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PACIFIC AIR FORCES

CAPE ROMANZOF LRRS
ALASKA

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Installation Restoration Program (IRP) Remedial Investigation/Feasibility Study

Stage 1

Cape Romanzof LRRS, Alaska

Prepared by

Woodward-Clyde Consultants
500 12th Street, Suite 100, Oakland, CA 94607-4014

March 1991

Technical Report Addendum
(August 1990 - March 1991)

Prepared for

Alaskan Air Command
(HQ AAC/DEPV)
Elmendorf Air Force Base, Alaska 99506

United States Air Force
Human Systems Division (AFSC)
IRP Program Office (HSD/YAQ)
Brooks Air Force Base, Texas 78235-5501

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DRAFT
INSTALLATION RESTORATION PROGRAM
REMEDIAL INVESTIGATION/FEASIBILITY STUDY

STAGE 1

TECHNICAL REPORT ADDENDUM

FOR

CAPE ROMANZOF LRRS (ROM), ALASKA

March 1991

Prepared by

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, California 94607

USAF CONTRACT F33615-85D-4544, DELIVERY ORDER NO. 10

APPROVED FOR PUBLIC RELEASE/UNLIMITED DISTRIBUTION

Prepared for

Alaskan Air Command
HQ AAC/DEPV
Elmendorf AFB, Alaska 99506

IRP Program Office (HSD/YAQ)
Charles Attebery, Captain, USAF
Project Manager

HUMAN SYSTEMS DIVISION
IRP PROGRAM OFFICE (HSD/YAQ)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

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work was conducted at four sites
Additional remedial investigation/feasibility studies documented in the WCC
at the Cape Romanzof LRRS, Alaska to supplement included water sampling a
report dated June 1, 1990. The field investigation (Lower Camp) including sever
three sites, and geophysical surveys at one area and qualitative risk assessme
sites. As a result of the additional 1990 work having no significant risks.
one site (ROM-1S) was classified as Category 1, were conditionally classified as
Two sites (ROM-2 and the area of Well No. 1) sampling/testing for Secondary Maximum
Category 1 Sites, pending confirmatory One site (ROM-8) remains as a Category 3
Contaminant Level (SMCL) analytes. No changes were made to the existin
site, requiring further remedial action.
feasibility study for ROM-8 (in WCC 1990 RI/FS report).

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Captain Charles Attebery

22b TELEPHONE (Include Area Code)
800-821-4528

22c OFFICE SYMBOL
AFHSD/YAQ

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PREFACE

This Technical Report Addendum supplements the Woodward-Clyde Consultants Stage 1 RI/FS Report (dated June 1, 1990). The 1990 report describes the investigation and evaluation techniques and results adopted for the USAF under contract F33615-85D-4544 delivery order number 0010 to conduct an IRP Remedial Investigation/Feasibility Study (RI/FS) for the Cape Romanzof Long Range Radar Site (LRRS), one of the Alaskan Long Range Radar locations.

The overall assignment included reviewing site history and defining the framework for the RI/FS; establishing the environmental setting through existing reports; conducting the field investigation program in conformance with the Stage 1 Final Work Plan; discussing results and significant findings, including providing a qualitative risk screening of identified contaminated sites; identification, screening, and analysis of remedial measures; and recommending which sites require no further IRP action, require additional IRP effort, or require recommended remedial actions. The original field work took place in summer 1989 and was documented in the June 1990 report.

Supplemental field work was implemented in summer 1990, in accordance with Order 0010 Modification 1. The results of this field work, the following analytical work, the evaluations including a supplementary qualitative risk screening, and the conclusions and recommendations regarding site classification and future IRP work are presented in this Technical Report Addendum.

Captain Charles Attebery, Human Systems Division, IRP Program Office (HSD/YAQ), was the Technical Program Manager.

Approved:

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As a follow-on to the 1989 field investigation, which is documented in Woodward Clyde's June 1990 report (WCC 1990), some additional field investigations were implemented in 1990 and are documented herein. The purpose of the 1990 work was to clarify or confirm findings of the 1989 work at three sites at Cape Romanzof LRRS. The sites, and the purposes of the additional investigations, were:

- ROM-1S area, which also includes Well No. 1 and, on a broader scale, the entire Lower Camp area. The purposes were to resample all three wells in the area, to close two wells, and to better define the area's hydrogeology in view of contaminant transport and a potential new installation water supply well location.
- ROM-2, the Weather Station area, and in particular Well No. 3 near the Weather Station. The purpose was to ascertain the quality of the Well No. 3 water, which had not been sampled previously in Stage 1.
- ROM-8, the landfill located about one-half mile west of the Composite Facility. It was considered useful to resample the wells, which had been installed at the landfill and sampled in 1989.

Accordingly, an additional field investigation was planned and implemented in August 1990. It consisted of:

- In ROM-1S/Lower Camp area:
    - Geologic reconnaissance, and review of available well information
    - Sampling of three wells
    - Downhole geophysical survey of two wells
    - Seismic refraction geophysical survey over approximately 5500 feet of survey line
    - Proper abandonment of two wells
- At ROM-2, Weather Station:
    - Sampling of one well
    - Review of well information
- At ROM-8, Landfill:
    - Sampling of three wells; the fourth well was found to be damaged and could not be sampled.

The results of the investigation were compiled and evaluated, and compared to applicable standards. A summary of 1990 positive chemical results, and corresponding 1989 results, is as follows:

		1990	1989
ROM-1S/Lower Camp Area			
Well A	TPH (mg/l)	<1.0	Not detected
Well B	TPH (mg/l)	<2.0	4.0
Well No. 1	TPH (mg/l)	<1.0	2.0
ROM-2 -- Weather Station			
Well No. 3	TPH (mg/l)	<1.0	Not sampled
ROM-8 -- Landfill			
MW-1	TPH (mg/l)	<1.0	Not detected
MW-2	TPH (mg/l)	<1.0	Not detected
MW-4	TPH (mg/l)	<1.0	2.0
	Toluene (µg/l)	7.6 & 9.2	Not detected
	Ethylbenzene (µg/l)	1.2 & 1.3	Not detected
	Xylenes (µg/l)	5.0 & 6.1	6.7
	1,4 Dichlorobenzene (µg/l)	4.2 & 5.2	3.8

Regarding the hydrogeology of the Lower Camp Area, it was found that:

- Contaminant transport at ROM-1S is downslope and away from Well No. 1.
- Well No. 1 is near an optimum location for a water supply well, considering downgradient contamination potential and potential well yield.

A qualitative risk screening indicated negligible health risk for the ROM-1S/Lower Camp area including Well No. 1, and for ROM-2 Well No. 3, subject to satisfactory confirmation sampling and testing of Wells No. 1 and 3 for Secondary Maximum Contaminant Levels (SMCLs).

At the ROM-8 landfill, the results confirmed the 1989 results and, therefore, the risk screening results, feasibility study, and recommended remedial action documented in the 1990 Stage 1 RI/FS report (WCC 1990) following the 1989 field investigation.

The conclusions and recommendations of the present report are:

- ROM-1S (Wells A and B) is a Category 1 site, requiring no further action.
- Well No. 1 and ROM-2 (Well No. 3) are conditional Category 1 sites, requiring no further action, subject to satisfactory confirmation sampling and testing for SMCLs.
- ROM-8 (landfill) remains a Category 3 site requiring a remedial action. The feasibility study and recommended remedial action documented in WCC (1990) are unchanged.

DRAFT
IRP RI/FS
TECHNICAL REPORT ADDENDUM
Cape Romanzof LRRS, Alaska

1.0
INTRODUCTION

The U.S. Air Force (USAF) contracted Woodward-Clyde Consultants (WCC) to assess past hazardous material disposal and spill sites at the Cape Romanzof Long Range Radar Site (LRRS), Alaska, and to develop remedial actions for those sites which pose a threat to human health and welfare or to the environment. The project was authorized under the USAF Installation Restoration Program (IRP), which is similar to the U.S. Environmental Protection Agency (EPA) Remedial Investigation/Feasibility Study (RI/FS) Program. The USAF IRP was developed to provide response actions on USAF installations under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980. A USAF Handbook entitled "USAF Occupational and Environmental Health Laboratory Technical Service Division (AFOEHL/TS) Handbook to Support the Installation and Restoration Program Statements of Work for Remedial Investigation/Feasibility Studies," Version 2.0, April 1988, was developed to provide guidance to contractors in performing RI/FS at USAF sites meeting NPL criteria.

Cape Romanzof LRRS is not classified as a National Priority List (NPL) site under the EPA CERCLA program. Therefore, not all of the requirements in the USAF Handbook were necessarily satisfied during the Cape Romanzof studies. The data and evaluations described in this report are an Addendum to the Second Draft RI/FS Stage 1 Report for the Cape Romanzof sites (WCC 1990).

The work discussed in this report addendum was implemented pursuant to the Schedule of Changes, Modification No. 1 to Order No. 10 under Contract

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No. F33615-85-D-4544. The Schedule of Changes is included in Appendix D. The report addendum discusses:

- Additional information regarding the environmental setting -- specifically the glacial deposits, hydrogeology of the water-bearing geologic units, and water use (Section 2.0).
- The field investigation program of 1990, which addressed contamination at sites ROM-1S (including Well No. 1), ROM-2, ROM-8, and the geometry of the groundwater aquifer within the Lower Camp area, in conformance with F33615-85-D-4544, Order 10, Proposed Modification 1 (Section 3.0).
- Results and significant geologic, hydrogeologic, chemical, and contaminant findings (Section 4.0).
- Impact of findings on Feasibility Study (FS) remedial alternatives in previous RI/FS report (WCC 1990) (Section 5.0).
- Recommendations for Category 1, 2, or 3 status for investigated sites - ROM-1S, ROM-2, ROM-8 (Section 6.0).

1.1 OBJECTIVES

Three sites at Cape Romanzof were re-investigated in August 1990: ROM-1S (including Well No. 1), ROM-2, and ROM-8. A regional location map for Cape Romanzof is provided on Figure 1-1. Locations of the subject sites within the Cape Romanzof LRRS are shown on Figure 1-2.

Wells at these sites were sampled, and samples were analyzed for aromatic volatile organics and total petroleum hydrocarbon (TPH) contamination. In addition, one area (defined as Lower Camp Area and shown on Figure 1-2) was investigated using geophysical surveys to provide preliminary identification of: 1) subsurface aquifer boundaries, 2) general extent of the groundwater resource, and 3) potential alternate locations for the base water supply well. This Lower Camp Area included several previously investigated sites, including ROM-1S and ROM-3.

1.2 SITE DESCRIPTIONS

The following site and area descriptions are based on descriptions in the existing RI/FS report (WCC 1990) plus additional data obtained since preparation of that report.

ROM-1S - Spill/Leak No. 5

This site is located south of the sewage lagoon and west of ROM-3, as shown on Figure 1-2. The Phase 1 Records Search (Engineering Science [ES] 1985) reports that spills from various waste accumulation areas plus spill/leaks at and north of ROM-3 have contributed to the waste concentration at ROM-1S. Approximately 14,000 gallons of diesel fuel were lost in one of these spills. The area contains through-flowing surface water; a tributary of Fowler Creek flows through the site.

For the purposes of the 1990 investigations, this site also included Well No. 1, located about 300 feet southeast of ROM-1S, as shown on Figure 1-2. This inclusion was made to allow an evaluation of subsurface hydrogeology and contamination migration between ROM-1S and Well No. 1.

ROM-1S contained two unsealed wells, which were open to their total depths of 55 feet and 26 feet prior to plugging during the 1990 field work. Limited information concerning these wells was found in U.S. Geological Survey-Water Resources Division files.

ROM-2 - Weather Station Well

The weather station and associated water well are located approximately 600 feet east of the southwest end of the airstrip (see Figure 1-2). The existing well (now known to be Well No. 3) is enclosed within a wooden structure, and is located 210 feet northeast of and uphill from the weather station building. Based on recently obtained U.S. Army Corps of Engineers records, there were actually two wells drilled at or near the weather station. The existing well is the second of these wells, and was constructed in 1972.

The first well (Well No. 2) was drilled in 1962, and was reportedly located near the southeast corner of the weather station building (U.S. Army Corps of Engineers, 1963). Groundwater from this well was reported to be contaminated with fuel oil in 1964 (Feulner, 1966). The 1989 field investigation and the 1990 visit at this site found no evidence of any well at this reported location; an above-ground petroleum storage tank was observed uphill from this location.

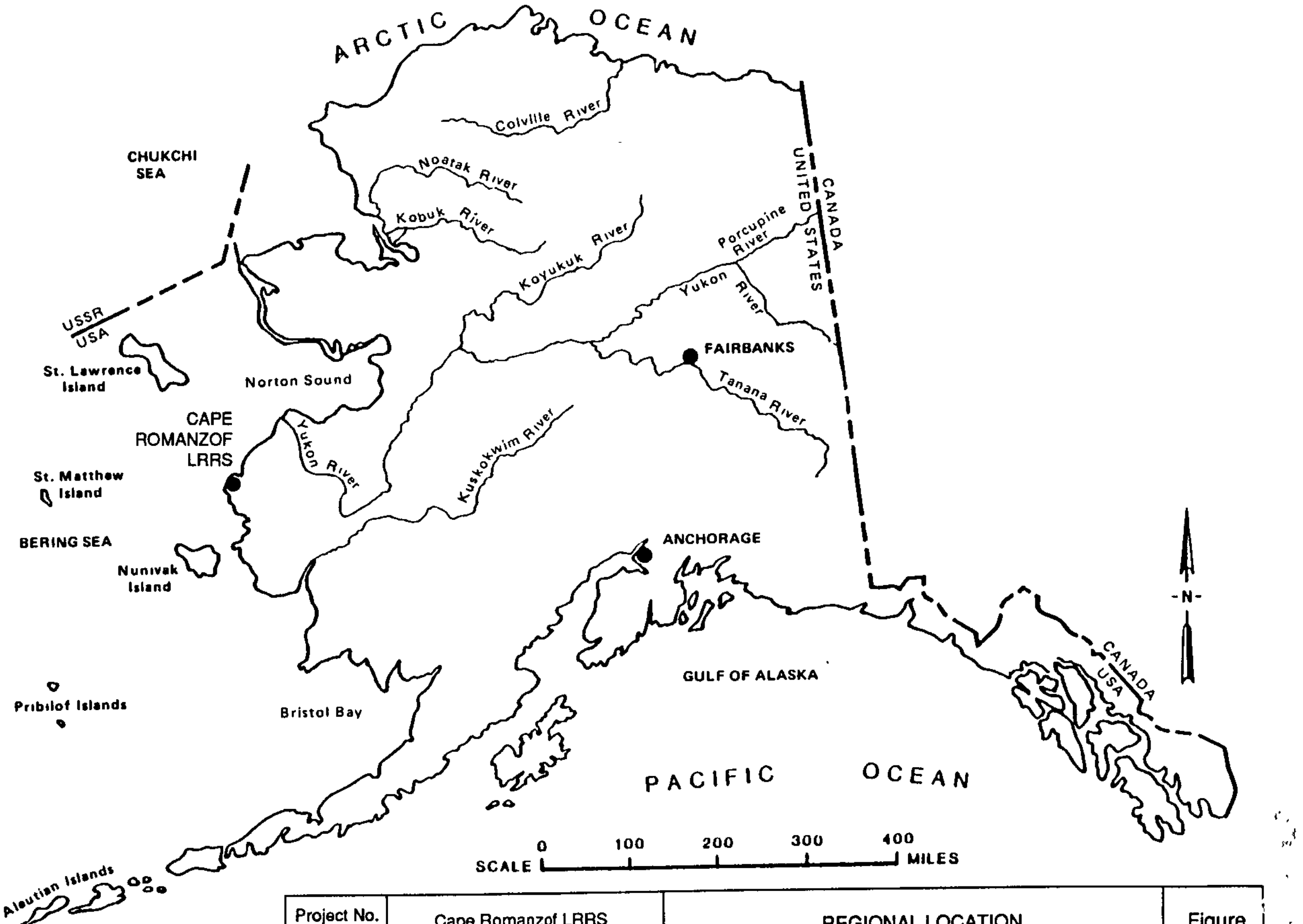
ROM-8 - Landfill No. 2 (Old Landfill)

This landfill is located on the south side of the access road between Lower Camp and the airstrip, about ½ mile downhill from the Composite Facility as shown on Figure 1-2. The landfill occupies an area of about 1 to 1.5 acres, and was operated until the mid-1970s. This landfill has received garbage, rubbish, wood, metal, plastic, construction and demolition debris, shop wastes, and incinerator ash (ES 1985). Water constantly flows through or underneath the landfill. Effluent streams have locally deposited a reddish sediment, and some vegetation around the streams has been affected.

In 1989, four groundwater monitoring wells were installed at this site, two wells upgradient and two wells at the outer/lower limits of the landfill.

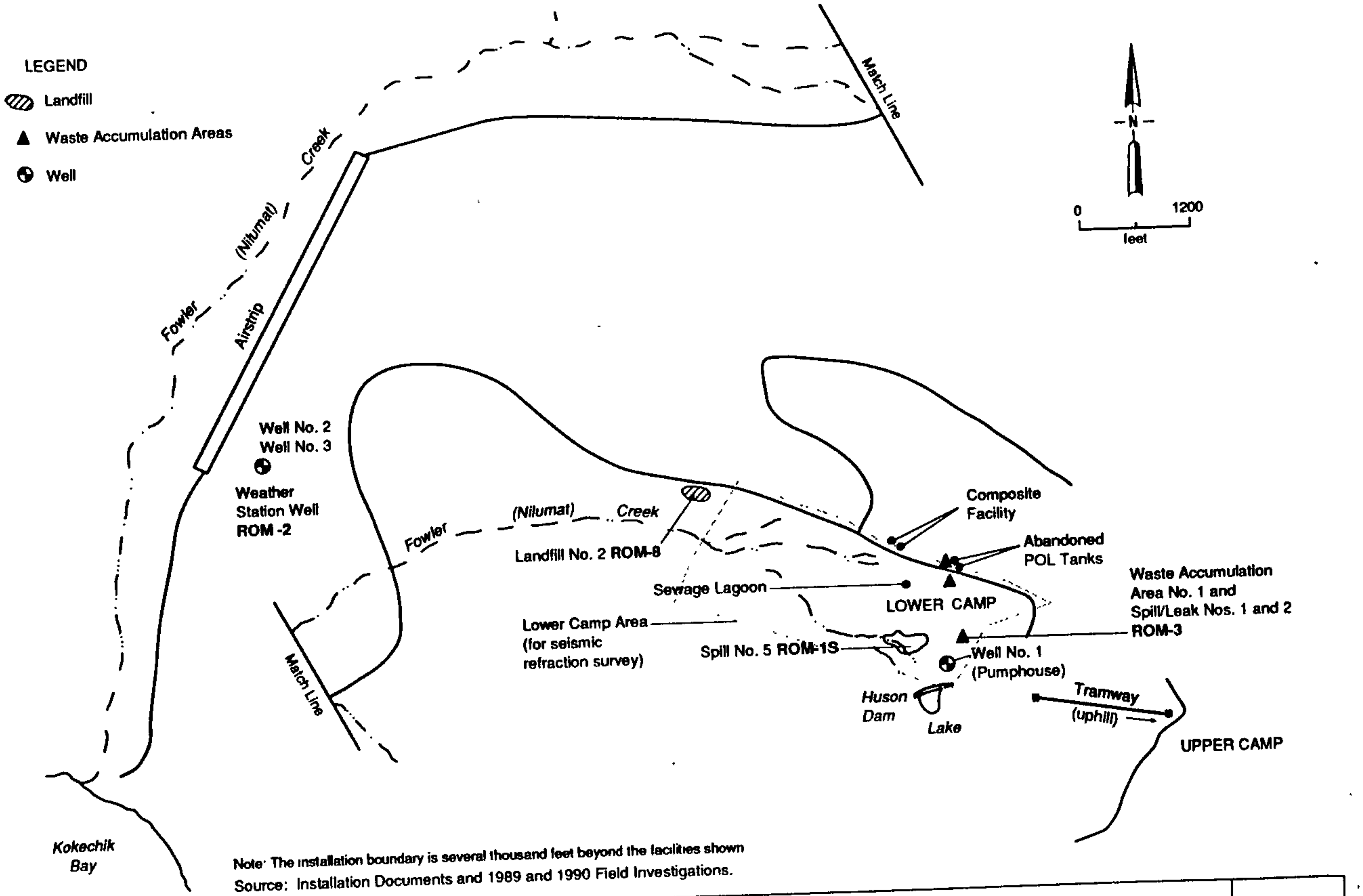
Lower Camp Area

This area is located in the upper part of Fowler Creek valley, and includes the Composite Facility, the area of demolished Lower Camp buildings, and several contamination sites, as shown in Figure 1-2. At the headwaters of Fowler Creek, the valley splits into two tributary valleys, one to the south (the principal course of Fowler Creek containing Huson Dam), and one to the north (located southeast of the Composite Facility).



Source: Installation documents

Project No. 90275L	Cape Romanzof LRRS	REGIONAL LOCATION, CAPE ROMANZOF LRRS, ALASKA	Figure 1-1
Woodward-Clyde Consultants			



Note: The installation boundary is several thousand feet beyond the facilities shown

Source: Installation Documents and 1989 and 1990 Field Investigations.

Project No. 90275L	Cape Romanzof LRRS	SITE LOCATION MAP	Figure 1-2
Woodward-Clyde Consultants			

2.0
ENVIRONMENTAL SETTING

During the 1990 field investigations, additional information regarding the environmental setting was obtained. This information concerned: 1) extent and type of glacial deposits underlying the floor of Fowler Creek Valley, 2) hydrogeology of these deposits and underlying weathered bedrock, and 3) water use data. These data are presented below as Section 2.1, Geology; Section 2.2, Hydrology and Groundwater; and Section 2.3, Water Use. These data provide supplements to the Environmental Setting discussion in the Second Draft RI/FS Report (WCC 1990).

2.1 GEOLOGY

2.1.1 Extent of Glacial Deposits in Fowler Creek Valley

The glacial deposits underlying Fowler Creek Valley and the Lower Camp Area were found to extend downstream from Lower Camp for approximately 1 mile, nearly to the junction with a southern tributary of Fowler Creek, as shown on the regional topographic map on Figure 2-1. The western end of these deposits was identified based on geomorphic evidence - namely the abrupt steep slope at the western terminus of an elongate topographic mass which extends up the valley and contains known glacial deposits at Lower Camp. It is likely that the steep front of this mass comprises a terminal moraine.

The overall geometry of this mass of glacial material was first observed clearly in August 1990, during rare clear weather which fortuitously coincided with an incoming flight to the site. An oblique aerial photograph of this steep-fronted mass of glacial deposits is shown on Figure 2-2. Numerous solifluction lobes and fronts can also be seen moving down the steep-fronted terminus.

2.1.2 Type of Glacial Deposits in Fowler Creek Valley

Lake Deposits - During seismic refraction investigations, small holes up to 3 feet deep were excavated at various points on the flat Fowler Creek Valley floor in order to bury explosives. The detonations provided seismic energy for the investigation. It was noted that most of these holes contained an upper 1 foot of tundra vegetation, and a lower 1-2 feet of soft blue-gray water-saturated clay.

Such a wide-spread clay deposit was probably formed in an old post-glacial lake, which likely had been ponded behind coarser terminal moraine deposits located downstream. Furthermore, the local drainage in this part of Fowler Creek Valley is erratic and often non-integrated, as can be seen in the aerial photographs on Figure 2-3. Several small ponds remain on this old surface; these ponds and many old drainage lines, faintly visible on Figure 2-3, are apparently not directly related to present-day Fowler Creek. The present tributaries of Fowler Creek are interpreted to be much younger features, which have incised through the old glacial surface, and are now slowly eroding the mass of glacial material.

Lateral Moraines - During the period of unusually clear weather which fortuitously occurred during the first part of the 1990 investigation, it was possible to observe features along the side walls of Fowler Creek Valley. A prominent terrace-like feature was observed on the south side of Fowler Creek Valley, across from Lower Camp. This feature was examined from a distance and at close hand, and is interpreted to be a remnant of a lateral moraine. Photographs of this probable moraine are shown on Figure 2-4. It is not known whether this moraine was related to the period of glaciation that preceded the lake deposits. On the opposite (north) side of Fowler Creek Valley, similar but smaller terrace-like features were observed; these may also be lateral moraine remnants.

2.2 HYDROLOGY AND GROUNDWATER

2.2.1 Hydrogeology of Granitoid Colluvium and Bedrock

At ROM-2 (Weather Station) additional data on two water supply wells were obtained from the U.S. Army Corps of Engineers, Anchorage office. These data are presented in Section 4.2.3 of this report. The log of Well No. 3, the existing well, indicates that it was completed (in 1972) apparently within a 16-foot open uncased zone containing both granitoid colluvium (or weathered bedrock) and bedrock. The water-bearing zone was reportedly confined to a 1/2 foot-thick layer at the base of the colluvium/weathered bedrock, at the contact with "rock" (presumably bedrock) at 77-foot depth. Static water level was 16 feet above the top of the uncased zone. In a pumping test of unknown length in 1972, a pumping rate of 5 gallons per minute (gpm) was achieved with an accompanying drawdown of 15 feet (U.S. Army Corps of Engineers, unpublished file data, Anchorage, Alaska).

2.2.2 Hydrogeology of Weathered Bedrock

Also at ROM-2 (Weather Station), the log of Well No. 2 indicates that it was completed (in 1962) within weathered granitoid bedrock. A 5.5-foot screen was installed at the base of the well, at (90 to 95.5-foot depth), and static water level was found to be 9 feet above the top of screen. A pumping test of four days' duration was conducted in 1962; and a pumping rate of 3 gpm was achieved with an accompanying drawdown of 9 feet (U.S. Army Corps of Engineers, 1963).

Well No. 1 (at Lower Camp) was completed in 1957, also within weathered granitoid bedrock. Casing was driven to the total depth of 154 feet, and casing perforations were made at two separate water-bearing zones: one 20-foot-thick zone (82- to 102-foot depths), and one two-foot-thick zone (146- to 148-foot depths). A pumping test of 25-1/2 hours' duration was conducted in 1957, and a pumping rate of 60 to 67 gpm was achieved with an accompanying drawdown of 2 feet (U.S. Geological Survey-Water Resources Division, unpublished file data, Anchorage, Alaska).

2.2.3 Hydrogeology of Glacial Deposits

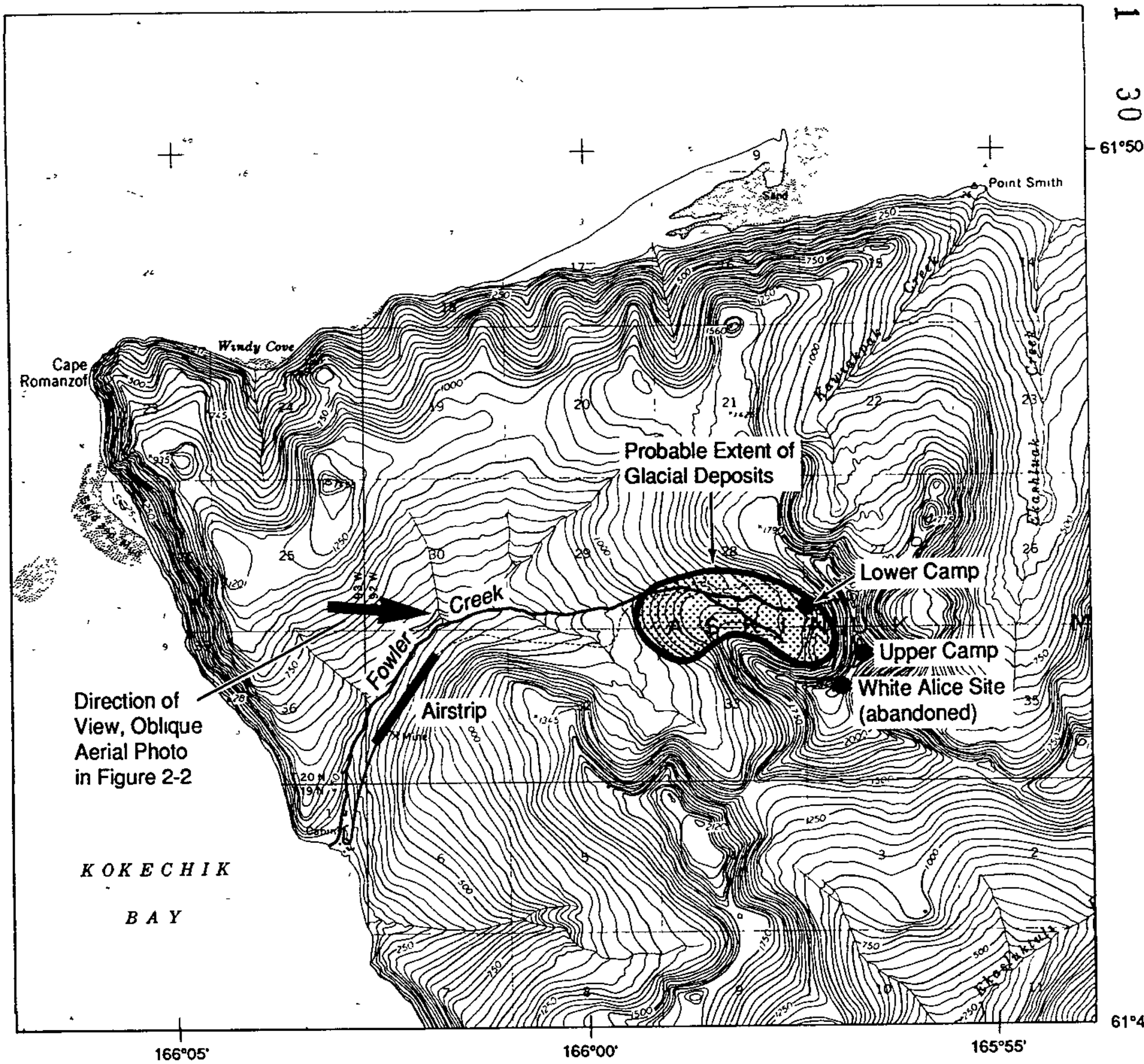
Well No. 1 (at Lower Camp) also penetrated 57 feet of probable glacial deposits. Most of these deposits contained much clay and were found to be "not water-bearing". Two thin water-bearing units were identified: 30- to 34-foot depths ("gravelly clay") and 43- to 46-foot depths ("granite sand"). The 3-foot thick sand zone reportedly produced 12 to 15 gpm during a test (bailer test) conducted while drilling. However, the casing across this zone was not perforated, so its long-term producing capability is not known (U.S. Geological Survey-Water Resources Division, unpublished file data, Anchorage, Alaska).

2.3 WATER USE

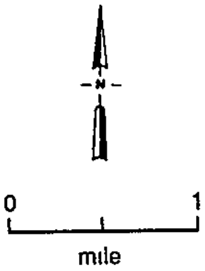
Operations started at Cape Romanzof in 1953 (ES 1985). Based on the publications of Feulner (1960, 1962), water needs until 1958 were met at Cape Romanzof by a surface water reservoir, presumably the lake behind Huson Dam (see Figure 3-1). Water consumption data from 1955 through 1957 (using the lake) show a monthly water use ranging from 162,000 gallons to 849,000 gallons. Well No. 1 was constructed in 1957 (U.S. Geological Survey-Water Resources Division, unpublished file data). From 1958 to 1965, monthly water use (using mostly Well No. 1) ranged from 241,000 gallons to 1.2 million gallons (Feulner 1960, 1962, 1966). The higher consumption rates occurred during the July through September summer months, when weather conditions allowed field operations to be conducted.

Since 1977, when operations were converted from military to contractor personnel, the number of station personnel has decreased from more than 100 to less than 15 (ES 1985). In 1990, there were 8 station personnel plus up to 10 persons on short-term work assignments, mostly during the summer months (C. Humphrey, personal communication, October 1990).

According to station personnel, the present water supply well is pumped only intermittently (once every several days) to fill a storage tank located adjacent to the Industrial Dome (see Figure 3-1). Water consumption in 1990 is estimated to be 38,000 to 174,000 gallons per month (C. Humphrey, personal communication, October 1990).

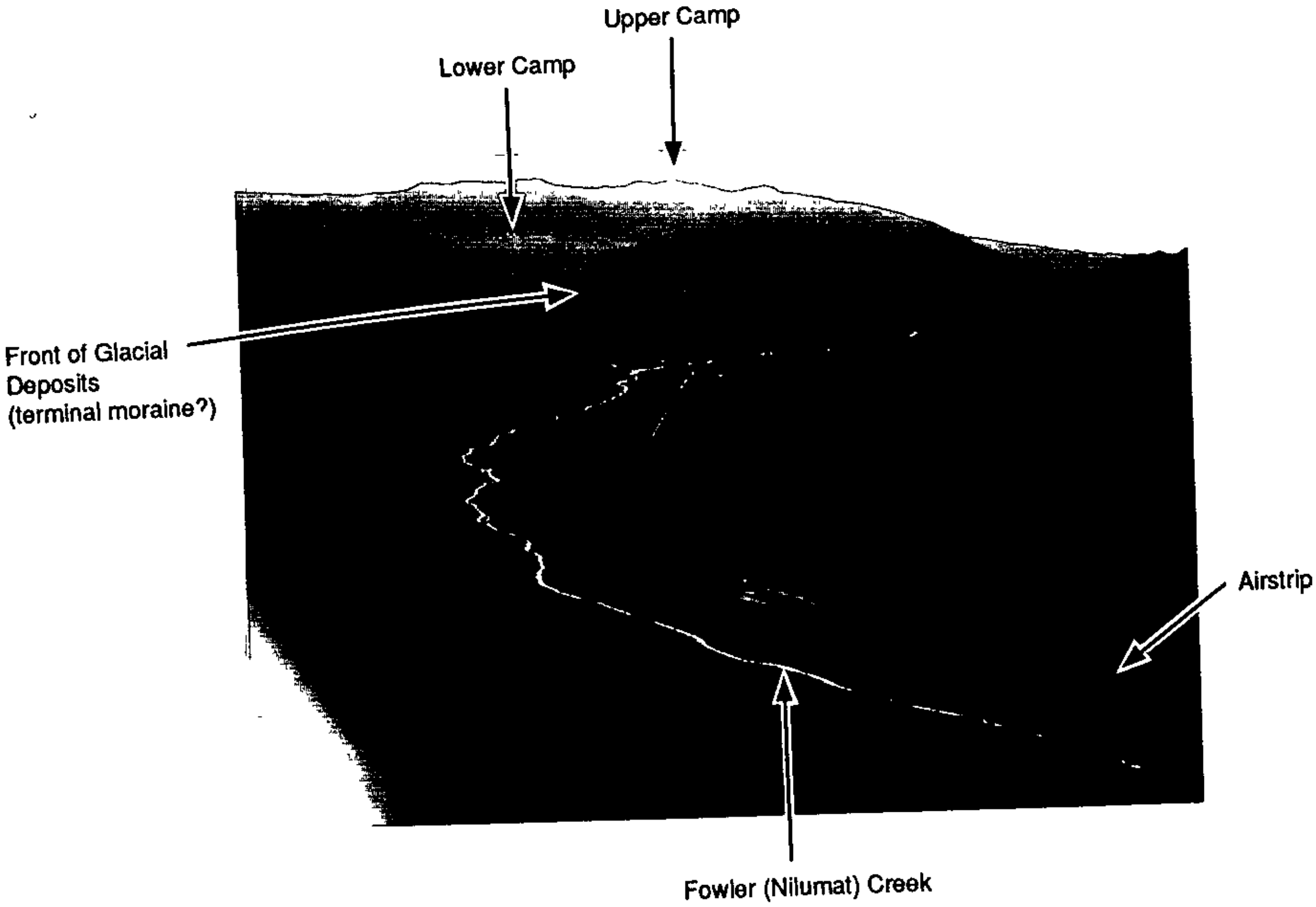


Source: U.S. Geological Survey Topographic Map, Hooper Bay (D-3) Quadrangle, Scale 1:63,360

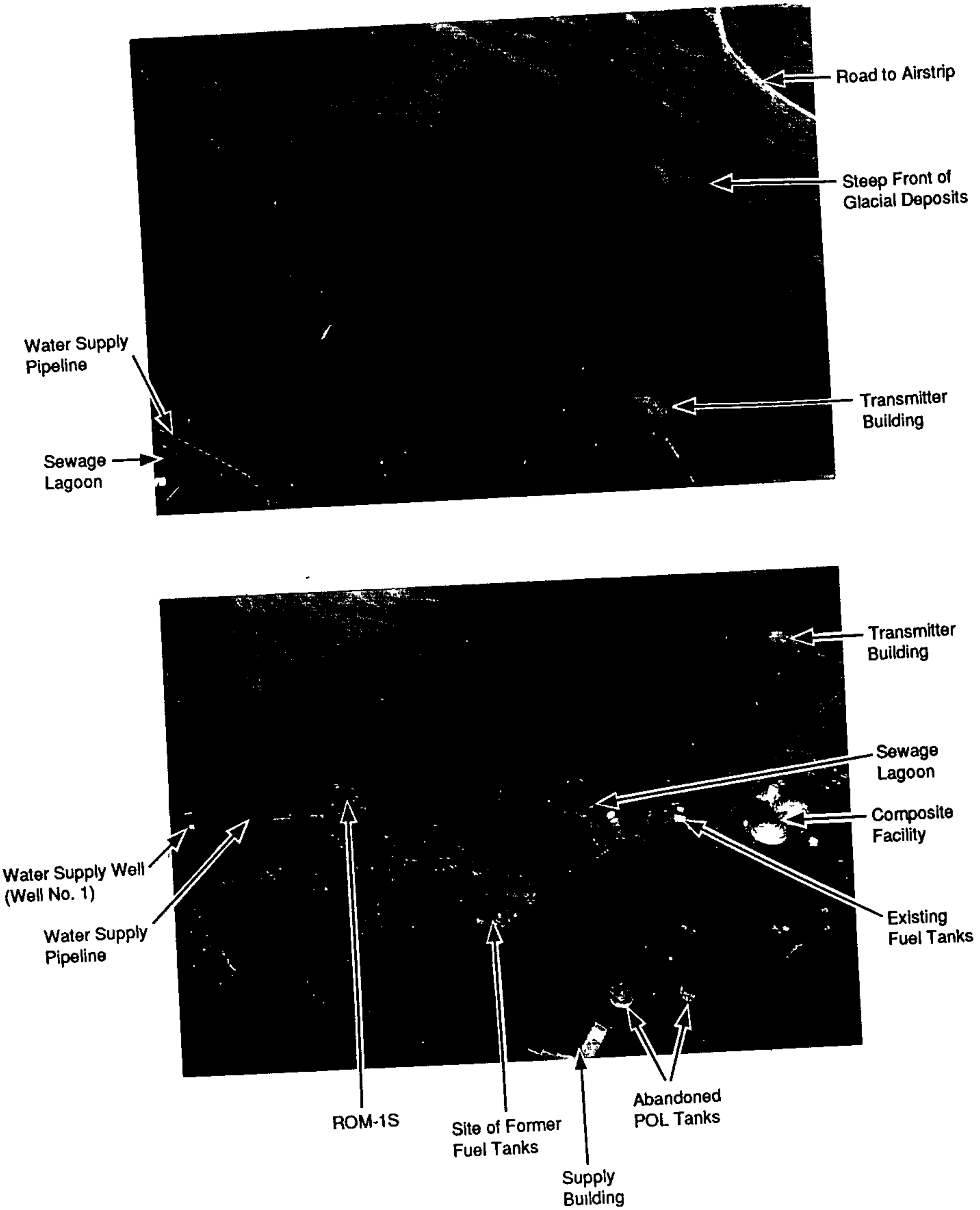


Project No. 90275L	Cape Romanzof LRRS	LOCATION AND PROBABLE EXTENT OF GLACIAL DEPOSITS, FOWLER CREEK VALLEY	Figure 2-1
Woodward-Clyde Consultants			

11 31



Project No. 90275L	Camp Romanzof LRRS	OBLIQUE AERIAL PHOTOGRAPH LOOKING UPSTREAM ALONG FOWLER CREEK, SHOWING GLACIAL DEPOSITS	Figure 2-2
Woodward-Clyde Consultants			



Project No. 90275L
Camp Romanzof LRRS
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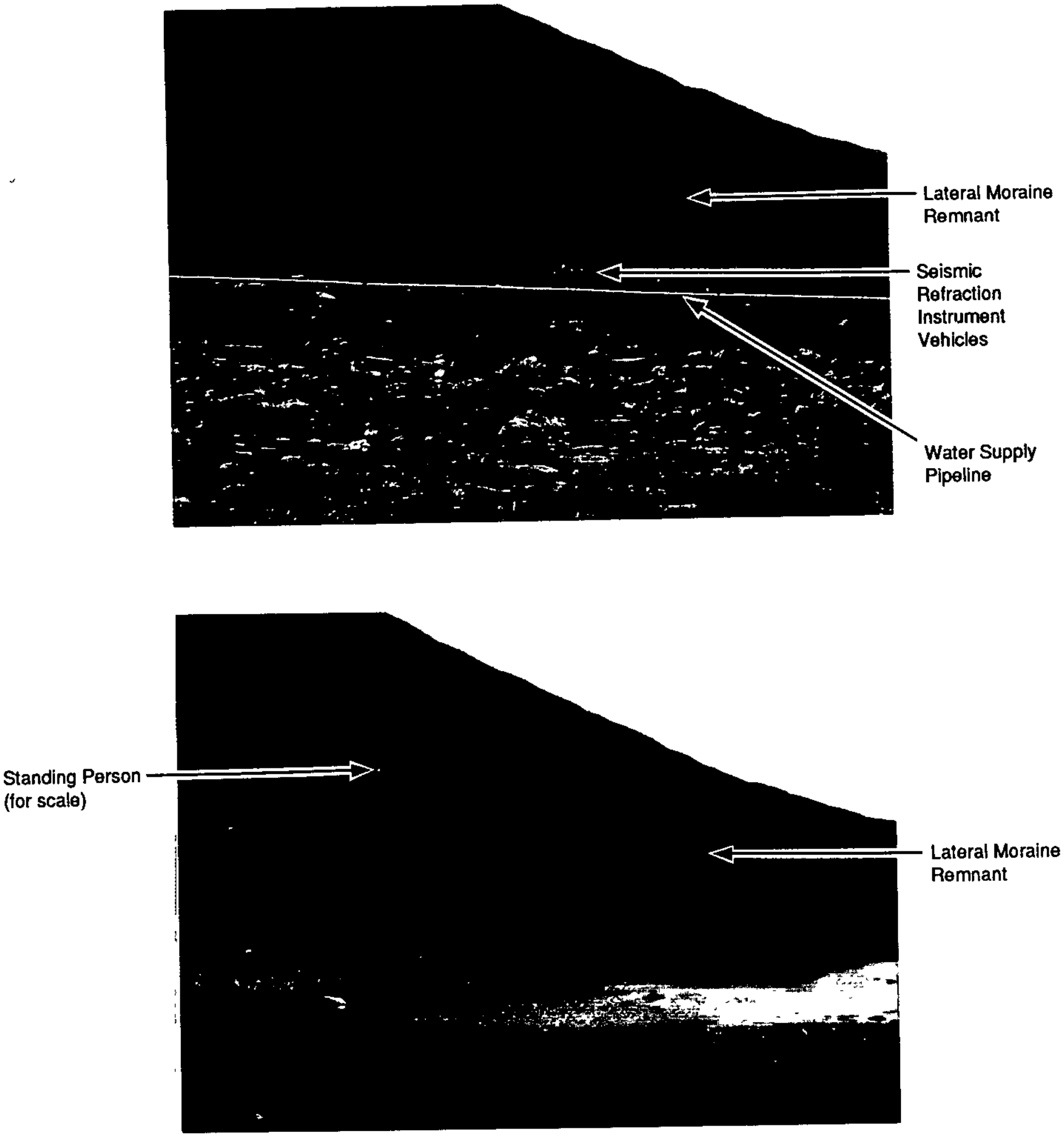
NEAR-VERTICAL AERIAL PHOTOGRAPHS, SHOWING DRAINAGE FEATURES ON GLACIAL DEPOSITS

Figure 2-3

11 - 33



Project No. 90275L	Camp Romanzof LRRS	GROUND-LEVEL PHOTOGRAPHS OF PROBABLE LATERAL MORAINE SOUTH MARGIN OF FOWLER CREEK VALLEY	Figure 2-4
Woodward-Clyde Consultants			

3.0
FIELD INVESTIGATION PROGRAM

3.1 FIELD INVESTIGATIONS AT EACH SITE

This section discusses field activities conducted in Summer 1990 at ROM-1S/Well No. 1, Lower Camp Area, ROM-2, and ROM-8. Section 3.2 discusses data quality objectives and Quality Assurance/Quality Control procedures.

The field work was done subject to an Addendum, dated July 24, 1990, to the original Cape Romanzof Health and Safety Plan, dated July 6, 1989. Further, the work was done under an Addendum, dated July 26, 1990, to the Final Quality Assurance Project Plan for Cape Romanzof AFS, dated March 1989.

Appendix C presents a summary of 1990 field sampling activities.

3.1.1 ROM-1S (Large Fuel Spill) and Well No. 1: Groundwater Monitoring and Well Plugging

Three wells, Well A, Well B, and Well No. 1 were sampled for chemical analysis. In addition, Wells A and B were grouted and abandoned. Locations of these wells are shown on Figure 3-1. Well No. 1 is the current base water supply well. Wells A and B were cased but open, unsealed wells discovered in the field reconnaissance of 1989. Groundwater from all three wells had been chemically analyzed in 1989 and found to contain levels of total petroleum hydrocarbons (TPH) and (in Well B) a pesticide, alpha-BHC, above detection limits. The 1990 sampling team collected groundwater samples from these three wells for analysis of TPH (EPA Method 418.1) and aromatic volatile organics (EPA Method 8020).

Wells A and B were purged of at least three casing volumes of groundwater by using a 3-inch submersible pump powered by a gas-powered generator. Water quality parameters were taken at intervals to ensure that formation water was being pumped. The groundwater was subsequently sampled. Samples were collected with a decontaminated Teflon bailer. The pump was left in the well during the sampling. Removal of the pump before sampling would have stirred up the sediment residing in the casing and caused the sample to be turbid and not representative of the true groundwater.

Well No. 1 was sampled in the following manner: A flow rate was established by pumping the well with the permanently installed pump and collecting and timing the discharge into a 55-gallon drum. Using an established flow rate of 45 gpm, three casing volumes were purged from the well using the existing pump. After inspecting the well head, it was found that the sampling bailer could not be lowered down the casing among the wires and pipes. Therefore, the sample for TPH and aromatic volatile organics analysis was taken through a faucet off the main discharge line within the pumphouse. This was the same faucet from which the 1989 sample had been collected. The well head was closed after the sample was collected.

Wells A and B were abandoned using a well plugging procedure prescribed by the Municipality of Anchorage in a municipality-wide well abandonment program conducted in 1990 (Municipality of Anchorage, 1989). This procedure consists of two steps: 1) filling the well with pea gravel to within 10 feet of ground surface, and 2) filling the remaining 10 feet to ground surface with concrete or neat cement. For the Cape Romanzof wells, this procedure was judged to be appropriate and prudent because these wells penetrate only one aquifer; and this aquifer seems to contain water in perched conditions, as described in Section 4.1.5. This abandonment procedure was discussed with ADEC.

After groundwater samples were collected from Wells A and B, the aboveground steel casing of Well A was cut off by torch. Wells A and B were then filled with pea gravel and concrete grout to or above ground surface. For Well A, concrete grout extended 2 feet above the casing cutoff level. For Well B, grout extended to the top of an enclosing concrete block, or to approximately 2.5 feet above ground surface.

3.1.2 Lower Camp Area: Aquifer Boundary Identification/Groundwater Resources

In 1989, a groundwater sample from Well No. 1 was found to contain TPH contamination of 2 milligram per liter (mg/l). Because concentrations of known toxic and known/suspected carcinogenic compounds (benzene, PAHs) were not found above detection limits from other analyses of this same sample, it was concluded that the TPH constituents present may be relatively nonhazardous (WCC 1990). Further investigations were recommended to better define the boundaries and extent of the aquifer, and to identify potential alternate locations for a new water supply well, should that option be selected by the U.S. Air Force.

The area defined to accomplish this work included ROM-1S, ROM-3 (including Well No. 1), and other areas, as shown on Figure 3-1. The investigation consisted of two separate geophysical surveys, as follows:

- downhole geophysical surveys (gamma ray logging) at well locations to define aquifer and aquitard-type materials

- surface-based seismic refraction survey to assist in delineating subsurface structure and aquifer extent.

Results of this work were then integrated with results of groundwater monitoring, presented in Section 4.1.2.

3.1.2.1 Downhole Geophysical Surveys. Natural gamma ray log surveys were planned for the three wells in this area, Well No. 1, Well A, and Well B. The planned log in Well No. 1 was intended to supplement the existing drilling log and to provide a possible calibration for logs of Wells A and B. However, after opening the well casing and examining Well No. 1, it was found that there was insufficient space to allow for lowering and raising of the gamma ray logging tool. Therefore the attempt to log Well No. 1 was abandoned.

Natural gamma logs were run in Wells A and B (Figure 3-1) to correlate strata between them and to decide whether they are likely to penetrate the same units. Both wells have 8-inch diameter casing. No lithologic logs were available. Gamma logging was chosen for these wells because it has the advantage of being able to sense lithologic information through casing. Clay minerals contain a higher concentration of radioactive elements than most other silicates, so the gamma log provides a qualitative indicator of clay content in materials within a given stratum. Clay-rich materials, such as shale, claystone, clayey soil, and some silts, will tend to have a relatively high gamma count. Materials with little clay, such as sand, sandstone, most gravels, and some silts, will tend to have a low gamma count. In a typical depositional sequence, therefore, aquifer materials (sand, gravel) usually have a lower gamma count than aquitard materials (clay, silt).

The gamma logs were run with a Mount Sopris, model 1000-C logger. The tool is equipped with a sodium iodide, thallium activated scintillation crystal and measures gross count, dead-time-corrected gamma radiation. The measurement units are counts per second (cps). A piece of flexible metal was taped to the logging sonde to keep the scintillator close to the borehole wall and prevent the tool from swinging back and forth. Distance from the sensor to the side of the hole was therefore kept reasonably constant. The zero-depth datum was ground level. Zero depth was set such that the counter would read zero with the sensor (scintillator) at ground level. Well B is located in a concrete enclosure that extends both below and above the ground surface; ground level was visually estimated as the ground level outside the enclosure. In both wells, space limitations made it impractical to log data shallower than 1.5 feet depth. Space limitations also limited the depth of the log to approximately one foot above the bottom of the hole. The tool was lowered into the hole with the gamma circuit on and the recording pen lifted above the chart. The scale was adjusted while the tool was lowered so that the maximum deflections would have optimum amplitudes without running the pen off the chart. The depths of major deviations were noted to check that the log repeated the same major deflections. The pen was then set and the log was run while pulling the tool out of the hole at a constant rate of 15 feet per minute. The vertical scale on the field logs was set at three feet per centimeter division. Both logs were run with the gamma scale set at 25 cps per division (cps/div). The log of Well B was repeated at 50 cps/div in an attempt to get maximum definition of anomalies on the chart.

3.1.2.2 Seismic Refraction Geophysical Survey. Three surface-based seismic refraction profiles were obtained within the Lower Camp/Fowler Creek area; locations of the profiles are shown on Figure 3-1. The purpose of this work was to obtain measurements useful to: 1) characterize subsurface layers in this area that may reflect and control groundwater occurrence and movement; and 2) assess the depths to these subsurface layers along Fowler Creek and at locations near the Composite Facility.

The seismic refraction technique is based on the measurement of the time required for a shock wave to travel from a sourcepoint (shotpoint) to one or more co-linear sensors (geophones). Measurements were obtained using an EG&G ES-1201F seismograph with twelve geophones. The source consisted of either explosive charges or multiple sledgehammer blows to a groundplate. Individual charges nominally consisted of 0.2 lbs of a binary explosive buried one to two feet deep, and initiated with a seismic-grade blasting cap. The rocky ground precluded the deeper placement of the charges. Up to four charges were fired together in order to obtain sufficient energy. The geophones were spaced at 25-foot or 50-foot intervals, and were in-line with the source. Shotpoints were nominally placed at the center of the line, at each end, and offset 140 feet or 275 feet from each end. In practice, two offsets were often used at some combination of these distances. Also, many of the center shotpoints were not used due to the site conditions described below. Line segments were generally overlapped to provide continuous profiles. The primary constraint on data quality was noise from intermittent high velocity winds. The seismograph and other associated instrumentation were transported across the tundra terrain using a 4-wheel All Terrain vehicle and trailer.

The seismic travel times were plotted on time-distance graphs (shown in Appendix A), and were interpreted using time-term methods. The resulting models represent the bedrock and soil depths and velocities which would account for the measured travel times. The models are non-unique, but appear to be the most reasonable interpretations based on the known geology.

3.1.3 ROM-8 (Landfill): Groundwater Monitoring

The four groundwater monitoring wells constructed in 1989 were inspected. Locations of these wells are shown on Figure 3-2. Three of the wells, MW-1, MW-2, and MW-4, had measured total depths about 1.5 feet shallower than recorded in 1989. Fragments of ice were retrieved during bailing, indicating some frozen groundwater in the well casings. The fourth well, MW-3, had a total depth of 9.75 feet, instead of the completion depth of about 18 feet. Less than 3 inches of water was present in the casing at 9.75 feet. The exposed part of the casing was tilted in an upslope direction, rather than being vertical as installed in 1989. Based on these observations, it was judged that either the lower part of the casing had rotated, or the upper part had moved downslope, causing a casing shear at 9.75-foot depth. The action was attributed to frost heave

11 40

processes, which could have 1) caused a boulder previously drilled through to shift or rotate and break the casing; or 2) caused general downslope processes to shear the casing below the base of the landfill. Sampling of groundwater at MW-3 was abandoned.

Groundwater sampling at MW-1, MW-2, and MW-4 followed the methods used in 1989. Three casing volumes were removed by manual bailing with clean dedicated Teflon bailers. Recharge was slow for Wells 1 and 4, and bailing continued over a two-day period. Once the wells had been purged, a sample each for TPH (EPA Method 418.1) and aromatic volatile organics analysis (EPA Method 8020) was collected from each of the three wells using the dedicated bailers. The wells were then closed and locked again.

3.1.4 ROM-2 (Weather Station): Groundwater Monitoring

The U.S. Army Corps of Engineers records indicate that two wells have been constructed at the Weather Station Building Area. One well, Well No. 2, was constructed in 1962 (U.S. Army Corps of Engineers 1963); and according to Feulner (1966) was contaminated with fuel oil in 1964. In late 1965, water treatment efforts at this well, using a charcoal filter, were underway (Feulner 1966). No evidence of this well was found during the field investigations of 1989 and 1990. The area around the Weather Station Building has been extensively reworked by heavy equipment and it is believed that Well No. 2 may have been buried or destroyed.

Well No. 3 was constructed in 1972 (U.S. Army Corps of Engineers, unpublished file data). This well was located in 1989, enclosed in a wooden well house. In 1990, the well was opened and sampled. A sketch map showing these wells is shown on Figure 3-3.

Well No. 3 was opened for sampling. The well was purged of three casing volumes with the 3-inch submersible pump and a sample was collected using a decontaminated Teflon bailer. The sample was analyzed for TPH (EPA Method 418.1) and aromatic volatile organics (EPA Method 8020).

3.2 QUALITY ASSURANCE/QUALITY CONTROL

3.2.1 Data Quality Objectives for Chemical Analyses

Data quality objectives for the Cape Romanzof LRRS RI/FS are discussed in the IRP Stage 1 Final Quality Assurance Project Plan (WCC 1989). Enseco Rocky Mountain Analytical Laboratory (RMAL) in Arvada, Colorado, provided analytical laboratory services for the Cape Romanzof LRRS RI/FS.

The purpose of QA/QC procedures is to produce data of known quality that meet or exceed the requirements of standard analytical methods, and satisfy the program requirements. The objectives of the quality assurance efforts for this program were twofold. First, they provided the mechanism for ongoing control and evaluation of measurement data quality throughout the course of the project. Second, quality control data were used to define data quality for the various measurement parameters in terms of precision and accuracy. Data quality objectives for the various measurement parameters associated with site characterization efforts are presented in Table 3-1 and are discussed below.

3.2.1.1 Precision and Accuracy. Rocky Mountain Analytical Laboratory's quality control (QC) program is based on the results of Laboratory Control Samples (LCS), which are well-characterized, laboratory-generated samples used to monitor the laboratory's day-to-day performance of routine analytical methods. Duplicate Control Samples (DCS) and Single Control Samples (SCS) are LCS which are used to monitor the precision and accuracy of the analytical process, independent of matrix effects. Method Blanks, which are also LCS, are used to identify any background interference or contamination of the analytical system which may lead to the reporting of elevated concentration levels or false positive data. The purpose of the LCS is to establish control limits. These limits are used to determine whether data generated by the laboratory on any given day are in control. The precision, accuracy, and percent recovery for environmental samples were calculated using the formulas presented in the IRP RI/FS Stage 1 Final Quality Assurance Project Plan (WCC 1989).

When RMAL prepares QC samples, these samples are labeled with a QC lot number. The QC lot number is associated with the date the sample was prepared. Samples analyzed concurrently by the same test are assigned the same QC lot number. Projects which contain numerous samples, analyzed over several days, may have multiple QC lot numbers associated with each test. The quality control information includes a listing of the QC lot numbers associated with each of the samples reported, DCS and SCS recoveries from the QC lots associated with the samples, and control limits for these lots. The QC data were reported by test code in the QA section.

Control limits for accuracy (percent recovery) were based on the average, historical percent recovery ±3 standard deviation units. These control limits were fairly narrow, based on the consistency of the matrix being monitored, and were updated on a quarterly basis.

For organic analyses, an additional control measure was taken in the form of an SCS. The SCS is a control sample spiked with surrogate standards which were analyzed with every analytical lot. The recovery of the SCS was charted in exactly the same manner as described for the LCS, and provides a daily check on the performance of the method.

The laboratory control sample and surrogate control sample reports were reviewed for the data report obtained from laboratory analysis of samples collected at Cape Romanzof LRRS. The accuracy (percent recovery) of LCS samples was within laboratory-established limits for all of the QC lots analyzed in the data report. The precision, which is measured by the relative percent difference (RPD) for the LCS samples, was within laboratory-established limits for all of the QC lots analyzed in the data report. Laboratory Control Samples were prepared and analyzed for aromatic volatile organics by gas chromatography (GC) and wet chemistry analysis (total petroleum hydrocarbons). SCSs were prepared and analyzed for volatile organics by GC.

Field blank results were used to assess the effect of field conditions on analytical data. One ambient condition (field) blank was collected and analyzed for aromatic volatile organics by GC. This sample was found to be free of contamination. It can be concluded that volatile organic analyses of analytical samples collected at Cape Romanzof LRRS were not contaminated or influenced by field conditions.

3.2.1.2 Completeness. Completeness is defined as a measure of the amount of valid data obtained from a measurement system compared with the amount that is expected to be obtained under normal conditions. The completeness of the analysis was documented by providing information that allowed the analyst to assess the quality of the results. Included in the data reports were an overview of the report, sample description information, analytical results, quality control reports, and a description of analytical methodology. Also included in the reports, if applicable, were second column laboratory work sheets. The objective for completeness of data capture was reached for all measurement parameters.

3.2.1.3 Representativeness. The representativeness of the data is the degree to which data delineate a characteristic of a population, parameter variations at a sampling point, or an environmental condition. All analytical data represented the sample analyzed. Duplicate samples were analyzed and provided a representation of parameters of interest at each specific location. Analytical methods were selected to provide the best available measurements of parameter concentrations.

3.2.1.4 Comparability. Comparability was expressed by the confidence with which one data set can be compared to another data set measuring the same property. RMAL used approved analytical methods which originate predominantly from regulatory agencies. Generally, the methods used were those specified by the EPA and other federal agencies. The laboratory quality control program at RMAL was designed to establish consistency in the performance of these methods by monitoring data quality with internal

QC checks. Internal QC checks included the use of surrogates in samples and matrix and method spikes. All are traceable to reference materials. All positive gas chromatographic results were confirmed by second column analysis by ENSECO. Both results were reported and the preferred value was identified by the laboratory on the data sheet. In addition, the laboratory participates in two separate performance evaluation programs, Environmental Research Associates (ERA) samples and EPA Certified Laboratory Program (CLP), in accordance with specified methods.

3.2.2 Field QA/QC Program

The field QA/QC program for the Cape Romanzof LRRS RI/FS, which included sampling procedures, sample custody, internal quality control checks, field calibration, and field preventive maintenance procedures, followed guidelines outlined in the IRP RI/FS Stage 1 Final Quality Assurance Project Plan (WCC 1989), with Addendum of July 26, 1990. A summary of field activities for each site is given in Section 3.1 and summarized in Appendix C. A summary of the field QA/QC validation is given in Section 4.5.

3.2.3 Laboratory QA/QC Program

The laboratory QA/QC program for the 1990 Cape Romanzof LRRS Field Program follows the same procedures as discussed in the IRP RI/FS Stage 1 Final Quality Assurance Project Plan (WCC 1989) with Addendum of July 26, 1990.

Calibration of instruments was routinely done to ensure that the analytical system was operating correctly and functioning at the proper sensitivity to meet established detection limits. The complexity of modern instruments has created the demand for tighter control so that malfunctions may be quickly detected and the quality of analytical results continually maintained. Each instrument was calibrated with standard solutions appropriate for the type of instrument and the linear range established for the analytical method. The frequency of calibration and the concentration of standards were determined by the manufacturer's guidelines and the analytical method.

To minimize downtime in the laboratory, preventive maintenance was routinely performed on each analytical instrument. Designated laboratory personnel were factory-trained in the routine maintenance procedures for every major instrumentation. When repairs were necessary, they were performed by either the in-house technicians/engineers or the instrument manufacturer under service contracts and warranties. The laboratory maintained detailed logbooks of preventive maintenance and repairs for each analytical instrument. Instrument performance was typically checked by monitoring instrument performance criteria for known standards.

3.2.4 QA/QC For Downhole Geophysical Survey

The Mount Sopris borehole logger and gamma probe were factory calibrated in July 1990. Batteries in the unit were charged the night before the logs were run. While lowering the tool into the borehole, the gamma circuit was turned on with the pen lifted above the chart. Deflections of the pen and the depths where they occurred were observed and the scale was adjusted to give the maximum defections without going off the chart. Subsequently, the log was run with the pen on the chart during the tool raising phase. This allowed a qualitative check of the log without needing to rely on a repeat of the log.

The chart drive is connected to the winch such that the chart moves up and down one centimeter for each three feet of cable. This allows multiple logs (e.g., SP, Resistance, Gamma, and different scale settings) to be run on the same section of chart for comparison. When repeated logs were run, the depth drive did not always return to zero. When this happened, the hysteresis was noted on the field log.

Table 3-1. ANALYTICAL OBJECTIVES FOR PRECISION, ACCURACY, COMPLETENESS, AND ESTIMATED DETECTION LIMITS, WATER ANALYSIS AT CAPE ROMANZOF LRRS

Parameter	Reference Method	Detection Limit**	Precision Objective*+	Accuracy Objective+	Completeness Objective+
Volatiles	SW8010/SW8020	0.1 to 9 µg/l	± 24%	60-130% spike recovery	90%
Total Petroleum Hydrocarbons	E418.1	1 mg/l	± 100%	50-150% spike recovery	90%

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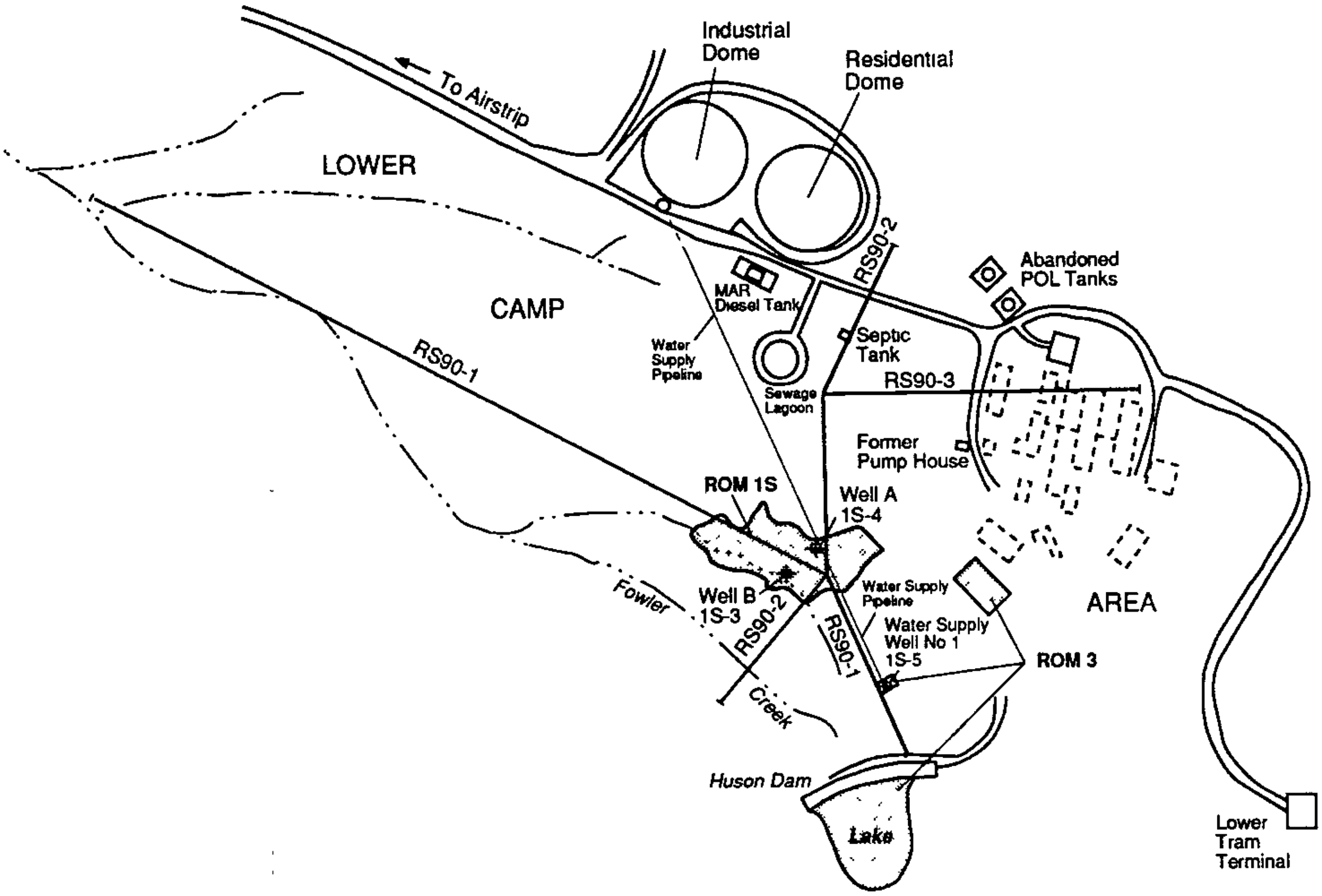
* As measured by relative percent difference of sample duplicates. Precision and accuracy objectives (limits) are not available for environmental samples. Rocky Mountain Analytical Laboratory (RMAL) does not maintain limits due to variability associated with these types of samples.

** Values provided for detection limits are based on actual data provided by the subcontract laboratory for routine sample types. These values are considered estimates, as actual detection limits achieved for specific samples will vary due to interferences or required dilutions. For methods containing multiple analytes, a range of values is given to account for different detection limits for individual analytes.

\+ Quality Control Acceptance Criteria established by RMAL.



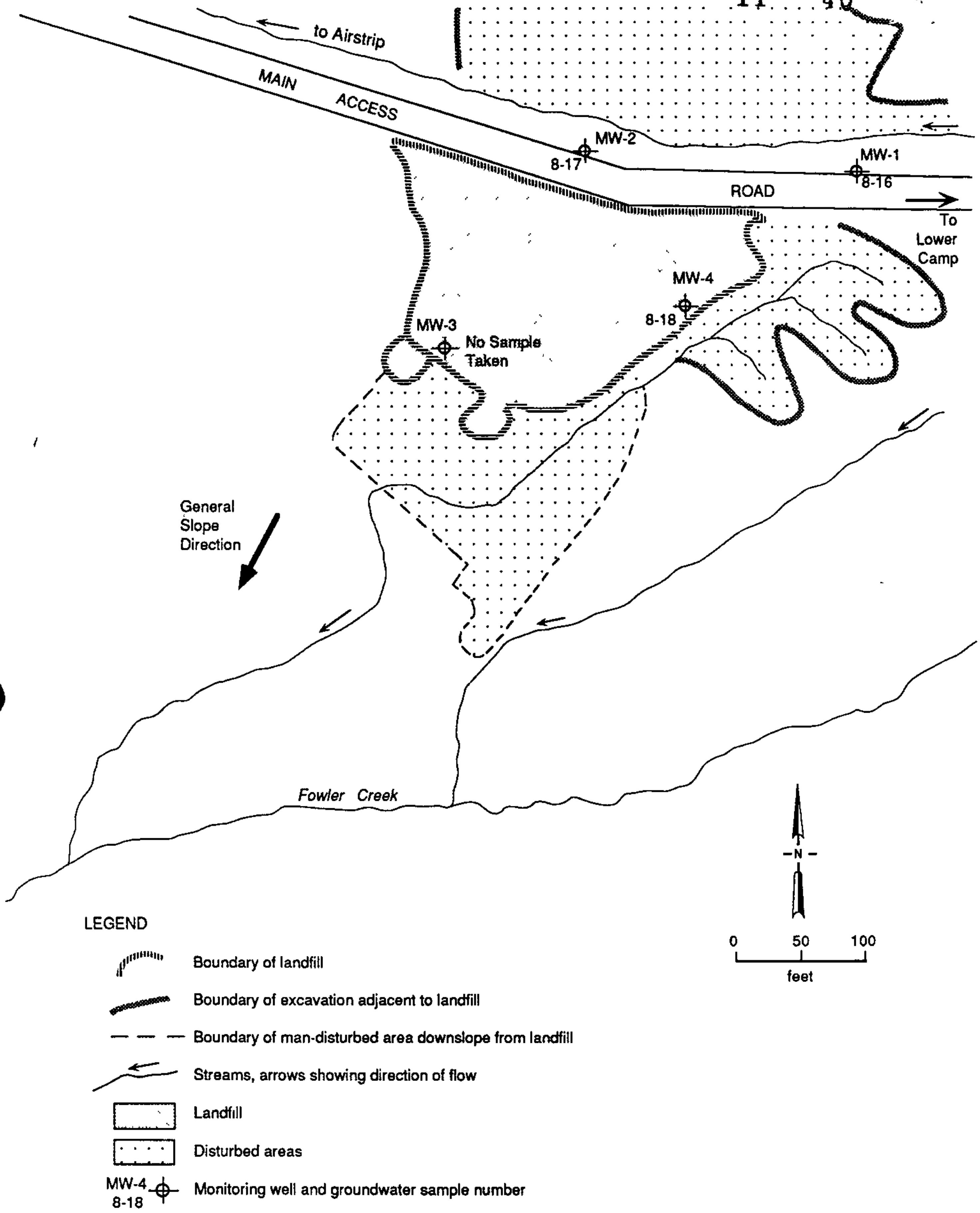
LEGEND

⬚	Demolished Buildings
▨	ROM Sites
Well A ⌖ 1S-4	Well Providing Groundwater Sample (1S-4= sample number) Well A, Well B, Well No. 1
⌖	Wells Having Downhole Geophysical Surveys (Wells A and B)
RS90-1 ├──┤	Location of Seismic Refraction Survey Line

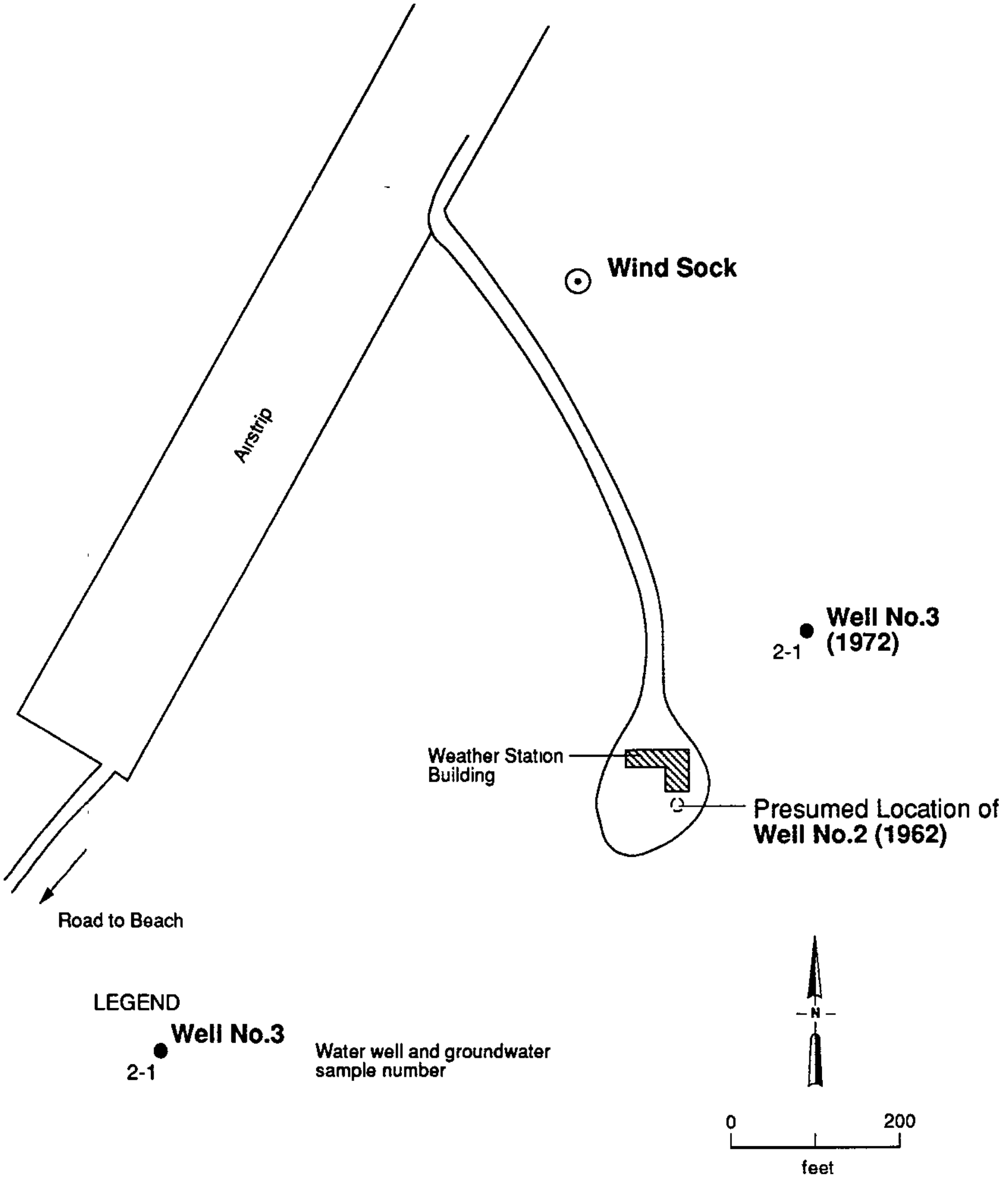
N

0 200 400
feet

Project No. 90275L	Cape Romanzof LRRS	WATER WELLS, GROUNDWATER SAMPLING LOCATIONS, AND GEOPHYSICAL SURVEYS AT ROM-1S AND THE LOWER CAMP AREA	Figure 3-1
Woodward-Clyde Consultants			



Project No. 90275L	Cape Romanzof LRRS	GROUNDWATER MONITORING WELLS AND SAMPLING LOCATIONS AT ROM-8 (LANDFILL)	Figure 3-2
Woodward-Clyde Consultants			



Project No. 90275L	Cape Romanzof LRRS	WELLS NO. 2 AND NO.3 AND GROUNDWATER SAMPLING LOCATION AT ROM-2 (WEATHER STATION)	Figure 3-3
Woodward-Clyde Consultants			

4.0

RESULTS AND SIGNIFICANCE OF FINDINGS

This section contains the results and significant findings of 1990 work at ROM-1S and Well No. 1 area, Lower Camp area, ROM-2 (Weather Station), and ROM-8 (Landfill). Sections 4.1 through 4.4 present data at the various sites. Section 4.5 presents QA/QC validation data and Section 4.6 discusses how the contaminant concentrations found at these sites compare with applicable cleanup standards. Section 4.6 also presents a risk screening analysis for ROM-1S/Well No. 1 area and ROM-2.

A summary of laboratory analysis results on 1990 samples is given in Appendix B. A copy of the laboratory report for these samples is provided in Appendix E. The laboratory results are summarized in Table 4-1.

The results and evaluations from the geophysical investigations are pertinent to both the ROM-1S/Well No. 1 area and the Lower Camp area. Most of the geophysical data and evaluations are presented in discussion of ROM-1S/Well No. 1 (Section 4.1).

4.1 ROM-1S -- LARGE FUEL SPILL/WELL NO. 1 AREA

4.1.1 Review of Available Data

A search for further information regarding Well No. 1 and Wells A and B in ROM-1S was conducted. Inquiries were made at the Anchorage office of the U.S. Army Corps of Engineers, USAF-11th Tactical Wing, U.S. Geological Survey - Water Resources Division, and Alaska Department of Natural Resources. Additional data regarding these three wells were found at the U.S. Geological Survey - Water Resources Division in Anchorage, Alaska.

For Well No. 1, a driller's log and data on well history, well construction, and well testing were found at the U.S. Geological Survey - Water Resources Division, in unpublished and undated data files. Water use and chemical analysis data were found in Feulner (1960, 1962, 1966).

For Wells A and B, reference to these wells as existing "abandoned" wells was found in the 1957 well testing data for Well No. 1. Therefore, these wells were drilled before the September 1957 testing of Well No. 1, and after 1953 when the Cape Romanzof operations started. No other information regarding these wells was found.

4.1.2 Groundwater Monitoring Analytical Results

Groundwater samples from Wells A and B (in ROM-1S) and Well No. 1 (in ROM-3) were analyzed for BTEX (using EPA Method 8020) and TPH (using EPA Method 418.1). Locations of wells are shown on Figure 4-1. Analytical results are shown on Figure 4-1 and in Table 4-1.

Regarding BTEX, none of the four major constituents (benzene, toluene, ethylbenzene, and xylenes) was found in concentrations above reporting limits in Well No. 1, Well A, or Well B. The reporting limits for these analytes ranged from 0.7 µg/l to 2.0 µg/l (see Table 4-1). An additional compound (1,4 dichlorobenzene) was found in the Well B sample in one of two analytical runs. On the first run, 1.9 µg/l of this compound was detected, while on the second column analysis, this analyte was not found above the reporting limit of 0.5 µg/l. According to the laboratory, the second column result is the preferred value (see Appendix B). In trip blanks and equipment blanks, concentrations of EPA Method 8020 analytes were all below reporting limits.

Regarding TPH, concentrations above the reporting limit of 0.05 mg/l were found in all groundwater samples. The highest value was 1.6 mg/l at Well B, followed by 0.3 mg/l at Well A and 0.23 mg/l at Well No. 1. A TPH concentration of 0.43 mg/l was also found in the equipment blank, as discussed in the QA/QC validation (Section 4.5). Because of this situation, the exact concentration values for TPH stated above and shown in Table 4-1 cannot be used for quantitative comparisons. Therefore, the TPH concentrations are used hereafter in this report (e.g. Figure 4-1) in the following qualitative terms:

Well B - less than 2.0 mg/l
Well A, Well No. 1 - less than 1.0 mg/l

4.1.3 Downhole Geophysical Surveys

The natural gamma log plots run in Wells A and B are shown in Figure 4-2. The plots show gamma ray counts increasing to the right. Tie lines are drawn between the two logs showing probable correlations. A large concrete block at the well head of Well B apparently extends four and a half feet below ground level, as indicated by the strong gamma minimum in the upper part of the log. This block also extends 2-1/2 feet above ground surface, enclosing the well casing. Both logs show relatively high gamma values in the upper twenty feet and relatively low values below a depth of 20 feet. Well B penetrates only the top five feet of the "low gamma" zone. In Well A, the gamma count continued to decrease and reached a minimum at a depth of about 29 feet. Gamma increased from 29 feet to about 40 feet, from where it fluctuated around higher values to the bottom of the log at 51 feet.

The two logs indicate that the wells penetrate the top of a layer with low clay content at a depth of approximately 20 feet. The bottom of the low-clay layer in Well A has a gradational character on the log, so its depth can only be identified as being approximately at 36 ± 3 feet. The "low gamma" layer probably has a relatively low clay content and can be interpreted as having higher permeability than the overlying and underlying layers. The general stratigraphy of the wells seems to consist of a more permeable zone between about 20 and 36-foot depth overlain and underlain by aquitards.

Limitations. Gamma counts are probabilistic and subject to statistical fluctuation. Repeated logs therefore do not provide identical traces; however, their general character should be the same. Interpretation of gamma logs is based on the general shape of the curves and differences in gamma intensity between strata. The absolute gamma count is therefore not important.

The gamma log alone does not provide porosity or permeability information, so complete interpretation should be done in conjunction with other information such as lithologic data from cores or cuttings. Borehole conditions, such as hole diameter, thickness of casing and sand pack, bentonite seals, and hole deviation may affect the character of the gamma logs, so they should be used only as a general overview of the wells.

4.1.4 Seismic Refraction Geophysical Survey

The interpreted seismic refraction profiles are shown on Figure 4-3. Profile elevations were obtained from the USAF Base Plan Map (scale: 1 inch = 400 feet). Three seismic layers are evident. The surficial layer has an average velocity of 2,800 feet per second (fps) and is typically 40 to 70 feet thick. The intermediate layer has a velocity of about 8,500 fps. The deep layer contains high velocity materials averaging 15,500 fps; the top of this layer is found typically at 180- to 250-foot depths. Some velocity deviations occurred on Profile RS90-3, where the deep layer velocity is 18,500 fps and a portion of the intermediate layer has a velocity of 6,000 fps. The latter could be an artifact related to the extensive reworking of the soils in this area which contains demolished former camp structures.

The only available borehole data which may be correlated with these results are from a driller's log of Well No. 1. This log is shown on Figure 4-4. The depth to weathered bedrock on this log closely matches the depth to the second (intermediate) seismic layer (57 feet on log versus 60 feet on seismic data). The depth to probable unweathered bedrock on this log does not correlate well with the depth to the high velocity layer (150 feet on log versus about 190 feet on seismic data). This difference may not be significant, however, due to the difficulty of identifying the base of weathering in terms of seismic velocity using normal borehole logging methods.

Based on these correlations, several conclusions can be drawn about the nature of the materials. Any water within the surficial layer (2,800 fps overall velocity) must be in thin perched zones, because the overall velocity is well below that expected in saturated materials. Furthermore, stratigraphic conditions within this surficial layer are probably quite variable both laterally and vertically, based on the presence in the raw data of multiple and often complex arrivals. Thus, local and discontinuous perched aquifers probably occur here.

The intermediate layer (8,500 fps overall velocity) could contain water under saturated conditions, because the overall velocity is greater than that of water. However, no inference based solely on these data can be made as to the depth or extent of any groundwater within this layer.

The layer thickness variations imply that the valley fill materials in the surficial seismic layer become somewhat thinner westward; however, the overall slope is still to the west due to the decrease in elevation. Minor thinning of the surficial layer occurs near the perimeter of the valley. Similarly, the fresh bedrock interface seems to rise toward the valley perimeter.

Limitations. Basic assumptions inherent in this geophysical method include the expectation that velocity increases downward, that layers are relatively continuous and thick enough to be individually resolved, and that significant velocity differences are present between the layers of interest. The generally accepted value for depth accuracy when these assumptions are satisfied is 20%.

Glacial deposits are one of the most problematic soil types for seismic investigation because one or more of the above assumptions is usually violated. In this case, evidence in the seismic data points to all of these assumptions being to some degree affected. For example, the presence of discontinuous localized boulder or block layers is inferred from multiple often-complex arrivals in the raw data. Such layers act as waveguides, and cause irregularities and errors in the depth calculations. As a result, the arrival times were based on low-frequency arrivals, and velocities were based on averaged values.

Another factor causing these multiple and complex arrivals is the probable occurrence of thin perched water zones, perhaps located within discontinuous porous strata above the continuously saturated zone. Also, the top of the continuously saturated zone (or phreatic surface) is usually associated with the top of a layer having seismic velocity greater than 5,000 fps. The top of this zone may not be readily apparent if it occurs in high-velocity materials.

For these reasons, minor variations evident in the results should be discounted, and correlation with borehole data should be made cautiously. Despite these limitations, the absolute depth accuracy is expected to be within 30%, and the relative depth accuracy should be better.

4.1.5 Evaluation and Significance of Findings

4.1.5.1 Hydrogeologic Framework. Based on the results of the geophysical surveys described above (Figures 4-2 and 4-3) and the known geologic and hydrogeologic data, it is concluded that the top of the phreatic zone occurs at approximately 60 feet (±18 feet) below ground surface in the ROM-1S/Well No. 1 area. Above that general level, water is believed to occur under perched conditions within lenticular and laterally discontinuous bodies of permeable material (sand/gravel) enclosed within relatively impermeable materials (clay, bouldery clay). Such complex stratigraphic conditions are typical in continental glacial deposits, and thus are to be expected in the ROM-1S/Well No. 1 area. Also, local evidence for this type of stratigraphic condition is provided by the seismic refraction data, in the form of multiple and complex arrivals on the seismic record (see Section 4.1.4). Therefore, the local geologic cross section in the ROM-1S/Well No. 1 area (Figure 4-5) was constructed showing a lack of correlation between the thin sandy water-bearing zone in Well No. 1 (43- to 46-foot depths) and the thicker interpreted permeable zone in Well A (20- to 36-foot depths).

Stratigraphic and water level relationships in Well No. 1 (shown on Figure 4-5) indicate that the upper, mostly clayey materials above 43-foot depth are acting as an aquitard which provides confining conditions within the underlying aquifer. Confining conditions in this well are shown by the piezometric level at 24-foot depth, which is 19 feet above the top of the aquifer. During drilling, the thin water-bearing sand at 43- to 46-foot depth reportedly produced 12-15 gpm during a bailer test (Figure 4-4).

Wells A and B (in ROM-1S), are apparently located within the clay-rich upper aquitard zone. Water levels in these wells were found at 22-foot and 21-foot depths within the one identified permeable zone (Figure 4-5). These water levels are near but below the top contact of this zone. This likely represents perched water present within this permeable zone, which seems to be both overlain and underlain by aquitard material.

A potential for local southwestward groundwater flow from Wells A and B toward Well No. 1 (opposite to the topographic gradient) was hypothesized in the Cape Romanzof Second Draft RI/FS Report (WCC 1990, Figure 4-2). No evidence for such a southwest flow has been identified after analysis of the geophysical data. First, Wells A and B are now believed to represent perched water conditions within the upper aquitard zone, and (by contrast) the deeper Well No. 1 is now believed to represent conditions in the underlying confined aquifer. Therefore water levels in these wells cannot be compared to identify a groundwater gradient within the confined aquifer. Second, no evidence of a possible subsurface bedrock sill was found downstream, which could have provided a ponding influence and promoted southeastward flow (see seismic refraction line RS90-1 on Figure 4-3). Therefore, based on all accumulated geologic, geophysical, and hydrologic data and assessments, and in the absence of a definitive set of water level data, it is judged that the general direction of groundwater flow in this area is probably northwestward following the topographic gradient of Fowler Creek.

4.1.5.2 Contamination Migration. Based on the hydrogeologic analysis, migration of ROM-1S contamination is expected to be downstream or northwesterly, and away from Well No. 1. Also it is unlikely that the current limited pumping of Well No. 1 (see Section 2.4) would result in reversing the inferred natural northwestward gradient and thereby pulling ROM-1S contamination towards Well No. 1. The interpreted phreatic surface (shown on seismic refraction profile RS90-1, Figure 4-3) is nearly flat in the ROM-1S/Well No. 1 area. This configuration may represent the base of the overlying aquitard layer rather than a gradient within the underlying confined aquifer. Since only one point is available that shows the piezometric surface for the confined aquifer, direction and magnitude of the gradient within the confined aquifer cannot be determined at this time.

A comparison of the chemical analysis results for the Summer 1989 investigation (WCC 1990) and the Summer 1990 investigation (Section 4.1.2) is consistent with an interpreted northwesterly gradient, away from Well No. 1. Well B showed a reduction from 4 mg/l TPH in 1989 to less than 2 mg/l TPH in 1990. Well No. 1 showed a reduction from 2 mg/l TPH in 1989 to less than 1 mg/l TPH in 1990. This suggests that a northwesterly gradient is moving contamination away from Well No. 1, and is reducing concentrations at both wells.

Based on the above discussion, a source for the TPH contamination in Well No. 1 is not likely to be downstream from that well. Therefore, the most likely source is ROM-3 (see Figure 3-1), where documented high levels of TPH soil contamination (2,400 mg/kg in soil) are located upslope and northeast of Well No. 1 (WCC 1990, Section 4.1.4.6, Sample 3-5).

4.2 LOWER CAMP AREA - GROUNDWATER RESOURCES AND CONTAMINATION EVALUATION

4.2.1 Groundwater Resources in Glaciated Granitoid Terrains - General

Groundwater production in this type of terrain is commonly obtained from either permeable glacial deposits (sand and gravel) or fractured granitoid bedrock. Weathered granitoid bedrock may also provide groundwater flow to wells if chemical weathering products such as clay have been removed from the material by groundwater percolation, and a disaggregated granitoid mass (called grus) remains in place. The development of grus is summarized by Birkeland (1984). In addition, small amounts of groundwater may be produced from granitoid colluvium, particularly at its basal contact with in-place granitoid materials.

Well yields in granitoid terrains can range from less than 10 gallons per minute (gpm) to as high as 90+ gpm (Le Grand 1954). Where such yields are related to fractured granitoid rocks, the fracture permeability is generally limited to a surficial zone within tens of meters of ground surface. Permeability is found to characteristically decrease with depth, due to the tendency of fractures to close with depth because of associated high confining pressures (Freeze and Cherry 1979). Well yields in granitoid terrains have also been found to vary systematically with topography; higher yields are found in valleys and lower yields are found on hills or ridges (LeGrand 1954).

4.2.2 Regional Hydrogeologic Data at Cape Romanzof

The hydrogeologic interpretation presented in Section 4.1.5.1 and shown on Figure 4-5 can be extended throughout the Lower Camp area to the full extent of the seismic refraction lines and beyond. Such an interpretation is illustrated in a regional cross section in Figure 4-6, which includes seismic refraction profile RS90-1 and a southeast projection to the top of Towak Mountain (near the abandoned White Alice site). The location of this cross section is shown on Figure 4-7.

On the seismic profile RS90-1, the upper velocity contrast boundary is interpreted to be related primarily to the top of the water-saturated zone. This boundary is generally parallel with the ground surface, except for a slight convergence to the northwest, toward the lowest part of the valley. Based on the confined hydrologic conditions apparent at Well No. 1 (discussed in Section 4.1.5.1), this boundary may also represent the base of the upper aquitard layer, below which confined water likely occurs in permeable glacial deposits, in weathered bedrock, and in fresh fractured bedrock.

The lower (deeper) velocity contrast, as discussed above in Section 4.1.4, is probably related to the base of weathered bedrock, in terms of overall rock mass velocity. Although this level may be deeper than a visual determination of "base of weathering" would indicate, the geometry of this lower velocity contrast provides a general structural form line that is likely parallel to other shallower geologic boundaries, such as base of glacial deposits. Therefore, using the driller's log for Well No. 1 and the deeper velocity contrast as a form line, a probable base of glacial deposits has been plotted on Figure 4-6. This plot suggests that a greater thickness of glacial deposits below the phreatic surface is present downstream from Well No. 1 than at this well.

Similar interpretations can be made along seismic profiles RS90-2 and RS90-3. This indicates that general conditions described above probably extend across most of Fowler Creek Valley.

4.2.3 Groundwater Occurrence and Apparent Yields at Cape Romanzof Wells

Three known wells have been drilled for water supply at Cape Romanzof LRRS. These are Well No. 1 at Lower Camp (see log and current piezometric level on Figure 4-4), and Wells No. 2 and 3 at the Weather Station, ROM-2 (see logs for both wells and current piezometric level for Well No. 3 only, on Figure 4-8). Insufficient data were found regarding the pumping tests in these wells to judge whether or not the reported pumping rates constituted true well yields. The apparent yields of these wells are significantly different, as are the saturated zone materials from which water is produced. A pumping test at Well No. 1 (following its completion in 1957) indicated an apparent yield of 60 to 67 gpm with an accompanying drawdown of 2 feet (U.S. Geological Survey-Water Resources Division unpublished file data). During the August 1990 purging of this well prior to groundwater sampling, a pumping rate of approximately 45 gpm was achieved. By contrast, pumping tests at Wells No. 2 and 3 (conducted immediately after their construction in 1962 and 1972, respectively) indicated apparent yields of less than 10 gpm (see discussion below).

4.2.3.1 Well No. 1 (Lower Camp). This well is producing from two zones within weathered bedrock, as indicated on the well log in Figure 4-4. This was the second attempt to construct a well at this location; the first attempt (July 1957) was abandoned at 71 feet (within the weathered bedrock zone). The second attempt for Well No. 1 was drilled to 154 feet total depth during August and September 1957. Apparent "fresh" granitoid rock was finally penetrated at 150 feet on September 18. Extremely difficult drilling was encountered within the weathered bedrock zone, requiring blasting with dynamite locally to advance the hole (see Figure 4-4).

The well was drilled using driven casing; 8-inch casing extends from near ground surface to 98 feet, and 6-inch casing extends from 98 to 154 feet. Water-bearing zones were identified in both the weathered bedrock and the overlying glacial deposits during drilling. Two of these zones (in weathered bedrock) were selected for casing perforation during well completion, as shown in Figure 4-4.

Static water level was found during drilling to be at 30-foot depth (when boring depth was 98 feet) and at 29-foot depth (when boring depth was 110 feet). After well completion, a pumping test was conducted for 25-1/2 hours (September 23 and 24, 1957). Pumping rates during this test varied from 60 to 67 gpm, and the accompanying drawdown was 2 feet. Immediately after the test (during which almost 100,000 gallons of water had been produced) the water level recovered to within 0.5 foot of the original level in 1 minute.

The thickness of weathered bedrock in Well No. 1 (93 feet, see Figure 4-4) seems unusually large, particularly when compared to the much smaller thickness in Well No. 2 (22 feet, see Figure 4-8). However, after inspection of the literature it was found that such a thickness variation and maximum thickness are often found in granitoid terrains in the western United Sates. Wahrhaftig (1965) found, in the southern Sierra Nevada of California, thicknesses of disintegrated granite (grus) varying from 10 feet to as much as 100 feet within distances of a few miles. Based on a recent survey of depth of weathering in granitic terrain in the western United States, significant thickness variations (such as at Cape Romanzof) are commonly found (D. Levich, personal communication, Colorado State University, September 1990).

4.2.3.2 Wells No. 2 and 3 (Weather Station). Well histories, well logs, and well construction diagrams were available for these wells from U.S. Army Corps of Engineers files. Well No. 2 was completed with 5.5 feet of screen set within weathered bedrock at the contact with "fresh" granitoid bedrock (see Figure 4-8). Static water level was found to be 9 feet above the top of screen, prior to a 4-day pumping test. During this test period, pumping rates ranged from an initial 14.5 gpm to a minimum of 2 gpm. On the last day of testing, it was found that a 3 gpm pumping rate (apparent yield) maintained the drawdown level at 90-foot depth (the top of screen). At some unknown time after this test period, static water level was found to be 4 feet above the top of screen.

Well No. 3 was apparently completed mostly within granitoid bedrock. The only water-bearing zone was reportedly a 1/2 foot thick interval at the contact between bedrock and overlying material. This material may be either colluvium or weathered bedrock. Casing was set at 76-foot depth (one foot above this interval) and an open hole was left from 76 feet to total depth at 92 feet. Static water level was found to be 16 feet above the base of casing, prior to a pumping test. During the test (of unknown length) an apparent yield of 5 gpm was achieved with an accompanying drawdown of 15 feet (to 1 foot above the base of casing).

4.2.3.3 Comparison of Wells No. 1, 2, and 3. Based on the above data, there is clearly a wide variation in apparent yields from the water-bearing zones in these wells. A very low apparent yield (less than 10 gpm) was obtained from mostly granitoidal bedrock in Well No. 3. Apparent yields from weathered bedrock in Well No. 1 and Well No. 2 are strikingly different from each other. Well No. 1 at Lower Camp produced 60 gpm; whereas Well No. 2 at the Weather Station produced less than 10 gpm.

No data are available for apparent yield from the glacial deposits, because no well had screens or perforated casing placed across these deposits. However, these water-bearing glacial deposits present in Well No. 1 were tested during drilling. A three-foot zone of such deposits was found to produce 12-15 gpm, or about two-thirds of the volume produced from a similar test of a 20-foot zone in the weathered bedrock (see Figure 4-4). This 20-foot zone of weathered bedrock produces most of the 60 gpm apparent yield in Well No. 1. This suggests that significant additional water production could have been obtained from the glacial deposit unit, had this interval been perforated in Well No. 1.

The variation in apparent yields between the two weathered bedrock sites may be partly a function of topographic location, as was noted above in Section 4.2.1. The higher yield location in the valley bottom (Well No. 1) has a much larger upgradient head and storage capacity than the lower yield side-hill location (Well No. 2).

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4.2.4 Evaluation and Significance of Findings

4.2.4.1 Possible Subsurface Aquifer Boundaries. Based on the well data and seismic refraction results, the aquifer at Well No. 1 seems to be located beneath an upper confining aquitard zone across most of Fowler Creek Valley. The top of this aquifer (based on seismic refraction data) is at depths of approximately 42 to 78 feet below ground surface. The base of the aquifer is likely located at some uncertain depth within granitoid bedrock (more than 150-foot depth at Well No. 1). The lateral extent of the aquifer is probably defined by the steep bedrock sidewalls of Fowler Creek Valley.

4.2.4.2 Aquifer Components. This aquifer is judged to be complex, being composed of several different materials in a vertical sequence, each of which probably has significant lateral variations in properties. At Well No. 1, the aquifer consists of the following from top to bottom: 1) 14 feet of glacial deposits, including an upper 3-foot thick water-bearing sand; 2) 93 feet of weathered granitoid bedrock, containing two water-bearing zones--one central 20-foot zone and one lower 2-foot zone; and 3) an unknown thickness of granitoid bedrock, likely containing groundwater in fractures.

The water-bearing glacial deposits are likely to be thickest in the central part of Fowler Creek Valley, where they probably occur as old stream channel deposits. Toward the valley sides and valley headwaters, these deposits are probably thinner than at Well No. 1, and they may be locally absent. Similarly, the weathered bedrock and its internal water-bearing zones are likely to be thickest in the central part of the valley.

4.2.4.3 Extent of Groundwater Resources. Based on the data and evaluations presented above, most of the groundwater resources seem to be contained within the central part of Fowler Creek Valley, in permeable glacial deposits and weathered bedrock, located beneath the upper aquitard zone. Well No. 1 is producing only from the weathered bedrock, although additional production is probably available from the overlying permeable glacial deposits.

According to the regional cross section along Fowler Creek Valley (Figure 4-6), similar or even greater thicknesses of glacial deposits may be found downstream from Well No. 1 in the central part of the valley. Southeastward from Well No. 1, and toward the steep valley sides, the total section of glacial deposits is expected to become thinner, and may even be partly truncated by the overlying clay-rich aquitard. Also, along the valley margins the top of the phreatic zone may pass down-section into weathered bedrock, below the glacial deposits, thus limiting the groundwater resource to water-bearing zones of uncertain extent within the weathered bedrock. Some perched water may be present in glacial deposits within the vadose zone (as at Wells A and B), but such local perched water probably does not provide a reliable groundwater source.

Subsurface conditions along seismic profiles RS90-2 and RS90-3 (see locations on Figure 3-1) should be similar to those along the eastern part of seismic profile RS90-1 (in the Well No. 1 - ROM-1S area). The north part of RS90-2 (near the Residential Dome) and the east part of RS90-3 are expected to be similar to the southeastern part of RS90-1 as discussed above--namely as the steep valley walls are approached, the permeable glacial deposits become thinner or absent, and the top of the phreatic zone may pass downward into weathered bedrock. Similarly, the water-bearing zones in the weathered bedrock may become thinner or absent near the valley sides.

The seismic refraction data on lines RS90-2 and RS90-3 do not indicate whether or not permeable glacial deposits or water-bearing zones in weathered bedrock occur within the saturated zone along RS90-2 or RS90-3. The presence of such deposits would have to be documented by drilling.

In summary, on the basis of available data, the area having the best chance of obtaining a moderate well yield similar to the present Well No. 1 is the central part of Fowler Creek Valley, downstream from Well No. 1. Chances for such a yield progressively decrease as the sidewalls or headwall of Fowler Creek Valley are approached.

4.2.4.4 Water Quality at Well No. 1. The following 1989 and 1990 analytical results from Well No. 1 regarding organic contaminants are summarized from discussions in Sections 4.1.2 and 4.1.5.2, and in WCC (1990):

TPH (418.1)	BTEX (8020)
1990 - less than 1 mg/l	1990 - below reporting limits
1989 - 2.0 mg/l	1989 - below reporting limits

The 1990 concentration of TPH (detected by Method 418.1) has decreased since 1989, while 1990 BTEX constituents (detected by Method 8020) remained at below-reporting-limit levels. It should be noted that the laboratory reporting limit for TPH was 1.0 mg/l for the 1989 data, and 0.05 mg/l for the 1990 data, as can be seen by comparing Appendix B of this report with Appendix B of WCC (1990).

Several inorganic water quality analyses of samples from this well were made from 1958 to 1965 (Feulner, 1966, 1962, 1960). All of these analyses showed very low levels of total dissolved solids (18-25 ppm), hardness as $CaCO_3$ (5-9 ppm), and iron (0.07-0.09 ppm). Feulner and others (1971) reported that the Cape Romanzof water sample had the lowest total dissolved solids value within the entire Yukon River subregion of Alaska.

4.2.4.5 Contamination Constraints. Existing known contamination sites provide constraints on the area where potentially usable groundwater resources may occur. As shown on Figure 3-1, the area of greatest resource potential is also downstream and downgradient from all of the known ROM contamination sites, plus the sewage lagoon and septic tank. Areas upgradient or mostly upgradient from the contamination sources have a groundwater resource significantly less than at the existing Well No. 1.

4.2.4.6 Potential Alternate Locations for Well No. 1. The areas upgradient from known contamination sources are most favorable for finding uncontaminated groundwater supplies. Potential locations within such areas that would also be reasonably close to water use points at the Composite Facility are: 1) northeast of the Residential Dome, or 2) east of the Residential Dome and east (upgradient) from the old POL tanks (see Figure 3-1). However, as stated in Section 4.2.4.4, these areas are likely to have a groundwater resource significantly less than the existing Well No. 1. The true extent of available groundwater at these potential locations and an assessed well yield could only be identified on the basis of further drilling.

4.3 ROM-2 -- WEATHER STATION

4.3.1 Review of Available Data

Further information regarding the existing water well at ROM-2 was located in U.S. Army Corps of Engineers files. Based on the U.S. Army Corps of Engineers records and the results of the 1989 field investigation, the existing well at ROM-2 was identified as Well No. 3. As described above in Section 3.1.4, no evidence of Well No. 2 was found during either the 1989 or 1990 investigations.

4.3.2 Groundwater Monitoring Analytical Results

A groundwater sample from Well No. 3 was analyzed for BTEX and TPH, as at the ROM-1S/Well No. 1 Area (see Table 4-1). The location of Well No. 3 is shown in Figure 3-3. Regarding BTEX, none of the four constituents were found at concentrations above reporting limits.

Regarding TPH, a concentration of 0.31 mg/l was detected, which is higher than the reporting limit of 0.05 mg/l. Because of the equipment blank contamination situation discussed in Section 4.5, this concentration is hereafter used in the qualitative form of "less than 1.0 mg/l."

4.3.3 Evaluation and Significance of Findings

Well No. 3 is located approximately 200 feet northeast of the weather station building and associated facilities, as shown in Figure 3-3. The well is also uphill from and up-groundwater gradient from any visible or known sources of contamination, such as the fuel tanks near the weather station building. Therefore the source of the less than 1.0 mg/l TPH concentration in Well No. 3 groundwater is uncertain; possible sources include inadvertent introduction of hydrocarbons into the well during operations, or naturally occurring hydrocarbons in groundwater. Considering the similar level of TPH contamination of the equipment blank, there may be no TPH contamination in Well No. 3 at all.

Use of groundwater from this well is reportedly confined at present to non-drinking purposes, namely for general washing and toilet operations at the weather station building.

4.4 ROM-8 (LANDFILL)

Groundwater samples from three of the four monitoring wells installed in 1989 were again taken in 1990 and analyzed for BTEX and TPH, as at ROM-1S/Well No. 1 area (see Table 4-1). The locations of these three wells (MW-1, MW-2, MW-4) are shown in Figure 3-2. No groundwater sample could be obtained from MW-3 due to deformation of the well casing, as described in Section 3.1.3.

4.4.1 Groundwater Monitoring Analytical Results

Regarding BTEX, all constituents were found at concentrations below reporting limits for Wells MW-1 and MW-2; these wells are located upgradient from the landfill. Well MW-4 is located within the landfill, near its eastern margin. In the MW-4 groundwater sample, concentrations of toluene, ethylbenzene and xylenes were found above the reporting limit. Two separate analyses, each consisting of two runs, were conducted on the MW-4 sample. The highest concentration (preferred result) was 9.2 µg/l toluene. In addition, a maximum of 5.2 µg/l of 1,4-dichlorobenzene (preferred result) was found in the MW-4 sample.

Regarding TPH, concentrations above the reporting limit were found in all wells, as at ROM-1S/Well No. 1 and at ROM-2. At ROM-8 these concentrations were 0.30 mg/l at MW-1, 0.26 mg/l at MW-2, and 0.39 mg/l and 0.48 mg/l at MW-4 (2 runs). Because of the equipment blank contamination situation discussed in Section 4.5, these concentrations at all ROM-8 wells are hereafter used in the qualitative form "less than 1.0 mg/l."

4.4.2 Evaluation and Significance of Findings

A comparison of the 1989 and 1990 analytical results from MW-1, MW-2, and MW-4 show that these data sets are similar. Regarding BTEX, both the 1989 and 1990 data show concentration below reporting limits for the upgradient wells (MW-1 and MW-2). Well MW-4 contained only xylenes above reporting limits in 1989, but contained xylenes, ethylbenzene, and toluene above reporting limits in 1990. The analyte 1,4-dichlorobenzene was found in 1989 at a concentration of 3.8 µg/l, and in 1990 at 5.2 µg/l.

Regarding TPH, the 1989 and 1990 results are also similar. For the upgradient wells MW-1 and MW-2, concentrations in 1989 were below the reporting limit (1.0 mg/l); and in 1990 the reported concentrations were positive values less than 1.0 mg/l, with some uncertainty due to apparent equipment blank contamination. These data are consistent because the reporting limit in 1989 was 1 mg/l, and in 1990 was changed to 0.05 mg/l. For MW-4, the concentration of TPH was 2 mg/l in 1989, and less than 1 mg/l in 1990.

4.5 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) VALIDATION

The Enseco Rocky Mountain Analytical Laboratory (RMAL) of Arvada, Colorado, performed the chemical analyses for the Cape Romanzof LRRS project. Appendix E contains all 1990 laboratory data for the project. The data validation consisted of a review of holding times, duplicate analysis, QC samples, blank review, and matrix spike review.

All samples were checked to see if they were analyzed within the required holding period. All samples were analyzed within their method-specific holding times. Two duplicate water samples were collected to estimate sample variability in laboratory results and for qualitative verification of a substance's presence or absence. Table 4-2 summarizes QA/QC data for the 1990 results. The relative percent difference (RPD) for sample ROM8-B-WG-N-018 ranged from 8% to 21% for analyses of total petroleum hydrocarbons and aromatic volatile organics. These RPDs were within ENSECO control limits for internal QA/QC samples. ENSECO does not maintain limits for matrix specific samples. RPDs could not be defined for the second duplicate sample, ROM1S-WF-N-005, because both primary and duplicate analyses were reported non-detected. Both duplicate sample results are considered acceptable.

Quality control samples were collected in the field during the sampling effort, to ensure that contamination from improperly cleaned field equipment, from ambient conditions or from transportation had not occurred. One ambient condition blank, one travel blank, and two equipment blanks were collected. Results of all analyses of blanks were reported as non-detect for both the 418.1 (TPH) and 8020 analyses, and considered free of contamination, except for one of the equipment blanks. One of the two equipment blanks collected for total petroleum hydrocarbons (TPH) analysis broke during shipment to the laboratory, so only one trip blank could be analyzed for TPH contamination. TPH was detected in the one equipment blank at a concentration of 0.43 mg/l, i.e., at a concentration similar to those reported in the samples. This equipment blank was collected after all sampling was completed, therefore it cannot be determined exactly at what sampling point decontamination of the equipment became insufficient. As a result, the TPH data cannot be used in a quantitative comparative analysis of the site; rather they are being used in a semi-quantitative comparison. All TPH detections below 1 mg/l are classified as less than 1 mg/l. These results should not be utilized for comparative purposes. This includes samples ROM1S-B-WG-N-003, ROM1S-WF-WP-N-005, ROM2-B-WG-N-001, ROM8-B-WG-N-016, ROM8-B-WG-N-017, ROM8-B-WG-N-018, and ROM8-B-WG-FR-018. TPH results greater than 1 mg/l but less than 2 mg/l, should be utilized as estimates of less than 2 mg/l. ROM1S-B-WG-N-004 is the only sample with TPH results between 1 mg/l and 2 mg/l.

In summary, the data were reviewed for holding times, QC samples, method blank results, spikes, and duplicate analyses. All samples were analyzed in the specified holding period; all method blanks were free of laboratory contamination; all spikes had acceptable recoveries; all QC samples were free of contamination, except for the one case mentioned above; and the duplicate results were good. The TPH results for the data set are of limited applicability due to the contamination reported in the last equipment blank collected; this should be considered when evaluating the contamination at the site.

4.6 SITE RISK SCREENING

This section considers application of the risk screening process (used previously in WCC 1990) to the three Cape Romanzof locations where additional or initial data were obtained in Summer 1990. These locations are:

ROM-1S/Well No. 1 Area (groundwater)
ROM-2
ROM-8

For ROM-8, this is the second screening, based on both 1989 and 1990 data. For ROM-2 and ROM-1S/Well No. 1 Area (groundwater), this is the first screening, based on 1990 data for ROM-2 and 1989 and 1990 data for ROM-1S/Well No. 1 Area.

4.6.1 Cleanup Standards

Designated cleanup standards, including EPA-defined ARARs (applicable or relevant and appropriate requirements) and TBC (to be considered criteria) have been discussed for the Cape Romanzof sites in WCC (1990). Because groundwater was the only medium tested during the 1990 work, only groundwater contamination regulations and guidelines are discussed in this section.

The contaminants analyzed in groundwater during the 1990 program and the analytical methods used are listed in Table 4-1. Contaminants found above reporting limits were toluene, ethylbenzene, xylenes, 1,4 dichlorobenzene, and TPH (total petroleum hydrocarbons). Federal and State of Alaska criteria relating to concentrations of these chemicals in groundwater are shown in Tables 4-3 and 4-4. Information from the most recent ADEC document "Interim Guidance for Surface and Groundwater Cleanup Levels" (dated September 26, 1990) is included in Table 4-4.

The ADEC Interim Guidance document states that, in general, groundwater should be cleaned up to levels not exceeding the final or proposed maximum contaminant levels (MCL) specified in the May 1989 Federal Register (see Table 4-3). These cleanup levels serve as general guidance until formally promulgated cleanup levels are established. The Guidance Document states that final cleanup levels shall be determined by the ADEC Regional Supervisor or his designee based on site-specific conditions.

In addition, the ADEC document states that for groundwater which is used as a drinking water source, secondary maximum contaminant levels (SMCLs) may be used. This guidance is pertinent at Cape Romanzof for both

Well No. 1 and ROM-2 (Well No. 3). The secondary contaminants contained in SMCLs are mainly related to the aesthetic qualities of drinking water, and in general provide guidelines for public water supplies. Such contaminants include both elemental constituents (e.g., iron, copper, and zinc) and compound, substance, or symptomatic constituents (e.g., sulphate, foaming agents, total dissolved solids, odor).

4.6.2 Contamination Concentration and Standards, By Site

ROM-1S/Well No. 1 Area--Groundwater samples were collected in 1989 and 1990 from wells in this area. BTEX constituents (benzene, toluene, ethylbenzene, and xylenes) were found in 1989 and 1990 at concentrations below reporting limits in all groundwater samples (see Table 4-1 for 1990 results). In 1990, the compound 1,4 dichlorobenzene was found in Well B (ROM-1S) at a concentration of 1.9 μg/l in one analysis, but in a second column analysis (preferred result) at less than the reporting limit (0.5 μg/l).

TPH (in 1990 sampling) was found in concentrations above the 1990 reporting limit (0.05 mg/l) in all samples collected, and also in the equipment blank (see Table 4-1). The maximum concentration was less than 2.0 mg/l at Well B (ROM-1S); other concentrations were less than 1.0 mg/l in Well No. 1 and Well A. In the 1989 sampling at these same wells, the maximum TPH concentration was 4.0 mg/l at Well B; other concentrations were 2.0 mg/l at Well No. 1, and ND (less than 1.0 mg/l) at Well A. Thus, the 1989 and 1980 results were similar, despite the change in reporting limit from 1.0 mg/l (in 1989) to 0.05 mg/l (in 1990).

The ROM-1S/Well No. 1 Area is subjected to the two-tier screening process because the 1989 analysis detected a concentration of the pesticide alpha-BHC in Well B that exceeded the federal Ambient Water Quality Criteria (AWQC). Pesticides were not tested for in 1990.

ROM-2--Groundwater samples from this site (Well No. 3) were collected only in 1990. The BTEX constituents were not detected in concentrations above reporting limits, while TPH was detected above the 1990 reporting limit but below the 1989 reporting limit; compare Table 4-1 of this report with Table B-1 in WCC (1990).

Because TPH concentrations have been found to exceed reporting limits (and thus State criteria--Table 4-4) this site is subjected to the two-tier screening process.

ROM-8--Groundwater samples were collected in 1989 and 1990 from wells at this site. Except for Well MW-4, BTEX constituents were not found at concentrations above reporting limits (see Table 4-1). At Well MW-4, maximum 1990 concentrations of 9.2 µg/l toluene, 1.3 µg/l ethylbenzene, and 6.1 µg/l xylenes were reported. In 1989, the only BTEX constituent found in Well MW-4 above reporting limits was xylenes at 6.7 µg/l. All of these concentrations are well below federal and state standards.

The compound 1,4 dichlorobenzene was found in MW-4 at a concentration of 5.2 µg/l in 1990. In 1989, this compound was found in MW-4 at 3.8 µg/l. These concentrations are well below the federal MCL level of 75 µg/l.

TPH (in 1990 sampling) was found in concentrations above the 1990 reporting limit in all samples. The maximum measured concentration was 0.48 mg/l at MW-4; other concentrations were 0.30 and 0.26 mg/l. Because of the equipment blank problem discussed earlier, all these values are considered as "less than 1.0 mg/l." Samples collected from these same wells in 1989 had TPH concentrations either similar to or higher than the 1990 concentrations, taking into account the higher 1989 reporting limit (1.0 mg/l).

ROM-8 has already been subjected to the two-tier screening process and a feasibility study (FS) in WCC (1990). The results of the 1990 analysis of groundwater confirm the 1989 results, for those compounds tested in both years. Therefore, no reapplication of the screening process, and no changes to the feasibility study and the remedial option selected in WCC (1990) for ROM-8 are judged to be needed. Thus, ROM-8 is not considered further in this report addendum.

4.6.3 Risk Screening

The two-tier hierarchical decision scheme that constitutes the risk screening process (described and used in WCC 1990) is applied to the ROM-1S/Well No. 1 Area (groundwater) and the ROM-2 site. Both of these locations involve wells that are or were intended to be drinking water sources; therefore secondary maximum contaminant levels (SMCLs) are also considered for those wells, as specified in ADEC (1990).

The risk screening process is summarized in the flow diagram on Figure 4-9, and is discussed in WCC (1990). The site contaminants considered in this screening process are TPHs and alpha-BHC for ROM-1S/Well No. 1 Area, and TPHs only for ROM-2.

4.6.3.1 Tier 1 Screening Results Both criteria were met for each site. Both sites are within 1 mile of Fowler Creek or the AFS living quarters; and contamination was found at both sites, as described above. Therefore, the screening process proceeds to Tier II.

4.6.3.2 Tier II Screening Results A summary of the Tier II Screening results is presented in Table 4-5. The ratings are subdivided for the ROM-1S/Well No. 1 Area, so that Well No. 1 can be evaluated separately from Wells A and B (in ROM-1S).

Exposure Potential. The first two of the three criteria under exposure potential, contaminant release and migration, are judged to be met at all three locations. The presence of contamination in groundwater suggests that release has occurred and migration in a down-gradient direction from the sites into Fowler Creek is possible; and thence into Kokechik Bay beyond the AFS. The third criterion, environmental persistence, is judged to be met only at Well B (ROM-1S), because of the presence in Well B of the pesticide alpha-BHC (see classification of this chemical in WCC 1990).

Toxicity Threshold. The exposure duration/frequency criterion is judged to be met at Well No. 1 and Well No. 3 (ROM-2). These wells are now available as water supply wells for station personnel, although Well No. 3 is currently not used for drinking water. At ROM-1S (former Wells A and B) this criterion is judged not to be met. Wells A and B are now plugged and abandoned, so that access to contaminated groundwater at ROM-1S would require drilling of a new well. Furthermore, these former wells likely tap a different (higher) aquifer than Well No. 1 (see Figure 4-5); and migration of contamination from these wells up-gradient to Well No. 1 is judged to be highly unlikely. In addition, although down-gradient release of existing TPH and alpha-BHC groundwater contamination into Fowler Creek is possible, two downstream surface water samples in Fowler Creek near ROM-8 (see WCC 1990) had non-detect levels of these compounds. Thus, if such contamination is reaching Fowler Creek, it is being diluted to levels below reporting limits.

The exceedance of standards or criteria is judged to be met only at Wells A and B (ROM-1S), where TPH has been found above 1989 reporting limits (State standard) and alpha-BHC has been found above Federal MCL levels. For Well No. 1 and for Well No. 3 at ROM-2 (both of which are drinking water sources), federal MCLs were not exceeded, and state standards were not exceeded if the 1989 TPH reporting limit is used. Therefore, secondary maximum contaminant levels (SMCLs) specified in 18 AAC 80.070(b) were used as alternative cleanup levels, as described below.

Water quality analyses of groundwater samples from Well No. 1 have been made at various times since the well was constructed in 1957. The most recent known analysis prior to IRP work was conducted on a sample collected on September 13, 1965 (Feulner 1966). Results of this analysis were similar to the three previous analyses (in 1961, 1958, and 1957--see Feulner 1960, 1962). Results of the 1965 analysis are shown in Table 4-6. Concentrations of copper and zinc for Well No. 1 sample shown in Table 4-5 are provided from analyses of samples collected by WCC in August/September 1989 and reported in WCC (1990). Also shown on Table 4-6 are the State of Alaska SMCLs. It is evident that the concentrations in Well No. 1 were significantly lower than maximum concentrations in the specified SMCLs, for all analytes tested in 1965 and 1989.

The water quality data in Table 4-6 related to SMCLs are incomplete (no data for corrosivity or foaming agents) and were taken from two sampling events widely separated in time (1965 and 1989). Therefore, it seems prudent to collect an additional groundwater sample from Well No. 1 and analyze it at one time for all SMCL parameters. In the expected event that the analyses show concentrations or numbers below or within specified SMCL levels, Well No. 1 may be considered to have met the SMCL target cleanup levels; and thus no exceedence of standards will be present for this well. This expected condition (pending resampling) is shown in the Summary of Tier II Screening Results (Table 4-5).

For Well No. 3 (ROM-2), there are no water quality data comparable to those at Well No. 1. However, based on the general observations and evaluations presented in Section 4.3.3, it is judged that SMCLs would not be exceeded at this well. To confirm this, an additional groundwater sample would need to be collected and analyzed, as at Well No. 1. This expected condition (pending resampling) is presumed in Table 4-5.

Regarding the acute toxicity criterion, none of the contaminants considered are considered to be highly toxic to humans (as discussed in WCC 1990). Therefore, this criterion is not met at any of the subject locations.

4.6.4 Summary of Risk Screening

Both of the screened locations (ROM-1S/Well No. 1 Area and ROM-2) met the Tier I criteria, and thus proceeded to Tier II. As shown on Table 4-5, after consideration of Tier II criteria, both locations and each part of the ROM-1S/Well No. 1 Area had an estimated risk judged to be "not significant." This risk rating was made pending confirmation sampling and analysis of Wells Nos. 1 and 3 showing results that meet Alaska SMCLs, as shown on Table 4-6.

As discussed in WCC (1990), this risk screening process is qualitative, and may result in underestimation or overestimation of actual risk. As a further check on the "not significant" risk ratings, additional analysis for SMCLs are recommended in the cases of Wells Nos. 1 and 3.

Also for ROM-1S, the presence of an environmentally persistent chemical (alpha-BHC) at a concentration 10 times above the federal MCL, along with low TPH concentrations, is of potential concern. However, slow migration and subsequent dilution apparently reduce any ROM-1S groundwater contaminant concentrations to below reporting limits by the time they reach surface water downstream locations in Fowler Creek.

4.6.5 Site Categorization

Based on the two-tiered screening evaluation, the two locations considered (ROM-1S/Well No. 1 Area and ROM-2) are found to have insignificant risk. This risk rating is made pending confirmatory sampling and testing of groundwater at Well No. 1 and Well No. 3 (ROM-2), as described above. Therefore, pending results of this additional sampling, these locations are recommended for no further remedial action, and are tentatively identified as Category 1 sites.

4.7 IDENTIFICATION OF SITE CLASSIFICATIONS

On the basis of the results and evaluations presented in this Section 4.0, the sites are classified in regard to further IRP actions as follows:

- Site requiring no further remedial action: ROM-1S (Wells A and B)
- Sites requiring confirmation sampling and testing especially for SMCLs prior to expected classification as sites requiring no further action:

  - Well No. 1
  - ROM-2 (Well No. 3)

- Site where contamination was confirmed in 1990, and earlier (WCC 1990) feasibility study is applicable: ROM-8 (Landfill)

Table 4-1. CONCENTRATIONS OF CHEMICALS IDENTIFIED IN GROUNDWATER SAMPLES FROM THREE LOCATIONS AT CAPE ROMANZOF LRRS IN 1990

	EPA Method 8020 (μg/l)					EPA Method 418.1 (mg/l)
Location	Benzene	Toluene	Ethylbenzene	Xylene	1,4 Dichlorobenzene	TPH
<u>ROM-1S/Well No. 1 Area</u>						
Well A	ND	ND	ND	ND	ND	0.3
Well B	ND	ND	ND	ND	ND	1.6
Well No. 1	ND	ND	ND	ND	ND	0.23
<u>ROM-2</u>						
Well No. 3	ND	ND	ND	ND	ND	0.31
<u>ROM-8</u>						
MW-1	ND	ND	ND	ND	ND	0.30
MW-2	ND	ND	ND	ND	ND	0.26
MW-4	ND	7.6	1.2	5.0	4.2	0.39
MW-4	ND	9.2	1.3	6.1	5.2	0.48
Trip Blank	ND	ND	ND	ND	ND	
Ambient Blank	ND	ND	ND	ND	ND	
Equipment Blank (Aug. 9, 1990)	ND	ND	ND	ND	ND	
Equipment Blank (Aug. 10, 1990)						0.43
Reporting Limit	0.7	1.0	1.0	2.0	0.5	0.05

ND = Not Detected above reporting limit.

Table 4-2. SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL DATA FOR CAPE ROMANZOF LRRS

Sample Number	Total Petroleum Hydrocarbons Method E418.1 (mg/l)	Aromatic Volatile Organics Method SW 8020			
		Toluene µg/l	Ethyl-benzene µg/l	Xylenes (total) µg/l	1,4-Dichloro-benzene µg/l
ROM1S-WF-WP-N-005		ND	ND	ND	ND
ROM1S-WF-WP-FR-005		ND	ND	ND	ND
Relative Percent Difference		--	--	--	--
ROM8-B-WG-N-018	0.39	7.6	1.2	5.0	4.2
ROM8-B-WG-FR-018	0.48	9.2	1.3	6.1	5.2
Relative Percent Difference	20.7%	19.0%	8.0%	19.8%	21.3%

Samples collected by WCC during Summer 1990 and analyzed by RMAL.

ND = Not Detected.

Table 4-3. FEDERAL REGULATIONS AND GUIDELINES FOR CONTAMINANTS IN WATER

Contaminant	Federal (EPA) MCLs (May 22, 1989 Federal Register p.22064) (μg/l)	Federal Ambient Water Quality Criteria - 1986 (EPA 440/5-86-001) (μg/l)
Toluene	2,000 (p)	14,300
Ethylbenzene	700 (p)	1,400
Xylenes (total)	10,000 (p)	NE
1,4 Dichlorobenzene	75 (f)*	400
Total Petroleum Hydrocarbons (TPH)	NE	NE
alpha-BHC	NE	0.0092

(p) = proposed MCL

(f) = final MCL

NE = Not Established

* = From 52 Federal Register 25712, July 8, 1987

Table 4-4. STATE OF ALASKA REGULATIONS AND GUIDELINES FOR CONTAMINANTS IN WATER

Contaminant	State Drinking Water MCLs - 1989 (18 AAC 80.070) (µg/l)	State Water Quality Standard Regulations for Drinking/ Culinary, and Food Processing (18 AAC 70.020) (µg/l)	ADEC (1990) Interim Guidance for Surface and Groundwater Cleanup Levels (9/26/90) (µg/l)
Toluene	NE	Note 1	2,000
Ethylbenzene	NE	Note 1	700
Xylenes (total)	NE	Note 1	10,000
1,4 Dichlorobenzene	75	Note 1	75
Total Petroleum Hydrocarbons (TPH)	NE	Note 2	Note 3
alpha-BHC	NE	Note 1	NE

NE = Not established

Note 1 Substances shall not exceed Alaska Drinking Water Standards (18 AAC 80 - this table) or Federal Ambient Water Quality Criteria - 1986 (see Table 4-3).

Note 2 Shall not cause a visible sheen upon the surface of the water. Shall not exceed concentrations which individually or in combination impact odor or taste as determined by organoleptic tests.

Note 3 For groundwater used as a drinking water source... "final or proposed secondary maximum contaminant levels (SMCLs) may be used as cleanup target levels." For groundwater, TPH... "should be cleaned up to non-detectable levels as measured by EPA Method 418.1."

Table 4-5. SUMMARY OF TIER II SCREENING RESULTS, CAPE ROMANZOF LRRS

	ROM-1S/Well No. 1 Area		ROM-2
Criterion	ROM-1S (Wells A & B)	Well No. 1	Well No. 3
<u>Exposure Potential</u>			
Contaminant Release from Site	X	X	X
Contaminant Migration from Station	X	X	X
Environmental Persistence	X (Well B only)	--	--
<u>Toxicity Threshold</u>			
Exposure Duration/ Frequency	--	X	X
Standard or Criterion Exceeded	X	--*	--*
Acute Toxicity	--	--	--
<u>Estimated Risk</u>	Not Significant	Not Significant	Not Significant

X = criterion is met

-- = criterion is not met

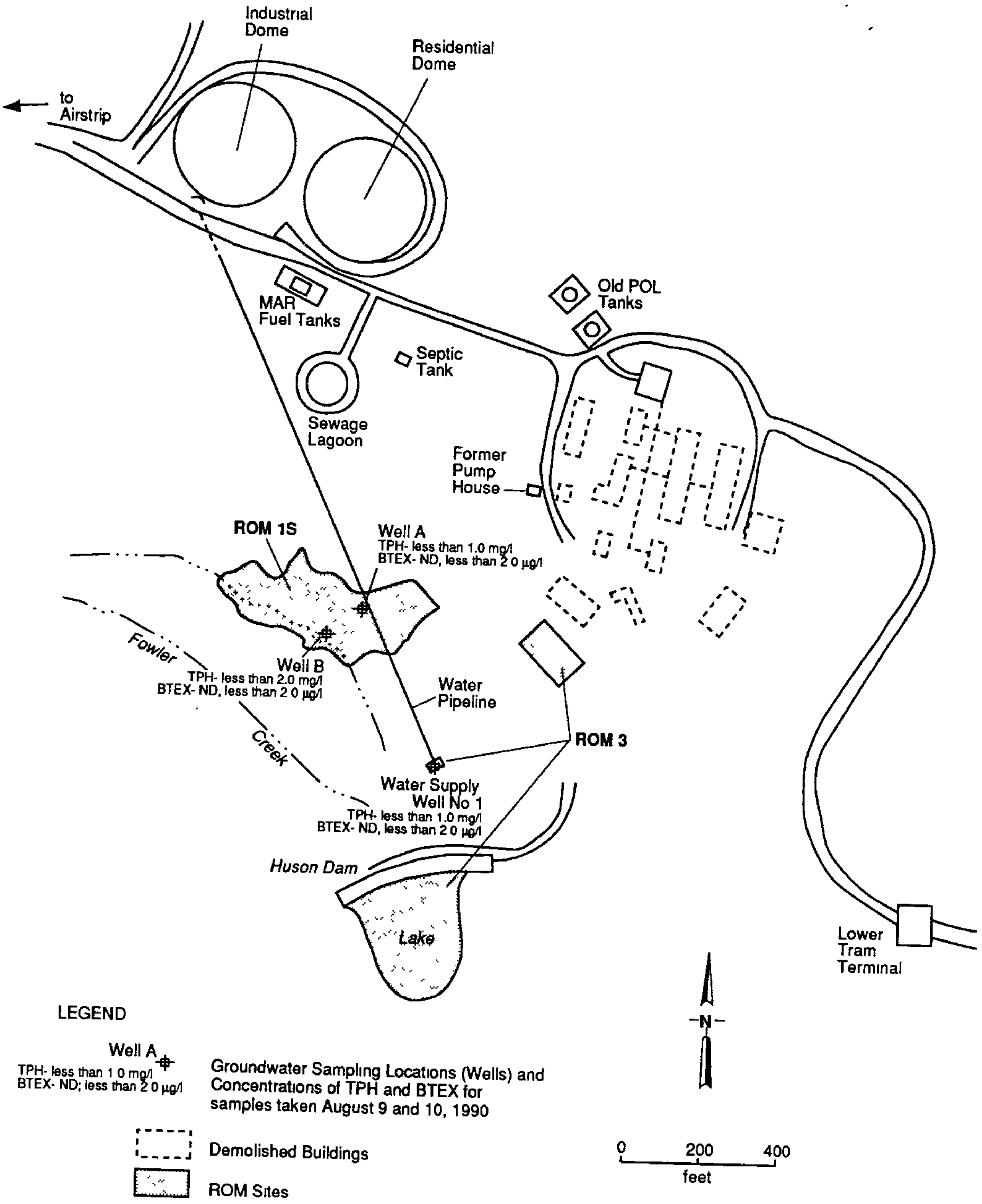
* = Pending resampling of Wells No. 1 and 3 and analysis for SMCLs

Table 4-6. WATER QUALITY ANALYSES OF GROUNDWATER AT WELL NO. 1, AND ALASKA SECONDARY MAXIMUM CONTAMINANT LEVELS

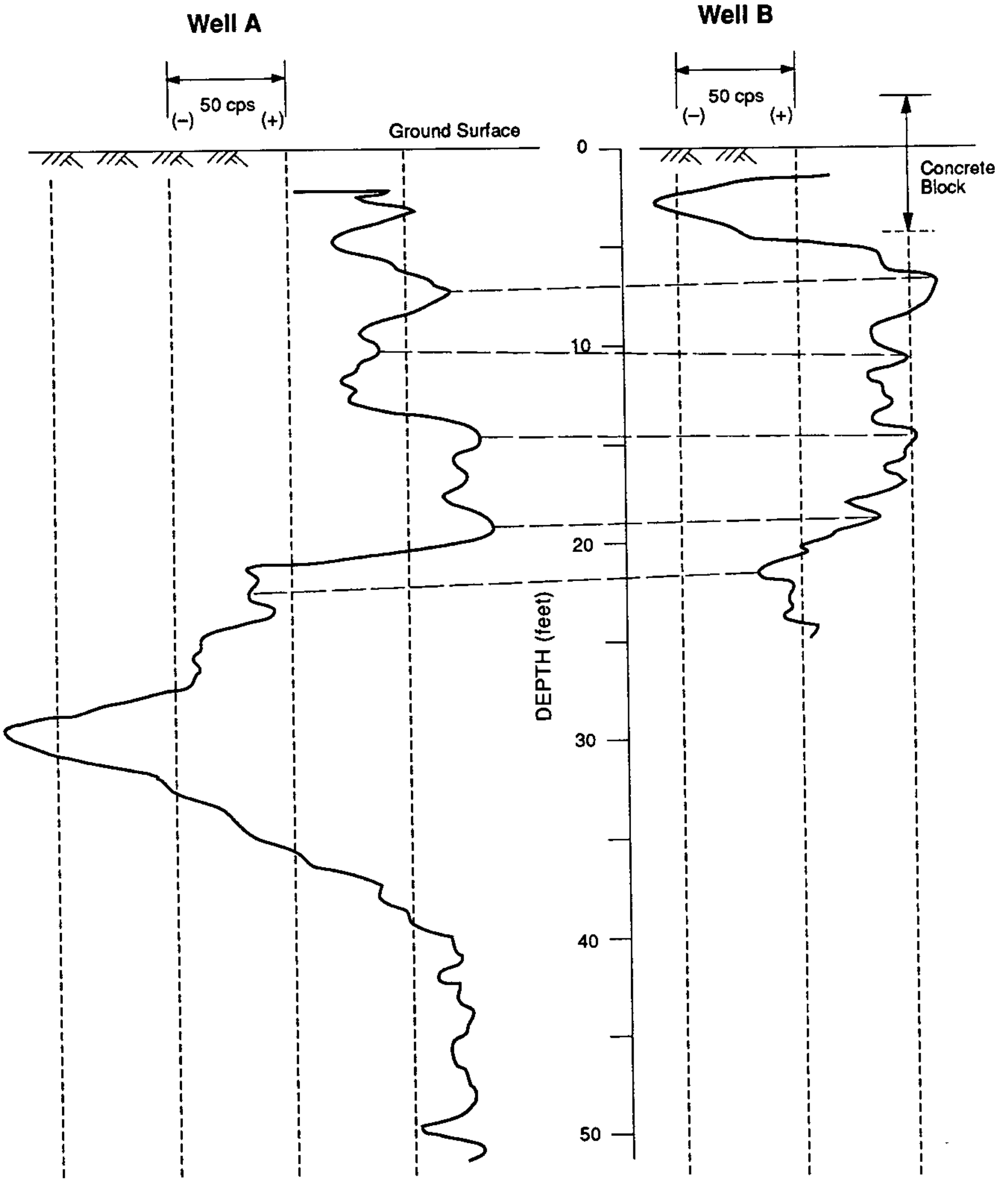
Analyte	Well No. 1 Analysis Aug/Sept 1989 (WCC 1990)	Well No. 1 Analysis (9/13/65) (Feulner 1966)	Alaska SMCLs (18 AAC 80.070(b))
Chloride		6.0 ppm	250 mg/l
Color		10 units	15 units
Copper	less than 0.3 mg/l	NA	1 mg/l
Corrosivity		NA	Noncorrosive
Fluoride		0.0 ppm	2.0 mg/l
Foaming Agents		NA	0.5 mg/l
Iron	0.09 ppm	0.09 ppm	0.3 mg/l
Manganese	less than 0.01 ppm	0.0 ppm	0.05 mg/l
Odor	No noticeable odor	NA	3 threshold odor no.
pH		6.6	6.5-8.5
Sodium		3.4 ppm	250 mg/l
Sulphate		0.0 ppm	250 mg/l
Total Dissolved Solids		22 ppm	500 mg/l
Zinc	0.03 mg/l	NA	5 mg/l

NA = Not Analyzed

SMCLs = Secondary Maximum Contaminant Levels



Project No. 90275L	Cape Romanzof LRRS	ROM 1S AND ROM 3 GROUNDWATER SAMPLING LOCATIONS AND ANALYTICAL RESULTS	Figure 4-1
Woodward-Clyde Consultants			



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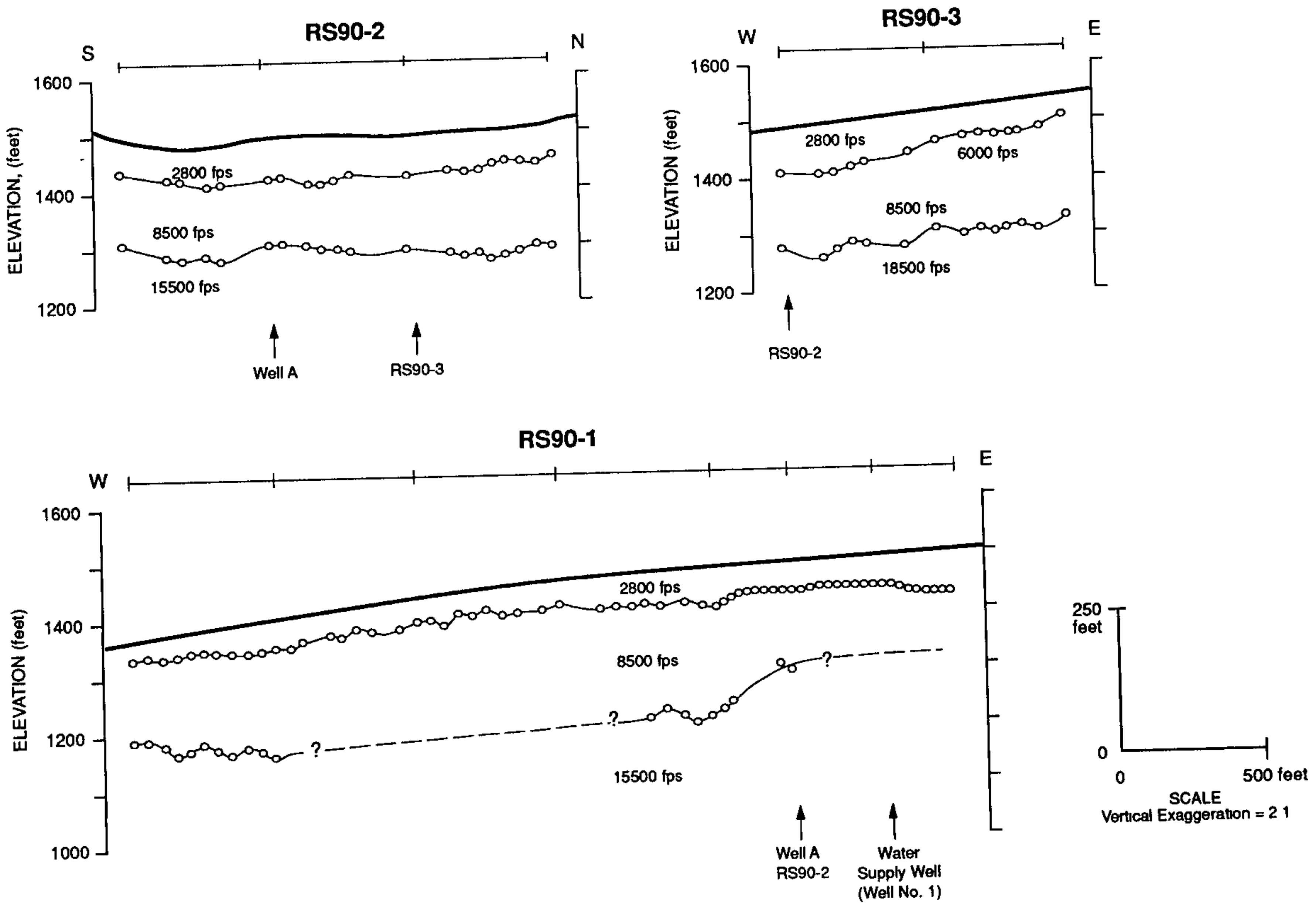
cps Count per second

—— Correlation lines between logs

Project No. 90275L	Cape Romanzof LRRS	GAMMA LOGS FOR WELLS A AND B AT ROM-1S	Figure 4-2
Woodward-Clyde Consultants			



Project No. 90275L	Cape Romanzof LRRS	SEISMIC REFRACTION PROFILES RS90-1, RS90-2, RS90-3	Figure 4-3
Woodward-Clyde Consultants			

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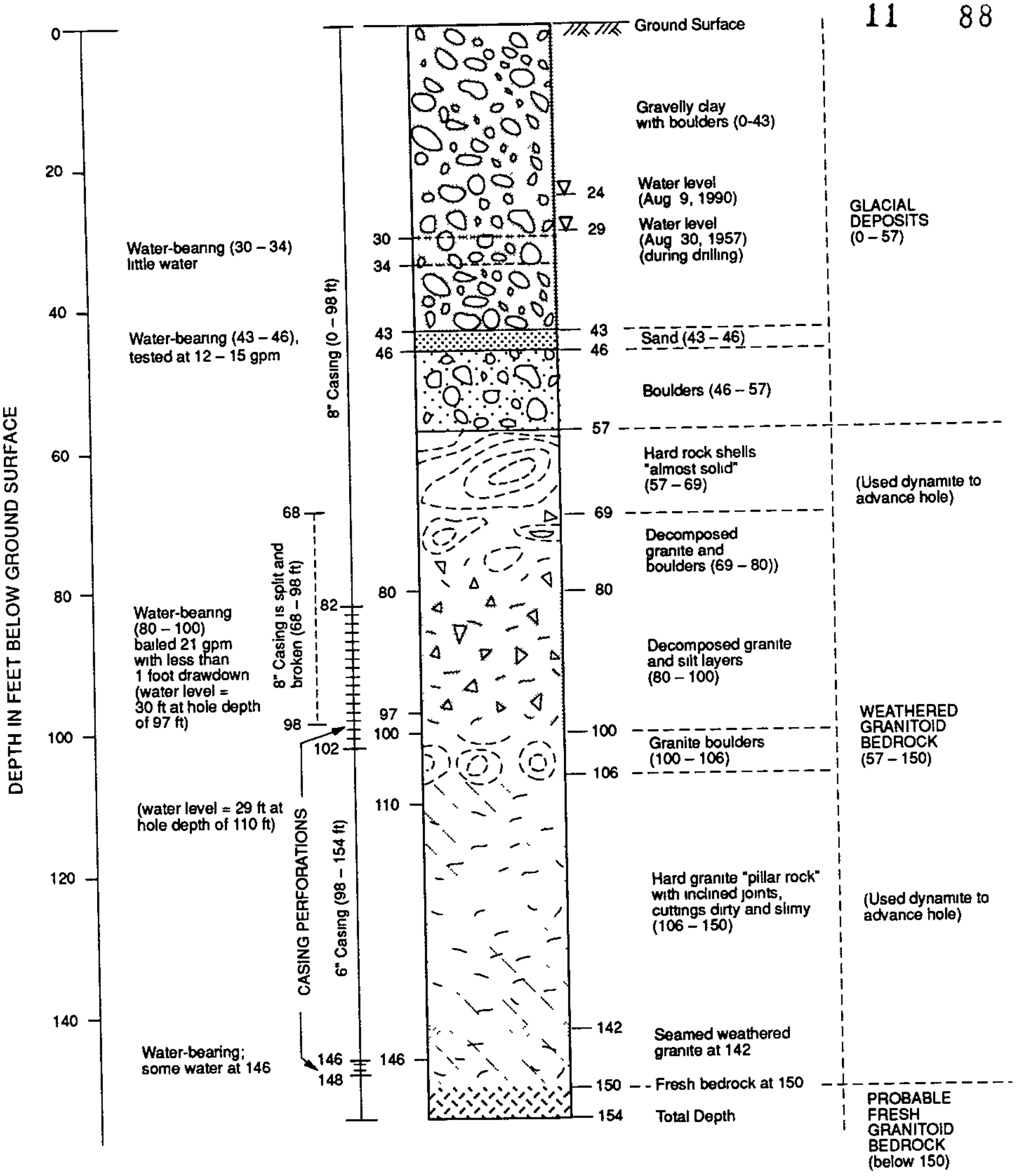
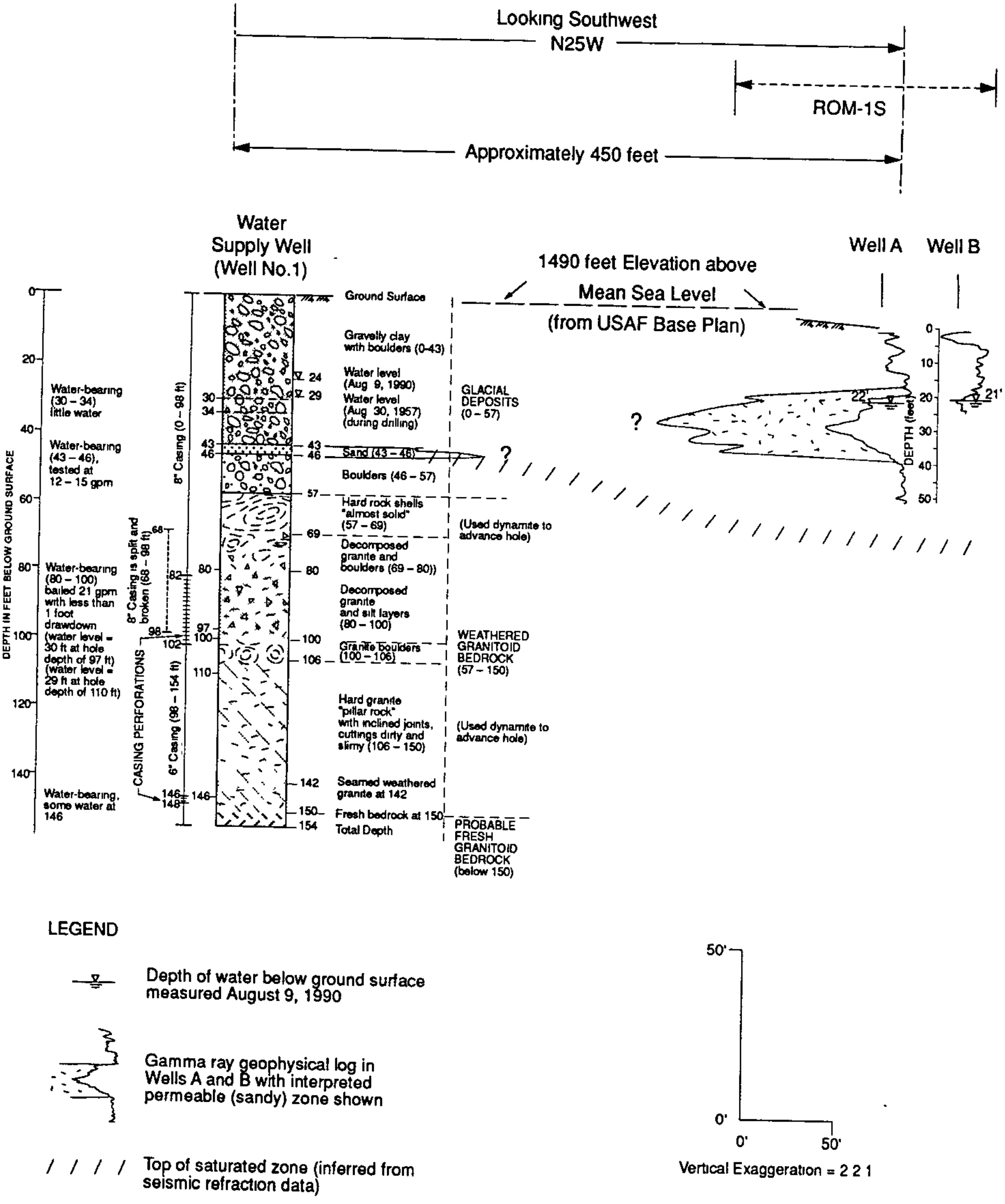


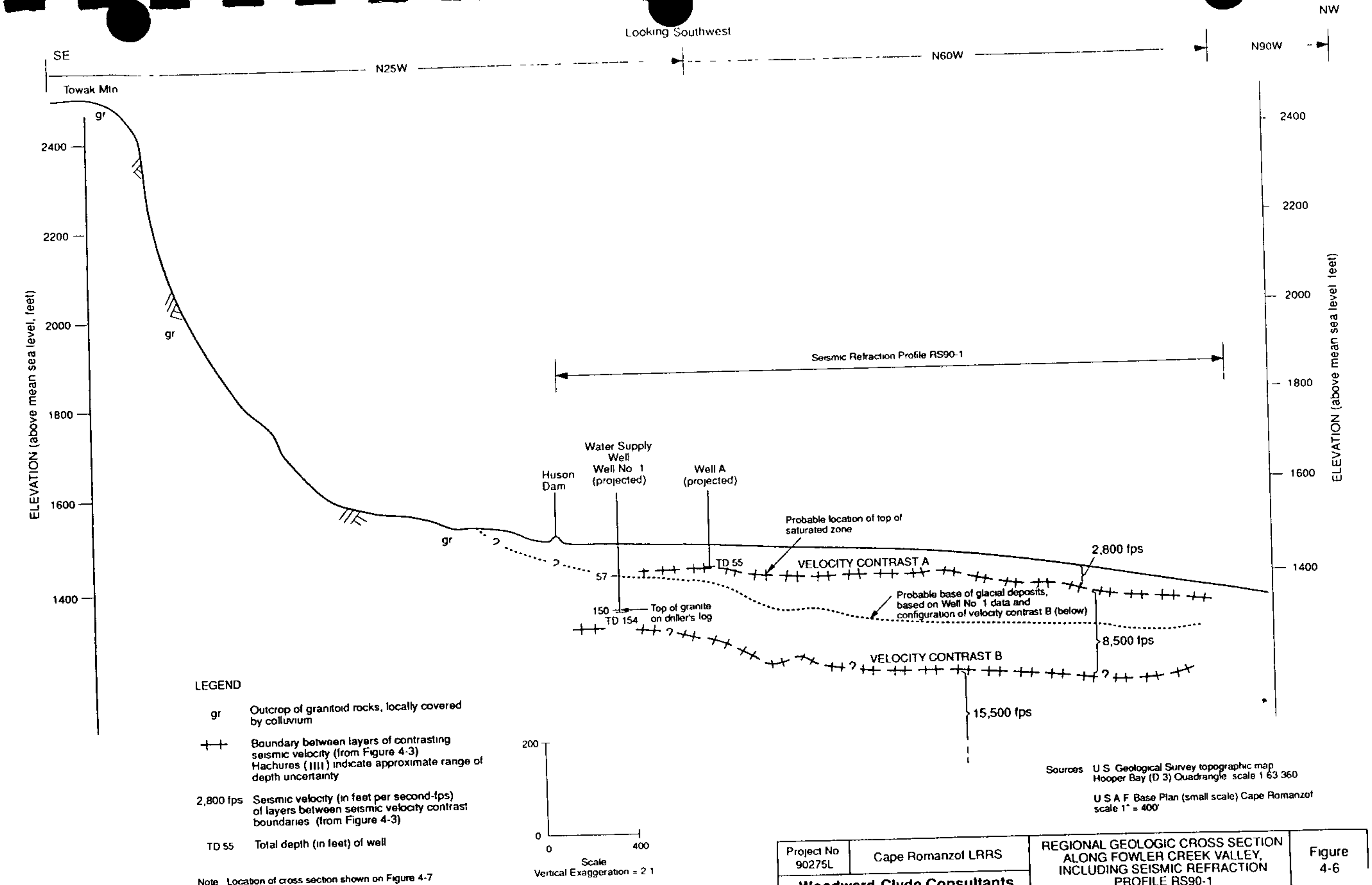
Note: Well No. 1 drilled in August/September 1957

Source: Modified from U.S Geological Survey Water Resources Division File Data, Undated

Project No. 90275L	Cape Romanzof LRRS	LOG AND WELL CONSTRUCTION DATA WELL NO.1 LOWER CAMP AREA	Figure 4-4
Woodward-Clyde Consultants			



Project No. 90275L	Cape Romanzof LRRS	LOCAL GEOLOGIC CROSS SECTION ALONG WATER SUPPLY PIPELINE WELL NO. 1 TO ROM-1S	Figure 4-5
Woodward-Clyde Consultants			



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gr	Outcrop of granitoid rocks, locally covered by colluvium
++	Boundary between layers of contrasting seismic velocity (from Figure 4-3) Hachures (IIII) indicate approximate range of depth uncertainty
2,800 fps	Seismic velocity (in feet per second-fps) of layers between seismic velocity contrast boundaries (from Figure 4-3)
TD 55	Total depth (in feet) of well

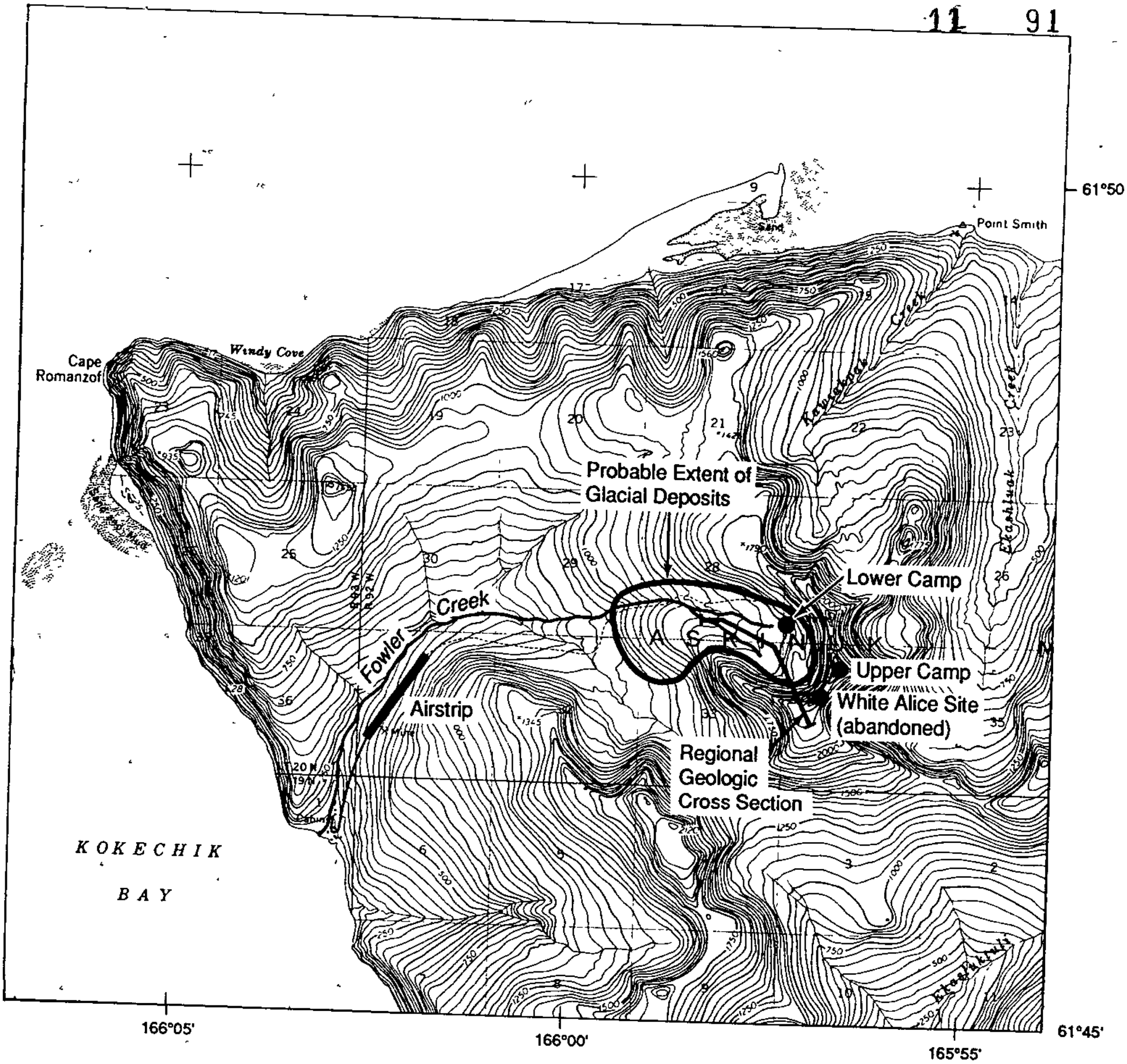
Note Location of cross section shown on Figure 4-7

Sources U S Geological Survey topographic map Hooper Bay (D 3) Quadrangle scale 1 63 360

U S A F Base Plan (small scale) Cape Romanzof scale 1" = 400'

Project No 90275L	Cape Romanzof LRRS	REGIONAL GEOLOGIC CROSS SECTION ALONG FOWLER CREEK VALLEY, INCLUDING SEISMIC REFRACTION PROFILE RS90-1	Figure 4-6
Woodward-Clyde Consultants			

11 90



Source: U.S. Geological Survey Topographic Map, Hooper Bay (D-3) Quadrangle, Scale 1:63,360

0 1
mile

Project No. 90275L	Cape Romanzof LRRS	LOCATION OF REGIONAL GEOLOGIC CROSS SECTION ON FIGURE 4-6	Figure 4-7
Woodward-Clyde Consultants			

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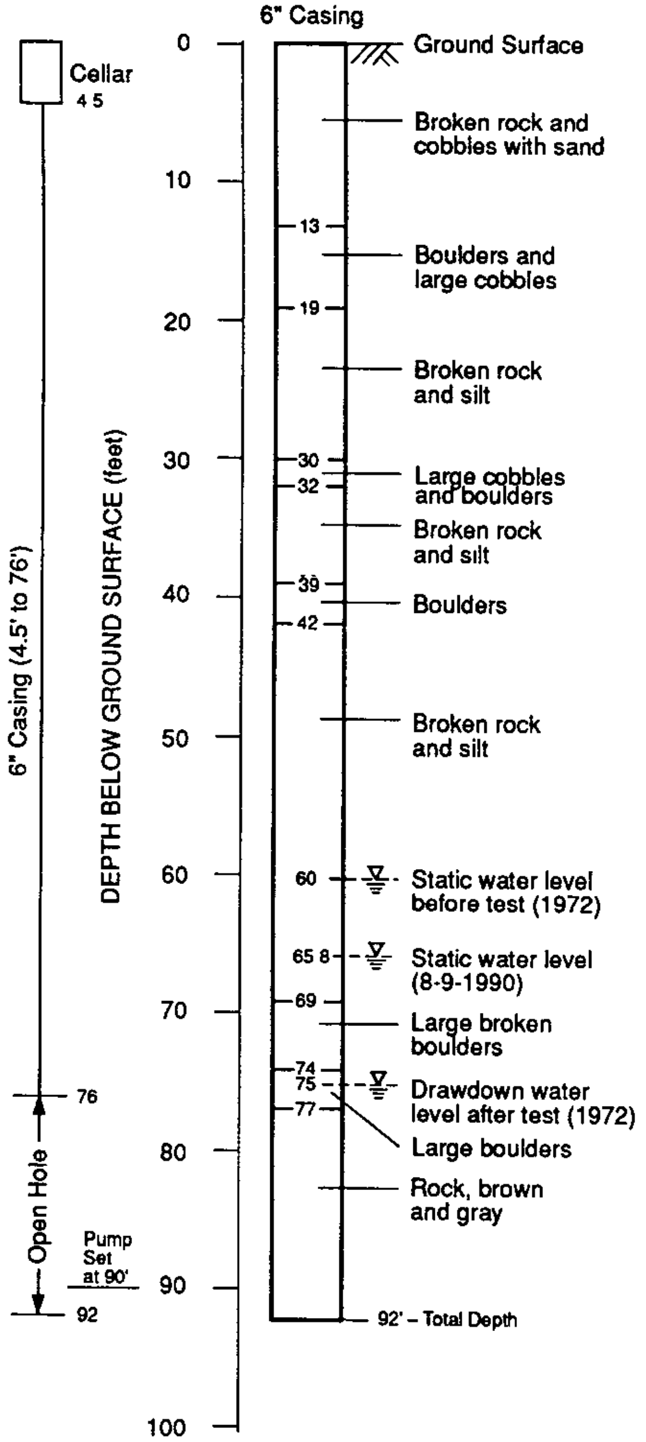
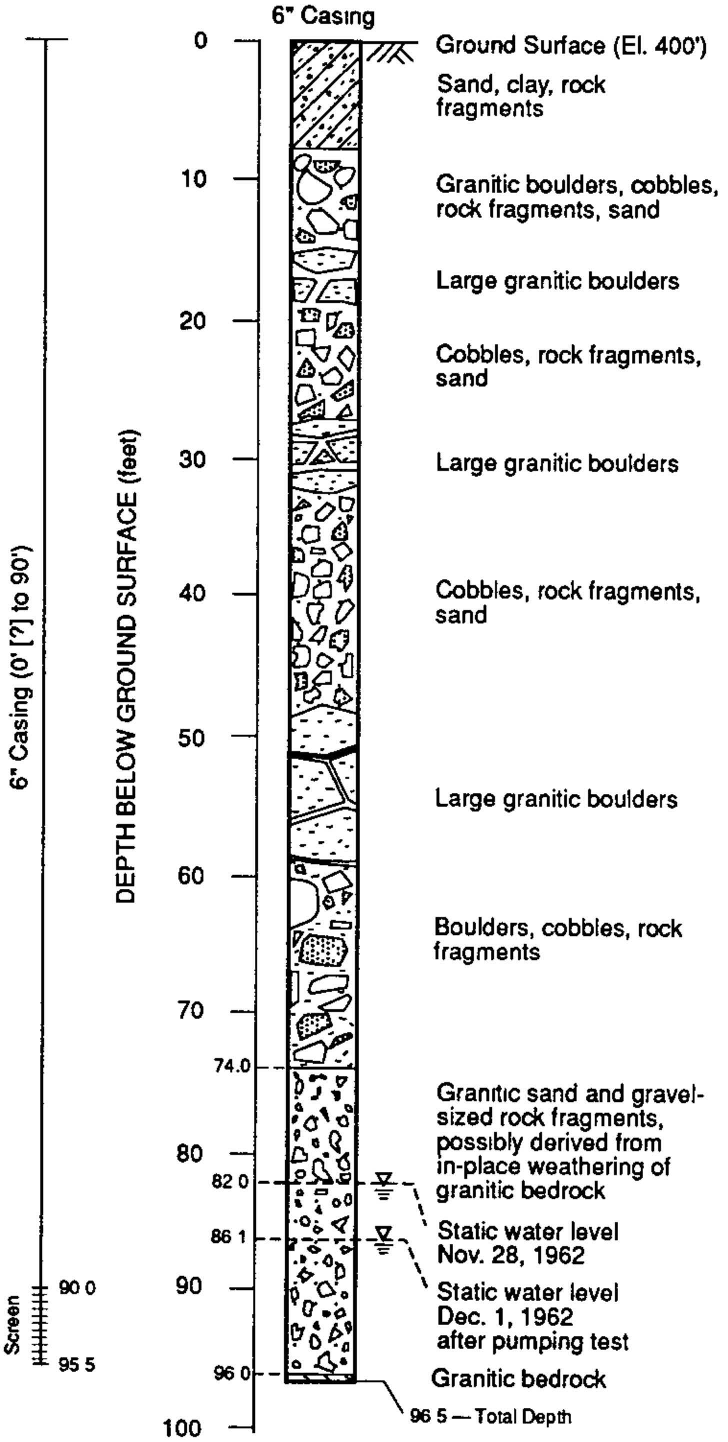


WELL NO. 3
(Existing)
(constructed in 1972)

Source· U.S Corps of Engineers (unpublished file data)

Note Water-bearing stratum was encountered at 77 0 to 77.5 foot depth

Well was drilled Aug 23 to Nov. 8, 1972. The hole was surged and bailed with casing to 76 ft. and open hole at 76 to 92 ft



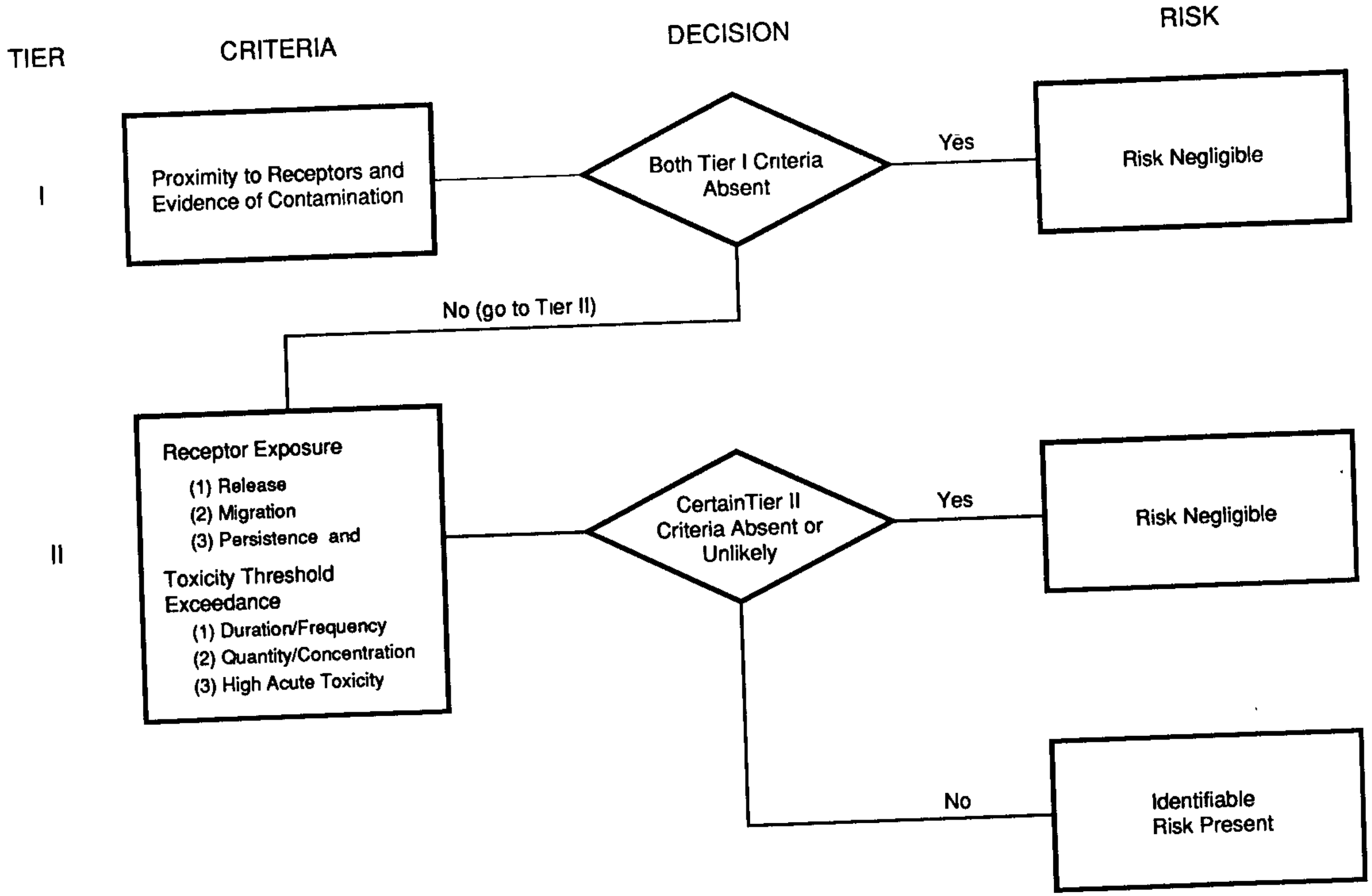
WELL NO. 2
(not found)
(constructed in 1962)

Source U S Corps of Engineers (1963)

Note: No frozen formations reported during drilling

Well was drilled Oct. 25 – Nov 17, 1962 by F&M Braneb A 6" dia 20-slot screen, 5 5 ft long was set with bottom at 95 5 ft, and well was developed by surging and bailing 2 hrs. 10 min Nov. 27 1962

Project No. 90275L	Cape Romanzof LRRS	LOGS AND WELL CONSTRUCTION DATA WELLS NO. 2 AND 3 (ROM-2)	Figure 4-8
Woodward-Clyde Consultants			



Project No. 90275L	Cape Romanzof LRRS	FLOW DIAGRAM SHOWING TWO LEVELS OF RISK SCREENING AND CRITERIA FOR DECISION MAKING AT EACH LEVEL	Figure 4-9
Woodward-Clyde Consultants			

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5.0
FEASIBILITY STUDY

Additional groundwater sampling at ROM-8 in 1990 confirmed the contaminant concentration levels found in the 1989 investigation, for those analytes tested in both years. Therefore, no update of the feasibility study and recommended remediation for ROM-8, documented in WCC (1990), is needed.

Based on the 1990 field data and evaluations described in this report, no additional sites require remedial action. Therefore, no additional feasibility studies were conducted.

6.0
RECOMMENDATIONS

6.1 CATEGORY 1 SITES

Site ROM-1S (Groundwater), the area of Wells A and B, requires no further action as a result of the sampling/testing and well abandonment activities implemented in 1990.

Site ROM-2 (Well No. 3 at Weather Station) and the area of Well No. 1 conditionally require no further action as a result of the two-tiered screening process presented in Section 4. This designation includes a requirement that additional confirmatory sampling and analyses show groundwater results that meet Alaska SMCLs.

6.2 CATEGORY 3 SITE

Site ROM-8 (landfill) remains a Category 3 site requiring further remedial action. Based on the results in the 1990 study, no changes to the existing feasibility study in WCC (1990) are needed.

6.3 GROUNDWATER RESOURCES IN LOWER CAMP AREA

Based on the groundwater resources evaluation in Section 4.2, it is recommended that Well No. 1 be retained as the station water supply source, pending confirmatory sampling which produces results meeting State of Alaska SMCL standards. In the expected event that confirmatory sampling shows analyte concentrations in Well No. 1 below SMCLs, it is further recommended that sampling and analysis be conducted again after 2 years and

5 years. Alternate locations for Well No. 1 having equivalent groundwater production potential would be more likely than Well No. 1 to be adversely affected by known contamination. Alternate locations for Well No. 1 that would be less likely to be contaminated would be nearer the edge of the valley (e.g., near the Composite Facility), and would likely have lower yields than Well No. 1.

7.0
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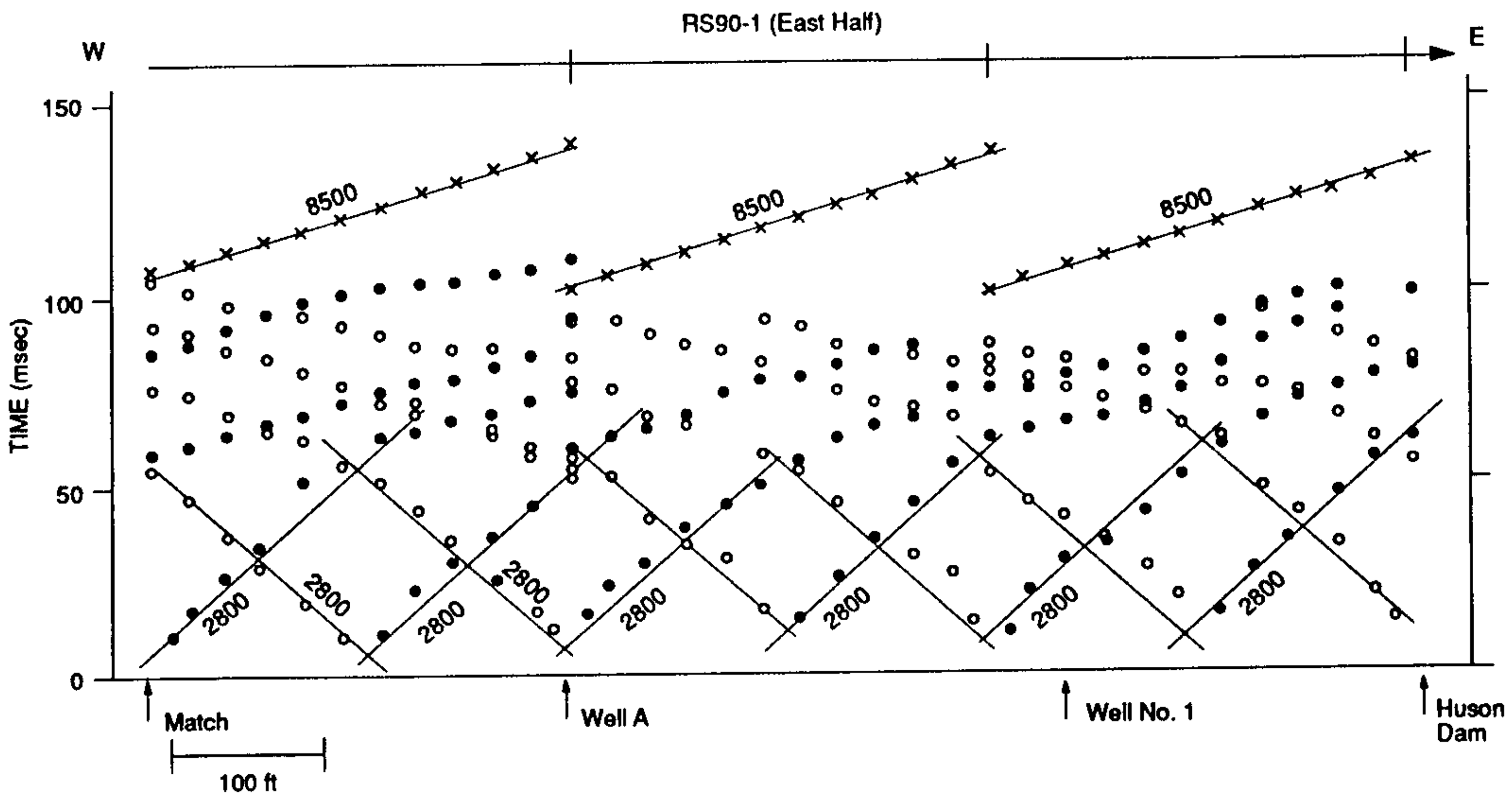
APPENDIX A

SEISMIC REFRACTION TIME-DISTANCE PLOTS



LEGEND

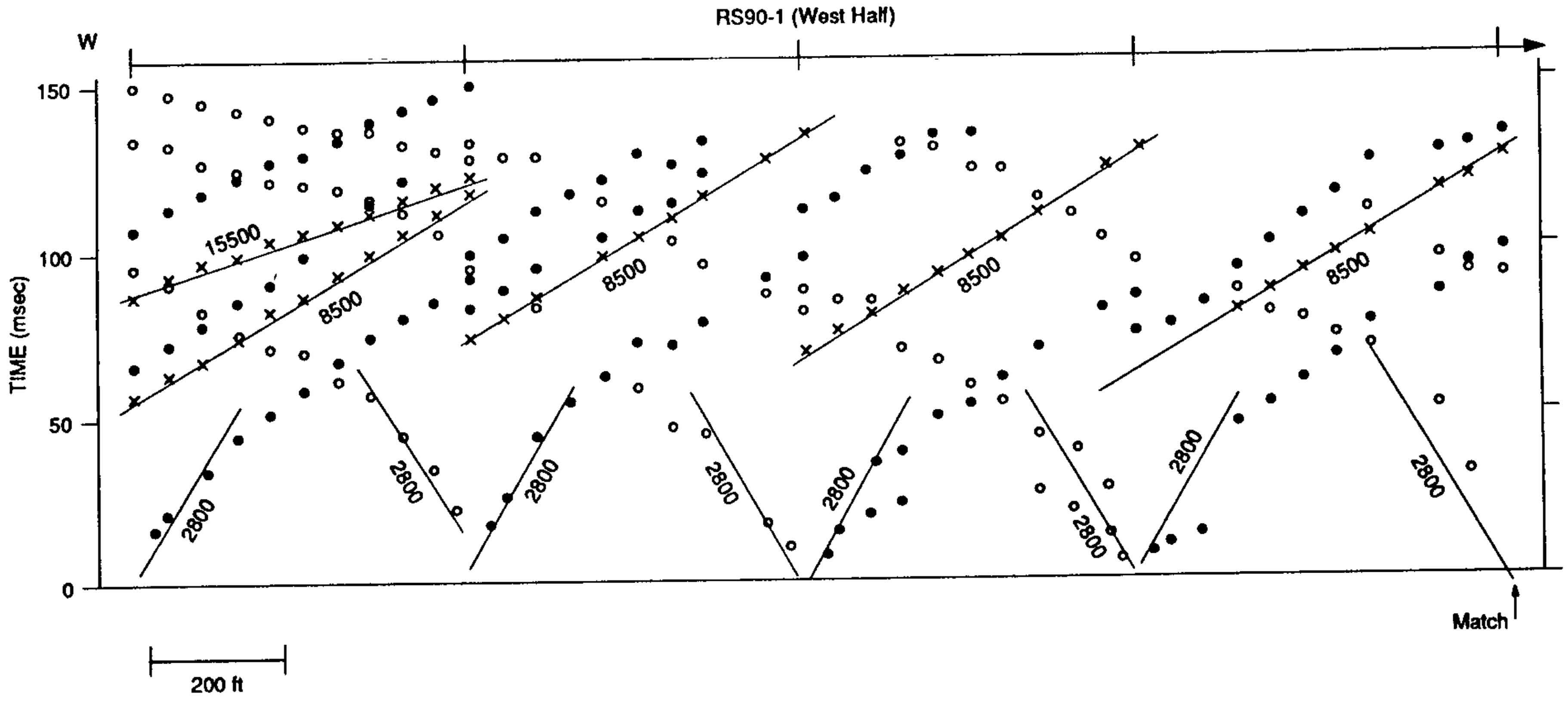
15500 Velocity valves (15500) are compression wave velocities in feet per second

○ ● Raw data

× Derived velocity function

11 100

Project No. 90275L	Cape Romanzof LRRS	TIME DISTANCE PLOT SEISMIC REFRACTION LINE RS90-1 (EAST HALF)	Figure A-1
Woodward-Clyde Consultants			



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15500 Velocity valves (15500) are compression wave velocities in feet per second

○● Raw data

× Derived velocity function

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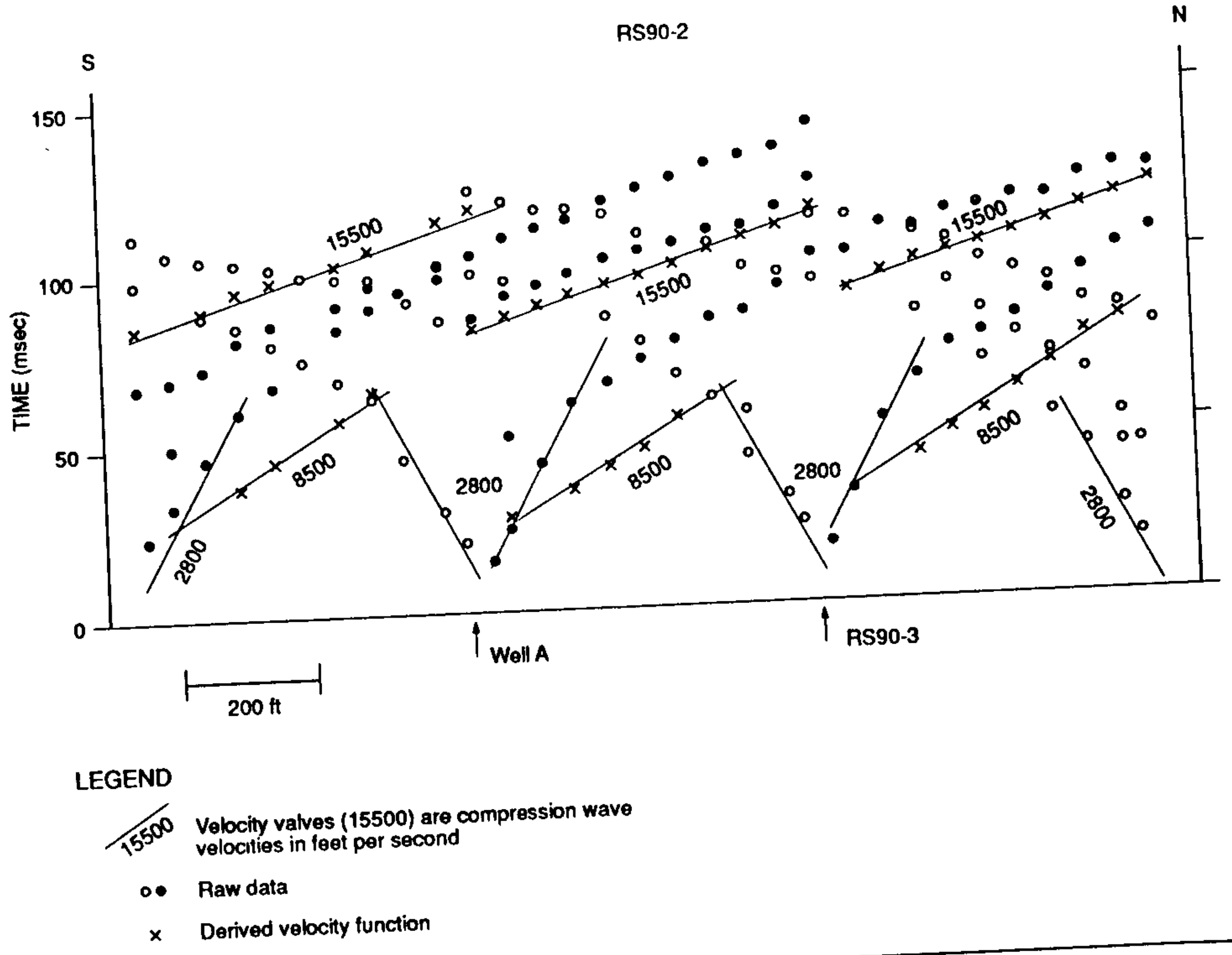
Project No. 90275L

Cape Romanzof LRRS

Woodward-Clyde Consultants

TIME DISTANCE PLOT
SEISMIC REFRACTION LINE RS90-1 (WEST HALF)

Figure A-2



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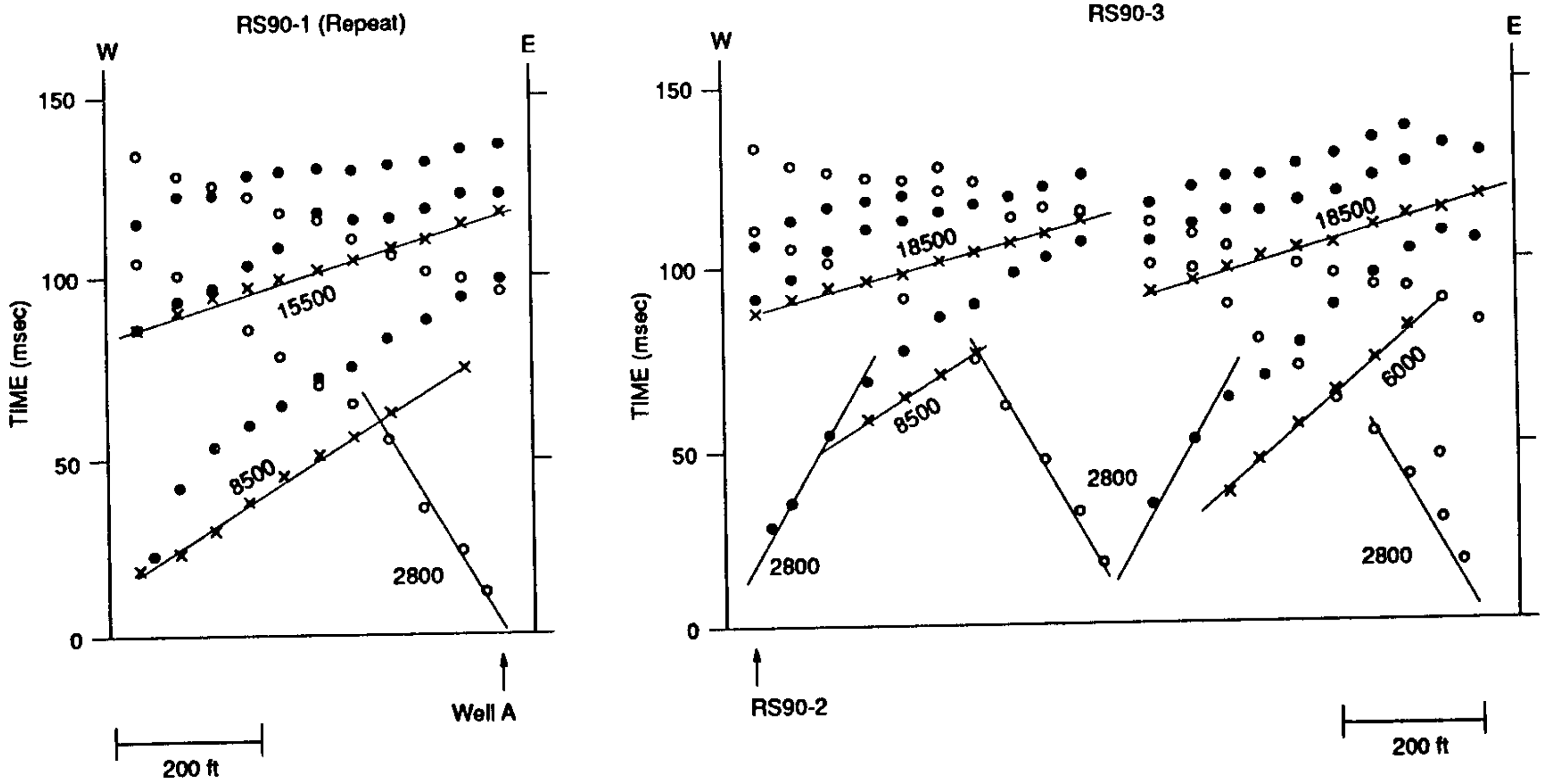
Project No. 90275L	Cape Romanzof LRRS	TIME-DISTANCE PLOT SEISMIC REFRACTION LINE RS90-2	Figure A-3
W dward-Clyd C nsultants			



LEGEND

15500 Velocity valves (15500) are compression wave velocities in feet per second

○● Raw data

× Derived velocity function

Project No. 90275L	Cape Romanzof LRRS	TIME-DISTANCE PLOTS SEISMIC REFRACTION LINES RS90-1 (REPEAT) AND RS90-3	Figure A-4
Woodward-Clyd Consultants			

APPENDIX B
LABORATORY ANALYSIS SUMMARY

This appendix summarizes the results of analyses for all water samples collected at Cape Romanzof LRRS during August 1990. No soil samples were collected during this period.

Table B-1 shows only those analytes having concentrations above reporting limits in at least one sample. Other analytes for which no values above reporting limits were reported are:

- benzene (reporting limit = 0.7 μg/l)
- chlorobenzene (reporting limit = 1.0 μg/l)
- 1,3-dichlorobenzene (reporting limit = 2.0 μg/l)
- 1,2-dichlorobenzene (reporting limit = 2.0 μg/l)

Table B-1. LABORATORY ANALYSIS SUMMARY FOR WATER SAMPLES TAKEN AT CAPE ROMANZOF - AUGUST 1990

SAMPLE IDENTIFICATION	DATE	ANALYSES	ANALYTICAL RESULTS					COMMENTS
			Toluene (µg/l)	Ethyl-benzene (µg/l)	Xylenes (µg/l)	1,4-Dichloro-benzene (µg/l)	TPH (mg/l)	
EB-001	09 AUG 90	8020	ND	ND	ND	ND	--	
AB-001	09 AUG 90	8020	ND	ND	ND	ND	--	
ROM1S-B-WG-N-003	09 AUG 90	8020,418.1	ND	ND	ND	ND	0.30	
ROM1S-B-WG-N-004	09 AUG 90	8020,418.1	ND	ND	ND	1.9	1.60	
*ROM1S-WF-WG-N-004	09 AUG 90	8020	ND	ND	ND	ND	--	2nd Column Analysis
ROM1S-WF-WP-N-005	09 AUG 90	8020,418.1	ND	ND	ND	ND	0.23	
ROM1S-WF-WP-FR-005	09 AUG 90	8020	ND	ND	ND	ND	--	
ROM2-B-WG-N-001	09 AUG 90	8020,418.1	ND	ND	ND	ND	0.31	
EB-002	10 AUG 90	8020	ND	ND	ND	ND	--	
ROM8-B-WG-N-016	10 AUG 90	8020,418.1	ND	ND	ND	ND	0.30	
ROM8-B-WG-N-017	10 AUG 90	8020,418.1	ND	ND	ND	ND	0.26	
ROM8-B-WG-N-018	10 AUG 90	8020,418.1	12	1.4	9.1	2.9	0.39	
*ROM8-B-WG-N-018	10 AUG 90	8020	7.6	1.2	5.0	4.2	--	2nd Column Analysis
ROM8-B-WG-FR-018	10 AUG 90	8020,418.1	12	1.4	9.1	2.8	0.48	
*ROM8-B-WG-FR-018	10 AUG 90	8020	9.2	1.3	6.1	5.2	--	2nd Column Analysis
TB-001	12 AUG 90	8020	ND	ND	ND	ND	--	
EB-001	10 AUG 90	418.1	--	--	--	--	0.43	
Reporting Limit			1.0	1.0	2.0	0.5	0.05	

* Preferred value according to RMAL.

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APPENDIX C

FIELD SAMPLING SUMMARY

Table C-1. CAPE ROMANZOF LRRS FIELD SAMPLING SUMMARY - GROUNDWATER INVESTIGATIONS, 1990

Sample I.D.	Sample Location	Date Sampled	Sampler	Sampling Method	Analyses
ROM-1S-B-WG-N-003	Well A	9 AUG 90	RS	Bailer	418.1, 8020
ROM-1S-B-WG-N-004	Well B	9 AUG 90	RS	Bailer	418.1, 8020
ROM-1S-WF-WP-N-005	Well 1	9 AUG 90	RS	Grab at faucet	418.1, 8020
ROM-1S-WF-WP-FR-005	Well 1	9 AUG 90	RS	Grab at faucet	8020
ROM-2-B-WG-N-001	Well 3	9 AUG 90	RS	Bailer	418.1, 8020
ROM-8-B-WG-N-016	MW1	10 AUG 90	RS	Bailer	418.1, 8020
ROM-8-B-WG-N-017	MW2	10 AUG 90	RS	Bailer	418.1, 8020
ROM-8-B-WG-N-018	MW3	10 AUG 90	RS	Bailer	418.1, 8020
ROM-8-B-WG-FR-018	MW3	10 AUG 90	RS	Bailer	418.1, 8020
ROM-EB-001	QA/QC	9 AUG 90	RS	Grab	8020
ROM-AB-001	QA/QC	9 AUG 90	RS	Grab	8020
ROM-EB-002	QA/QC	10 AUG 90	RS	Grab	8020
ROM-EB-001	QA/QC	10 AUG 90	RS	Grab	418.1
ROM-TB-001	QA/QC	12 AUG 90	RS	Grab	8020

Key:
B = Bailer
WG = Groundwater
N = Normal
WF = Water Faucet
DW = Drinking Water

FR = Field Replicate
EB = Equipment Blank
AB = Ambient Conditions Blank
TB = Travel Blank
RS = Robin Spencer

418.1 = Total Petroleum Hydrocarbons
8020 = Aromatic Volatile Organics (benzene, toluene, ethylbenzene, xylenes, dichlorobenzenes)

APPENDIX D

STATEMENT OF WORK FOR 1990
CAPE ROMANZOF LRRS, ALASKA
F33615-85-D-4544. ORDER 10, MODIFICATION 1

SCHEDULE OF CHANGES

Contract Number: F33615-85-D-4544

Order Number: 0010

Modification Number: 0001

Contractor: Woodward-Clyde Consultants

Date of Modification: 13 Jun 90

Pen-and-Ink Changes:

Paragraph	Changes
1.4.5.9.1	Add the following paragraph: "1.4.5.9.1 Plug and abandon wells A and B at Site ROM-1s in accordance with applicable state and local abandonment guidelines."
1.4.11.3	Add the following paragraph: "1.4.11.3 Seismic Refraction Survey. Perform a Seismic Refraction Survey across the floor of Fowler Creek valley. Evaluate the depth to bedrock and provide preliminary estimates of the subsurface boundaries and shape of the aquifer."
1.4.11.4	Add the following paragraph: "1.4.11.4 Downhole Geophysical Survey. Perform three (3) downhole gamma ray logs at site ROM-1s to provide stratigraphic information of the site."
1.4.12.1	Change entire paragraph to read: "Collect a maximum of fourteen (14) groundwater and thirteen (13) surface water samples. The maximum number of analyses for each parameter and the required analytical method is given in Tables A-4 and A-7, Annex A."
1.4.13.3	Add an "a." before "field tasks..." Add the following sentences: "b. If pumping is required, remove the existing pumping and piping system and provide a pumping system. A portable power supply may be needed to operate this system. c. After collection of the groundwater sample seal/close up the well."
1.11.1.5	Add the following paragraph: "1.11.1.5 Report Addendum. Provide a Report Addendum describing the results of the additional work at sites ROM-1s, ROM-2, and ROM-8. Use applicable portions of the format in section 3 of the Handbook. Include an evaluation of the results with consideration of the data provided in the

Technical Report (WCC, 1990, under separate cover) (Item VI, sequence no. 4, paragraph 6.1)."

VI.6.1 Add:

"4 (Report Addendum) I.1.11.1.5 ONE/R 90JUL02 90SEP26 90DEC19 **"

ANNEX A Add:

Tables A-6, A-7 and A-8 attached

ANNEX A, Table A-6
CAPE ROMANZOF AFS FIELD STUDY SCOPE FOR ADDITIONAL SAMPLING

	ROM-1s	ROM-2	ROM-8	TOTAL
Groundwater samples	3	1	4	8
Number of Downhole Logs	3	-	-	3
Well Abandonment	2	-	-	2
Days Seismic Refraction Survey	9	-	-	9

ANNEX A, Table A-7
Approximate Number of Water Analyses by Site for Additional Sampling

PARAMETER	ANALYTICAL METHOD	ROM-1s	ROM-2	ROM-8	Total
Specific Conductance (Field Test)	E120.1	3	1	4	8
pH (Field Test)	E150.1	3	1	4	8
Temperature (Field Test)	E170.1	3	1	4	8
Petroleum Hydrocarbons	E418.1	3	1	4	8
Purgeable Aromatics	SW5030/ SW8020	3	1	4	8

ANNEX A, Table A-8
Analytical Methods and TOTAL Number of Water Analyses for Additional Sampling

PARAMETER	ANALYTICAL METHOD (a)	REPORTING UNITS	NUMBER OF ANALYSES	TRIP BLANKS	AMB COND BLANKS	EQUIP BLANKS	DUP/REP	SECOND COLUMN (b)	TOTAL ANALYSES
Specific Conductance (Field Test)	E120.1	umhos/cm	8						8
pH (Field Test)	E150.1	pH Units	8						8
Temperature (Field Test)	E170.1	deg C	8						8
Petroleum Hydrocarbons	E418.1	mg/L	8			2	1		11
Purgeable Aromatics	SW5030/ SW8020	ug/L	8	1	1	2	2	7	21

APPENDIX E
INFORMAL TECHNICAL INFORMATION REPORT: PRELIMINARY ANALYTICAL DATA

Installation Restoration Program
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
STAGE 1

REPORT ADDENDUM

INFORMAL TECHNICAL INFORMATION REPORT: PRELIMINARY DATA

FOR

CAPE ROMANZOF LRRS, ALASKA

November 1990

Prepared by

Woodward-Clyde Consultants
500 12th Street, Suite 100
Oakland, CA 94607-4014

USAF CONTRACT F33615-85D-4544, DELIVERY ORDER NO. 0010

Prepared for

ALASKA AIR COMMAND
ELMENDORF AFB, ALASKA 88506

IRP PROGRAM OFFICE (HSD/YAQ)
Charles Attebery, Capt., USAF
Project Manager

Human Systems Division
IRP Program Office (HSD/YAQ)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

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1.0
DATA REPORTS

1.1 DATA REPORT 1 RMAL NO. 010824

Analytical Results

The analytical results for this project are presented in the following data tables. Each data table includes sample identification information, and when available and appropriate, dates sampled, received, authorized, prepared and analyzed. The authorization data is the date when the project was defined by the client such that laboratory work could begin.

Data sheets contain a listing of the parameters measured in each test, the analytical results and the Enseco reporting limit. Reporting limits are adjusted to reflect dilution of the sample, when appropriate. Solid and waste samples are reported on an "as received" basis, i.e. no correction is made for moisture content.

Enseco-RMAL is no longer routinely blank-correcting analytical data. Uncorrected analytical results are reported, along with associated blank results, for all organic and metals analyses. Analytical results and blank results are reported for conventional inorganic parameters as specified in the method. This policy is described in detail in the Enseco Incorporated Quality Assurance Program Plan for Environmental Chemical Monitoring, Revision 3.3, April, 1989.

The results from the Standard Enseco QA/QC Program, which generates data which are independent of matrix effects, is provided subsequently.

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1.1
DATA REPORT 1

SAMPLE DESCRIPTION INFORMATION
for
Woodward-Clyde Consultants

Lab ID	Client ID	Matrix	Sampled Date	Sampled Time	Received Date
010824-0001-SA	CAPRM-EB-001	AQUEOUS	09 AUG 90	10:25	13 AUG 90
010824-0002-SA	CAPRM-AB-001	AQUEOUS	09 AUG 90	10:30	13 AUG 90
010824-0003-SA	CAPRM-ROM1S-B-WG-N-003	AQUEOUS	09 AUG 90	14:50	13 AUG 90
010824-0004-SA	CAPRM-ROM1S-B-WG-N-004	AQUEOUS	09 AUG 90	15:35	13 AUG 90
010824-0005-SA	CAPRM-ROM1S-WF-WP-N-005	AQUEOUS	09 AUG 90	14:30	13 AUG 90
010824-0006-SA	CAPRM-ROM1S-WF-WP-FR-005	AQUEOUS	09 AUG 90	14:30	13 AUG 90
010824-0007-SA	CAPRM-ROM2-B-WG-N-001	AQUEOUS	09 AUG 90	18:45	13 AUG 90
010824-0008-SA	CAPRM-EB-002	AQUEOUS	10 AUG 90	09:50	13 AUG 90
010824-0009-SA	CAPRM-ROM8-B-WG-N-016	AQUEOUS	10 AUG 90	10:00	13 AUG 90
010824-0010-SA	CAPRM-ROM8-B-WG-N-017	AQUEOUS	10 AUG 90	10:15	13 AUG 90
010824-0011-SA	CAPRM-ROM8-B-WG-N-018	AQUEOUS	10 AUG 90	10:30	13 AUG 90
010824-0012-SA	CAPRM-ROM8-B-WG-FR-018	AQUEOUS	10 AUG 90	10:30	13 AUG 90
010824-0013-SA	CAPRM-TB-001	AQUEOUS	12 AUG 90		13 AUG 90
010824-0014-SA	CAPRM-EB-001	AQUEOUS	10 AUG 90	17:00	13 AUG 90

ANALYTICAL TEST REQUESTS
for
Woodward-Clyde Consultants

Lab ID: 010824	Group Code	Analysis Description	Custom Test?
0001 - 0002, 0006 , 0008, 0013	A	Aromatic Volatile Organics-2nd Column Analysis Aromatic Volatile Organics	N N
0003 - 0005, 0007 , 0009, 0010 - 0012	B	Total Petroleum Hydrocarbons (TPH), IR Aromatic Volatile Organics-2nd Column Analysis Aromatic Volatile Organics	N N N
0014	C	Total Petroleum Hydrocarbons (TPH), IR	N

Enseco

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Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-EB-001
Lab ID: 010824-0001-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90

Enseco ID: 1087973
Sampled: 09 AUG 90
Prepared: NA

Received: 13 AUG 90
Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit
Benzene	ND	ug/L	0.70
Toluene	ND	ug/L	1.0
Chlorobenzene	ND	ug/L	1.0
Ethylbenzene	ND	ug/L	1.0
Xylenes (total)	ND	ug/L	2.0
1,3-Dichlorobenzene	ND	ug/L	2.0
1,2-Dichlorobenzene	ND	ug/L	2.0
1,4-Dichlorobenzene	ND	ug/L	0.50
a,a,a-Trifluorotoluene	115	%	--

D = Not detected
A = Not applicable

ported By: Nathaniel Biah

Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-AB-001
Lab ID: 010824-0002-SA
Enseco ID: 1087974
Matrix: AQUEOUS
Sampled: 09 AUG 90
Received: 13 AUG 90
Authorized: 14 AUG 90
Prepared: NA
Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	108	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah

Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM1S-B-WG-N-003
Lab ID: 010824-0003-SA Enseco ID: 1087975
Matrix: AQUEOUS Sampled: 09 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	109	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM1S-B-WG-N-004
Lab ID: 010824-0004-SA Enseco ID: 1087976
Matrix: AQUEOUS Sampled: 09 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	1.9	ug/L	0.50	
a,a,a-Trifluorotoluene	106	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics-2nd Column Analysis

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM1S-B-WG-N-004
Lab ID: 010824-0004-SA Enseco ID: 1087976
Matrix: AQUEOUS Sampled: 09 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	V
a,a,a-Trifluorotoluene	101	%	--	

Note V : Secondary column result is the preferred value.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM1S-WF-WP-N-005
Lab ID: 010824-0005-SA
Enseco ID: 1087977
Matrix: AQUEOUS
Sampled: 09 AUG 90
Received: 13 AUG 90
Authorized: 14 AUG 90
Prepared: NA
Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	114	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah
Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name:	Woodward-Clyde Consultants		
Client ID:	CAPRM-ROM1S-WF-WP-FR-005		
Lab ID:	010824-0006-SA	Enseco ID: 1087978	
Matrix:	AQUEOUS	Sampled: 09 AUG 90	Received: 13 AUG 90
Authorized:	14 AUG 90	Prepared: NA	Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	117	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM2-B-WG-N-001
Lab ID: 010824-0007-SA Enseco ID: 1087979
Matrix: AQUEOUS Sampled: 09 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	115	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-EB-002
Lab ID: 010824-0008-SA
Enseco ID: 1087980
Matrix: AQUEOUS
Sampled: 10 AUG 90
Received: 13 AUG 90
Authorized: 14 AUG 90
Prepared: NA
Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	112	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah

Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-016
Lab ID: 010824-0009-SA Enseco ID: 1087981
Matrix: AQUEOUS Sampled: 10 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	95	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

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Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-017
Lab ID: 010824-0010-SA   Enseco ID: 1087982
Matrix: AQUEOUS   Sampled: 10 AUG 90   Received: 13 AUG 90
Authorized: 14 AUG 90   Prepared: NA   Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	96	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah   Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-018
Lab ID: 010824-0011-SA Enseco ID: 1087983
Matrix: AQUEOUS Sampled: 10 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	12	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	1.4	ug/L	1.0	
Xylenes (total)	9.1	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	2.9	ug/L	0.50	
a,a,a-Trifluorotoluene	98	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-FR-018
Lab ID: 010824-0012-SA Enseco ID: 1087984
Matrix: AQUEOUS Sampled: 10 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	12	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	1.4	ug/L	1.0	
Xylenes (total)	9.1	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	2.8	ug/L	0.50	
a,a,a-Trifluorotoluene	113	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics-2nd Column Analysis

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-018
Lab ID: 010824-0011-SA Enseco ID: 1087983
Matrix: AQUEOUS Sampled: 10 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	
Toluene	7.6	ug/L	1.0	V
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	1.2	ug/L	1.0	V
Xylenes (total)	5.0	ug/L	2.0	V
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	4.2	ug/L	0.50	
a,a,a-Trifluorotoluene	108	%	--	

Note V : Secondary column result is the preferred value.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics-2nd Column Analysis

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-FR-018
Lab ID: 010824-0012-SA Enseco ID: 1087984
Matrix: AQUEOUS Sampled: 10 AUG 90 Received: 13 AUG 90
Authorized: 14 AUG 90 Prepared: NA Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	
Toluene	9.2	ug/L	1.0	V
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	1.3	ug/L	1.0	V
Xylenes (total)	6.1	ug/L	2.0	V
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	5.2	ug/L	0.50	
a,a,a-Trifluorotoluene	110	%	--	

Note V : Secondary column result is the preferred value.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah Approved By: Jeff Lowry

Aromatic Volatile Organics

Method 8020

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-TB-001
Lab ID: 010824-0013-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90

Enseco ID: 1087985
Sampled: 12 AUG 90
Prepared: NA

Received: 13 AUG 90
Analyzed: 15 AUG 90

Parameter	Result	Units	Reporting Limit	
Benzene	ND	ug/L	0.70	T
Toluene	ND	ug/L	1.0	
Chlorobenzene	ND	ug/L	1.0	
Ethylbenzene	ND	ug/L	1.0	
Xylenes (total)	ND	ug/L	2.0	
1,3-Dichlorobenzene	ND	ug/L	2.0	
1,2-Dichlorobenzene	ND	ug/L	2.0	
1,4-Dichlorobenzene	ND	ug/L	0.50	
a,a,a-Trifluorotoluene	104	%	--	

Note T : Preferred values unless footnoted on secondary column test.

ND = Not detected
NA = Not applicable

Reported By: Nathaniel Biah

Approved By: Jeff Lowry

General Inorganics

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM1S-B-WG-N-003
Lab ID: 010824-0003-SA
Matrix: AQUEOUS
Sampled: 09 AUG 90
Received: 13 AUG 90
Authorized: 14 AUG 90
Prepared: See Below
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.30	mg/L	0.053	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

Client Name:	Woodward-Clyde Consultants
Client ID:	CAPRM-ROM1S-B-WG-N-004
Lab ID:	010824-0004-SA
Matrix:	AQUEOUS
Authorized:	14 AUG 90

Sampled: 09 AUG 90
Prepared: See Below

Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	1.6	mg/L	0.052	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 139

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM1S-WF-WP-N-005
Lab ID: 010824-0005-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90
Sampled: 09 AUG 90
Prepared: See Below
Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.23	mg/L	0.053	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 140

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM2-B-WG-N-001
Lab ID: 010824-0007-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90
Sampled: 09 AUG 90
Prepared: See Below
Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.31	mg/L	0.052	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 141

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-016
Lab ID: 010824-0009-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90
Sampled: 10 AUG 90
Prepared: See Below
Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.30	mg/L	0.055	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 142

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-017
Lab ID: 010824-0010-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90
Sampled: 10 AUG 90
Prepared: See Below
Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.26	mg/L	0.056	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 143

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-N-018
Lab ID: 010824-0011-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90
Sampled: 10 AUG 90
Prepared: See Below
Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.39	mg/L	0.052	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 144

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-ROM8-B-WG-FR-018
Lab ID: 010824-0012-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90
Sampled: 10 AUG 90
Prepared: See Below
Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.48	mg/L	0.052	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

Client Name: Woodward-Clyde Consultants
Client ID: CAPRM-EB-001
Lab ID: 010824-0014-SA
Matrix: AQUEOUS
Authorized: 14 AUG 90

Sampled: 10 AUG 90
Prepared: See Below

Received: 13 AUG 90
Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Total Petroleum Hydrocarbons	0.43	mg/L	0.057	418.1	NA	01 SEP 90

ND = Not detected
NA = Not applicable

Reported By: Ron Maiorana

Approved By: Toni Stovall

11 146

2.0
QUALITY ASSURANCE/QUALITY CONTROL SUMMARY REPORTS

Quality Control Results

The Enseco laboratories operate under a vigorous QA/QC program designed to ensure the generation of scientifically valid, legally defensible data by monitoring every aspect of laboratory operations. Routine QA/QC procedures include the use of approved methodologies, independent verification of analytical standards, use of duplicate Laboratory Control Samples to assess the precision and accuracy of the methodology on a routine basis, and a rigorous system of data review.

In addition, the Enseco laboratories maintain a comprehensive set of certifications from both state and federal governmental agencies which require frequent analyses of blind audit samples. Enseco - Rocky Mountain Analytical Laboratory is certified by the EPA under the EPA/CLP program for both Organic and Inorganic analyses, under the USATHAMA (U.S. Army) program, by the Army Corps of Engineers, and the states of Colorado, New Jersey, New York, Utah, and Florida, among others.

The standard laboratory QC package is designed to:

1) establish a strong, cost-effective QC program that ensures the generation of scientifically valid, legally defensible data

2) assess the laboratory's performance of the analytical method using control limits generated with a well-defined matrix

3) establish clear-cut guidelines for acceptability of analytical data so that QC decisions can be made immediately at the bench, and

4) provide a standard set of reportables which assures the client of the quality of his data.

The Enseco QC program is based upon monitoring the precision and accuracy of an analytical method by analyzing a set of Duplicate Control Samples (DCS) at frequent, well-defined intervals. Each DCS is a well-characterized matrix which is spiked with target compounds at 5-100 times the reporting limit, depending upon the methodology being monitored. The purpose of the DCS is not to duplicate the sample matrix, but rather to provide an interference-free, homogeneous matrix from which to gather data to establish control limits. These limits are used to determine whether data generated by the laboratory on any given day is in control.

Control limits for accuracy (percent recovery) are based on the average, historical percent recovery +/- 3 standard deviation units. Control limits for precision (relative percent difference) range from 0 (identical duplicate DCS results) to the average, historical relative percent difference + 3 standard deviation units. These control limits are fairly narrow based on the consistency of the matrix being monitored and are updated on a quarterly basis.

For each batch of samples analyzed, an additional control measure is taken in the form of a Single Control Sample (SCS). The SCS consists of a control matrix that is spiked with either representative target compounds or surrogate compounds appropriate to the method being used. An SCS is prepared for each sample lot for which the DCS pair are not analyzed.

Accuracy for DCS and SCS is measured by Percent Recovery.

$$\%\ \text{Recovery} = \frac{\text{Measured Concentration}}{\text{Actual Concentration}} \times 100$$

Precision for DCS is measured by Relative Percent Difference (RPD).

$$\text{RPD} = \frac{|\ \text{Measured Concentration DCS1} - \text{Measured Concentration DCS2}\ |}{(\text{Measured Concentration DCS1} + \text{Measured Concentration DCS2})/2} \times 100$$

All samples analyzed concurrently by the same test are assigned the same QC lot number. Projects which contain numerous samples, analyzed over several days, may have multiple QC lot numbers associated with each test. The QC information which follows includes a listing of the QC lot numbers associated with each of the samples reported, DCS and SCS (where applicable) recoveries from the QC lots associated with the samples, and control limits for these lots. The QC data is reported by test code, in the order that the tests are reported in the analytical results section of this report.

11 150

2.1
QA/QC SUMMARY REPORT 1

QC LOT ASSIGNMENT REPORT
Volatile Organics by GC

11 151

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
010824-0001-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0002-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0003-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0004-SA	AQUEOUS	602-A	15 AUG 90-Q	30 AUG 90-Y
010824-0004-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0005-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0006-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0007-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0008-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0009-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0010-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0011-SA	AQUEOUS	602-A	15 AUG 90-Q	23 AUG 90-Y
010824-0011-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0012-SA	AQUEOUS	602-A	15 AUG 90-Q	23 AUG 90-Y
010824-0012-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q
010824-0013-SA	AQUEOUS	602-A	15 AUG 90-Q	15 AUG 90-Q

DUPLICATE CONTROL SAMPLE REPORT
Volatile Organics by GC

11 152

Category: 602-A
Matrix: AQUEOUS
QC Lot: 15 AUG 90-Q
Concentration Units: ug/L

Analyte	Concentration Spiked	Measured DCS1	DCS2	AVG	Accuracy Average(%) DCS	Limits	Precision (RPD) DCS	Limit
Benzene	5.0	5.12	4.81	4.96	99	80-120	6.2	15
Toluene	5.0	5.35	4.88	5.12	102	80-120	9.2	15
Ethylbenzene	5.0	5.28	4.79	5.04	101	80-120	9.7	15
Xylenes (total)	5.0	5.25	4.76	5.00	100	80-120	9.8	15
1,3-Dichlorobenzene	5.0	5.34	4.83	5.08	102	80-120	10	15

Calculations are performed before rounding to avoid round-off errors in calculated results.

SINGLE CONTROL SAMPLE REPORT
Volatile Organics by GC

Analyte	Concentration		Accuracy(%)	
	Spiked	Measured	SCS	Limits
Category: 602-A Matrix: AQUEOUS QC Lot: 15 AUG 90-Q QC Run: 15 AUG 90-Q Concentration Units: ug/L				
a,a,a-Trifluorotoluene	30.0	34.0	113	20-160
Category: 602-A Matrix: AQUEOUS QC Lot: 15 AUG 90-Q QC Run: 30 AUG 90-Y Concentration Units: ug/L				
a,a,a-Trifluorotoluene	30.0	29.1	97	20-160
Category: 602-A Matrix: AQUEOUS QC Lot: 15 AUG 90-Q QC Run: 23 AUG 90-Y Concentration Units: ug/L				
a,a,a-Trifluorotoluene	30.0	29.8	99	20-160

Calculations are performed before rounding to avoid round-off errors in calculated results.

METHOD BLANK REPORT
Volatile Organics by GC

Test: 602-AFIR-A
Matrix: AQUEOUS
QC Lot: 15 AUG 90-Q QC Run: 15 AUG 90-Q

Analyte	Result	Units	Reporting Limit
Benzene	ND	ug/L	0.70
Toluene	ND	ug/L	1.0
Chlorobenzene	ND	ug/L	1.0
Ethylbenzene	ND	ug/L	1.0
Xylenes (total)	ND	ug/L	2.0
1,3-Dichlorobenzene	ND	ug/L	2.0
1,2-Dichlorobenzene	ND	ug/L	2.0
1,4-Dichlorobenzene	ND	ug/L	0.50

Test: 602-AFIR-A
Matrix: AQUEOUS
QC Lot: 15 AUG 90-Q QC Run: 15 AUG 90-Q

Analyte	Result	Units	Reporting Limit
Benzene	ND	ug/L	0.70
Toluene	ND	ug/L	1.0
Chlorobenzene	ND	ug/L	1.0
Ethylbenzene	ND	ug/L	1.0
Xylenes (total)	ND	ug/L	2.0
1,3-Dichlorobenzene	ND	ug/L	2.0
1,2-Dichlorobenzene	ND	ug/L	2.0
1,4-Dichlorobenzene	ND	ug/L	0.50

Test: 602-AFIR-2-A
Matrix: AQUEOUS
QC Lot: 15 AUG 90-Q QC Run: 30 AUG 90-Y

Analyte	Result	Units	Reporting Limit
Benzene	ND	ug/L	0.70
Toluene	ND	ug/L	1.0
Chlorobenzene	ND	ug/L	1.0
Ethylbenzene	ND	ug/L	1.0
Xylenes (total)	ND	ug/L	2.0
1,3-Dichlorobenzene	ND	ug/L	2.0
1,2-Dichlorobenzene	ND	ug/L	2.0
1,4-Dichlorobenzene	ND	ug/L	0.50

METHOD BLANK REPORT
Volatile Organics by GC (cont.)

Test: 602-AFIR-2-A
Matrix: AQUEOUS
QC Lot: 15 AUG 90-Q QC Run: 23 AUG 90-Y

Analyte	Result	Units	Reporting Limit
Benzene	ND	ug/L	0.70
Toluene	ND	ug/L	1.0
Chlorobenzene	ND	ug/L	1.0
Ethylbenzene	ND	ug/L	1.0
Xylenes (total)	ND	ug/L	2.0
1,3-Dichlorobenzene	ND	ug/L	2.0
1,2-Dichlorobenzene	ND	ug/L	2.0
1,4-Dichlorobenzene	ND	ug/L	0.50

QC LOT ASSIGNMENT REPORT
Wet Chemistry Analysis and Preparation

11 156

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
010824-0003-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0004-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0005-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0007-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0009-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0010-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0011-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0012-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A
010824-0014-SA	AQUEOUS	TPH-IR-A	01 SEP 90-A	01 SEP 90-A

DUPLICATE CONTROL SAMPLE REPORT
Wet Chemistry Analysis and Preparation

Analyte	Concentration				Accuracy Average(%)		Precision (RPD)	
	Spiked	Measured DCS1	Measured DCS2	AVG	DCS	Limits	DCS	Limit
Category: TPH-IR-A Matrix: AQUEOUS QC Lot: 01 SEP 90-A Concentration Units: mg/L								
Total Petroleum Hydrocarbons	20	19.6	19.4	19.5	98	75-125	1.0	20

Calculations are performed before rounding to avoid round-off errors in calculated results.

METHOD BLANK REPORT
Wet Chemistry Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: TPH-IR-A Matrix: AQUEOUS QC Lot: 01 SEP 90-A QC Run: 01 SEP 90-A			
Total Petroleum Hydrocarbons	ND	mg/L	0.050
Test: TPH-IR-A Matrix: AQUEOUS QC Lot: 01 SEP 90-A QC Run: 01 SEP 90-A			
Total Petroleum Hydrocarbons	ND	mg/L	0.050

11 159

3.0

SUMMARY OF ANALYTICAL PROBLEMS AND CORRECTIVE ACTIONS

11 160

3.0
SUMMARY OF ANALYTICAL PROBLEMS AND CORRECTIVE ACTIONS

3.1 DATA REPORT 1 RMAL NO.: 010824

Approximately 14 aqueous samples were analyzed for Total Petroleum Hydrocarbons (TPH), EPA Method 418.1, and aromatic volatile organics, EPA Method 8020. Sample 018024-08 arrived at the laboratory empty. The sample was not collected in duplicate, so it could not be analyzed. All of the samples were analyzed within the specified holding times. Due to limited sample volume (less than 900 mL) collected for the TPH analyses, the reporting limits for all the TPH samples had to be adjusted. The adjusted reporting limits did not affect the sample results. TPH was detected in all samples at concentrations over the adjusted reporting limits.

All of the method blanks associated with the samples were reported non-detected, it can be assumed the samples were not contaminated by laboratory procedures. The DCS and SCS samples performed for this reported were all within laboratory established limits of acceptability for both methods.

11 161

4.0

SUMMARY OF IDENTIFICATION AND CROSS-REFERENCE

11 162

Table 4-1. SUMMARY IDENTIFICATION AND CROSS-REFERENCE

Laboratory I.D.	Client I.D.	Sample Description	Page
010824-01-SA	CAPRM-EB-001	Aqueous	1-6
010824-02-SA	CAPRM-AB-001	Aqueous	1-7
010824-03-SA	CAPRM-ROM1S-B-WG-N-003	Aqueous ROM1S	1-8, 1-22
010824-04-SA	CAPRM-ROM1S-B-WG-N-004	Aqueous ROM1S	1-9, 1-10, 1-23
010824-05-SA	CAPRM-ROM1S-WF-WP-N-005	Aqueous ROM1S	1-11, 1-24
010824-06-SA	CAPRM-ROM1S-WF-WP-FR-005	Aqueous ROM1S	1-12
010824-07-SA	CAPRM-ROM2-B-WG-N-001	Aqueous ROM2	1-13, 1-25
010824-08-SA	CAPRM-EB-001	Aqueous	1-14
010824-09-SA	CAPRM-ROM8-B-WG-N-016	Aqueous ROM8	1-15, 1-26
010824-10-SA	CAPRM-ROM8-B-WG-N-017	Aqueous ROM8	1-16, 1-27
010824-11-SA	CAPRM-ROM8-B-WG-N-018	Aqueous ROM8	1-17, 1-18, 1-28
010824-12-SA	CAPRM-ROM8-B-WG-FR-018	Aqueous ROM8	1-19, 1-20, 1-29
010824-13-SA	CAPRM-TB-001	Aqueous	1-21
010824-14-SA	CAPRM-EB-001	Aqueous	1-30

5.0

ANALYTICAL METHODOLOGY

Analytical Methodology

Enseco - Rocky Mountain Analytical Laboratory performs analytical services according to methods approved by EPA and other regulatory agencies, whenever possible.

Methods for metals and organic compounds are primarily derived from three sources of EPA methods, 1) the methods promulgated in 40 CFR 136 for priority pollutants, 2) the methods published in SW-846 and 3) methods developed by the EPA-EMSL/LV for Superfund investigations, as well as several documents published by the EPA and Enseco - Rocky Mountain Analytical Laboratory in 1984 and 1985. These methods all use the same generic technology as summarized below:

- Metals: acid digestion followed by analyses by ICP supported by graphite furnace AA
- Volatile Organics: purge and trap GC/MS or purge and trap GC with a selective detector.
- Semivolatile (base/neutral and acid) organics: solvent extraction followed by capillary column GC/MS, and
- Pesticides/Herbicides: solvent extraction, followed by gas chromatography.

Exact method references are provided in the Analytical Methodology Tables.

ANALYTICAL METHODOLOGY - INORGANIC TESTS

11 165

Test	Description	Methodology	Reference
ICP	Trace Metals	ICP Emission Spectroscopy	200.7(1)/6010(2)
FSB	Antimony	Furnace Atomic Absorption	204.2(1)/7041(2)
FAS	Arsenic	Furnace Atomic Absorption	206.2(1)/7060(2)
FCD	Cadmium	Furnace Atomic Absorption	213.2(1)/7131(2)
FPB	Lead	Furnace Atomic Absorption	239.2(1)/7421(2)
FSE	Selenium	Furnace Atomic Absorption	270.2(1)/7740(2)
FAG	Silver	Furnace Atomic Absorption	272.2(1)/7761(2)
FTL	Thallium	Furnace Atomic Absorption	279.2(1)/7841(2)
CVHG	Mercury	Cold Vapor Atomic	245.1(1)/7471(2)
CR + 6	Chromium (VI)	Colorimetric	312B(3)
IC CL	Chloride	Ion Chromatography	300.0(1)
BURCL	Chloride	Manual Titrimetric	325.3(1)
METF	Fluoride	Electrode	340.2(1)
IC SO4	Sulfate	IC	300.0(1)
SPESO4	Sulfate	Manual Turbidimetric	375.4(1)
METALK	Alkalinity, Total	Titrimetric	310.1(1)
METACK	Alkalinity, Forms	Titrimetric	403(3)
TECNOXT	Nitrate+Nitrite as N	Cd Reduction Colorimetric	353.2(1)
METPH	pH	Meter	150.1(1)/9045(2)
CELSP	Specific Conductance @ 25°C	Bridge	120.1(1)
BALTDS	Total Dissolved Solids	Gravimetric, 180°C	160.1(1)
BALTSS	Total Suspended Solids	Gravimetric, 105°C	160.2(1)
BALTS	Total Solids	Gravimetric, 105°C	160.3(1)
BALTVS	Total Volatile Solids	Gravimetric, 550°C	160.4(1)
TECO P	Ortho-Phosphate as P	Two Reagent Colorimetric	365.3(1)
TECT P	Total Phosphorus as P	Digestion-Colorimetric	365.3(1)
ICP	Total Phosphorus as P	Digestion-ICP/AES	200.7(1)
ICP	Silica as SiO_2	ICP/AES	200.7(1)
SPESIO2	Silica as SiO_2	Colorimetric	370.1(1)
METBOD	Biochemical Oxygen Demand	Dilution Bottle-D.O. probe	405.1(1)
METCOD	Chemical Oxygen Demand	Micro Colorimetric	410.4(1)
TOCTOC	Total Organic Carbon	UV Oxidation-IR	415.2(1)
METNH3	Ammonia as N	Electrode	350.3(1)
TECNH3	Ammonia as N	Automated Colorimetric	350.1(1)
METTKN	Total Kjeldahl Nitrogen as N	Digestion-Electrode	351.4(1)
TECTKN	Total Kjeldahl Nitrogen as N	Digestion-Colorimetric	351.2(1)
TOXTOX	Total Organic Halogen	Combustion-Titrimetric	9020(2)
TONO1	Total Organic Nitrogen	Calculation ($TKN-NH_3$)	-
BAL O&G	Oil and Grease	Freon Extraction-Gravimetric	413.1(1)
IR AO&G	Oil and Grease	Freon Extraction-IR	413.2(1)
TECCN F	Cyanide Amendable to Chlorination	Chlorination-Distillation-Colorimetric	335.1(1)
TECCN W	Weak & Dissolved Cyanide	Distillation-Colorimetric	412H(3)
TECCN T	Total Cyanide	Distillation-Colorimetric	335.2(1)/9010(2)
STEPHEN	Phenolics	Distillation-Colorimetric	420.1(1)
COLIF F	Fecal Coliform	Membrane Filter	909C(3)
COLIF T	Total Coliform	Membrane Filter	909A(3)

ANALYTICAL METHODOLOGY - INORGANIC TESTS (CONT.)

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Test	Description	Methodology	Reference
IC BR	Bromide	Ion Chromatography	300.0(1)
POTCL2R	Residual Chlorine	Amperometric	330.2(1)
NESCOLR	Color	Pt-Co Colorimetric	110.2(1)
ICPHAR	Hardness as $CaCo_3$	Calculation	200.7(1)/314A(3)
TECNO2	Nitrite as N	Colorimetric	354.1(1)
SPES	Sulfide	Colorimetric	376.2(1)/9030(2)
BURSO3	Sulfite	Titrimetric	377.1(1)
SPEMBAS	MBAS (Surfactants)	Colorimetric	425.1(1)
SPETURB	Turbidity	Turbidimeter	180.1(1)
Gross Alpha		Proportional Counter	703(3)
Gross Beta		Proportional Counter	703(3)
Radium 226		Separation - Counter	705(3)
Radium 228		Separation - Counter	707(3)
Uranium		Fluorimetric	D2907.75(4)

References

(1) Code of Federal Regulations, Chapter 40, Part 136 (40 CFR 136).
(2) SW-846, 2nd Edition, 1984.
(3) "Standard Methods for the Examination of Water and Wastewater", 15th Edition, 1980.
(4) "Annual Book of ASTM Standards", Part 31, Water, 1980.

ANALYTICAL METHODOLOGY - ORGANIC TESTS

Test	Description	Methodology	Reference
VOA	Volatile Organics	Purge & Trap, GC/MS	624(1)/8240(2)
BNA	Semivolatile Organics	Extraction, GC/MS	625(1)/8270(2)
DXN	Dioxin	Extraction, GC/MS	613(1)/8280(2)
601	Halogenated Volatile Organics	Purge & Trap GC/Hall	601(1)/8010(2)
THM	Trihalomethanes	Purge & Trap GC/Hall	601(1)/8010(2)
602	Aromatic Volatile Organics	Purge & Trap GC/PID	602(1)/8020(2)
OCP	Organochlorine Pesticides	Extraction, GC/ECD	608(1)/8080(2)
OPP	Organophosphate Pesticides	Extraction, GC/FPD	614(1)/8140(2)
619	Triazine Pesticides	Extraction, GC/NPD	619(1)
LC CARB	Carbamate and Urea Pesticides	Extraction, HPLC	632(1)
PCB	PCB's	Extraction, GC/ECD	608(1)/8080(2)
HRB	Phenoxyacid Herbicides	Extraction, GC/ECD	615(1)/8150(2)
603	Acrolein & Acrylonitrile	Purge & Trap GC/FID	603(1)/8030(2)
604	Phenols	Extraction, GC/FID	604(1)/8040(2)
605	Benzidines	Extraction, HPLC	605(1)/8050(2)
606	Phthalate Esters	Extraction, GC/FID	606(1)/8060(2)
607	Nitrosamines	Extraction, GC/NPD	607(1)
609	Nitroaromatics & Cyclic Ketones	Extraction, GC/NPD	609(1)/8090(2)
PNA	Polynuclear Aromatic Hydrocarbons	Extraction, HPLC	610(1)/8310(2)
611	Haloethers	Extraction, GC/ECD	611(1)
612	Chlorinated Hydrocarbons	Extraction, GC/ECD	612(1)/8120(2)
GD FID	Hydrocarbon Scan	Extraction, GC/FID	D3328-78(3)
GC BPD	Boiling Point Determination	Extraction, GC/FID	D2887-84(4)

References

(1) Code of Federal Regulations, Chapter 40, Part 136 (40 CFR 136).
(2) SW-846, 2nd Edition, 1984.
(3) "Annual Book of ASTM Standards", Volume 11.01, 1985.
(4) "Annual Book of ASTM Standards", Volume 05.02, 1984.

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS

Analytical Method	Parameters	Units	Reporting Limits
Gen Inorgs.	TPH	mg/L	0.5
Gen Inorgs.	TPH	mg/L	1.0
Gen Inorgs.	Total Solids	%	0.1
TOTAL AND DISSOLVED METALS (WATER)			
EPA 200.7	Aluminum	mg/L	0.05
EPA 200.7	Antimony	mg/L	0.05
EPA 200.7	Arsenic	mg/L	0.1
EPA 200.7	Barium	mg/L	0.005
EPA 200.7	Beryllium	mg/L	0.001
EPA 200.7	Boron	mg/L	0.01
EPA 200.7	Cadmium	mg/L	0.005
EPA 200.7	Calcium	mg/L	0.1
EPA 200.7	Chromium	mg/L	0.01
EPA 200.7	Cobalt	mg/L	0.01
EPA 200.7	Copper	mg/L	0.006
EPA 200.7	Iron	mg/L	0.05
EPA 200.7	Lead	mg/L	0.002
EPA 200.7	Magnesium	mg/L	0.1
EPA 200.7	Manganese	mg/L	0.005
EPA 200.7	Mercury	mg/L	0.0001
EPA 200.7	Molybdenum	mg/L	0.02
EPA 200.7	Nickel	mg/L	0.01
EPA 200.7	Potassium	mg/L	5
EPA 200.7	Selenium	mg/L	0.2
EPA 200.7	Silica as SiO2	mg/L	0.1
EPA 200.7	Silver	mg/L	0.005
EPA 200.7	Sodium	mg/L	0.4
EPA 200.7	Thallium	mg/L	1
EPA 200.7	Vanadium	mg/L	0.01
EPA 200.7	Zinc	mg/L	0.01
TOTAL METALS (SOIL)			
SW6010	Aluminum	mg/kg	10
SW6010	Antimony	mg/kg	5
SW6010	Barium	mg/kg	0.5
SW6010	Beryllium	mg/kg	0.1
SW6010	Boron	mg/kg	2
SW6010	Cadmium	mg/kg	0.5
SW6010	Calcium	mg/kg	20

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
SW6010	Chromium	mg/kg	1
SW6010	Cobalt	mg/kg	1
SW6010	Copper	mg/kg	0.6
SW6010	Iron	mg/kg	10
SW6010	Lead	mg/kg	5
SW6010	Magnesium	mg/kg	10
SW6010	Manganese	mg/kg	0.5
SW6010	Mercury	mg/kg	0.05
SW6010	Molybdenum	mg/kg	2
SW6010	Nickel	mg/kg	4
SW6010	Potassium	mg/kg	500
SW6010	Silica as SiO2	mg/kg	20
SW6010	Silver	mg/kg	0.5
SW6010	Sodium	mg/kg	20
SW6010	Thallium	mg/kg	300
SW6010	Vanadium	mg/kg	1
SW6010	Zinc	mg/kg	1
AROMATIC VOLATILE ORGANICS (WATER)			
SW8020	Benzene	µg/L	0.70
SW8020	Toluene	µg/L	1.0
SW8020	Chlorobenzene	µg/L	1.0
SW8020	Ethyl benzene	µg/L	1.0
SW8020	m-Xylene	µg/L	2.0
SW8020	o & p Xylene(s)	µg/L	2.0
SW8020	1,3-Dichlorobenzene	µg/L	2.0
SW8020	1,2-Dichlorobenzene	µg/L	2.0
SW8020	1,4-Dichlorobenzene	µg/L	0.50
HALOGENATED VOLATILE ORGANICS (WATER)			
SW8010	Chloromethane	µg/L	0.40
SW8010	Bromomethane (Methylbromide)	µg/L	6.0
SW8010	Dichlorodifluoromethane	µg/L	9.0
SW8010	Vinyl chloride	µg/L	0.20
SW8010	Chloroethane	µg/L	3.0
SW8010	Methylene chloride	µg/L	2.0
SW8010	Trichlorofluoromethane	µg/L	5.0
SW8010	1,1-Dichloroethene	µg/L	0.70
SW8010	1,1-Dichloroethane	µg/L	0.40
SW8010	trans-1,2-Dichloroethene	µg/L	0.50

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
SW8010	Chloroform	µg/L	0.20
SW8010	1,2-dichloroethane	µg/L	0.20
SW8010	1,1,1-Trichloroethane	µg/L	0.20
SW8010	Carbon tetrachloride	µg/L	0.60
SW8010	Bromodichloromethane	µg/L	0.50
SW8010	1,2-Dichloropropane	µg/L	0.20
SW8010	trans-1,3-Dichloropropane	µg/L	2.0
SW8010	Trichloroethene	µg/L	0.60
SW8010	Chlorodibromomethane	µg/L	0.50
SW8010	cis-1,3-Dichloropropene	µg/L	1.0
SW8010	1,1,2-Trichloroethane	µg/L	0.10
SW8010	2-Chloroethyl vinyl ether	µg/L	0.70
SW8010	Bromoform	µg/L	1.0
SW8010	1,1,2,2-Tetrachloroethane	µg/L	0.20
SW8010	Tetrachloroethene	µg/L	0.20
SW8010	Chlorobenzene	µg/L	1.2
SW8010	1,3-Dichlorobenzene	µg/L	1.0
SW8010	1,2-Dichlorobenzene	µg/L	0.50
SW8010	1,4-Dichlorobenzene	µg/L	0.50
SW8010	Benzyl chloride	µg/L	6.8
SW8010	Bromobenzene	µg/L	1.0
SW8010	Chloroacetaldehyde	µg/L	--
SW8010	1-Chlorohexane	µg/L	0.55
SW8010	Chloromethyl methyl ether	µg/L	--
SW8010	2-Chlorotoluene	µg/L	--
SW8010	Dibromomethane	µg/L	0.82
SW8010	1,1,1,2-Tetrachloroethane	µg/L	0.24
SW8010	1,2,3-Trichloropropane	µg/L	4.4
SW8010	Bis(2-chloroethoxy) methane	µg/L	--
SW8010	bis(2-Chloroisopropyl) ether	µg/L	10
SEMIVOLATILE ORGANICS (SOIL)			
SW8270	Phenol	mg/kg	0.50
SW8270	bis(2-Chloroethyl)ether	mg/kg	0.50
SW8270	2-Chlorophenol	mg/kg	0.50
SW8270	1,3-Dichlorobenzene	mg/kg	0.50
SW8270	1,4-Dichlorobenzene	mg/kg	0.50
SW8270	1,2-Dichlorobenzene	mg/kg	0.50
SW8270	bis(2-Chloroisopropyl)ether	mg/kg	0.50
SW8270	N-Nitroso-di-n-propylamine	mg/kg	0.50
SW8270	Hexachloroethane	mg/kg	0.50

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
SW8270	Nitrobenzene	mg/kg	0.50
SW8270	Isophorone	mg/kg	0.50
SW8270	2-Nitrophenol	mg/kg	0.50
SW8270	2,4-dimethylphenol	mg/kg	0.50
SW8270	bis(2-Chloroethoxy)methane	mg/kg	0.50
SW8270	2,4-Dichlorophenol	mg/kg	0.50
SW8270	1,2,4-Trichlorobenzene	mg/kg	0.50
SW8270	Naphthalene	mg/kg	0.50
SW8270	Hexachlorobutadiene	mg/kg	0.50
SW8270	4-Chloro-3-methylphenol	mg/kg	0.50
SW8270	2,4,6-Trichlorophenol	mg/kg	0.50
SW8270	2,4,5-Trichlorophenol	mg/kg	1.5
SW8270	2-Chloronaphthalene	mg/kg	0.50
SW8270	Dimethyl phthalate	mg/kg	0.50
SW8270	Acenaphthylene	mg/kg	0.50
SW8270	Acenaphthene	mg/kg	0.50
SW8270	2,4-Dinitrophenol	mg/kg	0.50
SW8270	4-Nitrophenol	mg/kg	0.50
SW8270	2,4-Dinitrotoluene	mg/kg	1.5
SW8270	2,6-Dinitrotoluene	mg/kg	3.5
SW8270	Diethyl phthalate	mg/kg	0.50
SW8270	4-Chlorophenyl phenyl ether	mg/kg	0.50
SW8270	Fluorene	mg/kg	0.50
SW8270	4,6-Dinitro-2-methylphenol	mg/kg	1.5
SW8270	4-Bromophenyl ether	mg/kg	0.50
SW8270	Hexachlorobenzene	mg/kg	0.50
SW8270	Pentachlorophenol	mg/kg	0.50
SW8270	Phenanthrene	mg/kg	0.50
SW8270	Anthracene	mg/kg	0.50
SW8270	Di-n-butyl phthalate	mg/kg	0.50
SW8270	Fluoranthene	mg/kg	0.50
SW8270	Pyrene	mg/kg	0.50
SW8270	Butyl benzyl phthalate	mg/kg	0.50
SW8270	3,3'-Dichlorobenzidine	mg/kg	0.50
SW8270	bis(2-Ethylhexyl)phthalate	mg/kg	0.50
SW8270	Chrysene	mg/kg	0.50
SW8270	Di-n-octyl phthalate	mg/kg	0.50
SW8270	Benzo(b)fluoranthene	mg/kg	0.50
SW8270	Benzo(k)fluoranthene	mg/kg	0.50
SW8270	Benzo(a)pyrene	mg/kg	0.50
SW8270	Indeno(1,2,3-c,d)pyrene	mg/kg	0.50
SW8270	Dibenzo(a,h)anthracene	mg/kg	0.50
SW8270	Benzo(g,h,i)perylene	mg/kg	0.50

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
VOLATILE ORGANICS (SOIL)			
SW8240	Chloromethane	mg/kg	0.10
SW8240	1,1,2-Trichloroethane	mg/kg	0.10
SW8240	2-Butanone	mg/kg	0.10
SW8240	Carbon tetrachloride	mg/kg	0.10
SW8240	1,1,1-Trichloroethane	mg/kg	0.10
SW8240	1,2-Dichloropropane	mg/kg	0.10
SW8240	Benzene	mg/kg	0.10
SW8240	trans-1,3-Dichloropropene	mg/kg	0.10
SW8240	Bromodichloromethane	mg/kg	0.10
SW8240	1,2-Dichloroethane	mg/kg	0.10
SW8240	cis-1,3-Dichoropropene	mg/kg	0.10
SW8240	2-Chloroethyl vinly ether	mg/kg	0.10
SW8240	Bromoform	mg/kg	0.10
SW8240	Ethyl benzene	mg/kg	0.10
SW8240	Chlorbenzene	mg/kg	0.10
SW8240	Toluene	mg/kg	0.10
SW8240	Tetrachloroethene	mg/kg	0.10
SW8240	1,1,2,2-Tetrachloroethane	mg/kg	0.10
SW8240	4-Methyl-2-pentanone	mg/kg	0.10
SW8240	Vinyl chloride	mg/kg	0.10
SW8240	Trichlorofluoromethane	mg/kg	0.10
SW8240	1,2-Dichlorobenzene	mg/kg	0.10
SW8240	1,4-Dichlorobenzene	mg/kg	0.10
SW8240	1,3-Dichlorobenzene	mg/kg	0.10
SW8240	Chloroethane	mg/kg	0.10
SW8240	Methylene chloride	mg/kg	0.10
SW8240	Acetone	mg/kg	0.10
SW8240	Carbon disulfide	mg/kg	0.10
SW8240	1,1-Dichloroethene	mg/kg	0.10
SW8240	1,1-Dichloroethane	mg/kg	0.10
SW8240	trans-1,2-Dichloroethene	mg/kg	0.10
SW8240	Chloroform	mg/kg	0.10
SW8240	Bromomethane (Methylbromide)	mg/kg	0.10
SW8240	Trichloroethene	mg/kg	0.10
SW8240	Chlorodibromomethane	mg/kg	0.10
SW8240	Total xylenes	mg/kg	0.10
ORGANOCHLORINE AND PCB'S (WATER)			
EPA 608	Methoxychlor	µg/L	0.50
EPA 608	alpha-BHC	µg/L	0.050

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
EPA 608	beta-BHC	µg/L	0.050
EPA 608	delta-BHC	µg/L	0.050
EPA 608	Toxaphene	µg/L	1.0
EPA 608	gamma-BHC (Lindane)	µg/L	0.050
EPA 608	Heptachlor	µg/L	0.020
EPA 608	Aldrin	µg/L	0.050
EPA 608	Heptachlor epoxide	µg/L	0.050
EPA 608	Endosulfan I	µg/L	0.050
EPA 608	Dieldrin	µg/L	0.020
EPA 608	4,4'-DDE	µg/L	0.10
EPA 608	Endrin	µg/L	0.060
EPA 608	Endosulfan II	µg/L	0.10
EPA 608	4,4'-DDD	µg/L	0.10
EPA 608	Endosulfan sulfate	µg/L	0.10
EPA 608	4,4'-DDT	µg/L	0.10
EPA 608	Endrin aldehyde	µg/L	0.10
EPA 608	Chlordane	µg/L	0.050
EPA 608	Arochlor-1016	µg/L	0.50
EPA 608	Arochlor-1221	µg/L	0.50
EPA 608	Arochlor-1232	µg/L	0.50
EPA 608	Arochlor-1242	µg/L	0.50
EPA 608	Arochlor-1248	µg/L	0.50
EPA 608	Arochlor-1254	µg/L	1.0
EPA 608	Arochlor-1260	µg/L	1.0
ORGANOCHLORINE AND PCB's (SOIL)			
SW8080	Endrin aldehyde	mg/kg	0.010
SW8080	alpha-BHC	mg/kg	0.010
SW8080	beta-BHC	mg/kg	0.010
SW8080	delta-BHC	mg/kg	0.010
SW8080	gamma-BHC (Lindane)	mg/kg	0.010
SW8080	Heptachlor	mg/kg	0.010
SW8080	Endosulfan I	mg/kg	0.010
SW8080	Dieldrin	mg/kg	0.020
SW8080	4,4'-DDE	mg/kg	0.020
SW8080	Endrin	mg/kg	0.020
SW8080	Endosulfan II	mg/kg	0.020
SW8080	4,4'-DDT	mg/kg	0.020
SW8080	Endosulfan sulfate	mg/kg	0.020
SW8080	4,4'-DDT	mg/kg	0.020

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
SW8080	Methoxychlor	mg/kg	0.010
SW8080	Chlordane	mg/kg	0.10
SW8080	Toxaphene	mg/kg	0.20
SW8080	Arochlor 1016	mg/kg	0.10
SW8080	Arochlor 1221	mg/kg	0.10
SW8080	Arochlor 1232	mg/kg	0.10
SW8080	Arochlor 1242	mg/kg	0.10
SW8080	Arochlor 1248	mg/kg	0.10
SW8080	Arochlor 1254	mg/kg	0.20
SW8080	Arochlor 1260	mg/kg	0.20
SW8080	Heptachlor epoxide	mg/kg	0.010
SEMIVOLATILE ORGANICS (WATER)			
EPA 625	Phenol	µg/L	10
EPA 625	bis(2-Chloroethyl)ether	µg/L	10
EPA 625	2-Chlorophenol	µg/L	10
EPA 625	1,3-Dichlorobenzene	µg/L	5.0
EPA 625	1,4-Dichlorobenzene	µg/L	5.0
EPA 625	1,2-Dichlorobenzene	µg/L	5.0
EPA 625	bis(2-Chloroisopropyl)ether	µg/L	10
EPA 625	N-Nitroso-di-n-propylamine	µg/L	10
EPA 625	Hexachloroethane	µg/L	10
EPA 625	Nitrobenzene	µg/L	10
EPA 625	Isophorone	µg/L	10
EPA 625	2-Nitrophenol	µg/L	10
EPA 625	2,4-dimethylphenol	µg/L	10
EPA 625	bis(2-Chloroethoxy)methane	µg/L	10
EPA 625	2,4-Dichlorophenol	µg/L	10
EPA 625	1,2,4-Trichlorobenzene	µg/L	10
EPA 625	Naphthalene	µg/L	10
EPA 625	Hexachlorobutadiene	µg/L	10
EPA 625	4-Chloro-3-methylphenol	µg/L	10
EPA 625	2,4,6-Trichlorophenol	µg/L	10
EPA 625	2,4,5-Trichlorophenol	µg/L	50
EPA 625	2-Chloronaphthalene	µg/L	10
EPA 625	Dimethyl phthalate	µg/L	10
EPA 625	Acenaphthylene	µg/L	10
EPA 625	Acenaphthene	µg/L	10
EPA 625	2,4-Dinitrophenol	µg/L	50
EPA 625	4-Nitrophenol	µg/L	50

Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (continued)

Analytical Method	Parameters	Units	Reporting Limits
EPA 625	2,4-Dinitrotoluene	µg/L	10
EPA 625	2,6-Dinitrotoluene	µg/L	10
EPA 625	Diethyl phthalate	µg/L	20
EPA 625	4-Chlorophenyl phenyl ether	µg/L	10
EPA 625	Fluorene	µg/L	10
EPA 625	4,6-Dinitro-2-methylphenol	µg/L	50
EPA 625	4-Bromophenyl ether	µg/L	10
EPA 625	Hexachlorobenzene	µg/L	10
EPA 625	Pentachlorophenol	µg/L	30
EPA 625	Phenanthrene	µg/L	10
EPA 625	Anthracene	µg/L	10
EPA 625	Di-n-butyl phthalate	µg/L	10
EPA 625	Fluoranthene	µg/L	10
EPA 625	Pyrene	µg/L	10
EPA 625	Butyl benzyl phthalate	µg/L	10
EPA 625	3,3'-Dichlorobenzidine	µg/L	30
EPA 625	bis(2-Ethylhexyl)phthalate	µg/L	10
EPA 625	Chrysene	µg/L	10
EPA 625	Di-n-octyl phthalate	µg/L	10
EPA 625	Benzo(b)fluoranthene	µg/L	10
EPA 625	Benzo(k)fluoranthene	µg/L	10
EPA 625	Benzo(a)pyrene	µg/L	10
EPA 625	Indeno(1,2,3-c,d)pyrene	µg/L	10
EPA 625	Dibenzo(a,h)anthracene	µg/L	10
EPA 625	Benzo(g,h,i)perylene	µg/L	10
EPA 625	Benzo(g,h,i)perylene	µg/L	10
EPA 625	Hexachlorocyclopentadiene	µg/L	10
EPA 625	Acetophenone	µg/L	50
EPA 625	Aniline	µg/L	50
EPA 625	4-Aminobiphenyl	µg/L	50
EPA 625	Benzidine	µg/L	170
EPA 625	Benzoic acid	µg/L	50
EPA 625	Benzyl alcohol	µg/L	20
EPA 625	4-Chloroaniline	µg/L	20
EPA 625	1-Chloronaphthalene	µg/L	50
EPA 625	Dibenz(a,j)acridine	µg/L	--
EPA 625	Dibenzofuran	µg/L	10
EPA 625	p-Dimethylaminoazobenzene	µg/L	50
EPA 625	7,12-Dimethylbenz-anthracene	µg/L	50
EPA 625	a,a-Diphenylhydrazine	µg/L	--
EPA 625	Diphenylamine	µg/L	50

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Table 5-1. ANALYTICAL DETECTION AND QUANTITATION LIMITS (concluded)

Analytical Method	Parameters	Units	Reporting Limits
EPA 625	1,2-Diphenylhydrazine	µg/L	50
EPA 625	Ethyl methanesulfonate	µg/L	50
EPA 625	3-Methylcholanthrene	µg/L	50
EPA 625	Methyl methanesulfonate	µg/L	50
EPA 625	2-Methylnaphthalene	µg/L	10
EPA 625	1-Naphthylamine	µg/L	50
EPA 625	2-Naphthylamine	µg/L	50
EPA 625	2-Nitroaniline	µg/L	50
EPA 625	3-Nitroaniline	µg/L	50
EPA 625	4-Nitroaniline	µg/L	50
EPA 625	Pentachlorobenzene	µg/L	50
EPA 625	Pentachloronitrobenzene	µg/L	50
EPA 625	Phenacetin	µg/L	50
EPA 625	2-Picoline	µg/L	50
EPA 625	Pronamide	µg/L	50
EPA 625	1,2,4,5-Tetrachlorobenzene	µg/L	50
EPA 625	2,6-dichlorophenol	µg/L	50
EPA 625	2-Methylphenol	µg/L	10
EPA 625	4-Methylphenol	µg/L	10
EPA 625	2,3,4,6-Tetrachlorophenol	µg/L	50
EPA 625	N-Nitrosodimethylamine	µg/L	50
EPA 625	N-Nitrosodi-n-butylamine	µg/L	50
EPA 625	N-Nitrosodiphenylamine	µg/L	10

6.0

SUMMARY OF EXTRACTION AND ANALYSIS DATES

Table 6-1. SUMMARY OF EXTRACTION AND ANALYSIS DATES

Sample No.	Sampling Date	EPA Method 418.1 Extraction Date	EPA Method 418.1 Analysis Date	EPA Method 8020 Extraction Date	EPA Method 8020 Analysis Date
CAPRM-EB-001	09 Aug 90			NA	15 Aug 90
CAPRM-AB-002	09 Aug 90			NA	15 Aug 90
CAPRM-ROM1S-B-WG-N-003	09 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM1S-B-WG-N-004	09 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM1S-WF-WP-N-005	09 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM1S-WF-WP-FR-005	09 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM2-B-WG-N-001	09 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-EB-002	10 Aug 90			NA	15 Aug 90
CAPRM-ROM8-B-WG-N-016	10 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM8-B-WG-N-017	10 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM8-B-WG-N-018	10 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-ROM8-B-WG-FR-018	10 Aug 90	NA	01 Sept 90	NA	15 Aug 90
CAPRM-TB-001	12 Aug 90			NA	15 Aug 90
CAPRM-EB-001	10 Aug 90	NA	01 Sept 90		

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7.0
CHAIN-OF-CUSTODY FORMS

Enseco - Rocky Mountain Analytical

4955 Yarrow Street
Arvada, Colorado 80002
303/421-6611 Facsimile: 303/431-7171

CHAIN OF CUSTODY

No.

Attn: Cindy Ingram

Enseco Client: Woodward Clyde Consultants

Project: Cape Romanzof

Sampling Co.: Woodward-Clyde Consultants

Sampling Site: Cape Romanzof, Alaska

Team Leader: Robin Spencer

SAMPLE SAFE™ CONDITIONS

1. Packed by: ______ Seal # ______
2. Seal Intact Upon Receipt by Sampling Co.: Yes No
3. Condition of Contents: good
4. Sealed for Shipping by: R Spencer
5. Initial Contents Temp.: 4 °C Seal # ______
6. Sampling Status: [✓ Done] Continuing Until ______
7. Seal Intact Upon Receipt by Laboratory: Yes No
8. Contents Temperature Upon Receipt by Lab: ______ °C
9. Condition of Contents: ______

Date	Time	Sample ID/Description	Sample Type	No. Containers	Analysis Parameters	Remarks
8/1/90	1025	CAPRM-EB-001	water	3	8020	
	1030	CAPRM-AB-001		3	8020	
	1450	CAPRM-ROM15-B-WG-N-003 Well A		4	418.1, 8020	
	1535	CAPRM-ROM15-B-WG N-004 Well B		4	418.1, 8020	
	1430	CAPRM-ROM15-WF-WP-N-005 Well 1		4	418.1, 8020	Well water contained bubbles like carbonation when it settled, it formed a big bubble when collected no head space was available
	1430	CAPRM-ROML15-WF-WP FR 005 Well 1		3	8020	
	1845	CAPRM-ROML2-B-WG-N-001 Well 3		4	418.1, 8020	
8/10/90	0950	CAPRM-EB-002		3	8020	
	1000	CAPRM-ROM8-B-WG-N-016 MW-1		4	418.1, 8020	
	1015	CAPRM-ROM8-B-WG-N-017 MW 2		4	418.1, 8020	

CUSTODY TRANSFERS PRIOR TO SHIPPING

	Relinquished by: (signed)	Received by: (signed)	Date	Time
1			8/10/90	2000
2				

SHIPPING DETAILS

Delivered to Shipper by: R Spencer 0490 8000

Method of Shipment: Alaska Airbill # ~~1913 3376~~

Received for Lab: ______ Signed: ______ Date/Time ______

Enseco Project No. ______

Enseco - Rocky Mountain Analytical

4955 Yarrow Street
Arvada, Colorado 80002
303/421-6611 Facsimile: 303/431-7171

CHAIN OF CUST DY

No.

Attn: Cindy Ingram

Enseco Client Woodward Clyde Consultants

Project Cape Romanzof

Sampling Co. Woodward Clyde Consultants

Sampling Site Cape Romanzof, Alaska

Team Leader Robin Spencer

SAMPLE SAFE™ CONDITIONS

1. Packed by: ______ Seal # ______
2. Seal Intact Upon Receipt by Sampling Co: Yes No
3. Condition of Contents: good
4. Sealed for Shipping by. R Spencer
5. Initial Contents Temp 4 °C Seal # ______
6. Sampling Status. [✓ Done] Continuing Until ______
7. Seal Intact Upon Receipt by Laboratory: Yes No
8. Contents Temperature Upon Receipt by Lab: ______ °C
9. Condition of Contents: ______

Date	Time	Sample ID/Description	Sample Type	No. Containers	Analysis Parameters	Remarks
8/10/90	1030	CAPRM-ROMB-B-WS-N-018 MW-4	water	4	418.1, 8020	
↓	1030	CAPRM-ROMB-B-WS-FR 018 MW-4	↓	94	418.1, 8020	
8/12/90		CAPRM-TB 001		1	8020	
8/16/90	1700	CAPRM-EB-001		1	418.1	
8/16/90	1705	CAPRM-EB-002		1	418.1	

CUSTODY TRANSFERS PRIOR TO SHIPPING

	Relinquished by (signed)	Received by: (signed)	Date	Time
1	R Spencer		8/16/90	[illegible]
2				

SHIPPING DETAILS

Delivered to Shipper by: R Spencer

Method of Shipment Alaska Gold Streak / MarkAir Airbill # 0440 2800 [illegible]

Received for Lab. ______ Signed: ______ Date/Time ______

Enseco Project No ______

FINAL PAGE

ADMINISTRATIVE RECORD

FINAL PAGE