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HEADQUARTERS 377TH AIR BASE WING (AFMC)

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PROGRAM

4 April 1994

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2000 Wyoming Blvd SE
Kirtland AFB NM 87117-5659

Ms. Barbara Hoditschek, Project Manager
New Mexico Environment Department
Hazardous and Radioactive Materials Bureau
525 Camino de los Marquez, Ste 4
Santa Fe NM 87502

Dear Ms. Hoditschek

Enclosed are two copies of the revised pages for final Post-Closure Plan, Sewage Lagoons and Golf Course Main Pond.

If you have any questions, please feel free to contact me at (505) 846-2773/0053.

Sincerely

CHRISTOPHER B. DeWITT, R.P.G.
IRP Geologist
Environmental Mgmt Division

Attachment:
Revised Pages (2 cys)

KAFB1392

DANIEL B. STEPHENS & ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS AND ENGINEERS

POST-CLOSURE PLAN
SEWAGE LAGOONS AND
GOLF COURSE MAIN POND

Prepared for

Kirtland Air Force Base

Albuquerque, New Mexico

April 1, 1994

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1. INTRODUCTION

Daniel B. Stephens & Associates, Inc. has prepared this final draft of the post-closure plan for the sewage lagoons and golf course main pond at Kirtland Air Force Base (KAFB) in response to direction provided by the New Mexico Environment Department (NMED). Clean closure of the two sites was certified in a letter dated August 12, 1993 from KAFB to the NMED (KAFB, 1993). However, clean closure was not accepted by NMED on the basis that total chromium (Cr) in some ground-water samples collected from wells at each site have exceeded regulatory limits for Cr (NMED, 1993). In the September 27, 1993 letter denying clean closure, NMED suggested that the post-closure plan include information and discussion that address the issue of Cr in ground-water samples.

1.1 Scope of Work

The scope of work (SOW) for this project is defined in a work assignment form dated December 6, 1993 as part of contract number F29650-93D0019. The SOW includes the preparation of a post-closure plan for two sewage lagoons and the golf course main pond at KAFB. The post-closure plan includes two phases, as outlined below:

- Phase I is for additional sampling and Cr analysis to be done in two stages. Phase I includes collection and analysis of two additional sludge samples from the two sewage lagoons and an additional year of quarterly ground-water sampling from all four wells at each site.

- Phase II activities to further define or remediate Cr contamination will depend on the results of all Phase I activities.

1.2 Objectives and Organization

The primary objectives of this plan are to document the technical and regulatory framework supporting clean closure at these two sites and to outline proposed actions to confirm the presence or absence of Cr in the ground water beneath these two sites. The activities

documented in this post-closure plan will be carried out under the direction of the Environmental Management Division at KAFB. The point of contact is Colonel Thomas A. Norris (or his representative), who can be contacted at the following address or phone number:

377 ABW/EM
2000 Wyoming Boulevard SE
Kirtland Air Force Base, New Mexico 87117-5659
505/846-2751

This draft post-closure plan contains a review of site histories and a summary of previous investigations (Sections 2 and 3). The plan also includes a brief review of pertinent issues regarding the presence of Cr in ground water at KAFB (Section 4). Discussion of the regulatory framework for the closure, as understood by KAFB, includes a brief review of issues pertinent to clean closure and a review of site and waste characterization and classification (Section 5). The plan concludes with the proposed sampling activities for Phase I and, should they be necessary, proposed Phase II activities of the post-closure period (Section 6). A schedule with milestones is also included in Section 6.

2. SITE HISTORY

This section provides a brief description of the location, dates of operation, types of wastes, and general management of the sewage lagoons (Site 5) and the golf course main pond (Site 6) at KAFB. KAFB is located in southeast Albuquerque, New Mexico (Figure 1). This section has been divided in two subsections; Section 2.1 discusses the sewage lagoon and Section 2.2 the golf course main pond. Most of the information provided in this section is compiled from the Stage 2 RI/FS technical report prepared by U.S. Geological Survey (USGS) (1993a).

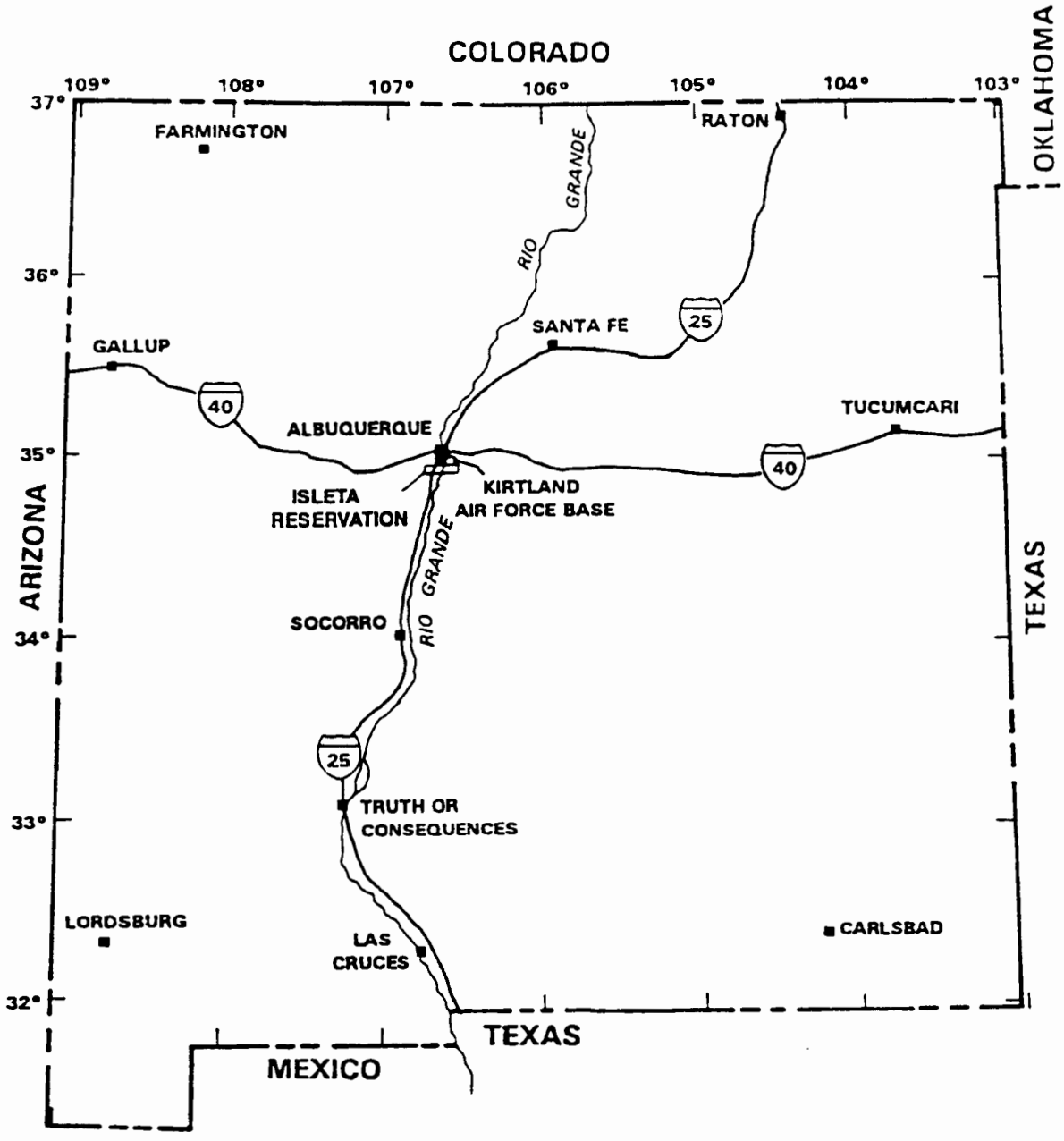
2.1 Sewage Lagoons

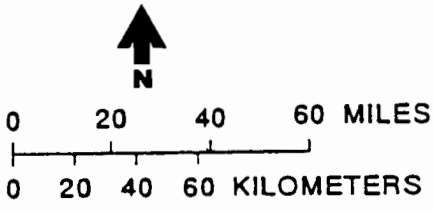
The KAFB sewage lagoons are located 1½ miles southeast of the main runway of the Albuquerque International Airport and northwest of the Trestle Aircraft Testing Facility (Figure 2). The site altitude is 5,355 feet above sea level.

The site consists of two adjacent lagoons called the north and south lagoons (Figure 3). The lagoons are square, measuring approximately 550 feet on each side, covering approximately 6.35 acres in surface area, and approximately 6 feet deep. The lagoons were constructed on native soils and local fill from on-site grading. The lagoons were filled by two pipes that discharged sewage influent into the center of each lagoon. A 20-inch outlet pipe in the southeastern corner of the south lagoon allowed liquid to gravity-flow to the golf course main pond (Site 6).

The lagoons are in an open space relatively isolated from occupied areas. Access to the sewage lagoons is limited: a security fence with warning signs surrounds the area, limiting entry by unauthorized personnel. Access to KAFB is also secured.

The sewage lagoons were constructed by the Air Force in 1962 as part of a water conservation system. They were used until 1987 for treatment of raw sewage collected through sewer lines from facilities on the southeast quadrant of KAFB, including office buildings, flight-line units, aircraft maintenance shops, Sandia National Laboratories, and base housing units. Depending upon irrigation needs at the KAFB golf course, 40 to 100 percent of the untreated base sewage was routed to the lagoons from April to October of each year. From November to March, all base





Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

KAFB
Location Map

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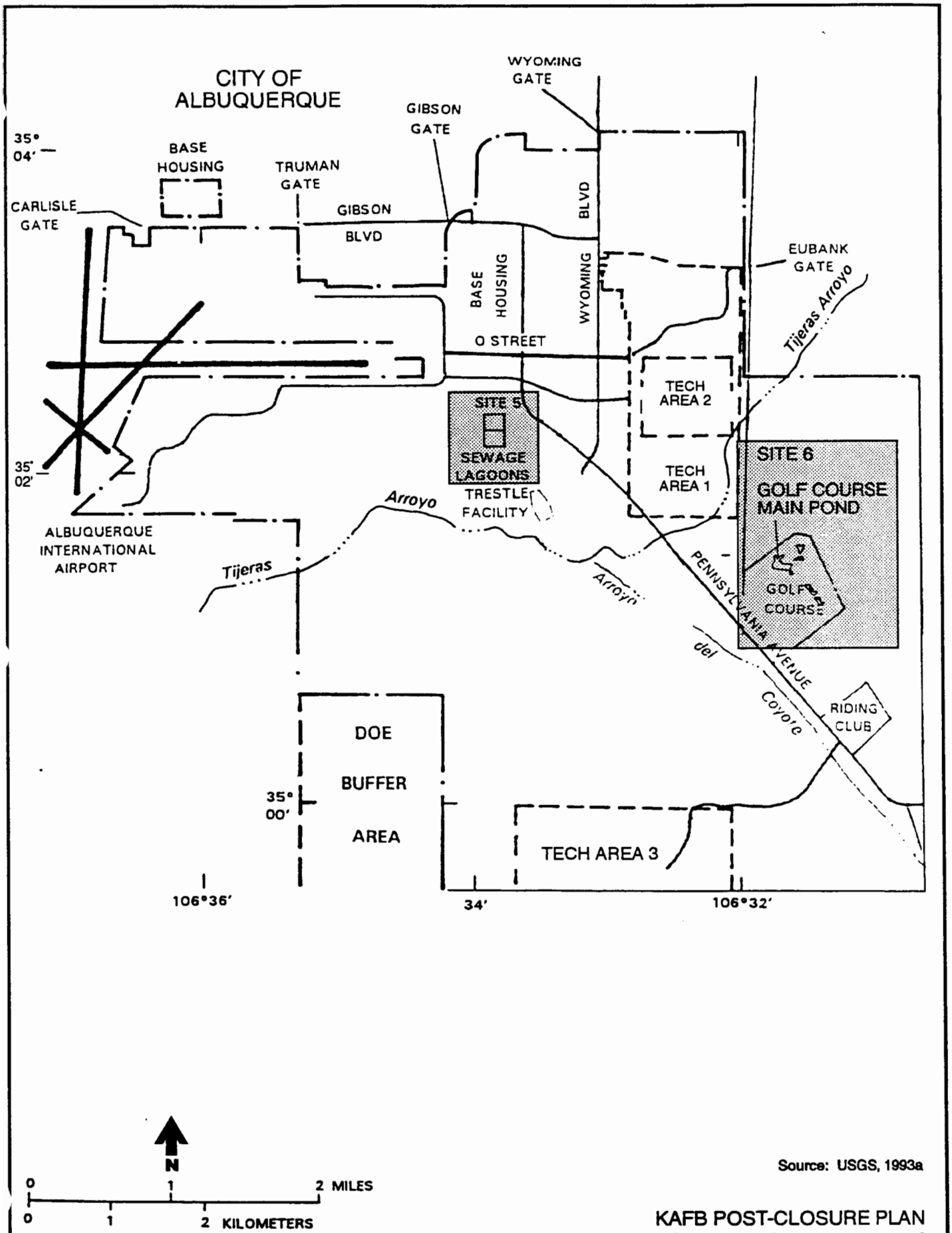
Figure 1



Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Sewage Lagoons and Golf Course Main Pond Location Map

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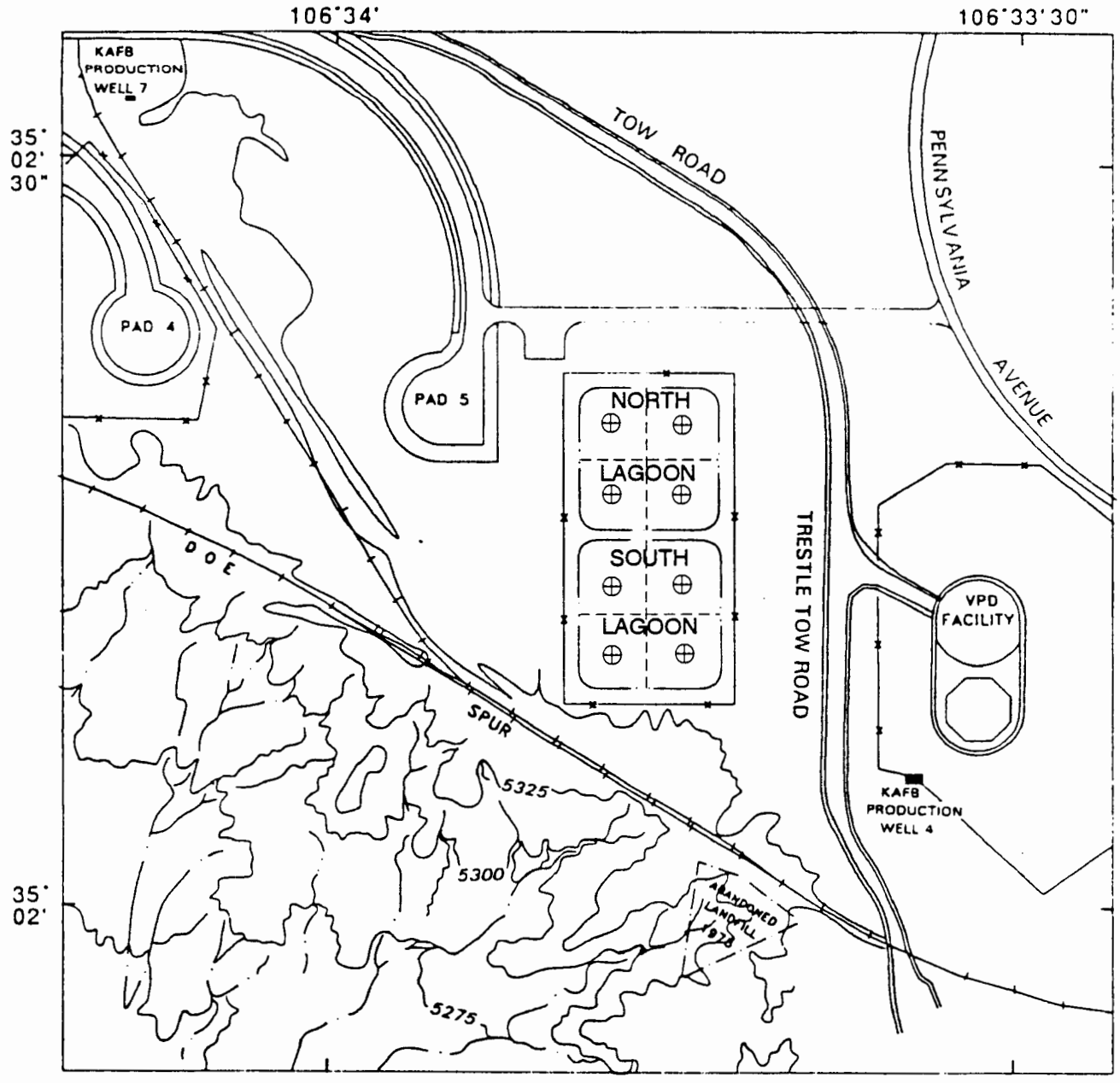
Figure 2



Sewage Lagoon Area

N

0 200 400 600 800 FEET

0 100 200 METERS

CONTOUR INTERVAL 25 FEET

Explanation

- Subsample Location
- Production Well
- Fence
- Paved Road

Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Sewage Lagoons Site Map

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Figure 3

sewage was routed to the Albuquerque municipal sewage treatment facilities, and the KAFB lagoons were unused.

The lagoons last received untreated sewage in October 1987. The liquid in the lagoons had evaporated as of January 1989, and only a thin layer of dry sludge was in the lagoons during sampling in 1990. The sludge averaged 1.39 inches thick in the north lagoon and 0.98 inch thick in the south lagoon at that time. Based on these depths, approximately 2,000 cubic yards of sludge remained in the lagoons. Periodic biological activity has reduced the quantity of sludge since operations ceased in 1987.

The flat bottoms of the lagoons are unlined, allowing the infiltration of precipitation. However, the potential for downward migration is much less than it was during the operation of the lagoons when positive hydraulic head provided by ponded water resulted in potentially higher seepage rates.

The piping and other facilities associated with the lagoon operation remain in place. The sludge remaining in the lagoons is a fibrous, organic-rich material that is not prone to erosion by wind. The site is bermed as protection from run-on and run-off erosion. The thin layer of sewage sludge that accumulated during the operations at the sewage lagoons has dried and is currently covered with vegetation.

All precipitation that falls on the lagoons either evaporates or infiltrates through the sludge into the underlying soil. At present the primary concern is the potential for migration of Cr from the sludge into the ground water, which occurs about 450 feet below the land surface. Ground-water samples have been collected on a periodic basis since the installation of four monitor wells during Stage 2 of the base-wide RCRA Facility Investigation (RFI) in 1989 (USGS, 1993a).

2.2 Golf Course Main Pond

The golf course main pond is located on the northwest side of the Tijeras Arroyo Golf Course on KAFB. The golf course is a half-mile southeast of Tijeras Arroyo and 1 mile north of the riding stables (Figure 2). The site is 5,350 feet above sea level.

The golf course main pond lies in an open area accessible to Tijeras Arroyo Golf Course patrons (Figure 4). The golf course main pond does not have a security fence, but warning signs pertaining to the water in the pond are posted around the pond. Access onto KAFB is secured.

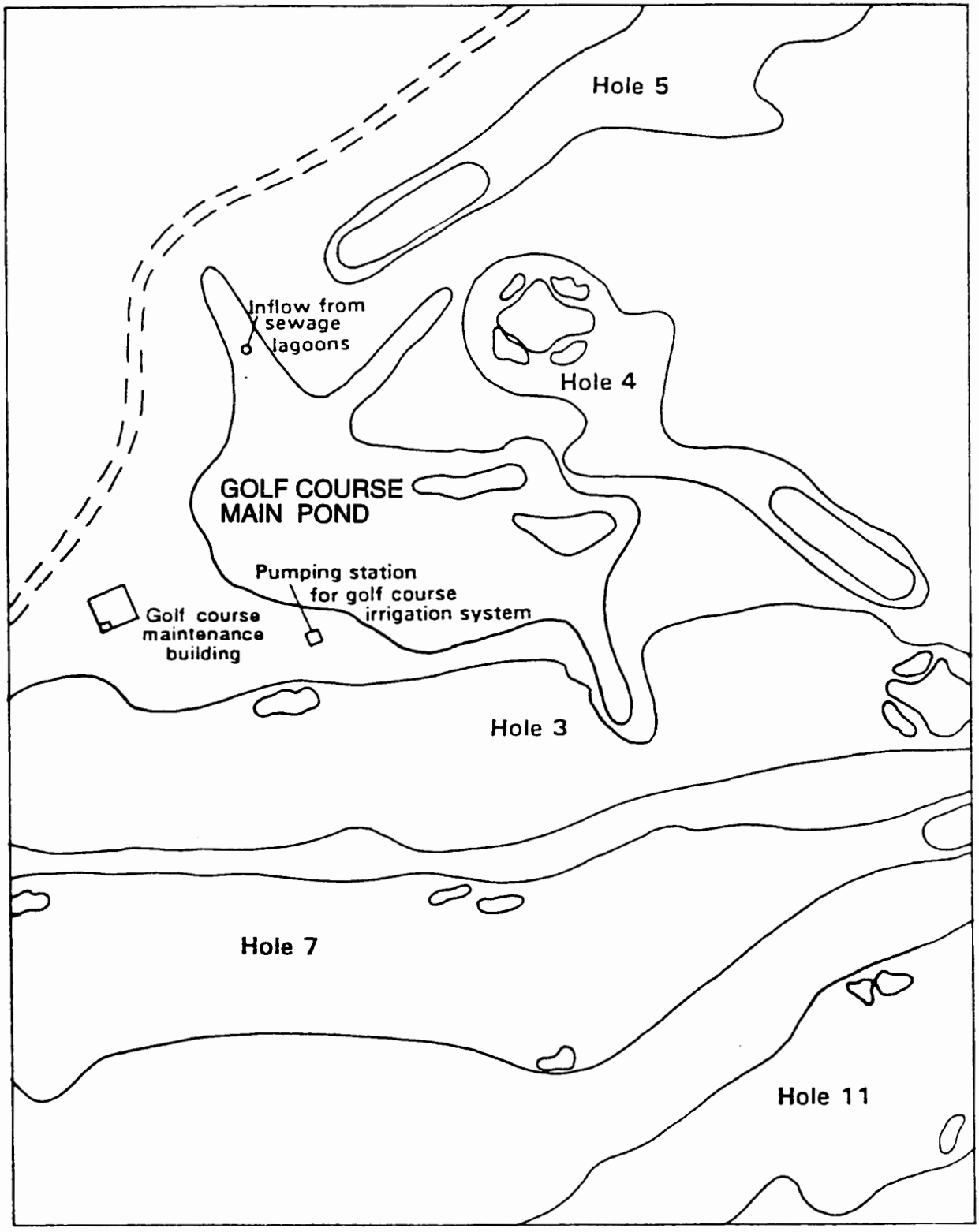
The golf course main pond was constructed by the U.S. Air Force in 1962. As part of a water conservation program, the golf course main pond served as a storage pond for wastewater that flowed by gravity through a 20-inch pipeline from the sewage lagoons (Site 5). The pond was constructed by excavating below the surrounding grade in a pre-existing drainage, building an earthen dam on the west end of the excavated area, and lining the base of the pond with plastic, making the golf course main pond a surface-water catchment.

The watershed area above the golf course main pond is about 3 square miles on a steep west-facing slope that reaches an elevation of about 1,000 feet above the pond. The wastewater in the pond was mixed with surface-water runoff and well water and used to irrigate the golf course from April to October of each year. Depending upon irrigation needs, 40 to 100 percent of the untreated base sewage wastewater was routed through the lagoons to the golf course main pond.

The liquid in the golf course main pond had evaporated as of January 1989, and currently only dry sediment is in the pond. The pond covers 2.61 acres. The bed of the pond is somewhat irregular in elevation, and the sediment thickness varies from 6 to 12 inches. Assuming an average depth of 8 inches, the volume of sediment would be about 3,000 cubic yards.

A thin layer of sludge accumulated in the bottom of the main pond during its use (1962 through 1987). The sludge in the main pond was analyzed in 1989 and determined to be free of any Appendix VIII constituents (as defined in 40 Code of Federal Regulations [CFR], Part 261), except acetone in one sediment sample. Beryllium concentrations in the pond sediments were similar to those naturally occurring in soils at KAFB (Section 3.2.2.1).

As with the sewage lagoons, the primary concern at the main pond is the potential for migration of Cr from the sludge into the ground water beneath the site. Ground water is approximately 320 feet below the land surface. Ground-water samples have been collected on a periodic basis since the installation of four monitor wells during Stage 2 of the base-wide RFI in 1990 (USGS, 1993a).



N

0 100 200 300 FEET

0 100 METERS

Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Golf Course Main Pond Site Map

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Figure 4

3. PREVIOUS INVESTIGATIONS

This section summarizes data collected during previous investigations at the KAFB sewage lagoon and the golf course main pond. This section has been divided into two subsections; Section 3.1 addresses the sewage lagoon and Section 3.2 the golf course main pond. Most of the information provided in this section was compiled from the Stage 2 RI/FS technical report (1993a) and the draft Stage 2A RFI report (1993b), both prepared by the U.S. Geological Survey. Because Cr, both in the trivalent [Cr(III)] and hexavalent [Cr(VI)] form, is the primary constituent of concern at this stage of activities at these sites, it is the focus of the review that follows.

3.1 Sewage Lagoons

A series of samples, including surface water, sediment, sludge, soil, and ground-water samples, have been collected in and around the sewage lagoon since the spring of 1988 as part of the previous investigations at KAFB. Subsections 3.1.1 through 3.1.3 discuss the findings of these investigations. One additional round of ground-water samples (May 1992) was collected after the end of Stage 2A field work.

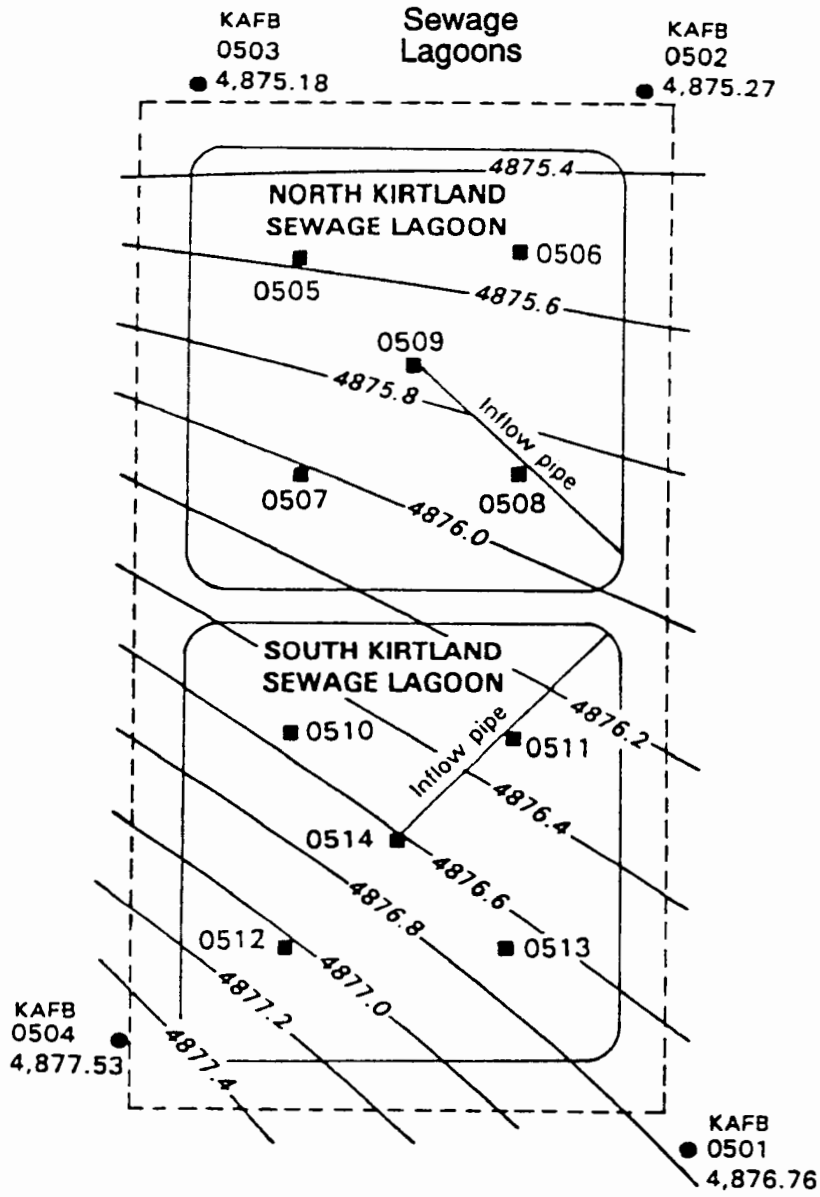
3.1.1 Pre-Stage 2 Investigations

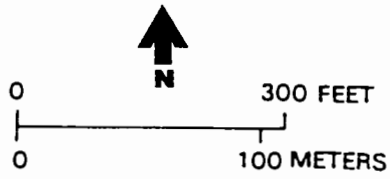
In March of 1988, prior to the complete evaporation of the sewage lagoons, the USGS collected surface water and sediment samples from the lagoons. The samples contained measurable levels of metals, 1,1-dichloroethane, and toluene.

3.1.2 Stage 2 Investigation

Between September 1989 and November 1990, the USGS collected dry sludge, soil, ground-water, and drilling mud samples as part of the Stage 2 Investigation (USGS, 1993a).

3.1.2.1 Sludge and Soils Directly Beneath the Dry Sludge. During the Stage 2 Investigation, dry sludge samples were collected at 10 locations from the surface of the sewage lagoon (Figure 5). Soil samples were collected immediately beneath the dry sludge/soil interface. These dry sludge





EXPLANATION

— 4875.8 — WATER-LEVEL CONTOUR, IN FEET--Interval 0.2 foot

------ FENCE

KAFB 0502 4,875.27 — MONITORING WELL--Upper number is well number; lower number is water-table altitude on July 31, 1990, in feet. Datum is sea level

■ 0514 — DRY SLUDGE AND SOIL SAMPLING LOCATION AND LOCATION NUMBER

Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Sewage Lagoons
1990 Water Table Contour Map

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Figure 5

and soil samples were analyzed for volatile organic compounds, semivolatile organic compounds, inductively coupled argon plasma spectrometry (ICP) metals screen, chromium, mercury, nitrogen (nitrate-nitrite, ammonia, total Kjeldahl nitrogen), extraction procedure toxicity (EP Tox) for metals and pesticides, and soil moisture content. Chromium is the primary metal of concern for this post-closure plan. The Cr results for the dry sludge samples are listed in Table 1, and the Cr results for the soil beneath the sludge are listed in Table 2.

The action level for Cr(III) in soil is 80,000 mg/kg based on the Cr(III) toxicity value from the U.S. Environmental Protection Agency's (EPA) Integrated Risk Information System (IRIS) and the action level calculation algorithm presented in the proposed Subpart S, Examples of Concentrations Meeting Criteria for Action Levels (U.S. EPA, 1990). The action level for Cr(VI) in soil is 400 mg/kg (see Appendix A) and is also taken from the proposed Subpart S. The use of soil-based action levels to determine the significance of contamination in dry sludge does not strictly apply because the two media are markedly different. Sewage sludge generally contains a wider range of metal concentrations than soil. However, because there are no action levels for sludge, the reported concentrations of analytes of interest in the dry sludge samples were compared to the soil action levels as an indication of contamination.

The metal beryllium (Be) was the only analyte of interest reported above the soil action level of 0.1 mg/kg in the dry sludge samples from this site. Because Be concentrations in the dry sludge (up to 0.8 mg/kg) closely approximate the background concentrations found in soils on KAFB (USGS, 1993b), Be is not considered to be a significant contaminant in the dry sludge samples.

Because only total Cr concentrations were reported, it is not known whether the action level of 400 mg/kg for Cr(VI) was exceeded for the dry sludge samples. Dry sludge samples were subsequently collected on August 23, 1991 from the same locations and analyzed for Cr(VI); the analytical results for these samples are presented in Appendix B. The Cr(VI) concentrations in all 10 dry sludge samples were below the sample detection limit of 1.0 mg/kg. Therefore, it appears that all Cr in the dry sludge is present as Cr(III), in which case concentrations for both Cr(III) and Cr(VI) are well below the action levels for soil.

Table 1. Chromium Results for Dry Sludge at the Sewage Lagoons

Sample Number	Sample Location	Date	Chromium[1] (mg/kg)	EP Tox Chromium[2] (mg/L)
KAFB 050501-1	5	12/08/89	874 J	0.09
KAFB 050601-1	6	12/08/89	2,225 J	0.08
KAFB 050701-1	7	01/11/90	721 J	0.13
KAFB 050801-1	8	01/11/90	1,129 J	0.11
KAFB 050901-1	9	01/11/90	865 J	0.24
KAFB 051001-1	10	01/11/90	752 J	<0.05
KAFB 051101-1	11	01/11/90	629 J	<0.05
KAFB 051201-1	12	01/11/90	487 J	0.07
KAFB 051301-1	13	01/12/90	875 J	0.10
KAFB 051401-1	14	12/08/89	1,025 J	0.12
KAFB 051402-1	14 (Duplicate)	12/08/89	1,225 J	<0.05

Table 2. Chromium Results for Soil Directly Beneath Dry Sludge at the Sewage Lagoons

Sample Number	Sample Location	Date	Chromium[1] (mg/kg)
KAFB 050502-1	5	06/05/90	22.8
KAFB 050503-1	5 (Duplicate)	06/05/90	22.2
KAFB 050602-1	6	06/05/90	22.3
KAFB 050702-1	7	06/05/90	27.2
KAFB 050802-1	8	06/05/90	24.1
KAFB 050902-1	9	06/05/90	16.0
KAFB 051002-1	10	06/05/90	15.2
KAFB 051102-1	11	06/05/90	16.3
KAFB 051202-1	12	06/05/90	21.0
KAFB 051302-1	13	06/05/90	13.1
KAFB 051403-1	14	06/05/90	11.3

Notes: [1]EPA test methods 3050/7191; project detection limit for chromium = 0.1 mg/kg
[2]EPA test methods 1310/6010; project detection limit for chromium leachate = 0.5 mg/L

J values are estimates. Recovery of analyte from matrix spike and/or matrix spike duplicate was not within limits.

Source: USGS, 1993a

The results of the EP Tox analysis performed on all dry sludge samples indicated that the metals barium, cadmium, chromium, lead, and silver are not readily leachable from the dry sludge. None of these metals exceeded the EP Tox action levels. The highest reported concentration of Cr in the EP Tox leachate was 0.24 mg/L, which is well below the action level of 5 mg/L. The EP Tox Cr values are estimated (J qualified) because the sludge sample matrix spike/matrix spike duplicate (MS/MSD) recovery was low. The low recovery is probably due to the fact that the concentration of the MS/MSD spike was several orders of magnitude smaller than the sludge sample result (see Appendix C).

3.1.2.2 Deep-Augered Soil Samples. Four 100-foot boreholes were augered at the corners of the sewage lagoon site (locations KAFB 0501, KAFB 0502, KAFB 0503, and KAFB 0504, Figure 5), and a ground-water monitor well was drilled immediately adjacent to each borehole.

Soil samples were collected at depths of approximately 5, 20, 50, and 100 feet and were analyzed for volatile organic compounds, ICP metals screen, chromium, mercury, nitrogen (nitrate-nitrite, ammonia, total Kjeldahl nitrogen), EP Tox for metals and pesticides, and soil-moisture content. The Cr results for the soil samples are listed in Table 3.

3.1.2.3 Ground Water. The water table is located approximately 475 feet below the bottom of the sewage lagoon and slopes generally to the north at about 9 feet per mile (0.0017 ft/ft) (Figure 5). However, seasonal pumpage from KAFB production wells located at various distances and directions from the sewage lagoon could induce changes in the direction and slope of the water table. The nearest production well is KAFB well 4, about 800 feet to the southeast, followed by KAFB well 7, about 2,000 feet to the northwest.

Monitor wells at the sewage lagoon were completed with the screened interval partially penetrating the saturated zone. Monitor wells KAFB 0501 and KAFB 0504 are located generally upgradient of the lagoons, and wells KAFB 0502 and KAFB 0503 are generally downgradient of the lagoons (Figure 5). As previously mentioned, the hydraulic gradient and flow direction are influenced by pumping at the nearby water supply wells.

Table 3. Chromium Results for Soil Samples from Deep Augered Borings at the Sewage Lagoons

Sample Number	Sample Location (boring # / depth [ft])	Date	Chromium[1] (mg/kg)	EP Tox Chromium[2] (mg/L)
KAFB 050101-1	1 / 5	09/07/89	4.7	<0.05
KAFB 050102-1	1 / 20	09/07/89	6.6	<0.02
KAFB 050103-1	1 / 50	09/09/89	10.5 J	0.06
KAFB 050104-1	1 / 100	09/11/89	20.0 J	<0.01
KAFB 050105-1	1 / 100 (Duplicate)	09/11/89	4.3 J	<0.01
KAFB 050201-1	2 / 5	09/19/89	5.3	<0.05
KAFB 050202-1	2 / 20	09/19/89	7.0	<0.02
KAFB 050203-1	2 / 46.5	09/19/89	5.6	0.01
KAFB 050206-1	2 / 99	09/22/89	7.3	0.02
KAFB 050301-1	3 / 5	09/23/89	5.3	<0.05
KAFB 050302-1	3 / 20	09/23/89	5.9	<0.05
KAFB 050303-1	3 / 50	09/23/89	12.0	<0.05
KAFB 050304-1	3 / 50 (Duplicate)	09/20/89	10.2	<0.05
KAFB 050305-1	3 / 100	09/27/89	8.1	<0.05
KAFB 050401-1	4 / 5	09/27/89	28.0	<0.05
KAFB 050402-1	4 / 20	09/27/89	6.1	<0.05
KAFB 050403-1	4 / 50	09/29/89	8.7 J	<0.05
KAFB 050404-1	4 / 100	10/11/89	5.3	<0.05

Notes: [1]EPA test methods 3050/7191; project detection limit for chromium = 0.1 mg/kg
[2]EPA test methods 1310/6010; project detection limit for chromium leachate = 0.5 mg/L

J values are estimates. Analyte detected in prep blank or method blank.

Source: USGS, 1993a

Initial ground-water samples were collected from each monitor well in May 1990, after the wells were developed. The ground-water samples were analyzed for total petroleum hydrocarbons, arsenic, chromium, lead, mercury, selenium, total dissolved solids, common anions, nitrogen (nitrate-nitrite, ammonia, and total Kjeldahl nitrogen), Appendix IX analytes (as defined in 40 CFR, Part 264, volatile organic compounds, semivolatile organic compounds, dioxins and furans, organochlorine pesticides and PCBs, chlorinated herbicides, total recoverable and dissolved metals, cyanide, fluoride, and sulfide), gross alpha and beta, radium 226, and radium 228. In addition, temperature, pH, specific conductance, and alkalinity were measured when the samples were collected.

The monitor wells were resampled in August 1990 and November 1990. These samples were analyzed for total organic carbon, total organic halogens, and any significant contaminant(s) that appeared during the first round of sampling. The Cr results for all three sampling events are listed in Table 4.

Dissolved Cr and total Cr concentrations have exceeded EPA and New Mexico maximum contaminant levels (MCLs) in the past (Table 4); however, there has been a trend of decreasing Cr concentrations in the ground water over time. Dissolved Cr was detected in concentrations of 0.051 mg/L and 0.046 mg/L in ground-water samples collected in May 1990 from monitor wells KAFB 0501 and KAFB 0503, respectively. However, dissolved Cr concentrations have been below 0.010 mg/L or below the detection limit in the two subsequent rounds of ground-water samples collected from these wells, with the exception of the August 1990 sample from well KAFB 0504.

Total Cr was detected above the MCL in the May 1990 ground-water sample collected from well KAFB 0501 (0.140 mg/L), and in the May, August, and November 1990 and November 1991 ground-water samples collected from well KAFB 0503 (0.120 mg/L, 0.120 mg/L, 0.082 mg/L, and 0.055 mg/L, respectively). The total Cr concentration was near the MCL in the May 1990 ground-water sample collected from well KAFB 0502 (0.045 mg/L). Total Cr concentrations were below the MCL in all other ground-water samples collected at this site. Total Cr values may be an artifact of well construction and completion procedures or sample collection methods, as discussed in Section 4.2.

Table 4. Chromium Results for Ground-Water Samples from Monitor Wells at the Sewage Lagoons

Well ID	Date	Dissolved Chromium[1] (mg/L)	Total Chromium[2] (mg/L)	Chromium (VI)[3] (mg/L)
KAFB 0501	05/09/90	**0.051**	**0.14 J**	NA
	08/28/90	<0.005	0.014	NA
	11/27/90	0.0067	0.0024 J	NA
	02/25/91	0.0076	0.028	ND
	05/29/91	ND	ND	ND
	11/13/91	ND	0.0075	ND
	05/18/92	ND	ND	NA
KAFB 0502	05/10/90	0.0072	0.045 J	NA
	08/28/90	0.005	0.017	NA
	11/27/90	0.0014	ND	NA
	02/26/91	ND	0.0037	ND
	05/30/91	ND	ND	ND
	11/12/91	ND	ND	ND
	05/18/92	ND	ND	NA
KAFB 0503	05/10/90	0.046	**0.12 J**	NA
	05/10/90 D	0.047	**0.097 J**	NA
	08/30/90	0.0094	**0.12**	NA
	11/28/90	0.0070	**0.082 J**	NA
	02/26/91	0.0011	0.037	ND
	05/29/91	ND	0.024	0.020
	11/13/91	0.0030	**0.055**	ND
	05/18/92	0.013	0.012	NA
KAFB 0504	05/17/90	<0.050	0.029 J	NA
	08/30/90	<0.050	0.023	NA
	11/29/90	0.0017	0.0061 J	NA
	02/27/91	0.0012	0.0059	ND
	06/05/91	ND	0.0033	ND
	11/14/91	ND	0.0033	ND
	05/16/92	ND	0.028	NA

Notes: [1] EPA test method 7191
[2] EPA test methods 3020/7191
[3] EPA test method 7196

NA = Not available
ND = Not detected
D = Duplicate sample

Values above the MCL are shown in bold.

J values are estimates. Recovery of analyte from matrix spike and/or matrix spike duplicate was not within limits.

Source: USGS, 1993a, 1993b

3.1.3 Stage 2A Investigation

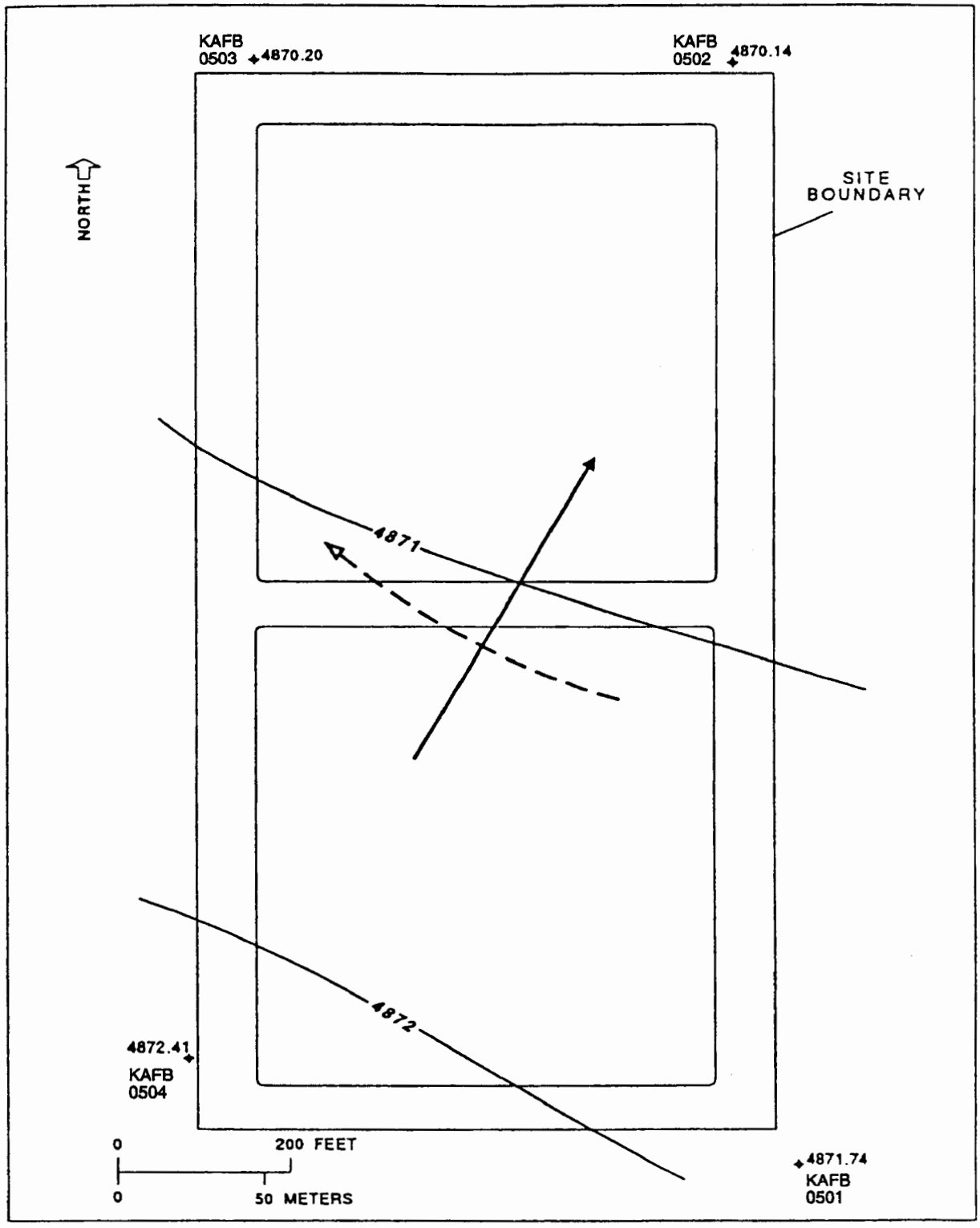
During the Stage 2A RFI (USGS, 1993b), three additional rounds of ground-water samples were collected from the sewage lagoon wells. In addition to total and dissolved Cr analyses, total and dissolved Cr(VI) analyses were also conducted. Ground-water elevation measurements were taken on a monthly basis. The USGS also collected 18 soil and 8 ground-water samples to establish base-wide concentrations of naturally occurring soil metals and ground-water quality parameters.

3.1.3.1 Ground Water. The depth to water beneath the sewage lagoon site ranged from approximately 474 to approximately 491 feet below land surface, based on monthly water level measurements of four wells taken between May 1990 and September 1993. The local slope of the water table beneath the sewage lagoon is toward the northeast at about 9 feet per mile. However, pumpage from KAFB production wells located northwest, north, and southeast of the site could influence the direction and slope of the water table. The regional slope of the water table in September 1992 was toward the northeast as shown in Figure 6.

Table 4 summarizes the results of the ground-water Cr analyses. Total Cr was detected above the MCL in the sample from KAFB 0503 (0.055 mg/L). In addition, Cr(VI) was detected above the quantitation limit in the sample from KAFB 0503 (0.020 mg/L).

3.1.3.2 Background Concentrations. The USGS determined background concentrations by calculating an upper tolerance limit (UTL) for each analyte and matrix for which there were a sufficient number of detected concentrations (see Appendix A). The procedures followed for calculating UTL are outlined in *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities* (U.S. EPA, 1989b). The UTLs for Cr in background soils and ground water are listed below:

- UTL for Cr in background soil - 10.307 mg/kg
- UTL for Cr in background ground water - 0.029 mg/L



Source: USGS, 1993b

EXPLANATION

4872.41 — Monitor well; number is altitude of water level, September 1992

4872 — Water-level contour, September 1992. Contour interval = 1 foot

Regional ground-water-flow direction, 1960

Regional ground-water-flow direction, September 1992

KAFB POST-CLOSURE PLAN

Sewage Lagoons

1992 Water Table Contour Map

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Figure 6

A correction was made by DBS&A for the ground-water background Cr concentration (0.026 mg/L) reported in the Stage 2A draft report (USGS, 1993b). The corrected UTL of 0.029 mg/L is based on the six reported values of Cr above the detection limit, rather than the total number of analyses performed, which was eight.

3.2 Golf Course Main Pond

A series of samples, including surface-water, sediment, soil, drilling-mud, and ground-water samples, have been collected in and around the golf course main pond since the spring of 1988 as part of previous investigations at KAFB. Subsections 3.2.1 through 3.2.3 discuss the findings of these investigations.

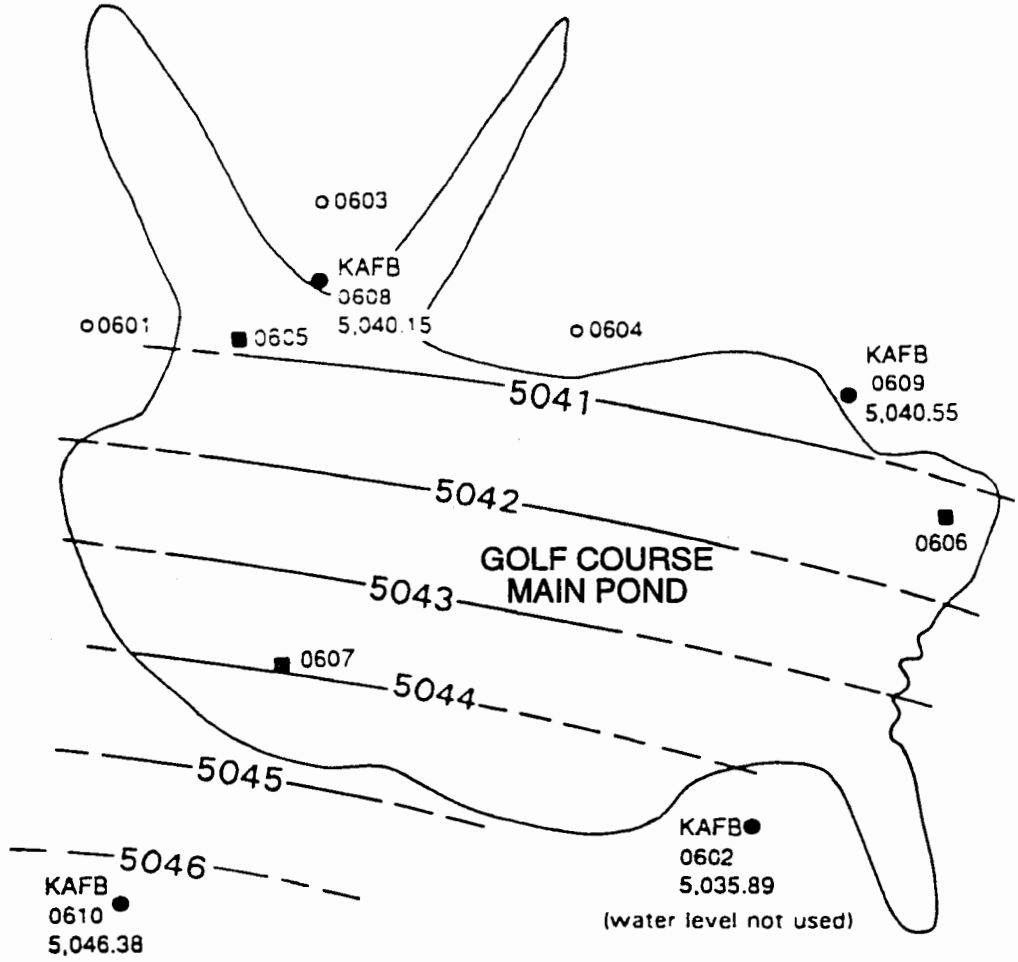
3.2.1 Pre-Stage 2 Investigations

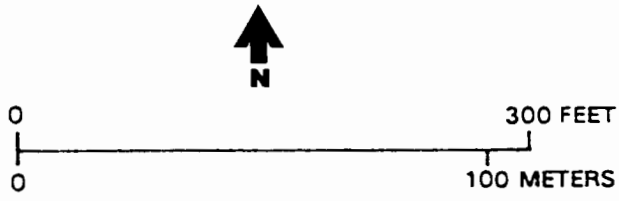
In March 1988, prior to the complete evaporation of the golf course main pond, the USGS sampled the pond water and sediment. Water samples were analyzed for aromatic volatile organics, halogenated volatile organics, total recoverable metals, arsenic, mercury, and selenium. The results of the water analyses did not show concentrations exceeding the EPA or New Mexico MCLs for these analytes.

3.2.2 Stage 2 Investigation

As part of the Stage 2 Investigation, the USGS collected dry-pond sediment, soil, drilling-mud, and ground-water samples from the golf course main pond and vicinity during the period between November 1989 and December 1990.

3.2.2.1 Dry-Pond Sediments. Dry-pond sediment samples were collected from the surface of the dry pond at three locations (designated as KAFB 0605, KAFB 0606, and KAFB 0607 in Figure 7). The dry-pond sediments were dark-colored, fine-grained materials that probably include a mixture of dry sludge with silt and clay washed in from the watershed above the pond. Dry-pond sediment samples were analyzed for soil moisture content, volatile organic compounds, ICP metals screen, chromium, mercury, nitrogen (nitrate-nitrite, ammonia, total Kjeldahl nitrogen), and EP Tox for metals and pesticides. The Cr results for dry-pond sediment are listed in Table 5.





EXPLANATION

o 0601	SOIL SAMPLING LOCATION AND LOCATION NUMBER--Power augered to 100 feet
■ 0607	DRY POND SEDIMENT SAMPLING LOCATION AND LOCATION NUMBER
● KAFB 0610 5,046.38	MONITORING WELL--Upper number is well number; lower number is water-table altitude on July 31, 1990, in feet. Datum is sea level
——5046 — —	WATER-LEVEL CONTOUR, IN FEET--Dashed where approximately located; interval 1 foot. Datum is sea level

Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Golf Course Main Pond
1990 Water Table Contour Map

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Figure 7

Table 5. Chromium Results for Dry-Pond Sediments at the Golf Course Main Pond

Sample Number	Sample Location	Date	Chromium[1] (mg/kg)	EP Tox Chromium[2] (mg/L)
KAFB 060501-1	5	12/08/89	103 J	0.10
KAFB 060601-1	6	01/11/89	39 J	<0.05
KAFB 060701-1	7	01/11/89	71 J	<0.05

Notes: [1]EPA test methods 3050/7191; project detection limit for chromium = 0.1 mg/kg
[2]EPA test methods 1310/6010; project detection limit for chromium leachate = 0.5 mg/L

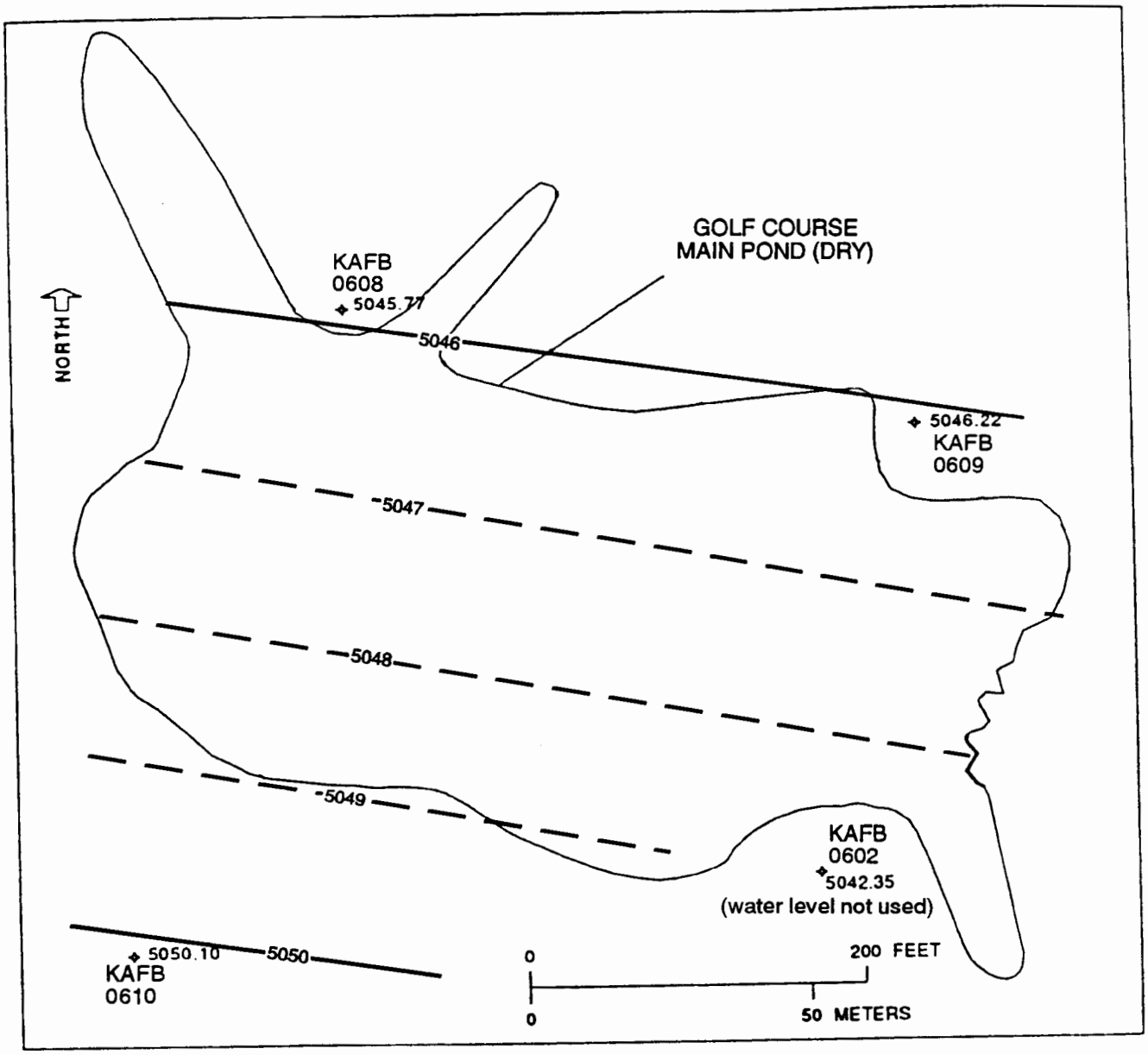
J values are estimates. Recovery of analyte from matrix spike and/or matrix spike duplicate was not within limits.

Source: USGS, 1993a

The use of soil-based action levels to determine the significance of contamination in the dry-pond sediments does not strictly apply, because the composition of the pond sediment has partially been determined by inflow from the sewage lagoon. However, because there are no action levels for solid media other than soil, the reported concentrations of analytes of interest in the dry-pond sediment samples are compared to soil action levels as an indication of contamination.

The metal Be was the only analyte of interest reported above the soil action level of 0.1 mg/kg in the dry-pond sediment samples from this site. Because Be concentrations in the dry-pond sediment (0.4 to 0.5 mg/kg) closely approximate the concentrations found in soils on KAFB, Be is not considered to be a significant contaminant in the dry-pond sediment.

3.2.2.2 Deep-Augered Soil Samples. A 100-foot borehole was augered at each of four locations (designated as KAFB 0601, KAFB 0602, KAFB 0603, and KAFB 0604 in Figure 8) in the area of the golf course main pond. Samples were collected for analysis at 5-, 20-, 50-, and 100-foot depths from each borehole. The samples were analyzed for soil moisture, volatile organic compounds, ICP metal screen, chromium, mercury, nitrogen (nitrate-nitrite, ammonia, total Kjeldahl nitrogen), and EP Tox for metals and pesticides. The Cr results for soil samples are listed in Table 6. Beryllium was detected in the soil samples at concentrations above the action



EXPLANATION

5050.10 ◆ Monitor well; number is altitude of water level, September 1992

5050 Water-level contour, September 1992. Contour interval = 2 feet

Source: USGS, 1993b

KAFB POST-CLOSURE PLAN

Golf Course Main Pond
1992 Water Table Contour Map

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Figure 8

Table 6. Chromium Results for Soil Samples from Deep Augered Borings at the Golf Course Main Pond

Sample Number	Sample Location (boring # / depth [ft])	Date	Chromium[1] (mg/kg)
KAFB 060101-1	1 / 5	10/31/89	9.1 J
KAFB 060102-1	1 / 20	10/31/89	38.0 J
KAFB 060103-1	1 / 50	11/01/89	8.7 J
KAFB 060104-1	1 / 99	12/05/89	8.8 J
KAFB 060201-1	2 / 5	01/04/90	3.6
KAFB 060202-1	2 / 20	01/04/90	4.5
KAFB 060203-1	2 / 50	01/04/90	2.9
KAFB 060204-1	2 / 100	01/05/90	15.0
KAFB 060205-1	2 / 100 (Duplicate)	01/05/90	3.5
KAFB 060301-1	3 / 5	12/09/89	5.0 J
KAFB 060302-1	3 / 20	12/09/89	9.8 J
KAFB 060303-1	3 / 50	12/09/89	7.7 J
KAFB 060401-1	4 / 5	12/06/89	7.2 J
KAFB 060402-1	4 / 24	12/06/89	8.6 J
KAFB 060403-1	4 / 50	12/07/89	8.0 J
KAFB 060404-1	4 / 100	12/08/89	5.0

Notes: [1]EPA test methods 3050/7191; project detection limit for chromium = 0.1 mg/kg

J values are estimates. Analyte detected in prep blank or method blank.

Source: USGS, 1993a

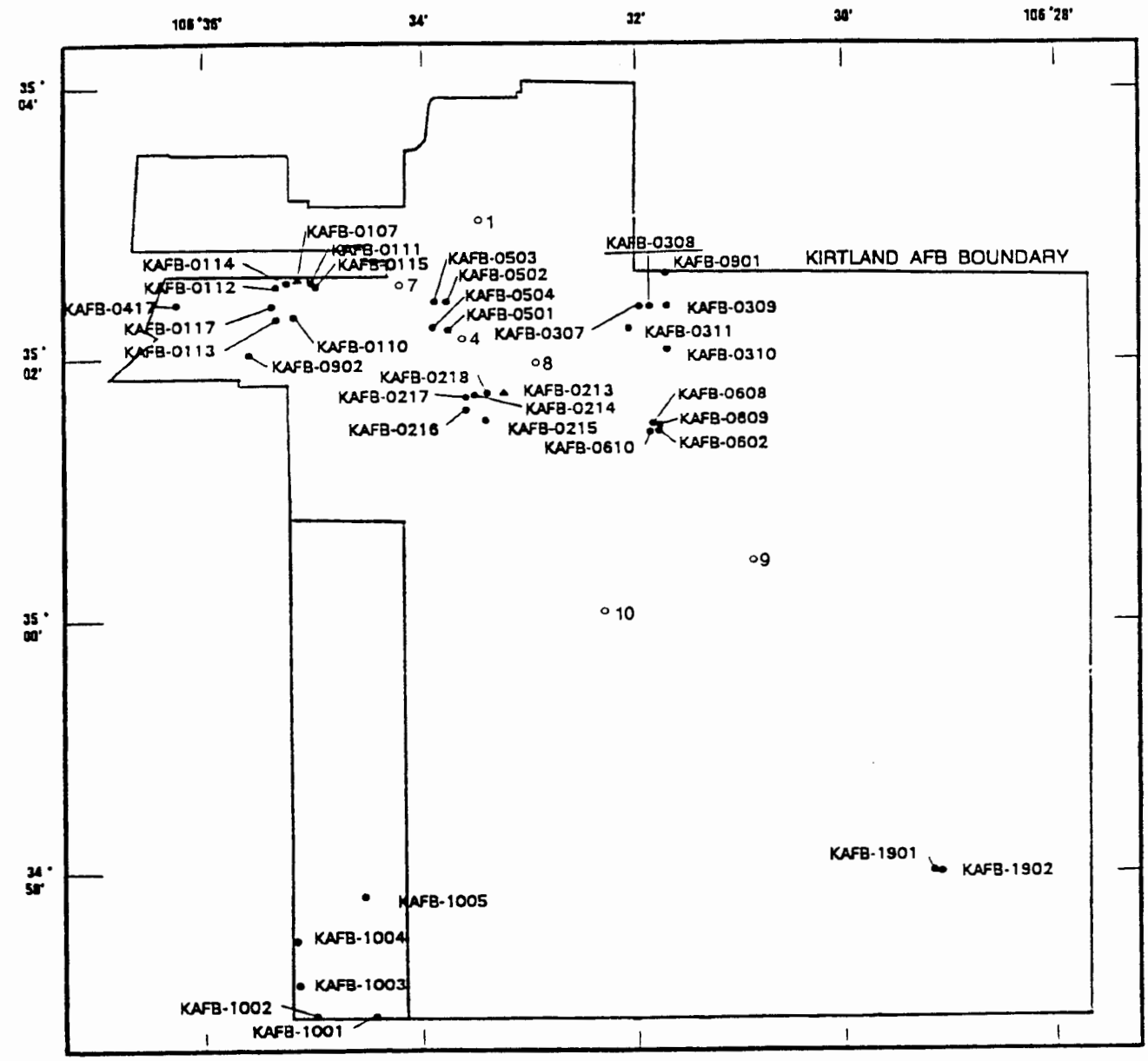
level; however, the concentrations are considered to be naturally occurring as they are within the range (from <0.2 to 0.8 mg/kg) found in soil samples collected over a wide areal extent at KAFB.

3.2.2.3 Ground Water. Ground-water monitor wells were installed at each of four locations (designated as KAFB 0602, KAFB 0608, KAFB 0609, and KAFB 0610 in Figure 7) adjacent to the golf course main pond. Monitor well KAFB 0602 was drilled immediately adjacent to the augered borehole of the same number.

The depth to the water table at the golf course main pond is between 310 and 325 feet below land surface (Figures 7 and 8). The static water levels in monitor wells near the pond are about 100 feet higher than would be expected based on water level measurements in more distant wells, initially leading to the hypothesis that a ground-water mound exists in the vicinity of the golf course. Based on this hypothesis, any wells to the north, west, or south could be considered downgradient of the site (Figure 9). Monitor well KAFB 0213 is located about 1.3 miles to the west-northwest, and monitor well KAFB 0901 is located about 1.4 miles to the north. Production well 11 is approximately 1.25 miles to the north. No wells are known to exist in the area east of the site and closer to the Manzanita Mountain front.

The proximity of the Sandia Mountains suggests another hypothesis for the generally shallower ground water at the golf course. The Sandia and West Sandia Faults occur east of the golf course. Recent analysis of the North Albuquerque Basin suggests that a series of downthrown blocks occurs along both sides of the basin (Hawley, 1993). According to this hypothesis, the shallower ground-water elevations at the golf course may be due to the presence of another fault west of the golf course. A stratigraphic investigation of this area is beyond the scope of any environmental restoration activities at KAFB, in particular, this post-closure plan. However, the poorly defined influence of structural features (faults and blocks) on the hydrogeology at this and other sites should be recognized. This data gap is being addressed by Sandia National Laboratories, which is conducting a base-wide geologic characterization study for the Department of Energy.

The two monitor wells on the northern margin of the pond, wells KAFB 0608 and KAFB 0609, were completed with the screened interval intersecting the water table. Wells KAFB 0602 and



EXPLANATION

- ● USGS WELL DRILLED FOR IRP AND WELL IDENTIFICATION NUMBER
- ○ KIRTLAND AFB PRODUCTION WELL
- ▲ OTHER WELL

Source: USGS, 1993b

KAFB POST-CLOSURE PLAN

Monitor Well Location Map

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Figure 9

KAFB 0610 were constructed with the well screen set deeper into the saturated zone. The water levels in these wells were approximately 114 and 26 feet, respectively, above the tops of the screens.

The slope of the water table at the golf course main pond is toward the north-northeast at approximately 4 feet per 100 yards (0.013 ft/ft) (Figure 7). This slope may be temporary (for 1990 only) and may not prevail for any great distance beyond the perimeter outlined by the wells in Figure 9. The slope is based on water level elevations in wells KAFB 0608, KAFB 0609, and KAFB 0610. The water level elevation in KAFB 0602 was not in this current analysis because the well screen was set too deep into the saturated zone, and there appears to be a significant downward vertical gradient in the upper part of the aquifer at the golf course main pond. The water level measurement in well KAFB 0610 is probably lower than the actual water table elevation at this location because the screen in this well was also submerged.

Initial ground-water samples were collected from each monitor well in May 1990 after the wells were developed. The ground-water samples were analyzed for petroleum hydrocarbons, arsenic, chromium, lead, mercury, selenium, total dissolved solids, common anions, nitrogen (nitrate-nitrite, ammonia, and total Kjeldahl nitrogen), Appendix IX analytes (volatile organic compounds, semivolatile organic compounds, dioxins and furans, organochlorine pesticides and PCBs, chlorinated herbicides, total recoverable and dissolved metals, cyanide, fluoride, and sulfide), gross alpha and beta, radium-226, and radium-228. In addition, temperature, pH, specific conductance, and alkalinity were measured when the samples were collected. The Cr results for the ground-water samples are listed in Table 7.

The monitor wells were resampled twice (August/September 1990 and November/December 1990). The ground-water samples collected during these subsequent rounds were analyzed only for significant contaminant(s) detected during the first round of sampling (May 1990).

Dissolved Cr, total Cr, nitrate, and gross alpha activity were detected in ground-water samples collected from the site in concentrations in excess of the action levels of 0.050 mg/L, 0.050 mg/L, 10 mg/L, and 15 pCi/L, respectively. Dissolved Cr concentrations of 0.054 and 0.042 mg/L were detected in samples from wells KAFB 0602 and KAFB 0610, respectively, during the May 1990

Table 7. Chromium Results for Ground-Water Samples from Monitor Wells at the Golf Course Main Pond

Well ID	Date	Dissolved Chromium[1] (mg/L)	Total Chromium[2] (mg/L)	Chromium (VI)[3] (mg/L)
KAFB 0602	05/04/90	**0.054**	**0.240 J**	NA
	09/05/90	<0.005	0.045	NA
	12/10/90	ND	0.013 J	NA
	03/05/91	ND	0.019	ND
	06/04/91	ND	0.011	ND
	11/19/91	ND	ND	ND
	05/12/92	ND	0.017	NA
KAFB 0608	05/17/90	<0.010	0.038 J	NA
	09/05/90	0.0074	0.014	NA
	11/30/90	0.0096	0.0083 J	NA
	03/04/91	0.011	**0.075**	0.023
	05/31/91	0.0084	0.011	0.011
	11/15/91	0.0066	0.011	ND
	05/19/92	ND	ND	NA
KAFB 0609	05/08/90	0.0098	0.031 J	NA
	08/29/90	<0.005	0.014	NA
	11/29/90	0.0034	0.047 J	NA
	02/27/91	0.0011	0.028	ND
	05/30/91	ND	0.0076	0.011
	11/12/91	ND	0.025	ND
	05/11/92	ND	0.028	NA
KAFB 0610	05/03/90	0.042	NA	NA
	08/31/90	<0.005	**0.051**	NA
	12/06/90	ND	0.014 J	NA
	03/06/91	0.0034	**0.053**	ND
	06/03/91	0.0059	0.015	ND
	11/19/91	ND	0.012	ND
	05/20/92	ND	ND	NA

Notes: [1] EPA test method 7191
[2] EPA test methods 3020/7191
[3] EPA test method 7196

NA = Not available
ND = Not detected

Values above the MCL are shown in bold.

J values are estimates. Recovery of analyte from matrix spike and/or matrix spike duplicate was not within limits.

Source: USGS, 1993a, 1993b

sampling. Dissolved Cr concentrations have been below 0.010 mg/L in subsequent ground-water samples collected from these wells (August/September and November/December 1990), as well as in all ground-water samples collected from wells KAFB 0608 and KAFB 0609.

Total Cr was reported above the action level in the first ground-water sample collected from well KAFB 0602 (0.240 mg/L) and in the August 1990 ground-water sample collected from KAFB 0610 (0.51 mg/L). Total Cr concentrations were below the action level in all other ground-water samples collected from this site (Table 7). Total Cr may be an artifact of well construction and completion procedures or sample collection, as discussed in Section 4.2.

3.2.3 Stage 2A Investigation

Four wells, installed during the Stage 2 investigation, were monitored during the Stage 2A investigation to determine whether a release had occurred at the golf course main pond. Three additional rounds of samples were collected. In addition to total and dissolved Cr analyses, total and dissolved Cr(VI) analyses were also conducted. Ground-water elevation measurements were taken on a monthly basis.

The depth to water at the golf course main pond ranged from approximately 305 to approximately 329 feet below land surface based on monthly water level measurements from four monitor wells between April 1990 and September 1993. The local slope of the water table at the golf course site is generally to the southeast (Figure 8).

Table 7 summarizes the results of the ground-water analyses for Cr. Dissolved Cr was not detected above the MCL. Total Cr was detected above the MCL in KAFB 0608 (0.075 mg/L) and KAFB 0610 (0.053 mg/L). In addition, Cr(VI) was detected above the quantitation limit in samples from wells KAFB 0608 (0.023 and 0.011 mg/L) and KAFB 0609 (0.011 mg/L).

4. CHROMIUM IN GROUND WATER

This section briefly reviews aspects of chromium that are pertinent to the presence of the element in ground water at KAFB. Section 4.1 briefly addresses Cr geochemistry and redox properties. Section 4.2 contains a discussion about the affect that turbidity can have on the analyzed composition of ground water. Section 4.3 contains a brief presentation of the hazard that Cr poses to human health.

4.1 Geochemistry and Redox Reactions between Cr(VI) and Cr(III)

Geochemically, Cr is characterized by its predominant radius and charge (0.64 angstroms and +3), which allow it to readily substitute for [iron Fe(III), 0.67 angstroms] and aluminum [Al(III), 0.56 angstroms] in the crystal structure of minerals. Cr(III) generally crystallizes out early in an igneous sequence and occurs in the chromite spinel group associated with mafic minerals. It can be released from silicates, but due to relatively strong sorption, tends to be incorporated into shales and, after metamorphosis, schists.

Chromium exists in two oxidation states in natural aqueous systems: trivalent [Cr(III)] and hexavalent [Cr(VI)]. Cr(VI) is the thermodynamically stable form under well-oxygenated (or high electrical potential, Eh) and usually alkaline pH conditions. It is also more soluble than Cr(III). It occurs as an oxyanion (CrO_4^{2-}) and, like other negatively charged ions, is poorly sorbed on clays and hydrous oxides. Conversely, it is strongly sorbed by activated carbon and oxidizes organic matter. Cr(VI) is reduced to Cr(III) by ferrous iron, dissolved sulfides, and certain organic groups containing sulfhydryl groups. Although Cr(III) is oxidized to Cr(VI) by manganese oxide (MnO_2) or oxygen, the kinetics of oxidation are relatively slow and Cr(III) bound to naturally occurring solids can persist under otherwise oxidizing conditions.

Studies have shown that the majority of Cr (67 to 98 percent) is sorbed to particulate materials in municipal waters (Jan and Young, 1978). Of the dissolved fraction, an even greater majority (97 to 99 percent) occurs as Cr(III). As will be discussed in Section 4.2, filter size may have a great influence on the concentrations that are observed in "dissolved" fractions. Previous

researchers (Pfeiffer et al., 1980) have observed that most Cr(VI) discharged to freshwater is removed by reduction to the trivalent form and subsequently sorbed to sediment.

Cr(VI) can also occur naturally under certain conditions. Robertson (1975) observed Cr(VI) concentrations above the health standard of 0.05 mg/L in the ground water of the Paradise Valley, Maricopa County, Arizona. The highest Cr(VI) concentrations were associated with fine-grained sediments in the center of a closed-basin or playa depositional environment. The pH in these sediments was alkaline due to silicate hydrolysis and provided conditions favorable for oxidation of Cr(III) to Cr(VI).

4.2 Influence of Turbidity

Given the preference that Cr(III) shows for sorption on colloidal particles and the standard preservation technique of acidifying natural water samples collected for metals analysis, the turbidity of ground-water samples from the wells at the sewage lagoons and golf course main pond is a matter of fundamental concern. In addition to preventing the growth of microorganisms in the sample, acidification changes the composition of turbid samples by displacing adsorbed cations and shifting the charge balance of pH-dependent charge sites, which lowers the sorption capacity of the suspended solids. For many oxide and hydrous oxide minerals there is a sharp increase in solubility as pH decreases, further adding to the observed "dissolved" metal concentrations. The resulting samples are not representative of actual ground-water concentrations.

Possible remedies for the problem of turbid ground-water samples include minimizing the amount of silt or clay collected during ground-water sampling by either improving the hydraulic characteristics of the monitor well or adjusting the ground-water sampling technique to minimize the disturbance of silt and clay in the silt trap, the filter pack, or the formation. Specific recommendations for monitor well design in low-permeability formations begin with the recognition of silty or clayey layers within the screened interval (Gass, 1988). Steps should be taken to minimize the surge energy that reaches the formation during development (or filter pack cleaning) and sampling.

Well construction steps that will minimize the surge energy include increasing the diameter and carefully maintaining the uniformity of an appropriately designed filter pack (Gallagher, 1987). Wells completed in low-permeability formations should not be aggressively developed. The water velocity within the formation should also be controlled during well purging and aquifer water sampling (Gass, 1988). Water sampling techniques to minimize surge energy in the formation include the use of small diameter pumps or bailers (about one half the casing diameter), sampling at least 2 feet above the bottom of the well, slow pump or bailer introduction and withdrawal rates, and low pumping rates. Details of the actual USGS sampling procedure at KAFB are not well documented, nor were turbidity measurements routinely made; however, ground-water samples reportedly were "cloudy" in several cases.

Filtering ground water is recommended for dissolved metals analyses as part of a dual sampling approach (Puls and Barcelona, 1989). Puls and Barcelona stated that colloidal particles likely to be filtered out could also account for the mobility of metals; therefore, they recommended that unfiltered water samples be analyzed as well. However, the intended use of the data must be considered. They state that "if the purpose of the sampling is to determine possible mobile contaminant species, the unfiltered samples should be given priority." As support for this recommendation, they cite the conclusions of several studies, most of which were performed in sand or sand and gravel porous media. The lack of data on filtering samples collected from monitor wells completed in finer-textured media limits the usefulness of such a general recommendation.

Another approach to the problem of turbid ground-water samples is to re-evaluate the nature of the contaminants of concern. The contribution of desorbed contaminants will vary, depending on the chemical properties of the contaminant, the turbidity of the ground-water sample, and the level of contamination in the ground-water portion of the turbid sample. For inorganic analytes, especially for metals, suspended colloidal material can have an important effect on the analytical results. Careful well purging and sampling techniques should minimize any uncertainty. To address this issue, KAFB proposes to use low volume, small diameter pumps and slow introduction and withdrawal rates during the proposed Phase I ground-water sample collection.

4.3 Toxicology

Although Cr is a toxin, it also has mutagenic, cytogenic, and carcinogenic effects on living organisms (Langard, 1982). Although both Cr(VI) and Cr(III) have been investigated, there is little evidence that Cr(III) causes cancer (Hayes, 1982). Epidemiological studies of cancer occurrence have been conducted on workers exposed at chrome plating facilities and during the production of Cr chemicals, chromate pigments, and Cr steels. An increased frequency of cancer associated with the respiratory tract and the lungs has often been found and is attributed to the inhalation of Cr(VI)-containing particles, as Cr(VI) is absorbed rapidly through pulmonary tissue. Efforts to reduce respiratory exposure appear to have a beneficial effect on the cancer rates associated with these occupations (Hayes, 1982).

As Cr(VI) compounds are generally very soluble, they have been shown to produce cytotoxic effects at concentrations 100 to 1,000 times lower than for Cr(III) compounds. Once inside cells, Cr(VI) can function as an oxidizing agent and be reduced to Cr(III). This oxidation-reduction reaction may cause fragmentation of macromolecules, such as DNA. Gastric fluids and liver cells have also been shown to reduce Cr(VI) to Cr(III). Once present inside cells, Cr(III) appears to bind to nitrogen and phosphorus contained in macromolecules, changing both their conformations and abilities to function normally (Levis and Bianchi, 1982). However, Cr is also considered an essential nutrient at lower concentrations. It tends to accumulate in both freshwater and marine biota in concentrations much higher than in the surrounding water (Callahan et al., 1979).

Due to the reducing action of gastric acids, the potentially most hazardous ground-water exposure route for Cr(VI) would be through inhalation of droplets during showering. However, the Cr(VI) concentrations usually found in water are much lower than those associated with air-borne particulates in industrial settings.

5. REGULATORY BACKGROUND

A variety of regulations have been reviewed for the post-closure plan. These include guidelines for clean closure and hazardous waste listing as well as recently promulgated regulations for the use and disposal of sewage sludge.

5.1 Waste Characterization

Based on the EP Tox analysis of sludge samples, the sludge in both the sewage lagoons and the golf course main pond is not a hazardous waste. However, the sewage lagoon sludge does contain some hazardous waste constituents at concentrations above those in background soils at the site. According to 40 CFR, Part 261.11(a)(3), a waste may also be listed as hazardous if it contains hazardous waste constituents and the EPA Administrator (or his/her representative, e.g., state authorities) determines that the waste poses a present or potential hazard to human health or the environment. Such a determination may be based on the following criteria, which are listed in Part 261.11(a)(3).

- Nature of toxicity presented by the contaminant
- Concentration of the contaminant
- Potential for migration of the contaminant
- Persistence of the contaminant
- Potential for degradation or transformation of the contaminant
- Bioaccumulation potential of the contaminant
- Plausible improper management of the site (and resulting release of the contaminant)
- Nature and severity of any damage that already has occurred
- Other actions at similar sites
- Any other appropriate factors

Each of these criteria is discussed below with respect to Cr.

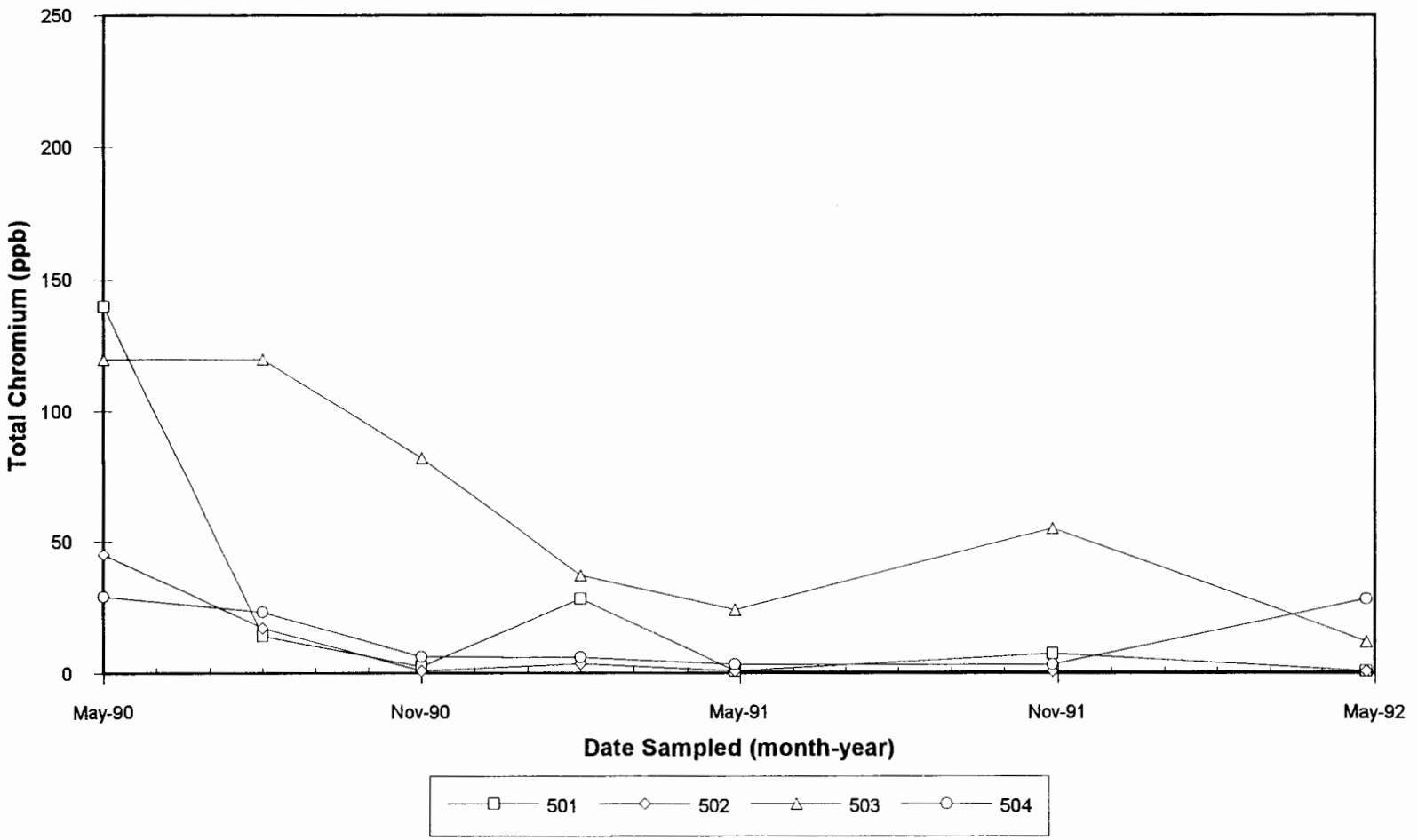
Nature of toxicity presented by the contaminant. At sufficient concentrations in air and water, Cr(VI) is considered both a toxicant and a carcinogen. Standards for exposure to Cr(VI) are

primarily determined on the basis of its carcinogenicity. The primary exposure route is through inhalation with subsequent effects on the upper respiratory tract and the lungs. Ingestion of Cr(VI) is much less hazardous, as it is reduced to Cr(III) in the gastrointestinal tract and in the liver (Levis and Bianchi, 1982). Cr(III) is an essential trace element for good health, but the greater solubility of Cr(VI) in aqueous solution makes it possible for Cr(VI) to greatly exceed nutritional requirements.

Concentration of the contaminant. The concentrations of total and dissolved Cr in ground water from wells around the sewage lagoons and the golf course main pond range from non-detectable to several hundred parts per billion (ppb). These analyses do not differentiate between Cr(III) and Cr(VI), although it is conservatively assumed that dissolved Cr is comparable to Cr(VI). Dissolved Cr actually is an operationally defined quantity, based on filtering ground water through a 0.45-micron filter. This measures not only true solution Cr, but all Cr that may occur on suspended particles that pass through a filter of this size.

The New Mexico Water Quality Control Commission (WQCC) and Federal MCL for Cr(VI) in drinking water is 50 ppb (or µg/L). This is the same concentration level currently listed as the interim primary drinking water standard in Appendix III of 40 CFR Part 265. The highest Cr concentrations were observed in the initial (1990) samples collected from the monitor wells at the two sites. Concentrations since the first round of sampling have generally declined, although total Cr concentrations have occasionally exceeded the applicable MCL (Figures 10 and 11). The observed Cr might be highly influenced by borehole drilling/well installation and purge/sampling techniques (Section 4.2).

Potential for migration of the contaminant. Cr(VI) is soluble in water and thus has potential to migrate if sufficient leaching solution is available. This property probably accounts for the decreasing Cr concentration levels observed in successively deeper soil samples from boreholes at the sewage lagoons. However, except for relatively well defined and rather unique geochemical environments, Cr(VI) is unstable. It is reduced to Cr(III) by ferrous iron, sulfides, and organic matter, and then precipitates onto or adsorbs to the solid phase in natural porous media.



KAFB POST-CLOSURE PLAN

Chromium in Ground Water at Sewage Lagoons Site

Figure 10

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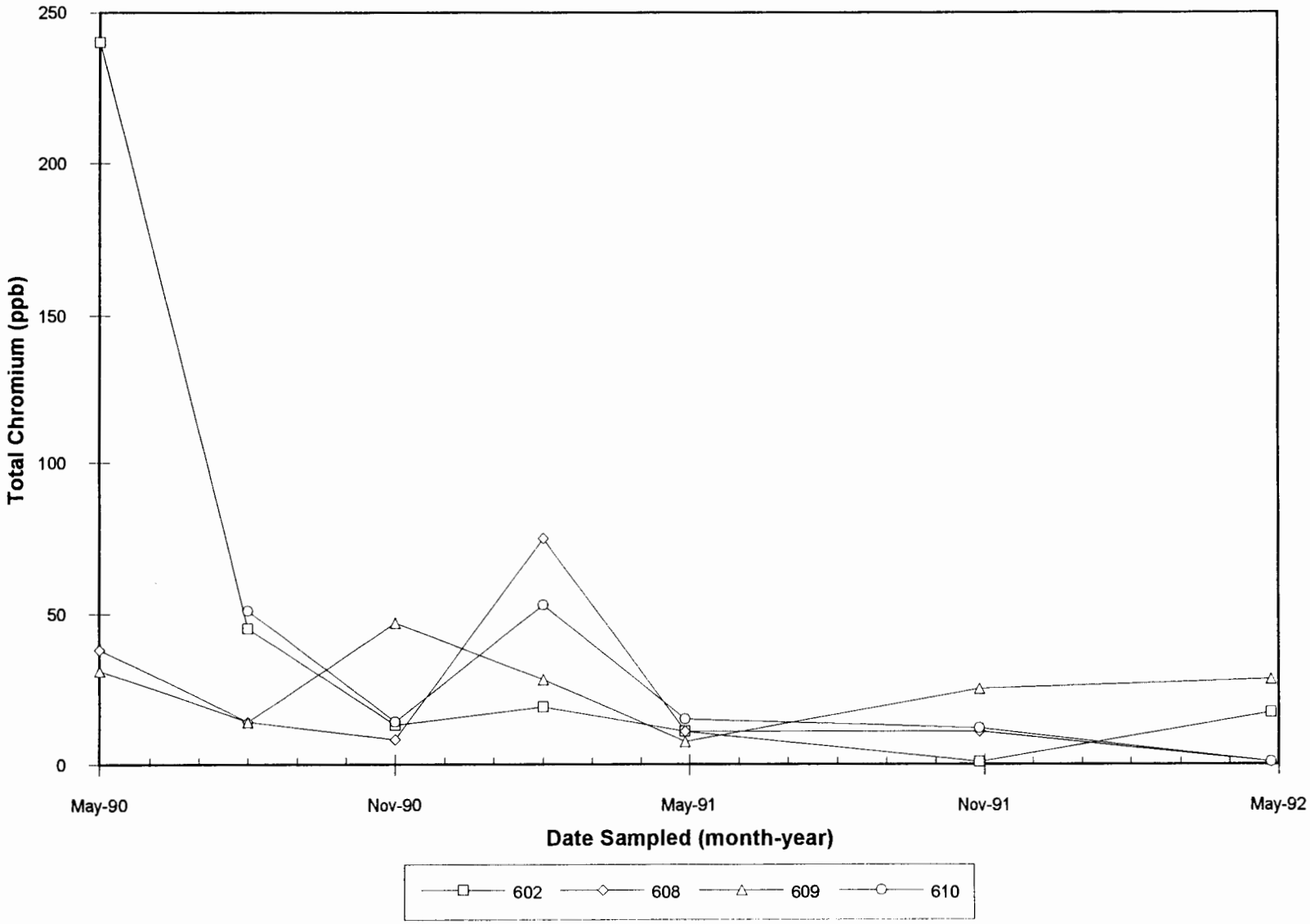

KAFB POST-CLOSURE PLAN

Chromium in Ground Water at Golf Course Main Pond Site

Figure 11

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Persistence of the contaminant and potential for degradation or transformation of the contaminant. Cr(VI) is not likely to persist in either the sludge or soil at these sites. Highly oxidizing conditions, high pH, and the absence of reducing agents such as ferrous iron, sulfide, or organic matter are necessary for the presence of Cr(VI) (Robertson, 1975). Given the abundance of organic material at both sites, it is likely that any Cr(VI) that may have been initially present in sewage effluent was transformed to Cr(III) and precipitated with or adsorbed on iron oxyhydroxides or carbonate materials.

Bioaccumulation potential of the contaminant. Cr is an essential element for good nutrition. It is bioaccumulated, but generally at lower rates than those associated with other trace metals.

Plausible improper management of the site (and resulting release of the contaminant). The sewage lagoons were unlined surface impoundments that were used for sewage effluent from the facilities of KAFB, its contractors, and the numerous tenants, including Sandia National Laboratories, who have conducted operations at KAFB. The design and use of unlined sewage treatment facilities do not comply with current standards for segregation or containment of effluent wastewater. However, the use of wastewater from the lagoons was accepted practice at the time of their construction. Furthermore, such use addressed a need that persists for communities in arid environments, namely, the conservation of water resources. Both the sewage lagoons and golf course main pond are currently unused.

Nature and severity of any damage that already has occurred. No damage to human health or the environment has been documented due to use of the sewage lagoons or the golf course main pond.

Other actions at similar sites. The treatment of sewage sludge using unlined surface impoundments was a common practice in the past, especially in the arid southwest where high evaporation rates prevail for much of the year. Current sludge land application guidelines (Section 5.2) allow the use of sewage sludge with Cr concentrations nearly 50 percent higher than the highest concentration known to be present in the sludge remaining in the sewage lagoons. These regulations reflect the mechanisms leading to Cr reduction and immobilization in soils that are protective of ground-water supply sources and thus to human health.

5.2 New Standards for Use or Disposal of Sewage Sludge

The EPA published new regulations for the disposal of sewage sludge on February 19, 1993 in the Federal Register. These regulations, Part 503, Standards for Use or Disposal of Sewage Sludge, contain concentration guidelines for evaluating land application as a means of sludge disposal.

Although not strictly applicable to the lagoon or pond sites, the metal application limits presented in Subpart B, Land Application (Part 503.13) do provide a relevant and useful perspective for interpreting the concentrations of Cr encountered in the sludge and soil at these sites. The ceiling concentration allowed for sewage sludge is 3000 mg/kg, a value that is not exceeded by any of the sludge sample analyses conducted thus far. The highest concentration observed in sludge samples collected to date is 2250 mg/kg, and most sludge sample Cr concentrations are much lower.

The cumulative loading limit for Cr is 3000 kilograms per hectare (kg/ha) (or about 2,679 pounds per acre [lb/a]). Based on the estimated volume of sludge remaining in the lagoons (2,023 cubic yards) and a density of 87.4 pounds per cubic foot, a conservative maximum cumulative metal loading at the sewage lagoons is 836 lb/a, well below the 2,679-lb/a (or 3,000-kg/ha) limit listed in Table 2 of Part 503.13. Details of this calculation are presented in Appendix D.

5.3 Clean Closure Requirements

KAFB has proposed clean closure for the sewage lagoons and golf course main pond, based on characterization of the sludge as a nonhazardous solid waste and declining concentrations of total Cr in ground-water samples collected over the past four years.

5.3.1 Clean Closure

According to the definition of clean closure, all hazardous wastes must be removed or decontaminated. The remedy includes no engineering controls, and no operation or maintenance activities are required to maintain the site. In addition, no land use restrictions are imposed at the site. With respect to minimizing hazards to human health and the environment, any ground water that could be affected must meet drinking water standards. Leachate from the closed facility must meet TCLP regulatory levels.

5.3.2 Hybrid Clean Closure

A variation of clean closure, termed hybrid clean closure, has been presented as a means of allowing practical and more cost-effective solutions to be implemented at some sites (U.S. EPA, 1989a). The remedies for these sites must still provide protection from hazards to human health and the environment. For example, low concentrations of waste that do not pose a threat of exposure through migration by any route may remain in place; however, ground water must be sufficiently protected so that it meets either drinking water standards or the risk range calculated for the site.

5.3.3 Closure at the Sewage Lagoons and Golf Course Main Pond

Certification that the sewage lagoons and golf course main pond were closed was documented in a letter to NMED dated August 12, 1993 (KAFB, 1993). The only deviation from the approved closure plan was to leave the sludge in place. KAFB believes that the closure qualifies as a hybrid clean closure based on characterization of the lagoon and pond sludges as non-hazardous solid wastes that do not pose a present or potential hazard to human health or the environment. Based on the analytical results, it appears that most of the Cr present in soil, sludge, pond sediment, and ground-water samples is Cr(III). Although the sludge at both sites was originally accumulated in a surface impoundment, KAFB believes that both facilities qualify in their current condition and use as land application sites, and that the metal concentration guidelines for sewage sludge provide a reasonable perspective from which to view the proposal for clean closure of these sites. However, to meet the requirements for clean closure under HWMR-7, Part VI 40 CRF 265.228(a)(1) at the end of Phase I, the following conditions must be met:

1. Either sludge analysis results show Cr concentrations below both TCLP regulatory levels and soil action levels or sludge and pond sediments are removed or decontaminated.

2. Ground-water monitoring results show Cr concentrations below WQCC levels.

6. PHASE I SAMPLING AND ANALYSIS PLAN

The purpose of this Phase I sampling and analysis plan is to collect additional samples to verify the downward trend shown in previous Cr sampling results in support of clean closure of the KAFB sewage lagoon and golf course main pond. All field and laboratory activities specified in this plan will be conducted in general accordance with the procedures contained in the Installation Restoration Program (IRP) Stage 2 Sampling and Analysis Plan (SAP) for KAFB (USGS, 1989), DBS&A Standard Operating Procedures (SOPs)(Appendix E), and the site-specific health and safety plan (HSP) contained in Appendix F.

Two sludge samples will be collected as part of the Phase I sampling activities. In addition, four rounds of quarterly ground-water samples will be collected and analyzed from all four wells at each site for one year. Field and laboratory quality control (QC) procedures followed during Phase I work activities will conform with those contained in the IRP Stage 2 SAP for KAFB (USGS, 1989), described in Section 6.3 of this plan. However, all wells will be purged and sampled using low-flow, submersible pumps. All nondisposable sampling equipment will be carefully decontaminated with Liquinox® and rinsed with distilled water prior to use, and a pair of new clean latex or plastic gloves will be donned prior to handling each new sludge or ground-water sample.

Sample containers will be labeled and marked with indelible ink and then placed on ice inside an insulated cooler. Ample ice will be used to maintain a temperature of 4°C inside the cooler. Chain-of-custody forms will be completed for all samples collected, and the forms will be placed in a sealed plastic bag and taped to the inside of the cooler lid. Chain-of-custody seals will be placed across the front and back of the cooler lid such that they will be broken in the event of tampering. The cooler lid will be firmly taped shut with several layers of shipping tape encircling the ends of the cooler. The samples will be shipped by overnight courier to Analytical Technologies, Inc. (ATI) in Phoenix, Arizona. Sampling and analysis requirements are described in more detail below.

6.1 Sludge Sampling

Four sewage sludge samples will be collected from each of the two KAFB sewage lagoons to be combined into one composite sample for each lagoon. The proposed subsampling locations are shown in Figure 3. Subsamples will be collected using clean stainless steel equipment in accordance with DBS&A SOP 13.3.2 (Appendix E) and KAFB procedures. One split-ring sample will be collected from each of the four subsampling locations, and the depth of sludge at each location will be recorded. These samples will be maintained under custody in the event that additional analysis is requested for individual subsamples.

The composite sample will be composed of equal volumes of each sludge subsample mixed in a stainless steel bowl. After thorough mixing, one sampling jar for each lagoon will be filled with the composite sludge material. Sludge samples will be shipped by overnight courier to ATI in for analysis of total Cr, Cr(VI), and for Cr by the toxicity characteristic leaching procedure (TCLP). EPA methods 3050 and 1311 will be used for sample preparation and methods 7191, furnace atomic absorption (AA), and 7196, colorimetric for Cr(VI), for speciation. Sampling and preservation requirements are shown in Table 8.

Table 8. Container/Preservative Requirements for Sludge and Ground-Water Samples

Sample Type	Analysis	Container	Preservative	Holding Time (from sampling date)
Sludge	Total chromium	4-oz. jar	--	6 months
Sludge	Hexavalent chromium	4-oz. jar	--	28 days
Sludge	TCLP chromium	8-oz. jar	--	6 months
Ground water	Total chromium	16-oz. plastic	1 mL HNO_3	6 months
Ground water	Hexavalent chromium	16-oz. plastic	Unpreserved	24 hours
Ground water	Turbidity	4-oz. plastic	Unpreserved	48 hours

6.2 Monitor Well Sampling

The Phase I field sampling activities will include quarterly collection and analysis of samples from monitor wells KAFB 0501, 0502, 0503, 0504, 0602, 0608, 0609, and 0610 for a period of one year, in accordance with DBS&A SOP 13.5 (Appendix E) and KAFB procedures for ground-water sampling. The monitor well locations are shown in Figure 9.

Prior to purging and ground-water sample collection, the area around each monitor well will be inspected for wellhead integrity, cleanliness, and signs of possible contamination, and any deficiencies will be noted in the field logbook. In addition, the depth to ground water will be measured, in general accordance with KAFB procedures. All equipment that comes in contact with the ground water will be decontaminated prior to use in order to avoid cross-contamination between monitor wells.

Prior to sampling, approximately three to five well volumes will be purged from each monitor well using a submersible pump. The purge water will be held under custody in secure, labeled and dated 55-gallon drums and appropriately disposed of upon receipt of the laboratory analytical results.

Ground-water samples will be collected using a submersible pump. Extreme care will be taken to minimize the turbidity of the ground-water samples, and measurements of turbidity will be recorded in the field. Samples will be collected in clean bottles provided by the analytical laboratory and will be shipped by overnight courier to ATI for analysis of total Cr and hexavalent Cr. EPA methods 7191 and 7196 will be used for speciation. Sampling and preservation requirements are shown in Table 8.

In the event that the concentration of total Cr in any ground-water sample exceeds one half the WQCC standard (0.5 * 0.050 mg/L = 0.025 mg/L), an additional background ground-water sample will be collected immediately from KAFB production well 4, which is located approximately 200 yards southeast of the south sewage lagoon. Samples will also be collected from this well during the remaining rounds of quarterly ground-water sampling.

The proposed quarterly sampling dates include July 1994, October 1994, January 1995, and April 1995. All data will be reviewed at the end of this one-year period to evaluate the necessity of continued ground-water monitoring at the site.

6.3 Quality Assurance/Quality Control Procedures

Field QC procedures will consist of conformance with this plan and associated KAFB and DBS&A procedures, and collection of field duplicate samples. Any variance to this plan will be noted in the field logbook. No field duplicate sludge samples will be collected. One field duplicate ground-water sample will be collected to determine the precision of the sample collection system. Duplicate sample collection methods will be identical to those for the original sample, and samples will be handled and analyzed in an identical manner. Results of the duplicate analysis will be reported as a relative percent difference (RPD). Laboratory QC procedures will include the analysis of laboratory batch control samples, method blanks, matrix spikes, and matrix spike duplicates. QC requirements are summarized in Tables 9 and 10.

Table 9. Laboratory Quality Control Limits for Matrix Spikes, Matrix Spike Duplicates, and Surrogate Spikes

Analytical Method	Spiking Compounds	Spike Concentration		Laboratory Established Control Limits			
				% Recovery		Relative % Difference	
		Water (μg/L)	Soil (mg/kg)	Water	Soil	Water	Soil
SW 7191	Matrix: Chromium	0.2	20	75-125	75-125	<20	<20

6.4 Health and Safety Procedures

A site-specific HSP has been prepared for this project and is contained in Appendix F. Field personnel will be required to read the HSP and sign a statement that they understand the health and safety requirements of the project. The purpose of the HSP is to outline site activities and

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The proposed quarterly sampling dates include March 1994, June 1994, September 1994, and December 1994. All data will be reviewed at the end of this one-year period to evaluate the necessity of continued ground-water monitoring at the site.

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Field QC procedures will consist of conformance with this plan and associated KAFB and DBS&A procedures, and collection of field duplicate samples. Any variance to this plan will be noted in the field logbook. No field duplicate sludge samples will be collected. One field duplicate ground-water sample will be collected to determine the precision of the sample collection system. Duplicate sample collection methods will be identical to those for the original sample, and samples will be handled and analyzed in an identical manner. Results of the duplicate analysis will be reported as a relative percent difference (RPD). Laboratory QC procedures will include the analysis of laboratory batch control samples, method blanks, matrix spikes, and matrix spike duplicates. QC requirements are summarized in Tables 9 and 10.

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Table 10. Field and Laboratory Quality Control Furnace AA Screen (Chromium) SW 7191

QC Check	Frequency	Acceptance Criteria	Corrective Action
Field QC:			
Equipment blank	1 per day	Any compounds detected must be less than 3 times the project detection level.	If compounds found in equipment blank are also found in samples at similar concentrations, resample all samples since last acceptable equipment blank.
Duplicate	1 duplicate ground-water sample	Concentration must be within 30% RPD for water samples and within 40% RPD for soil samples.	Use data to evaluate sample collection procedures. Resample if procedures are found to be out of control.
Laboratory QC:			
Calibration curve	Established daily, verified every 10 samples	Initial calibration verification check standard must be within 10% of calibration curve.	1. Validate standards. If standard is still outside acceptance criteria, obtain fresh, certified standards. 2. Recalibrate instrument. 3. Document actions taken.
Interelement check sample	Quarterly	Concentration of analyte subject to potential spectral interference must be within 10% of calibration curve.	1. Compute and apply correction factor. 2. If correction factor shows a steadily changing trend, clean and recalibrate instrument. 3. Document actions taken.
Method blank	1 per batch	Concentrations must not exceed two times the reporting level of the analyte.	1. Determine if concentration levels in the sample exceed those found in blank. If so, raise reporting limit and qualify data. 2. If not, reprepare blank, QC samples, and affected samples. 3. Document actions taken.
Duplicate control sample (DCS)	1 duplicate	80% of values must be within 3 standard deviations of mean historical values or methodology control limits of precision and accuracy.	1. Validate instrument parameters, sensitivity and linearity. Correct problems and document. 2. Validate standards. 3. Validate DCS preparation. 4. Reanalyze DCS and samples. 5. If repreparation of samples is not possible, qualify data. 6. Document actions taken.

RPD = Relative percent difference

the personal protective equipment (PPE) necessary to ensure that all sampling activities are conducted in a safe manner. It is assumed that all sampling activities may be accomplished using Level D PPE. Health and safety procedures are discussed in more detail in Appendix F.

6.5 Phase I Reports

A report describing the initial Phase I field activities and results will be prepared following receipt of the laboratory analytical results. Thereafter, quarterly reports will be prepared following receipt of the laboratory analytical results for each succeeding round of quarterly ground-water sampling. The schedule for post-closure activities is shown in Table 11.

Table 11. Schedule for Post-Closure Activities

Milestone	Date
NMED/KAFB meeting	10 January 1994
Submit revised post-closure plan	1 April 1994
Post-closure plan approved	6 July 1994
Phase I sampling	
Sludge	8 July 1994
Ground water	8 July 1994
Analyses	5 August 1994
Initial Phase I report	26 August 1994
Ground water monitoring	
Second quarter	October 1994
Third quarter	January 1995
Fourth quarter	April 1995
Quarterly monitoring reports	3 weeks after receipt of analytical results

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Table 11. Schedule for Post-Closure Activities

Milestone	Date
NMED/KAFB meeting	10 January 1994
Submit revised post-closure p	10 February 1994
Finalize post-closure plan	24 February 1994
Phase I sampling	
Sludge	4 March 1994
Ground water	18 March 1994
Analyses	18 April 1994
Initial Phase I report	16 May 1994
Ground water monitoring	
Second quarter	June 1994
Third quarter	September 1994
Fourth quarter	December 1994
Quarterly monitoring reports	3 weeks after receipt of analytical results

6.6 Phase II Sludge and Sediment Management Activities

If, after completing sludge sampling, Cr TCLP concentration of any sludge sample exceeds the regulatory level of 5.0 mg/L or either Cr(III) or Cr(VI) concentrations exceed the appropriate soil-based action level, KAFB will remove or decontaminate the associated sludge and dry sediment from the sewage lagoon and golf course main pond as hazardous wastes according to 40 CFR 265.228(a). Removal and decontamination procedures will be fully described in a remedial action plan that will be submitted to NMED within 90 days of receipt of the laboratory analytical results. The remedial action will be initiated within 30 days of final approval of the remedial action plan.

6.7 Phase II Ground-Water Management Activities

If, at the end of Phase I monitoring, total Cr concentrations in ground water at either unit, minus the acceptable background concentration of total Cr determined during Phase I, exceed the WQCC standard of 0.05 mg/L, KAFB will continue quarterly ground-water monitoring at both the noncomplying site and at least one background well according to 40 CFR 265.117 and Subpart F. Furthermore, KAFB will develop a ground-water quality assessment plan according to 40 CFR 265.93(d). The sampling and analytical procedures will be the same as those conducted during Phase I.

If, at the end of Phase I monitoring, total Cr concentrations in ground-water at either unit, minus the acceptable background concentration of total Cr determined during Phase I, do not exceed the WQCC standard, KAFB will cease further ground-water monitoring activities. KAFB will then close both sites by managing the sludge and dry sediments as described above.

The following annotated outline addresses two anticipated potential scenarios for Phase I and Phase II management activities.

I. Cr concentrations exceed the WQCC standard

If ground-water total Cr concentrations at either site exceed the WQCC standard, KAFB will carry out the following post-closure activities according to 40 CFR 265.117.

A. *Ground-water monitoring.* Quarterly ground-water monitoring at the noncomplying unit and at least one background well will continue in compliance with 40 CFR 265, Subpart F. The sampling and analytical procedures will be the same as those conducted during Phase I.

B. *Ground-water quality assessment and remedial action plans.* KAFB will prepare a quality assessment plan to determine the concentrations, rate, and extent of migration of Cr in the ground water. KAFB will also, in conjunction with NMED, prepare a remedial action plan to reduce the concentration of total Cr in the ground-water aquifer beneath the noncomplying unit(s).

C. *Cover design plan.* KAFB will prepare cover design plans for the noncomplying unit(s). All plans will be subject to NMED approval. The cover design will meet the requirements of 40 CFR, Parts 265.228, for surface impoundments, and 265.310, for landfills. These two sections detail requirements that include, at a minimum, provisions for (1) minimal migration of fluids through the closed unit, (2) minimal maintenance requirements, (3) adequate surface drainage run-off and erosion control, (4) settling and subsidence, to maintain cover integrity, and (5) cover permeability less than or equal to the natural subsoils present at the unit.

II. *No Cr concentrations exceed the WQCC standard*

If total Cr concentrations in all ground-water samples collected at the sewage lagoons and the golf course main pond do not exceed the WQCC standard, KAFB will close the two sites by managing the sludge and dry sediments, according to guidelines based upon the results of sludge sampling.

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APPENDIX A

ACTION LEVELS AND UPPER TOLERANCE LIMITS

Action Levels and Upper Tolerance Limits

The following sections that comprise Appendix A (4.1.2 and 4.1.3) are copied from the RFI Stage 2A Final Technical Report (USGS, 1993b).

Please note that the soil action level listed in Table 4.1.3.1 for Chromium (total) should actually refer to trivalent chromium, Cr(III). The value listed (80,000 mg/kg) is based on the following calculation (Federal Register, July 27, 1990, p. 30870):

$$C_{cr} = \frac{Rfd \cdot W}{I \cdot A}$$

Where
- Rfd = Reference dose (1.0 mg/kg/day)
- W = Body weight (16 kg for children)
- I = Intake assumption (0.2 g/day for children)
- A = Absorption factor (assumed 1)

Surrogate spike recoveries

Surrogates are organic compounds with similar chemical behavior as the analytes of interest, but which are not normally found in environmental samples. Consequently, surrogate recoveries were done only for methods SW8240 and SW8270. The surrogate recoveries monitored the matrix effect of environmental samples on the accuracy of the analyses.

Samples with surrogate recoveries not within-control limits are listed in Appendix G. Analytes not within-control limits included several semi-volatile organic compounds, and the volatile organic compounds 4-bromofluorobenzene, 1,2-dichloroethane-d4, and toluene-d8.

4.1.2 Statistical analyses and results of background data

Analytical results of the RFI were statistically evaluated to determine Base-wide background concentrations for naturally occurring soil metals and ground-water quality parameters. Background concentrations were not determined for all of the soil metals and groundwater metals because there were not enough detected background data to support meaningful statistical calculations. The background concentrations were compared to results of soil and ground-water samples collected from potentially contaminated areas (site results) for each analyte. This comparison provided a valid method to determine if concentrations of site results differed from naturally occurring background concentrations. No background concentrations were determined for surface water because there were an insufficient number of samples taken upstream in Tijeras Arroyo to calculate background, and there was no background sampling location for Lake Christian.

The background determination was made by calculating an upper tolerance limit (UTL) for background concentration for each analyte and matrix for which there were a sufficient number of detected concentrations. Analyte concentrations from each site were then compared to the UTL. The UTL test is considered an extreme value test because analyte results from a site are compared to the background sample group (by analyte) rather than comparing the site as a whole to the background levels. Any analyte concentration below UTL can be considered background. The individual comparisons are then considered for each site as a group to determine recommendations for that site. The results of the statistical comparisons are discussed for each site in the subsection titled Analytical Results.

Statistical Methodology

A statistical tolerance interval results in a concentration range that contains a specified proportion (p%) of a population (in this case background) with a specified confidence coefficient, γ. The proportion of the population, p, is referred to as the coverage. For Kirtland AFB, the calculation of tolerance intervals was made using a coverage of c=95% and a confidence of $\gamma = 95\%$ as recommended in Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (EPA, 1989). The UTL for background thus defines a limit such that 95% of background results should be less than upper limit 95% of the time. In calculating a normal UTL for background, the assumption is that the background are approximately normally distributed. This was generally true for the background data.

The UTL for background was calculated using the following equation:

$$UTL_{\gamma, c} = \bar{X} + S_x K_{\gamma, c} \tag{4-1}$$

where:

$$\bar{X} = \frac{\sum X_i}{n} \tag{4-2}$$

$$S_x = \sqrt{\frac{\sum (X_i - \bar{X})^2}{n-1}}$$

X_i = individual measurement results

n = the total number of measurements

$K_{\gamma, c}$ = K-factor for confidence level (γ) and coverage (c)

γ = the confidence level

c = the coverage level

Summary of Soil Metals Results

Eighteen background soil samples were collected at locations upslope and updip from seven of the fourteen sites where soil samples were collected. Sixteen of the samples were collected at depths of 3 to 5 feet and the other 2 samples were collected at 25 feet. Table 4.1.2.1 lists the sample and location identification and the location description. Each of the 18 background soil samples was analyzed for the 24 metals listed in table 4.1.2.2. The environmental soil samples other than the background samples were collected from soil borings on or adjacent to the 14 SWMUs sites where soils were potentially contaminated. Summaries of analytical results are included in the sections titled Analytical Results for each site. Complete results for background and potentially contaminated soil samples from sites are included in the ITIRs in Appendix G.

UTLs were calculated for those analytes detected in a sufficient number of the 18 background samples for meaningful statics. Antimony, arsenic, mercury, molybdenum, selenium, and silver were not detected in any of the 18 background samples; cadmium and thallium were detected in only one of the 18 samples. No UTLs were calculated for these eight metals. RCRA guidance (EPA, 1989) recommends calculating UTLs when an analyte is detected in 50 to 100% of the samples. This was the case for the other 16 metals listed in table 4.1.2.2. For these 16 metals, the not-detected results were assigned a value of one-half of the detection limit for each metal. Table 4.1.2.2 is a summary of the percent detected, mean, standard deviation, K-factor, and UTL, where calculated.

SAMPLE/LOCATION ID	LOCATION DESCRIPTION
KAFB042002-1	Upslope from Fire Training Area clearing
KAFB042101-1	Upslope from Fire Training Area clearing
KAFB080402-1	Upslope from Explosive Ordnance Disposal clearing
KAFB080501-1	Upslope from Explosive Ordnance Disposal clearing
KAFB110301-1	On hill above Landfill no. 3 arroyo fill area
KAFB110401-1	On hill above Landfill no. 3 arroyo fill area
KAFB141101-1	Upslope from Manzano Sewage Lagoons
KAFB141102-1	Upslope from Manzano Sewage Lagoons
KAFB141201-1	Upslope from Manzano Sewage Lagoons
KAFB141301-1	Upslope from Manzano Sewage Lagoons
KAFB150601-1	Upslope from Manzano Dump
KAFB150701-1	Upslope from Manzano Dump
KAFB150801-1	Upslope from Manzano Dump
KAFB151302-1	Upslope from Unnamed Dump
KAFB181401-1	Upslope from Unnamed Dump
KAFB210401-1	Upslope from Landfill B
KAFB210405-1	Upslope from Landfill B
KAFB210501-1	Upslope from Landfill B

Table 4.1.2.1.--Location of Background Soil Samples.

Table 4.1.2.2--Upper tolerance limits for background soil samples

[Confidence level = 95%; tolerance level = 95%; NC, not calculated]

Analyte	Number detected	Total number of analyses	Percent detected (percent)	Mean (mg/kg)	Standard deviation (mg/kg)	K-Factor	Upper tolerance limit (mg/kg)
Aluminum	18	18	100	5,275.556	1,887.554	2.543	10,075.61
Antimony	0	18	0	5.5	0	2.543	NC
Arsenic	0	18	0	2.85	0	2.543	NC
Barium	18	18	100	121.238	83.648	2.543	333.957
Beryllium	17	18	94.4	0.348	0.115	2.543	0.643
Cadmium	1	18	5.55	0.163	0.056	2.543	NC
Calcium	18	18	100	36,956.11	39,614.06	2.543	137,694.7
Chromium	16	18	88.9	4.066	2.454	2.543	10.307
Cobalt	17	18	94.4	4.119	2.058	2.543	9.354
Copper	17	18	94.4	6.986	4.209	2.543	17.692
Iron	18	18	100	9,269.444	3,899.918	2.543	19,186.94
Lead	9	18	50	4.08	2.604	2.543	10.704
Magnesium	18	18	100	4,473.889	3,153.859	2.543	12,494.15
Manganese	18	18	100	206.461	108.172	2.543	481.544
Mercury	0	18	0	0.025	0	2.543	NC
Molybdenum	0	18	0	0.45	0	2.543	NC
Nickel	18	18	100	6.461	2.391	2.543	12.543
Potassium	18	18	100	1,316.167	719.901	2.543	3,146.875
Selenium	0	18	0	0.1	0	2.543	NC
Silver	0	18	0	0.5	0	2.543	NC
Sodium	17	18	94.4	364.016	510.139	2.543	1,661.302
Thallium	1	18	5.55	0.112	0.049	2.543	NC
Vanadium	18	18	100	18.961	9.301	2.543	42.614
Zinc	18	18	100	27.65	12.318	2.543	42.511

Summary of Ground Water Results

Eight background ground-water samples were collected from wells upgradient from four of the six sites where ground-water samples were collected from wells drilled for Stage 2A. Table 4.1.2.3 lists the sample and location identification and the location description. Each of the 8 background water samples was analyzed for the 10 non-metallic analytes and the 26 metals listed in table 4.1.2.4. The environmental ground-water samples other than the background samples were collected from wells located on or adjacent to the six SWMUs sites where wells were drilled for Stage 2A, and from the 13 wells drilled and sampled during Stage 2. Summaries of analytical results are included in the sections titled Analytical Results for each site. Complete results for background and potentially contaminated water samples are included in the ITIRs in Appendix G.

UTLs were calculated for those analytes and properties detected in a sufficient number of the eight background samples for meaningful statistics. UTLs were calculated only for dissolved metals, because total metals analyses include metals digested from suspended sediments in the samples. Cyanide, nitrate, and sulfide were detected in two or less of the eight background samples. No UTLs were calculated for these analytes. Aluminum, antimony, beryllium, cadmium, cobalt, copper, iron, mercury, molybdenum, nickel, silver, tin, and thallium were not detected in any of the eight background samples; lead and selenium were each detected in only two of the eight samples. No UTLs were calculated for these 15 metals. UTLs were calculated for the other 11 metals listed in table 4.1.2.4. For these metals, the not-detected results were assigned a value of one-half of the detection limit for each metal. Table 4.1.2.4 is a summary of the percent detected, mean, standard deviation, K-factor, and UTL, where calculated

4.1.3 RCRA risk-based action levels

Action levels for RCRA corrective actions are quantitative standards for a variety of pollutants established for different media (air, water, soil). The proposed RCRA Subpart S in 40 CFR Part 264 contains methodology and criteria for calculating action levels for contaminants in soil, water, and air. Action levels derived according to these criteria represent valid, reasonable estimates of levels in media at or below which corrective action is unlikely to be necessary. Action levels are not, however, cleanup standards. Cleanup standards will be established later in the RCRA corrective action process; action levels will be used as a screen to determine if corrective actions are unlikely to be necessary, or as starting criteria, together with consideration of background concentrations, for setting cleanup standards.

Soil action levels are derived from reference doses (RfDs) or carcinogenic slope factors (SFs). Existing action levels for metals in soil are listed in table 4.1.3.1. All of the action levels shown on the table are derived from RfDs except the action level for beryllium, which is derived from a SF. Exceedances of these action levels are described by site in the following sections.

Action levels for ground water are derived from RfDs or SFs, or are EPA Maximum Contaminant Levels (MCLs) or the New Mexico Human Health Standards. In cases where multiple action levels were available for a particular analyte, the most stringent value was used. Action levels for non-metallic analytes, water properties, and metals in ground water are listed in table 4.1.3.2.

MONITOR WELL ID	LOCATION DESCRIPTION
KAFB011008	Upgradient from Landfill no. 1
KAFB011312	Upgradient from Landfill no. 1
KAFB011707	Upgradient from Landfill no. 1
KAFB021511	Upgradient from Landfill no. 1
KAFB021609	Upgradient from Landfill no. 1
KAFB031007	Upgradient from Landfills no. 4-5-6
KAFB100109	Upgradient from McCormick Ranch
KAFB100208	Upgradient from McCormick Ranch

Table 4.1.2.3--Location of Background Ground-Water Samples.

Table 4.1.2.4.--Upper tolerance limits for background ground-water samples

[Confidence level = 95%; Tolerance level = 95%; NC = not calculated]

Analyte	Number detected	Total number of analyses	Percent detected (percent)	Mean (mg/L)*	Standard deviation (mg/L)*	K-Factor	Upper tolerance limit (mg/L)*
Alkalinity as $CaCO_3$	8	8	100	140	38.619	3.188	263.117
Chloride	8	8	100	32.175	50.909	3.188	194.474
Conductivity (µS/cm)	8	8	100	506	231.924	3.188	1245.376
Cyanide	0	8	0	0.005	0	3.188	NC
Fluoride	7	8	87.5	0.427	0.336	3.188	1.501
Nitrate + Nitrite as N	8	8	100	2.711	2.216	3.188	9.779
Nitrate as N	2	8	25	0.115	0.211	3.188	NC
Sulfate	8	8	100	59.3	35.021	3.188	170.947
Sulfide	1	8	12.5	0.020	0.012	3.188	NC
Total Dissolved Solids	8	8	100	347.25	157.952	3.188	850.803
Dissolved Metals							
Aluminum	0	8	0	0.029	0.000	3.188	NC
Antimony	0	8	0	0.055	0.000	3.188	NC
Arsenic	5	8	62.5	0.0015	0.0011	3.188	0.005
Barium	8	8	100	0.069	0.026	3.188	0.153

Table 4.1.2.4.--Upper tolerance limits for background ground-water samples--Continued

Analyte	Number detected	Total number of analyses	Percent detected (percent)	Mean (mg/L)*	Standard deviation (mg/L)*	K-Factor	Upper tolerance limit (mg/L)*
Beryllium	0	8	0	0.001	0.000	3.188	NC
Cadmium	0	8	0	0.002	0.000	3.188	NC
Calcium	8	8	100	57.438	34.280	3.188	168.318
Chromium	6	8	75	0.0064	0.0060	3.188	0.026
Cobalt	0	8	0	0.005	0.000	3.188	NC
Copper	0	8	0	0.003	0.000	3.188	NC
Iron	0	8	0	0.024	0.000	3.188	NC
Lead	2	8	25	0.001	0.001	3.188	NC
Magnesium	8	8	100	12.234	7.229	3.188	35.278
Manganese	5	8	62.5	0.008	0.013	3.188	0.048
Mercury	0	8	0	0.00005	0.000	3.188	NC
Molybdenum	0	8	0	0.005	0.000	3.188	NC
Nickel	0	8	0	0.007	0.000	3.188	NC
Potassium	8	8	100	3.313	0.445	3.188	4.730
Selenium	2	8	25	0.002	0.003	3.188	NC
Silver	0	8	0	0.005	0.000	3.188	NC
Sodium	8	8	100	36.112	15.416	3.188	85.258

Table 4.1.2.4.--Upper tolerance limits for background ground-water samples--Continued

Analyte	Number detected	Total number of analyses	Percent detected (percent)	Mean (mg/L)*	Standard deviation (mg/L)*	K-Factor	Upper tolerance limit (mg/L)*
Tin	0	8	0	0.060	0.000	3.188	NC
Thallium	0	8	0	0.001	0.000	3.188	NC
Uranium (µg/L)	4	8	50	1.563	1.299	3.188	5.705
Vanadium	4	8	50	0.006	0.003	3.188	0.017
Zinc	3	8	37.5	0.016	0.023	3.188	0.088

*Units are milligrams per liter (mg/L) except for conductivity which is microsiemens per centimeter (µS/cm) at 25° Celsius and uranium which is micrograms per liter (µg/L).

CHEMICAL	SOIL ACTION LEVEL (mg/kg)
Acetone	8000
Antimony	32
Arsenic	24
Barium	5600
Benzoic acid	320000
Beryllium	0.2
Butanone	48000
Butyl benzyl phthalate	16000
Cadmium	40
Chromium (total)	80000
Chromium VI	400
Di-n-butyl-phthalate	1600
Manganese	400
Mercury	20
Molybdenum	400
Methylene chloride	93
Nickel	1600
Selenium	400
Silver	400
Thallium	6.4
Toluene	16000
Xylenes	160000
Zinc	24000

Table 4.1.3.1.--Action levels for soil.

Table 4.1.3.2.--Action levels from water-quality standards

[The basis for an action-level selection is the most stringent regulatory concentration and is denoted with a letter as follows: M, Federal Safe Drinking Water Act (SWDA) maximum contaminant level; R, RCRA non-carcinogenic oral reference dose (RfD) for water; S, RCRA carcinogenic oral slope factor for water; G, New Mexico Water Quality Control Commission (NMWQCC) ground-water standard. --, no action level; *, secondary maximum contaminant level, non-enforceable; **, providing <4 mrem/yr by beta emitters]

Analyte	Units	Federal SDWA Maximum Contaminant Level	RCRA action-level (RfD based; April 1993 IRIS listing)	RCRA action level (slope-factor based; April 1993 IRIS listing)	NMWQC ground-w standar
Acetone	µg/L	--	3,500 R	--	--
Acetonitrile	µg/L	--	210 R	--	--
Aluminum	mg/L	0.05*	--	--	5
Antimony	mg/L	0.006 M	0.014	--	--
Arsenic	mg/L	0.050	0.011 R	--	0.1
Barium	mg/L	2	2.5	--	1.0
Benzene	µg/L	5.0	--	1.2[a] S	10
Beryllium	mg/L	0.004	0.175	0.000008[b] S	--
Alpha-BHC (Alpha-hexa-chlorocylohexane)	µg/L	--	--	0.0056[b] S	--
Bromodichloromethane	µg/L	100	700	0.565[b] S	--
2-Butanone (MEK)	µg/L	--	21,000 R	--	--
Cadmium	mg/L	0.005 M	0.0175	--	0.01
Calcium	mg/L	--	--	--	--
Chloride	mg/L	250*	--	--	250
Chloroform	µg/L	100	350	5.74[b] S	100
Chloromethane	µg/L	--	--	--	--
Chromium	mg/L	0.10	35	--	0.05
Chromium (VI)	mg/L	--	0.175 R	--	--
Chrysene	µg/L	0.2[d] M	--	--	--
Cobalt	mg/L	--	--	--	0.05
Copper	mg/L	1.3	--	--	1.0
1,3-Dichlorobenzene	µg/L	600 M	--	--	--
1,4-Dichlorobenzene	µg/L	600 M	--	--	--
1,1-Dichloroethene	µg/L	7	315	0.583[c] S	5
1,2-Dichloroethane	µg/L	5	--	0.385[b] S	10
1,2-Dichloropropane	µg/L	5 M	--	--	--
Dichlorodifluoromethane	µg/L	--	7,000 R	--	--
Di-n-octyl phthalate	µg/L	--	--	--	--

Table 4.1.3.2.--Action levels from water-quality standards—Continued

Analyte	Units	Federal SDWA Maximum Contaminant Level	RCRA action-level (RfD based; April 1993 IRIS listing)	RCRA action level (slope-factor based; April 1993 IRIS listing)	NMWQCC ground-water standard
EDB (1,2-Dibromoethane)	µg/L	0.05	--	0.00041[b] S	0.10
bis-(2-Ethylhexyl) phthalate	µg/L	6.0	700	2.5[b] S	--
Fluoride	mg/L	4	2.1	--	1.6 G
Gross alpha radioactivity	pCi/L	15[d] M	--	--	--
Gross beta radioactivity	pCi/L	50**[d] M	--	--	--
Heptachlor epoxide	µg/L	0.2	0.045	0.0038[b] S	--
2-Hexanone	µg/L	--	--	--	--
Iron	mg/L	0.3*	--	--	1.0 G
Lead	mg/L	0.015 M	--	--	0.05
Magnesium	mg/L	--	--	--	--
Manganese	mg/L	0.05*	0.175 R	--	0.2
Mercury	mg/L	0.002 M	--	--	0.002
Methylene chloride	µg/L	5	2,100	4.67[b] S	100
Molybdenum	mg/L	--	0.175 R	--	1.0
Nickel	mg/L	0.1 M	0.70	--	0.2
Nitrate as N	mg/L	10 M	56	--	10
Nitrate plus nitrite as N	mg/L	10 M	56	--	--
Nitrite as N	mg/L	1.0 M	3.5	--	--
Orthophosphate as P	mg/L	--	--	--	--
Potassium	mg/L	--	--	--	--
Radium-228	pCi/L	20[d] M	--	--	30
Radium-226	pCi/L	20[d] M	--	--	
Selenium	mg/L	0.05 M	0.175	--	0.06
Silver	mg/L	0.1*	0.175	--	0.05 G
Sodium	mg/L	--	--	--	--
Sulfate	mg/L	250*	--	--	600 G
Sulfide, total	mg/L	--	--	--	--
Tetrachloroethene	µg/L	5 M	350	--	20
Tin	mg/L	--	--	--	--
Toluene	µg/L	1,000	7,000	--	750 G
Total dissolved solids	mg/L	500*	--	--	1,000 G
Total organic halogen as Cl^-	µg/L	--	--	--	--
Total organic carbon	mg/L	--	--	--	--
Total suspended solids	mg/L	--	--	--	--
Trichloroethene	µg/L	5 M	--	--	100
Turbidity	NTU	--	--	--	--

Table 4.1.3.2.--Action levels from water-quality standards—Continued

Analyte	Units	Federal SDWA Maximum Contaminant Level	RCRA action-level (RfD based; April 1993 IRIS listing)	RCRA action level (slope-factor based; April 1993 IRIS listing)	NMWQCC ground-water standard
Uranium	µg/L	20[d] M	105	--	5,000
Uranium, natural	µg/L	20[d] M	105	--	5,000
Vanadium	mg/L	--	0.315 R	--	--
Zinc	mg/L	5*	10.5	--	10 G

[a] Class A carcinogen.
[b] Class B carcinogen.
[c] Class C carcinogen.
[d] Proposed.

APPENDIX B

LAGOON SLUDGE Cr(VI) ANALYTICAL RESULTS

ANALYTICAL RESULTS

FOR

U.S. GEOLOGICAL SURVEY

ENSECO-RMAL NO. 016612

SEPTEMBER 6, 1991

Enseco
A CORNING Company

Enseco

ANALYTICAL RESULTS

FOR

U.S. GEOLOGICAL SURVEY

ENSECO-RMAL NO. 016612

SEPTEMBER 6, 1991

Reviewed by: Toni L. Stovall

Lindsay Breyer

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Introduction

This report presents the analytical results as well as supporting information to aid in the evaluation and interpretation of the data and is arranged in the following order:

- Sample Description Information
- Analytical Test Requests
- Analytical Results
- Quality Control Report

Due to turbidimetric interferences all samples were diluted and the reporting limits have been raised accordingly for the Chromium (VI) test.

Sample Description Information

The Sample Description Information lists all of the samples received in this project together with the internal laboratory identification number assigned for each sample. Each project received at Enseco - RMAL is assigned a unique six digit number. Samples within the project are numbered sequentially. The laboratory identification number is a combination of the six digit project code and the sample sequence number.

Also given in the Sample Description Information is the Sample Type (matrix), Date of Sampling (if known) and Date of Receipt at the laboratory.

Analytical Test Requests

The Analytical Test Requests lists the analyses that were performed on each sample. The Custom Test column indicates where tests have been modified to conform to the specific requirements of this project.

Enseco
A Corning Company

SAMPLE DESCRIPTION INFORMATION
for
U.S. Geological Survey

Lab ID	Client ID	Matrix	Sampled Date	Sampled Time	Received Date
016612-0001-SA	KAFB060502-1	SOIL	23 AUG 91	14:59	24 AUG 91
016612-0002-SA	KAFB060503-1	SOIL	23 AUG 91	14:59	24 AUG 91
016612-0003-SA	KAFB050504-1	SOIL	23 AUG 91	14:00	24 AUG 91
016612-0004-SA	KAFB060602-1	SOIL	23 AUG 91	15:06	24 AUG 91
016612-0005-SA	KAFB050603-1	SOIL	23 AUG 91	13:58	24 AUG 91
016612-0006-SA	KAFB050604-1	SOIL	23 AUG 91	13:58	24 AUG 91
016612-0007-SA	KAFB060702-1	SOIL	23 AUG 91	15:11	24 AUG 91
016612-0008-SA	KAFB050703-1	SOIL	23 AUG 91	14:16	24 AUG 91
016612-0009-SA	KAFB050803-1	SOIL	23 AUG 91	14:08	24 AUG 91
016612-0010-SA	KAFB050903-1	SOIL	23 AUG 91	14:03	24 AUG 91
016612-0011-SA	KAFB051005-1	SOIL	23 AUG 91	14:22	24 AUG 91
016612-0012-SA	KAFB051103-1	SOIL	23 AUG 91	14:33	24 AUG 91
016612-0013-SA	KAFB051203-1	SOIL	23 AUG 91	14:25	24 AUG 91
016612-0014-SA	KAFB051303-1	SOIL	23 AUG 91	14:30	24 AUG 91
016612-0015-SA	KAFB051404-1	SOIL	23 AUG 91	14:38	24 AUG 91

Enseco
A Corning Company

ANALYTICAL TEST REQUESTS
for
U.S. Geological Survey

Lab ID: 016612	Group Code	Analysis Description	Custom Test?
0001 - 0015	A	Percent Water: ASTM D2216	N
		Chromium VI	N

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, May, 1989.

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

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB060502-1
Lab ID: 016612-0001-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	1.8	mg/kg	1.0	7196	NA	27 AUG 91
Water	6.7	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB060503-1
Lab ID: 016612-0002-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	8.3	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB050504-1
Lab ID: 016612-0003-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	3.1	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB060602-1
Lab ID: 016612-0004-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	30.1	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB050603-1
Lab ID: 016612-0005-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	4.0	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB050604-1
Lab ID: 016612-0006-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	4.0	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB060702-1
Lab ID: 016612-0007-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	40.4	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB050703-1
Lab ID: 016612-0008-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	6.3	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB050803-1
Lab ID: 016612-0009-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	4.4	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB050903-1
Lab ID: 016612-0010-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	8.4	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB051005-1
Lab ID: 016612-0011-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	1.7	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB051103-1
Lab ID: 016612-0012-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	4.9	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB051203-1
Lab ID: 016612-0013-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	4.9	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB051303-1
Lab ID: 016612-0014-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	2.9	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Enseco
A Corning Company

General Inorganics

Client Name: U.S. Geological Survey
Client ID: KAFB051404-1
Lab ID: 016612-0015-SA
Matrix: SOIL Sampled: 23 AUG 91 Received: 24 AUG 91
Authorized: 24 AUG 91 Prepared: See Below Analyzed: See Below

Parameter	Result	Units	Reporting Limit	Analytical Method	Prepared Date	Analyzed Date
Chromium (VI)	ND	mg/kg	1.0	7196	NA	27 AUG 91
Water	2.1	%	0.1	D2216	NA	26 AUG 91

ND = Not detected
NA = Not applicable

Reported By: Kathy Inman Approved By: Brett Allison

Appendix

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.

Enseco
A Corning Company

QC LOT ASSIGNMENT REPORT
Wet Chemistry Analysis and Preparation

Laboratory Sample Number	QC Matrix	QC Category	QC Lot Number (DCS)	QC Run Number (SCS/BLANK)
016612-0001-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0002-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0003-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0004-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0005-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0006-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0007-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0008-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0009-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0010-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0011-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0012-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0013-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0014-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A
016612-0015-SA	SOIL	CR6-S	26 AUG 91-A	26 AUG 91-A

Enseco
A Corning Company

DUPLICATE CONTROL SAMPLE REPORT
'et Chemistry Analysis and Preparation

Analyte	Concentration Spiked	Measured DCS1	Measured DCS2	Measured AVG	Accuracy Average(%) DCS	Accuracy Limits	Precision (RPD) DCS	Precision Limit
Category: CR6-S								
Matrix: SOIL								
QC Lot: 26 AUG 91-A								
Concentration Units: mg/kg								
Chromium (VI)	0.500	0.550	0.590	0.570	114	75-125	7.0	2(

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

Enseco
A Corning Company

METHOD BLANK REPORT
Wet Chemistry Analysis and Preparation

Analyte	Result	Units	Reporting Limit
Test: CR6-SPEC-S			
Matrix: SOIL			
QC Lot: 26 AUG 91-A QC Run: 26 AUG 91-A			
Chromium (VI)	ND	mg/kg	0.10

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

1661-08

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
SS - Special Source

Station Name	Field ID	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc.7		USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB050703-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1416						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) & Soil Moisture
SW 7196 D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox III	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY SLUDGE

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611
ATTENTION: Lindsay Bruer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612-05

Site Type (circle one)
SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field ID	Field Office	Project	Collector	Phone (FTS)
5 2nd AFB, Site 5, Sample bc. 6		USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB050603-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1358						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox III	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	[illegible]	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY SLUDGE

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611
ATTENTION: Lindsay Bruer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

1667 - 06

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc.6	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

KAFB050604-1 — Station ID or Unique Number*

463536001 — Project Account #

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1358						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods	Chromium (Hexavalent)	& Soil Moisture
	SW 7196	D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5 DRY SLUDGE

Record 6

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612-07

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Field ID

Station Name*	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 6, Sample bc.7	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB060702-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1511						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY POND SEDIMENT

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bruer (303) 421-10

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612-09

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc. 8	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB050803-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1408						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY SLUDGE

Record 6:

al number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611
ATTENTION: Lindsay Bruer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

Field ID: 16600-10

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc.9	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB050903-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1403						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	H or 9 Analysis Status**	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY SLUDGE

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

1662-11

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc.10	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

KAFB05100~~3~~5-1 — Station ID or Unique Number*

463536001 — Project Account #

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1422						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**
Analytical Methods	Chromium (Hexavalent) SW 7196				& Soil Moisture D 2216	

Chain-of-Custody Record

PROJECT NAME Kirtland AFB/IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5 DRY SLUDGE

Record 6

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-10

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

1612 -12

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
1st and AFB, Site 5, Sample bc.11	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

KAFB051103-1 — Station ID or Unique Number*

46353600.1 — Project Account #

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1433						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) & Soil Moisture
SW 7196 D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 46353600.1 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5 DRY SLUDGE

Record 6

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bruer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612 -13

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

K and AFB, Site 5, Sample bc.12 (Station Name) | USGS-WRD-NMD (Field Office) | KAFB-IRP (Project) | Ralph Wilcox (Collector) | (505) 262-5340 (Phone (FTS))

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

KAFB051203-1 (Station ID or Unique Number*)

463536001 (Project Account #)

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1425						

Begin Date | Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5 DRY SLUDGE

Record 6

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

1662-14

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field ID	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc.13		USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB051303-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1430						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	H or 9 Analysis Status**	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph W. Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMA	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY SLUDGE

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

Field ID: 166126-15

Site Type (circle one): SW - Surface Water, GW - Ground Water, ME - Meteorological, LK - Lake, ES - Estuary, SP - Spring, (SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 5, Sample bc. 14	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one): Q - WATSTORE, X - Lab File

For Laboratory Use Only:

Sample identification

Station ID or Unique Number*: KAFB051404-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1438						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME: Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY SLUDGE

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-10

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612-01

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
SS - Special Source

Station Name	Field ID	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 6, Sample bc.5		USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB060502-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1459						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
[signature]	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	[signature] RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY POND SEDIMENT

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bryer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612-02

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 6, Sample bc. 5	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number*: KAFB060503-1

Project Account #: 463536001

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1459						

Begin Date — Composite End Date

Analysis level codes and schedules

H or 9

Sample Medium**	Geologic Unit	Analysis Status**	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
[signature]	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	[signature] RMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY POND SEDIMENT

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bruer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

1662-03

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
(SS) - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
2nd AFB, Site 5, Sample bc.5	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

KAFB050504-1 — Station ID or Unique Number*

463536001 — Project Account #

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1400						

Begin Date — Composite End Date

Analysis level codes and scnedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	[illegible]	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5 DRY SLUDGE

Record 6

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611
ATTENTION: Lindsay Bryer (303) 421-102

SS-034

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

16612-04

Field ID

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
SS - Special Source

Station Name	Field Office	Project	Collector	Phone (FTS)
Kirtland AFB, Site 6, Sample bc. 6	USGS-WRD-NMD	KAFB-IRP	Ralph Wilcox	(505) 262-5340

File Deposition* (Circle one)
Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

KAFB060602-1 — Station ID or Unique Number*

463536001 — Project Account #

Year*	Month*	Day*	Time*	Month	Day	Time	State Code*	District/ User Code*	County Code
1991	08	23	1506						

Begin Date — Composite End Date

Analysis level codes and schedules

Sample Medium**	Geologic Unit	Analysis Status** (H or 9)	Analysis Source**	Hydrologic Condition**	Sample Type**	Hydrologic Event**

Analytical Methods: Chromium (Hexavalent) SW 7196 & Soil Moisture D 2216

Chain-of-Custody Record

PROJECT NAME Kirtland AFB / IRP PROJECT NO. 463536001 P.O. NO.

Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Ralph Wilcox	to Federal Express	8-23-91	1630
Relinquished by: (Signature)	Received by: (Signature)	Date	Time
Relinquished by: (Signature)	Received at lab by: (Signature)	Date	Time
	Chris Pan GMAL	08-24-91	0900
Relinquished from lab by: (Signature)	Received by: (Signature)	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5: DRY POND SEDIMENT

Record 6:

Total number of sample bottles for this request: 1

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: Lindsay Bruer (303) 421-1025

SS-034

APPENDIX C

MATRIX SPIKE DATA SHEETS

Enseco
A Corning Company

SAMPLE DESCRIPTION INFORMATION
for
U.S. Geological Survey

Lab ID	Client ID		Matrix	Sampled Date	Sampled Time	Received Date
029311-0001-SA	KAFB080203-1F		SOIL	06 JAN 93		04 JUN 93
029311-0001-MS	KAFB080203-1F		SOIL	06 JAN 93		04 JUN 93
029311-0001-SD	KAFB080203-1F		SOIL	06 JAN 93		04 JUN 93
029311-0002-SA	KAFB011201-1F		SOIL	26 MAY 91		04 JUN 93
029311-0002-MS	KAFB011201-1F		SOIL	26 MAY 91		04 JUN 93
029311-0002-SD	KAFB011201-1F		SOIL	26 MAY 91		04 JUN 93
029311-0003-SA	KAFB040202-1F		SOIL	07 JAN 90		04 JUN 93
029311-0003-MS	KAFB040202-1F		SOIL	07 JAN 90		04 JUN 93
029311-0003-SD	KAFB040202-1F		SOIL	07 JAN 90		04 JUN 93
029311-0004-SA	KAFB050504-1	dry sludge	SOIL	03 JUN 93	14:10	04 JUN 93
029311-0004-MS	KAFB050504-1		SOIL	03 JUN 93	14:10	04 JUN 93
029311-0004-SD	KAFB050504-1		SOIL	03 JUN 93	14:10	04 JUN 93
029311-0005-SA	KAFB050505-1	soil beneath sludge	SOIL	03 JUN 93	14:15	04 JUN 93
029311-0005-MS	KAFB050505-1		SOIL	03 JUN 93	14:15	04 JUN 93
029311-0005-SD	KAFB050505-1		SOIL	03 JUN 93	14:15	04 JUN 93
029311-0006-SA	KAFB060502-1	Dry pond sediment	SOIL	03 JUN 93	14:30	04 JUN 93
029311-0006-MS	KAFB060502-1		SOIL	03 JUN 93	14:30	04 JUN 93
029311-0006-SD	KAFB060502-1		SOIL	03 JUN 93	14:30	04 JUN 93
029311-0007-SA	KAFB070302-1	" " "	SOIL	03 JUN 93	14:45	04 JUN 93
029311-0007-MS	KAFB070302-1		SOIL	03 JUN 93	14:45	04 JUN 93
029311-0007-SD	KAFB070302-1		SOIL	03 JUN 93	14:45	04 JUN 93

MATRIX SPIKE / MATRIX SPIKE DUPLICATE REPORT
Metals Analysis and Preparation (cont.)

Analyte	Sample	Concentration Matrix Spike	Matrix Spike Dup	Spiked MS	MSD	%Recovery MS	MSD	% RPD
Silver	110	145	131	5.1	5.1	NC	NC	NC
Sodium	ND	8300	8890	10300	10300	81	86	7
Vanadium	42.1	86.8	94.6	51.5	51.5	87	102	16
Zinc	1320	1240	1430	51.5	51.5	NC	NC	NC
Test: HG-CVAA-AFCEE-S Matrix SOIL Sample: 029311-0004 Units: mg/kg								
Mercury	1.1	1.6	1.6	0.51	0.51	96	86	11
Test: CR-FAA-AFCEE-S Matrix SOIL Sample: 029311-0004 Units: mg/kg								
Chromium	1630	1600	1550	20.6	20.6	NC	NC	NC
Test: SE-FAA-AFCEE-S Matrix SOIL Sample: 029311-0004 Units: mg/kg								
Selenium	4.6	7.2	6.3	3.1	3.1	82	55	39
Test: TL-FAA-AFCEE-S Matrix SOIL Sample: 029311-0004 Units: mg/kg								
Thallium	0.49 J	2.7	2.4	3.1	3.1	71	61	16
Test: SB-FAA-AFCEE-S Matrix SOIL Sample: 029311-0004 Units: mg/kg								
Antimony	ND	31.8	33.6	51.5	51.5	62	65	5

J = Result is detected below the reporting limit or is an estimated concentration.
ND = Not detected
NC = Not calculated, calculation not applicable

All results and spike amounts are reported on a dry weight basis.

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

Enseco
A Corning Company

MATRIX SPIKE / MATRIX SPIKE DUPLICATE REPORT
Metals Analysis and Preparation (cont.)

Analyte	Sample	Concentration Matrix Spike	Matrix Spike Dup	Spiked MS	MSD	%Recovery MS	MSD	% RPD
Test: ICP-AFCEE-S Matrix SOIL Sample: 029311-0005 Units: mg/kg								
Aluminum	4700	10000	9630	5080	5080	105	97	8
Arsenic	ND	40.6	34.5	50.8	50.8	80	68	16
Barium	121	264	277	203	203	70	77	9
Beryllium	0.27 J	4.4	4.8	5.1	5.1	81	89	9
Cadmium	2.4	6.5	6.2	5.1	5.1	80	74	7
Calcium	59900	69600	66100	10200	10200	NC	NC	NC
Cobalt	2.3 J	42.6	43.6	50.8	50.8	79	81	3
Copper	76.6	95.8	86.4	25.4	25.4	76	39	64
Iron	6960	11000	10900	4470	4470	90	88	3
Lead	8.2	46.8	49.4	50.8	50.8	76	81	7
Magnesium	2010	6450	6310	5080	5080	87	85	3
Manganese	59.0	102	102	50.8	50.8	84	84	0
Molybdenum	ND	42.1	40.6	50.8	50.8	83	80	4
Nickel	11.6	51.4	50.6	50.8	50.8	78	77	2
Potassium	950	5330	5310	5080	5080	86	86	0
Silver	10.2	13.1	12.5	5.1	5.1	57	47	19
Sodium	ND	8520	8580	10200	10200	84	84	1
Vanadium	16.3	57.8	61.3	50.8	50.8	82	89	8
Zinc	68.8	105	93.4	50.8	50.8	72	48	39
Test: HG-CVAA-AFCEE-S Matrix SOIL Sample: 029311-0005 Units: mg/kg								
Mercury	0.20	0.76	0.70	0.51	0.51	110	98	11
Test: CR-FAA-AFCEE-S Matrix SOIL Sample: 029311-0005 Units: mg/kg								
Chromium	29.9	49.3	46.8	20.3	20.3	96	83	14

J = Result is detected below the reporting limit or is an estimated concentration.
ND = Not detected
NC = Not calculated, calculation not applicable

All results and spike amounts are reported on a dry weight basis.

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

Enseco
A Coming Company

MATRIX SPIKE / MATRIX SPIKE DUPLICATE REPORT
Metals Analysis and Preparation (cont.)

Analyte	Sample	Concentration Matrix Spike	Matrix Spike Dup	Spiked MS	MSD	%Recovery MS	MSD	% RPD
Test: SE-FAA-AFCEE-S Matrix SOIL Sample: 029311-0005 Units: mg/kg								
Selenium	ND	2.4	2.4	3.1	3.1	79	77	3
Test: TL-FAA-AFCEE-S Matrix SOIL Sample: 029311-0005 Units: mg/kg								
Thallium	ND	2.0	2.0	3.1	3.1	65	64	2
Test: SB-FAA-AFCEE-S Matrix SOIL Sample: 029311-0005 Units: mg/kg								
Antimony	ND	29.4	32.5	50.8	50.8	58	64	10
Test: ICP-AFCEE-S Matrix SOIL Sample: 029311-0006 Units: mg/kg								
Aluminum	8590	15000	14300	5100	5100	126	112	12
Arsenic	ND	33.4	32.9	51.0	51.0	65	64	2
Barium	189	379	394	204	204	93	101	8
Beryllium	0.49	5.1	5.5	5.1	5.1	90	97	7
Cadmium	1.5	6.2	5.6	5.1	5.1	92	80	14
Calcium	62000	69200	69300	10200	10200	NC	NC	NC
Cobalt	4.6	46.3	45.8	51.0	51.0	82	81	1
Copper	108	134	130	25.5	25.5	NC	NC	NC
Iron	12200	16500	16000	4490	4490	96	86	12
Lead	20.5	64.2	59.4	51.0	51.0	85	76	11
Magnesium	5440	10400	10300	5100	5100	97	95	2
Manganese	218	264	276	51.0	51.0	NC	NC	NC
Molybdenum	ND	41.8	43.7	51.0	51.0	82	86	4
Nickel	13.9	56.3	55.1	51.0	51.0	83	81	3
Potassium	2870	7970	7970	5100	5100	100	100	0

ND = Not detected
NC = Not calculated, calculation not applicable

All results and spike amounts are reported on a dry weight basis.

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

MATRIX SPIKE / MATRIX SPIKE DUPLICATE REPORT
Metals Analysis and Preparation (cont.)

Analyte	Sample	Concentration Matrix Spike	Matrix Spike Dup	Spiked MS	MSD	%Recovery MS	MSD	% RPD
Silver	33.7	36.5	36.9	5.1	5.1	NC	NC	NC
Sodium	ND	9320	9320	10200	10200	91	91	0
Vanadium	22.8	68.3	69.4	51.0	51.0	89	91	2
Zinc	78.5	124	119	51.0	51.0	89	79	13
Test: HG-CVAA-AFCEE-S Matrix SOIL Sample: 029311-0006 Units: mg/kg								
Mercury	0.054 J	0.54	0.55	0.51	0.51	95	97	2
Test: CR-FAA-AFCEE-S Matrix SOIL Sample: 029311-0006 Units: mg/kg								
Chromium	82.7	101	93.9	20.4	20.4	NC	NC	NC
Test: SE-FAA-AFCEE-S Matrix SOIL Sample: 029311-0006 Units: mg/kg								
Selenium	0.42 J	2.3	2.5	3.1	3.1	62	67	7
Test: TL-FAA-AFCEE-S Matrix SOIL Sample: 029311-0006 Units: mg/kg								
Thallium	ND	1.8	2.1	3.1	3.1	58	67	14
Test: SB-FAA-AFCEE-S Matrix SOIL Sample: 029311-0006 Units: mg/kg								
Antimony	ND	22.7	22.1	51.0	51.0	44	43	3

J = Result is detected below the reporting limit or is an estimated concentration.
ND = Not detected
NC = Not calculated, calculation not applicable

All results and spike amounts are reported on a dry weight basis.

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

Enseco
A Corning Company

MATRIX SPIKE / MATRIX SPIKE DUPLICATE REPORT
Metals Analysis and Preparation (cont.)

Analyte	Sample	Concentration Matrix Spike	Matrix Spike Dup	Spiked MS	MSD	%Recovery MS	MSD	% RPD
Test: ICP-AFCEE-S Matrix SOIL Sample: 029311-0007 Units: mg/kg								
Aluminum	11800	16500	15100	5090	5090	93	64	37
Arsenic	ND	39.3	32.2	50.9	50.9	77	63	20
Barium	132	313	309	204	204	89	87	2
Beryllium	0.70	5.6	5.5	5.1	5.1	97	94	3
Cadmium	0.47 J	5.0	4.9	5.1	5.1	90	88	2
Calcium	13400	20000	19000	10200	10200	65	54	17
Cobalt	8.2	54.6	53.5	50.9	50.9	91	89	2
Copper	19.9	41.2	39.7	25.4	25.4	84	77	8
Iron	22200	24500	22400	4480	4480	NC	NC	NC
Lead	13.3	59.9	55.7	50.9	50.9	92	83	9
Magnesium	6910	11400	10800	5090	5090	89	76	16
Manganese	365	371	373	50.9	50.9	NC	NC	NC
Molybdenum	ND	45.1	46.2	50.9	50.9	89	91	2
Nickel	11.8	57.9	56.0	50.9	50.9	91	87	4
Potassium	3230	8060	7750	5090	5090	95	89	7
Silver	1.3 J	5.2	5.0	5.1	5.1	78	74	6
Sodium	ND	10200	9790	10200	10200	100	96	4
Vanadium	37.9	84.2	79.4	50.9	50.9	91	82	11
Zinc	67.9	107	104	50.9	50.9	76	71	7
Test: HG-CVAA-AFCEE-S Matrix SOIL Sample: 029311-0007 Units: mg/kg								
Mercury	ND	0.50	0.51	0.51	0.51	99	101	2
Test: CR-FAA-AFCEE-S Matrix SOIL Sample: 029311-0007 Units: mg/kg								
Chromium	14.3	31.6	29.9	20.4	20.4	85	77	10

J = Result is detected below the reporting limit or is an estimated concentration.
ND = Not detected
NC = Not calculated, calculation not applicable

All results and spike amounts are reported on a dry weight basis.

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

Enseco
A Corning Company

MATRIX SPIKE / MATRIX SPIKE DUPLICATE REPORT
Metals Analysis and Preparation (cont.)

Analyte	Sample	Concentration Matrix Spike	Concentration Matrix Spike Dup	Spiked MS	Spiked MSD	%Recovery MS	%Recovery MSD	% RPD
Test: SE-FAA-AFCEE-S Matrix SOIL Sample: 029311-0007 Units: mg/kg								
Selenium	ND	2.2	2.2	3.1	3.1	73	71	4
Test: TL-FAA-AFCEE-S Matrix SOIL Sample: 029311-0007 Units: mg/kg								
Thallium	ND	2.7	2.8	3.1	3.1	89	90	1
Test: SB-FAA-AFCEE-S Matrix SOIL Sample: 029311-0007 Units: mg/kg								
Antimony	ND	21.6	27.7	50.9	50.9	42	54	25

ND = Not detected
NC = Not calculated, calculation not applicable

All results and spike amounts are reported on a dry weight basis.

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

APPENDIX D

CHROMIUM LOADING CALCULATIONS

DANIEL B. STEPHENS & ASSOCIATES, INC.

Calculation Cover Sheet

Project Name KAFB SEWAGE LAGOONS Project Number 3186.005

Calculation Number 3186.005-H-1 Discipline Hydrology No. of Sheets 6

PROJECT

KAFB Sewage lagoons and Golf Course Main Pond Post-Closure Plan

SITE

KAFB Sewage Lagoons

SUBJECT

Chromium Loading Calculations

SOURCES OF DATA

1. IRP Stage 2 RI/FS Technical Report for KAFB, August 1993.
2. 40 CFR 503.13, Table 2, Cumulative Pollutant Loading Rates.

SOURCES OF FORMULAE & REFERENCES

1. Metcalf & Eddy, Inc. Wastewater Engineering: Treatment/Disposal/Reuse, 2nd Ed. Rev. George Tchobanoglous. McGraw-Hill Book Co. 1979,

☐ Preliminary Calculation ☒ Final Calculation Supersedes Calculation No. _____

Rev. No	Revision	Calculation By	Date	Checked By	Date	Approved By	Date
1	N/A	LJD	12-28-93	REM	12/29/93	[illegible]	12/30/93

DBS&A Form No. 119 5/93

DANIEL B. STEPHENS & ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS AND ENGINEERS

Calculation Sheet

L.M. COONS PE, PHg

Project No. 3186.005 | Date 12-28-93
Subject Chromium Loading Calculations | DEC '93 | Sheet 1 of 6
By LJD | Checked By RM | Calculation No. 3186.005-H-1

I. PURPOSE

The purpose of this calculation is to determine the Chromium loading at the KAFB Sewage lagoons.

II. METHODS

Loading (in lbs/acre) is determined from knowledge of:

1. Chromium concentration (lbs/ton) in sewage sludge
2. Mass of Sewage Sludge applied (tons), and
3. Area of Application (acres):

Cr loading (lbs/acre) = mass (tons) * concentration (lbs/ton) ÷ area (acres)

III. ASSUMPTIONS

A number of assumptions had to be made in order to complete the calculations. These include:

1. Density of dry sludge = 1.4 g/cm³ = 87.40 lbs/ft³ * (conservative assumption)
2. Max. concentration of Cr in sludge (2,225 mg/Kg) is representative of the entire volume of sludge (conservative assumption).
3. Sludge is 1.39 inches thick in North Lagoon and 0.98 inches thick throughout the South Lagoon and each lagoon is 6.35 acres.

* REF: Metcalf & Eddy, 1979. (attach)

DBS&A Form No. 026 Rev. 5/93

DANIEL B. STEPHENS & ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS AND ENGINEERS

L.M. COONS PE, PHg **Calculation Sheet**

DEC '93

Project No. 3186.005 Date 12-23-93

Subject Chromium Loading Calculations Sheet 2 of 6

By LJD Checked By RM Calculation No. 3186.005-H-1

IV. MATERIAL PROPERTIES

The material properties include:

1. Density of Dry Sludge = 1.4 g/cm³ (assumption).
2. Concentration of Cr in Dry Sludge = 2,225 mg/kg. ✓

V. DATA SOURCE

Data used in this calculation came from:

1. IRP Stage 2 RI/FS Technical Report for KAFB, August 1993.
2. 40 CFR 503.13, Table 2, Cumulative Pollutant Loading Rates.

VI. SOLUTION

Cr Loading (lbs/acre) = mass (tons) * concentration (lbs/ton) ÷ area (acres)

A. Mass of Sludge (tons):

Assume: ρ_{SLUDGE} = 1.4 g/cm³ = 87.04 lbs/ft³

$87.04 \frac{lbs}{ft^3} \times 54{,}622\ ft^3 = 4{,}754{,}300\ lbs = \underline{2{,}377\ tons}$ ✓

(VOLUME OF SLUDGE)

VOLUME OF SLUDGE => Assume: 1.39" THICK IN N. LAGOON
0.98" " " S. "

DBS&A Form No. 026 Rev. 5/93

SOURCE: METCALF & EDDY, INC. WASTEWATER ENGINEERING; TREATMENT/DISPOSAL/REUSE. 2nd Ed. Rev. GEORGE TCHOBANOGLOUS. McGRAW-HILL BOOK CO. 1979.

Table 11-4 Typical chemical composition of untreated and digested sludge

Item	Untreated primary sludge		Digested sludge	
	Range	Typical	Range	Typical
Total dry solids (TS), %	2.0–8.0	5.0	6.0–12.0	10.0
Volatile solids (% of TS)	60–80	65	30–60	40.0
Grease and fats (ether-soluble, % of TS)	6.0–30.0	...	5.0–20.0	...
Protein (% of TS)	20–30	25	15–20	18
Nitrogen (N, % of TS)	1.5–6.0	4.0	1.6–6.0	4.0
Phosphorus (P_2O_5, % of TS)	0.8–3.0	2.0	1.5–4.0	2.5
Potash (K_2O, % of TS)	0–1.0	0.4	0.0–3.0	1.0
Cellulose (% of TS)	8.0–15.0	10.0	8.0–15.0	10.0
Iron (not as sulfide)	2.0–4.0	2.5	3.0–8.0	4.0
Silica (SiO_2, % of TS)	15.0–20.0	...	10.0–20.0	...
pH	5.0–8.0	6.0	6.5–7.5	7.0
Alkalinity (mg/L as $CaCO_3$)	500–1500	600	2500–3500	3000
Organic acids (mg/L as HAc)	200–2000	500	100–600	200
Thermal content (MJ/kg)	14–23	16.5[a]	6–14	9[b]

[a] Based on 65 percent volatile matter.
[b] Based on 40 percent volatile matter.
Note: MJ/kg × 429.92 = Btu/lb

Table 11-5 Typical data on the physical characteristics and quantities of sludge produced from various wastewater-treatment processes

Treatment process	Specific gravity of sludge solids	Specific gravity of sludge	Dry solids, kg/10³ m³	
			Range	Typical
Primary sedimentation	1.4	1.02	110–170	150
Activated sludge (waste sludge)	1.25	1.005	70–100	85
Trickling filtration (waste sludge)	1.45	1.025	55–90	70
Extended aeration (waste sludge)	1.30	1.015	80–120	100[a]
Aerated lagoon (waste sludge)	1.30	1.010	80–120	100[a]
Filtration	1.20	1.005	10–20	15
Algae removal	1.20	1.005	10–25	15
Chemical addition to primary clarifiers for phosphorus removal				
Low lime (350–500 mg/L)	1.9	1.04	250–400	300[b]
High lime (800–1600 mg/L)	2.2	1.05	600–1280	800[b]
Suspended-growth nitrification	...	...	...	...[c]
Suspended-growth denitrification	1.20	1.005	10–30	16
Backwashing filters	1.28	1.020	...	...[d]

[a] Assuming no primary treatment.
[b] Sludge in addition to that normally removed by primary sedimentation.
[c] Negligible.
[d] Included in sludge production from biological secondary treatment processes.
Note: kg/10³ m³ × 0.0083 = lb/10³ gal

Sheet 3 of 6

DANIEL B. STEPHENS & ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS AND ENGINEERS

L.M. COONS PE, Mg **Calculation Sheet**

DEC '93

Project No. 3186.005 Date 12-28-93

Subject Chromium Loading Calculations Sheet 4 of 6

By LJD Checked By AM Calculation No. 3186.005-H-1

V. SOLUTION (CONTINUED)

A. Mass of Sludge (continued)

N - $1.39\ in \times \frac{1ft}{12in} \times 6.35\ acres \times \frac{1ft^2}{2.296\times10^{-5}\ acre} = 32{,}036\ ft^3$

S - $0.98\ in \times \frac{1ft}{12in} \times 6.35\ acres \times \frac{1ft^2}{2.296\times10^{-5}\ acre} = 22{,}586\ ft^3$

Total Volume Sludge = 54,622 ft^3

(= 2,023 cy.)

B. Concentration (lbs/ton)

$[Cr] = 2{,}225\ \frac{mg}{Kg} = 4.45\ \frac{lbs}{ton}$ ✓

C. Area (Acres)

6.35 acres per lagoon = 12.7 acres (total)

Solution:

Cr Loading = 2,377 tons * $4.45\ \frac{lbs}{ton}$ ÷ 12.7 acres

Cr Loading = **833 lbs/acre** ✓

From Table 2 of 40 CFR Part 503.13 (attached) Cumulative Pollutant Loading Rates, the allowable loading rate for chromium is 3000 $\frac{kg}{ha}$ (2679 lbs/acre). Therefore, the chromium loading at the Sewage Lagoons is well below the allowable limit. ✓

DBS&A Form No. 026 Rev. 5/93

SOURCE: 40 CFR PART 503

sewage sludge shall not exceed the concentration for the pollutant in Table 3 of § 503.13.

(4) If sewage sludge is sold or given away in a bag or other container for application to the land, either:

(i) The concentration of each pollutant in the sewage sludge shall not exceed the concentration for the pollutant in Table 3 of § 503.13; or

(ii) The product of the concentration of each pollutant in the sewage sludge and the annual whole sludge application rate for the sewage sludge shall not cause the annual pollutant loading rate for the pollutant in Table 4 of § 503.13 to be exceeded. The procedure used to determine the annual whole sludge application rate is presented in appendix A of this part.

(b) Pollutant concentrations and loading rates—sewage sludge.

(1) Ceiling concentrations.

TABLE 1 OF § 503.13.—CEILING CONCENTRATIONS

Pollutant	Ceiling concentration (milligrams per kilogram)[1]
Arsenic	75
Cadmium	85
Chromium	3000
Copper	4300
Lead	840
Mercury	57
Molybdenum	75
Nickel	420
Selenium	100
Zinc	7500

[1] Dry weight basis.

(2) Cumulative pollutant loading rates.

TABLE 2 OF § 503.13.—CUMULATIVE POLLUTANT LOADING RATES

Pollutant	Cumulative pollutant loading rate (kilograms per hectare)
Arsenic	36.6 41
Cadmium	34.8 39
Chromium	2679 3000
Copper	1340 1500
Lead	268 300
Mercury	15.2 17
Molybdenum	16.1 18
Nickel	375 420
Selenium	89.3 100
Zinc	2500 2800

(3) Pollutant concentrations.

TABLE 3 OF § 503.13.—POLLUTANT CONCENTRATIONS

Pollutant	Monthly average concentrations (milligrams per kilogram)[1]
Arsenic	41
Cadmium	39
Chromium	1200
Copper	1500

TABLE 3 OF § 503.13.—POLLUTANT CONCENTRATIONS—Continued

Pollutant	Monthly average concentrations (milligrams per kilogram)[1]
Lead	300
Mercury	17
Molybdenum	18
Nickel	420
Selenium	36
Zinc	2800

[1] Dry weight basis.

(4) Annual pollutant loading rates.

TABLE 4 OF § 503.13.—ANNUAL POLLUTANT LOADING RATES

Pollutant	Annual pollutant loading rate (kilograms per hectare per 365 day period)
Arsenic	1.8 1.786 2.0
Cadmium	1.7 1.647 1.9
Chromium	134 134 150
Copper	67 75
Lead	13.4 15
Mercury	0.76 0.85
Molybdenum	0.80 0.90
Nickel	18.75 21
Selenium	4.47 5.0
Zinc	125 140

(c) Domestic septage.

The annual application rate for domestic septage applied to agricultural land, forest, or a reclamation site shall not exceed the annual application rate calculated using equation (1).

$$AAR = \frac{N}{0.0026} \quad \text{Eq. (1)}$$

Where:

AAR=Annual application rate in gallons per acre per 365 day period.

N=Amount of nitrogen in pounds per acre per 365 day period needed by the crop or vegetation grown on the land.

§ 503.14 Management practices.

(a) Bulk sewage sludge shall not be applied to the land if it is likely to adversely affect a threatened or endangered species listed under section 4 of the Endangered Species Act or its designated critical habitat.

(b) Bulk sewage sludge shall not be applied to agricultural land, forest, a public contact site, or a reclamation site that is flooded, frozen, or snow-covered so that the bulk sewage sludge enters a wetland or other waters of the United States, as defined in 40 CFR 122.2, except as provided in a permit issued pursuant to section 402 or 404 of the CWA.

(c) Bulk sewage sludge shall not be applied to agricultural land, forest, or a reclamation site that is 10 meters or less from waters of the United States, as defined in 40 CFR 122.2, unless otherwise specified by the permitting authority.

(d) Bulk sewage sludge shall be applied to agricultural land, forest, a public contact site, or a reclamation site at a whole sludge application rate that is equal to or less than the agronomic rate for the bulk sewage sludge, unless, in the case of a reclamation site, otherwise specified by the permitting authority.

(e) Either a label shall be affixed to the bag or other container in which sewage sludge that is sold or given away for application to the land, or an information sheet shall be provided to the person who receives sewage sludge sold or given away in an other container for application to the land. The label or information sheet shall contain the following information:

(1) The name and address of the person who prepared the sewage sludge that is sold or given away in a bag or other container for application to the land.

(2) A statement that application of the sewage sludge to the land is prohibited except in accordance with the instructions on the label or information sheet.

(3) The annual whole sludge application rate for the sewage sludge that does not cause any of the annual pollutant loading rates in Table 4 of § 503.13 to be exceeded.

§ 503.15 Operational standards—pathogens and vector attraction reduction.

(a) *Pathogens—sewage sludge.*

(1) The Class A pathogen requirements in § 503.32(a) or the Class B pathogen requirements and site restrictions in § 503.32(b) shall be met when bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site.

(2) The Class A pathogen requirements in § 503.32(a) shall be met when bulk sewage sludge is applied to a lawn or a home garden.

(3) The Class A pathogen requirements in § 503.32(a) shall be met when sewage sludge is sold or given away in a bag or other container for application to the land.

(b) *Pathogens—domestic septage.*

The requirements in either § 503.32 (c)(1) or (c)(2) shall be met when domestic septage is applied to agricultural land, forest, or a reclamation site.

(c) *Vector attraction reduction—sewage sludge.*

(1) One of the vector attraction reduction requirements in § 503.33 (b)(1) through (b)(10) shall be met when bulk sewage sludge is applied to agricultural land, forest, a public contact site, or a reclamation site.

VII. SENSITIVITY

No sensitivity analysis was performed. Because the most conservative of assumptions was used in the calculation (e.g., upper limit for sludge density, highest sludge chromium analytical result), the calculated Cr loading should also be the most conservative. The actual Cr loading is probably much less than the calculated value. Therefore, it seemed unnecessary to perform a sensitivity analysis since all other calculated values would be less than the current value and would have no bearing on the recommendations and conclusions.

VIII. RECOMMENDATIONS/CONCLUSIONS

The calculated Chromium loading at the Sewage lagoons was 833 lbs/acre. 40CFR Part 503.13 sets the maximum allowable chromium loading rate at 3000 Kg/ha or 2,679 lbs/acre. Therefore, the chromium loading at the Sewage lagoons is well within the limit set forth in the Federal Regulations, and no action is deemed necessary.

APPENDIX E

DBS&A STANDARD OPERATING PROCEDURES

DBS&A FIELD TECHNICAL STANDARD OPERATING PROCEDURES

Provided herein are field technical standard operating procedures (SOPs) applicable to the Post-Closure Plan for Sewage Lagoons and Golf Course Main Pond at Kirtland Air Force Base, Albuquerque, New Mexico. All SOPs included in this appendix are proprietary in nature and shall not be copied, reproduced, or distributed without the expressed written approval of an authorized DBS&A representative. The scope of the procedures provided in this appendix is outlined in the following table.

Field Technical Standard Operating Procedures

Standard Operating Procedure No.	Title
Section 13.3.2	Soils Logging, Handling, and Shipping for Geotechnical and Chemical Analysis
Section 13.5	Water Sampling
Section 13.5.1	Preparation for Water Sampling
Section 13.5.2	Decontamination of Field Equipment
Section 13.5.3	Measurement of Field Parameters
Section 13.5.4	Collection of Ground-Water Samples
Section 13.5.5	Collection of Surface Water Samples
Section 13.5.6	Sample Preservation
Section 13.5.7	Sample Filtration
Section 13.5.8	Quality Assurance/Quality Control (QA/QC) Samples
Section 13.6.1	Ground-Water Level Measurement

1. PURPOSE

The following SOP describes the appropriate procedures for the logging, sampling, handling, and shipping of soil during soil boring investigations. Sampling methodologies and shipping requirements are provided for collection of geotechnical, physical, and chemical soil samples.

2. SCOPE

This procedure is applicable to all DBS&A employees and subcontractors who are engaged in soil boring activities. It provides the minimum logging requirements, sampling protocols, and shipping requirements for soil boring investigations. The appropriate form for logging soil is included in this SOP as Attachment 1, Soil Boring Log (DBS&A Form No. 080). A soils classification chart is included as Attachment 2. Tables 13.3.2-1 and 13.3.2-2 provide handling and transport, and volume requirements for soil physical analysis samples, respectively.

3. PROCEDURES

3.1 Soils Logging

Soil descriptions and other pertinent information will be recorded on the Soil Boring Log form during boring operations. The Soil Boring Form contains a header for recording the boring specifics and a log for describing and classifying soil and tracking soil sampling. Soils will be identified and described in accordance with ASTM D 2488, Standard Practice for Description and Identification of Soil (Visual-Manual Practice). Table 13.3.2-3 provides a list of equipment that may be required for soils logging, sampling, handling, and shipping.

3.1.1 Completing the Header

Most of the header is self-explanatory. On the first page of the log, it is important to complete the entire header. If subsequent forms are necessary, complete the page number, the site, the client, the person logging the soil, the boring number, and the date. On the first page, sketch a location map for the boring, referencing it to known features or landmarks. When specifying the drilling method and drill rig, note the diameter of the drill bit or augers.

3.1.2 Completing the Boring Log

PID/FID - record head space measurements made with the PID/FID in this column in the appropriate depth interval from which the sample was collected.

Blow Counts - if driving a split-barrel sampling device with a hammer, record the number of hammer "blows" per 6 inches of penetration. Ensure that the driller marks the 6 inch intervals on the drill stem prior to hammering the split-barrel.

Sampling Device - specify the sampling device (i.e., split-barrel, split-barrel with brass or stainless steel rings, Shelby tube); specify the inside diameter of the sampling device.

Sample Interval - specify the sampling interval (starting and finishing) by placing an "X" across the appropriate depth interval in this column.

Sample Recovery - state, in tenths of feet, the amount of sample which is recovered.

Sample Number - record the designated sample number in this column.

Depth (Feet) - complete this column in 5-foot intervals to keep a running tally of the depth of the borehole.

USCS Symbol - provide the USCS symbol for the soil be described; draw a solid contact line at the appropriate depth to signify changes in soil type.

Soil Description - describe the soil in the format listed on the boring log; for non-cohesive soils, estimate the grain distribution, gradation, and grain shape; for cohesive soils, note the plasticity and clay consistency; if possible, a soil classification and geotechnical gauge and a color chart should be used to aid in describing soil.

3.2 Soil Sampling

Soil samples will typically be collected for geotechnical, physical, or chemical analysis. Geotechnical samples will be collected with a split-barrel sampler lined with brass rings or in the case of cohesive soils to be analyzed for compressive strength, a thin-walled tube sampler. Chemical samples will be collected with an unlined split-barrel sampler or a ring-lined split-barrel sampler. Regardless of which sampling device is employed, care should be taken to minimize slough in the borehole. Slow withdrawal of the drill bit prior to sampling will minimize slough. When drilling below the water table, ensure that the water level in the borehole (or within driven casing) is maintained at or above the water table elevation.

3.2.1 Geotechnical/Physical Properties Samples

Geotechnical and/or physical properties samples will be collected with either a ring-lined split-barrel sampler or a thin-walled Shelby tube. If possible, use a ring-lined sampler for physical properties analysis. For triaxial and unconfined compression tests, either a ring-lined sampler or a thin-walled tube sampler may be employed. For cohesive soils, the thin-walled tube sampler should be used for obtaining the least disturbed samples. In non-cohesive soils, a ring-lined sampler is required because of poor sample recovery experienced with a thin-walled sampler.

3.2.1.1 Ring-lined Split-Barrel Sampler (ASTM D 3350)

1. Assemble the sampler with the specified rings. For physical properties analysis, the typical ring is 3 inches in length and constructed of brass. Ring requirements will be specified in the Field Sampling Plan (FSP).

2. Attach the sampler to the drill stem and carefully lower it to the bottom of the borehole.

3. Hydraulically push the sampler into the soil in a rapid, continuous manner to a length not to exceed that of the sampler. In dense, non-cohesive soils, the sampler may have to be driven. If so, record the blow counts.

4. Carefully disassemble the sampler to minimize soil disturbance. Trim the individual rings flush with a clean knife, and place plastic caps over the ring ends. Use the soil in one of the rings for field classification. Secure the caps with tape and label the ring, including the vertical orientation.

5. The samples can be shipped in a dry cooler. If the possibility exists the samples will be handled roughly, pack them with shipping material in the cooler.

3.2.1.2 Thin-Walled Tube Sampler (ASTM D 1587)

1. Attach the sampling tube to the drill stem and carefully lower to the bottom of the borehole.

2. Rapidly and continuously hydraulically push the Shelby tube a distance of 5 to 10 times the tube diameter in non-cohesive soils and 10 to 15 times the diameter in cohesive soils. In dense, non-cohesive soils it is permissible to drive the sampler. Record the blow counts. It is permissible to "twist" the drill stem to shear the sample bottom prior to retrieval.

3. Carefully withdraw the sampler from the formation to minimize disturbance.

4. The sample can be shipped either unextruded or after extrusion at the site.

   Unextruded - Measure the length of the sample in the tube. Remove any slough from the top of the tube. Remove at least 1 inch of soil from the bottom of the tube for field classification. Seal the top and bottom of the tube with plastic caps and secure with tape.

   Extruded - Following extrusion, select a 12- to 15-inch segment of the sample which appears least disturbed. Carefully cut the ends with a clean knife, and immediately wrap the sample in cellophane wrap, then aluminum foil. Place the sample in a plastic tube, and cap the ends. Describe the soil with the remainder of the sample. Describe the prepared interval to the extent practicable. ***DO NOT*** cut or disturb the interval to be submitted to the laboratory.

5. The samples can be shipped in a similar manner as described in 3.2.1.1(5) above.

3.2.2 Soil Chemistry Samples

Soil chemistry samples can be collected with either the split-barrel sampler or with the ring-lined split-barrel sampler. The primary difference in the two methods is the preparation of the samples. In the case of samples obtained from the split-barrel, the soil must be transferred to soil containers (typically glass jars). In the case of the ring-lined sampler, the rings will be either stainless steel or brass which are capped with

Teflon-lined caps. The rings are labeled, secured with toluene-free tape, and submitted directly for analysis. Exact sample methods, volumes, containers, preservation, and chain of custody procedures will be outlined in the FSP. In general, for soil matrix samples, EPA SW-846 (EPA, 1986) methods will be specified. Both the split barrel sampler and the ring-lined sampler are hydraulically pushed or driven in the same manner described in 3.2.1.1(2-3) above.

3.2.2.1 Split-Barrel Samples (ASTM D 1586)

1. Upon retrieval of the sample, carefully open the split-barrel. Trim the sample with a decontaminated, sharp stainless-steel knife. Note the general soil type.

2. As quickly as possible, collect samples for volatile organic and semi-volatile organic analysis. Be sure that headspace is minimized in the volatile organic analysis samples. Collect field duplicates and specify that the laboratory perform matrix spike/matrix spike duplicates from the same interval as the sample. Place the samples in certified clean glass jars with Teflon-lined caps.

3. Collect samples for other required analyses. If the FSP specifies mixing the split barrel sample prior to filling additional sample containers, do so in a stainless-steel mixing bowl. Sample volumes and containers will be specified in the FSP.

4. Label the samples in accordance with the FSP. At a minimum, this will include: (1) the sample number; (2) boring number and interval (if different from the sample number); (3) time and date; and (4) required analysis. If chain of custody seals are required, secure them across the container lid.

5. Place the sample containers in "ziplock" bags and place on ice. Prior to shipment, the sample containers must be wrapped in bubble-pack, or other suitable packing material.

6. Fully describe the soil sample.

7. Log the sample information in the field log book for later transfer to the Chain-of-Custody Form (DBS&A Form No. 095), which is included as Attachment 3 in this SOP.

3.2.2.2 Ring-Lined Split-Barrel Samples (ASTM D 3350)

1. Upon retrieval of the sampler, carefully open the split-barrel. Trim the ends of the rings with a clean stainless-steel knife. Cap the rings with Teflon-lined caps and seal with toluene-free tape.

2. Using one or more of the rings (if possible), and soil trimmed from the ring ends, describe and log the soil.

3. Follow the steps described in 3.2.2.1(5-7) above. Packing material is optional for the ring samples.

3.3 Sample Shipment

Proper shipment of samples is critical for ensuring that reliable analytical results are obtained. In the case of geotechnical or physical properties analysis samples, this involves protecting the samples against excessive impacts which may disturb the samples. For soil chemical analyses, it is important to protect the samples from breakage if they were collected in glass jars. In addition, most chemical methods call for the samples being maintained at a constant 4°C.

3.3.1 Geotechnical and Physical Properties Samples

Shipping requirements for geotechnical and physical properties samples are listed in Table 13.3.2-2. In general, samples should be shipped in a dry cooler. If the cooler is not being hand-carried to the laboratory (i.e., shipped by overnight carrier) the samples should be protected with packing material to prevent sample disturbance. Plastic bubble-wrap, shredded paper, foam "peanuts", and vermiculite provide adequate sample protection when properly used. It is important to provide packing materials between all samples, such that samples do not come in contact. When shipping samples, it important to enclose a chain-of-custody form in the cooler as specified in the FSP.

3.3.2 Soil Chemistry Samples

Soil chemistry samples collected in glass containers must be protected from breakage. Individually wrapping the sample containers in plastic bubble-wrap provides excellent protection. After wrapping the samples in bubble-wrap, they should be placed in sealed "zip-lock" bags. Brass or stainless-steel ring samples need only be placed in sealed "zip-lock" bags. If the FSP calls for chain-of-custody seals to be placed on individual samples, place them across the jar lid or plastic ring cap. Chain-of-custody forms should be filled out in accordance with the FSP, placed in a "ziplock" bag, and taped to the inside of the cooler lid. It is important to use an ample volume of ice in order to maintain the required temperature of 4°C. Chain of custody seals will be placed across the front and back of the cooler lid such that they will be broken in the event of tampering. The cooler lid should be firmly taped shut with several layers of shipping tape encircling the ends of the cooler. Finally, for chemical analyses, *always* ship the samples by overnight carrier.

4.0 REFERENCES

ASTM D 1586-84 Standard Method for Penetration Test and Split-Barrel Sampling of Soils

ASTM D 1587-83 Standard Practice for Thin-Walled Tube Sampling of Soils

ASTM D 2488-90 Practice for Description and Identification of Soils (Visual-Manual)

ASTM D 3350-84 Standard Practice for Ring-Lined Barrel Sampling of Soils

U.S. EPA, 1986, Test Methods for Evaluation of Solid Wastes, SW-846, 3rd Ed.

5.0 ATTACHMENTS

1. Boring Log (DBS&A Form No. 080 3/92)
2. Unified Soil Classification System Chart (DBS&A Form No. 049)
   - Table 13.3.2-1, Soil Physical Sample Handling and Transport
   - Table 13.3.2-2, Soil Physical Sample Volume Requirements
   - Table 13.3.2-3, Soil Sampling Field Equipment List
3. Chain-of-Custody Form (DBS&A Form No. 95)

Prepared by: _____

Reviewed by: _____
Quality Assurance Manager

Approved by: _____
Daniel B. Stephens

Reviewed by: _____
Systems Operations Manager

DANIEL B. STEPHENS & ASSOCIATES, INC.

Boring Log

Page____of____

Site		Location Map
Logged by	Client/Project #	
Boring Number	Drilling Co.	
Drilling Method	Drill Rig	
Date Started	Date Completed	

PID/FID Reading	Blow Counts	Sampling Device	Sample Recovery	Sample Interval	Sample Number	USCS Symbol	Depth (feet)	Soil Description/Remarks Soil type, color, texture, grain size, sorting, roundness, plasticity, consistency, moisture content

DBS&A Form No. 080 3/92

USCS GROUP SYMBOLS

MAJOR DIVISIONS			GRAPH SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
Course Grained Soils More than 50% of Material is Larger than Silt (No. 200 Sieve Size)	Gravel and Gravelly Soils More than 50% of Course Fraction Retained on No. 4 Sieve	Clean Gravels (little or no fines <5%)		GW	Well-graded gravels, gravel-sand mixtures. Little or no fines.
				GP	Poorly-graded gravels. Gravel-sand mixtures. Little or no fines.
		Gravels with Fines (appreciable amount of fines >15%)		GM	Silty gravels. Gravel-sand-silt mixtures.
				GC	Clayey gravels. Gravel-sand-clay mixtures.
	Sand and Sandy Soils More than 50% of Course Fraction Passing No. 4 Sieve	Clean Sand (little or no fines <5%)		SW	Well-graded sands. Gravelly sands. Little or no fines.
				SP	Poorly-graded sands. Gravelly sands. Little or no fines.
		Sands with Fines (appreciable amount of fines >15%)		SM	Silty sands. Sand-silt mixtures.
				SC	Clayey sands. Sand-clay mixtures.
Fine Grained Soils More than 50% of Material is Smaller than Silt (No. 200 Sieve Size)	Silts and Clays	Liquid Limit Less than 50		ML	Inorganic silts and very fine sands. Rock flour. Silty or clayey fine sands or clayey silts with slight plasticity.
				CL	Inorganic clays of low to medium plasticity. Gravelly clays. Sandy clays, silty clays, lean clays.
				OL	Organic silts and organic silty clays or low plasticity.
	Silts and Clays	Liquid Limit Greater than 50		MH	Inorganic silts. Micaceous or diatomaceous fine sand or silty soils.
				CH	Inorganic clays of high plasticity. Fat clays.
				OH	Organic clays of medium to high plasticity. Organic silts.
Highly Organic				PT	Peat, humus, swamp soils with high organic content.

DBS&A Form No. 049 4/91

TABLE 13.3.2-1. SOIL PHYSICAL ANALYSIS SAMPLE REQUIREMENTS AND TRANSPORT

PHYSICAL PROPERTY TEST	SAMPLE REQUIREMENT	SHIPPING REQUIREMENT
Soil Moisture	2.5" O.D. x 3" long ring or in double plastic bag with air removed	Dry cooler
Hydraulic Conductivity	2.5" O.D. x 3" sealed ring	Dry cooler
Moisture Retention (Ψ-Θ)	2.5" O.D. x 3" sealed ring	Dry cooler with packing material
Air Permeability	2.5" O.D. x 3" sealed ring	Dry cooler with packing material
Bulk Density	2.5" O.D. x 3" sealed or waxed ring	Dry cooler with packing material
Porosity	2.5" O.D. x 3" sealed ring	Dry cooler with packing material
Specific Gravity	2.5" O.D. x 3" sealed ring or plastic bag for bulk sample	Dry cooler
Particle Size	2.5" O.D. x 3" sealed ring; plastic bag for gravelly soil	Dry cooler
Atterberg Limits	2.5" O.D. x 3" sealed ring or plastic bag	Dry cooler preferred
Proctor Tests	5 gallon plastic bucket or large plastic bags	No shipping requirements
Compression Tests	Unextruded in thin-walled tube; extruded wrapped in cellophane wrap and placed in plastic tube; or 2.5" O.D. x 6" sealed ring	Dry cooler with packing material

TABLE 13.3.2-1. SOIL PHYSICAL ANALYSIS SAMPLE REQUIREMENTS AND TRANSPORT

PHYSICAL PROPERTY TEST	SAMPLE REQUIREMENT	SHIPPING REQUIREMENT
Soil Moisture	2.5" O.D. x 3" long ring or in double plastic bag with air removed	Dry cooler
Hydraulic Conductivity	2.5" O.D. x 3" sealed ring	Dry cooler
Moisture Retention (Ψ-Θ)	2.5" O.D. x 3" sealed ring	Dry cooler with packing material
Air Permeability	2.5" O.D. x 3" sealed ring	Dry cooler with packing material
Bulk Density	2.5" O.D. x 3" sealed or waxed ring	Dry cooler with packing material
Porosity	2.5" O.D. x 3" sealed ring	Dry cooler with packing material
Specific Gravity	2.5" O.D. x 3" sealed ring or plastic bag for bulk sample	Dry cooler
Particle Size	2.5" O.D. x 3" sealed ring; plastic bag for gravelly soil	Dry cooler
Atterberg Limits	2.5" O.D. x 3" sealed ring or plastic bag	Dry cooler preferred
Proctor Tests	5 gallon plastic bucket or large plastic bags	No shipping requirements
Compression Tests	Unextruded in thin-walled tube; extruded wrapped in cellophane wrap and placed in plastic tube; or 2.5" O.D. x 6" sealed ring	Dry cooler with packing material

TABLE 13.3.2-2. SOIL PHYSIC/ AMPLE VOLUME REQUIREMENTS

SAMPLE REQUIREMENTS FOR ADDITIONAL TESTS	PRIMARY TEST REQUESTED											
	Moisture Content (volumetric)	Hydraulic Conductivity K_{sat}	Hydraulic Conductivity K_{unsat}	Moisture Retention Ψ - Θ	Air Permeability K_{air}	Bulk Density	Porosity (Calculated)	Porosity (Air Pycnometer)	Particle Density	Particle Size Analysis	Atterberg Limits	Compaction (Proctor) Test
Moisture Content (Volumetric)		Same Sample	(3) Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Hydraulic Conductivity	Same Sample		(3) Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Hydraulic Conductivity	(3) Same Sample	Same Sample		Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Moisture Retention	Same Sample	Same Sample	(3) Same Sample		Same Sample	Same Sample	Same Sample	Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Air Permeability	Same Sample	Same Sample	(4) Same Sample	Same Sample		Same Sample	Same Sample	Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Bulk Density	Same Sample	Same Sample	(4) Same Sample	Same Sample	Same Sample		(5) Same Sample	Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Porosity (Calculated)	Same Sample	Same Sample	(4) Same Sample	Same Sample	Same Sample	Same Sample		Same Sample	(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Porosity (Air)	Same Sample	Same Sample	(4) Same Sample	Same Sample	Same Sample	Same Sample	Same Sample		(1) Same Sample	(1) Same Sample	Extra Sample	Extra Sample
Particle Density	Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	Same Sample	(6) Same Sample	Same Sample		Same Sample	Same Sample	Extra Sample
Particle Size Analysis	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample	(2) Extra Sample		Extra Sample	Extra Sample
Atterberg Limits	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Same Sample	Extra Sample		Extra Sample
Compaction (Proctor)	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	Extra Sample	

(1) Same sample may be run for this additional test provided sample is in a sample ring and meets the sample size requirements for the additional test.

(2) Same sample may be used if sample meets sample size requirements for additional test (is there sufficient sample; usually only fine-grained samples will meet this requirement).

(3) Required for all unsaturated hydraulic conductivity calculations except column imbibition method.

(4) Same sample may be used except for column imbibition test.

(5) Additional test required to perform calculations of primary test.

(6) Additional test preferred for best results of primary test.

TABLE 13.3.2-3. SOIL SAMPLING FIELD EQUIPMENT LIST

	ITEM	DESCRIPTION
1.	Soil Kit	Geologic hammer Electrical and solvent-free tape Flagging tape Assorted sharpies Munsel Soil Color Chart Grain size chart USCS Soil Classification Guide Carpenter's rule (6 feet marked in tenths) Spatulas Dilute Hydrochloride acid
2.	Boring Log forms and clip board	
3.	Field book	
4.	Meters:	Photoionization Detector MX25 explosivity meter Water level meter Flame Ionization Detector or methane meter Geiger-Mueller radiation meter
5.	Tagline:	Fiberglass with weight taped OR Steel tape with steel weight and no tape to attach weight
6.	300-foot fiberglass tape	
7.	Latex gloves (2 or more boxes)	
8.	Health and Safety kits:	Earplugs Hard hat Steel-toed boots Safety glasses Tyvek, Respirator
9.	Coolers:	One for food only 3 or more for samples

TABLE 13.3.2-3. SOILS SAMPLING FIELD EQUIPMENT LIST (CONTINUED)

ITEM	DESCRIPTION
10. Decontamination:	3 plastic tubs Plastic brushes Liquinox Distilled water, 10-15 gallons minimum Paper towels Garbage bags (large/small)
11. Soil sample containers:	Brass rings (for soil physical properties) Stainless steel rings (for organic chem analyses) Teflon liners (for organic chem analyses) Plastic endcaps Sealing tape and/or purifier wax Glass jars (4 or 8 oz for chemical analyses) Quart and gallon ziplock bags

DANIEL B. STEPHENS & ASSOCIATES, INC.

Chain of Custody

To:

_____ Date _____ Project No. _____

_____ Client _____

_____ Relinquished by _____

Sent by: ☐ Fed Ex ☐ DHL ☐ Other _____

Purpose of Shipment _____

Possible Contaminants _____

Item No.	Sample No.	Analysis to be Done	Sample Container	Comments

Date Received _____ by _____
Company Representative

Received the above articles in good condition

Except as noted _____

_____

_____

DBS&A Form No. 095 5/92

1. PURPOSE

The purpose of this standard operating procedure (SOP) is to present guidelines and procedures for collection, preservation, and shipment of water samples for laboratory chemical analysis. This SOP also outlines procedures for measurement of field water quality parameters during sample collection activities.

2. SCOPE

The SOPs included in this section are applicable to all DBS&A employees, and its contractors and subcontractors, for the conduct of all activities listed in this section. **All SOPs described in this section are proprietary in nature and shall not be copied or reproduced, or distributed to any person or organization not employed by DBS&A, without the expressed written approval of the Systems Operations Manager (SOM) or President of DBS&A.** The scope of the procedure described in this section includes the following:

13.5.1 Preparation for Water Sampling
13.5.2 Decontamination of Field Equipment
13.5.3 Measurement of Field Parameters
13.5.4 Collection of Ground-Water Samples
13.5.5 Collection of Surface Water Samples
13.5.6 Sample Preservation
13.5.7 Sample Filtration
13.5.8 Quality Assurance/Quality Control (QA/QC) Samples

This SOP includes guidelines for preparation for water sampling, collection of surface- and ground-water samples, sample preservation, chain of custody procedures, and quality assurance/quality control procedures. This SOP is applicable to the collection of surface- and ground-water samples to be analyzed for organic, inorganic and radionuclide constituents and for measurement of field parameters including temperature, conductivity, pH, alkalinity, oxidation/reduction potential (Eh), and dissolved oxygen.

3. PROCEDURES

These SOPs shall be reviewed and updated at least once annually by the Systems Operations Manager (SOM), or person(s) designated by the SOM. Revisions and additions to these SOPs shall be made as needed to assure consistency with industry standards and the collection of high quality data in the field. Requests for revisions shall be made on Form No. 127 in accordance with the procedure described in Section 0.2 of the DBS&A Operations Manual. The Proprietary Copy Request and Authorization Form (DBS&A Form No. 043) shall be used in requesting, authorizing, and documenting any SOP, or part of any SOP, copied or distributed for uses described in Section 13.5 of the Operations Manual. All or parts of the SOPs described in this section may be reproduced and used in DBS&A reports, proposals, and work plans with the verbal consent of either the SOM or President of DBS&A. The SOM shall be responsible for filing and maintaining requests made on Form Nos. 127 and 043.

Prepared by: _____

Reviewed by: _____
Quality Assurance Manager

Approved by: _____
Daniel B. Stephens

Reviewed by: _____
Systems Operations Manager

1. PURPOSE

The following SOP defines activities to be completed prior to each sampling event. A checklist/summary of water sampling preparation activities is included as Attachment 1 to this SOP.

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors when preparing to sample water.

3. PROCEDURES

3.1 DBS&A Warehouse

Prior to any water sampling event, the water sampler shall requisition all necessary equipment and supplies by completing a DBS&A Field Equipment and Materials Load-Up Sheet (see Section 13.1.1 of the DBS&A Operations Manual) and giving it to the warehouse manager. The load-up sheet should be provided to the warehouse manager as much in advance as is possible, so that equipment and supply requisitions can be made.

All equipment to be used, with the exception of rental equipment, shall be calibrated and tested in the DBS&A warehouse by the warehouse manager prior to being sent to the field per the guidance prescribed in Section 13.1.1 of the DBS&A Operations Manual. Meter calibration shall be conducted in accordance with standard manufacturer recommended procedures using clean, fresh reagents. The warehouse manager shall ensure that all equipment is clean and in working order prior to leaving the DBS&A warehouse.

3.2 Analytical Laboratory

Prior to a water sampling event, the number and type of samples to be collected (field and quality assurance samples) shall be determined by the Project Manager (PM) or designated project Technical Representative (TR). The PM or project TR shall order appropriate sample containers (Section 13.1.1) from the analytical laboratory and shall inform the analytical laboratory of the expected arrival date of the samples, the analytes to be determined for each sample, and the required turnaround time. It is the water sampler's (Field Representative; FR) responsibility to confirm that all sample bottles have been received and are loaded for sampling. The duties and responsibilities of TRs and FRs are described in Section 13.2 of the DBS&A Operations Manual.

3.3 Site-Specific Instructions

The first time that a site is sampled, or the first time that any new location is sampled, the designated sample identification number shall be determined by the PM or TR prior to field sampling.

Prior to each water sampling event, the PM or TR shall compile a list of samples (including quality assurance samples) to be collected. The order in which the samples should be collected shall also be listed. In general, locations with the lowest concentrations of select analytes shall be sampled before wells with higher

concentrations, so the potential for cross-contamination can be minimized. The PM or TR will also list any special procedures that are unique to the site or to the sampling event.

Before each sampling round, the PM or TR shall make all access arrangements with the client and/or property owners. The FR(s) will confirm that access arrangements have been made and should determine if additional on-site access procedures are required.

Prior to leaving for the field, FR(s) shall assemble and be familiar with materials that describe the general conditions of the site, the hydrogeology, well completion information, and objectives of the sampling program. The project health and safety plan shall also be consulted before initiation of the field program.

Prepared by: Joanne Hilton

Reviewed by: Quality Assurance Manager

Approved by: Daniel B. Stephens

Reviewed by: Systems Operations Manager

1. PURPOSE

The following SOP defines activities required to decontaminate water sampling equipment in order to prevent cross-contamination of samples from different sampling locations.

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors involved in water sampling activities.

3. PROCEDURES

All non-disposable field equipment that may potentially come in contact with any water sample shall be decontaminated in order to minimize the potential for cross-contamination between sampling locations. Thorough decontamination of all sampling equipment shall be conducted in the warehouse before each sampling event. In addition, the FR shall decontaminate all equipment in the field as required to prevent cross-contamination of water samples (see Section 13.1.1 of the DBS&A Operations Manual). The procedures described in this section are specifically for field decontamination of sampling equipment.

For wells or surface waters to be sampled for inorganics and/or metals, or for locations outside of the area of known contamination, the following procedures shall be used:

1. Wash the equipment in a solution of non-phosphate detergent (Liquinox) and distilled/deionized water. All surfaces that may come in direct contact with the samples shall be washed. Use a clean Nalgene tub to contain the wash solution and a scrub brush to mechanically remove loose particles. Wear clean latex or plastic gloves during all washing and rinsing operations.

2. Rinse twice with distilled/deionized water.

3. Dry the equipment before use, to the extent practical.

If the sample is collected from a highly contaminated area or is to be analyzed for organics, follow steps 1 and 2, then rinse once more with organic-free water obtained from the laboratory or other supplier. Contain all wash solutions for proper disposal.

4. REFERENCES

- American Petroleum Institute. 1987. Manual of Sampling and Analytical Methods for Petroleum Hydrocarbons in Groundwater and Soil. API Publication No. 4449. American Petroleum Institute, Washington. DBS&A #3600/API.

Prepared by: Joanne Hilton

Reviewed by: Quality Assurance Manager

Approved by: Daniel B. Stephens

Reviewed by: Systems Operations Manager

1. PURPOSE

This section outlines procedures for field measurement of electrical conductivity, temperature, pH, alkalinity, oxidation/reduction potential (Eh), and dissolved oxygen (DO).

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors involved in water sampling activities. These parameters should be measured during monitor well purging prior to sampling. Surface water samples should also be characterized when they are collected.

3. PROCEDURES

3.1 Conductivity and Temperature

This SOP describes the procedure for determining the specific conductance (conductivity) and temperature of a water sample using the YSI Model 33 SCT Meter. Conductance, or conductivity, is a measure of the ease of flow of electric current, and is the inverse (reciprocal) of resistivity. The term specific conductance (SpC), sometimes referred to simply as "conductivity," is defined as the electrical conductance that would occur through the water between the faces of a 1-cm cube of the water. SpC is usually reported in units of µmhos/cm, which has recently been renamed microsiemens per centimeter (µS/cm). By measuring the specific conductance of a water sample in the field, one can estimate the total dissolved solids (TDS) concentration of the water using the approximate conversion TDS = 0.6 x SpC. Because the SpC of a water allows rapid determination of TDS (salinity), SpC is probably the single most useful water quality parameter.

The conductance of water containing dissolved ions increases with increasing temperature of the water. The temperature dependence varies for different waters and is dependent on the type and concentrations of dissolved ions, but an approximate rule of thumb is that SpC increases 2% per °C temperature increase. For quantitative comparison of SpC values measured on different water samples at different field temperatures, it is necessary to correct all values to the SpC at 25°C. For most qualitative work, however, this is unnecessary. Whether or not temperature corrections are to be applied, the SpC value as measured at field temperature should always be recorded in the field logbook (see Section 13.2.6 of the DBS&A Operations Manual), along with the temperature of the water sample at the time the measurement was made.

The following equipment is needed to measure SpC in the field:

- YSI Model 33 SCT Meter & probe
- Spare D-cell batteries
- Beaker for water sample
- Deionized water in squirt bottle
- KCl conductivity standard solution

The following procedure shall be used to measure SpC in the field:

1. Verify that the meter needle rests on zero prior to turning on the meter. If not, adjust it to zero using the set screw on the face of the meter movement.

2. Calibrate the meter by turning the *MODE* switch to *REDLINE* and adjusting the *REDLINE* control knob until the needle lines up with the small red line on the meter scale. (If unable to calibrate meter, replace the batteries.)

3. Plug in probe cable, and insert gray plastic probe into water sample. Allow at least one minute for temperature equilibration of probe.

4. Set *MODE* control to *TEMPERATURE* and record the temperature of the water sample in the field logbook. (Note that the temperature scale is at the bottom of the meter face and that the values decrease to the right)

5. Switch the *MODE* control to the conductivity setting that gives the maximum needle deflection without going offscale (X100, X10, or X1). Do not allow the probe to touch the sides or bottom of the beaker when making a measurement because this can result in a low reading.

6. Record the SpC value, remembering to multiply the meter reading by the appropriate factor if using the X10 or X100 settings.

7. Rinse the probe with deionized water prior to making another measurement or putting the instrument away.

Other information about the YSI Model 33 SCT Meter may be needed occasionally:

- The probe preferably should be stored in deionized water between uses during each day of field work. If the probe has been stored dry, it is recommended that it be soaked in deionized water at the start of the day prior to making any measurements. This is not absolutely essential, however.

- The *SALINITY* mode will not ordinarily be used unless dealing with brines or other samples with salinity of seawater or above. The *TEMPERATURE* potentiometer only functions in *SALINITY* mode; it does nothing when operating in SpC mode and cannot be used to correct SpC values to 25°C.

- To test probe operation, press the *CELL TEST* button while measuring the SpC of a water sample on the X10 or X100 scales. If the probe is functioning properly, the meter reading should not fall more than 2% when depressed. If the meter reading falls more than 2%, notify the equipment technician that the probe needs attention.

- The meter and probe should be periodically checked against a standard potassium chloride (KCl) solution to verify proper internal calibration. To do so, immerse the (clean) probe in the KCl standard, and record the temperature and SpC values as described above. Check that the SpC value is within

± 5% of the nominal SpC value for that particular KCl solution at that temperature. Record the observed value and the nominal value (from label on bottle) in the field logbook.

3.2 pH

This section describes the procedure for determining the pH of a water sample using the Orion Model 250A pH/mV meter with automatic temperature compensation. Calibration of the meter is performed at least daily using two buffer solutions that bracket the sample pH. A temperature sensor is included on the pH probe to make the minor correction from the sample temperature to 25°C. For information on manual temperature correction, refer to meter instruction manual. The Orion 250A can also be used in millivolt mode with a variety of ion selective electrodes (refer to ISE SOPs).

The following equipment is needed to measure pH in the field:

- Orion Model 250A pH meter
- Buffer solutions (pH 4.01, 7.00, 10.00)
- Spare 9-volt battery
- Beaker for water sample
- Deionized water in squirt bottle

The following procedure shall be used to measure pH in the field:

1. Plug the pH probe and thermistor (ATC) into the appropriate jacks of the meter.

2. Insert battery (if necessary), and press the power button to turn on the meter.

3. If the meter is not already in pH mode as indicated by the caret at the bottom of the display, press the mode button to select pH mode.

4. Rinse the probe with deionized water to remove any dried KCl salts, and slide the silicone rubber sleeve down to expose the electrolyte fill hole. Leave the hole uncovered during measurement, but do not allow the hole to be submerged in the sample.

5. Remove the plastic end cap on the probe, rinse the tip of the probe in deionized water, and insert the probe in the pH 7.0 buffer.

6. Press "2nd," then "Cal" to put the meter in calibration mode. The word "calibrate" should appear on the display, and the designation "P1" indicates that the meter is ready for the first buffer calibration.

7. Stir the probe gently in the pH 7.0 buffer solution. When the reading has stabilized, the meter will beep and the word "ready" will appear. Press "yes" to accept the reading and set the pH 7.0 calibration. "P2" will be displayed, indicating that the meter is ready for the second buffer solution.

8. Rinse the probe with deionized water, and insert it in the pH 4.0 buffer. (If the pH of the water sample is anticipated to be >7, then substitute the pH 10.0 buffer.)

9. When the meter indicates "ready," press "measure" to accept the pH 4.0 calibration. The slope of the calibration curve will be displayed briefly. Record the slope in the field logbook. The slope value should be within the range of 90 to 110. If not, repeat the calibration procedure. The meter will automatically exit the calibration mode, and the word "measure" will be displayed.

10. Rinse the probe and insert it into the water sample to be measured. Stir gently while waiting for the word "ready" to appear. Record the pH value in the field logbook.

11. If more measurements are to be made, rinse the probe and store temporarily in a beaker of deionized water. If finished for the day, turn the meter off, rinse the probe, disconnect the plugs, and store the probe with a few milliliters of the KCl electrode storage solution inside the black plastic end cap.

3.3 Alkalinity

This section describes the procedures for determining the total alkalinity in near-neutral pH, high-alkalinity water samples (most ground waters) using the Hach Test Kit. For information on the procedure for low-alkalinity samples or high pH samples (pH>8), refer to the Hach instruction sheet.

The following equipment is needed to determine total alkalinity in the field:

- Hach Alkalinity Test Kit

The following procedure shall be used to determine total alkalinity in the field:

1. Fill the small plastic test tube with the water to be tested.

2. Pour the contents of the test tube into the square glass bottle.

3. Add the contents of one foil packet containing the *Bromcresol Green/Methyl Red* color indicator. The water will turn a dark green.

4. Carefully begin adding the standard sulfuric acid titrant dropwise using the eye dropper, counting the number of drops added and swirling to mix the solution. Keep the eye dropper nearly vertical to maintain a constant drop volume.

5. When the solution begins to change from green to red, slow down. The titration is complete when the solution is a bright pink color.

6. Record the total number of drops added. Multiply the number of drops by 20 to obtain the total alkalinity, reported as mg/L of $CaCO_3$.

3.4 Oxidation-Reduction Potential (Eh)

This section describes the procedure for determining oxidation reduction potential of water in the field using an electrode.

The following equipment is needed to measure Eh in the field:

- Yellow Oxidation-Reduction Potential (ORP) Electrode
- Orion Model 250A pH/mV meter or YSI Model 3500 flow-thru cell meter
- Standard Zobell solution

The following procedure should be used to measure Eh in the field:

1. Plug the BNC connector into an Orion 250A pH/mV meter (or YSI 3500 meter).

2. Turn on the meter. If using the Orion 250A, use *MODE* key to set meter to "mV" mode (**not** *rel mV*). If using the YSI 3500, turn the black knob to "mV".

3. Check probe operation by immersing it in a disposable beaker with Zobell Solution. The reading should be ± 10 mV of that listed on the table with the Zobell Solution at the temperature of the solution (e.g., 231 mV at 25° C).

4. Rinse the probe and immerse it in the ground-water sample. Following stabilization, record the mV value, along with a ± estimate to indicate the stability of the meter. Also record the sample temperature.

3.5 Dissolved Oxygen (DO)

This section describes the procedure for determining the dissolved oxygen (DO) concentration using the YSI Model 57 DO meter. The meter is calibrated using the air calibration procedure, with corrections for ambient temperature and altitude/barometric pressure. Refer to the instruction manual for details of meter operation and replacement of the probe membrane.

The following equipment is needed to measure dissolved oxygen in the field:

- YSI Model 57 Dissolved Oxygen Meter
- Beaker for water sample
- Deionized water in squirt bottle
- Means of determining the approximate altitude of the site (topo map, altimeter, etc.)

The following procedure shall be used to measure dissolved oxygen in the field:

1. Turn the meter on approximately 15 minutes before measuring samples to allow the probe to polarize. The probe shall be kept in the clear plastic cover. Add a few drops of deionized water

to the small sponge inside the cover to maintain 100% relative humidity around the tip of the probe during storage.

2. Set the salinity knob to "fresh" for normal ground waters, or adjust to the appropriate salinity if brackish or saline waters are to be measured (as determined by specific conductance or previous laboratory analysis).

3. Set the zero on the meter by turning the switch to *ZERO* and adjusting the zero potentiometer until the needle falls on zero.

4. Set the red line on the meter by turning the switch to *RED LINE* and adjusting the appropriate potentiometer.

5. With the probe still in its cover, set the switch to *TEMPERATURE* and note the ambient air temperature displayed on the meter.

6. Determine the maximum (sea level) dissolved oxygen concentration (mg/L) possible for that temperature by referring to the table on the back of the DO meter (also in the instruction manual). Note this value in the field logbook.

7. Determine the approximate altitude of the site, and find the appropriate altitude correction factor on the table on the back of the meter (also in the instruction manual).

8. Multiply the saturated DO concentration determined in Step 5 by the altitude correction factor determined in Step 6. Note the value in the field logbook. This is the corrected saturated DO concentration (corrected for both temperature and altitude). Calibration should be periodically checked during the day as the temperature changes, and adjusted if necessary.

9. Switch the meter to the appropriate measurement scale for the corrected DO concentration determined in Step 7 (e.g., 0-10 mg/L scale), and use the *CALIBRATE* knob to air calibrate the meter by adjusting until the needle falls on the value determined in step 8. The meter is now ready to measure water samples.

10. Rinse the probe with deionized water, and insert it in the water sample and stir gently. Set the switch to *TEMPERATURE*, and record the reading in the field logbook.

11. Set the switch to the appropriate DO scale (e.g., 0-5 mg/L) to keep the needle on scale, and stir gently until a stable reading is obtained. It is important to be stirring the sample when the actual reading is taken. Record the value in the field logbook.

12. The probe may be stored temporarily in deionized water between measurements. When finished for the day, rinse the probe, and store with the dampened sponge in the plastic cap.

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1. PURPOSE

The following SOP defines activities to be completed for the collection of ground-water samples.

2. SCOPE

This procedure is applicable to all DBS&A employees, its contractors and subcontractors, when collecting ground-water samples.

3. PROCEDURES

3.1 Wellhead Preparation

Prior to ground-water sample collection, the following wellhead protection activities shall be conducted:

1. Inspect the area around the well for wellhead integrity, cleanliness, and signs of possible contamination.

2. Spread a clean plastic sheet over the ground around the wellhead, where required.

3. Remove the cap on the wellhead. Note any obvious odors within the wellbore in the field logbook.

4. If possible, measure the static water level (see Section 13.6.1 of the DBS&A Operations Manual) prior to initiation of water sampling. Clean the steel tape or electrical sounder used for water level measurement after each use, as described in Section 13.5.2 of the Operations Manual, to avoid cross contamination.

5. If floating product (e.g., gasoline) is suspected at the site, conduct the following procedures:

   - Use a bailer to extract a sample from the surface of the water within the well, if possible.

   - After an initial visual inspection, slowly pour the fluid from the bailer into a small tub or container in order to check for a sheen or any other sign of free product. Note any obvious odors in the field logbook.

   - If free product is detected, use the bailer to remove as much free product as is possible from the wellbore. Lower the bailer into the water slowly in order to prevent mixing and volatilization. Contain all recovered product for proper disposal and note the quantity of product removed in the field logbook.

   - If the site has not been previously sampled, a sample of the free product may be desired. Consequently, place some of the product in an unpreserved 40-mL glass VOA vial, and store it away from the other samples. Confirm sample analysis with the project manager.

- After any free product has been removed from the wellbore, spread a fresh plastic sheet around the wellhead, and clean all contaminated equipment, or segregate it from the other equipment.

3.2 Well Purging

The purpose of purging the well prior to sampling is to remove stagnant water from the well bore so that a representative ground-water sample can be collected. The method of purging can have a pronounced effect on the quality of the ground-water sample. For example, rapid purging may increase sample turbidity and is, therefore, not recommended.

In general, positive displacement (bladder) pumps are preferred for most sampling situations. However, depending on the hydraulic conductivity of the aquifer to be sampled and the project objectives, wells may either be equipped with dedicated pumps or may need to be purged with bailers. Consequently, purging techniques may vary depending on the aquifer conditions, the presence or absence of a dedicated pump, and the proposed sample analytes.

The optimum amount of water to be purged from each well also varies between sites. According to Barcelona et al., 1985, pg. 47, "The number of well volumes to be pumped from a monitoring well prior to the collection of a water sample must be tailored to the hydraulic properties of the geologic materials being monitored, the well construction parameters, the desired pumping rate, and the sampling methodology to be employed."

Site-specific purging procedures shall be prepared for each site. The following purging procedure can be used as a general guideline:

1. Calculate the volume of water standing in the casing by using the formula:

   $$V = \pi r^2 L$$

   where
   r = the radius of the casing (remember to convert inches to feet)
   L = the length of the water column (total depth of well minus the static water level)

2. Purge the well at a rate equal to or greater than the sampling rate.

3. Measure applicable field parameters (see Section 13.5.3 of the Operations Manual) at the pump outlet at a minimum after each 0.5 casing volume is pumped. Purging is generally considered complete when the above parameters are approximately stable over at least one casing volume. Wherever possible, purge a minimum of three (3) casing volumes from each well.

4. In low permeability formations, it may not be possible to purge three casing volumes before the well goes dry. When the formation permeability is too low to allow for continuous purging, remove all of the standing water in the well by pumping or bailing. As soon as the well has recharged sufficiently, collect a sample so as to minimize volatilization in the wellbore.

5. Contain all fluid from obviously contaminated or potentially contaminated wells for later disposal. Anomalous values for the above field parameters, odor, visible sheen, or the presence of free product may be taken as signs of contamination. Results of previous water sampling events will be consulted when available.

6. Take careful notes in order to document all purging procedures. The notes shall include: date, time, name(s) of sampler(s), weather, purge rate, purge method, field parameters (at each time measured, with corresponding purge volume), visual observations, odor, and any other relevant information.

The following guidelines as outlined in pertinent references on water sampling can be used when developing site-specific purging procedures:

- Pg. 103 of the EPA RCRA Technical Enforcement Guidance Document (TEGD) states, "in low yield formations, water should be purged so that it is removed from the bottom of the well." (NWWA, 1986).

- Pg. 103 of the TEGD also states "Whenever a well is purged to dryness, a sample for field parameters should be collected as soon as the well has recovered sufficiently. A second measurement of field parameters should be made immediately after sampling. Do not pump a well to dryness if it causes formation water to cascade down the well." (Ibid).

- The inlet line of the sampling pump or the submersible pump should be placed near the bottom of the screen section, and pump approximately one well volume of water at the well's recovery rate, and then collect the sample from the discharge line (EPA 1977, pg. 211).

- According to Wehrmann (1984), "For high yielding monitoring wells which cannot be pumped to dryness, bailing without pre-pumping the well is not recommended; there is no absolute safeguard against contaminating the sample with stagnant water." The following procedures should be used:

  Place the inlet line of the sampling pump just below the surface of the well water, and pump three to five volumes of water at a rate equal to the well's recovery rate. This provides reasonable assurance that all stagnant water has been evacuated and that the sample will be representative of the groundwater body at that time.

- Wehrmann (1984) further states, "The rate at which wells are purged should be kept to a minimum. Purging rates should be lower than development rates so that well damage does not occur. Pumping at very low rates in effect, isolates the column of stagnant water in the well bore and negates the need for its removal, if the pump intake is placed at the top of, or in, the well screen. This approach can be very useful when disposal of purge water is a problem."

- If a well completed in a highly permeable formation is being purged, it may be useful to periodically move the intake of the purge pump during purging so that stagnant water does not remain in the well bore while fresh water comes in at only one level (Scalf et al., 1981, pg. 44).

3.3 Ground Water Sample Collection

The following procedure shall be used to collect ground-water samples:

1. If the well is not equipped with a sampling pump, use only teflon or stainless steel bailers for sampling. In order to minimize agitation and volatilization, bailers shall be equipped with bottom emptying devices when VOA samples are collected.

2. Whenever possible, collect ground-water samples first from wells that have the lowest potential concentrations of analytes of interest, and last from the wells with the highest suspected concentrations (i.e., clean → dirty). The specific sampling order will be detailed in the site-specific sampling plan.

3. Pumps equipped with Teflon tubing or disposable teflon bailers are generally recommended for collection of samples to be analyzed for volatile organics.

4. Select the appropriate sample container and preservative as described in Section 13.5.6.

5. After the well has been purged, collect water samples as soon as possible in order to reduce the possibility of volatilization within the wellbore. If a pump has been used for purging, lower the pump rate so that the sampling rate is lower than the purge rate. If volatile organic samples are to be collected, set the pump at the lowest possible setting. If possible, the sampling rate should be less than 100 ml per minute, or the minimum setting on the pump.

6. Collect samples in decreasing order of volatility, i.e. collect samples to be analyzed for volatile organic compounds (VOCs) first, followed by semi-volatile organic compounds, PCBs and pesticides, and inorganics. The preferred order of sampling according to the TEGD is VOCs, SVOCs, purgeable organic halogens (POX), total organic halogens (TOX), total organic carbon (TOC), extractable organics, total metals, dissolved metals, phenols, cyanide, sulfate and chloride, turbidity, nitrate and ammonia, and radionuclides.

7. Do not allow the outlet of the sampling pump discharge tubing to come into direct contact with the sample vial or the water within the vial.

8. Make sure that no air is entrapped in the sample vials to be analyzed for volatile organics. Take the sample by holding the vial at an angle so that aeration is minimized. Avoid touching the lip of the vial or the Teflon liner. If the sample cannot be transferred directly to the vial, (i.e. high production well) use a clean stainless steel cup to pour the water into the vial. Direct the water stream against the inside surface of the vial. Allow a convex meniscus to form across the mouth of the filled vial. Carefully cap the vial, then invert and tap the vial to insure that no entrapped air is present. If entrapped air is present, recollect the sample.

9. If filtering of any samples is required by the site specific sampling plan, use the filtering procedure described in Section 13.5.7.

10. Preserve the sample as indicated in Section 13.5.6. Whenever possible, use pre-preserved containers supplied by the analytical laboratory rather than adding preservatives in the field.

11. Measure field parameters as described in Section 13.5.3. Temperature, electrical conductivity, and pH generally will be measured at all locations. Alkalinity, dissolved oxygen, and Eh will be measured only as required by the site specific sampling plan.

12. If the sample is to be collected from a domestic well or location other than a monitoring well, it may be necessary to clean the sampling port prior to sample collection (e.g., an outside hose bib or an inside water facet). Flush the faucet/line by allowing it to run for a minimum of five minutes.

13. Collect samples from domestic wells downstream of water softeners or chlorinators or in-home filters that modify water quality. However, if the objective of the domestic sampling is to evaluate the ground water prior to treatment, the samples may be taken upstream of such devices.

14. Record all pertinent information in the field notebook. Data to be recorded include the date and time of sample collection, climatic conditions at the time of sampling, well sampling sequence, types of sample containers used, sample identification numbers, field parameter data, name(s) of collector(s), deviations from established sampling protocol (e.g., equipment malfunctions), purpose of sampling (e.g., surveillance, compliance), and collection of quality control samples.

4. REFERENCES

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1. PURPOSE

The following SOP defines activities to be completed for the collection of surface water samples.

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors when collecting surface water samples.

3. PROCEDURES

A site-specific water sampling plan shall be prepared to define surface water sampling locations and procedures that are unique to each site. The following general procedure shall be followed for collection of surface water samples:

1. Select the water sampling location. Collect spring samples as close to the source as possible. Do not collect spring or stream samples from stagnant pools; collect these samples from free running locations if possible. The selection of the optimum sampling locations should be based on the objectives of the site-specific sampling plan.

2. Whenever possible, make a discharge measurement at the time of water sampling. If it is not possible to gauge the surface water discharge (see Section 13.9 of the DBS&A Operations Manual), make an estimate, and describe the procedure used to estimate the discharge in the field logbook.

3. Collect surface water samples as "grab" samples unless a depth integrated sampler or other procedure is required in the site specific sampling plan.

4. If the surface water is frozen, ice samples should not be taken in lieu of water samples.

5. Select the appropriate container as described in Section 13.5.6 of the Operations Manual.

6. For non-volatile analytes, dip a clean unpreserved container directly into the surface water, and partially fill the container. Swirl and rinse the container, and then discard the water.

7. Rinse the container two more times.

8. Fill the container with surface water.

9. Collect samples in decreasing order of volatility, i.e. collect samples to be analyzed for volatile organic compounds (VOCs) first, followed by semi-volatile organic compounds (SVOC), PCBs and pesticides, and inorganics. The preferred order of sampling according to the TEGD is VOCs, SVOCs, purgeable organic halogens (POX), total organic halogens (TOX), total organic carbon (TOC), extractable organics, total metals, dissolved metals, phenols, cyanide, sulfate and chloride, turbidity, nitrate and ammonia, and radionuclides.

10. Make sure that no air is entrapped in the sample vials to be analyzed for volatile organics. Take the sample by holding the vial at an angle so that aeration is minimized. Avoid touching the lip of the vial or the Teflon liner. If the sample cannot be collected directly from the water source, use a clean stainless steel cup. Direct the water stream against the inside surface of the vial. Allow a convex meniscus to form across the mouth of the filled vial. Carefully cap the vial, then invert and tap the vial to insure that no entrapped air is present. If entrapped air is present, recollect the sample.

11. If filtering of any samples is required by the site specific sampling plan, use the filtering procedure described in Section 13.5.7 of the Operations Manual.

12. Either add preservatives directly to the container as described in Section 13.5.6 of the Operations Manual, or transfer the sample to a pre-preserved container. If transferring the sample between containers, pour the water slowly from the glass bottle or cubitainer to the sample container.

13. Fill a clean beaker or other appropriate container with surface water for field parameter measurement as discussed in Section 13.5.3 of the Operations Manual. Temperature, electrical conductivity, and pH generally will be measured at all locations. Alkalinity, dissolved oxygen, and Eh will be measured only as required by the site-specific sampling plan.

14. Carefully document the surface water sampling location. Photographs of the sampling location should be taken from several locations if possible. Describe each photograph along with the photo number in the log book (e.g., photo #5-Upstream (south) view of location # SPG-014, taken from the west bank). Also include the time, date, and the name of the photographer in the log book, and transfer this information to the back of photograph when it is received. In addition, provide a detailed written description of the sample location in the log book.

15. Record all pertinent information in the field notebook. Data to be recorded include the date and time of collection, climatic conditions at the time of sampling, well sampling sequence, types of sample containers used, sample identification numbers, field parameter data, name(s) of collector(s), deviations from established sampling protocol (e.g., equipment malfunctions), purpose of sampling (e.g., surveillance, compliance), and collection of quality control samples. Also note any obvious stress to vegetation, which may be a result of contamination.

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1. PURPOSE

The following SOP defines activities to be completed to properly preserve a water sample for shipment to an analytical laboratory for analysis.

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors when preserving water samples in the field.

3. PROCEDURES

Table 13.5.6-1 of this SOP lists recommended containers, preservatives, and holding times for individual analytes or analytical methods. The suggestions for sample storage and preservation presented are intended to serve as general guidelines. The analytical laboratories shall be consulted for the proper preservation and storage procedure for the analytical methods that will be used (e.g., this guideline recommends preservation of volatile organic samples with hydrochloric acid (HCl), but some laboratories require preservation with mercuric chloride).

Samples for volatile organics analysis (EPA 602, 624 or 8020) shall be collected in pre-cooled, pre-acidified, certified-clean 40 ml borosilicate vials with teflon septum caps supplied by the analytical laboratory. Samples to be analyzed for other constituents should be collected in appropriate containers as listed in Attachment 1 to this SOP.

4 ATTACHMENTS

- Table 13.5.6-1, Container/Preservative Reference Chart (5 sheets)

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TABLE 13.5.6-1. CONTAINER/PRESERVATIVE REFERENCE CHART
General/Inorganic Chemistry

Analysis	*Container*	*Preservative (Chill to 40°C)*	*Container*	*Holding Time (From Sampling Date)*	
	Water	Water	Soil	Water	Soil
Alkalinity	4 oz. Plastic	Unpreserved	N/A	14 days	N/A
Ammonia (NH_3)	4 oz. Plastic	.25 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
BOD	16 oz. Plastic[B]	Unpreserved	N/A	48 hr.	N/A
Boron	4 oz. Plastic	Unpreserved	4 oz. jar	28 days	28 days
Bromide	16 oz. Plastic	Unpreserved	8 oz. jar	28 days	28 days
Chloride	4 oz. Plastic	Unpreserved	8 oz. jar	28 days	28 days
COD	4 oz. Plastic	.25 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
Color	4 oz. Plastic	Unpreserved	N/A	48 hr.	N/A
Cyanide (total and/ or amenable)	4 oz. Plastic	2 ml 1.5N NaOH[B]	4 oz. jar	14 days	No Specified Time
Electrical Conductivity	4 oz. Plastic	Unpreserved	4 oz. jar	28 days	28 days
Flashpoint	8 oz. Amber Glass w/Septum[B]	Unpreserved	8 oz. jar	28 days	28 days
Fluoride	4 oz. Plastic	Unpreserved	4 oz. jar	28 days	28 days
Formaldehyde	1 L Glass	1% Methanol	4 oz. jar	28 days-Pres. 7 days-Unp.	28 days
General Minerals • General Minerals • NO_3 • Metals	 1 L Plastic 4 oz. Plastic 16 oz. Plastic	 Unpreserved .25 ml H_2SO_4[A] 1 ml HNO_3[A]	16 oz. jar	28 days	28 days
Gross Alpha/Beta	1 L Plastic	2 ml HNO_3[A]	4 oz. jar	6 mo.	6 mo.
Hardness	4 oz. Plastic	Unpreserved	N/A	28 days	N/A
Hexavalent Chromium (CR^{+6})	16 oz. Plastic	Unpreserved	4 oz. jar	24 hr.	28 days

A - Typical volume needed to bring the pH to <2
- Headspace free
C - Typical volume needed to bring the pH to >12
D - Typical volume needed to bring the pH to >9

TABLE 13.5.6-1. CONTAINER/PRESERVATIVE REFERENCE CHART (CONTINUED)
General/Inorganic Chemistry

Analysis	*Container*	*Preservative (Chill to 40°C)*	*Container*	*Holding Time (From Sampling Date)*	
	Water	Water	Soil	Water	Soil
Iodide	4 oz. Plastic	Unpreserved	4 oz. jar	24 hr.	28 days
Nitrate/Nitrite (NO_3/NO_2) • NO_3	4 oz. Plastic 4 oz. Plastic	.25 ml H_2SO_4[A] Unpreserved	4 oz. jar 4 oz. jar	28 days 48 hr.	28 days 28 days
Odor	4 oz. Glass	Unpreserved	N/A	48 hr.	N/A
Oil & Grease	1 L Glass	2 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
418.1 (TPH by IR)	1 L Glass	2 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
pH	4 oz. Plastic	Unpreserved	4 oz. jar	immediately	14 days
Phenolics	4 oz. Amber Glass	.25 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
Phosphorus • Total (P)	4 oz./8 oz. Plastic	.25 ml/.5 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
Phosphorus • Ortho (PO_4)	4 oz./8 oz. Plastic (Filtered)	Unpreserved	4 oz. jar	48 hr.	28 days
Silica	4 oz. Plastic	Unpreserved	4 oz. jar	28 days	28 days
Solids (Residue) • Total dissolved • Total suspended • Total settleable • Total solids	 16 oz. Plastic 16 oz. Plastic 1 L Plastic 16 oz. Plastic	 Unpreserved Unpreserved Unpreserved Unpreserved	 N/A N/A N/A N/A	 7 days 7 days 48 hr. 7 days	 N/A N/A N/A N/A
Specific Gravity	4 oz. Plastic	Unpreserved	4 oz. jar	28 days	28 days
Sulfate	4 oz. Plastic	Unpreserved	4 oz. jar	28 days	28 days
Sulfide	4 oz. Plastic	6 drops-2N Zn acetate & 8 drops 6N NaOH[D]	N/A	7 days	N/A
Sulfite	4 oz. Plastic	1 ml EDTA	N/A	28 days-Pres. 6 hr.-Unp.	N/A

A - Typical volume needed to bring the pH to <2
B - Headspace free
C - Typical volume needed to bring the pH to >12
D - Typical volume needed to bring the pH to >9

TABLE 13.5.6-1. CONTAINER/PRESERVATIVE REFERENCE CHART (CONTINUED)
General/Inorganic Chemistry

Analysis	*Container*	*Preservative (Chill to 40°C)*	*Container*	*Holding Time (From Sampling Date)*	
	Water	Water	Soil	Water	Soil
Surfactants (MBAS)	1 L Plastic	Unpreserved	N/A	48 hr.	N/A
Total Coliform	8 oz. Glass or Polypropylene (Sterilized)	0.008% $Na_2S_2O_3$	N/A	6-8 hr.	N/A
TKN (Kjeldahl Nitrogen)	4 oz. Plastic	.25 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
Total Organic Carbon (TOC)	4 oz. Amber Glass w/Septum[B]	.25 ml H_2SO_4[A]	4 oz. jar	28 days	28 days
Total Organic Halide (TOX)	8 oz. Amber Glass w/Septum[B]	.5 ml H_2SO_4[A]	4 oz. jar	7 days	No Specified Time
Total Radium	1 L Plastic	2 ml HNO_3[A,C]	4 oz. jar	6 mo.	6 mo.
Turbidity	4 oz. Plastic	Unpreserved	N/A	48 hr.	N/A

A - Typical volume needed to bring the pH to <2
B - Headspace free
C - Typical volume needed to bring the pH to >12
D - Typical volume needed to bring the pH to >9

TABLE 13.5.6-1. CONTAINER/PRESERVATIVE REFERENCE CHART (CONTINUED)
Organic Chemistry

Analysis	*Container (Glass- and Teflon-lined caps only)*	*Preservative (Chill to 40°C)*	*Container (Glass- and Teflon-lined caps only - Chill to 40°C)*	*Holding Time (From sampling date)*	
	Water	Water	Soil	Water	Soil
8010/8020 • 8010 • 8020 • BTXE	3X VOA[A] 3X VOA[A] 3X VOA[A] 3X VOA[A]	3 drops HCl[B] 3 drops HCl[B] 3 drops HCl[B] 3 drops HCl[B]	4 oz. jar 4 oz. jar 4 oz. jar 4 oz. jar	14 days-Pres., 7 days-Unp. 14 days 14 days-Pres., 7 days-Unp. 14 days-Pres., 7 days-Unp.	14 days until Analysis 14 days until Analysis 14 days until Analysis 14 days until Analysis
Modified 8015 (TPH) • Gasoline Range • Diesel Range	4 oz. Amber Glass w/Septum[A] 2X VOA 4 oz. Amber Glass w/Septum[A]	.25 ml HCl[B] 3 drops HCl[B] .25 ml HCl[B]	4 oz. jar 4 oz. jar 4 oz. jar	14 days until Analysis 14 days until Analysis 14 days until Extraction 40 days after Extraction until Analysis	14 days until Analysis 14 days until Analysis 14 days until Extraction 40 days after Extraction until Analysis
8240	2X VOA	3 drops HCl[B]	4 oz. jar	14 days-Pres., 7 days-Unp.	14 days until Analysis
EDB	1 L Glass	Unp.	8 oz. jar	28 days until Analysis	28 days until Analysis
8040	1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
8080	2 x 1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
8100/8310	1 L Amber Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
8140	1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
8150	1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
Modified 619	1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
8270	2 x 1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
Modified 632	1 L Glass	Unp.	4 oz. jar	7 days until Extraction 40 days after Extraction until Analysis	14 days until Extraction 40 days after Extraction until Analysis
TCLP • Volatiles (zero headspace extraction) • Non-Volatiles	N/A N/A	N/A N/A	4 oz. jar 16 oz. jar	N/A N/A	14 days until Extraction 14 days after Extraction until Analysis 14 days until TCLP Leaching

A - Headspace free
B - Typical amount to bring the pH to <2

TABLE 13.5.6-1. CONTAINER/PRESERVATIVE REFERENCE CHART (CONTINUED)
Metals

Analysis	*Container*	*Preservative*	*Holding Time* *(From Sampling Date)*
WATER			
Metals (1 or more metals)			
• Total	16 oz. Plastic	l-ml HNO_3[A]	6 mo. (28 days-Hg)
• Dissolved • Filtered in Field	16 oz. Plastic	l-ml HNO_3[A]	6 mo. (28 days-Hg)
• Not Filtered	16 oz. Plastic (Specify "To be lab filtered")	Unpreserved	6 mo. (28 days-Hg)
• Organic Lead	8 oz. Amber Glass (Glass Only) w/Septum (Headspace Free)	Unpreserved Chill to 4°C	14 days until Analysis (laboratory recommended)
• Hexavalent Chromium (Cr^{+6})	16 oz. Plastic	Unpreserved	24 hr.
SOIL			
Metals (1 or more metals)			
• Total	4 oz. jar		6 mo.
• Soluble			
• EP Toxicity	8 oz. jar		6 mo.
• WET	8 oz. jar		6 mo.
• TCLP (see also Organic Chemistry)	8 oz. jar		6 mo.
• Hexavalent Chromium (Cr^{+6})	4 oz. jar		28 days
• Organic Lead	4 oz. jar	Chill to 4°C	14 days until Analysis (laboratory recommended)

A - Typical amount to bring the pH to <2.

1. PURPOSE

The following SOP defines activities to be completed to properly filter water samples in preparation for analysis by an analytical laboratory.

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors when filtering water samples.

3. PROCEDURES

Recent research indicates that if samples are obtained correctly, field filtration for metals may not be necessary (Puls and Powell, 1992). However, filtration of samples to be analyzed for dissolved metals may be required in some cases. If filtration is required, it shall be outlined in the site specific sampling plan.

If filtration is required, filter the samples in the field if possible. If field filtering is not possible, preserve the sample by chilling to 4°C (i.e. do not add acid), and immediately ship the sample via overnight delivery to the laboratory. Indicate on the chain of custody that laboratory filtration and preservation are required.

Vacuum filtration of ground water samples is not recommended (Barcelona et al., 1985, pg. 65). Samples to be analyzed for TOC, VOCs or other organic compounds should not be filtered. Filtration may be performed on samples collected for analysis of dissolved metals, however.

The following procedure shall be followed to filter samples in the field with the GeoPump:

1. Connect the GeoPump to an automobile cigarette lighter or outlet if electricity is available.

2. Replace the tubing for the GeoPump at the beginning of each sampling round. If the samples are collected in any order other than most contaminated to least contaminated, or if very high levels of contamination are suspected or observed, then replace the tubing between each sample or as necessary.

3. If the tubing is not replaced between each sample, flush the lines with Liquinox followed by at least three flushes with distilled water.

4. Collect an unfiltered water sample as discussed in Sections 13.5.4 and 13.5.5 of the DBS&A Operations Manual.

5. Place the intake line in the unfiltered sample.

6. Pump at least a few hundred milliliters of the sample through the GeoPump prior to sample collection in order to flush the line. Set the GeoPump at the lowest rate possible in order to minimize aeration. Dispose of this water appropriately.

7. Place a disposable 45 micron filter on the output line. Direct the output stream below the filter into the pre-acidified sample container, as outlined in Section 13.5.6 of the DBS&A Operations Manual

4. REFERENCES

- Barcelona, Michael J., James P. Gibb, John A. Helfrich and Edward E. Garske. 1985. Practical Guide for Ground-Water Sampling. Prepared in cooperation with RSKERL, Ada, Oklahoma. SWS Contract Report 374. DBS&A #560/BAR/1985.

- Puls, Robert W. and Robert M. Powell, R.S. Kerr Environmental Research Laboratory (RSKERL). 1992. Acquisition of Representative Ground Water Quality Samples for Metals. *Ground Water Monitoring Review, Summer 1992.*

Prepared by: _____

Approved by: _____
Daniel B. Stephens

Reviewed by: _____
Quality Assurance Manager

Reviewed by: _____
Systems Operations Manager

1. PURPOSE

The following SOP defines activities to be completed to assure quality assurance and quality control for water samples collected in the field.

2. SCOPE

This procedure is applicable to all DBS&A employees and its contractors and subcontractors when collecting water samples in the field.

3. PROCEDURES

QA/QC samples include split samples, duplicates, blind duplicates, blind check standards, trip blanks, and equipment blanks. The specific QA/QC samples that will be collected during each sampling event shall be designated in the site sampling plan.

3.1 General QA/QC Guidelines

The following general guidelines shall be followed for collection of QA/QC samples:

1. Include a trip blank with each cooler that contains samples to be analyzed for volatile organic compounds (VOCs). Ideally, trip blanks will be prepared at the lab in advance and will be shipped with the sample bottle order. If trip blanks are prepared in the DBS&A warehouse or in the field, prepare well away from any areas of known or suspected contamination. Prepare the trip blanks by filling a pre-acidified 40-ml VOA vials with organic-free water.

2. Collect an equipment (rinsate) blank from any non-disposable equipment that comes in contact with the water to be sampled, such as non-dedicated pumps or bailers or field filtration devices. Collect the equipment blank by running or pouring deionized water through any portion of the device that normally comes in contact with the water sample or presents a potential for cross-contamination, including hoses, valves, etc. Equipment blanks generally are not required for disposable equipment which is certified clean by the manufacturer (e.g., disposable teflon bailers). The exact number and type of equipment blanks to be collected will be determined on a site-specific basis. Describe the process used to collect the equipment blank in the field log book (see Section 13.2.6 of the DBS&A Operations Manual).

3. Replicate samples consist of two aliquots of the same sample analyzed independently. Replicate samples are used to evaluate laboratory precision.

4. A duplicate consists of two separate samples from the same source, analyzed independently. Duplicates are used to evaluate laboratory precision, heterogeneity of the material, and precision of field sampling techniques.

5. Split samples are replicate samples divided into two portions, sent to different laboratories, and analyzed for the same parameters.

6. In some cases, blind check standards may be submitted to the analytical laboratory. These may be obtained commercially or prepared in advance in the DBS&A laboratory. Alternatively, a duplicate sample may be spiked in the field with a known quantity of the analyte(s) of concern.

3.2 Well Security

All monitor wells shall be securely locked following the completion of sampling.

3.3 Chain-of-Custody Procedures

Chain-of-custody (COC) documents shall be kept for all samples collected by DBS&A. The COC program includes proper labeling of the samples to prevent misidentification. The following general guidelines for sample handling and custody procedures will be followed:

1. As few people as possible should handle the samples.

2. Samples must be within a locked/secure area at all times when not within view of DBS&A personnel.

3. Use the COC form provided by the analytical laboratory that will be performing the analyses. A representative form is included as Attachment 1 to this SOP (DBS&A Form No. 095).

4. The FR is responsible for the custody of the samples until they are transferred to the analytical laboratory or until custody is transferred to another designated individual. If the sample is transferred to another DBS&A employee, both people should sign and date the "relinquished" and "received" sections of the form, respectively.

5. Include the following information on the COC form:

   - The date and time of sample collection
   - The exact identification of the sample
   - The type of sample (e.g., water, soil, fuel)
   - Any preservatives used
   - The number of containers for each sample
   - The job number and name
   - Whether or not the sample was filtered
   - The analytical methods to be used (e.g., EPA 8240)

6. Have a second member of the water sampling team check the chain of custody document to ensure that all data is correct and exactly matches the information on the sample bottle labels. Place the appropriate copies of the COC form(s) in a sealed plastic bag taped to the inside lid of the cooler containing the samples. If more than one cooler is being shipped, each cooler should have a separate COC form listing all samples in that cooler.

7. Whenever the sample leaves control of the sampling team (e.g., when shipped by common carrier) place a COC seal on the shipping container or individual sample bottles. Sign and date the COC seal. The purpose to the seal is to ensure that the samples have not been tampered with prior to receipt at the lab.

8. If samples are shipped to arrive on Friday afternoon, weekends, or holidays, special arrangements need to be made with the analytical laboratory to ensure that someone will be available for sample receipt, and that the holding times will be met.

4. ATTACHMENTS

1. Chain-of-Custody Form (DBS&A Form No. 095)

Prepared by: _____

Reviewed by: _____
Quality Assurance Manager

Approved by: _____
Daniel B. Stephens

Reviewed by: _____
Systems Operations Manager

DANIEL B. STEPHENS & ASSOCIATES, INC.

Chain of Custody

To:

_____ Date _____ Project No. _____

_____ Client _____

_____ Relinquished by _____

Sent by: ☐ Fed Ex ☐ DHL ☐ Other _____

Purpose of Shipment _____

Possible Contaminants _____

Item No.	Sample No.	Analysis to be Done	Sample Container	Comments

Date Received _____ by _____
Company Representative

Received the above articles in good condition

Except as noted _____

_____

_____

DBS&A Form No. 095 5/92

1. PURPOSE

The purpose of this procedure is to provide DBS&A personnel with the information necessary to collect accurate water-level data from ground-water wells. Water level measurements provide the fundamental data needed to determine aquifer characteristics; therefore, it is crucial that the appropriate methods are used to meet the data requirements of an aquifer investigation.

2. SCOPE

The following procedures are applicable to all DBS&A employees and subcontractors engaged in the measurement of ground-water levels in wells. Several methods are available for determining the depth to water (DTW); this SOP briefly describes methods used to measure water levels manually, and automatically with the help of data recorders. This information is intended to help DBS&A personnel determine the appropriate equipment to collect water levels for background trend analysis and aquifer tests.

3. PROCEDURES

Immediately following well construction (see Section 13.4.1 of the DBS&A Operations Manual), a measuring point shall be clearly labeled "MP" with a permanent marker at the top of the casing. The designated MP shall be located at a point which is unlikely to change in elevation during the life of the well. This will prevent repeated surveys to determine the reference elevation of the measuring point. If the MP does change, it shall be clearly re-marked and referenced to the original elevation or a new survey will be necessary. Water levels will be measured in accordance with ASTM D 4750, Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).

The water level measurement (depth to water; DTW) shall be recorded on the Water Level Measurement Form included as Attachment 1 to this SOP (DBS&A Form No. 120). In addition, the following information shall be recorded on the form: the person making the measurement, the measuring device, the surveyed point from which the measurement is made, the time of day (military time), the date, the wellhead condition, and any measuring point (MP) changes.

Ground-water level data may also be recorded in the field log and on other applicable DBS&A forms including but not limited to those used for water sampling and drilling/soils logging.

The following subsections will describe the most commonly used techniques for obtaining water-level data in the field.

3.1 Steel Tape

Graduated steel tapes provide accurate measurements to within approximately 0.01 foot of the actual DTW for depths of 100 feet or less. The rigidity of the tape allows it to hang straight in the well. Steel tapes should generally not be used when many measurements must be made in rapid succession, such as during an aquifer test. Measurements with a steel tape are relatively time consuming.

When using a steel tape the lower 2 to 3 feet is wiped dry and coated with carpenters chalk or water finding paste before being lowered down the well. The tape is then lowered into the well to the estimated DTW. The tape should be held on a foot marker at the well-head measuring or reference point (MP). After removing the tape, the wetted end is read and subtracted from the previous reading; the difference is the actual DTW. If tape graduations are greater than 0.1 foot apart, a separate engineering tape or scale shall be used to accurately determine the wetted end measurement.

The steel tape should not stretch more than 0.05% under normal use and should not cause more than an 0.05-foot perceived rise in water level during measurement. If more than a 0.05-foot rise in water level occurs during measurement, a correction shall be made for the displacement. Steel tapes shall be calibrated against a surveyor's reference tape annually by the DBS&A Environmental Equipment Coordinator. Information from these calibrations shall be kept on hand at the DBS&A equipment supply facility.

The main disadvantage of the steel tape method is that the approximate depth to water must be known prior to the measurement. In addition, interferences such as cascading water, smearing, and/or evaporation may compromise the accuracy of the wetted-end measurement. However, steel tapes are relatively inexpensive and generally more durable than electrical instruments for measuring water levels.

3.2 Electrical Sounders

Electrical sounders operate by completing a circuit when the probe contacts the water level. Upon completion of the circuit a light, buzzer, or ammeter needle indicates that the probe is in contact with the water table. The probe is connected to a graduated tape, usually made from plastic and fiberglass. Batteries supply the necessary current through electrical wires contained in the graduated tape. Measurements are commonly made to within 0.01 foot with electrical sounders.

Electrical sounders are the most commonly used ground-water level measuring device on DBS&A projects. The major advantage of electrical sounders is that many measurements can be made rapidly and accurately without removing the probe from the well. Field personnel should position themselves near the MP so the DTW can be read at eye level. A second check reading should be taken before withdrawing the electric tape from the well. Most DBS&A sounders are marked every 0.02 foot.

The length of the electric line shall be calibrated annually with an engineers tape by the DBS&A Environmental Equipment Coordinator. Information from these calibrations shall be kept on hand at the DBS&A equipment supply facility.

Potential disadvantages of the electrical sounder devices include: the expense of an accurate sounder; inaccurate measurements that may be made due to stretching or kinking of the tape; electrical shorts that may be caused by broken or corroded wires; false readings due to cascading water; snagging of the sounder tip on pump columns and cables; or incomplete circuits due to low concentrations of total dissolved solids in the water.

3.3 Automated Water Level Measurements

To determine background water level trends, the most economic approach is to set up a continuous data recorder capable of making many measurements automatically. Driscoll (1986) discusses the application and installation of such systems in detail. The most common recorders produce a graphical chart or store the data electronically for future retrieval. Continuous water level records are quite useful for determining daily and seasonal fluctuations resulting from recharge and discharge periods, evapotranspiration and tidal stress, and during aquifer tests when there are not enough field personnel to collect all the necessary data. The following paragraphs briefly review equipment used with continuous recorders to measure water levels.

Automated pressure transducers are useful for collecting large quantities of water-level data rapidly during labor intensive aquifer tests. DBS&A owns an electronic data logging system consisting of a Campbell Scientific 21X data logger and DRUK pressure transducers which can be calibrated to output feet of water above the transducer. Refer to Section 13.6.4 of the Operations Manual for detailed information on using the system. The system can be programmed to collect data on arithmetic and logarithmic time scales. Measurements are accurate to approximately 0.01 foot providing there is no turbulence in the well.

Airline bubblers are commonly used by the U.S. Geological Survey for measuring stream stage and water levels in wells over periods of several years. Airline bubblers usually operate on nitrogen gas. The device works on the principal that the gas pressure required to push all the water out of the submerged portion of the tube equals the water pressure of a column of water equal to that height. Measurements are accurate to within 0.01 foot.

Float sensors can also be used to determine long term variation in background water levels. Float sensors consist of a tape or cable passing over a pulley with a float attached to one end and a counterweight attached to the other. The float follows the rise and fall of the water level. A graphic or electronic recorder is attached to the calibrated pulley to store the water level data. Float sensors work best in large diameter wells (4 inches or greater). The greatest disadvantage of this method is the potential for the float to stick on the side of the casing or jump the pulley resulting in a "stair stepping" record or no record at all. Measurements are accurate to 0.1 foot or greater depending on the precision of the recorder and pulley calibration.

4. ATTACHMENTS

1. Water Level Measurements (DBS&A Form No. 120)

5. REFERENCES

ASTM. 1990. Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers. Standard D 5092-90. Philadelphia, PA.

Driscoll, F.G. 1986. Groundwater and Wells. Johnson Division. St. Paul, MN. 1089 p.

Prepared by: Bob Marley

Approved by: D B Stephens
Daniel B. Stephens

Reviewed by: Jerry M. Cl
Quality Assurance Manager

Reviewed by: Jerry M. Cl
Systems Operations Manager

DANIEL B. STEPHENS & ASSOCIATES, INC.

Water Level Measurements

Project Name _____ Measurement Date _____

Project Number _____ Field Staff _____

Measuring Points and Datum Used _____

Observations _____

Well Number	Time	Elevation of Measuring Point (feet, mean sea level)	Depth Below Measuring Point (feet)	Water Level Elevation (feet, mean sea level)

Signature _____ Date _____

DBS&A Form No. 120 5/93

APPENDIX F

HEALTH AND SAFETY PLAN

DANIEL B. STEPHENS & ASSOCIATES, INC.

ENVIRONMENTAL SCIENTISTS AND ENGINEERS

KAFB SEWAGE LAGOONS/GOLF COURSE MAIN POND

HEALTH AND SAFETY PLAN

FOR

MONITOR WELL AND SLUDGE SAMPLING

Prepared By: _____ Date: _____

Reviewed By: _____ Date: _____

Approved By: _____ Date: _____

1. INTRODUCTION

This health and safety (H&S) plan contains guidelines for Daniel B. Stephens & Associates, Inc. (DBS&A) worker safety during the monitor well and sewage sludge sampling program at the KAFB sewage lagoons and golf course main pond. The site itself is described in detail in the *KAFB Post-Closure Plan for Sewage Lagoons and Golf Course Main Pond.* The proposed sampling locations are shown in Figures A-1 and A-2.

The objective of this H&S plan is to familiarize field personnel with safe operating procedures to be followed while working around potential chemical and physical hazards associated with sampling, and to serve as a general guideline for the implementation of these procedures.

The DBS&A project manager shall provide all DBS&A field personnel with copies of this plan, which they are required to read and keep available at all times during field work. It is the direct responsibility of the DBS&A on-site health and safety officer to ensure that all requirements and procedures contained in this H&S plan are followed during the sampling program. Safety is considered to be the first priority during all field sampling activities. DBS&A field personnel shall not perform any task which they personally feel is unsafe.

1.1 Potential Contamination

Potential contaminants, including nitrates and heavy metals, are related to sewage sludge. Contaminants that cause a potential health and safety concern are not expected to be encountered, and no air monitoring is warranted for the planned sampling program.

1.2 Other Potential Hazards

Work at KAFB has potential physical hazards, and staff must be cautious of all machinery and vehicles operating at the site. All mechanical hazards must be avoided to the greatest extent possible, and all driving must be performed in a safe manner when traveling about the site.

The following physical hazards may be present during sampling:

- Uneven surfaces that could cause slips, trips, and falls
- Dust
- Snake bites
- Heat stress

Proper precautions to take in order to protect against these hazards are described in Section 2.

2. SAFETY GUIDELINES FOR SAMPLE COLLECTION

These guidelines cover operations by DBS&A field staff for sewage sludge sample collection. In order to maintain a safe job site, all potentially dangerous conditions or practices must be corrected before proceeding with field work. The field H&S officer will notify contractors and the DBS&A project manager of any unsafe practices, and will reserve the right to stop all work on DBS&A projects if contractors do not abide by this plan.

2.1 Personal Health and Safety

A 25-foot radius around each sampling location will be designated as the work area. All DBS&A field work is given a designation for levels of personal protection of either A, B, C, or D, in order of decreasing personal hazard. The criteria for the selection of the correct level of personal protection are discussed below. All DBS&A employees performing field work have received the necessary training and instruction as required by 29 CFR 1910.120 for work at potential hazardous waste sites.

LEVEL D - All sampling activities will be conducted under level D protection since it is anticipated that the atmosphere will contain no known hazard and there will be no danger of splashing, immersion, or unexpected contact with hazardous levels of any chemicals. The following level D personal safety equipment shall be available and worn whenever the field personnel are within the 25-foot work area:

- Steel-toed work boots
- Hard hat
- Long pants
- Long sleeved shirt
- Gloves
- Protective eyewear
- Hearing protection, if needed

LEVEL C - If level C personal protection is warranted, field activity will temporarily cease and the project manager will be contacted.

2.2 Heat Stress

If any physical symptoms of heat stress are observed (e.g., headache, nausea, dizziness, sweating), the minimum heat stress indicators of heart rate and body temperature will be monitored approximately hourly. If the pulse rate exceeds 110 beats per minute (or the body temperature exceeds 99° F), then the length of the next work period shall be reduced to 40 minutes and the heat stress parameters observed again at that time. If the pulse rate at the beginning of the next test period exceeds 100, and the last reading was over 110 (or the body temperature exceeds 99.7° F and the last reading was over 99° F), the subsequent work cycle should be reduced by one-third. Whenever pulse rate or body temperature are elevated, work should not be resumed until the pulse rate is below 100 beats per minute and the body temperature is below 99° F.

If signals of heat stroke are observed (dry, hot, red skin, very high body temperature, fast, weak pulse, and fast, shallow breathing), then the person shall be cooled immediately and emergency medical attention shall be obtained. Heat stroke can be life threatening.

2.3 Eating and Drinking

No eating, drinking, smoking, or gum or tobacco chewing is allowed within the 25-foot work zone or during sample collection and handling. Field personnel will wash hands thoroughly before eating and drinking to avoid ingestion of hazardous chemicals.

2.4 Eye Protection

OSHA-approved protective eyewear should be worn at all times when within the 25-foot radius work zone. Shatterproof glasses or goggles are recommended for eye protection.

2.5 Dust Protection

When blowing dust makes it necessary to protect personnel, NIOSH-approved disposable-type dust masks will be worn.

2.6 Snake Bites

If, while on-site, sampling personnel are bitten by a poisonous or unidentifiable snake, they should proceed immediately to the hospital (see below).

3. MEDICAL EMERGENCIES

In the event of a minor injury, the employee will be transported to Lovelace Hospital, 5400 Gibson Blvd. SE (294-2700). In the event of an extreme medical emergency, an ambulance will be contacted by dialing 144/844-0081 or 911. The route to Lovelace Hospital is shown in Figure A-3.

4. INITIAL H&S BRIEFING

An H&S briefing will be conducted before initiation of field activities. The initial H&S briefing will be conducted by the designated DBS&A on-site H&S officer and will be attended by all DBS&A personnel involved in the particular task. The H&S plan and all pertinent H&S issues will be discussed during the briefing. All attendees will initial the H&S briefing form.

5. DAILY SAFETY MEETINGS

Prior to commencing each day's sampling activities, a "tailgate" safety meeting will be conducted by the designated DBS&A on-site safety officer. The meeting will address specific issues regarding on-site health and safety, including

- Chain of command
- Recommended personal safety equipment, as outlined in Section 2.1 of this document.
- Emergency response
- Appropriate site-specific issues, such as soil contamination levels, ambient air temperature, dust conditions, and weather conditions.

All attendees will be required to sign an attendance sheet.

6. ACKNOWLEDGEMENTS

NAME	TITLE	SIGNATURE	DATE

PROJECT: _____

TASK: _____

_____

_____

_____

_____

_____

_____

_____

DANIEL B. STEPHENS & ASSOCIATES, INC.
FIELD INSTRUCTIONS AND PROCEDURES
HEALTH & SAFETY BRIEFING

Project Number: _____

Field Location: _____ Date: _____

Purpose of Work: _____

_____

Tasks to be Accomplished: _____

_____

_____

SOPs Required: _____

Health and Safety Issues Discussed: _____

_____

_____

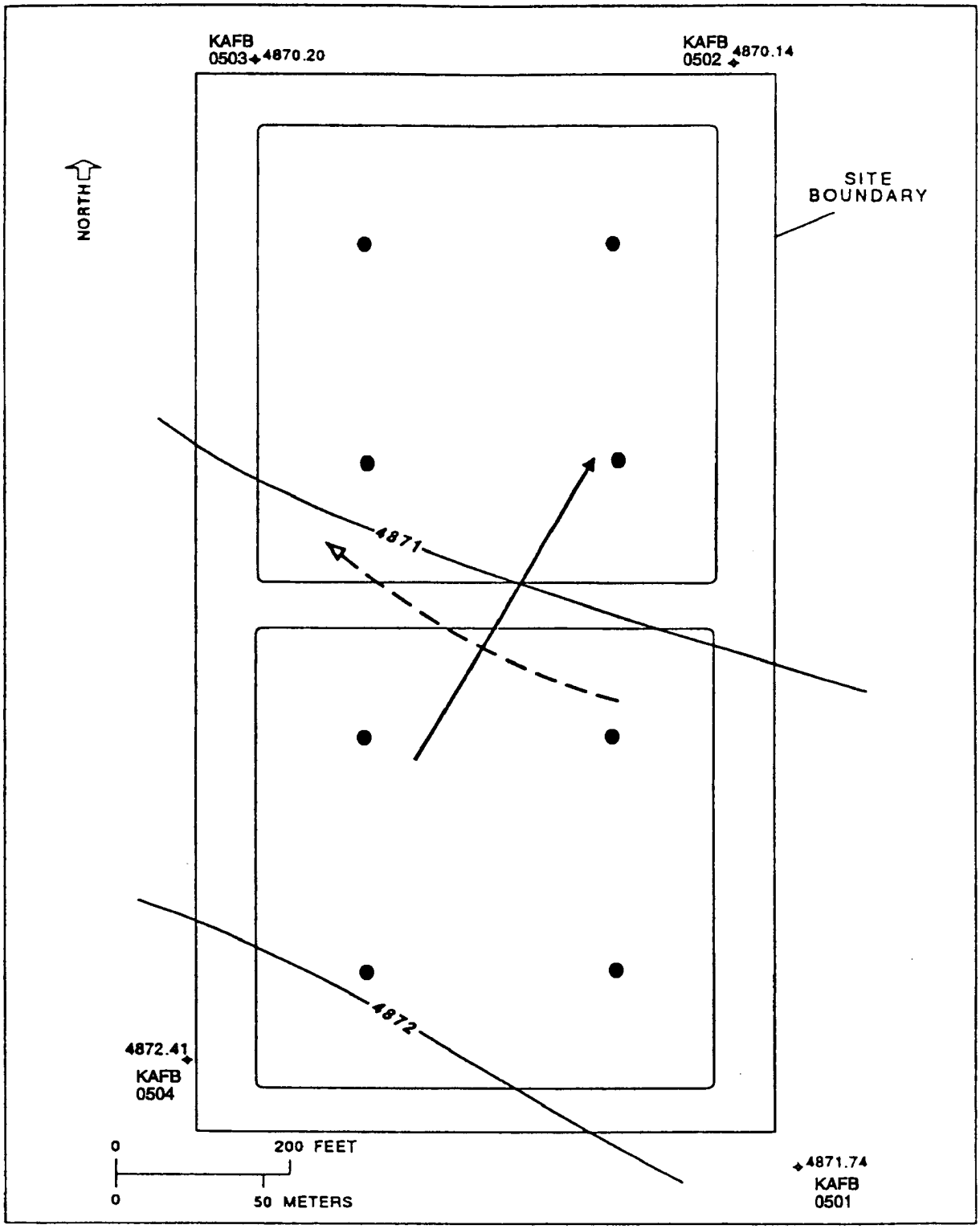
_____

_____

DBS&A Health and Safety Officer: _____

ATTENDEES

NAME	TITLE	SIGNATURE	DATE



Source: USGS, 1993b

EXPLANATION

4872.41 — Monitor well; number is altitude of water level, September 1992

4872 — Water-level contour, September 1992. Contour interval = 1 foot

● Sludge subsample location

Regional ground-water-flow direction, 1960

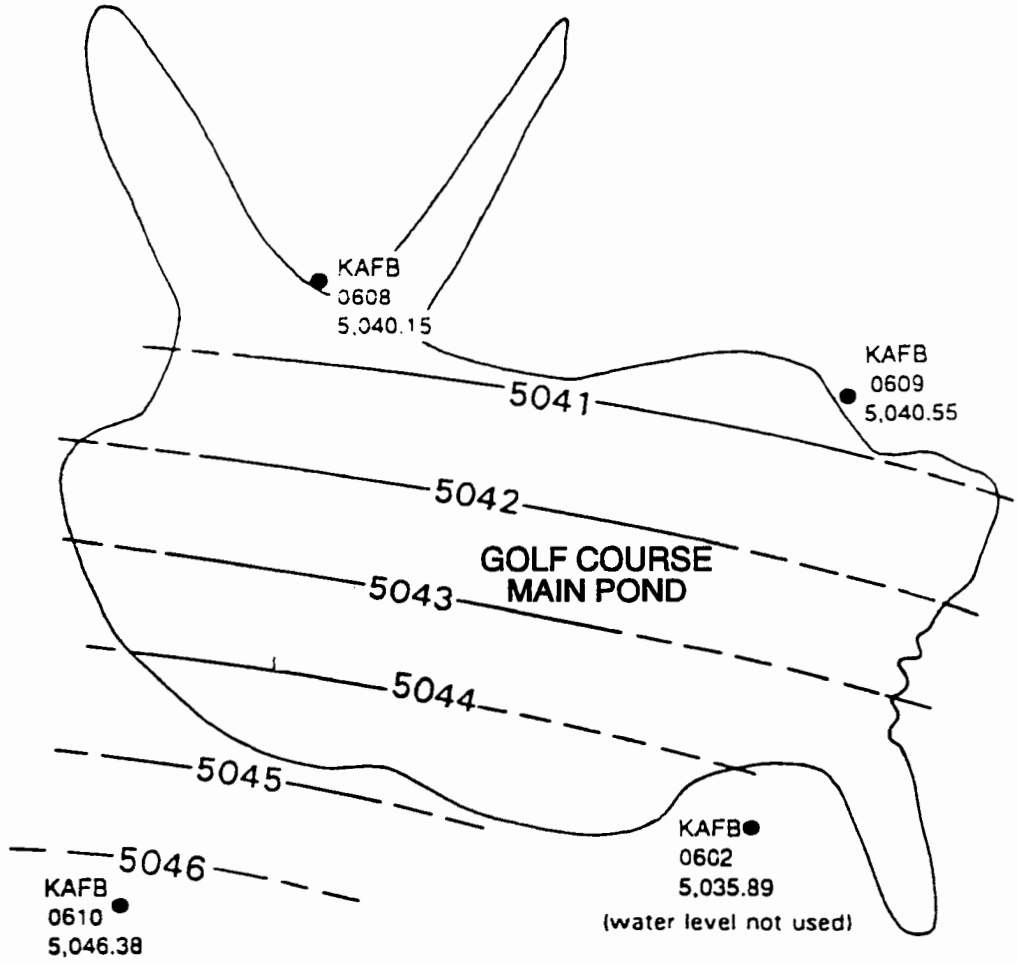
Regional ground-water-flow direction, September 1992

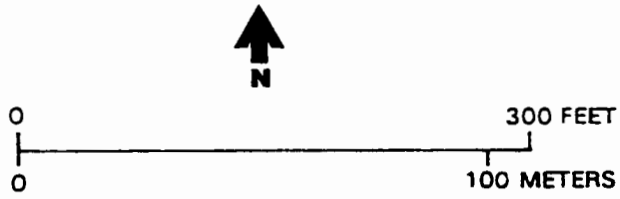
KAFB POST-CLOSURE PLAN

Sewage Lagoons Sample Location Map

DANIEL B. STEPHENS & ASSOCIATES, INC.

12-93 JN 3186





EXPLANATION

○ 0601	SOIL SAMPLING LOCATION AND LOCATION NUMBER--Power augered to 100 feet
■ 0607	DRY POND SEDIMENT SAMPLING LOCATION AND LOCATION NUMBER
● KAFB 0610 5,046.38	MONITORING WELL--Upper number is well number; lower number is water-table altitude on July 31, 1990, in feet. Datum is sea level
——5046 — —	WATER-LEVEL CONTOUR, IN FEET--Dashed where approximately located; interval 1 foot. Datum is sea level

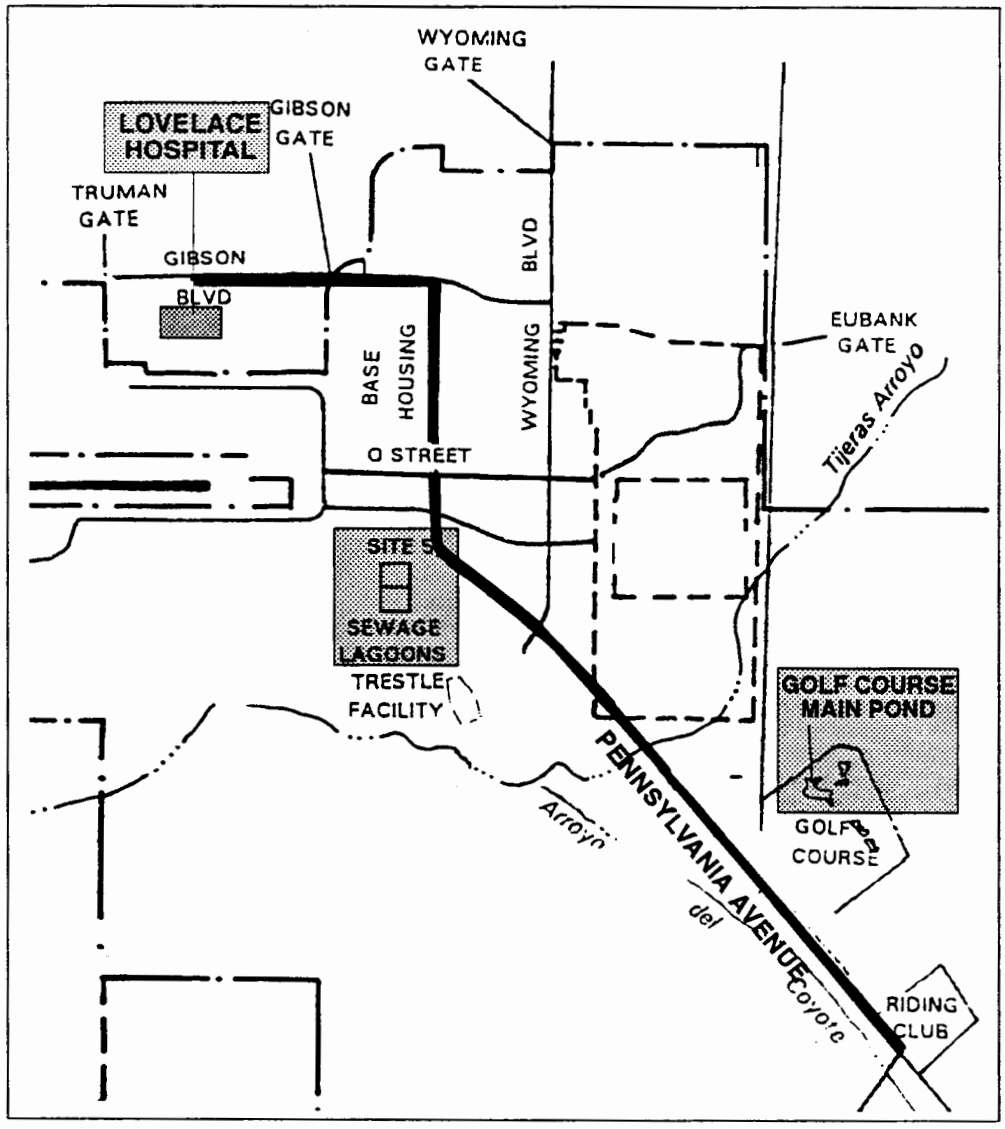
Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Golf Course Main Pond Sample Location Map

DANIEL B. STEPHENS & ASSOCIATES, INC.

12-93 JN 3186



N

0 1 2 MILES

0 1 2 KILOMETERS

Source: USGS, 1993a

KAFB POST-CLOSURE PLAN

Medical Emergency Route to Lovelace Hospital

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