consisted of a records search to determine if conditions may have occurred at the Iowa Air National Guard Base, Des Moines, Iowa that are within the scope of work of the IRP. Phase II is to determine if contamination exists or has moved beyond where hazardous or toxic materials were disposed of or leaked from storage (Stage 1) and to determine the extent and movement of the contaminants (Stage 2). Phase III would consist of a technology base development study of alternatives for remedial action to control migration or restore the installation. Phase IV is the implementation of the effort to control identified hazardous conditions. The investigation and results described in this report are for Phase II, Stage 1 of the IRP for the Iowa Air National Guard Base, Des Moines, Iowa (hereafter referred to as the Base). A report was produced detailing the results of Phase I (CH2M-HILL Southeast Inc., 1983).

Purpose and scope

The purpose of Phase II, Stage 1 is to determine if any contamination has occurred in areas at or beyond where hazardous or toxic materials were disposed of or leaked from storage. A presurvey report was produced prior to beginning work on Phase II, Stage 1 (U.S. Geological Survey, 1984) outlining the planned method of investigation and the areas of the Base to be considered for investigation. All recommendations presented in the presurvey report were based on information presented in the Phase I report (CH2M HILL Southeast Inc., 1983) and as a result of touring the Base.

The U.S. Geological Survey was requested by the U.S. Air Force to perform the Phase II, Stage 1 investigation of the Base on July 25, 1984. The description of the work requested is contained in Appendix F. The request was signed and returned on July 30, 1984. All work was performed under provisions of contract # OEH-4-006. Field work, consisting of test-hole drilling, monitoring-well construction, and soil

and water sampling, was conducted during August and September, 1984. Phase II, Stage 1 is completed upon acceptance and publication of this final report.

History

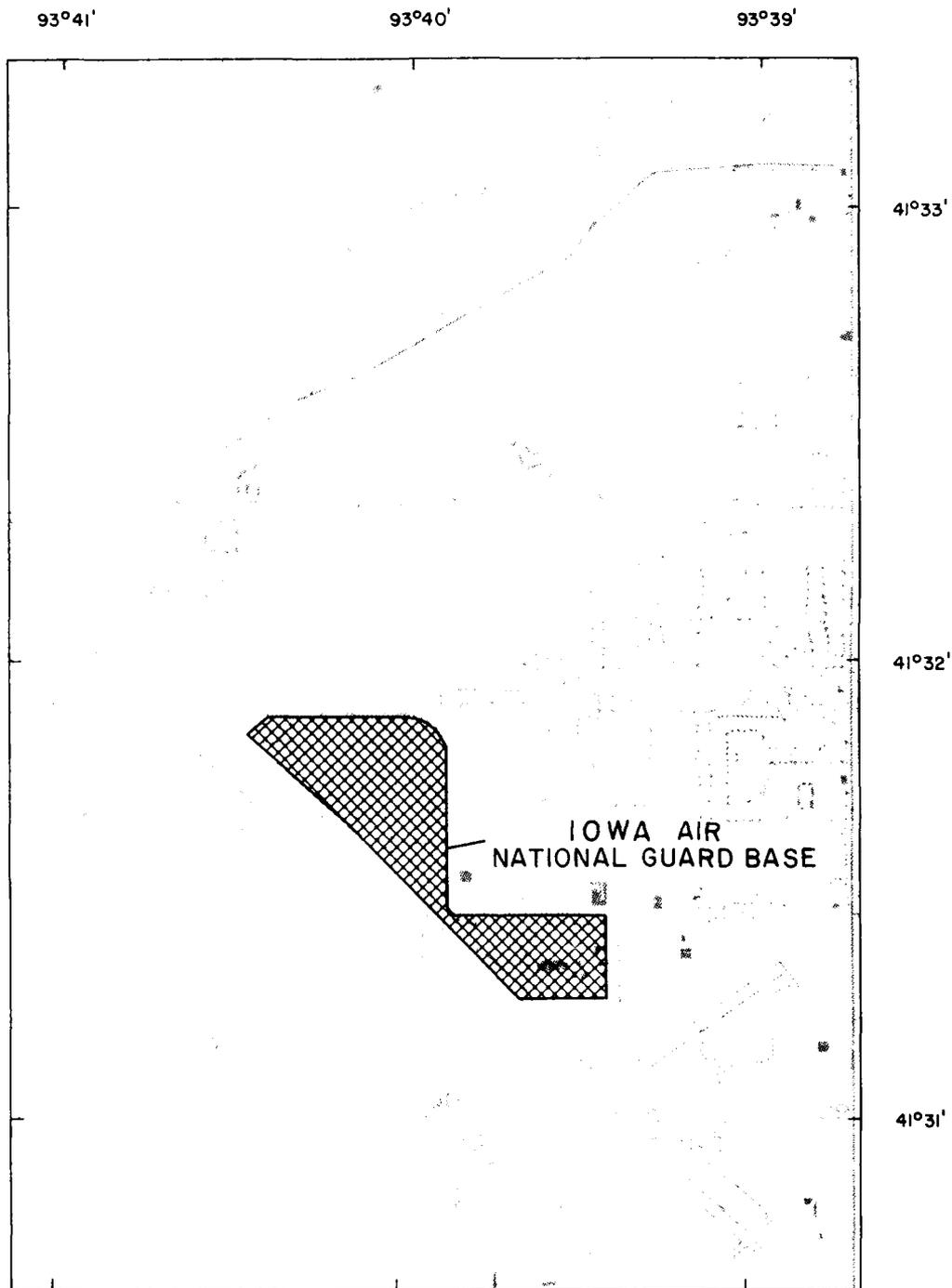
The Base, which is located on leased land at the Des Moines Municipal Airport (Fig. 2), has been in operation since 1941. Initially the Base was established as the 124th Observation Squadron for the Field Artillery. In 1946 the organization was changed to the 132nd Fighter Group with the 124th Fighter Squadron of the Iowa National Guard. Since 1950 the Base has been the 132nd Tactical Fighter Wing. The Phase I report (CH2M HILL Southeast Inc., 1983) documents the types, amounts, and sources of wastes generated by the Base and disposal practices in use from 1941 to 1983.

Description of sites and contaminants

Various potentially contaminated sites on the Base were identified and recommended in the Phase I report (CH2M HILL Southeast Inc., 1983). The Phase II, Stage 1 presurvey report (U.S. Geological Survey, 1984) identified several other locations for possible investigation. Sites from both these sources are listed in Table 3. The Air Force request for the Phase II, Stage 1 investigation contained provisions to investigate four sites on the Base and one ground-water seep immediately down-gradient from a part of the Base. They are numbers 1, 2, 3, 5, and 7 in the list given in Table 3 and their locations are shown on Figure 3.

Table 3.--Potential Sites for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa

Number	Site Name	Identifying Document
1.	Old Fire Training Area	Phase I Report
2.	New Fire Training Area	Phase I Report
3.	Vehicle Maintenance Fuel Tank	Phase I Report
4.	Original Fire Training Area	Phase II Presurvey Report
5.	North Runway Drain	Phase II Presurvey Report
6.	Old Septic Tank and Storm-water Retention Area	Phase II Presurvey Report
7.	Vehicle Maintenance Fuel Tank Excavation Material	Phase II Presurvey Report



Base from U.S. Geological Survey
Des Moines SW, Iowa 1:24,000, 1971

0 1000 2000 3000 FEET
0 200 400 600 800 METERS

CONTOUR INTERVAL 10 FEET



Figure 2.--Index map of Des Moines Municipal Airport area and Iowa Air National Guard Base, Des Moines, Iowa

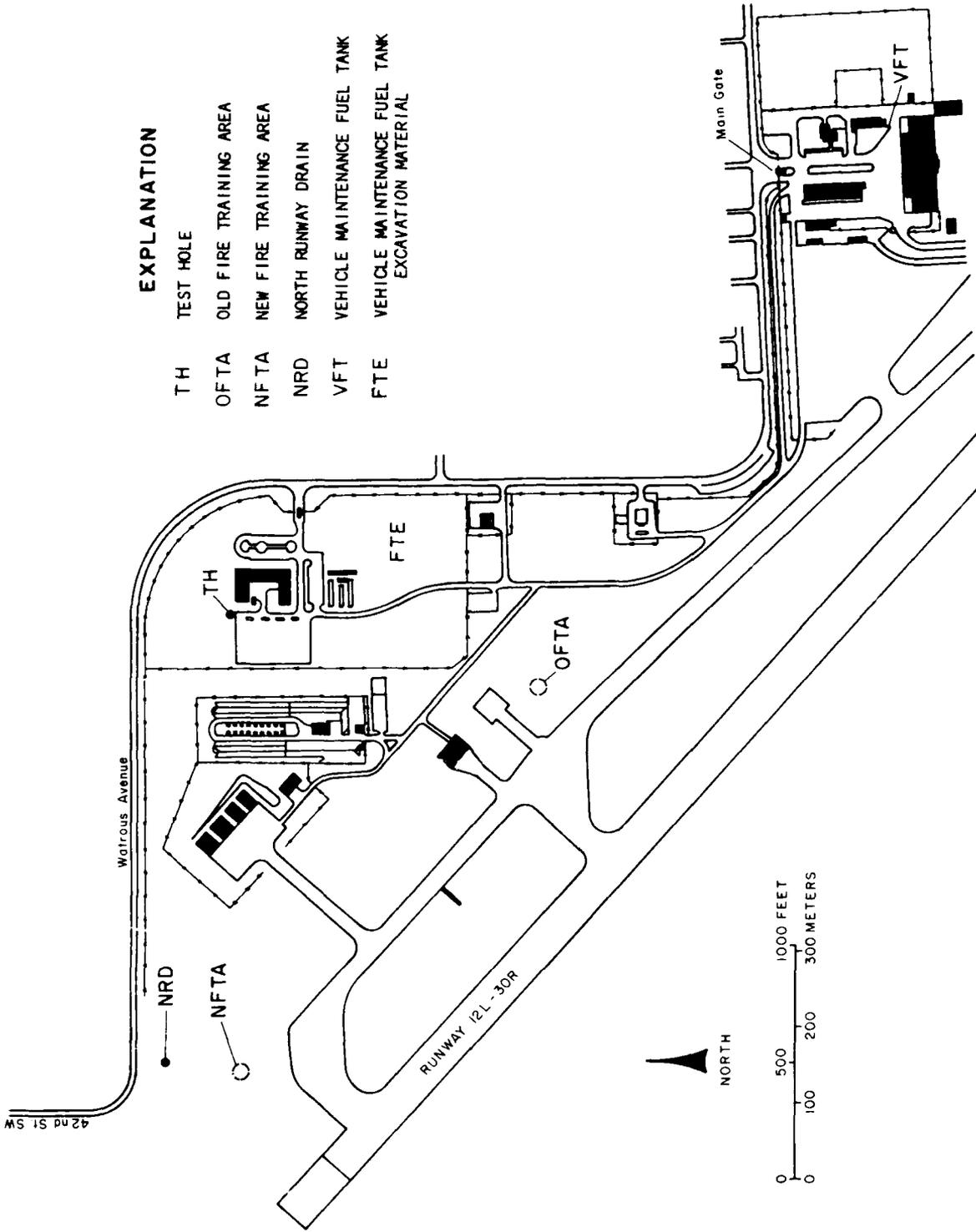


Figure 3.--Map of Iowa Air National Guard Base with four sites and test hole included in IRP Phase II, Stage 1 Iowa Air National Guard Base, Des Moines, Iowa

The Vehicle Maintenance Fuel Tank (VFT) (Fig. 4) was the site of a 2000 gallon underground metal tank installed in 1954 and used to store heating oil for the Base Vehicle Maintenance Facility. In 1982 the tank was tested and was reported to leak as fast as it was filled. The tank was replaced with a fiberglass unit in 1982. The exact amount of fuel leaked or the time frame of leakage was not determined.

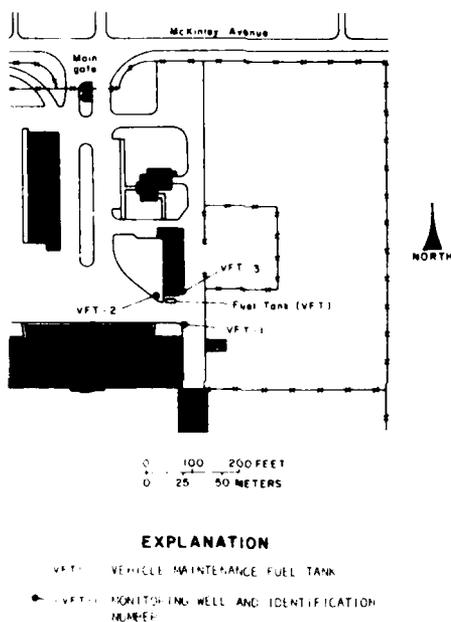


Figure 4.--Site diagram of Vehicle Maintenance Fuel Tank, Iowa Air National Guard Base, Des Moines, Iowa

When the Vehicle Maintenance Fuel Tank was replaced in 1982, some of the material excavated was disposed of on the Base at a site proposed for a ball field (Fig. 5). The amount of excavation material disposed of has been estimated to be 12 to 15 cubic yards and its location on the field is not known.

The remaining sites under investigation are the result of Base disposal

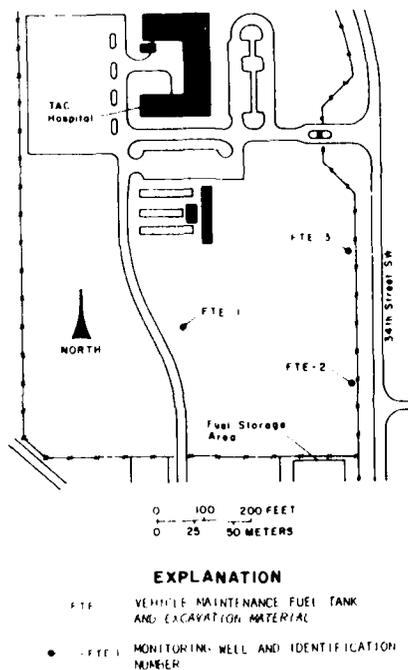


Figure 5.--Site diagram of Vehicle Maintenance Fuel Tank Excavation Material, Iowa Air National Guard Base, Des Moines, Iowa

operations from 1966 to 1981. Waste fuel, oil, lubricants and solvents were stored until a specific quantity was reached. These wastes were then taken to a shallow pit adjacent to a runway, dumped on the ground, and ignited. The fires were then extinguished by fire-fighting units as training exercises at a designated Fire Training Area (FTA). The chemicals that were used for fire fighting were not identified.

The old FTA (OFTA) is shown in Figure 6 and was in use from 1966 to 1971. Wastes disposed of at this site were about 200 gallons of JP-4 fuel, engine oil, and solvents approximately 12 times per year. This site has been disturbed and covered by the construction of concrete pads and facilities for aircraft maintenance and testing. The exact location of the pit under the concrete pad is not known and has

been estimated by means of an aerial photograph taken during the time period when the burn pit was in use.

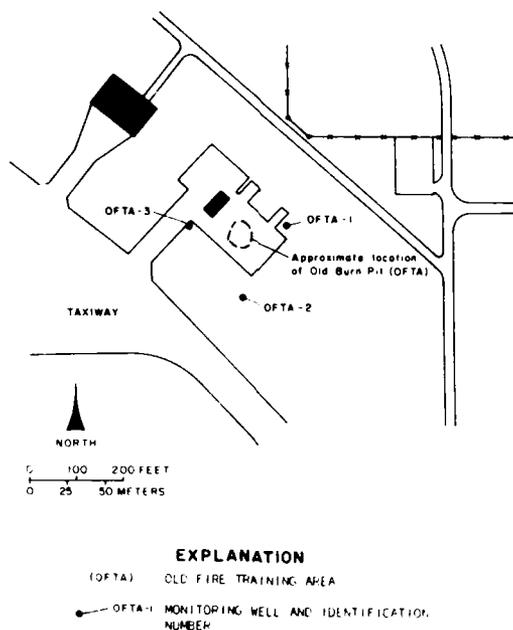


Figure 6.--Site diagram of Old Fire Training Area, Iowa Air National Guard Base, Des Moines, Iowa

The new FTA (NFTA), located near the end of Runway 12L-30R (Fig. 7), was in use from 1971 to 1981. During this time approximately 420 gallons of petroleum, oil, and lubricants were disposed of about 16 times per year.

Also shown in Figure 7 is the North Runway Drain (NRD) that is the probable outlet for the surface-water and part of the ground-water drainage from the area near the new FTA. This drainage leads to Frink Creek which is upstream of the Des Moines municipal water supply. This seep is considered as an additional sampling point for the new FTA site. The seep also is down gradient from a nearby

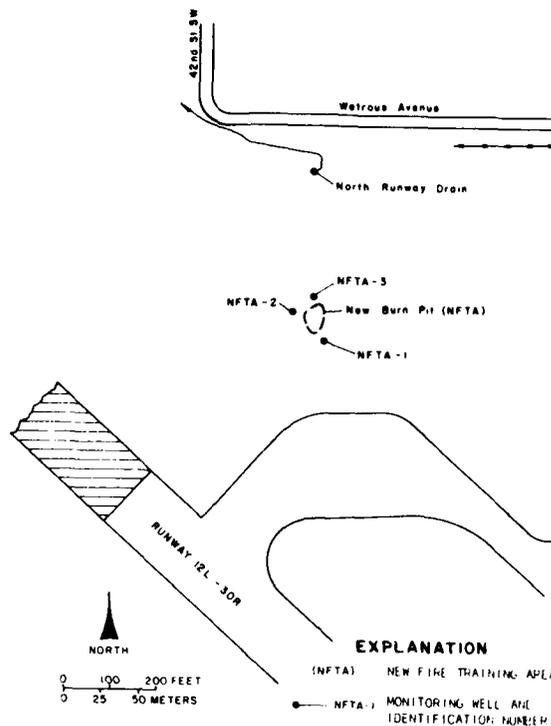


Figure 7.—Site diagram of New Fire Training Area and North Runway Drain, Iowa Air National Guard Base, Des Moines, Iowa

storm-water retention pond. According to CH2M HILL Southeast Inc. (1983), much of the surface-water and storm-water drainage from the Base is towards this area. It is expected that this runoff would contain many of the substances commonly referred to as urban runoff, particularly fuel and hydrocarbons. The storm-water retention pond appeared to be in the latter stages of construction and contained no water during the field activities of this project. Any impact of the new FTA on the quality of water associated with the storm-water retention pond may be very difficult to determine because of the potential contaminants present in the runoff from other areas of the Base.

No wastes from the Base have been disposed of by means of the fire-training activities since 1981. All hazardous wastes are now disposed of through contract

disposal at Offutt Air Force Base in Omaha, Nebraska.

The Phase I report (CH2M HILL Southeast Inc., 1983) identified the potential contaminants for these sites as organic compounds. Analyses designed to detect these contaminants in soil and water samples, were performed by the U.S. Geological Survey, Water Resources Division Central Laboratory in Arvada, Colorado. Specific analyses were conducted for total recoverable lead, total recoverable oil and grease, total organic carbon (TOC), volatile organic compounds (VOC), and organic substances using gas chromatograph-flame ionization detector scans (GC-FID scans) for screening and gas chromatograph-mass spectrometer (GC-MS) for confirmation. Total organic halide (TOX) was analyzed for by Rocky Mountain Analytical Laboratory, Arvada, Colorado¹.

¹ Use of the firm name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey

III. Environmental Setting

III. ENVIRONMENTAL SETTING

Location and climate

The Base is located on approximately 113 acres leased from the Des Moines Municipal Airport (Fig. 2), approximately 4 miles south of downtown Des Moines. The airport is situated on an upland, south of the Raccoon River. It is at an elevation of about 950 feet above sea level with a relief of about 150 feet between it and the river valleys. Topography of the area consists of rolling hills dissected by small drainages leading to the Raccoon or Des Moines Rivers. The typical continental-type climate is characterized by wide seasonal temperature variations. Normal daily temperatures, based on records from 1951-1980 (National Climatic Data Center, 1983) range from 18.6 degrees Fahrenheit (°F) in January to 76.3°F in July. Highest recorded temperature is 108°F in August 1983. Lowest recorded temperature is -24°F in January 1970. Normal annual rainfall for the period 1951-1980 is 30.83 inches with most occurring in the summer months. All measurements are made at the Des Moines Municipal Airport (Fig. 8). During Phase II, Stage 1 data collection, precipitation was below normal and temperature was above normal (Fig. 8).

Geology

Surficial geology of the area is characterized by soils formed mainly in Wisconsin age loess which overlies glacial till of Kansan age. Thicknesses of the loess and till are quite variable throughout the area due to variations in amounts deposited and local erosion rates. Generally loess and till are thickest on the upland areas and thinnest on steep slopes and small valleys. The valleys of the Des Moines and Raccoon River contain significant amounts of alluvial material. Des Moines obtains much of its public water supply from the alluvium of the Raccoon River. A test hole (TH) was drilled on the Base to determine the surficial geology in an uncontaminated upland area (Fig. 3). Materials encountered in the drilling of this hole are listed in Table 4, Appendix C.

The upper bedrock geology of the area consists of sedimentary rocks ranging in age from about 280 to 600 million years old. Table 5, Appendix C illustrates the sequence of occurrence of these rocks in central Iowa. Rocks of Precambrian age and older are usually not considered important as a source of water in Iowa because of the depth at which they occur and their generally crystalline nature. Specific hydrologic information is not known about them.

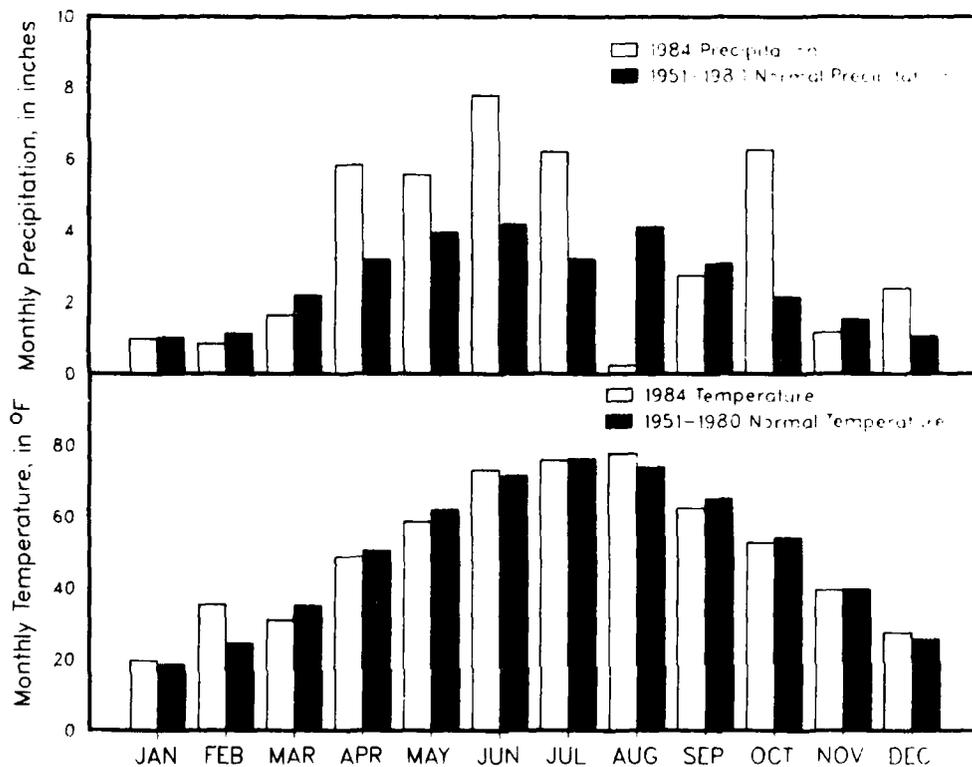


Figure 8.--Graph of 1951-80 and 1984 normal monthly temperature and precipitation for Des Moines Municipal Airport, Des Moines, Iowa

The shallowest bedrock found in the area of the Base is a soft shale of Pennsylvanian age. Outcrops of this rock occur in areas near the Base, however no known outcrops exist on the Base. This shale was encountered in the drilling of the test hole at a depth of about 34 feet below land surface. Rocks of Pennsylvanian age contain coal deposits in central and southern Iowa, including the Des Moines area. Coal can be a potential source of interference in organic analyses, however none of the monitoring wells sampled for chemical analyses were drilled to a depth where coal would be expected.

Hydrogeology

Recharge to the ground-water system in the study area is from the infiltration of rainfall, melting snow and ice, and surface-water storage. Much of the water that infiltrates the local ground-water system is discharged locally to the small drainages that dissect the rolling hills. Evapotranspiration also serves as a means for discharging the upper materials.

Indirect recharge to deeper materials occurs to a lesser degree by leakage of water through confining or semi-confining units separating water-producing materials. The rate and movement of this leakage is determined by the vertical hydraulic conductivity of the confining unit, its thickness, and the hydraulic head gradient on either side of the confining unit. The amount of vertical leakage between the upper unconsolidated materials and bedrock aquifers is hypothesized to be nearly zero because of the effectiveness of the Pennsylvanian shale as a confining layer.

Flow relationships within and among the different types of surficial materials are complex. In general, variable permeability has a dominant effect on hydrology of the unconsolidated materials. Particle-size analyses of loess and glacial till samples provide some information about the nature of the materials, however these particle-size analyses are used to determine size fractions of the particles, not the specific type of particles. Hence it is possible that many of the sand-sized particles found in the samples were clay minerals not reduced to their minimum possible particle size. Results of particle-size analyses for samples collected at selected depths for each monitoring well are given in Table 4, Appendix C.

The depth to the top of the zone of saturation or water table in the unconsolidated materials varies with the type and thickness of material present and extent of natural and artificial drainage at any particular location. Figure 9 is a conceptual diagram of the variety of materials and possible encounters that wells completed in the area may have with these materials.

In areas of relatively thick loess overlying the glacial till, the water table is located within the loess (hole D, Figure 9) but at a greater depth below land surface than in areas where thin or no loess overlies the glacial till. This may be due to several factors. First, the areas that have the thickest loess are the upland caps of the hills and are probably quite well surficially drained. Secondly, the possibly higher hydraulic conductivity of the loess allows water to drain laterally and vertically out of the loess, discharging as seeps at the contact points of the loess and till on eroded side slopes. Only one seep was noted on the Base, that being the North Runway Drain shown in Figure 7 and described in the

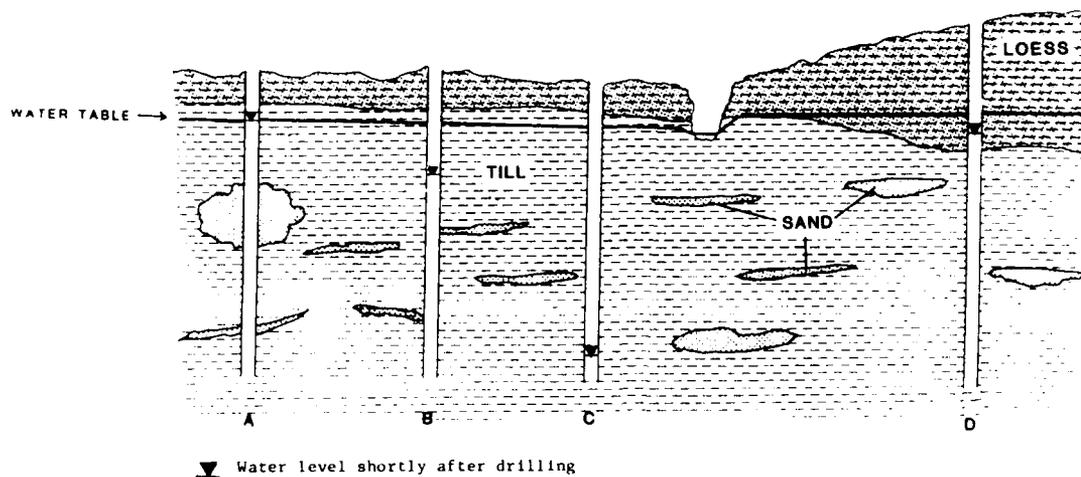


Figure 9.--Conceptual diagram of loess/till geohydrology at the Des Moines Municipal Airport

section INTRODUCTION, Description of sites and contaminants. Finally, the loess may have higher evapotranspiration rates than the glacial tills.

In areas where the water table is in the glacial till (holes A,B,C, Fig. 9), water enters the borehole at a much slower rate than wells completed in saturated loess. This is due to the lower hydraulic conductivity of the clays in the till. One major exception to this is when sand deposits within the till are penetrated by the borehole (hole A, Fig. 9). Sand lenses in the saturated till supply water to the well at a greater rate than the loess. The amount of water supplied to the well by these sand deposits is dependent on the size of the deposit and its hydraulic interconnection with other sand deposits. Sand deposits encountered during drilling operations ranged from pockets about two feet in thickness to small circuitous sand-filled tunnels fractions of an inch in diameter, observed in soil samples. The degree to which sand deposits are hydraulically connected is not known.

Water-level changes in monitoring wells vary depending on the source of water to the well. Figure 10 shows the water levels that were measured in the monitoring wells between drilling and sampling dates. In wells completed in saturated loess, no water was present in the well immediately after drilling, however water was evident within several hours.

Wells finished in glacial till provided a wide range of water-level responses. Some wells, such as OFTA-3 and NFTA-2, penetrated sand deposits at random depths similar to hole A, Figure 9, and made drilling difficult by the augering method

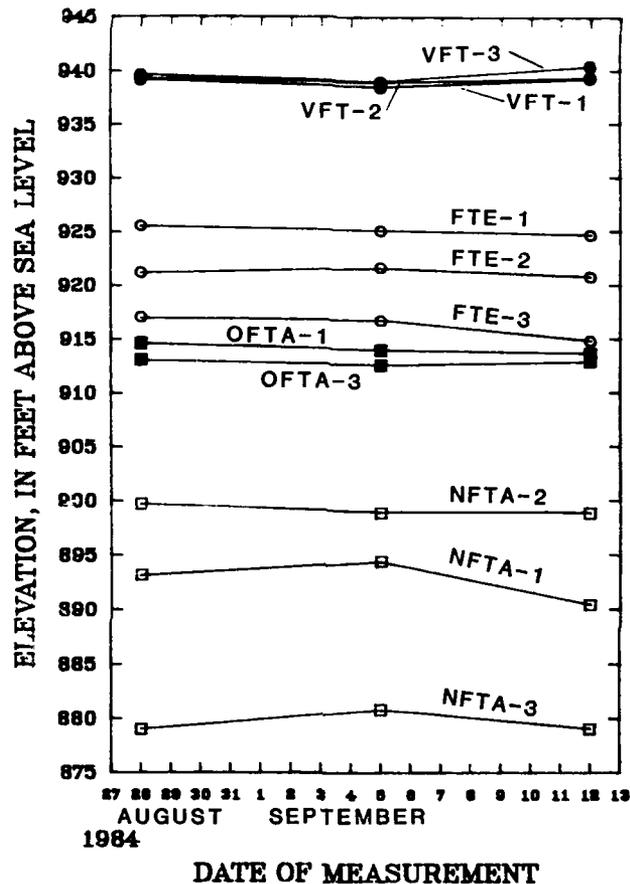


Figure 10.--Graph showing water-level measurements in monitoring wells installed for IRP Phase II, Stage 1 Iowa Air National Guard Base, Des Moines, Iowa, August-September, 1984

used. These sand deposits, ranging in thickness from 0.5 to 2.0 feet, are scattered throughout the glacial till and their locations and extent were not predictable using methods of this investigation. During the drilling of wells penetrating these deposits, water would enter the hole so fast that the borehole collapsed and filled with water while drilling. The extent of these sand deposits is limited and there is insufficient water in storage within these sand deposits to provide a reliable

source of water to a well. This was evidenced during attempts to develop the monitoring wells after construction by bailing. It was possible to bail each of the monitoring wells dry. This indicates that the subsurface soil materials at the Base do not reliably supply water to a well and can not be considered as an aquifer. An extreme example of the tightness of the soils was noted in OFTA-2. This well penetrated only clay, similar to hole C, Figure 9, and was completely dry several weeks after drilling. The well eventually contained several inches of water at the time of sampling.

Wells that penetrated amounts of sand and clay between these two extremes reached equilibrium with the water table at rates dependent on the sand lens content of the till. A good illustration of this occurred at the new FTA between August 28, 1984 and September 5, 1984 (Fig. 10). During this period there was little or no precipitation for recharging the water table. The water level in NFTA-2, which reached equilibrium with the water table rapidly because of a large sand lens, dropped 0.80 feet. The other wells at this site had increased water levels of 1.25 and 1.83 feet during the same period, indicating that at the time of the August 28th measurement they were probably not yet in equilibrium with the water table.

Hydrology at study sites

The area surrounding the Vehicle Maintenance Fuel Tank (Figs. 2, 3, and 4) for a distance of many feet in all directions is nearly completely paved over. This reduces both surface recharge and evapotranspiration in this area to almost zero. Table 4, Appendix C shows the materials encountered in wells VFT-1, VFT-2, and VFT-3 surrounding the fuel tank. Comparison of the surficial geology at this site with the test hole indicates that much of the loess cap has been removed, probably as a result of the leveling and construction of Base facilities in the area. Analysis of topographic contour maps indicates that natural drainage may have been to the southwest and then into Frink Creek before airport development. The present drainage is controlled by storm sewers and pavement in the area which may intercept and divert surface and shallow ground-water flow. The Phase I report (CH2M HILL Southeast Inc., 1983) shows the surface drainage to be towards the south and southwest into Frink Creek for this part of the Base. A shallow ground-water gradient existed towards the southeast during Phase II, Stage 1 field activities.

The Vehicle Maintenance Fuel Tank Excavation Material disposal area (Figs. 2, 3, and 5) is located at the head of a small valley, draining to the north. Visual inspection of the site confirms this by the direction of surface erosion evident. Shallow ground water during Phase II, Stage 1 field activities exhibited a gradient to the east. Table 4, Appendix C shows the surficial materials encountered in wells FTE-1, FTE-2, and FTE-3. The first several feet of material encountered was

determined to be fill, of which the fuel tank excavation material is a part.

The area surrounding the old FTA (Figs. 2, 3, and 6) probably has been subjected to disturbance caused by construction of the runways and Base facilities. Topographic analysis suggests that historically, natural drainage of the area may have been to the southwest into Frink Creek. Both surface-drainage systems and storm sewers have altered the natural drainage from the area. The Phase I report (CH2M HILL Southeast Inc., 1983) indicates some drainage to the northwest, parallel with runway 12L-30R and eventually to Frink Creek. Estimates of ground-water gradients during Phase II, Stage 1 field activities were not possible because well OFTA-2 was dry during most of the field activities.

The area surrounding the new FTA (Figs. 2, 3, and 7) is located at the head of a small valley draining to the northwest into Frink Creek. Visual examination of the area indicates that the burn pit has overflowed at least once, spreading disposal residues over the ground down gradient from the burn pit. This overflow probably entered the gully near the intersection of Watrous Avenue and 42nd Street SW, where storm sewer lines and a ground-water seep draining the area near the fire-training area also discharge. This seep was included within the scope of this investigation as a part of the new FTA. Shallow ground-water movement is estimated to be towards the north at this site. Materials encountered while drilling monitoring wells at the new FTA (NFTA-1, NFTA-2, and NFTA-3) and the old FTA (OFTA-1, OFTA-2, and OFTA-3) are given in Table 4, Appendix C

Area water supplies

Drinking water supplies for area residents and the Base are obtained from the Des Moines municipal water supply. No inventory of wells was conducted in the area, however any wells near the Base are probably drilled into bedrock at depths below the Pennsylvanian shale or are drilled in the Raccoon or Des Moines River alluvium. Wells penetrating and open to the loess and till materials such as those at the Base, are unlikely to yield sufficient amounts of water for most uses. There is no known shallow aquifer in the unconfined materials near the Base other than the alluvium of the Raccoon and Des Moines Rivers.

Des Moines obtains part of its municipal water supply from the alluvium of the Raccoon River. Recharge to the aquifer is probably from the Raccoon River, small tributary drainages up gradient of the well field, and ground-water flow from the valley sides. Frink Creek, which receives a large portion of the drainage from the Base and the airport, discharges into the Raccoon River upstream of the Des Moines water supply. In 1980 the City of Des Moines pumped about 36 million gallons per day for municipal supplies (Buchmiller and Karsten, 1983).

A report by the Iowa Department of Water, Air and Waste Management (1984) mentions that water used for public supply from the Raccoon River alluvium near Des Moines had concentrations of nitrate in excess of acceptable levels. The report also mentions that the alluvial water supply of the City of Des Moines is being influenced by trichloroethylene and vinyl chloride. Concentrations of these substances are reported by the Iowa Department of Water, Air and Waste Management to have ranged from 0 to 10 parts per billion for vinyl chloride and 1 to 90 parts per billion for trichloroethylene during the past 10 years (Rick Kelley, oral commun., 1985). Neither of these substances were detected during this investigation. It has been demonstrated under laboratory conditions that tetrachloroethene may degrade to trichloroethylene (TCE). If this reaction is possible under field conditions, evidence of TCE should be detectable in samples containing tetrachloroethene. Trichloroethylene was not detected in the water sample that contained tetrachloroethene. This indicates that the reaction is not occurring or is occurring at a rate that produces TCE in quantities below detection limits.

IV. Field Program

IV. FIELD PROGRAM

Data collection

An investigative approach for the Base was designed and outlined in the Phase II presurvey report (U.S. Geological Survey, 1984). The approach and methods selected were designed to meet the needs of the Phase II, Stage 1 scope of work.

Because the specific hydraulic properties of the unconsolidated materials are not known, an exploratory strategy was selected which would allow detection of lateral movement of ground water and organic constituents. This was accomplished by drilling three monitoring wells in the configuration of a triangle encompassing each of the four identified sites. The location of each well is immediately adjacent to the known location of disposal or spill and at a point most likely to provide the best information about ground-water movement and gradients. One additional test hole was drilled in an area of the Base removed from areas of potential contamination to define the surficial geology.

All holes were drilled by means of solid-stem continuous-flight augers. The method used was to corkscrew about five feet into the unconsolidated material, then pull this 5-foot plug of material out of the hole using the auger rig's hydraulic system. This method resulted in a representative core of the material being brought up on the auger stem for examination. Samples for particle-size analysis were collected at regular depths and at points of particular geologic interest from this exposed core. The field descriptive log of each hole (Table 4, Appendix C) was also obtained from examination of this core. Soil samples for chemical analysis were obtained from 18-inch Shelby-tube cores taken at 5-foot intervals in each borehole. The procedure for this is as follows: Auger to a depth of 3.5 feet, pull out auger stem, push a Shelby tube from the depth of 3.5 feet to a depth of 5.0 feet, pull out the Shelby tube, auger from the depth of 3.5 feet to 8.5 feet, pull out auger, push another Shelby tube, etc. Cores were removed from the Shelby tubes in the field using the auger rig's hydraulic system. The cores were then sectioned to obtain samples for laboratory analysis. These samples were obtained from the middle of the core to reduce the possibility of contamination at the ends of the core.

Holes were drilled a few feet beyond the estimated depth of the water table. Upon reaching the final depth of each hole, well screens and casing were set and a

monitoring well constructed. Casing consisted of 2-inch inside-diameter stainless steel because the wells were to be sampled primarily for unknown organic constituents. A 3-foot section of 25-slot wire-wound stainless steel well screen was open to the gravel pack and placed just below the estimated water table. The annular space surrounding the well casing was packed with Number 1 gravel. The annular space was sealed against the entrance of surface-water drainage by grouting with a bentonite plug and cement at the surface. A schematic diagram of the well construction is shown in Figure 11.

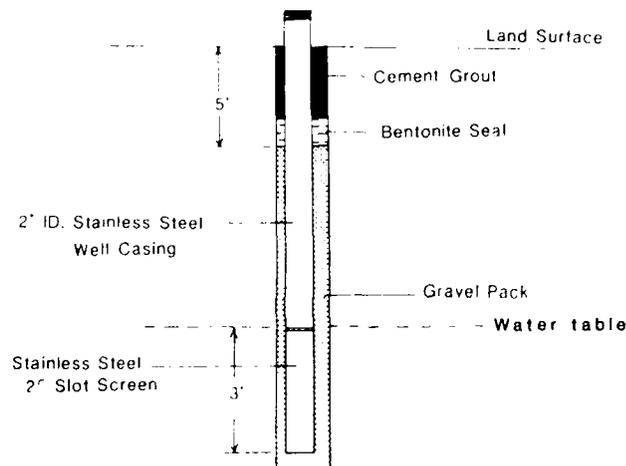


Figure 11.--Diagram of monitoring well design details for IRP Phase II, Stage 1 Iowa Air National Guard Base, Des Moines, Iowa

The monitoring wells were developed by bailing with a stainless steel bailer until dry. The wells were allowed several weeks to reestablish equilibrium with the water table before collecting water samples with a stainless steel bailer. This length of time was needed because of the slow rate of movement of water into the wells. Refer to page III-3 for a discussion of ground-water flow to the wells. Samples of the water in the wells are representative of the water in the soil because no fluids were used during the drilling of the wells and all materials entering a well were cleaned prior to use. Wells FTE-2, FTE-3, and OFTA-2 did not

provide enough water during sampling to perform analyses for all parameters. The missing data is noted in the appropriate data table.

Water levels were measured in all the monitoring wells during the field data collection period by measuring the depth to water from the top of the well casing with a steel tape. A layer of floating hydrocarbons was observed at the VFT site. Water-level measurements at this site were not corrected for the hydrocarbon layer because of the considerations discussed in the Hydrogeology section, page III-3. The three monitoring wells at each site were leveled with respect to each other and sea level. This was accomplished by plotting the wells on a topographic contour map of the airport with a contour interval of two feet. From this map, the land surface at one well at each site was assigned an elevation. The height of the top of the well casing above the land surface was added to this land-surface elevation, resulting in an altitude for the top of the well. A transit was used to determine the differences in elevation of the other two wells at each site. These differences were compared to the altitude of the reference well, resulting in altitudes for the other two wells at each site. The accuracy of the altitudes is probably within two to four feet of actual altitude above sea level, assuming the 2-foot contour interval topographic map is accurate. Actual differences in elevation between the three wells at each site are probably accurate to within several hundredths of a foot.

Soil samples were obtained from three locations at each site (Figs. 4, 5, 6, and 7) and at various depths. Each soil sample was assigned an ID consisting of the alphabetic site identifier from Figure 3, a numeric location identifier from the site specific diagrams (Figs. 4, 5, 6, or 7), and a numeric depth identifier. FTE-1-15 for example, is a soil sample taken from the Vehicle Maintenance Fuel Tank Excavation Material, monitoring well 1, at a depth of 15 feet below land surface. Since water may enter a monitoring well from any depth in contact with the gravel pack, the depth identifier was dropped from water sample ID's.

Quality Assurance

Because concentrations were expected to be small if contaminants were present, measures were taken to reduce the possibility of inadvertant contamination. In addition to the stainless steel well casings, stainless steel bailers were used to obtain water samples, and stainless steel utensils were used for sectioning the Shelby-tube cores. All materials that were used on more than one well were cleaned

between uses with acetone and allowed to evaporate before reuse.

The new steel Shelby tubes were shipped with an oily coating, probably to reduce corrosion while in storage. A sample of the oil on the tubes was extracted with hexane and sent to the laboratory for reference analysis. The tubes were then cleaned, first with a heavy-duty detergent, then rinsed with hexane and finally rinsed again with acetone and allowed to evaporate. The cleaned Shelby tubes were then stored in sealed plastic bags until used.

The stainless steel well casings were shipped with small amounts of a water-soluble lubricant on them, which probably was used in cutting the threads on the ends of the pipe. These pipes were cleaned with detergent and rinsed with copious amounts of water from the Iowa City, Iowa municipal supply. Iowa City water supplies have not been identified as having organic contamination problems. It was determined in the laboratory that the lubricant was not soluble in methylene chloride and was therefore ruled out as a potential source of inadvertant contamination.

All soil samples and all water samples to be analyzed for organic constituents were contained in specially cleaned glass bottles with Teflon lid liners. All soil samples and all water samples were chilled to 4 degrees Celsius (°C) immediately after collection in the field. Water samples for total recoverable lead were acidified with nitric acid at the time of collection. Laboratory procedures for TOC and oil and grease include acidification of the samples at the laboratory. Splits of all samples were sent to the U.S. Air Force, Occupational and Environmental Health Laboratory.

Two samples were collected to aid in the interpretation of the soil and water samples collected from the four sites investigated. A sample of the surficial soils in the burn pit at the new FTA was obtained and analyzed by GC-MS and GC-FID to provide information on the residues from fire training activities. A sample of aggregate wastes from the Base's industrial operations was obtained and analyzed to provide information about the types of substances potentially present on the Base. This sample is referred to in the report and results as the aggregate Base industrial waste sample.

Information relating to the quality assurance of laboratory procedures is

available in Peart and Thomas (1983) and briefly described in Appendix E.

Laboratory analyses

Chemical analyses of soil and water samples were conducted at the U.S. Geological Survey Central Laboratory in Arvada, Colorado. The samples were analyzed for constituents that would indicate the presence of organic contamination in the samples. Capillary column gas chromatography (GC) was used with two different types of detectors to provide information about possible contaminants. These were a flame ionization detector (FID) and a mass spectrometer (MS). Gas chromatograph-flame ionization detector scans (GC-FID scans) were used to provide some of the organic chemical interpretation. Samples that appeared to have the greatest potential to contain contamination were also analyzed by capillary gas chromatograph-mass spectrometer (GC-MS) in an attempt to determine specific chemical compounds present and to aid in interpretation of the GC-FID scans.

Other analyses performed on all samples were: total recoverable oil and grease, total recoverable lead, and additionally on the water samples: volatile organic compounds (VOC), total organic carbon (TOC), and total organic halide (TOX). All analyses by the U.S. Geological Survey, except the GC-FID scans, were performed according to methods described in Wershaw and others (1983) and Skougstad and others (1979) and are approved U.S. Environmental Protection Agency procedures. Appendix E contains a summary of analytical techniques used in this investigation. Samples for particle-size analyses were analyzed according to Guy (1969). TOX analyses were performed by an independent laboratory, Rocky Mountain Analytical Laboratory, Arvada, Colorado¹. Methods for preparation and analysis of GC-FID and GC-MS are described below.

GC-FID scan and GC-MS samples are prepared by extracting sediments for 12 hours using continuous Soxhlet extraction with a solvent mixture of methylene chloride and methanol. Extracts were concentrated using a Kuderna-Danish apparatus. Water samples were extracted as outlined in Wershaw and others (1983) for acid extractable compounds and base-neutral extractable compounds. This extraction procedure will dissolve all substances soluble in methylene chloride and methanol and will not selectively screen non-target substances. These extracts, when run on a gas chromatograph and coupled to a universal detector, such as the Flame Ionization Detector (FID), will produce results for all substances dissolved in the solvent mixture, whether naturally occurring or man-made.

¹ Use of the firm name in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey

Chromatographic separations for both GC-FID and GC-MS were performed using a 25 meter by 0.21 millimeter inside-diameter, SE-54 fused silica capillary column. The gas chromatograph oven was temperature programmed from 50°C to 300°C at a rate of 6°C per minute, after an initial hold time of 5 minutes. For GC-MS analyses the capillary column was coupled directly to the mass spectrometer, which was set to analyze from 45-450 atomic mass units with a scan time of 0.25 seconds. Internal standards and surrogate samples are added to each sample to provide data on column and detector performance.

A computer is used to assist in the analysis of the GC-FID chromatogram. Analytical results are expressed as a peak on the chromatograph having a specific retention time, expressed in minutes. A computer program determines the area of each peak and records all peaks that have an area greater than 10 percent of the known internal standard peaks. The compounds that produce these peaks are considered to be potentially identifiable by GC-MS analysis. The program also lists any peaks found in a sample blank which are considered to be laboratory contaminants.

The retention-time values shown in Table 6, Appendix D are the retention times of chromatographic peaks that occurred in the GC-FID scan results for soil and water samples. These chromatographic peaks are caused by the substances that are considered to be potentially identifiable by GC-MS in each sample. The retention times of peaks that were found in sample blanks are not included in this table. The number of peaks listed for each sample provides an indication of the number of organic substances in the sample.

GC-MS identification of priority pollutants (U.S. Environmental Protection Agency, 1979) is based on comparison of the gas chromatographic retention-time peaks and mass spectra with the retention-time peaks and mass spectra of known compounds. GC-MS identified priority pollutants are confirmed by comparison with U. S. Environmental Protection Agency analytical grade reference standards run on the same instrument. Table 7, Appendix D presents the results of GC-MS analyses for priority pollutants in selected samples. Several of the phthalate compounds have been determined to be laboratory contaminants because of their presence in sample blanks and have been identified as such. The detection limits for some samples vary because of dilution factors used in the sample preparation and whether the sample was a soil or a water sample. Water samples generally have smaller detection limit concentrations than soil samples.

Identification of other organic substances in the GC-MS sample is obtained by computerized library searches for mass spectra which match those of the unknown compounds. Mass spectra corresponding to gas chromatographic peak maxima were compared by computerized library search with the National Bureau of Standards library reference spectra. The best library matches were selected according to a reliability factor, which is a computer library search algorithm to indicate the quality of the match between the sample and library spectra. The closer the reliability is to 100, the better the library match. The best computer matches were manually compared with the sample spectrum to ensure the best possible identification. Because these identifications have not been verified by comparison with standard compounds, they should be considered tentative.

Table 8, Appendix D lists these other substances tentatively identified by GC-MS in selected soil and water samples. Also included for reference in this table are the priority pollutants that occurred in the samples listed in Table 7, Appendix D at concentrations greater than the detection limits for the analysis. The threshold concentration value for each sample is given and provides an indication of the level at which the GC-MS will begin to detect the unknown organic compounds. This detection threshold varies from sample to sample due to the performance of the detector in relation to internal standards added to the sample.

Some GC-MS results are difficult to interpret. For example, certain types of organic substances, particularly alkenes, cyclic alkanes, and alcohols produce mass spectra which make them difficult to uniquely identify based solely on their mass spectra. No attempt has been made to identify compounds associated with chromatographic peaks and mass spectra data that produce this type of uncertainty. In some cases, certain compounds are identified by the generic term aliphatic hydrocarbon because the mass spectral data indicate the substance may be an aliphatic hydrocarbon whose exact isomeric form is not known. Because of differences in operating principles and sensitivity of the GC-FID and GC-MS instruments, it is not always possible to identify compounds with GC-MS that have been detected from GC-FID scans. The GC-FID instrument, for example, can be considered an order of magnitude more sensitive than GC-MS. Thus compounds in small concentrations detected by GC-FID cannot be identified by GC-MS.

V. Results

V. RESULTS

Discussion of Results

Basis for data interpretation

Two approaches were used in this investigation to determine if organic contamination has occurred in areas beyond where known contaminants were disposed of or leaked from storage. GC-FID scans were used to detect the presence of organic substances in soil and water samples. This method is very sensitive to organic compounds, particularly hydrocarbons, but it does not provide a positive identification of the compounds detected. GC-FID scans were performed on all soil and water samples as a screening tool to provide information on the number of organic substances in each sample. The patterns and retention times of the peaks were used to determine which samples were likely to contain the same organic compounds. Samples that appeared to have the greatest potential of contamination were subsequently analysed by GC-MS for identification of priority pollutants and other organic substances for which computerized library mass spectra data exist.

GC-MS data were inconclusive for some samples and for portions of some sample chromatograms because of the inability of GC-MS to identify some types of compounds. A technique was developed to correlate soil and water sample GC-FID retention-time peaks with similar retention-time peaks in samples with known contaminants or disposal residues. This technique is based on the GC-FID's ability to provide sensitive, unique, reproducible retention-time peaks for each organic substance. Because of the reproducibility of the GC-FID scan, samples with retention-time peaks of similar values are assumed to be identical substances. Slight variations in actual retention times are possible due to matrix effects and small variations in capillary column performance, however the retention-time peaks relative to the known internal standards and surrogate samples do not vary.

A comparison, Table 9, Appendix D, was prepared from selected GC-FID retention times found in Table 6, Appendix D to show the possible correlation between selected GC-FID scan retention-time peaks and samples that had peaks at similar retention-time values. This table provides the basis for the GC-FID correlative technique. GC-FID retention times that, upon examination, appear to recur in a number of samples are assumed to be produced by the same substance. Comparison of soil and water sample results with the aggregate Base industrial waste and new FTA

burn pit sample results therefore reveals which samples may have similar substances in them and be due to disposal activities. For example, because the aggregate waste sample had a substance that produced a peak at 5.73 minutes and soil sample FTE-1-15 had a peak at 5.74 minutes, it is interpreted that the soil sample contained the same substance as the aggregate Base industrial waste sample and is likely to be a result of disposal activities.

There are limitations to this correlation technique. First, there is no way at this time to specifically identify the organic substances producing most of the GC-FID retention-time peaks. Second, the GC-FID can be considered to be approximately an order of magnitude more sensitive than GC-MS. This creates some difficulties in interpreting the data from the analysis of the organic substances. If compounds are identified in small concentrations by GC-FID in the soil and water samples, they may be due to either bi-products and residues of natural biological activity or as a result of anthropogenic activity. Many of the substances found may also be considered ubiquitous in the environment.

Results of chemical organic and inorganic analyses on both soil and water samples from the four disposal or spill sites on the Base (Fig. 3) are presented in Tables 10 and 11, Appendix D. Table 10 presents the results of chemical analyses on all soil samples. Analysis of this data indicates that it is not possible to interpret the extent of organic presence in samples based solely on this type of information. Table 11 presents the results of chemical analyses on all water samples. With the exception of temperature, pH, specific conductance, total oil and grease, total organic carbon, total organic halide, and total lead, all other parameters included in this table are the compounds that comprise the volatile organic compound (VOC) analysis. These volatile organic compounds are all priority pollutants (U.S. Environmental Protection Agency, 1979).

Results for each site are discussed below. Comparison of concentrations for soil samples with concentrations for water samples should be done with caution. In many cases soil concentrations are reported in $\mu\text{g/g}$ (parts per million), while water samples are reported in $\mu\text{g/L}$ (parts per billion) or mg/L (parts per million). The results also are expressed on a weight/weight and weight/volume basis respectively.

Vehicle Maintenance Fuel Tank

The presence of contamination was observed at all three monitoring wells drilled at this site. During field exploration, soils below about three feet in depth contained a strong fuel odor. These soils also appeared discolored and oily. Fluids recovered during the drilling operation separated into two phases upon settling. There was also a multi-colored oil sheen on the surface of water samples that were collected from this site.

TOC values were 50, 63, and 80 mg/L for wells VFT-1, VFT-2, and VFT-3 respectively. Values for TOC in all water samples collected for Phase II, Stage 1 ranged from 140 to 0.9 mg/L. No drinking water standards exist for this parameter and background levels are variable due to the source of water. It appears, from analysis of data collected for Phase II, Stage 1, that 1 to 5 mg/L can be considered background for much of the Base. However, conditions may exist, as at FTE-1 below, that produce TOC concentrations larger than background concentrations, because of natural causes.

Total lead values for VFT-1, VFT-2, and VFT-3 were 0.130, 0.250, and 0.006 mg/L respectively. Values for all water samples ranged from less than 0.001 to 0.250 mg/L. A federal drinking water standard has been established for lead at a concentration of 0.050 mg/L (U.S. Environmental Protection Agency, 1976). Background lead levels for the Base, based on analysis of Phase II, Stage 1 water samples, are probably less than 0.005 mg/L.

No drinking water standard exists for oil and grease, however it is suggested that concentrations of oil and grease be virtually absent in drinking water (National Technical Advisory Committee on Water Quality Criteria, 1968). Values for oil and grease in water samples VFT-1 (4 mg/L), VFT-2 (23 mg/L), and VFT-3 (18 mg/L) were among the largest detected during Phase II, Stage 1. Values for oil and grease in all the water samples ranged from less than 1 to 23 mg/L.

Soil and water samples collected at most of the locations and depths at this site had to be diluted, sometimes by a factor of 200, to keep laboratory instruments from registering beyond their scale of measurement. The exact chemical composition of the fuel that leaked from storage is not known, but can be expected to contain a variety of aliphatic hydrocarbons and possibly additional organic substances. The

GC-FID scans detected numerous peaks, up to 262 per sample, in the retention-time range expected of hydrocarbon compounds. Figure 12A shows an undiluted GC-FID scan from soil sample VFT-2-9. Figure 12B shows the same sample diluted by a factor of 10. Also shown for comparison in Figure 12C is a GC-FID scan from OFTA-1-19. No significant peaks other than those due to internal standards and surrogate samples were identified in this sample. The OFTA-1-19 chromatograph can be considered as a "clean" soil GC-FID scan.

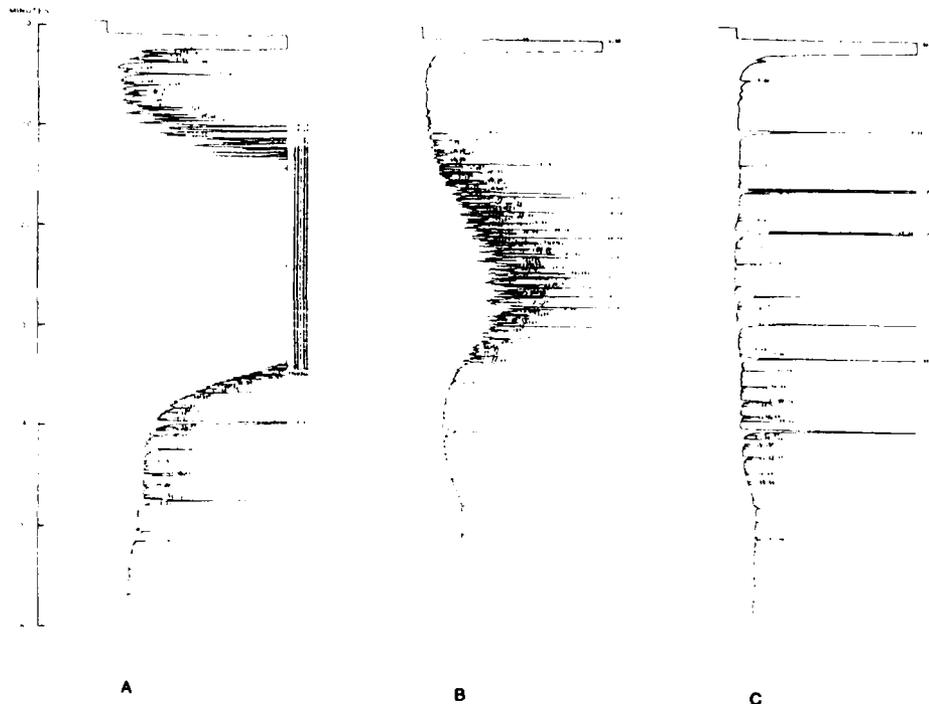


Figure 12.--Examples of chromatographs of GC-FID scans at A) VFT-2-9, B) VFT-2-9 diluted 1:10 and C) OFT-1-19 for IRP Phase II, Stage 1 Iowa Air National Guard Base, Des Moines, Iowa

Table 6, Appendix D lists the retention-time peaks from GC-FID scans for samples from the Vehicle Maintenance Fuel Tank site. Table 8, Appendix D lists the compounds or types of compounds that were identified by GC-MS in concentrations greater than detection limits for this site. Numerical chemical data for soil and water samples are presented in Tables 10 and 11, Appendix D respectively.

GC-MS analyses were performed on a water sample from VFT-1 and on soil samples VFT-1-9 and VFT-2-14. Priority pollutants found in some of these samples include:

phenol (0.0414 µg/g), 1,2-dichlorobenzene (0.0261 µg/g), acenaphthene (3.7 µg/L), phenanthrene (2.4 µg/L), and pyrene (0.6 µg/L). Numerous other organic compounds were tentatively identified and may be grouped into several categories of compounds: benzenes, naphthalenes, cyclohexanes, aliphatic hydrocarbons and others.

Vehicle Maintenance Fuel Tank Excavation Material

Numerical values for chemical analyses of soil and water samples collected at this site are presented in Tables 10 and 11, Appendix D. GC-FID results are shown in Table 6, Appendix D. GC-MS results are shown in Tables 7 and 8, Appendix D.

GC-MS analyses of soil samples identified the following priority pollutants: phenol (0.0253 µg/g), fluoranthene (0.0300 µg/g), phenanthrene (0.0200 µg/g), and pyrene (0.0344 µg/g). Several benzene compounds (0.0153 to 0.1739 µg/g) and aliphatic hydrocarbons (0.0186 to 0.1773 µg/g) were also tentatively identified in a soil sample from this site. The volatile priority pollutant tetrachloroethene (15.0 µg/L) was identified in a water sample from FTE-2. A water sample containing water from both wells FTE-2 and FTE-3 contained tentatively identified benzene substances (0.72 to 6.28 µg/L) and aliphatic hydrocarbons (0.17 to 0.49 µg/L). GC-FID scans and GC-MS results also indicate that there are unidentified organic compounds present in the soil and water at this site. It is not possible at this time to determine whether they can be associated with the material that was excavated from the Vehicle Maintenance Fuel Tank. It is quite possible that their presence is related to the chemical quality of the fill material. According to the Base civil engineer, over 99 percent of the fill at this site was obtained from construction of the Operations and Maintenance Building. It is also possible that the burial of natural vegetation at the site by fill could be responsible for the presence of some of the organic substances detected in subsurface soil and water samples. This may be the reason for the relatively large TOC value for water samples FTE-1 and FTE-2 (Table 11). FTE-1 had the largest TOC value of any water sample collected during the investigation, 140 mg/L. Values of TOC in all Base water samples ranged from 0.9 to 140 mg/L. The oil and grease value for well FTE-2, 6 mg/L, may be due to the same reasons as the large TOC values mentioned above. From Table 9, Appendix E, it can be seen that several compounds found in the sample had retention times similar to retention times found in the aggregate Base industrial waste sample.

The unexpected presence of tetrachloroethene was detected by GC-MS at a concentration of 15 µg/L in the water sample collected from well FTE-2 (Table 11). Tetrachloroethene also was detected in a duplicate sample from this well collected at the same time. This substance is not related to the types of substances found in samples collected at the Vehicle Maintenance Fuel Tank site and its source is not known. Tetrachloroethene, also known as tetrachloroethylene is a priority pollutant and a suspected carcinogen (Safe Drinking Water Committee, 1980). It is not naturally occurring.

Old Fire Training Area

Numerical values for chemical analyses of soil and water samples collected at this site are presented in Tables 10 and 11, Appendix D. GC-FID scan and GC-MS results are reported in Tables 6, 7, and 8, Appendix D.

From Table 9, Appendix D it appears that samples from all three wells at this site (OFTA-1, OFTA-2, and OFTA-3), the aggregate Base industrial waste sample, and the Vehicle Maintenance Fuel Tank spill site (VFT) had GC-FID peaks with similar retention times indicating they may contain some of the same compounds. This was substantiated by the GC-MS analyses for GC-FID peaks with retention times of 5.96 and 7.03 minutes in OFTA-2-29. These peaks are interpreted to be ethylbenzene and 1,4-dimethylbenzene respectively. OFTA-2 also had the largest TOC value at this site (7.0 mg/L). Well OFTA-2 did not produce water in an acceptable manner because of the absence of sand lenses in the area penetrated by the borehole. For this reason OFTA-2 may be in an area that does not adequately reflect the chemical quality of adjacent materials because of the permeability of the soils at this site.

GC-MS identified the priority pollutants phenol (0.1054 µg/g) and butylbenzylphthalate (0.0057 µg/g) in soil sample OFTA-1-9. Aliphatic hydrocarbons ranging from 0.0112 to 0.4574 µg/g were tentatively identified in soil samples from this site. Aliphatic hydrocarbons (0.58 to 1.58 µg/L) and benzenes (0.43 to 11.30 µg/L) were tentatively identified in a water sample from this site. It is not possible at this time to determine if this is due to past fire-training activities or current operations at this site.

New Fire Training Area and North Runway Drain

Numerical values for chemical analyses of soil and water samples collected at this site are presented in Tables 10 and 11, Appendix D and GC-FID scan and GC-MS results are shown in Tables 6, 7, and 8 Appendix D.

From Table 9, Appendix D it can be seen that samples from all three well locations (NFTA-1, NFTA-2, and NFTA-3), a sample of the aggregate Base industrial waste material, and a sample of soil taken from the actual burn pit contain some similar GC-FID retention-time peaks indicating they may contain similar organic substances. Well locations NFTA-2 and NFTA-3, that are topographically down-gradient from the pit, appear to be influenced by the pit. Water samples from both of these wells had significantly larger TOC values than NFTA-1 (Table 11). The TOC value for NFTA-2 (27 mg/L) is probably the result of the organic substances detected by the GC-FID scan and illustrated in Figure 13. Figure 13A shows a GC-FID scan for soil sample NFTA-2-4. Figure 13B shows a GC-FID scan for soil sample NFTA-2-9. NFTA-2-9 shows the same characteristic bulge, although at a somewhat later retention times, that was evident in VFT-2-9 (Fig 12B). This bulge occurs as a general shift to the right in the entire spectrum of retention-time peaks and base line values and occurs on the GC-FID chromatograph of NFTA-2-9 between retention times of about 30 to 42 minutes. It is interpreted that the GC-FID bulge is comprised of organics moving down gradient from the burn pit. Figure 13C is a GC-FID chromatograph of a surface soil sample of the new fire training burn pit, diluted by a factor of 25. It is provided for comparison purposes and as an indication of the magnitude of the presence of organic substances in the burn pit. Analyses for the seepage (NRD) located near Watrous Avenue did not produce evidence of contamination during the time of sampling.

GC-MS identified the priority pollutants phenol (0.0529 $\mu\text{g/g}$) and butylbenzylphthalate (0.0713 $\mu\text{g/g}$) in soil samples NFTA-1-15 and NFTA-2-9 respectively. These are the same priority pollutants identified at the old FTA (OFTA). Also tentatively identified in soil samples were aliphatic hydrocarbons ranging from 0.0212 to 0.0951 $\mu\text{g/g}$. A water sample from well NFTA-2 contained 1,4-dimethylbenzene (2.74 $\mu\text{g/L}$) and aliphatic hydrocarbons ranging from 0.38 to 0.44 $\mu\text{g/L}$.

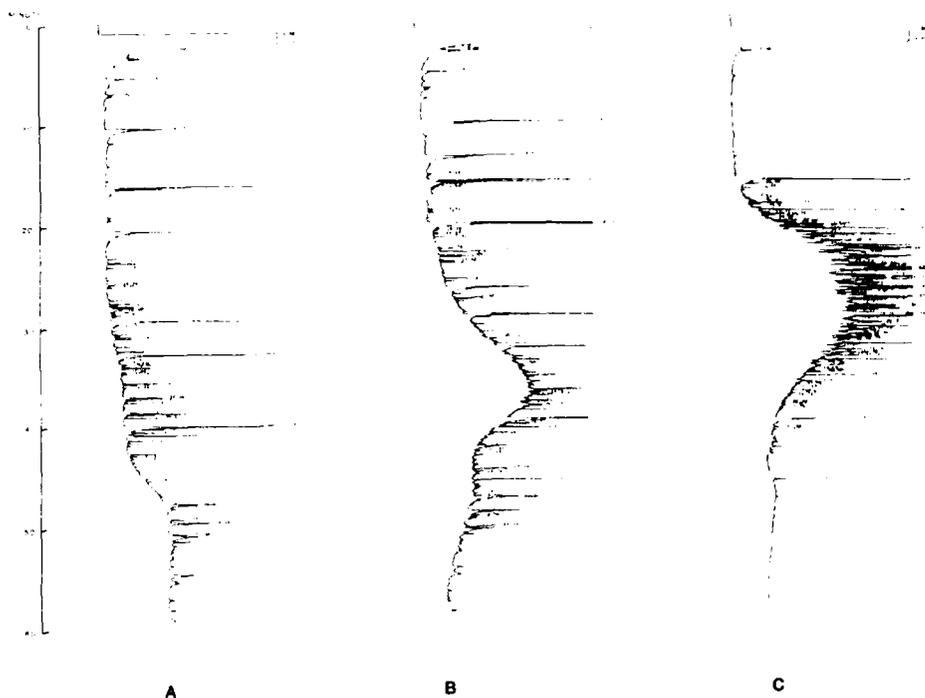


Figure 13.--Examples of chromatographs of GC-FID scans at A) NFT-2-4, B) NFT-2-9, and C) surface sample from NFTA burn pit diluted 1:25 for IRP Phase II, Stage 1 Iowa Air National Guard Base, Des Moines, Iowa

Significance of Findings

General

Interpretations of the results of the chemical and physical analyses of soil and water samples are the basis for conclusions reached concerning the four identified disposal or spill sites. Some of the interpretation is based on correlation of GC-FID scan retention-time peaks found in known wastes or disposal sites with similar retention-time peaks found in the soil and water samples. Specific identification of organic compounds was not possible by GC-FID scan techniques, however correlation of the various retention-time peaks served as a screening process for further analytical tests and for some interpretation. Read sections on Laboratory analyses and Basis for data interpretation for additional discussions on the use and limitations of this technique. GC-MS was used to identify or substantiate, where possible, peaks detected in GC-FID scans from

selected soil and water samples.

The presence of organic substances and some degree of contamination occurs at each of the four sites studied. With the exception of the VFT site, organic substances occur in very small concentrations near the remaining sites. Because the locations of the disposal or leakage sites were known and the monitoring wells were installed beyond or at the perimeter of the sites, the occurrence of contamination in these wells indicates the contamination has moved from its original source. It can be expected that aerobic and anaerobic degradation of some of the substances is occurring and volatile substances will be evaporated to the atmosphere upon exposure to surface runoff at each of the sites. It is also expected that discharge of ground water through the surficial loess and glacial till to surface runoff will be slow. Virtually no water from the surficial materials is expected to reach the bedrock aquifers beneath the Base. Insufficient technical data exist at this time to predict the extent of contamination at the sites studied.

Vehicle Maintenance Fuel Tank

Petroleum products or hydrocarbons are present at the Vehicle Maintenance Fuel Tank Site, even in a well (VFT-1) more than 40 feet from the location of the spill. Specifically identified compounds at this site include 1,2-dichlorobenzene, phenol, acenapthene, phenanthrene, pyrene, aliphatic hydrocarbons and others. Some of these are priority pollutants that could be due to substances in the fuel. Phenol and dichlorobenzene are not substances known to occur in the heating oil that was leaked at this site. Because these substances occur at concentrations of less than 0.05 µg/g, it is possible that they are due to natural sources or background concentrations of ubiquitous substances. However phenol was detected in the aggregate Base industrial waste sample, indicating a use and potential source of this substance on Base. Estimated concentrations of selected organics in a water sample at this site range as large as 49.55 mg/L. The odor and visual evidence of oil in samples from this site are conclusive that contamination of the areas soils and water have occurred, although it is not possible to determine from the methods used if a fuel lens exists at this site.

The extent of this contamination is not known. It is theorized that movement of these substances through the glacial till and loess, whether by dilution/dispersion or as a solvent front, will be slow, except in localized sand lenses. This will result in a lengthy residence time of the substances in the soils

of the area and also a slow release of the substances to ground-water discharge points. Considering the volume of the leaking storage tank that was excavated and the potential amount of fuel that may have leaked from the tank, it is not surprising to see evidence of fuel in wells VFT-2 and VFT-3 which were immediately adjacent to the tank. The fact that evidence of fuel was found in well VFT-1, over 40 feet from the tank, indicates that the material has moved from the site of the leak. No estimate of the extent and rate of movement has been made. The direction of movement is estimated to be to the south, towards the runways.

Vehicle Maintenance Fuel Tank Excavation Material

Conclusive evidence of fuel contamination due to the excavation material from the Vehicle Maintenance Fuel Tank was not found by the methods used in this investigation at the Vehicle Maintenance Fuel Tank Excavation Material disposal site. Organic compounds, including the priority pollutants phenol, fluoranthene, phenanthrene, and pyrene, were found. Some of the organic substances present at this site may be due to the chemical quality of the fill material placed at this site. The chemical quality of the fill material and the original soils at the site also may be affected by activities at the site or migration of contaminants from up-gradient sources adjacent to the site. The estimated concentrations of organics found at this site are in the range of concentrations that might reasonably be expected in an urban environment and considered ubiquitous. Considering the amount of vehicle maintenance fuel tank contaminated soil disposed of at the site and its incorporation with the significantly larger amount of fill material at the site, it does not appear that the vehicle maintenance fuel tank material would contribute detectable amounts of organic substances greater than background concentrations at the site.

The presence of tetrachloroethene in one well at this site however, indicates that a potential may exist for unexpected contamination from an unknown source. The source may be the unknown chemical quality of the fill material placed at the site or be the result of some leakage or disposal of the substance up gradient from the well it occurred in. The Phase I report (CH2M Hill Southeast Inc., 1983) mentions that the tanks at the major fuel storage area of the Base, which is up gradient of the well that the tetrachloroethene was detected in, are cleaned every three years. One of the uses of tetrachloroethene is as a solvent-degreaser.

New Fire Training Area

The two fire training areas under investigation also appear to have contaminated areas beyond where materials were disposed. The new FTA contained evidence of contamination in soil and water samples, particularly in the monitoring wells that are on the apparent down-gradient side of the burn pit. TOC results for the down gradient wells indicate considerably larger concentrations than in the well upgradient. This, in conjunction with the GC-FID correlations between the new FTA burn pit, the aggregate Base industrial waste sample, and the new FTA soil and water samples, indicates that some movement of organic substances has occurred at this site. No identified organic substance occurred in soil or water samples from this site at concentrations greater than 0.01 parts per million (ppm).

It is likely that ground-water flow from this area discharges to the surface down gradient from the burn pit. Here again, movement and discharge through glacial till and loess materials can be expected to be slow, except in localized sand lenses. Perhaps the greatest impact on local water quality occurs when surface runoff causes the burn pit to overflow after freshly disposed substances have been applied. The ground-water seep which is referred to as the North Runway Drain did not produce evidence of contamination during the dry hydrologic conditions present while sampling. It is possible that some other pathway for surface and subsurface drainage exists in this area. The probable direction of contaminant movement is towards the northwest.

Old Fire Training Area

The old FTA appears to be the least contaminated of the four sites studied. This may be misleading for several reasons: 1) the exact location of the old burn pit was not known, therefore the actual spatial relationship of the monitoring wells to the disposal site is not known, 2) gradients in the area may not be as great or apparent as those at the new FTA, making interception of mobilized materials from the unknown location more difficult, 3) the monitoring well that appears to be intercepting mobilized substances, in this case OFTA-2, may by chance be located in very tight materials which may not reflect the movement of organic substances adequately. And lastly, 4) because the old and new burn pits were operated in the same manner and used for the disposal of similar materials, it is likely that if contamination of adjacent materials is occurring in one fire training area it may also be occurring in the other one. Movement may be very slow in soils at this

site. GC-FID scan results for samples from OFTA-2 appear to have some correlation with GC-FID scan results for a sample of the aggregate Base industrial wastes. GC-MS identified phenol, butylbenzylphthalate, several aliphatic hydrocarbons, and several other organic substances in selected samples from this site. Butylbenzylphthalate and phenol also were present in samples from the new FTA and the aggregate Base industrial wastes, indicating that disposal of these substances by fire training activities may have occurred in the past. No organic substance occurred in soil and water samples at this site in concentrations greater than 0.46 ppm. The direction of any movement at this site is not known at this time.

VI. Alternative Measures

VI. ALTERNATIVE MEASURES

Options available to each site excluding mitigation and/or cleanup measures are as follows.

1. Proceed to the next step in the IRP process at all sites. The next step would be Phase II, Stage 2 - Problem Quantification Study at each site. A Phase II, Stage 2 study might contain Alternatives 4 and 5 below.

2. Design and conduct a long-term monitoring program at each site. Decisions relating to further actions could be deferred until results and trends established by the monitoring program are known on a site by site basis.

3. A combination of Alternatives 1 and 2 above could be established. Some sites could go to Phase II, Stage 2, others to a long-term monitoring program depending on the priority established for each of the sites. A suggested priority list is included in the Recommendations section.

4. A theoretical examination of the ground-water flow potential could be conducted in lieu of or in addition to Phase II, Stage 2. Various predictive techniques, including digital modeling, could be used to predict a range of possible ground-water flow relationships for the variety of loess/till combinations possible in the area.

5. A physical examination of the ground-water flow characteristics could be conducted in an area of the Base removed from the sites studied in this investigation. Data obtained would be used to provide more detailed input into hydraulic parameters needed to model ground-water flow at the Base, as in Alternative 4 above.

6. No further action is always a possible alternative.

VII. Recommendations

VII. RECOMMENDATIONS

Recommendations for the Installation Restoration Program for the Iowa Air National Guard Base, Des Moines Municipal Airport, Des Moines, Iowa are the result of the investigation of the four sites, described in the Introduction section of this report, and by methods described in the Field Program section of this report. Based on the significance of the findings described above, the following recommendations are made.

1. A long-term monitoring program is suggested as the minimal follow-up effort to this investigation. The results of this investigation are not sufficient to rule out existing or future environmental contamination from any of the sites examined in this effort. A monitoring program should build on the data base that was established by this investigation for the four sites and utilize some of the monitoring wells drilled for this investigation. The wells at the old FTA have been moved due to construction of additional Base facilities at this site. Although the new locations of the wells were selected to maintain the continuity of the monitoring network at this site, it is not known at this time whether chemical conditions in soils and water and hydraulic conditions at these new locations are relatable to data obtained in this investigation. Goals of the monitoring program should be to detect changes in water quality and to establish trends in water-quality parameter concentrations. Parameters to be sampled for include: TOC, total lead, oil and grease, and GC-FID. GC-FID would be used to screen samples for new occurrences of organics not detected during Phase II, Stage 1. Follow-up GC-MS would be used to identify and quantify changes in sample chemical quality.

2. The source of the tetrachloroethene at the Vehicle Maintenance Fuel Tank Excavation Material site needs to be investigated. The Phase I report (CH2M Hill Southeast, Inc.) did not specifically mention any use of this substance on the Base, however use of the substance at the up gradient fuel storage area can not be ruled out. A specific records search to determine proximity of any storage sources or Base uses of tetrachloroethene needs to be done. Well FTE-2, in which the tetrachloroethene occurred, needs to be resampled to verify the presence of tetrachloroethene at a time after its first detection. Well FTE-3 also should be resampled because during Phase II, Stage 1 the VOC analysis was unobtainable from this well. Field sampling should be expanded up gradient to pin-point the source of tetrachloroethene if a specific source can not be located via the records search.

A variety of methodologies may be applicable in determining the extent of an identified area of contamination. Soil-gas monitoring is one technique that may be used to determine the presence of volatile organic substances in unsaturated soils. The method is particularly well suited to areas where the depth to the zone of contamination is a factor to be considered and the construction of a number of monitoring wells is not desirable. Drawbacks to the method are that contaminants

may exist in the saturated zone that are not volatile and therefore not detectable in the unsaturated zone and degradation processes may exist in the unsaturated zone that yield concentrations of contaminants in the unsaturated zone different from concentrations within the saturated zone.

Based on the hydrologic and geologic conditions described in the section on hydrogeology in this report, the most cost efficient means of defining the extent of the contamination at various sites on the Base may be by obtaining water samples from open holes augered into the soil. This recommendation is based on the observation that the water table is usually encountered within 15 feet of land surface and the nature of the soils allows the auger hole to stand open, at least for a short while, after drilling. This time span may allow enough time for enough water to seep into the drill hole to be collected by stainless steel bailer. Samples collected in this manner would be representative of the ground water at the drilling location because no fluids would be used in the drilling of the hole and the water entering the hole would be collected as soon as possible. The advantages of this method are that a sample of the ground water is obtained and analysis for both volatile and non-volatile substances can be performed, the degree of technical difficulty in obtaining a sample is minimized, and the open holes can be backfilled, plugged and abandoned with a minimum of disruption at the drill sites. This method is recommended to determine the extent of the tetrachloroethene at the Vehicle Maintenance Fuel Tank Excavation Material site.

3. It is recommended that the Vehicle Maintenance Fuel Tank site be approved for a Phase II, Stage 2 study. Information is needed to determine if the concentrated fuel residues have the potential to migrate off Base, and if so at what rate and concentration. The method described above for obtaining water samples from open holes is recommended to determine the areal extent of contamination at this site. The in-field examination of the material augered out of the drill holes for this method will also be an important means of detecting contamination.

4. It is recommended that fire training exercises on the Base be discontinued until a facility can be constructed to minimize potential surface and ground water contamination from the burn pit. A burn pit such as the one currently located at the new FTA is subject to surface runoff and percolation of substances within the pit into the soil. Items to consider in any newly constructed burn pit should include a berm to prevent surface runoff from entering the pit, a means of preventing precipitation from filling the pit and overflowing the berm, a liner to further minimize potential ground water contamination from within the pit, and a means to periodically remove accumulated residues for disposal.

Documents received from the U.S. Air Force, Occupational and Environmental Health Lab at the start of the project contain references to three categories the sites could be classified into at the conclusion of the investigation. Category I

is described as "sites where no further action (including remedial action) is required. Data for these sites is considered sufficient to rule out unacceptable health or environmental risks." Category II includes sites "requiring additional monitoring or work to quantify or further assess the extent of current or future contamination." Category III sites are those "that will require remedial actions." Based on the results of this investigation and the above classification scheme it appears that the four sites at the Iowa Air National Guard Base would be classified as Category II sites (Table 12).

Table 12.--IRP Recommendation Categories for Phase II, Stage 1
Iowa Air National Guard (Iowa ANG), Des Moines, Iowa

Site No.	Site Name	Category*
1.	Vehicle Maintenance Fuel Tank	II
2.	Vehicle Maintenance Fuel Tank Excavation Material	II
3.	Old Fire Training Area	II
4.	New Fire Training Area	II

* Category II are sites requiring additional monitoring or work to quantify or further assess the extent of current or future contamination.

No attempt was made to determine the extent, magnitude, or rate of movement of any hazardous or toxic substances encountered during this investigation. Preliminary estimates have been made on the probable direction of movement. Information concerning extent and rate of movement will be addressed by a Phase II, Stage 2 study at the sites determined by the U.S. Air Force. The four sites investigated in this study are recommended for Phase II, Stage 2 in the following order: 1) Vehicle Maintenance Fuel Tank, 2) New Fire Training Area, 3) Old Fire Training Area, 4) Vehicle Maintenance Fuel Tank Excavation Material. The Vehicle Maintenance Fuel Tank Excavation Material site should be given top priority if an on-Base source for the tetrachloroethene is found. The priority rankings are listed in Table 13.

Table 13.--Priority Ranking of Phase II, Stage 1 sites for IRP
Phase II, Stage 2 Iowa Air National Guard (Iowa ANG),
Des Moines, Iowa

1. Vehicle Maintenance Fuel Tank site
2. New Fire Training Area
3. Old Fire Training Area
4. Vehicle Maintenance Fuel Tank Excavation Material *

* this site should receive top priority if a source of
tetrachloroethene is found for this area

VIII. Selected References

VIII. SELECTED REFERENCES

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Appendix A - Conversion Factors

CONVERSION FACTORS

For the use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

Multiply	By	To obtain
	<u>Length</u>	
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	<u>Mass</u>	
ounce, avoirdupois (oz)	28.35	gram (g)
	<u>Volume</u>	
gallon (gal)	3.785	liter (L)
quart (qt)	0.9464	liter (L)
cubic yard (yd ³)	0.7646	cubic meter (m ³)

Temperature can be converted to degrees Celsius (°C) or degrees Fahrenheit (°F) by the equations:

$$^{\circ}\text{C} = 5/9 (^{\circ}\text{F} - 32)$$

$$^{\circ}\text{F} = 9/5 (^{\circ}\text{C}) + 32$$

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

Appendix B - Definitions of acronyms and abbreviations

Definitions of acronyms and abbreviations

IRP - Installation Restoration Program

VFT - Vehicle Maintenance Fuel Tank Site well and sample identifier

FTE - Vehicle Maintenance Fuel Tank Excavation Material Site well and sample identifier

Base - Iowa Air National Guard Base, Des Moines Municipal Airport,
Des Moines, Iowa

FTA - Fire Training Area

OFTA - Old Fire Training Area Site well and sample identifier

NFTA - New Fire Training Area Site well and sample identifier

NRD - North Runway Drain

GC-FID - Gas chromatograph-flame ionization detector

TOC - Total organic carbon

TOX - Total organic halide

VOC - Volatile organic compounds

GC-MS - Gas chromatograph-mass spectrometer

µg/L - micrograms per liter, approximately equivalent to parts per billion

mg/L - milligrams per liter, approximately equivalent to parts per million

µg/g - micrograms per gram, approximately equivalent to parts per million

CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
of 1980

°F - temperature in degrees Fahrenheit

TH - Test hole

°C - temperature in degrees Celsius

ppm - parts per million, approximately equivalent to mg/L or µg/g

Appendix C - Geologic and soils information

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa

Site ID: Vehicle Maintenance Fuel Tank (VFT), Well 1

Measuring Point Altitude: 946.92

Date drilled: 8/8/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1.25	Asphalt, gravel, clay (pavement)		
1.25-8.5	Clay, silty, yellow-brown, reddish-yellow-brown and gray; soft; a few dark organic streaks	10, 61, 29	4.5
8.5-10	As above, but very wet, soft clay	6, 67, 27	9.0
10-11	Clay, silty, blue-gray; a few dark organic streaks; firmer clay than above; fuel odor		
11-13.5	Clay, silty, sandy (fine to medium), dark blue-gray and some yellow-brown; denser than above, tough	55, 27, 18	13.0
13.5-15	Shelby tube core, little or no fuel odor		

Fuel seems to be associated more with the water than the soil. Not as strong of fuel odor here as in VFT-2.

Casing record: set 8 feet of 2 inch stainless steel pipe from 0.1 feet below land surface to 8.1 feet below land surface and 3 feet of stainless steel screen from 8.1 to 11.1 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Vehicle Maintenance Fuel Tank (VFT), Well 2

Measuring Point Altitude: 948.99

Date drilled: 8/7/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1	Clay, silty, sandy (fine), yellow-brown; dry-crumbly; some dark organic streaks		
1-4.5	Clay, silty, sandy (very fine), yellow-brown and gray; moist		
4.5-11	Clay, silty, sandy (fine), blue-gray and some yellow-brown; fuel smell	19, 49, 32 28, 50, 22	5.0 9.5
11-15	Clay, silty, sandy (fine to medium), blue-gray; blocky clay structure; fuel smell	71, 12, 17	14.5
15-18.5	Clay, silty, sandy (fine to medium), gray and reddish-yellow brown; very dense, tough		

Casing record: set 10 feet of 2 inch stainless steel pipe from 2 feet above land surface to 8 feet below land surface and 3 feet of stainless steel screen from 8 to 11 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Vehicle Maintenance Fuel Tank (VFT), Well 3

Measuring Point Altitude: 948.09

Date drilled: 8/8/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIAL	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1.25	Asphalt, gravel, sand (pavement)		
1.25-5.5	Clay, silty, soft, yellow-brown and gray; moist; soft	17, 59, 24	4.0
5.5-10.5	As above, except blue gray color and wet, sticky; fuel odor	7, 78, 15	9.0
10.5-11	Clay, silty, dark gray; firmer than above		
11-13.5	Clay, silty, sandy (fine to medium), yellow-brown and some gray; blocky structure, very dense, tough		

Casing record: set 10 feet of 2 inch stainless steel pipe from 0.9 feet above land surface to 9.1 feet below land surface and 3 feet of stainless steel screen from 9.1 to 12.1 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: New Fire Training Area (NFTA), Well 1

Measuring Point Altitude: 905.62

Date drilled: 8/7/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1.75	Clay, slightly silty, gray		
1.75-3.5	Clay, silty, sandy, yellow-brown		
3.5-4.5	Clay, silty, sandy, yellow-brown and gray; some very sandy gray clay pockets	77, 10, 13	4.0
4.5-13.5	As above, but with a few pebbles and no sandy clay pockets	76, 8, 16	9.0
13.5-13.6	Iron concretion (nodule), red-brown; some white pebbles		
13.6-15.5	Clay, silty, sandy, some gravel mixed, yellow-brown and gray; some sandy gray clay pockets	77, 9, 14	15.0
15.5-16.5	Clay, silty, sandy, some gravel mixed, yellow-brown and gray; with thin beds of fine sandy gray clay		
16.5-19.5	Clay, silty, sandy, some gravel mixed, yellow-brown and gray	77, 7, 16	19.0
19.5-20	Clay, silty, very sandy (fine), some gravel mixed, light gray		
20-23.5	Clay, silty, sandy, some gravel mixed, yellow-brown and gray; a few iron concretions from 21-21.5 feet		
23.5-28	As above, but a denser pack, tighter	68, 13, 19	24.0
28-28.5	As above, but with thin beds of fine, clayey gray sand	76, 7, 17	28.0

Casing record: set 23 feet of 2 inch stainless steel pipe from 1.6 feet above land surface to 21.4 feet below land surface and 3 feet of stainless steel screen from 21.4 to 24.4 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage I Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: New Fire Training Area (NFTA), Well 2

Measuring Point Altitude: 903.29

Date drilled: 8/7/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-2.25	Clay, silty, sandy (fine), yellow-brown and gray; some black organics from 0 to 1.5 feet; a dry white powdery calcium deposit at 1.5 feet		
2.25-3.75	Sand, medium to very coarse grained, some clay mixed, yellow-brown		
3.75-8.5	Clay, silty, sandy, gravel (fine) mixed, gray and yellow-brown; some black organic streaks and pockets; some gray fine sand streaks	78, 6, 16	4.0
8.5-10	As above, but coarser gravel and sandier	58, 22, 20	9.0
10-10.5	Limestone boulder, brown		
10.5-11	Clay, silty, sandy, gravel (fine to very coarse) mixed, gray and yellow-brown; moist layer		
11-14	Clay, silty, sandy, gravel (fine to medium) mixed, yellow-brown; some fine gray sand streaks and pockets	83, 8, 9	14.0
14-15	As above, but very sandy and gravelly, and wet		
15-17	Clay, silty, sandy, some gravel (fine) mixed, gray and yellow-brown		
17-18.5	As above, but grading rapidly to a dark gray color as approach 18.5 feet, and very dense.		

Casing record: set 15 feet of 2 inch stainless steel pipe from 2.6 feet above land surface to 12.4 feet below land surface and 3 feet of stainless steel screen from 12.4 to 15.4 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage I Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: New Fire Training Area (NFTA), Well 3

Measuring Point Altitude: 903.56

Date drilled: 8/7/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-0.75	Clay, silty, dark brown; black organics		
0.75-3.5	Clay, silty, some gravel mixed, yellow-brown and gray; a dry white powdery pocket of material at 1 foot		
3.5-8.75	Clay, silty, sandy, gravel mixed, yellow-brown and gray; some black organic streaks; a moist layer in a very sandy (fine to medium) clay seam at 5 feet	75, 11, 14	4.0
8.75-9.25	Sand, clayey, light gray; sand has some dark minerals giving a salt and pepper appearance	70, 13, 17	9.0
9.25-16	Clay, silty, sandy, gravel mixed, yellow-brown and gray; denser than material from 3.5 to 8.75 feet		
16-19.5	As above, but dark gray streaks from 16 to 17.5 feet; from 17.5 to 19.5 feet grading to a very dark gray		
19.5-21.5	Clay, silty, sandy (fine), dark gray; a few white pebbles, dark gray		
21.5-21.6	Sand, medium to very coars grained, brown to gray with a gray clay matrix; moist zone		
21.6-23.5	Clay, silty, sandy (fine), pebbly, dark gray		

Casing record: set 23 feet of 2 inch stainless steel pipe from 3.2 feet above land surface to 19.8 feet below land surface and 3 feet of stainless steel screen from 19.8 to 22.8 feet, sand packed

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Old Fire Training Area (OFTA), Well 1

Measuring Point Altitude: 920.03

Date drilled: 8/8/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1	Clay, silty, sandy (fine to medium), yellow-brown; top 3 inches is a dark organic layer		
1-9.5	Clay, silty, sandy, gravel (fine to medium) mixed, yellow-brown and some gray; some dark organic streaks; a moist, soft layer at 1.5 feet; steadily gets moister from 5 to 8.5 feet; gets very soft and sticky from 8.5 to 9.5 feet	87, 9, 4	4.0
		69, 10, 21	9.0
9.5-14.5	Clay, silty, sandy, gravel (fine to medium) mixed, yellow-brown and some gray; very firm	73, 8, 19	14.0
14.5-15.5	As above, but many sand (fine to medium) seams running vertically and horizontally through the section; moist layer		
15.5-18.5	As above, but no sand seams		
18.5-24.75	As above, but with some small pockets of gray sand (fine to medium); color is grading from gray to dark gray with depth	77, 7, 16	19.0
24.75-29	Clay, silty, sandy, some gravel (fine) mixed, gray and some yellow-brown; very dense, tight	58, 22, 20	25.0

Casing record: set 23 feet of 2 inch stainless steel pipe from 2.3 feet above land surface to 20.7 feet below land surface and 3 feet of stainless steel screen from 20.7 to 23.7 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Old Fire Training Area (OFTA), Well 2

Measuring Point Altitude: 921.14

Date drilled: 8/8/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1.25	Clay, silty, yellow-brown and brown, black organics		
1.25-3.75	Clay, silty, yellow-brown and gray		
3.75-5	Clay, very sandy (fine), yellow-brown	63, 22, 15	4.0
5-8.5	Clay, silty, sandy, some gravel (fine), mixed, yellow-brown, gray and reddish- brown; some black organic streaks		
8.5-10	As above, but no reddish-brown color	82, 8, 10	9.0
10-13.5	As above, but not as sandy and denser		
13.5-28.5	Clay, silty, sandy, some gravel (fine to coarse) mixed, yellow-brown and gray; clay is very dense; some pockets of clayey gray sand (fine to medium)	78, 7, 15 76, 13, 11 77, 9, 14	14.0 19.0 24.0
28.5-33	As above, but a darker gray color; a decomposed granite boulder at 33 feet	78, 6, 16 79, 6, 15	29.0 33.0

Casing record: set 30 feet of 2 inch stainless steel pipe from 2.2
feet above land surface to 27.8 feet below land surface
and 3 feet of stainless steel from 27.8 to 30.8 feet,
sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage I Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Old Fire Training Area (OFTA), Well 3

Measuring Point Altitude: 917.37

Date drilled: 8/9/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIAL	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-0.5	Clay, silty, gray and some yellow-brown		
0.5-1.5	Clay, silty, yellow-brown and some gray; some dark organic streaks		
1.5-3.5	As above, but sandy (fine to medium)		
3.5-6	As above, but gravel (fine) mixed; white powdery (calcium) seam at 4 feet	84, 11, 5	4.0
6-6.5	Sand, fine to medium, yellow-brown; some clay mixed; moist		
6.5-8.5	Clay, silty, sandy (fine to coarse), some gravel (fine to medium) mixed, yellow-brown and gray; some dark organic streaks		
8.5-9.25	Sand, fine to coarse, some gravel (fine to coarse) mixed, yellow-brown; some yellow-brown and gray clay mixed	88, 6, 6	9.0
9.25-16.75	Clay, silty, sandy (fine to medium), gravel (fine to coarse) mixed, gray and yellow-brown; a few small isolated yellow-brown and gray sand pockets	68, 13, 19	14.0
16.75-17.5	Sand, very fine to fine, gray; a few dark minerals mixed (salt and pepper look); a small amount of clay mixed with sand but predominately sand	71, 22, 7	17.5
17.5-24	Clay, silty, sandy, yellow-brown and gray; dense, tough; some organic streaks; a few small gray sand (fine to medium) pockets	70, 16, 14 71, 21, 8	19.0 24.0

Unable to collect Shelby tubes below 14 feet due to sand

Logging records: set 14 feet of 2 inch stainless steel pipe from 0.35 feet above land surface to 14.65 feet below land surface and 1 foot of stainless steel screen from 14.65 to 17.65 feet, sand pocket.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Vehicle Maintenance Fuel Tank Excavation Material (FTE), Well 1

Measuring Point Altitude: 935.42

Date drilled: 8/7/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1.5	Fill	39, 49, 12	1.5
1.5-2	Old soil layer, grass		
2-6.5	Clay, silty, blue-gray	20, 47, 33 10, 65, 25	2.5 5.0
6.5-8.5	Clay, silty, yellow-brown and blue-gray		
8.5-10.75	Clay, silty, light gray; oxidized zones	6, 61, 33	9.0
10.75-13.5	Clay, silty, sandy, medium gray; gets sandier with depth		

Casing record: set 10 feet of 2 inch stainless steel pipe from 0.40 feet above land surface to 9.6 feet below land surface and 3 feet of stainless steel screen from 9.6 to 12.6 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Vehicle Maintenance Fuel Tank Excavation Material (FTE), Well 2

Measuring Point Altitude: 934.36

Date drilled: 8/9/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-0.75	Clay, silty, dark gray; dark organics		
0.75-10.5	Clay, silty, yellow-brown and gray, some dark organic streaks; moist from 3.5-10.5 feet	53, 35, 12 53, 40, 7	4.0 9.0
10.5-13.5	Clay, silty, sandy (fine to coarse), some gravel (fine) mixed, gray; dense, tough		
13.5-16	As above, but gray and yellow-brown	77, 10, 13	14.0
16-19	Clay, silty, very sandy, some gravel (fine to coarse) mixed, yellow-brown and some gray; softer than above	79, 16, 5	18.5

Casing record: set 11 feet of 2 inch stainless steel pipe from 0.65 feet above land surface to 10.35 feet below land surface and 3 feet of stainless steel screen from 10.35 to 13.35 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Vehicle Maintenance Fuel Tank Excavation Material (FTE), Well 3

Measuring Point Altitude: 928.23

Date drilled: 8/9/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE-SIZE ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-9.5	Clay, silty, dark gray to black and some yellow-brown; chunks of concrete; some gravel (limestone);	38, 52, 10	4.0
		59, 30, 11	9.0
9.5-10.25	Clay, silty, dark gray; dark organic zone-original soil layer		
10.25-12	Clay, silty, sandy (fine to medium), some gravel (fine) mixed, dark gray and some yellow-brown		
12-13.5	As above, but color is predominately yellow-brown with some gray	71, 12, 17	13.0

Casing record: set 10 feet of 2 inch stainless steel pipe from about 1.25 feet above land surface to 8.75 feet below land surface and 3 feet of stainless steel screen from about 8.75 to 11.75 feet, sand packed.

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Site ID: Test hole (TH)

Land Surface Altitude: 941.00

Date drilled: 8/6/84

DEPTH (feet)	FIELD DESCRIPTION OF MATERIAL	PARTICLE SIZE-ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
0-1.5	Soil, fill		
1.5-3	Clay, silty, brown; moisture content increasing	18, 50, 32	3.0
3-6.5	Clay, silty		
6.5-9	Clay, silty, brown with gray mottling; reddish-brown oxidized zones	46, 32, 22	8.0
9-10.5	Clay, silty, brown; oxidized zones	61, 22, 17	10.0
10.5-11.5	Clay, silty, sandy, brown to gray; oxidized zones grading to till		
11.5-14	Clay, sandy, gray	78, 6, 16	12.0
14-19	Clay, sandier than above, gray and brown mottling; oxidized zones	72, 9, 19	18.0
19-21	Clay, very sandy, gray and brown mottling; oxidized zones		
21-22	Clay, very sandy zone, gray with brown mottling; oxidized	74, 13, 13	22.0
22-24	Clay, very silty, sandy, gray; brown oxidized zones	74, 12, 14	23.0
24-26.5	Clay, sandy, brown; oxidized zones; streaks of black organics		
26.5-27.5	As above, but gravelly		
27.5-28	Sand, fine to coarse, brown, interbedded clay; wet	78, 10, 12	28.0
28-29	Clay, sandy, gravel mixed, brown; oxidized zones; streaks of black organics; standing water at 19 feet		
29-31	As above, but interbedded with sand seams	91, 6, 3	31.0
31-32	Sand, medium to coarse, some gravel mixed, brown; clay matrix; sand and		

Table 4.--Descriptive field logs and particle-size analyses for IRP
Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

SITE ID: Test hole (TH) --continued

DEPTH (feet)	FIELD DESCRIPTION OF MATERIALS	PARTICLE SIZE-ANALYSIS (percent sand, silt, clay)	SAMPLE DEPTH (feet)
	gravel is coarser from 31.5 to 32		
32-33.5	Clay, sandy (coarse), gravelly (fine to medium), brown; some gravel is gray oxidized sandstone chips		
33.5-34.5	Clay, brown, very dense; a pocket of brown sand (fine to medium), less than 1 inch thick; brown clay is mixed with gray shale from 34 to 34.5 feet		
34.5-35	Shale, red-brown, yellow-brown, and gray colors mixed	63, 15, 22	35.0
35-35.5	Shale, black with some interbedded gray; very dense, crumbly		
35.5-36	Shale, gray with some interbedded black; very dense, crumbly		
36-37.5	Shale, gray, yellow-brown, and black interbedded; softer than above		
37.5-39	Shale, gray and yellow-brown interbedded; crumbly		
39-40	CORE A: Shale, gray-green, yellow-brown CORE B: Shale, gray-green, yellow-brown, and some reddish-brown pebbles of shale CORE C: As above, CORE B		

No casing set in hole; plugged and abandoned

Table 5.--Aquifers and rocks in central Iowa near Iowa Air National Guard
(Iowa ANG), Des Moines, Iowa

Generalized hydrologic units	General thickness (feet)	Age of rocks	General description of rock units
Surficial aquifers Alluvial Buried channel Drift	0-380	Quaternary (0-1 million years old)	Primarily alluvium and drift composed of gravel, sand, silt, and clay
Confining material	0-550	Pennsylvanian (280-310 million years old)	Shale, sandstone, thin limestones, and coal
Upper bedrock aquifer	0-475	Mississippian (310-345 million years old)	Dolomite and limestone with some shale
Confining material	5-200	Devonian (345-405 million years old)	Siltstone, shale and dolomite
Middle bedrock aquifer	400-750		Limestone, dolomite, and shale
Confining material	330-700	Silurian (405-425 million years old)	Dolomite and sandy dolomite
		Ordovician (425-500 million years old)	Varying amounts of limestone, dolomite, shale, chert, and sandstone
Lower bedrock aquifer	375-560		Dolomite and sandstone
		Cambrian (500-600 million years old)	Sandstone and dolomite
Confining material	350-550		Sandstone, siltstone, and shale with some dolomite
		Precambrian (600 million to more than 2 billion years old)	Igneous and metamorphic rocks, locally overlain by sedimentary rocks that are chiefly sandstone

Modified from Twenter and Coble, 1965

Appendix D - Results of soil and water sample analyses

Table 6. --Potentially identifiable retention times, in minutes of GC-FID scans by site for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG) Des Moines Iowa (samples which are a result of a dilution are identified by 'X n' following the first retention time for the sample dilution factor)

FTE	Time	Site	NFTA-1-19	NFTA-1-19	NFTA-2	NFTA-2	NFTA-2-14	NFTA-2-14	OFTA-2
4.87	FTE-1	43.19	NFTA-1-19	43.19	NFTA-2	43.19	NFTA-2-14	43.19	OFTA-2
5.19	FTE-1-2	5.53	NFTA-1-24	5.53	NFTA-2	5.53	NFTA-2-14	5.53	OFTA-2-14
10.29	FTE-1-5	10.29	NFTA-1-24	10.29	NFTA-2	10.29	NFTA-2-14	10.29	OFTA-2-19
10.64	FTE-1-5	10.64	NFTA-1-24	10.64	NFTA-2	10.64	NFTA-2-14	10.64	OFTA-2-19
13.72	FTE-1-5	13.72	NFTA-1-24	13.72	NFTA-2	13.72	NFTA-2-14	13.72	OFTA-2-19
16.51	FTE-1-5	16.51	NFTA-1-24	16.51	NFTA-2	16.51	NFTA-2-14	16.51	OFTA-2-19
52.26	FTE-1-2	55.14	NFTA-1-24	55.14	NFTA-2	55.14	NFTA-2-14	55.14	OFTA-2-19
10.29	FTE-1-5	10.28	NFTA-2	10.28	NFTA-2	10.28	NFTA-2-14	10.28	OFTA-2-24
10.64	FTE-1-5	10.64	NFTA-2	10.64	NFTA-2	10.64	NFTA-2-14	10.64	OFTA-2-24
13.73	FTE-1-5	13.73	NFTA-2	13.73	NFTA-2	13.73	NFTA-2-14	13.73	OFTA-2-24
16.51	FTE-1-5	16.51	NFTA-2	16.51	NFTA-2	16.51	NFTA-2-14	16.51	OFTA-2-24
40.57	FTE-1-5	40.57	NFTA-2	40.57	NFTA-2	40.57	NFTA-2-14	40.57	OFTA-2-24
5.18	FTE-1-9	5.18	NFTA-2	5.18	NFTA-2	5.18	NFTA-2-14	5.18	OFTA-2-29
10.64	FTE-1-9	10.64	NFTA-2	10.64	NFTA-2	10.64	NFTA-2-14	10.64	OFTA-2-29
13.73	FTE-1-9	13.73	NFTA-2	13.73	NFTA-2	13.73	NFTA-2-14	13.73	OFTA-2-29
16.51	FTE-1-9	16.51	NFTA-2	16.51	NFTA-2	16.51	NFTA-2-14	16.51	OFTA-2-29
5.74	FTE-1-15	5.74	NFTA-2	5.74	NFTA-2	5.74	NFTA-2-14	5.74	OFTA-2-29
10.34	FTE-1-15	10.34	NFTA-2	10.34	NFTA-2	10.34	NFTA-2-14	10.34	OFTA-2-29
22.99	FTE-2	22.99	NFTA-2	22.99	NFTA-2	22.99	NFTA-2-14	22.99	OFTA-2-29
29.45	FTE-2	29.45	NFTA-2	29.45	NFTA-2	29.45	NFTA-2-14	29.45	OFTA-2-29
40.91	FTE-2	40.91	NFTA-2	40.91	NFTA-2	40.91	NFTA-2-14	40.91	OFTA-2-29
43.47	FTE-2	43.47	NFTA-2	43.47	NFTA-2	43.47	NFTA-2-14	43.47	OFTA-2-29
54.81	FTE-2	54.81	NFTA-2	54.81	NFTA-2	54.81	NFTA-2-14	54.81	OFTA-2-29
22.79	FTE-2	22.79	NFTA-2	22.79	NFTA-2	22.79	NFTA-2-14	22.79	OFTA-2-29
24.73	FTE-2	24.73	NFTA-2	24.73	NFTA-2	24.73	NFTA-2-14	24.73	OFTA-2-29
5.16	FTE-2-4	5.16	NFTA-2	5.16	NFTA-2	5.16	NFTA-2-14	5.16	OFTA-2-29
6.21	FTE-2-4	6.21	NFTA-2	6.21	NFTA-2	6.21	NFTA-2-14	6.21	OFTA-2-29
39.24	FTE-2-4	39.24	NFTA-2	39.24	NFTA-2	39.24	NFTA-2-14	39.24	OFTA-2-29
5.12	FTE-2-9	5.12	NFTA-2	5.12	NFTA-2	5.12	NFTA-2-14	5.12	OFTA-2-29
10.64	FTE-2-9	10.64	NFTA-2	10.64	NFTA-2	10.64	NFTA-2-14	10.64	OFTA-2-29
13.73	FTE-2-9	13.73	NFTA-2	13.73	NFTA-2	13.73	NFTA-2-14	13.73	OFTA-2-29
16.51	FTE-2-9	16.51	NFTA-2	16.51	NFTA-2	16.51	NFTA-2-14	16.51	OFTA-2-29
12.57	FTE-3	12.57	NFTA-2	12.57	NFTA-2	12.57	NFTA-2-14	12.57	OFTA-2-29
40.97	FTE-3	40.97	NFTA-2	40.97	NFTA-2	40.97	NFTA-2-14	40.97	OFTA-2-29
10.64	FTE-3-9	10.64	NFTA-2	10.64	NFTA-2	10.64	NFTA-2-14	10.64	OFTA-2-29
13.72	FTE-3-9	13.72	NFTA-2	13.72	NFTA-2	13.72	NFTA-2-14	13.72	OFTA-2-29
16.51	FTE-3-9	16.51	NFTA-2	16.51	NFTA-2	16.51	NFTA-2-14	16.51	OFTA-2-29
10.25	FTE-3-14	10.25	NFTA-2	10.25	NFTA-2	10.25	NFTA-2-14	10.25	OFTA-2-29
13.49	FTE-3-14	13.49	NFTA-2	13.49	NFTA-2	13.49	NFTA-2-14	13.49	OFTA-2-29
Time	Site	Time	Site	Time	Site	Time	Site	Time	Site
4.33	NFTA-1-9	4.33	NFTA-1-9	4.33	NFTA-1-9	4.33	NFTA-1-9	4.33	NFTA-1-9
6.25	NFTA-1-9	6.25	NFTA-1-9	6.25	NFTA-1-9	6.25	NFTA-1-9	6.25	NFTA-1-9
10.46	NFTA-1-9	10.46	NFTA-1-9	10.46	NFTA-1-9	10.46	NFTA-1-9	10.46	NFTA-1-9
40.79	NFTA-1-9	40.79	NFTA-1-9	40.79	NFTA-1-9	40.79	NFTA-1-9	40.79	NFTA-1-9
5.35	NFTA-1-15	5.35	NFTA-1-15	5.35	NFTA-1-15	5.35	NFTA-1-15	5.35	NFTA-1-15
10.28	NFTA-1-15	10.28	NFTA-1-15	10.28	NFTA-1-15	10.28	NFTA-1-15	10.28	NFTA-1-15
18.90	NFTA-1-15	18.90	NFTA-1-15	18.90	NFTA-1-15	18.90	NFTA-1-15	18.90	NFTA-1-15
23.61	NFTA-1-15	23.61	NFTA-1-15	23.61	NFTA-1-15	23.61	NFTA-1-15	23.61	NFTA-1-15
41.41	NFTA-1-15	41.41	NFTA-1-15	41.41	NFTA-1-15	41.41	NFTA-1-15	41.41	NFTA-1-15
41.89	NFTA-1-15	41.89	NFTA-1-15	41.89	NFTA-1-15	41.89	NFTA-1-15	41.89	NFTA-1-15
43.18	NFTA-1-15	43.18	NFTA-1-15	43.18	NFTA-1-15	43.18	NFTA-1-15	43.18	NFTA-1-15
51.81	NFTA-1-15	51.81	NFTA-1-15	51.81	NFTA-1-15	51.81	NFTA-1-15	51.81	NFTA-1-15
20.89	NFTA-1-15	20.89	NFTA-1-15	20.89	NFTA-1-15	20.89	NFTA-1-15	20.89	NFTA-1-15
22.41	NFTA-1-15	22.41	NFTA-1-15	22.41	NFTA-1-15	22.41	NFTA-1-15	22.41	NFTA-1-15
20.93	NFTA-2	20.93	NFTA-2	20.93	NFTA-2	20.93	NFTA-2	20.93	NFTA-2
20.95	NFTA-2	20.95	NFTA-2	20.95	NFTA-2	20.95	NFTA-2	20.95	NFTA-2
20.98	NFTA-2	20.98	NFTA-2	20.98	NFTA-2	20.98	NFTA-2	20.98	NFTA-2
21.02	NFTA-2	21.02	NFTA-2	21.02	NFTA-2	21.02	NFTA-2	21.02	NFTA-2
21.04	NFTA-2	21.04	NFTA-2	21.04	NFTA-2	21.04	NFTA-2	21.04	NFTA-2
21.06	NFTA-2	21.06	NFTA-2	21.06	NFTA-2	21.06	NFTA-2	21.06	NFTA-2
21.08	NFTA-2	21.08	NFTA-2	21.08	NFTA-2	21.08	NFTA-2	21.08	NFTA-2
21.11	NFTA-2	21.11	NFTA-2	21.11	NFTA-2	21.11	NFTA-2	21.11	NFTA-2
21.14	NFTA-2	21.14	NFTA-2	21.14	NFTA-2	21.14	NFTA-2	21.14	NFTA-2
21.16	NFTA-2	21.16	NFTA-2	21.16	NFTA-2	21.16	NFTA-2	21.16	NFTA-2
21.17	NFTA-2	21.17	NFTA-2	21.17	NFTA-2	21.17	NFTA-2	21.17	NFTA-2
21.19	NFTA-2	21.19	NFTA-2	21.19	NFTA-2	21.19	NFTA-2	21.19	NFTA-2
21.20	NFTA-2	21.20	NFTA-2	21.20	NFTA-2	21.20	NFTA-2	21.20	NFTA-2
21.21	NFTA-2	21.21	NFTA-2	21.21	NFTA-2	21.21	NFTA-2	21.21	NFTA-2
21.22	NFTA-2	21.22	NFTA-2	21.22	NFTA-2	21.22	NFTA-2	21.22	NFTA-2
21.23	NFTA-2	21.23	NFTA-2	21.23	NFTA-2	21.23	NFTA-2	21.23	NFTA-2
21.25	NFTA-2	21.25	NFTA-2	21.25	NFTA-2	21.25	NFTA-2	21.25	NFTA-2
21.27	NFTA-2	21.27	NFTA-2	21.27	NFTA-2	21.27	NFTA-2	21.27	NFTA-2
21.30	NFTA-2	21.30	NFTA-2	21.30	NFTA-2	21.30	NFTA-2	21.30	NFTA-2
21.32	NFTA-2	21.32	NFTA-2	21.32	NFTA-2	21.32	NFTA-2	21.32	NFTA-2
21.34	NFTA-2	21.34	NFTA-2	21.34	NFTA-2	21.34	NFTA-2	21.34	NFTA-2
21.36	NFTA-2	21.36	NFTA-2	21.36	NFTA-2	21.36	NFTA-2	21.36	NFTA-2
21.37	NFTA-2	21.37	NFTA-2	21.37	NFTA-2	21.37	NFTA-2	21.37	NFTA-2
21.40	NFTA-2	21.40	NFTA-2	21.40	NFTA-2	21.40	NFTA-2	21.40	NFTA-2
21.41	NFTA-2	21.41	NFTA-2	21.41	NFTA-2	21.41	NFTA-2	21.41	NFTA-2
21.43	NFTA-2	21.43	NFTA-2	21.43	NFTA-2	21.43	NFTA-2	21.43	NFTA-2
21.45	NFTA-2	21.45	NFTA-2	21.45	NFTA-2	21.45	NFTA-2	21.45	NFTA-2
21.47	NFTA-2	21.47	NFTA-2	21.47	NFTA-2	21.47	NFTA-2	21.47	NFTA-2
21.52	NFTA-2	21.52	NFTA-2	21.52	NFTA-2	21.52	NFTA-2	21.52	NFTA-2
21.53	NFTA-2	21.53	NFTA-2	21.53	NFTA-2	21.53	NFTA-2	21.53	NFTA-2
21.56	NFTA-2	21.56	NFTA-2	21.56	NFTA-2	21.56	NFTA-2	21.56	NFTA-2
21.59	NFTA-2	21.59	NFTA-2	21.59	NFTA-2	21.59	NFTA-2	21.59	NFTA-2
21.61	NFTA-2	21.61	NFTA-2	21.61	NFTA-2	21.61	NFTA-2	21.61	NFTA-2
21.64	NFTA-2	21.64	NFTA-2	21.64	NFTA-2	21.64	NFTA-2	21.64	NFTA-2
21.67	NFTA-2	21.67	NFTA-2	21.67	NFTA-2	21.67	NFTA-2	21.67	NFTA-2
21.68	NFTA-2	21.68	NFTA-2	21.68	NFTA-2	21.68	NFTA-2	21.68	NFTA-2
21.70	NFTA-2	21.70	NFTA-2	21.70	NFTA-2	21.70	NFTA-2	21.70	NFTA-2
21.74	NFTA-2	21.74	NFTA-2	21.74	NFTA-2	21.74	NFTA-2	21.74	NFTA-2
21.77	NFTA-2	21.77	NFTA-2	21.77	NFTA-2	21.77	NFTA-2	21.77	NFTA-2
21.78	NFTA-2	21.78	NFTA-2	21.78	NFTA-2	21.78	NFTA-2	21.78	NFTA-2
21.79	NFTA-2	21.79	NFTA-2	21.79	NFTA-2	21.79	NFTA-2	21.79	NFTA-2
21.80	NFTA-2	21.80	NFTA-2	21.80	NFTA-2	21.80	NFTA-2	21.80	NFTA-2
21.81	NFTA-2	21.81	NFTA-2	21.81	NFTA-2	21.81	NFTA-2	21.81	NFTA-2
21.84	NFTA-2	21.84	NFTA-2	21.84	NFTA-2	21.84	NFTA-2	21.84	NFTA-2
21.85	NFTA-2	21.85	NFTA-2	21.85	NFTA-2	21.85	NFTA-2	21.85	NFTA-2
21.86	NFTA-2	21.86	NFTA-2	21.86	NFTA-2	21.86	NFTA-2	21.86	NFTA-2
21.87	NFTA-2	21.87	NFTA-2	21.87	NFTA-2	21.87	NFTA-2	21.87	NFTA-2
21.88	NFTA-2	21.88	NFTA-2	21.88	NFTA-2	21.88	NFTA-2	21.88	NFTA-2
21.89	NFTA-2	21.89	NFTA-2	21.89	NFTA-2	21.89	NFTA-2	21.89	NFTA-2
21.90	NFTA-2	21.90	NFTA-2	21.90	NFTA-2	21.90	NFTA-2	21.90	NFTA-2
21.94	NFTA-2	21.94	NFTA-2	21.94	NFTA-2	21.94	NFTA-2	21.94	NFTA-2
21.95	NFTA-2	21.95	NFTA-2	21.95	NFTA-2	21.95	NFTA-2	21.95	NFTA-2
21.97	NFTA-2	21.97	NFTA-2	21.97	NFTA-2	21.97	NFTA-2	21.97	NFTA-2
21.98	NFTA-2	21.98	NFTA-2	21.98	NFTA-2	21.98	NFTA-2	21.98	NFTA-2
22.01	NFTA-2	22.01	NFTA-2	22.01	NFTA-2	22.01	NFTA-2	22.01	NFTA-2
22.04	NFTA-2	22.04	NFTA						

Table A. - Potentially identifiable retention times, in minutes of GC FID scans by site for IRP Phase II, Stage I Iowa Air National Guard (Iowa ANG) Des Moines, Iowa. Continued. Samples which are a result of a dilution are identified by "X n'" following the first retention time for the sample (n dilution factor).

21.34	VFT-1	40.54	VFT-1-9	21.09	VFT-2	11.40	VFT-2-4	23.76	VFT-2-4	41.46	VFT-2-4
21.38		43.39	VFT-1-9	21.32		11.91		23.86		43.73	VFT-2-4
21.48				21.33		13.00		23.95		51.18	VFT-2-4
21.58		10.33	VFT-1-14	21.34		13.43		24.13			
21.78		40.34	VFT-1-14	21.35		14.03		24.27		11.40	VFT-2-9
21.87		43.33	VFT-1-14	21.36		14.26		24.44		11.91	X 10
21.98				21.37		14.44		24.52		11.99	
22.14		9.85	VFT-2	21.38		14.53		24.64		12.33	
22.20		11.11	X 200	21.39		14.72		24.69		12.49	
22.30		11.61		21.40		14.80		24.80		12.58	
22.42		12.02		21.41		15.03		24.88		13.00	
22.51		12.19		21.42		15.28		24.99		13.28	
22.59		12.29		21.43		15.48		25.05		13.64	
22.84		12.39		21.44		16.17		25.14		13.90	
22.91		12.59		21.45		16.47		25.27		14.03	
23.09		12.96		21.46		16.72		25.42		14.26	
23.22		13.05		21.47		16.91		25.56		14.53	
23.33		13.70		21.48		17.15		25.74		14.73	
23.38		13.96		21.49		17.25		25.90		14.93	
23.52		14.17		21.50		17.47		26.28		15.03	
23.66		14.23		21.51		17.57		26.45		15.80	
23.80		14.42		21.52		17.64		26.65		16.00	
23.93		14.55		21.53		17.70		26.91		16.17	
24.02		14.58		21.54		17.84		27.01		16.39	
24.12		14.69		21.55		17.91		27.16		16.46	
24.29		15.14		21.56		17.95		27.26		16.72	
24.46		15.26		21.57		18.08		27.40		16.84	
24.70		15.44		21.58		18.12		27.62		16.91	
25.49		15.80		21.59		18.18		27.72		17.15	
25.53		15.85		21.60		18.24		27.84		17.25	
25.60		15.92		21.61		18.36		27.84		17.30	
25.60		16.07		21.62		18.42		28.08		17.56	
26.55		16.14		21.63		18.59		28.15		17.64	
26.55		16.20		21.64		18.68		28.26		17.70	
27.49		16.25		21.65		18.84		28.26		17.84	
27.69		16.38		21.66		19.09		28.43		17.88	
28.22		16.52		21.67		19.37		28.58		17.90	
28.41		16.52		21.68		19.43		28.72		17.95	
	VFT-1	16.60		21.69		19.53		28.81		18.07	
		16.75		21.70		19.65		28.91		18.12	
5.97	VFT-1-4	16.81		21.71		19.76		28.91		18.24	
7.04		16.92		21.72		19.91		29.07		18.30	
10.42		16.99		21.73		19.96		29.11		18.36	
17.21		17.15		21.74		20.04		29.20		18.42	
40.54		17.24		21.75		20.15		29.28		18.42	
43.34		17.33		21.76		20.22		30.24		18.53	
	VFT-1-4	17.58		21.77		20.38		30.36		18.59	
		17.64		21.78		20.61		30.63		18.68	
5.16	VFT-1-9	17.77		21.79		20.66		30.73		18.84	
5.07		17.92		21.80		20.77		30.82		19.03	
7.04		17.92		21.81		20.92		31.06		19.08	
14.53		17.96		21.82		21.15		31.18		19.37	
16.17		18.04		21.83		21.30		31.25		19.53	
16.91		18.11		21.84		21.49		31.38		19.64	
17.16		18.17		21.85		21.59		31.51		19.76	
18.19		18.20		21.86		21.71		31.51		19.85	
18.42		18.26		21.87		21.84		31.60		19.91	
19.33		18.35		21.88		21.97		31.85		20.16	
20.16		18.39		21.89		22.10		31.98		20.21	
20.92		18.52		21.90		22.13		32.08		20.38	
21.29		18.66		21.91		22.15		32.46		20.49	
21.55		18.72		21.92		22.15		32.54		20.60	
21.94		19.06		21.93		22.21		32.67		20.66	
22.56		19.13		21.94		22.32		32.81		20.71	
22.85		19.21		21.95		22.32		32.97		20.71	
22.85		19.30		21.96		22.56		33.08		20.92	
23.51		19.42		21.97		22.63		33.25		20.98	
23.66		19.51		21.98		22.75		33.43		21.08	
23.87		19.83		21.99		22.84		33.73		21.20	
24.81		19.99		22.00		22.91		34.04		21.29	
25.05		20.17		22.01		22.96		34.34		21.40	
26.92		20.33		22.02		23.02		34.55		21.46	
27.73		20.46		22.03		23.19		35.42			
27.84		20.60		22.04		23.25		38.23			
29.78		20.96		22.05		23.56		40.76			
	VFT-1-9	21.05	VF. 2	23.66	VFT-2-4		VFT-2-4		VFT-2-4		VFT-2-9

Table 6. Potentially identifiable retention times, in minutes of GC FID scans by site for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued
 (samples which are a result of a dilution are identified by 'X n' following the first retention time for the sample n=dilution factor)

21.54	VFT-2-9	30.81	VFT-2-9	18.70	VFT-3	16.15	VFT-3-4	16.87	VFT-3-9	23.43	VFT-3-9
21.66		30.90		18.77		16.90		16.98		23.55	
21.72		30.97		19.21		17.14		17.20		23.63	
21.82		31.06		19.31		18.10		17.21		23.75	
22.04		31.25		19.43		18.58		17.30		23.84	
22.13		31.38		19.83		19.52		17.50		23.86	
22.21		31.51		19.88		17.61		17.61		23.99	
22.32		31.64		20.45		20.14		17.69		24.03	
22.50		31.74		20.59		20.36		17.79		24.10	
22.56		31.85		20.95		21.53		17.96		24.18	
22.75		31.97		21.05		21.71		18.01		24.23	
22.84		32.09		21.12		21.92		18.14		24.35	
22.91		32.18		21.22		22.54		18.17		24.40	
22.98		32.26		21.35		22.83		18.26		24.41	
23.05		32.69		21.36		23.18		18.33		24.47	
23.10		32.80		21.48		23.49		18.43		24.51	
23.13		33.07		21.58		23.64		18.50		24.58	
23.27		33.26		21.77		23.74		18.58		24.73	
23.47		33.76		21.87		23.85		18.78		24.78	
23.57		33.81		21.87		23.95		18.74		24.78	
23.59		34.03		21.95		24.09		18.74		24.97	
23.63		34.15		22.13		25.03		18.90		24.97	
23.64		34.34		22.21		27.82		18.04		25.06	
23.92		34.34		22.30		29.76		18.15		25.13	
24.03	VFT-2-9	41.46	VFT-2-9	22.50		32.56		19.36		25.23	
24.12				22.42		32.56		19.45		25.28	
24.16	VFT-2-14	8.27	VFT-2-14	22.51		36.07		19.50		25.31	
24.31		8.44		22.60		36.43		19.60		25.32	
24.38		8.68		22.69		39.05		19.69		25.38	
24.49		9.13		22.84		39.21		19.81		25.44	
24.63		9.40		22.92		40.53		19.90		25.46	
24.68		9.72		23.24		40.70		19.97		25.47	
24.82		10.49		23.33		41.93		20.03		25.55	
24.92		11.40		23.41		43.22		20.11		25.56	
25.04		11.91		23.51		43.71		20.22		25.65	
25.23		12.33		23.56		44.71		20.33		25.71	
25.47		12.49		23.67		44.46		20.38		25.78	
25.57		14.26		23.82		45.66		20.50	VFT-3-9	25.79	
25.63		14.54		23.95				20.57	VFT-3-9	25.83	
25.71		14.73		24.03		8.44	VFT-3-9	20.66		25.87	
25.78		16.18		24.14		8.68	X 10	20.72		25.95	
25.88		16.91		24.30		9.13		20.85		26.06	
25.99		20.92		24.35		9.39		21.02		26.12	
26.15		22.84		24.47		9.48		21.23		26.15	
26.27		27.84		24.55		9.72		21.23		26.19	
26.37		29.78		24.70		11.13		21.29		26.28	
26.45		40.55		24.81		11.41		21.37		26.34	
26.52	VFT-2-14	43.30	VFT-2-14	24.89		11.65		21.40		26.45	
26.60				25.22		11.77		21.48		26.53	
26.92	VFT-3	11.11	VFT-3	25.36		11.92		21.54		26.60	
26.92	X 200	13.46	X 200	25.50		11.98		21.63		26.74	
27.38		14.18		25.54		12.34		21.75		26.84	
27.70		14.24		25.63		12.50		21.80		26.94	
27.75		14.74		25.65		12.59		22.11		27.00	
27.84		14.47		25.78		13.01		22.18		27.08	
27.93		14.57		25.92		13.13		22.31		27.19	
28.08		15.00		26.01		13.31		22.36		27.28	
28.23		15.14		26.09		13.38		22.57		27.37	
28.30		15.26		26.31		13.44		22.57		27.45	
28.42		15.44		26.35		13.54		22.59		27.52	
28.49		15.86		26.55		13.65		22.63		27.56	
28.59		16.23		26.66		14.06		22.71		27.63	
28.52		16.60		27.38		14.28		22.75		27.74	
28.73		16.82		27.49		14.36		22.84		27.84	
28.92		17.24		27.70		14.45		22.84		27.96	
28.98		17.33		28.22		14.55		22.96		28.00	
29.00		17.58		28.36		14.76		23.00		28.05	
29.06		17.76		28.70		14.88		23.05		28.11	
29.20		17.87		29.42		15.05		23.11		28.16	
29.78		17.97		30.89	VFT-3	15.20		23.18		28.22	
30.02		18.04		31.26	VFT-3	15.20		23.21		28.26	
30.15		18.10		5.96	VFT-3-4	16.22		23.21		28.31	
30.25		18.26		7.03	X 2	16.41		23.27		28.36	
30.41		18.52		14.52		16.76		23.33		28.41	
30.63	VFT-2-9	18.66	VFT-3								VFT-3-9

Table 6.--Potentially identifiable retention times, in minutes of GC-FID scans by site for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued (samples which are a result of a dilution are identified by "X n" following the first retention time for the sample n=dilution factor)

26.22	VFT-3-9	33.51	VFT-3-9	14.25	AGGREGATE WASTE
28.22		33.58		14.44	
28.28		33.75		15.28	
28.29		33.82		16.25	
28.31		33.96		29.26	
28.38		34.06		35.49	
28.45		34.15		38.88	
28.48		34.28		42.97	
28.56		34.37		43.58	AGGREGATE WASTE
28.66		34.62	VFT-3-9		
28.69		40.55			
28.80					
28.88					
28.99					
29.07					
29.13					
29.23					
29.26					
29.37					
29.39					
29.74					
29.88					
29.92					
30.04					
30.09					
30.17					
30.21					
30.30					
30.42					
30.46					
30.50					
30.56					
30.70					
30.80					
30.94					
31.03					
31.12					
31.19					
31.21					
31.31					
31.38					
31.44					
31.50					
31.57					
31.65					
31.78					
31.90					
32.02					
32.13					
32.22					
32.30					
32.31					
32.38					
32.43					
32.45					
32.50					
32.51					
32.56					
32.68					
32.72					
32.85					
32.86					
32.95					
32.96					
33.03					
33.09					
33.19					
33.28					
33.38					
33.40					
33.46					
33.98					
4.34	AGGREGATE WASTE SAMPLE				
4.82					
5.73					
5.99					
6.55					
6.77					
7.00					
7.98					
7.28					
7.46					
7.59					
7.86					
8.00					
8.17					
8.40					
8.90					
9.13					
9.21					
9.25					
9.44					
9.87					
10.18					
10.40					
10.85					
11.03					
11.12					
11.20					
11.36					
11.40					
11.63					
11.63					
12.26					
12.30					
12.41					
12.40					
12.67					
12.77					
13.14					
13.20					
13.98					

Table 2. Results of GC/MS analyses for non-volatile priority pollutants for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa
 (all concentrations in µg/g except VFT-1, FTE-2/FTE-3, OFTA-2, NFTA-2 where concentrations are in µg/L
 * indicates concentration was below the detection limit of the analysis)

Parameter	NEW AGGREGATE WASTE SAMPLE 50:1 diluted												
	VFT-1	VFT-1-9	VFT-2-14	FTE-1-2	FTE-2	OFTA-1-9	OFTA-2	OFTA-3-9	NFTA-1-15	NFTA-2	NFTA-2-9	BURN PIT	7-03-84
DATE	9-27-84	8-08-84	8-08-84	8-06-84	9-26-84	8-08-84	9-25-84	8-09-84	8-07-84	9-26-84	8-07-84	1435	7-03-84
TIME	0940	1600	1445	1500	1450	1115	1515	0915	0940	1040	1450	1435	1200
4-CHLORO-3-METHYLPHENOL	<30	<6	<6	<6	<30	<6	<30	<6	<6	<30	<6	<3	354000
2-CHLOROPHENOL	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
2,4-DICHLOROPHENOL	<20	<6	<6	<6	<20	<6	<20	<6	<6	<20	<6	<3	<20
2,4,6-TRICHLOROPHENOL	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
2,4-DIMETHYLPHENOL	<30	<6	<6	<6	<30	<6	<30	<6	<6	<30	<6	<3	<30
2-METHYL-4,6-DINITRO-PHENOL	<20	<6	<6	<6	<20	<6	<20	<6	<6	<20	<6	<3	<20
2,4-DINITROPHENOL	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
4-NITROPHENOL	<30	<6	<6	<6	<30	<6	<30	<6	<6	<30	<6	<3	<30
PENTACHLOROPHENOL	<30	<6	<6	<6	<30	<6	<30	<6	<6	<30	<6	<3	<30
PHENOL	<5	41	<2	25	<5	105	<5	<2	52	<5	<2	<1	34900
ACENAPHTHENE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
ACENAPHTHYLENE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
ANTHRACENE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
BENZ(a)ANTHRACENE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
BENZO(b)FLUORANTHENE	<10	<4	<4	<4	<10	<4	<10	<4	<4	<10	<4	<2	<10
BENZO(k)FLUORANTHENE	<10	<4	<4	<4	<10	<4	<10	<4	<4	<10	<4	<2	<10
BENZO(a)PYRENE	<10	<4	<4	<4	<10	<4	<10	<4	<4	<10	<4	<2	<10
BENZO(ghi)PERYLENE	<10	<4	<4	<4	<10	<4	<10	<4	<4	<10	<4	<2	<10
BUTYLBENZYL PHTHALATE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	71	<1	185000
BIS(2-CHLOROETHOXY)METHANE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
BIS(2-CHLOROETHYL)ETHER	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
BIS(2-CHLORISOPROPYL)ETHER	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
4-BROMOPHENYLENETHYLENETHYR	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
2-CHLOROPHTHALENE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
4-CHLOROPHTHALENE	<5	<2	<2	<2	<5	<2	<5	<2	<2	<5	<2	<1	<5
CHRYSENE	<10	<4	<4	<4	<10	<4	<10	<4	<4	<10	<4	<2	<10
DIBENZ(a,b)ANTHRACENE	<10	<4	<4	<4	<10	<4	<10	<4	<4	<10	<4	<2	<10

Table 7. Results of GC MS analyses for non-volatile priority pollutants for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa- Continued
 (all concentrations in ug/g except VFT-1, FTE-2/FTE-3, OFTA-2, NFTA-2 where concentrations are in ug/l.
 * indicates concentration was below the detection limit of the analysis)

Parameter	VFT-1	VFT-1-9	VFT-2 14	FTE-1-2	FTE-2	OFTA-1-9	OFTA-2 05A-3-9	NFTA-1-15	NFTA-2	NFTA-2-9	NEW BURN PIT	AGGREGATE WASTE SAMPLE 50:1 diluted
DATE	9-27-84	8-08-84	8-06-84	9-26-84	8-08-84	8-08-84	8-09-84	8-07-84	9-26-84	8-07-84	7-03-84	7-03-84
TIME	0940	1600	1445	1500	1450	1115	0915	0940	1040	1450	1435	1200
D1-N-BUTYLPHthalate	.5	*	*	*	*	*	*	*	*	*	<1	*
1,2-DICHLOROBENZENE	<5	26	<2	<2	<5	<2	<5	<2	<5	<2	<1	<5
1,3-DICHLOROBENZENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
1,4-DICHLOROBENZENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
DIETHYL PHthalate	<5	*	*	*	*	*	*	*	*	*	<1	<5
DIMETHYL PHthalate	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
2,4-DINITROTOLUENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
2,6-DINITROTOLUENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
D1-N-OCTYLPHthalate	<10	<4	<4	<4	<10	<4	<4	<4	<10	<4	<2	<10
BIS(2-ETHYLHEXYL)PHthalate	*	*	<2	<2	<2	*	*	*	*	*	<1	*
FLUORENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
FLUORANTHENE	<5	<2	<2	30	<5	<2	<2	<2	<5	<2	<1	<5
HEXACHLOROBENZENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
HEXACHLOROCYCLOPENTADIENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
HEXACHLOROCYCLOPENTADIENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
HEXACHLOROFTHALENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
INDENO(1,2,3-cd)PYRENE	<10	<2	<2	<2	<10	<2	<2	<2	<10	<2	<1	<10
ISOPHORONE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
NAPHTHALENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
NITROBENZENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
N-NITROSODIMETHYLAMINE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
N-NITROSODIETHYLAMINE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
N-NITROSODIPROPYLAMINE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5
PHENANTHRENE	2.4	<2	<2	20	<5	<2	<2	<2	<5	<2	<1	<5
PYRENE	.6	<2	<2	34	<5	<2	<2	<2	<5	<2	593	<5
1,2,4-TRICHLOROBENZENE	<5	<2	<2	<2	<5	<2	<2	<2	<5	<2	<1	<5

* found in sample blank

Table 8.--Non-volatile compounds identified by GC-MS at concentrations greater than detection limits in samples for IRP Phase II, Stage I Iowa Air National Guard (Iowa ANG), Des Moines, Iowa

SITE ID	SAMPLE SOURCE	THRESHOLD DETECTION	PRIORITY POLLUTANTS IDENTIFIED	CONCENTRATION	OTHER TENTATIVELY IDENTIFIABLE SUBSTANCES	ESTIMATED CONCENTRATION	RELIABILITY FACTOR ¹
VFT-1	water	0.17 µg/l	acenaphthene phenanthrene pyrene	3.7 µg/l 2.4 .6	benzene, 1,4-dimethyl-	.22 µg/l	36
					benzene, 1,3-dimethyl-	1.81	74
					benzene, 1-methyl-4-(1-methylethyl)-	2.30	76
					benzene, 1,1-dimethylpropyl-	.47	89
					benzene, 1-ethyl-2,4,5-trimethyl-	1.37	46
					benzene, 1,1-dimethylpropyl-	4.03	55
					benzene, 1-ethyl-2,4,5-trimethyl-	2.59	73
					1,1,2,3-tetramethylcyclohexane	.32	65
					1h-indene, 2,3-dihydro-	1.33	68
					1h-indene, 2,3-dihydro-1-methyl-	1.79	81
					1h-indene, 2,3-dihydro-1,3-dimethyl-	5.40	79
					1h-indene, 2,3-dihydro-1,3-dimethyl-	3.53	89
	4.34	83					
	12.06	88					
	6.63	64					
	1.19	56					
	1.25	89					
	5.35	97					
	10.31	76					
	15.27	99					
	6.55	69					
	2.19-49.55	100					
VFT-1-9	soil	.0121 µg/p	phenol benzene, 1,2-dichloro	.0414 µg/g .0261	benzene, methyl-	.0193 µg/g	25
					benzene, ethyl-	.0389	70
					benzene, 1,3-dimethyl-	.0131	89
					benzene, 1,4-dimethyl-	.3341	89
					4-heptanone	.0576	67
					2-methyldecalin	.0174	39
					naphthalene, decahydro-1,6-dimethyl-	.0509	59
					cyclohexane, 2-butyl-1,1,3-trimethyl-	.0200	71
					phenanthrene, 2,5-dimethyl-	.0599	84
					34 aliphatic hydrocarbons	.0164	27
						.0131-.7545	100
					VFT-2-14	soil	.0106 µg/g
benzene, 1,2-dimethyl-	.0281	79					
3-hexanone	.0436	37					
4-heptanone	.0129	43					
naphthalene, decahydro-	.0155	76					
thiophene, 2-heptyl-	.0233	27					
1-ethyl-2,6-trimethylcyclohexane	.0252	50					
cyclohexane, 1-(cyclohexylmethyl)-2-ethyl-trans-	.0176	52					
cyclohexane, (1-methylethyl)-	.0450	41					
cyclohexane, (4-methylpentyl)-	.0262	60					
cyclohexane, (1,3-dimethylbutyl)-	.0291	52					
44 aliphatic hydrocarbons	.0116-1.0730	100					

¹ Based on a computer algorithm to determine the quality of the match with National Bureau of Standards data, the closer the value to 100 the better the match

Table 8.--Non-volatile compounds identified by GC-MS at concentrations greater than detection limits in samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

SITE ID	SAMPLE SOURCE	THRESHOLD DETECTION	PRIORITY POLLUTANTS IDENTIFIED	CONCENTRATION	OTHER TENTATIVELY IDENTIFIABLE SUBSTANCES	ESTIMATED CONCENTRATION	RELIABILITY FACTOR ¹
FTE-2	water	.17	none		benzene, ethyl-	1.33 µg/L	52
FTE-3 (combined extract)		µg/L			benzene, 1,4-dimethyl- benzene, 1,2-dimethyl- 8 aliphatic hydrocarbons	6.28 .72 .17-.49	96 67 100
FTE-1-2	soil	.0106 µg/g	phenol fluoranthene phenanthrene pyrene	.0253 µg/g .0300 .0200 .0344	benzene, ethyl- benzene, 1,3-dimethyl- benzofuran, 2,3-dihydro- benzaldehyde, 3-hydroxy-4-methoxy- fatty acid methyl ester 12 aliphatic hydrocarbons	.0178 µg/g .1739 .0129 .0270 .0153 .0429 .0186-.1773	52 81 52 24 45 100 100
OFTA-2	water	.41 µg/L	none		benzene, ethyl- benzene, 1,2-dimethyl- 6 aliphatic hydrocarbons	.43 µg/L .53 11.30 .61 .58-1.58	15 76 95 48 100
OFTA-1-9	soil	.0102 µg/g	phenol butylbenzyl- phthalate	.1054 µg/g .0057	1b-indole fatty acid 12 aliphatic hydrocarbons	.0175 µg/g .0685 .0112-.4121	20 100 100
OFTA-3-9	soil	.0128 µg/g	none		benzothiazole 8 aliphatic hydrocarbons	.0417 µg/g .0142-.4574	43 100
NFTA-2	water	0.18 µg/L	none		benzene, 1,4-dimethyl- 2 aliphatic hydrocarbons	2.79 µg/L .38-0.44	86 100
NFTA-1-15	soil	.0182 µg/g	phenol	.0529 µg/g	fatty acid methyl ester 9 aliphatic hydrocarbons	.0212 µg/g .0242-.0951	100 100
NFT-2-9	soil	.0144 µg/g	butylbenzyl- phthalate	.0713 µg/g	3 aliphatic hydrocarbons	.0246-.0419 µg/g	100

¹ Based on a computer algorithm to determine the quality of the match with National Bureau of Standards data. the closer the value to 100 the better the match

Table 8.--Non-volatile compounds identified by GC-MS at concentrations greater than detection limits in samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

SITE ID	SAMPLE SOURCE	THRESHOLD DETECTION	PRIORITY POLLUTANTS IDENTIFIED	CONCENTRATION	OTHER TENTATIVELY IDENTIFIABLE SUBSTANCES	ESTIMATED CONCENTRATION	RELIABILITY FACTOR ¹
Aggregate Waste ² (diluted 1:50)	soil	16773.2 (µg/L)	phenol, 4-chloro-3-methyl- phenol butylbenzyl- phthalate naphthalene		2-pentanone, 4-methyl- benzene, methyl- benzene, ethyl- benzene, 1,4-dimethyl- benzene, 1,2-dimethyl- benzene, 1-methylethyl- benzene, 1,2,4-trimethyl- benzene, butyl- naphthalene, decahydro-2-methyl- naphthalene, 1-methyl- naphthalene, 1,4-dimethyl- naphthalene, 1,3-dimethyl- naphthalene, 2,3-dimethyl- cyclohexane, ethyl- nonox A	.6339 µg/g 1.1507 1.2305 .7263 .9008 .7978 .3985-8.3611	58 30 36 11 20 15 100
Burn Pit Sample	soil	.3955 µg/g	pyrene	.593 µg/g	51 aliphatic hydrocarbons naphthalene, 1,4,6-trimethyl- naphthalene, 2,3,6-trimethyl- naphthalene, 1,4,5-trimethyl- phenanthrene, 4-methyl- phenanthrene, 2,5-dimethyl- 34 aliphatic hydrocarbons		

¹ Based on a computer algorithm to determine the quality of the match with National Bureau of Standards data, the closer the value to 100 the better the match

² Sample was an aggregate of solvents, concentrations are not reported here because they are dependent on the amount of substance that was obtained in the grab sample

Table 5.--Recurrence of similar selected GC-FID retention times in soil and water samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa

Sample	Retention Times, in minutes							
	4.34	4.82	5.73	5.99	6.55	6.77	7.00	10.40
Aggregate Base Waste*								
Burn Pit*								
FTE-1		4.87						
FTE-1-2*								
FTE-1-15			5.74					
FTE-2*								
FTE-3*								
FTE-3-14								
NFTA-1-9	4.33							10.46
NFTA-1-15*								
NFTA-1-19			5.35					10.28
NFTA-2*								
NFTA-2-4								
NFTA-2-9*								
NFTA-2-14								
NFTA-3-4		4.83			6.56			
NFTA-3-9								
NFTA-3-19								
NFTA-3-24						6.80		
OFTA-1-4								
OFTA-1-9*			5.81					10.39
OFTA-2*		4.89						
OFTA-2-17								
OFTA-2-24								
OFTA-2-29				5.96			7.03	
OFTA-3-4								
OFTA-3-6*	4.46	4.62	5.39		6.41			10.44
VFT-1-4								
VFT-1-9*				5.97			7.04	10.42
VFT-1-14				5.97			7.04	
VFT-3-4				5.96			7.03	

(*) indicates sample was selected for GC-MS analysis

Table 9.--Recurrence of similar selected GC-FID retention times in soil and water samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Sample	Retention Times, in minutes			
Aggregate	12.60	13.48		
Base Waste*			20.89	22.54
Burn Pit*			22.82	23.64
				24.78
FTE-1				
FIE-1-2*			22.99	
FTE-1-15			22.79	24.73
FIE-2*				
FTE-3*	12.57			
FTE-3-14		13.49		
NFTA-1-9				23.61
NFTA-1-15*				
NFTA-1-19				
NFTA-2*	14.52		22.55	22.84
NFTA-2-4				22.99
NFTA-2-9*				22.99
NFTA-2-14				23.61
NFTA-3-4				
NFTA-3-9				
NFTA-3-19				
NFTA-3-24				
OFTA-1-4				
OFTA-1-9*				
OFTA-2*				
OFTA-2-19				
OFTA-2-24				
OFTA-2-29				
OFTA-3-4				
OFTA-3-9*				
VFT-1-4				
VFT-1-9*	14.53	16.17	16.91	20.92
VFT-1-14				21.94
VFT-3-4	14.52	16.15	16.90	20.90
				21.92
				22.54
				22.83
				22.85
				23.66
				24.81
				23.64
				24.79

(*) indicates sample was selected for GC-MS analysis

Table 9.--Recurrence of similar selected GC-FID retention times in soil and water samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued

Sample	Retention Times, in minutes			
Aggregate Base Waste*				
Burn Pit*	27.70	27.81	29.75	31.36
FTE-1			48.94	52.26
FTE-1-2*				
FTE-1-15				
FTE-2*				
FTE-3*				
FTE-3-14				
NFTA-1-9				
NFTA-1-15*			43.18	49.61
NFTA-1-19			43.19	51.81
NFTA-2*				
NFTA-2-4			43.19	49.42
NFTA-2-9*				
NFTA-2-14			43.17	51.82
NFTA-3-4				
NFTA-3-9			43.19	49.62
NFTA-3-19		29.74	43.18	49.61
NFTA-3-24	27.67	29.74	43.19	
OFTA-1-4			40.56	
OFTA-1-9*			40.54	40.69
OFTA-2*				
OFTA-2-19			40.66	49.44
OFTA-2-24				49.44
OFTA-2-29			40.52	43.38
OFTA-3-4			40.53	
OFTA-3-9*				
VFT-1-4			40.54	43.34
VFT-1-9*	27.73	27.84	40.54	43.34
VFT-1-14			40.54	43.33
VFT-3-4	27.71	27.82	40.53	43.22

(*) indicates the sample was selected for GC MS analysis

404 555 6 25 555 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 18000 19000 20000 21000 22000 23000 24000 25000 26000 27000 28000 29000 30000 31000 32000 33000 34000 35000 36000 37000 38000 39000 40000 41000 42000 43000 44000 45000 46000 47000 48000 49000 50000 51000 52000 53000 54000 55000 56000 57000 58000 59000 60000 61000 62000 63000 64000 65000 66000 67000 68000 69000 70000 71000 72000 73000 74000 75000 76000 77000 78000 79000 80000 81000 82000 83000 84000 85000 86000 87000 88000 89000 90000 91000 92000 93000 94000 95000 96000 97000 98000 99000 100000

Table 10.--Results of chemical analyses of soil samples for IRP Phase II, Stage 1
Iowa Air National Guard (Iowa ANG), Des Moines, Iowa
(< indicates concentration was below the detection limit of the analysis)

SITE ID	DEPTH (feet)	DATE (mm-dd-yy)	TIME	TOTAL RECOVERABLE LEAD (µg/g)	TOTAL RECOVERABLE OIL AND GREASE (µg/g)
VFT-1-4	4	08-08-84	1550	10	<1
VFT-1-9	9	08-08-84	1600	<10	<1
VFT-1-14	14	08-08-84	1615	10	<1
VFT-2-4	4	08-08-84	1415	20	<1
VFT-2-9	9	08-08-84	1430	20	<1
VFT-2-14	14	08-08-84	1445	10	
VFT-3-4	4	08-08-84	1645	10	<1
VFT-3-9	9	08-08-84	1700	<10	<1
FTE-1-2	2	08-06-84	1500	30	<1
FTE-1-5	5	08-06-84	1510	20	<1
FTE-1-9	9	08-06-84	1520	10	<1
FTE-1-15	15	08-06-84	1530	10	<1
FTE-2-4	4	08-09-84	1045	20	<1
FTE-2-9	9	08-09-84	1100	20	<1
FTE-2-14	14	08-09-84	1115	<10	1
FTE-3-9	9	08-09-84	1145	20	1
FTE-3-14	14	08-09-84	1200	20	<1
OFTA-1-4	4	08-08-84	1100	<10	<1
OFTA-1-9	9	08-08-84	1115	<10	<1
OFTA-1-14	14	08-08-84	1130	20	<1
OFTA-1-19	19	08-08-84	1145	10	<1
OFTA-2-4	4	08-08-84	0845	10	<1
OFTA-2-9	9	08-08-84	0900	<10	<1
OFTA-2-14	14	08-08-84	0910	20	<1
OFTA-2-19	19	08-08-84	0920	10	<1
OFTA-2-24	24	08-08-84	0935	20	<1
OFTA-2-29	29	08-08-84	1000	<10	<1
OFTA-3-4	4	08-09-84	0900	<10	<1
OFTA-3-9	9	08-08-84	0915	<10	<1
NFTA-1-4	4	08-07-84	0900	20	<1
NFTA-1-9	9	08-07-84	0920	20	1
NFTA-1-15	15	08-07-84	0940	<10	<1
NFTA-1-19	19	08-07-84	1000	10	1
NFTA-1-24	24	08-07-84	1030	20	<1
NFTA-2-4	4	08-07-84	1430	20	1
NFTA-2-9	9	08-07-84	1450	20	<1
NFTA-2-14	14	08-07-84	1510	10	1
NFTA-3-4	4	08-07-84	1240	10	<1
NFTA-3-9	9	08-07-84	1250	20	<1
NFTA-3-14	14	08-07-84	1310	10	<1
NFTA-3-19	19	08-07-84	1330	20	<1
NFTA-3-24	24	08-07-84	1350	10	<1
NRD	0	09-26-84	1200	30	<1

Table 11.--Results of chemical analyses of water samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa
(< indicates concentration was below the detection limit of the analysis)

PARAMETER	FIELD SITE ID												NRD			
	VFT-1	VFT-2	VFT-3	FTE-1	FTE-2	FTE-3	OFTA-1	OFTA-2	OFTA-3	NFTA-1	NFTA-2	NFTA-3				
DATE (mm-dd-yy)	9-27-84	9-27-84	9-27-84	9-26-84	9-26-84	9-26-84	9-25-84	9-25-84	9-25-84	9-25-84	9-26-84	9-26-84	9-26-84	9-26-84	9-26-84	9-26-84
TIME	0940	1010	1040	1400	1450	1535	1410	1515	1615	1000	1040	1120	1220			
AIR TEMP (°C)	8.5	8.0	8.0	12.0	9.0	10.5	12.0	13.0	13.0	9.0	8.0	8.5	8.5			
WATER TEMP (°C)	18.5	17.0	19.0	13.5	12.0	13.0	15.0	*	18.5	13.0	15.0	11.0	16.0			
FIELD pH (UNITS)	6.7	6.7	6.8	7.3	7.4	6.7	7.4	*	7.4	7.3	7.1	6.8	7.9			
SPECIFIC CONDUCTANCE (µS/L at 25° C)	1230	965	810	750	1020	865	725	*	745	800	1420	2580	490			
OIL AND GREASE, TOTAL (mg/L)	4	23	18	3	6	*	3	*	3	<1	3	<1	<1			
TOTAL ORGANIC CARBON (mg/L)	50	63	80	140	30	*	2.5	7.0	1.3	.9	27	10	2.3			
TOTAL ORGANIC HALIDE (µg Cl-/L) ¹	78	80	83	*	*	*	49	*	33	*	61	81	57			
LEAD, TOTAL (µg/L)	130	250	6	<1	<1	*	10	*	7	2	<1	16	1			
BENZENE, TOTAL (µg/L)	<3	6.3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
BROMOFORM, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
CARBON TETRACHLORIDE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
CHLOROBENZENE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
CHLORODIBROMOMETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
CHLOROETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
2-CHLOROETHYL VINYL-ETHER, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
CHLOROFORM, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
DICHLOROBROMOMETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
DICHLORODIFLUOROMETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			
1,1-DICHLOROETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3	<3			

* unable to analyze due to insufficient sample volume
1 analysis by independent laboratory

Table 11.--Results of chemical analyses of water samples for IRP Phase II, Stage 1 Iowa Air National Guard (Iowa ANG), Des Moines, Iowa--Continued
 (< indicates concentration was below the detection limit of the analysis)

PARAMETER	FIELD SITE ID											NRD
	VFT-1	VFT-2	VFT-3	FTE-1	FTE-2	FTE-3	OFTA-1	OFTA-2	OFTA-3	NFTA-1	NFTA-2	
DATE (mm-dd-yy)	9-27-84	9-27-84	9-27-84	9-26-84	9-26-84	9-26-84	9-25-84	9-25-84	9-25-84	9-26-84	9-26-84	9-26-84
TIME	0940	1010	1040	1400	1450	1535	1410	1515	1615	1000	1040	1120
1,2-DICHLOROETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,1-DICHLOROETHENE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,2-(TRANS)DICHLORO- ETHENE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,2-DICHLOROPROPANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,3-DICHLOROPROPANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
ETHYLBENZENE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
METHYLBROMIDE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
METHYLENECHLORIDE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,1,2,2-TETRACHLORO- ETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
TETRACHLOROETHENE, TOTAL (µg/L)	<3	<3	<3	<3	15	*	<3	<3	<3	<3	<3	<3
TOLUENE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,1,1-TRICHLORO- ETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
1,1,2-TRICHLORO- ETHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
TRICHLOROETHENE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
TRICHLOROFLUORO- METHANE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3
VINYLCHLORIDE, TOTAL (µg/L)	<3	<3	<3	<3	<3	*	<3	<3	<3	<3	<3	<3

* unable to analyze due to insufficient sample volume

Appendix E - Laboratory methods, sensitivity, and quality control

APPENDIX E

Laboratory analyses - parameters, detection limits, and methods

Parameter	Detection limit	Analytical method
Carbon, total organic in water	.1 mg/L	wet oxidation
Lead, total recoverable in water	1 µg/L	digest., atomic adsorption
Lead, total recoverable in sediments	10 µg/g	digest., atomic adsorption
Oil and grease, total recoverable in water	1 mg/L	freon-extraction, gravimetry
Oil and grease, total recoverable in sediments	10 µg/g	freon-extraction, gravimetry
Organic compounds, acid-extractable in water		methylene chloride-extraction, GC-MS*
4-Chloro-3-methylphenol	30 µg/L	
2-Chlorophenol	5 µg/L	
2,4-Dichlorophenol	5 µg/L	
2,4-Dimethylphenol	5 µg/L	
2,4-Dinitrophenol	20 µg/L	
4,6-Dinitro-2-methylphenol	30 µg/L	
2-Nitrophenol	5 µg/L	
4-Nitrophenol	30 µg/L	
Pentachlorophenol	30 µg/L	
Phenol	5 µg/L	
2,4,6-Trichlorophenol	20 µg/L	
Organic compounds, base/neutral-extractable in water		methylene chloride-extractable, GC-MS*
Acenaphthene	5 µg/L	
Acenaphthylene	5 µg/L	
Anthracene	5 µg/L	
Benzo (a) anthracene	5 µg/L	
Benzo (b) fluoranthene	10 µg/L	
Benzo (k) fluoranthene	10 µg/L	
Benzo (g,h,i) perylene	10 µg/L	
Benzo (a) pyrene	10 µg/L	
4-Bromophenyl phenyl ether	5 µg/L	
Butyl benzyl phthalate	5 µg/L	
bis (2-Chloroethoxy) methane	5 µg/L	
bis (2-Chloroethyl) ether	5 µg/L	
bis (2-Chloroisopropyl) ether	5 µg/L	
2-Chloronaphthalene	5 µg/L	
4-Chlorophenyl phenyl ether	5 µg/L	
Chrysene	10 µg/L	
Dibenzo (a,h) anthracene	10 µg/L	
1,2-Dichlorobenzene	5 µg/L	
1,3-Dichlorobenzene	5 µg/L	
1,4-Dichlorobenzene	5 µg/L	
Diethyl phthalate	5 µg/L	
Dimethyl phthalate	5 µg/L	
Di-n-butyl phthalate	5 µg/L	
2,4-Dinitrotoluene	5 µg/L	

APPENDIX E

Laboratory analyses - parameters, detection limits, and methods--Continued

Parameter	Detection limit	Analytical method
2,6-Dinitrotoluene	5 µg/L	
Di-n-octylphthalate	10 µg/L	
bis (2-Ethylhexyl) phthalate	5 µg/L	
Fluoranthene	5 µg/L	
Fluorene	5 µg/L	
Hexachlorobenzene	5 µg/L	
Hexachlorobutadiene	5 µg/L	
Hexachlorocyclopentadiene	5 µg/L	
Hexachloroethane	5 µg/L	
Indeno (1,2,3-cd) pyrene	10 µg/L	
Isophorone	5 µg/L	
Naphthalene	5 µg/L	
Nitrobenzene	5 µg/L	
n-Nitrosodimethylamine	5 µg/L	
n-Nitrosodi-n-propylamine	5 µg/L	
n-Nitrosodiphenylamine	5 µg/L	
Phenanthrene	5 µg/L	
Pyrene	5 µg/L	
1,2,4-Trichlorobenzene	5 µg/L	
Organic compounds, acid-extractable in sediments		methylene chloride-extraction, GC-MS*
4-Chloro-3-methylphenol	600 µg/kg	
2-Chlorophenol	200 µg/kg	
2,4-Dichlorophenol	200 µg/kg	
2,4-Dimethylphenol	200 µg/kg	
2,4-Dinitrophenol	600 µg/kg	
4,6-Dinitro-2-methylphenol	600 µg/kg	
2-Nitrophenol	200 µg/kg	
4-Nitrophenol	600 µg/kg	
Pentachlorophenol	600 µg/kg	
Phenol	200 µg/kg	
2,4,6-Trichlorophenol	600 µg/kg	
Organic compounds, base/neutral- extractable in sediment		methylene chloride-extraction, GC-MS*
Acenaphthene	200 µg/kg	
Acenaphthylene	200 µg/kg	
Anthracene	200 µg/kg	
Benzo (a) anthracene	200 µg/kg	
Benzo (b) fluoranthene	400 µg/kg	
Benzo (k) fluoranthene	400 µg/kg	
Benzo (g,h,i) perylene	400 µg/kg	
Benzo (a) pyrene	400 µg/kg	
4-Bromophenyl phenyl ether	200 µg/kg	
Butyl benzyl phthalate	200 µg/kg	
bis (2-Chloroethoxy) methane	200 µg/kg	
bis (2-Chloroethyl) ether	200 µg/kg	

APPENDIX E

Laboratory analyses - parameters, detection limits, and methods--Continued

Parameter	Detection limit	Analytical method
bis (2-Chloroisopropyl) ether	200 µg/kg	
2-Chloronaphthalene	200 µg/kg	
4-Chlorophenyl phenyl ether	200 µg/kg	
Chrysene	200 µg/kg	
Dibenzo (a,h) anthracene	400 µg/kg	
1,2-Dichlorobenzene	200 µg/kg	
1,3-Dichlorobenzene	200 µg/kg	
1,4-Dichlorobenzene	200 µg/kg	
Diethyl phthalate	200 µg/kg	
Dimethyl phthalate	200 µg/kg	
Di-n-butyl phthalate	200 µg/kg	
2,4-Dinitrotoluene	200 µg/kg	
2,6-Dinitrotoluene	200 µg/kg	
Di-n-octylphthalate	200 µg/kg	
bis (2-Ethylhexyl) phthalate	200 µg/kg	
Fluoranthene	200 µg/kg	
Fluorene	200 µg/kg	
Hexachlorobenzene	200 µg/kg	
Hexachlorobutadiene	200 µg/kg	
Hexachlorocyclopentadiene	200 µg/kg	
Hexachloroethane	200 µg/kg	
Indeno (1,2,3-cd) pyrene	200 µg/kg	
Isophorone	200 µg/kg	
Naphthalene	200 µg/kg	
Nitrobenzene	200 µg/kg	
n-Nitrosodimethylamine	200 µg/kg	
n-Nitrosodi-n-propylamine	200 µg/kg	
n-Nitrosodiphenylamine	200 µg/kg	
Phenanthrene	200 µg/kg	
Pyrene	200 µg/kg	
1,2,4-Trichlorobenzene	200 µg/kg	
Volatile organic compounds, total recoverable, water		GC-MS*
Benzene	3 µg/L	
Bromoform	3 µg/L	
Carbon tetrachloride	3 µg/L	
Chlorobenzene	3 µg/L	
Chloroethane	3 µg/L	
2-Chloroethyl vinyl ether	3 µg/L	
Chloroform	3 µg/L	
Chloromethane	3 µg/L	
Dibromochloromethane	3 µg/L	
Dichlorobromomethane	3 µg/L	
1,1-Dichloroethane	3 µg/L	
1,2-Dichloroethane	3 µg/L	
1,1-Dichloroethylene	3 µg/L	

APPENDIX E

Laboratory analyses - parameters, detection limits, and methods--Continued

Parameter	Detection limit	Analytical method
1,2-trans-Dichloroethylene	3 µg/L	
1,2-Dichloropropane	3 µg/L	
1,3-Dichloropropene	3 µg/L	
Ethylbenzene	3 µg/L	
Methyl bromide	3 µg/L	
Methylene chloride	3 µg/L	
1,1,2,2-Tetrachloroethane	3 µg/L	
Tetrachloroethylene	3 µg/L	
Toluene	3 µg/L	
1,1,1-Trichloroethane	3 µg/L	
1,1,2-Trichloroethane	3 µg/L	
Trichloroethylene	3 µg/L	
Vinyl chloride	3 µg/L	
Organic substances, total recoverable from water		methylene chloride extraction, GC-FID screening, no identification or quantification
Organic substances, total recoverable from sediments		methylene chloride extraction, GC-FID screening, no identification or quantification
Organic halide, total recoverable	5 µg/L	adsorption/coulometric

* Additional sensitivity may be available for some parameters. The additional sensitivity is dependant on sample volume, extraction efficiency, and the performance of the detector at the time of the analysis. Only values with a high degree of confidence are reported.

QUALITY CONTROL *

Quality control includes the acquisition and documentation of information on personnel, reagents and standards, equipment, and analytical procedures. The principles contained in this section apply to all analytical procedures contained in this manual and represents the minimum level for analytical quality control required to produce acceptable data. It supplements the practices contained in Book 5, Chapter A6 of the Techniques of Water Resources Investigations Series of the U.S. Geological Survey.

Qualification of analyst

Before performing any analyses, the analyst must demonstrate the ability to produce data of acceptable accuracy and precision with the method by successfully analyzing replicate aliquots of reference materials over the range of the method. To be considered successful, results obtained must fall within two standard deviations of the expected values for each constituent measured.

Reagents and standards

The purity of each reagent must be verified by analysis employing the analytical method at the lowest detection limit that will be reported. The frequency of verification is a function of the stability of each reagent. All reagents and adsorbents must be free of interfering contaminants. The presence of an interfering contaminant requires remedial action and reanalysis to verify reagent purity.

Before processing any samples, the analyst must demonstrate, through the analysis of an aliquot of reagent water equivalent in volume to a sample aliquot, that all glassware and reagent interferences are under control. A reagent water blank must be analyzed each time a set of samples is analyzed or there is a change in reagents.

Stock standard solutions need to be prepared from materials of highest available purity. All data concerning the preparation must be recorded in a notebook reserved for standard solution data. Prior to use the individual component standards need to be analyzed to assure the concentration and component response. Solutions of individual standards also need to be analyzed by an independent laboratory or a second analyst in the preparing laboratory to confirm the results. All differences need to be resolved before a standard solution is used.

As specified in the analytical method, from one to seven standard solutions in the concentration range of the procedure need to be analyzed with each sample set, and the results must agree with expected values before sample results can be reported.

Equipment

A notebook containing all information on repair, maintenance, and daily operating conditions needs to be maintained and available at each instrument work station.

* Wershaw and others, 1983

Analytical procedure

The analytical procedures contained in this manual must be followed exactly. Whenever possible, method performance must be demonstrated with each sample by the use of surrogate compound spikes. Appropriate surrogate compounds are listed in the analytical method along with applicable acceptance criteria. For analytical procedures for which appropriate surrogates are unavailable, the laboratory must arrange to receive at least 10 percent of samples in duplicate. One portion of each of these samples will be spiked with a mixture of the compounds of interest and analyzed by the analytical method. If the recovery for any constituent does not fall within control limits for method performance, the results reported for that constituent in all samples processed as part of the same set must be qualified as suspect. The laboratory must monitor the frequency of suspect data to ensure that it remains below 5 percent. For those samples (sediment, soil, and core material) for which the use of spikes are not appropriate, an estimate of analytical precision must be obtained and reported by analyzing at least 10 percent of samples in each set in duplicate.

Because of the rapid advances in analytical technology, the analyst is permitted certain options to improve separations or lower the cost of measurement. Such modification of methods, however, must conform to the following section, "Use and documentation of standard laboratory procedures".

USE AND DOCUMENTATION OF STANDARD LABORATORY PROCEDURES

The Water Resources Division (WRD) of the U.S. Geological Survey recognizes two types of water-quality analytical methods--Approved Methods and Special Methods. Definitions of the two types of methods and requirements for approval of analytical methods are given for the guidance of users of this manual who provide data to or evaluate data from WRD programs.

Approved Methods

Two categories of approved analytical methods have been formally established. These are: (1) official methods, and (2) provisional methods. A description of each of these categories and requirements for their approval are given below:

Official Methods

Methods in this category are considered to be the official water-quality analytical methods of the WRD. They are published in the Techniques of Water Resources Investigations (TWRI) series. Data collected by these methods may be stored in the national data file, WATSTORE, and published in the annual basic data reports of the WRD. Requirements for approval are:

1. Submission of documentation of the proposed method or modification of a presently used method in TWRI format to the Chief, Quality of Water Branch.
2. Submission to and approval by the Quality of Water Branch of a method-development report giving information and supporting data on the following:
 - (a) applicable range, detection limit, and sensitivity of the method,
 - (b) known and possible interferences,

- (c) precision and bias of the method; these data should as a minimum include: (1) single-laboratory and multiple-operator tests which include at least 10 replicate analyses each of pure solutions, natural water, and spiked natural waters at three concentrations covering the applicable range of the method,
- (d) production rates compared to other methods, when possible.

3. Submission of statements describing hazardous chemical reactions and/or reagents that are involved in the method, sample preservation requirements, and level of skill and/or special training requirements needed by personnel using the method.

4. In addition to the above minimum requirements for approval, if it is determined that the proposed method will be used in the Central Laboratories System, the Quality of Water Branch will initiate plans to obtain technical reviews of the method documentation and method development report by at least two colleagues, one of which must be outside the author's laboratory. In addition, if the method is developed in one of the Central Laboratories, the other Central Laboratory will be expected, if they have the equipment, to confirm the precision and bias of the method and to compare results with present methodology if a method exists. These requirements must be completed within 30 days. Approval of the method will be dependent on obtaining the reviews and additional data. The Quality of Water Branch may give Provisional Approval as outlined below during the period of review.

Provisional Methods

Methods in this category are believed to produce data comparable to those obtainable from official methods but are likely to be used by WRD to such a limited extent that they have not received extensive inhouse testing by WRD personnel. Many of the methods published in such reliable compendia as Standard Methods, Environmental Protection Agency Methods for Chemical Analysis of Water and Wastes, and the American Society for Testing and Materials Book of Standards, and which are used by inhouse, cooperator, or contractor laboratories in support of WRD programs, would be accepted for approval in this category. These methods will not be published in the TWRI series. Data collected by these methods may be stored in WATSTORE if a parameter code exists, and the data may be published in the annual basic data reports. Requirements for acceptance of methods in this category are as follows:

1. Submission of a copy of the method to the Chief, Quality of Water Branch, with an explanation of why approval of the method is desired.
2. Provision of the same type of information on precision and bias as required for Official Method approval, however, in this case, data obtained by other than WRD personnel will be acceptable for consideration.

Special Methods

In contrast to the two categories of approved analytical methods, there are some methods that have specialized or limited application and, therefore, need not be submitted to the Chief, Quality of Water Branch, for approval. These include methods used in support of research, experimental or developmental methods used by a Central Laboratory, and screening methods used in the field or in the

laboratory. Data collected by these methods are not to be stored in WATSTORE or published in the annual basic data reports. However, the data may be published in interpretive reports or project data reports, provided the method is fully described or an appropriate reference is cited to provide a basis for peer evaluation of analytical results. Defense of the validity of such a method is, therefore, the responsibility of the individual publishing the data.

Ordinarily, only approved methods will be used in the Central Laboratories unless a special method is requested and concurrence in its use is obtained from the responsible individual for Analytical Technology Transfer in the Office or the Analytical Services Coordinator. Analysts will not use a modification of an approved method without satisfying all previously stated requirements for an Approved Method. Furthermore, when a laboratory uses an alternate method to satisfy a specific analytical request because of technical or management considerations, the analytical method used must have been previously shown to have equivalent or better sensitivity, precision, and bias as compared to the method requested to the satisfaction of the individual responsible for Analytical Technology Transfer. If these conditions are not met, the requester must be notified promptly and approve the change in the method prior to analysis.

**Appendix F - Description of Work, Phase II, Stage 1 Iowa Air
National Guard, Des Moines, Iowa**

INSTALLATION RESTORATION PROGRAM
PHASE II TASK DESCRIPTION
DES MOINES ANG IA

I. DESCRIPTION OF WORK:

The purpose of this task is to undertake a field investigation at Des Moines AFB Iowa to determine: (1) The presence or absence of contamination within the specified areas of investigation; (2) the potential for migration of identified contaminants in the various environmental media; (3) additional investigations necessary to define the magnitude, extent, direction and rate of migration of identified contaminants; and (4) potential environmental consequences and health risks of migrating contaminants.

An adequate safety program shall be implemented to insure the protection of USGS, subcontractor, and Air Force personnel during drilling and sampling tasks.

The presurvey report and the Phase I IRP report (mailed under separate cover) give background information and describe the sites for this task. To accomplish the survey effort, the contractor shall take the following steps:

A. General

1. Well Installation and Design:

a. Install 12 ground-water monitoring wells. A maximum of 360 linear feet of wells shall be installed. Holes shall be augered with solid stem continuous flight augers (ST-CFA) and 2-foot shelby-tube core samples obtained on the unconsolidated material at 5-foot intervals for chemical analysis. Each of the four disposal sites shall be encompassed with a triangle of three immediately adjacent sampling wells to allow determination of lateral flow direction.

b. Des Moines ANG civil engineering shall be coordinated with to determine location of underground plumbing, electrical lines, and tanks prior to any well installation.

c. Sampling wells shall be drilled to the loess/till contact at each well location. Casing shall consist of 2-inch I.D. stainless steel with a 3-foot, 25-slot opening size, wire-wound stainless steel screen at the bottom of the casing. The top of the screen shall coincide with the water-table surface at the time of drilling. Sampling wells shall be sand packed to within 5-feet of land surface, sealed with bentonite and grouted to the surface with cement (Figure 1, Atch 1). A protective steel casing with locking cap shall be set in concrete at the surface.

d. Each well shall be developed as soon as practical after completion. Well development shall proceed until the discharge water is clear and free of sediment to the fullest extent practical.

2. Borehole Installation

A separate test hole shall be constructed in an area isolated from the disposal sites to determine the nature and thickness of materials overlying the bedrock. Soil samples shall be collected from the auger flights at 5-foot intervals down to bedrock (maximum of 100-feet). Analyze soil samples as shown in Table 1, Atch 2. After sampling, the borehole shall be tremie grouted to surface with a cement/bentonite grout.

3. Site Identification

Each sampling location (surface water, sediment, core sample, or ground-water monitoring well) shall be marked with a permanent marker (where practical) referenced to an easily identified bench mark. All locations shall be recorded on a project map for the site.

4. All well and boring area drill cuttings shall be removed and the general area cleaned following the completion of each well or boring. Only those drill cuttings suspected as being a hazardous waste (based on discoloration, odor, or organic vapor detection instrument) shall be properly containerized (according to base civil engineering requirements) by the USGS for eventual disposal by base personnel. The USGS will be responsible for transporting the suspected hazardous waste to an on-base holding area. The suspected hazardous waste shall be tested by the USGS for EP Toxicity and Ignitability. The USGS is not responsible for ultimate disposal of the drill cuttings.

5. Collect and analyze samples from each of the wells/boreholes as identified in Table 1, Atch 2. A total of 12 wells and two boreholes shall be sampled. If well(s) cannot be sampled due to well development, well characteristics, or other reason(s), the USGS shall indicate the reason(s) in the report identified in paragraph I.D. below.

6. All water and soil samples collected in A.5 above shall be analyzed for those contaminants summarized in Table 1, Atch 2. Required detection limits for the above analyses are specified in Atch 3.

7. The areal extent of each site shall be determined by reviewing available aerial photos of the base, and by field reconnaissance.

8. All water samples collected from each well or surface water shall be analyzed on site for pH, temperature, and specific conductance. Sampling, maximum holding time, and preservation of all the samples will strictly comply with the following references: Standard Methods for the Examination of Water and Wastewater, 15th Ed. (1980); ASTM, Section 11, Water and Environmental Technology, and Methods for Chemical Analysis of Water and Wastes, EPA Manual 600/4-79-020 (1979).

9. The specific Quality Assurance/Quality Control (QA/QC) protocols and procedures of the USGS shall include split samples for all samples. One sample shall be analyzed by the USGS. The other sample shall be forwarded through overnight delivery to:

USAF OEHL/SA
Bldg 140
Brooks AFB TX 78235

The sample sent to the USAF OEHL/SA shall be accompanied by the following information:

- a. Purpose of sample (analyte)
- b. Installation name (base)
- c. Sample number (on containers)
- d. Source/location of sample
- e. Contract Task Number and Title of Project
- f. Method of collection (bailer, suction pump, air-lift pump, etc.)
- g. Volumes removed before sample taken
- h. Special conditions (use of surrogate standard; special non-standard preservatives, etc.)
- i. Preservative used.

This information should be forwarded with each sample by properly completing an AF Form 2752 (mailed under separate cover). In addition, copies of field logs documenting sample collection should accompany the samples.

B. In addition to items specified in I.A. above, conduct the following specific actions at the sites identified:

1. Site 1, Vehicle Fuel Tank Area:

Three wells shall be drilled at this site as described in A.1. A maximum of 6 core samples shall be taken from each well and analyzed as shown in Table 1, Atch 2. In addition, one water sample shall be taken from each well and analyzed as shown in Table 1, Atch 2. A water sample from one of the three wells at this site shall be analyzed by GC/MS for those compounds represented by peaks in the GC-FID (GC-Flame Ionization Detection) scan.

2. Site 2, Existing Fire Training Area:

- a. Same as B.1.

b. One soil sample shall be collected in the upper-most material and analyzed as shown in Table 1, Atch 2.

3. Site 3, Old Fire Training Area: Same as B.1.

4. Site 5, Fuel Tank Excavation Area: Same as B.1.

5. Site 6, North Runway Drainage Ditch:

a. Collect one water sample and one sediment sample from the drainage ditch at or immediately below the point where the drainage intercepts ground-water seepage. Analyze sample as shown in Table 1, Atch 2.

b. Collect one water sample from the ground-water seep located in the open excavation pit adjacent to the existing fire training area. Analyze sample as shown in Table 1, Atch 2.

6. Site 8, Upgradient Test Hole: A separate test hole shall be constructed in an area isolated from the disposal sites to determine the nature and thickness of materials overlying the bedrock. No chemical analyses shall be performed on this sample; rather, the sample shall be analyzed as shown in Table 2, Atch 2.

C. Data Review

1. Any new data obtained for the sites shall be included in the monthly Research and Development (R&D) Status Report required by item D.1.

2. An Informal Technical Information Report (ITIR) in your own format shall be forwarded to the USAF OEHL/TS prior to the first draft. The ITIR shall include results of all physical, biological, and chemical sample analyses performed to date.

D. Reporting

1. The following reports shall be written during the performance of the upcoming survey task:

- a. R&D Status Report (monthly)
- b. Performance and Cost Report (monthly)
- c. Certificate of Services (monthly)
- d. Two draft finals and one final report.

2. A draft report delineating all findings of this field investigation shall be prepared and forwarded to the USAF OEHL/TS as specified in Item VI below for Air Force review and comment. This report shall include a discussion of the regional/site specific hydrogeology, well and boring logs, data from water level surveys, groundwater surface and gradient maps, water quality and soil analysis results, available geohydrologic cross sections and laboratory quality assurance information. The report shall follow the USAF OEHL supplied format.

3. The recommendation section will address each site and list them by categories. Category I will consist of sites where no further action, including remedial action, is required. Data for these sites are considered sufficient to rule out unacceptable health or environmental risks. Category II sites are those requiring additional monitoring or work to quantify or further assess the extent of current or future contamination. Category III sites are sites that will require remedial actions (ready for IRP Phase IV actions). In each case the USGS will summarize or present the results of field data, environmental or regulatory criteria, or other pertinent information supporting these conclusions.

4. Where possible, estimates shall be made of the magnitude, extent and direction of movement of contaminants discovered. Potential environmental consequences of discovered contamination must be identified.

5. The requirements of these reports are shown in Atchs 4-7. Use your own format for 1.a, b, and c. The format for 1.d is attached (Atch 7).

6. A minimum of two draft reports shall be required. After incorporating Air Force comments concerning the first draft report, the contractor shall supply the USAF OEHL with a second draft report. Contractor shall supply the USAF OEHL with 25 copies of each draft report and 50 copies plus the original camera ready copy of the final report. The following milestones shall be adhered to:

- a. 1st Draft Report: 6 months after contract (MAC)
- b. 2nd Draft Report: 9 MAC
- c. Final Report: 11 MAC

E. Meetings

The USGS project leader shall attend a maximum of two (2) meetings with representatives of HQ ANGSC/SGB, Des Moines ANG/SG/DE, USAF OEHL and regulatory agencies to take place at a time to be specified by the USAF OEHL. Each meeting shall take place at Des Moines ANG IA for a duration of one day (eight hours).

II. SITE LOCATION AND DATE:

Des Moines ANG IA
Time and dates to be established