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Department of Energy
Oak Ridge Operations
Weldon Spring Site
Remedial Action Project Office
Route 2, Highway 94 South
St. Charles, Missouri 63303

May 27, 1988

M-K FERGUSON CO.
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ADDRESSEES

RAFFINATE PIT SAMPLING PLAN

Enclosed is Revision 1 of the "Waste Assessment Raffinate Pit Sampling Plan" for the Weldon Spring Site. This plan has been revised to address comments received from USEPA and the Missouri Department of Natural Resources as indicated in the "Responsiveness Summary," also enclosed.

We trust that this adequately resolves the issues raised during the review of this Plan. We are proceeding with sampling activities as described in the enclosures.

If you have any questions concerning these items, please call.

Sincerely,

R. R. Nelson

R. R. Nelson
Project Manager
Weldon Spring Site
Remedial Action Project

Enclosures

cc w/o enclosures:
R. E. Hlavacek, MK-Ferguson

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United States Department Of Energy

WASTE ASSESSMENT
RAFFINATE PIT SAMPLING PLAN
WELDON SPRING SITE

REV. 1

WELDON SPRING SITE REMEDIAL ACTION PROJECT

WASTE ASSESSMENT

RAFFINATE PIT SAMPLING PLAN

WELDON SPRING SITE

REVISION 1

PREPARED FOR

U.S. DEPARTMENT OF ENERGY

PREPARED BY

MK-FERGUSON COMPANY

WSSRAP

May, 1988

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1.0 INTRODUCTION

The purpose of this sampling plan is to provide a summary of existing data and to define the rationale for collection of the complement of data necessary to fully characterize the wastes contained in the Weldon Spring Raffinate Pits (WSRP). For complete characterization of the WSRP, combined data from radiological, chemical and physical analyses must be evaluated. The existing data base provides limited characterization analyses to address the radiological and chemical parameters. Additional physical, chemical, and radiological testing of the sludge/sediment in the WSRP must be performed. This additional data is needed for sludge/sediment treatability studies which in turn are necessary for the development/evaluation of remediation alternatives, design of the selected alternative, and verification of remedial effectiveness.

This sampling plan will deal primarily with the sampling and analysis of the sludge/sediments in the WSRP. Section 1.2, Previous Studies, includes sufficient chemical characterization data to evaluate remedial alternatives for the water ponded on the raffinate pits.

1.1 BACKGROUND

1.1.1 Site History

In 1956, the Atomic Energy Commission (AEC) acquired about 89 hectares (ha) (220 acres) of the original Weldon Spring Ordnance Works property from the Department of Army (DA) for use as the Weldon Spring Uranium Feed Materials Plant (WSUFMP). The WSUFMP operated between 1957 and 1966 and during that time processed uranium ore concentrates and recycled scrap to produce pure uranium trioxide, uranium tetrafluoride, and uranium metal. An average of 16,000 tons of uranium materials were processed at this plant per year. Thorium ore concentrates were also processed. These processes generated several chemical and radioactive waste streams, including raffinate streams from the refinery operation and the magnesium fluoride slurry streams (washed slag) from the uranium recovery process. These streams were slurried to the pits where the solids settled out and the supernatant liquids drained to the plant process sewer which drained offsite to a natural drainageway and ultimately to the Missouri River. The solids remaining in the pits consist of silica and other insolubles associated with the yellow cake ore feed materials, along with hydroxides and other precipitates formed from the pH neutralization of the raffinates with lime. Washed slag residues from the uranium metal production operation were also discharged to the pits.

After the plant was closed by the AEC, the DA acquired the facility in 1967 to convert it to herbicide production. The project was cancelled prior to becoming operational.

The 21-ha (52-acre) portion of the site that contains the four raffinate pits was transferred back to AEC in 1971. As the successor agency to AEC, DOE has assumed responsibility for maintenance of the entire site including the WSRP area. The location of the WSRP area is shown in Figure 1-1.

Figure 1-2 is a plan view of the four pits. These pits were constructed by excavating down into the existing clay formation and using the removed clay for constructing the dikes.

1.1.2 Physical Description of Pits

Raffinate Pits 1 and 2 were constructed in 1958, adjacent to each other, on nearly level terrain. Each pit covers an area of about 0.5 ha (1.2 acres) and has a depth of about 4 m (13 ft). The dikes of these two pits are approximately 1 m (3 ft) above the surrounding grade. Pits 1 and 2 each contain approximately 13,300 m^3 (17,400 cy) of low-level radioactive residues from past uranium refining and metal production operations. These waste volumes represent 94 percent of the capacity of each of the two pits (NLO, 1977). Table 1-1 presents the surface area, volume, and content of each of the four pits.

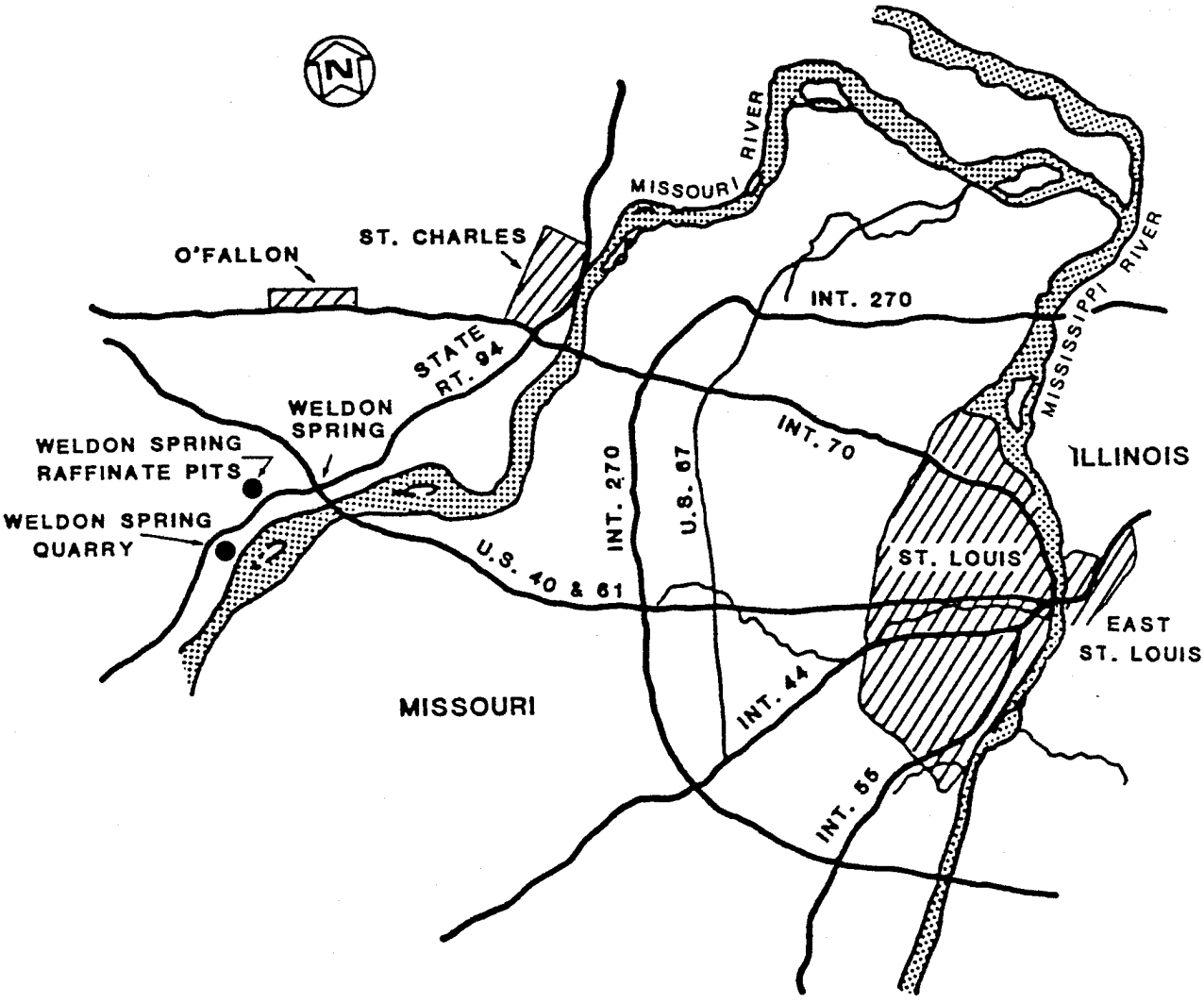

FIGURE 1-1

WSRP AREA MAP

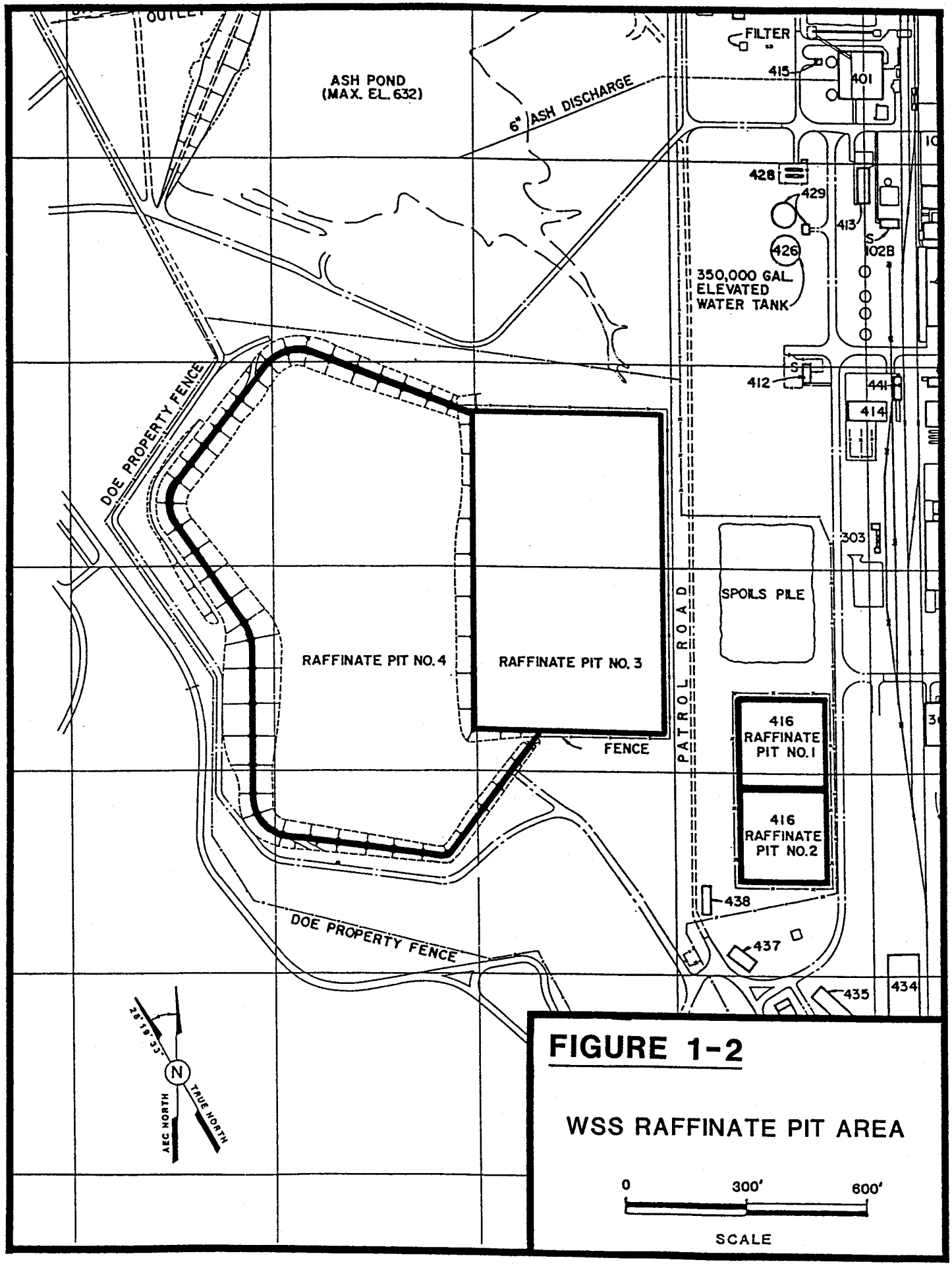

FIGURE 1-2

WSS RAFFINATE PIT AREA

TABLE 1-1
Surface Area and Volume of the Weldon Spring Raffinate Pits

Pit	Year Constructed	Surface Area	Total Pit Volume (acres)	Total Waste Volume (cy)	Percent Filled (cy)
1	1958	1.2	18,500	17,400	94
2	1958	1.2	18,500	17,400	94
3	1959	8.4	166,700	129,600	78
4	1964	15.0	444,400	55,600	12
TOTALS		**25.0**	**648,100**	**220,000**	

Note: To convert acres to hectares, multiply by 0.4047.

To convert cubic yards to cubic meters, multiply by 0.7646.

To convert tons to kilograms, multiply by 0.9071.

Ref. BNI, 1984

Pit 3 was constructed in 1959 with a design volume of 127,500 m^3 (166,700 cy), a surface area of approximately 3.4 ha (8.4 acres), and a depth of about 3.5 m (11 ft). The natural terrain slopes downward toward the west boundary so that the dikes around Pits 3 and 4, although approximately at the same elevation as those around Pits 1 and 2 are, in fact, much higher with respect to the original grade. A portion of the dike in the northeast corner of Pit 3 was constructed on existing terrain so that the dike is about 7 m (23 ft) above original grade in that area. Pit 3 contains approximately 99,100 m^3 (129,600 cy) of radioactive residues from past uranium refining and metal production operations and is 78 percent filled (NLO, 1977; Weidner and Boback, 1982).

Pit 4 was constructed in 1964 with a design volume of 339,800 m^3 (444,400 cy) and is approximately 12 percent filled. The east dike of Pit 4 is common to the west dike of Pit 3. The west dike of Pit 4 extends to a maximum of about 11 m (35 ft) above the existing grade. Approximately 42,500 m^3 (55,600 cy) of radioactive materials are stored in Pit 4, and the residue fill is irregular across the pit. Pit 3 is designed to overflow into Pit 4 through a connecting pipe 2 m (7 ft) below the top of the common dike.

The sludge material in the pits is covered with water for most of the year. The amount of water in the pits varies depending on the climatic conditions of a given year. During the hot, dry

summer months, the surface water in Pits 1 and 2 often evaporates, leaving the raffinate sludge with a dry and cracked surface. The level of water in Pits 3 and 4 also varies, but past observation has found some surface water always present.

Maintenance, surveillance, and environmental monitoring have been continually conducted at the WSRP site since the former DOE contractor, Bechtel National, Inc., began operation in 1981. The site is fenced, posted, and patrolled by security guards. The grass is mowed, brush is cleared for access to each pit, and the fences are repaired as necessary.

In 1982, a portion of the dike around Pit 4 was repaired to stabilize a shallow, circular arc slide. The slide occurred because of the steep (38-47%) side slopes of sections of the existing dikes. The side slopes of Pit 4 were constructed at undesirably steep slopes in this section because a perimeter road encroached on the space needed for construction.

1.1.3 Process Waste Description

There are three major waste types present at the WSRP site. These are:

1. Neutralized raffinate liquors generated from uranium refining operations, including washed slag residues

from uranium metal production operations and raffinate solids from the processing of thorium recycle materials;

2. Contaminated water ponded on each raffinate pit; and
3. Contaminated rubble.

Each of these waste types is addressed in greater detail in the following text.

1.1.3.1 Neutralized Raffinate Liquors

Neutralized raffinate liquors were generated as follows: the Weldon Spring Uranium Feed Materials Plant (WSUFMP) received yellow cake ore from various uranium mills across the U.S. The yellow cake feed material was ultimately dissolved in a process stream containing nitric acid solution. This solution contained the dissolved uranium along with all the other impurities found in the yellow cake ore. Once the uranium was stripped from the solution, the resulting waste was mixed with lime to produce what is referred to as neutralized raffinates. These neutralized raffinates were discharged directly to the raffinate pits.

In the final stage of the uranium production process, uranium tetrafluoride was reacted with magnesium producing uranium metal and magnesium fluoride. The magnesium fluoride slag was then redissolved with yellow cake feed material to recover unreacted uranium contained in the slag. The remaining magnesium

fluoride, or washed slag, was deposited in the pits. Neutralized raffinates and washed slag were processed out of Building 103, the digestion and denitration building of the WSUFMP.

The residues contained in Pits 1, 2, and 3 consist of the neutralized raffinates and washed slag residues as descirbed above. Thorium is also present in these pits from the uranium feed material and from uranium decay during storage in the pits.

Pit 4 contains the same types of residues that are present in Pits 1, 2, and 3 plus raffinate solids from processing of thorium-232. It also contains recycle materials and copious quantities of drums and rubble dumped during closure of the Feed Materials Plant.

1.1.3.2 Contaminated Water

Approximately 54 million gallons of water is currently ponded on the raffinate pits. Section 1.2.4 of this sampling plan provides a detailed discussion of the analysis performed on these waters.

1.1.3.3 Contaminated Rubble

The contaminated rubble consists of drums and steel scrap dumped during closure of the WSUFMP and when the Army began conversion of a portion of the plant for herbicide production. The main dumping area is in Pit 4. All of the rubble is presumed to be radiologically contaminated since it originated from the WSUFMP. There is no indication that any of this rubble includes containerized chemical wastes. Visual inspection of the rubble has revealed no drums remaining intact. A number of samples of the sludge material will be taken sufficiently close to the rubble area to verify the presence or absence of chemical contamination.

1.1.4 Raffinate Pit Constituents

Radium is present in the raffinate pits due to the decay of uranium to radium and trace amounts of radium in the yellow cake. In addition, some feed materials at the WSUFMP were high-grade uranium ore which would contribute both thorium-230 and radium-226 to the wastes in the raffinate pits.

The majority of the radium (both 226 and 228) was removed at the uranium mill and disposed of with the mill tailings. As for thorium, a significant amount is retained with the uranium when raw uranium ore is processed into yellow cake. Processes at the

Feed Materials Plant separated thorium-230 from the uranium and sent it to the raffinate pits.

The relative solubilities of uranium, thorium and radium determine the radiological composition of the raffinate pit water. Of the three, thorium is the most insoluble in aqueous solutions, while radium is slightly soluble in water with the evolution of hydrogen. However, uranium is attacked by water and several uranium compounds are stable in solution. Therefore, uranium activities should be greater than radium activities and both uranium and radium activities should be greater than thorium activities.

Numerous tanks, drums and other equipment were disposed of in Pit 4 during the 1967-1969 decontamination effort by the Army. Most of the equipment from Buildings 101, 103, and 105 was dismantled and dumped in Pit 4. The equipment in these buildings would have been contaminated with uranium in a soluble form. Near the end of production at the Feed Materials Plant, uranium was used to purge thorium wastes from all steps of the process. Wastes from this purge were disposed of in Pit 4.

1.2 PREVIOUS STUDIES

Three reports have been prepared regarding various properties of the raffinate pit sludges and sediments. Bechtel National, Inc. (BNI) subcontracted with Eberline Instrument Corporation in 1983

to take samples of the waste in the raffinate pits and analyze them for stable metals and radiochemistry. BNI also subcontracted with Environmental Science and Engineering, Inc. (ESE) in 1983 to sample and analyze the raffinate pit wastes in an effort to select equipment best suited to dewater the raffinate pit sludges. In 1986, BNI obtained samples of the raffinate pit sludges and subcontracted Thermo Analytical/Eberline Laboratory to perform radiological analysis and analysis for EP Toxicity, PCBs, reactivity, ignitability, and pH.

One report has also been prepared for characterization of the raffinate pit surface waters. This report was prepared by the current Project Management Contractor (PMC) in 1987.

1.2.1 Bechtel National, Inc. Study, 1983 (with Eberline)

The samples were collected and analyzed by Eberline Instrument Corporation in 1983. The data reported here are analytical results on a single, blended, mixed, composite sample prepared from multiple-location samples taken from each pit. The stable metals (Table 1-2) were analyzed using the method of atomic absorption analysis.

From the referenced study, results of analyses of the chemical components of the raffinate sludge in each pit are presented in Table 1-2 and the radiological components in Table 1-3.

TABLE 1-2
Analysis of Stable Metals from Previous Studies
Weldon Spring Raffinate Pits Sludge (mg/kg-dry)

Analysis	Pit 1 Composite	Pit 2 Composite	Pit 3 Composite	Pit 4 Composite
Aluminum	4.3	4.1	6.2	4.0
Arsenic	130	170	54	1.0
Boron	60	350	50	30
Barium	23	20	10	22
Beryllium	0.016	0.025	0.015	0.007
Cadmium	9.1	7.3	5.1	2.8
Calcium	980	990	990	980
Cobalt	9.4	14	11	2.1
Chromium	90	60	60	70
Copper	5.5	4.9	5.5	4.4
Iron	210	200	130	210
Lead	110	140	220	1.5
Lithium	4.4	9.2	23.7	10.1
Magnesium	1,800	1,700	1,700	860
Manganese	7.8	7.8	9.4	8.8
Mercury	1.8	0.75	17	2.3
Molybdenum	4,700	2,800	2,500	370
Nickel	30	27	27	22
Phosphate	0.7	0.6	0.8	0.5
Potassium	650	620	220	310
Selenium	0.89	0.5	1.4	0.5
(Total)Silicon	10,000	16,400	13,000	13,800
Silver	2.0	0.39	1.4	0.1
Strontium	84	220	50	40
Titanium	1,000	860	1,150	670
Vanadium	5,000	800	800	300
Zirconium	17,000	14,400	19,000	11,500
Sodium	10,000	5,000	5,000	4,000
Zinc	10	20	10	10
Nitrate	50,000	18,000	22,000	220
Fluoride	23,000	2,500	107,000	64,300
Chloride	670	230	300	50
Sulphate	400	200	370	270
Hydroxide (% $CaCO_3$)	7	10	10	11
pH (pH units)	8.1	8.7	9.4	8.5

Ref. BNI, 1983

TABLE 1-3

Raffinate Pits Radioisotope Contents From Previous Studies

(pCi/g dry)

Radioisotope	Pit 1	Pit 2	Pit 3	Pit 4
Radium-226	430±130	440±130	460±130	11±3
Radium-228	850±85	200±20	100±10	60±10
Thorium-232	100±20	120±20	120±20	120±20
Thorium-230	24000±1000	24000±1000	14000±1000	1600±100
Uranium-238	710±70	470±40	520±50	620±60
Uranium-234	810±80	560±50	570±50	610±60
Uranium-235	40±5	30±4	30±4	30±4

(a) These data do not include lead-210 which would increase total curies, if included. The activity of lead-210 at the WSRP site has not been measured. However, since almost all of the radioactive material brought onto the site was either uranium ore concentrates, uranium scrap, or thorium scrap, only an insignificant amount of lead-210 should be present, and this from radioactive decay of the radium and thorium in the pits. This is due to the long half-lives of radium-226 (1,600 years) and thorium-230 (80,000 years), and the short time (less than 40 years) during which decay has occurred. (Note: only lead-208 (stable) should be present from the thorium-232/thorium-228 chain).

(b) Data presented in this table are based on analysis of sludges obtained from the pits by BNI in May 1983.

Note: The ± values indicate measurement accuracy.

Table 1-2 shows the presence of high concentrations of silicon, zirconium, sodium, nitrates, and fluoride, as well as elevated levels of arsenic, calcium, magnesium, and molybdenum in all four pits.

Table 1-3 presents a preliminary estimate of the radioisotopic content of each of the four raffinate pits at the WSRP site. According to this estimate, the average concentration of radioactive materials in the raffinate sludge is about 3,500 pCi/g. The level of radiation at approximately 0.3 m (1 ft) above the sludge ranges from 0.2 to 1.5 mR/h.

1.2.2 Bechtel National, Inc. Study, 1983 (with Environmental Science & Engineering)

In 1983 Bechtel National, Inc. (BNI) contracted with Environmental Science and Engineering, Inc. (ESE) to sample and test the physical properties of the raffinate pit sludges. Testing was actually performed by Monteagle, Inc., Environmental and Energy Consultants, and Reitz & Jens, Inc.

The initial project intent was to use test results to select the type and size of mechanical dewatering equipment best suited to dewater the raffinate pit sludges. Early test results indicated that the sludges had a considerably higher solids content than expected. For this reason all further tests related to

mechanical dewatering were stopped and replaced with a series of tests useful in developing other treatment options.

Sludges in each of the raffinate pits were sampled by driving a core sampling device into the sludge bed at preselected locations. The sampling was conducted from a polystyrene barge. The sampler was driven with a safety slide hammer and extractor. The sampler itself was constructed of 3-inch PVC tubing with a retaining apparatus and check valve to hold the sample during extraction.

Sludge samples were obtained from eight locations (three each from Pits 3 and 4, one each from Pits 1 and 2). Sample locations are shown in Figure 1-3. A summary of the sampling data is provided in Table 1-4. Samples were obtained from the top, middle and bottom of each core, providing 24 individual sludge samples. Sludge composites were made by homogenizing individual samples from each location within each pit. Preliminary tests were conducted on individual sludge samples; most testing was conducted on the composite samples (Reference ESE, 1983).

Table 1-5 lists percent total solids of each discrete sample. Percent total solids is defined as the weight of the solids in a sample divided by the total weight of the sample times one hundred. The total solids determination is useful in estimating the homogeneity or heterogeneity of the sludge. It can be

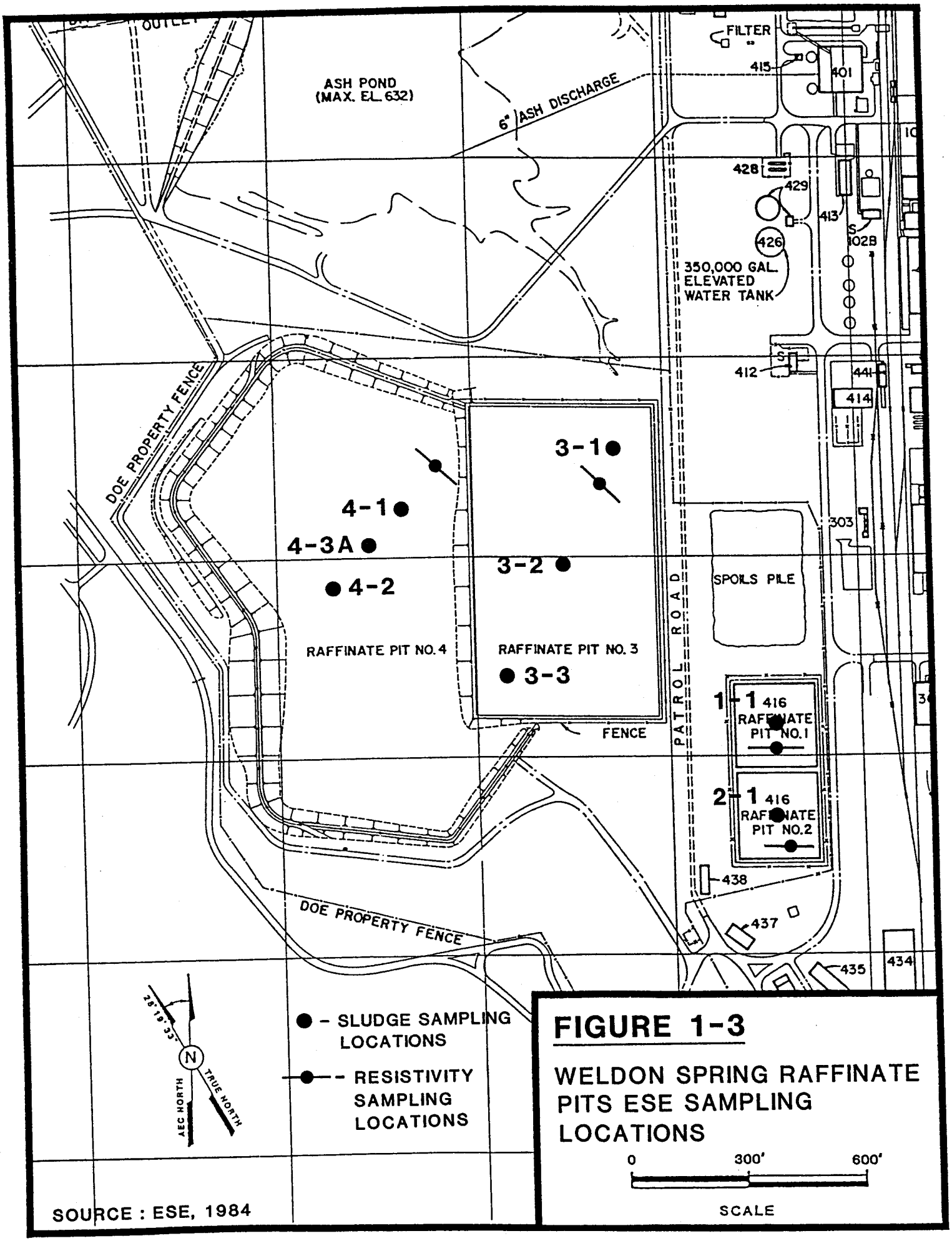

FIGURE 1-3

WELDON SPRING RAFFINATE PITS ESE SAMPLING LOCATIONS

SOURCE : ESE, 1984

TABLE 1-4

Weldon Spring Raffinate Pit Sampling Data

Sample Location	Time Sampled	Water Level Elevation	Depth to Top of Sludge (feet)	Depth to Bottom of Sludge (feet)	Depth of Sludge (feet)
3-3	1127 5/3/83	659.67	4.5	11.5	7.0
3-2	1140 5/3/83	659.67	4.0	13.0	9.0
3-1	1245 5/3/83	659.67	2.5	19.0	16.5
4-1	0846 5/5/83	647.68	6.0	9.0	3.0
4-2	1026 5/5/83	647.68	11.0	13.0	2.0
4-3a*	1328 5/5/83	647.68	9.5	12.0	2.5
2-1	1710 5/6/83	662.05	4.0	14.0	10.0
1-1	0908 5/6/83	662.01	4.0	15.5	11.5

* Station 4-3 was adjusted due to lack of sludge at original location; 4-3a was located between 4-1 and 4-2.

Source: Monteagle, Inc., 1983; and ESE, 1983.

TABLE 1-5

Total Solids - Discrete Samples

Sample I.D.	% Total Solids (by weight)	Sample I.D.	% Total Solids (by weight)
Pit No. 1:		Pit No. 4:	
P-1 Top	37.8	P-4 1-Top	33.6
P-1 Middle	30.2	P-4 1-Middle	37.1
P-1 Bottom	30.4	P-4 1-Bottom	27.7
Pit No. 2:			
P-2 Top	25.6	P-4 2-Top	27.2
P-2 Middle	24.5	P-4 2-Middle	20.0
P-2 Bottom	32.6	P-4 2-Bottom	18.2
Pit No. 3:			
P-3 1-Top	50.0	P-4 3-Top	38.5
P-3 1-Middle	24.5	P-4 3-Middle	42.3
P-3 1-Bottom	28.3	P-4 3-Bottom	67.9
P-3 2-Top	22.6		
P-3 2-Middle	27.0		
P-3 2-Bottom	25.6		
P-3 3-Top	24.3		
P-3 3-Middle	22.5		
P-3 3-Bottom	25.1		

Ref.: WSRP Sludge Core Samples - BNI 1983 - ESE

interpreted from the solids data in Table 1-5 that the physical density of the sludge appears to be heterogeneous with no discernible trends or patterns. Interpretation of the data, however, is difficult due to the vibratory sampling technique.

Table 1-6 is a summary of physical properties of the composite sludge samples. The liquid and plastic limits are expressed as moisture contents (weight of water divided by the weight of solids for a given sample). Above the liquid limits, the soil-water system is a suspension. Between the liquid limit and the plastic limit the system is said to be in the plastic state. The difference between these two limits is called the plasticity index and is the range over which a soil-water system acts as a plastic material.

The specific gravity of solids is the ratio of the dry density of the solid fraction (weight of solids divided by volume of sample) of a sample to the density of water (62.4 lbs/cf). This parameter can also be an indicator of homogeneity or heterogeneity. Although the specific gravity is shown to vary from pit to pit because the samples from each pit were composited for this particular test, the degree of heterogeneity within each pit is quantitatively indeterminate.

Resistivity is the measure of the resistance of a given material to electric current. This measurement was made in-situ at varying depths in an effort to identify the extent of layering

TABLE 1-6

WSRP Physical Properties of Composite Samples

Property	Pit 1	Pit 2	Pit 3	Pit 4
Moisture Content	262	240	266	295
Liquid Limit	126	140	129	157
Plastic Limit	65	75	66	70
Plasticity Index	61	65	63	87
Specific Gravity of Solids	2.94	2.73	2.68	2.75
Resistivity (ohm-meter)	0 to 16.47	0 to 5.74	0.82 to 9.88	16.47 to 72.51
Response to Vibration*	none	none	none	none
% Finer than #200 Screen	90.8	99.93	89.2	94

* Vibration testing performed with equipment conforming to ASTM D-2049.

Ref. Reitz & Jens, Inc. (BNI, 1983, ESE)

or stratification in each pit. The data exhibited on Table 1-6 shows a wide range of resistivities indicating the presence of stratification with depth.

Tests were conducted to determine whether the sludge solids would separate from the water fraction, or whether the sludge would flow in response to vibration, using ASTM D-2049. During the tests very little change in the material was observed after 15 minutes of vibration. The only visible change was that the top surface of the sample developed a smoother appearance. No change was observed when a furrow was struck across the sample and the sample was vibrated for 5 minutes. These results indicate that the material might possibly be excavated with conventional construction equipment (i.e. front end loaders) without recourse to special handling techniques.

The tests showing the percent finer than the #200 screen size indicate that the sludge consists primarily of very fine-grained particle size. Electron micrography photographs revealed that the particles are highly flocculated with some needle-shaped particles. These tests show that the sludge will not easily be dewatered using conventional mechanical methods.

Table 1-7 presents estimates of the sludge permeability range based on consolidation tests using Terzaghis one-dimensional consolidation theory (Reference Holtz and Kovacs, 1981).

TABLE 1-7
WSRP Permeability Results from Composite Samples of Raffinate Sludge

Pit	Natural w%*	Final w%*	Calculated Permeability Range
1	215.6	146.9	7×10^{-7} to 5×10^{-8} cm/sec.
2	196.4	158.6	5.8×10^{-7} to 1.1×10^{-8} cm/sec.
3	174.1	125.6	7.5×10^{-7} to 7.7×10^{-8} cm/sec.
4	171.6	121.1	9.4×10^{-7} to 1.5×10^{-7} cm/sec.

* water content by weight

Ref. Reitz and Jens, Inc. (ESE, 1983)

Permeability is a measure of the rate at which water flows through soil. The range of permeabilities presented in the table is beyond the limit (1×10^{-6}cm/s) of any reliable direct measurement using either a constant-head or falling-head permeameter testing apparatus. These test results can be interpreted as relative and imply that the permeability is less than 1×10^{-6} cm/s.

Table 1-8 presents additional test results for the composite samples. The use and interpretation of moisture content, total solids, density, and specific gravity have been discussed. An additional parameter, viscosity, is a measure of fluidity. Information on sludge viscosity is used in the selection and sizing of mechanical equipment which might be used for mixing or pumping the sludge. These data will be reviewed and applied as appropriate in conjunction with additional data which are to be collected by the PMC through the execution of this sampling plan.

1.2.3 Bechtel National, Inc., Study, 1986 (with Thermoanalytic/Eberline Laboratory)

BNI conducted an initial Resource Conservation and Recovery Act (RCRA) characteristic sampling program for the Weldon Spring Site (WSS) Raffinate Pits in 1986. The 28 sampling locations are shown on Figure 1-4. These locations were chosen using a random number generator method. At each location, up to three samples were obtained and sent to the Thermoanalytic/Eberline

TABLE 1-8

Composite Sample Testing Results of Raffinate Sludge

Pit No.	Moisture Content % of Wet Sample by Weight	Moisture* Content by Percentage	Total Solids % by Weight	Density (lbs/cf)	Specific Gravity of Sludge
1	72.4	123	27.6	200	1.189
2	70.6	142	29.4	235	1.217
3	72.7	191	27.3	320	1.204
4	74.7	254	25.3	380	1.182

Pit No.	Viscosity, cps **	Driving Weight, in grams to obtain 600 r.p.m
1	262%	74.35
2	240%	76.10
3	266%	75.29
4	295%	73.92

* Weight of water divided by weight of solids

** Centipoise

Ref. BNI 1983-ESE

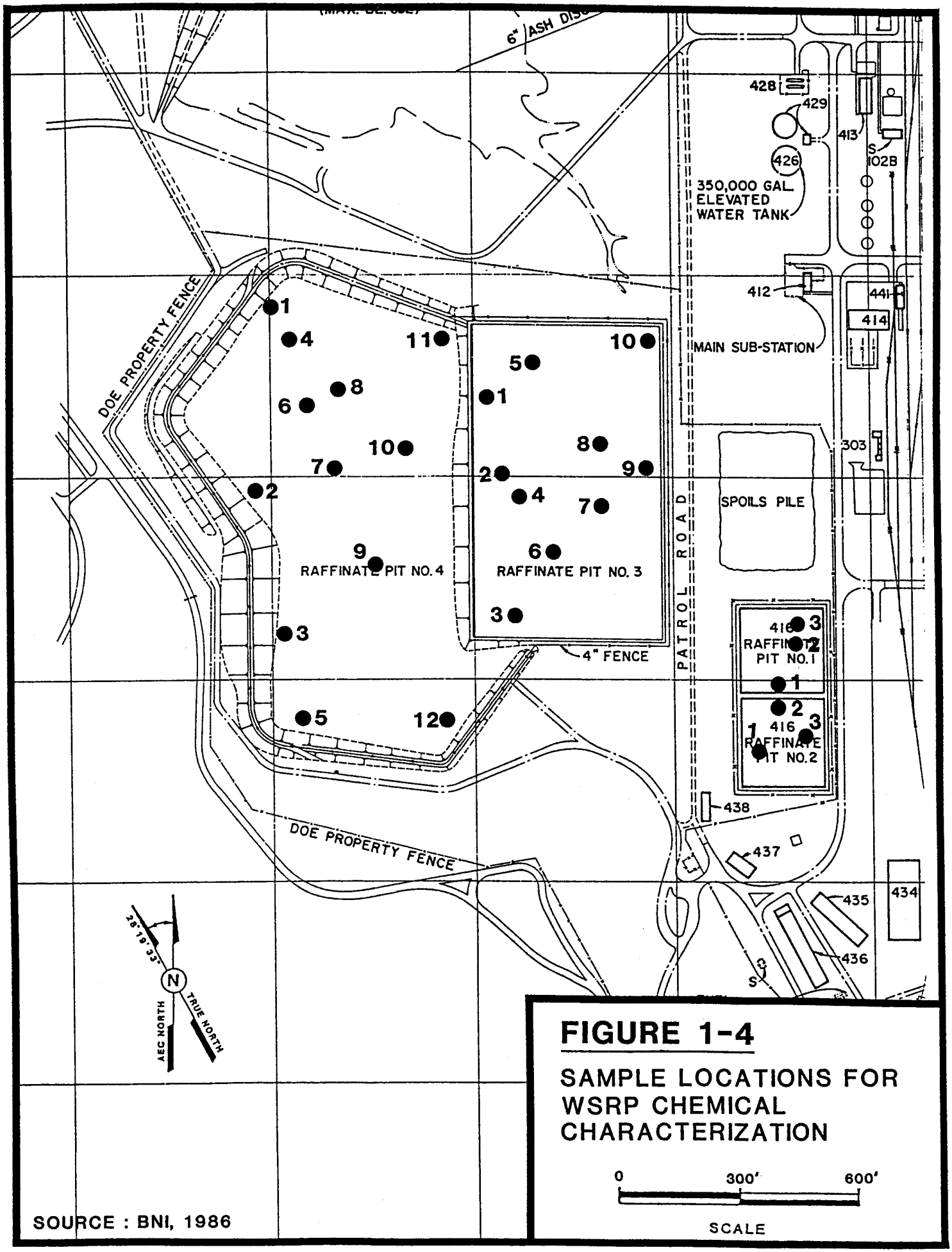

FIGURE 1-4

SAMPLE LOCATIONS FOR WSRP CHEMICAL CHARACTERIZATION

0 300' 600'

SCALE

SOURCE : BNI, 1986

Laboratory in Albuquerque, New Mexico, for radiological analysis. Each sample was analyzed for uranium 234, 235, and 238, thorium 230 and 232, radium 226 and 228, lead 210, and polonium 210. Maximum, minimum and average concentrations are given in Table 1-9.

Eighteen samples were analyzed by Eberline Analytical Laboratories (EAL) for EP toxicity, reactivity, ignitability, PCBs and pH. All analytical results reported were below regulatory limits and EAL concluded that the material did not exhibit any of the four characteristics of RCRA hazardous waste (Reference BNI, 1986).

1.2.4 WSSRAP Project Management Contractor Study, 1987

Surface water samples were collected from the four raffinate pits as a part of the Phase I Water Quality Assessment conducted in April of 1987 by the PMC. Representative samples for each pit were collected from the shore and composited from at least four locations per pit. These samples were collected using a stainless steel bailer which was slowly lowered to a point just above the sediment. These samples were analyzed for the groundwater parameters listed in Table 1-10.

TABLE 1-9
Weldon Spring Raffinate Pits
Sludge Sample Radionuclide Activities

Radionuclide		Concentrations in pCi/q-dry			
		Pit No. 1	Pit No. 2	Pit No. 3	Pit No. 4
U-234	Low	410	310	380	9
	High	2,100	1,700	5,900	2,200
	Avg.	1,057	910	1,588	291.5
U-238	Low	280	280	350	9
	High	1,800	1,700	6,000	2,200
	Avg.	900	884	1,580	291.5
Th-230	Low	70	40	130	1.8
	High	4,400	33,000	270,000	2,900
	Avg.	1,541	26,673	32,896	737
Th-232	Low	1	1	2	.8
	High	46	390	3,100	160
	Avg.	16	108	357	45
Ra-226	Low	930	270	86	.8
	High	3,600	3,600	3,600	190
	Avg.	2,404	1,452	1,211	50
Ra-228	Low	8	100	20	5
	High	200	430	300	870
	Avg.	98	195	189	182
Pb-210	Low	1,100	480	260	5
	High	5,400	4,700	4,400	350
	Avg.	2,600	2,384	1.685	103
Po-210	Low	610	540	130	2
	High	5,400	4,400	4,000	340
	Avg.	2,587	2,119	1,597	70
Locations sampled		3	3	10	12
Total No. samples		7	9	26	13

(BNI 1986 - EAL)

TABLE 1-10

Groundwater - Analytical Parameters

(Dissolved Fraction)

Phase 1 Water Quality Assessment

Uranium - Natural	Fluoride
Radium 226	Hardness
Radium 228	Total Dissolved Solids
Thorium 230	Total Organic Carbon
Thorium 232	CLP Metals; Lithium
Gross Alpha	CLP Organics
Gross Beta	U.S. ATHAMA Nitroaromatics
Nitrate	PCBs
Sulfate	Pesticides
Chloride	

Source: WSSRAP, 1987

The analyses in Table 1-10 (Groundwater - Analytical Parameters) were selected based on known or suspected contaminants (nitroaromatics, radionuclides, etc.) and to provide documentation of presence/absence regarding species not expected to be present in the water (organics, Hazardous Substance List (HSL) compounds, PCBs, pesticides, etc.).

Surface water samples from each pit were analyzed for nitroaromatics. A trace level (0.28 ppb) of 2,4 DNT was detected in Raffinate Pit 2. It is possible that some nitroaromatically contaminated soil from across the area of the former Ordnance Works Facility was used in the construction of this pit. No other nitroaromatics were detected in any of the raffinate pit waters, as expected.

Raffinate pit water samples were also tested for four inorganic anions (nitrate, sulfate, chloride, and fluoride) and three water quality indicator parameters (Total Organic Carbon (TOC), Total Dissolved Solids (TDS) and hardness). The results of these analyses are shown in Table 1-11. A comparison of recent data to historical data for the four inorganic anions is presented in Table 1-12.

Due to the nature of the uranium purification process used at the WSUFMP, high levels of nitrates and sulfates were present in the raffinate slurry as it entered the pits. Due to

TABLE 1-11

Inorganic Anion and Water Quality Data for the Raffinate Pits

Phase 1 Water Quality Assessment

Concentration mg/L Location No. Date Sampled	Nitrate (as N)	Sulfate	Chloride	Fluoride	Hardness	TDS	TOC	Cyanide	Phenol
SW-3001 Raffinate Pit #1	422	231	1.50	1.90	872	3160	12	0.032	<0.005
SW-3002 Raffinate Pit #2	10.1	493	2.34	1.57	422	818	8	0.025	<0.005
SW-3003 Raffinate Pit #3	947	704	3.37	4.84	2107	6390	6	0.027	<0.005
SW-3004 Raffinate Pit #4	46.6	136	5.69	4.69	252	694	8	0.032	<0.005

Source: WSSRAP, 1987

TABLE 1-12

Concentrations of Inorganic Anions in Raffinate Pit Water

Compound	Concentration (mg/L) 1987	1984[a]	1983[a]	1979[a]	1967[a]	Sludge - 1983 (mg/Kg dry)
Pit 1						
Nitrate (as N)	442	652	697	-	5625	11250
Sulfate	231	400	100	-	2300	400
Fluoride	1.9	2.5	1.1	-	--	23000
Chloride	1.5	17	15	-	210	670
Pit 2						
Nitrate (as N)	10	204	-	-	8550	4050
Sulfate	493	990	460	-	3300	200
Fluoride	2.3	2.7	1	-	--	2500
Chloride	1.6	5.7	6	-	50	230
Pit 3						
Nitrate (as N)	947	1890	1485	2925	8325	4950
Sulfate	704	640	268	620	2200	370
Fluoride	4.8	8.9	2.7	6	--	107000
Chloride	3.4	25	20	37	90	300
Pit 4						
Nitrate (as N)	47	92	99	126	4725	495
Sulfate	136	150	70	140	2200	270
Fluoride	4.7	7.8	5.8	13	--	64300
Chloride	5.7	7.7	7	10	90	50

[a] Source - DOE, DEIS - 1987.

stratification of the sludges and lack of mixing, significant quantities of the inorganic anions would be expected to be bound in the sludge. Much higher levels existed in past pit water samples and in the raffinate sludge (Table 1-12).

Sulfate concentrations in the pit waters are 231, 493, 704 and 136 mg/L in Pits 1 through 4, respectively. This contamination probably originated as wastes from the yellow cake impurities removed by the solvent extraction process. As with nitrates, much higher amounts of sulfates are contained in the raffinate sludge and interstitial water.

Fluoride levels are slightly elevated in raffinate pit waters. The presence of fluoride in the pits is due to the reintroduction of magnesium fluoride into the digestion phase of the process to recover entrapped uranium. A large portion of the raffinate pit sludge is presumed to consist of magnesium fluoride.

Chloride levels were low for all four pits as would be expected, since chlorides were not used in the uranium process.

Total dissolved solids and hardness varied from pit to pit. The highest value was observed in Pit 3 and the lowest in Pit 4. This is as anticipated since Pit 3 contains the largest volume of wastes and Pit 4 was used for only a short time before production ceased.

Total organic carbon concentrations ranged from 6 to 12 mg/L. These values are as expected since no organic chemicals were used in the processing operation. These levels are probably due to natural organic sources such as algae (which is present in all four pits) or decaying organic matter.

Surface water samples collected from the raffinate pits contained varying amounts of metals. The results for each pit are shown in Table 1-13. All but 4 of the 24 CLP metals analyzed were present in at least one of the pits. All of the metals present in the ponded waters are also present, at higher concentrations, in the raffinate sludge (DOE, DEIS 1987). Due to the pH of the water (8.4 to 9.4) and the low solubility of metals in high pH aqueous solutions, most of the metals are expected to exist as solids in the sludge.

In the digestion stage, the magnesium fluoride slag from the final stage of the process was redissolved with yellow cake feed material to recover unreacted uranium; thus substantial quantities of magnesium, as magnesium fluoride, were deposited in the pits. This explains the elevated magnesium levels.

The remaining metals (Table 1-13) probably originated as impurities in the yellow cake concentrate feed material which were removed during the metallurgical purification process.

TABLE 1-13

CLP Metals Concentrations in the WSRP
(ug/L)

U.S. E.P.A. Primary/Scndry Drinking Water Standard ug/L		Al	Sb	Ar	Ba	Be	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Ni	K	Se	Ag	Na	Tl	V	Zn
		S	S	50	1000	S	10	S	50	S	1000	300	50	S	S	50	2	S	S	10	50	S	S	S	5000
CRDL - ug/L **		200	60	10	200	5	5	5000	10	50	25	100	5	-	5000	15	0.2	40	5000	5	10	5000	10	50	20
Location No.	Date Sampled																								
SW-3001	4/24/87	405	U	22	71	8	0.5	254000	85	U	45	109	22	U	15400	17	U	11	28400	U	25	388000	U	2090	9
SW-3002	4/24/87	279	102	38	31	7	U	105700	83	U	12	220	U	U	40800	14	U	48	14300	U	10	113000	U	1800	15
SW-3003	4/24/87	517	395	5	86	3	U	260500	194	33	30	433	257	U	196000	33	U	174	78200	U	40	900000	U	535	26
SW-3004	4/24/87	230	U	U	102	U	U	11600	31	U	19	101	358	U	39400	10	U	33	15200	U	8	172000	U	89	19

Source WSSRAP, 1987

S - No Drinking Water Standard

** - Contract-Required Detection Limits, US EPA Contract Laboratory Program

U - Undetected at Contract-Required Detection Limits

Surface water samples from all four raffinate pits were also analyzed for volatile and semi-volatile organics, pesticides, and PCBs. No detectable levels of these compounds were observed in the water ponded on the raffinate pits.

Both Ra-226 and Ra-228 isotopes were present in raffinate pit ponded waters at varying activity levels. The highest level of radium-226 was detected in Pit 1 (61 pCi/L). Pit 4 contained the lowest radium-226 activity at 3.4 pCi/L. Radium-228 was observed in Pits 2, 3, and 4 at activities of 6, 32, and 13 pCi/L, respectively.

Thorium-230 was detected only in Pits 2 and 3 at levels of 13 and 16 pCi/L, respectively. Less than 5 pCi/L of thorium-230 was observed in Pit 4. Thorium-230 and thorium-232 activities could not be determined in Pit 1 due to interference. Based on thorium levels in the sludge in Pits 1 and 2, water in Pit 1 is expected to contain approximately 13 pCi/L thorium-230.

Based on the above analysis of surface water samples from the raffinate pits, no further analysis is deemed necessary at this time to characterize the waters ponded on the pits.

1.3 DATA NEEDS/SAMPLING PLAN OBJECTIVES

Radiological and chemical characterization thus far has provided an indication of the types of radiochemicals and chemicals

present in the raffinate pit sludges. From a radiologic standpoint, further testing is necessary to define the radioactive source term present in the raffinate sludge. Further chemical characterization is necessary to identify substances allegedly dumped during operation of the chemical plant and subsequent clean-up activities.

Physical characterization is complete enough to conclude that the sludges exist in a highly heterogeneous state and that the solids content is sufficiently high to preclude the effective use of mechanical dewatering techniques. Further testing is necessary, however, in connection with treatability studies. These studies will explore other stabilization technologies in an effort to achieve the regulatory goals of volume and toxicity reduction. The studies that will require additional sludge testing are: 1) stabilization studies including chemical methods, vitrification, pozzuolanic materials, dewatering techniques, and reprocessing the recoverable radioactive materials; and 2) liner compatibility studies. Section 3 of this sampling plan details all the proposed testing.

2.0 SAMPLING

2.1 SAMPLING RATIONALE

2.1.1 Radiological

The purpose of the radiological characterization of the raffinate pit sludges is to accurately determine the concentrations of radionuclides in the sludges. The importance of accurately determining these concentrations is two-fold. First, the radium-226 source term must be estimated to design an effective radon-222 barrier as part of an engineered cover. The second reason is to help assess the feasibility of recovering constituents (e.g. radionuclides or metals) from the sludges.

The radon barrier of a disposal cell is modeled in relation to a 1000-year design life (40 CFR 192). Significant concentrations of Ra-226 exist in the sludge today and, in 1000 years, 35 percent of the Th-230 will transform into Ra-226. Sixty-five percent of the original Ra-226 will also still be present. It is important, then, to estimate as accurately as possible the concentrations of these two radionuclides in the raffinate pit sludges in order to maximize the accuracy of subsequent radon barrier thickness calculations.

In 1984, the raffinate pit sludges were sampled by Bechtel National, Inc., (BNI). This is the most recent, most

comprehensive sampling effort of the sludges performed to date. This effort showed that there is great pit-to-pit variability for all radiologic species.

The BNI data was used to determine the number of samples per pit necessary to characterize the average radionuclide concentrations of each pit at a given level of statistical confidence. The accuracy determined to be adequate for this characterization was 90 percent confidence intervals about the mean with a relative error of the mean of 30 percent. The BNI data for Th-230 and Ra-226 was tabulated and the averages and standard deviations calculated. Only Th-230 was evaluated further because this radionuclide controls (for the 1000-year design-life of the disposal cell) the Ra-226 source term. Additionally, the statistical variability of the Ra-226 concentration was less than the statistical variability of the Th-230 concentration. The statistical variability of the uranium species concentrations is also less than the Th-230 concentration variability.

The derived sample requirements were then scaled volumetrically relative to Pit 3. Considering that Pit 3 contains nearly one-half the total sludge volume, the number of samples needed for the other pits could be scaled relative to Pit 3 without significant increases in error but with significant cost savings. This caused the number of samples to be reduced for Pits 1 and 2 and slightly increased for Pit 4. Then

approximately 85 percent of the sludge will be characterized with at least the desired level of accuracy.

It should be noted that the sludge is being characterized volumetrically and without regard to any vertical or horizontal stratification characteristics. It is not feasible to develop layer averages since there is no way to estimate how the sludge will be excavated and its subsequent disposal. The placement of the samples required to complete the sludge characterization will be made with regard to the previous sampling so as to provide uniform coverage of sludge area and depth.

2.1.2 Chemical

The purpose of the chemical characterization of the sludge/sediment material within the pits is to define the degree of contamination and to help quantify the magnitude of the effort that will be required to ultimately dispose of the wastes. The variability of contaminant types within the sludges will determine the disposal alternatives to be evaluated. Knowledge of these contaminants is required to develop the rationale behind liner engineering and compatibility testing.

The chemical characteristics of the raffinate sludge materials can be predicted to a limited extent from the history of the processes performed during the plant's operation, and from knowledge of the process sewers which drained to the pit.

However, because of alleged indiscriminate dumping of other chemicals into the pits, a scan for Hazardous Substance List (HSL) compounds will be conducted on samples acquired across each of the pits. This will determine the actual concentration of suspected wastes, as well as verify the presence or absence of other chemicals which may have been deposited in the pits.

The sludges will be analyzed for chemical products and by-products of process chemicals used on site, as well as their degradation products. These compounds include: metals, nitroaromatics and inorganic anions such as chloride, fluoride, nitrates, and sulfates. It is expected that no organic chemical contamination from volatile or semi-volatile fractions are present in the sludge; however, scans for likely compounds within these groups will be performed to confirm their absence. The sampling for the chemical parameters will be accomplished with the sampling efforts for radiologic characteristics. A list of the individual compounds and elements within each group is included as Attachment B.

Since these data will be applied primarily toward evaluation of disposal alternatives, a 90 percent confidence limit and one standard deviation about the mean were chosen as adequate for devising the sampling strategy.

The approach utilizes the formula

$$n=(cv)^2(t)^2/(p)^2$$

where n = the number of samples

cv = the coefficient of variation in percent

t = the student's t value for 90% confidence and 30 degrees of freedom

p = the acceptable error in percent

In the absence of usable data to determine actual variations in concentrations across the pits some assumptions must be made for the values of cv and p. Assumptions which were made for the raffinate sludge sampling were that the Coefficient of Variation equals 65% and the acceptable error will be chosen at 20%. The t-value for 90% confidence level and 30 degrees of freedom was obtained from the student's t table as 1.66. Calculating the minimum necessary number of samples (n) from these numbers:

$$n = (65)^2(1.66)^2/(20)^2$$

$$n = 29.10$$

Rounding up, n = 30

Approximately 30 samples would deliver a 90% confidence level with two standard deviations about the mean.

Since each of the pits contains, in effect, a different statistical population, a coverage of 30 samples per pit will be necessary to achieve the desired confidence. Consideration was given to combining the sampling efforts for Pits 1 and 2, since the pits are immediately adjacent to one another and the wastes were deposited in both pits in a relatively short span of time. However, review of existing data has shown some large variations in the concentrations of radiologic characters between the two pits. Therefore, these pits will be treated as separate statistical populations, with at least 30 samples taken in each of the four pits. Figure 2-1 exhibits the sample location layout.

A complete column of sample will be collected at each location to assess the degree of stratification of the waste materials. Of greatest concern with respect to high degrees of variation are the semi-volatile organic compounds and their impacts on liner compatibility. To date, no data have been collected on the semi-volatile fraction from the raffinate pit sludges. A breakdown of the numbers of samples and analyses to be performed, by pit, is given in Tables 3-2 through 3-6 (in Section 3.1).

Other parameters being investigated include CLP metals (plus lithium, molybdenum and zirconium), volatile organics, nitroaromatics, PCBs/pesticides, and inorganic anions (including chloride, fluoride, nitrate and sulfate). Previous studies have investigated, to a very limited extent, the sludge's content of

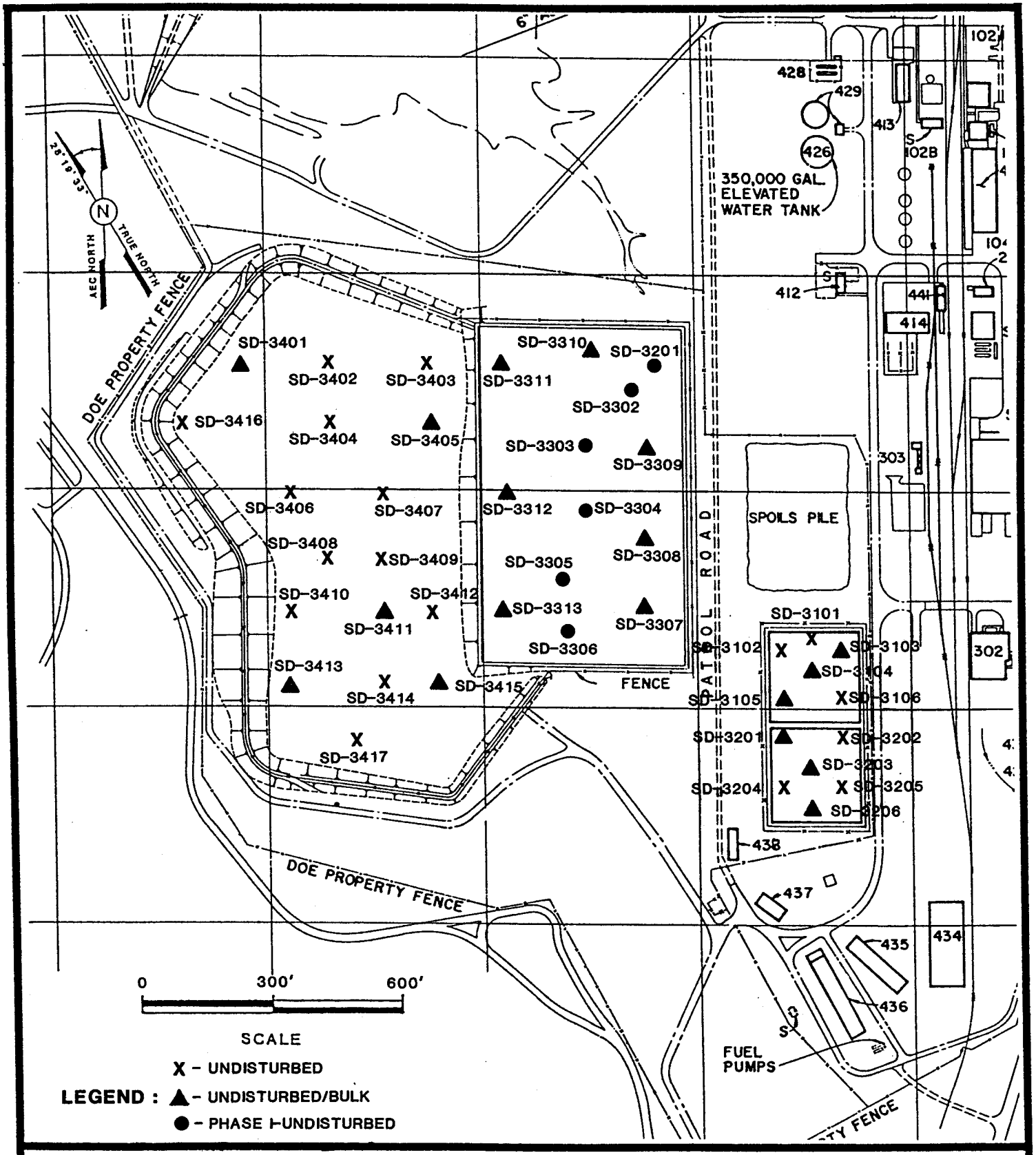

FIGURE 2-1

SAMPLING LOCATIONS FOR THE WSS RAFFINATE PITS CHARACTERIZATION

metals (minus lithium, molybdenum and zirconium), PCBs/pesticides, as well as the presence of nitroaromatics and inorganic anions in the supernatant waters. These studies revealed occasional areas across the pits where concentrations of metals (As, Ba, Cd, Pb, Hg, Ag) slightly exceeded detection limits (as determined through EP Toxicity tests). No evidence of PCB/pesticide contamination was found in the sludge. In the supernatant water of the raffinate pits, nitroaromatics were detected only in Pit 2. The inorganic anions were detected in waters from all four of the pits at varying concentrations.

Thirty samples will be collected from each pit, although the number of analyses for some parameters will be scaled down from thirty. Table 3-6 (Section 3.1) provides a breakdown of the analytical parameters in the investigation and the number of samples per pit for each parameter.

In an attempt to reduce the costs of the raffinate sludge characterization effort, yet maintain data reliability and statistical utility, factors such as pit size and previous data were considered when determining data quantity needs for volatile organics. Because of the relatively small size of Pits 1 and 2 (200 feet per side), the volatile nature of the compounds, and the age of the wastes in the pits (20-plus years) it is likely that variations in concentrations will be smaller than those for metals or semi-volatiles, if volatiles are present at all.

The number of analyses for PCBs/pesticides has been scaled back since some analyses previously performed on the sludges for these compounds indicated no presence above detection limits. Also, the number of analyses for nitroaromatics has been slightly decreased based on historical information and preliminary sampling of the supernatant waters which showed no evidence of these compounds in Pits 1, 3, and 4, and 0.28 ppb of 2,4 DNT in Pit 2. Should significant variability be encountered with the Phase 1 samples from Pit 3, then the analyses will be expanded.

Sampling, by a PMC subcontractor, will be accomplished in a single phase for Pits 1, 2, and 4 and in two phases for Pit 3. Pit 3 sampling will be expanded due to its considerably greater volume of sludge material.

Sampling will commence at Pit 3 with the collection of composite samples from six locations along a curved line (see Figure 2-1) from the southwest corner of the pit and moving towards the northeast corner (the corner from which the raffinate wastes were discharged). These samples will be submitted immediately for analysis, from which data will be used as a rough measure of the variability of concentrations across Pit 3. While awaiting analytical results (approximately 7 to 10 days) from Pit 3 samples, the sampling barge will be transferred to the other pits and complete sampling will be conducted at Pits 1, 2, and 4. The sample layout presented for Pit 3 in Figure 2-1 was devised assuming some reasonably limited analytical variation across the

pit area. If instead the pit shows a coefficient of variation near 100 percent or greater, alternative strategies may be considered prior to the Phase II sampling in Pit 3. Upon review and evaluation of Pit 3 Phase I data (concurrent with completion of sampling Pits 1, 2 and 4), a decision will be made on correct sample location layout, and the sampling equipment will be returned to Pit 3 to execute the appropriate sampling strategy.

2.1.3 Physical

The purpose of the physical characterization is to determine the degree of heterogeneity of the sludge both horizontally and vertically within each pit. In addition, selected physical parameters are indicative of the feasibility of various methods of stabilization. Since previous studies indicate a random distribution of physical parameters, sample locations are based on an even areal distribution across each pit. Samples at intervals of two feet will be taken continuously through the sludge.

The range of variation of physical parameters within each pit may have significant influence on in-situ stabilization techniques. A five-gallon grab sample from each discrete sample interval will be utilized in treatability studies.

Compositing of discrete samples for stabilization testing will be performed off-site and will be based on the parameters determined

in the physical characterization testing. Also, the stabilization technique under consideration will affect the extent of compositing. Composited samples from each pit will be used for vitrification, dewatering and reprocessing treatability studies. Compositing samples for in-situ stabilization techniques will be based on the effective depth range of the in-situ technique. Any remaining portion of sample will be stored for use in future bench scale studies, if required. If further testing is not necessary, the samples will be returned to the raffinate pits.

2.2 SAMPLING PROCEDURES

Characterization of the sludge material from the raffinate pits is necessary in order to define and evaluate the disposal alternatives. Representative samples of the sludge will be collected and evaluated for chemical, radiological, and physical parameters and the data used to support technical decisions and, if necessary, to demonstrate regulatory compliance.

The sample collection effort will be performed by a PMC subcontractor selected through a competitive bidding process. The precise sampling methodology will be determined by the subcontractor with approval of the DOE.

2.2.1 Description of the Sludge Material

Previous studies on the physical properties of the sludge indicate that the materials are very fine grained (nearly 95% passing the No. 200 sieve). The water content ranges from 70 to 75 percent with some stratification of solids apparent. The material has been described as having the consistency of pudding. Preliminary data indicates that wet bulk densities range from 73.9 lb/cf to 76.1 lb/cf. Depth estimates of the sludge range from an average of four feet in Pit 4 to approximately sixteen feet in Pit 3. The sludge is underlain by a stiff saturated clay.

2.2.2 Sample Location Access

The samples will be collected using a barge-mounted drilling rig. The barge rig will be maneuvered to specific sample locations through the use of ropes or cables. Samples will be located by line-of-sight cross-reference between survey grid stakes on each bank of the pits.

The individual samples will be acquired by driving an outer casing into the sludge in order to isolate a column of material. Drilling and sampling will take place within the casing.

2.2.3 Sample Collection

2.2.3.1 Method of Collection

Samples will be collected from the barge-mounted drilling rig as described above. It is anticipated that the material will be of such a consistency as to require casing of the entire column and sampling through the casing. Undisturbed samples will be collected with a piston sampler, consisting of an outer tube and a coaxial piston that creates a suction pressure within the tube. This method has been used successfully to retrieve high moisture content, fine-grained sludge material (see Reference 9). Bulk samples will be obtained by cleaning out an 8-10 inch casing. Different procedures will be attempted in order to optimize recovery, including augering, bailing or fabricating a large diameter piston sampler.

2.2.3.2 Quantity/Containers/Preservation

Analysis of sludge materials will require that some minimum quantities be properly packaged to maintain sample integrity. Table 2-1 details the container types and volumes to be used and the parameters to be tested on aliquots from each container. Finally, the table also lists the method by which the samples will be preserved.

Table 2-1
Sample Containers for Radiological and Chemical Analysis

Parameters	Containers	Preservatives
Volatile Organics	2-40ml vials	Refrigeration
Organics--Semi-Volatile, Pesticides, PCBs, Nitroaromatics	2-250ml wide-mouth amber glass jars	Refrigeration
Inorganics--Metals, Radiologic, Ionic Species	2-250ml wide-mouth amber glass jars	Refrigeration

2.2.3.3. Decontamination of Sampling Equipment

Equipment that could possibly influence the chemical or radiologic character (either concentration or substance) of the samples through direct or indirect contact will be decontaminated between uses, as necessary. Each discrete undisturbed sample will be collected with a sampler that has been decontaminated with pressure steam followed by a triple rinse with distilled water. Other sampling equipment that will potentially contact the sample material (casing, augers etc.) will be decontaminated with pressure steam between sampling locations. The flotation device and drilling rig will be decontaminated with pressure steam following sampling in each pit.

The decontamination procedures will consist of pressure steam cleaning (and abrasive brushing, if necessary) followed by a triple rinse with distilled water, where indicated. This method has been shown to be effective during previous investigations at the WSS. The effectiveness of the decontamination will be verified by the following methods: 1) visual inspection of the sampling components; 2) radiologic scan through the use of an alpha probe or GM probe (as appropriate); and 3) occasional collection of rinsate samples from the down-hole sampler.

2.2.4 Sample Container Labeling

All samples will be assigned specific numbers consistent with the WSSRAP Standard Operating Procedure's (SOP's) Environmental Numbering System for sediment. Information included on the labels will be site name and address, sample number, percent recovered, sampling personnel, date, time and comments. Following completion of each label with the specific sample data, the labels will be taped to protect the information and ensure that it remains legible.

3.0 SAMPLE ANALYSIS

All sample analysis will be performed according to industry standard testing protocols. The criteria to be met for each type of analysis are detailed in the following sections. Specific testing criteria are listed in Table 3-1 according to the parameters of interest in this study. Tables 3-2, 3-3, 3-4 and 3-5 show the number of analyses anticipated from the sampling effort in each pit. Table 3-6 provides a summary of sampling parameters and tests. These numbers are based on the sludge depths reported in Table 1-4 (Reference ESE, 1983).

3.1 RADIOLOGICAL

3.1.1 Uranium

In general the raffinate pit samples will be analyzed for total uranium with results reported as ppm-U. The analytical method used will follow EPA 600/4-80-032 "Prescribed Procedures for Measurement of Radiation in Drinking Water" August 1986. A small portion (2-10%) of the samples will be analyzed for isotopic uranium; U-234, U-235, U-238. The results will be reported as activity per unit volume and will be used to indicate the isotopic distribution of uranium in the sampled media. The

TABLE 3-1
Sample Analysis Criteria

Parameter	Standard Method of Analysis
Radiologic:	
Uranium and Thorium	EPA 520/5-84-006, Procedure 00-07
Radium	EPA 600/4-80-032
Chemical:	
Volatile Organics	CLP SOW #WA-87-J002
Semi-Volatile Organics	CLP SOW #WA-87-J002
PCBs	CLP SOW #WA-87-J002
Pesticides	CLP SOW #WA-87-J002
Metals (plus Li, Mo and Zi)	CLP SOW #WA-87-K026
Nitroaromatics	EPA Method 609 and USATHAMA Methodology
Inorganic Anions	EPA Method 300.0
Physical:	
Sludge Moisture Content	ASTM D2216
Sludge and Solid Specific Gravity	SMEWW Method 213E and ASTM D854
Sludge Capillary Moisture	ASTM D3152
Sludge Particle Size Analysis	ASTM D422
Sludge Viscosity and Gel Strength	See Note 1
Sludge Surface Charge	Zeta Meter
Atterberg Limits	ASTM 4318
Sludge Centrifuge Moisture Yield	ASTM D425
Sludge Consolidation	ASTM D2435
Sludge Phase Separation	See Note 2

Note 1: Viscosity and Gel Strength

Viscosity shall be measured according to ASTM D4016. To measure gel strength, the viscometer is turned off and the grout or sludge allowed to stand for ten (10) minutes. The viscometer is then turned on at a low rate of shear (5 s^{-1} for a Fann viscometer) and the gel strength is read directly as the maximum deflection on the scale.

Note 2: Phase Separation

Phase separation, a measurement of drainable water, is determined by a settling test in a 250-ml graduate cylinder. A sludge sample (200 ml) is poured into the graduate and allowed to stand. Phase separation is calculated as the volume of clear, drainable surface water divided by the total initial volume X 100.

TABLE 3-2
Pit 1
Sampling Parameters

DEPTH LOCATION	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.
1 - 1	V N S I P M	V N S I P M R	V N S I P M R	V N S I P M R	V N S I P M R
1 - 2	V N S I P M	V N S I P M R	V N S I M	V N S I M	V N S I P M R
1 - 3	V N S I P M	V N S I P M R	V N S I M	V N S I M	V N S I M
1 - 4	V N S I M	V N S I M	V N S I M	V N S I M	V N S I M
1 - 5	S I M	S I M	S I M	S I M	S I M
1 - 6	S I M	S I M	S I M	S I M	S I M

V = VOLATILES
S = SEMI-VOLATILES
P = PCB'S/PESTICIDES
M = METALS
N = NITROAROMATICS
I = INORGANIC ANIONS
R = RADIOLOGICAL

TABLE 3-3
Pit 2
Sampling Parameters

DEPTH LOCATION	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.
2 - 1	V N S I P M	V N S I P M R	V N S I P M R	V N S I P M	V N S I P M
2 - 2	V N S I P M	V N S I P M	V N S I M	V N S I M R	V N S I P M
2 - 3	V N S I P M	V N S I P M	V N S I M	V N S I M	V N S I M R
2 - 4	V N S I M	V N S I M	V N S I M	V N S I M	V N S I M
2- 5	S I M	S I M	S I M	S I M	S I M
2- 6	S I M	S I M	S I M	S I M	S I M

V = VOLATILES
S = SEMI-VOLATILES
P = PCB'S/PESTICIDES
M = METALS
N = NITROAROMATICS
I = INORGANIC ANIONS
R = RADIOLOGICAL

TABLE 3-4

Pit 3

Sampling Parameters

Depth Location	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.	10 - 12 ft.	12 - 14 ft.	UPPER COMP.	MIDDLE COMP.	LOWER COMP.
*3-1	V R	R	V R	R	V R	R	V R	N S I P M	N S I P M	N S I P M
*3-2	R	V R	R	R	V R	R		N S I P M		N S I P M
*3-3	V R	R	R	V R	R			N S I P M	N S I P M	N S I P M
*3-4	V R	R	R	V R	R		V	N S I P M		N S I P M
*3-5	R	V R	R	R	V R			N S I P M		N S I P M
*3-6	R	V R	R	R	V R			N S I P M		N S I P M
'3-7	R	R	R	R	R					
'3-8	R	R	R	R	R					
'3-9	R	R	R	R	R					
'3-10	R	R								
'3-11										
'3-12										
'3-13										

* = Phase 1 Locations

' = Phase 2 Chemical Parameters to be determined based on Phase 1 analytical data

V = VOLATILES

S = SEMI-VOLATILES

P = PCB'S/PESTICIDES

M = METALS

N = NITROAROMATICS

I = INORGANIC ANIONS

R = RADIOLOGICAL

TABLE 3-5
Pit 4
Sludge Sampling Parameters

DEPTH LOCATION	0 - 2 ft.	2 - 4 ft.	4 - 6 ft.	6 - 8 ft.	8 - 10 ft.
4 - 1	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V P N S M I
4 - 2	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V P N S M I
4 - 3	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V S M I
4 - 4	R S M I V P N	R S M I V P N	R S M I V P N	R S M I V P N	V S M I
4 - 5	R S M I V	R S M I V P N	R S M I V	R S M I V	V
4 - 6	R S M I	R S M I P N	R S M I	R S M I	
4 - 7	R	R S M I	R	R M	
4 - 8	R	R S M I	R		
4 - 9	R	R			
4 - 10	R	R			
4 - 11	R	R			
4 - 12	R	R			
4 - 13	R	R			
4 - 14	R	R			
4 - 15	R	R			
4 - 16	R	R			
4 - 17	R	R			

V = VOLATILES
S = SEMI-VOLATILES
P = PCB'S/PESTICIDES
M = METALS
N = NITROAROMATICS
I = INORGANIC ANIONS
R = RADIOLOGICAL

TABLE 3-6
Sampling Summary

	Pit 1	Pit 2	Pit 3	Pit 4	Total
# Locations	6	6	13	17	42
# Samples	30	30	51	54	165
Particle Size	2	2	7	4	15
Moisture Content	6	6	21	10	43
Specific Gravity	6	6	21	10	43
Phase Separation	6	6	21	10	43
Viscosity	6	6	21	10	43
Atterberg Limits	6	6	21	10	43
5-gal. composite	18	15	49	10	92
Volatiles	20	20	15	25	80
Semi-Volatiles	30	30	14	30	104
PCBs/Pesticides	10	10	14	20	54
Metals	30	30	14	30	104
Nitroaromatics	20	20	14	20	74
Inorganic Anions	30	30	14	30	104
Radiological	7	4	50	49	110
De-con Rinsates	2	2	3	3	10
Field Blanks	2	2	5	4	13
Field Duplicates	2	2	3	3	10

analytical method used for the isotopic uranium analyses will follow EPA 520/5-84-006 "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual" August 1984.

The results of these analyses will be used to estimate the uranium source term for the sampled media. The source term will then be used in various pathway analysis calculations, in risk assessments for total uranium, and in the final-disposal-cell design.

3.1.2 Thorium

The raffinate pit samples will be analyzed for isotopic thorium; Th-232, Th-230, and Th-228. The results will be reported as activity per unit volume and will be used to indicate the isotopic distribution of thorium in the sampled media. The analytical method used will follow EPA 520/5-84-006 "Eastern Environmental Radiation Facility Radiochemistry Procedures Manual" August 1984.

The results of these analyses will be used to estimate the thorium source term for the sampled media. The source term will then be used in various pathway analysis calculations for thorium (mainly Th-230), in the final-disposal-cell design, and in estimating thoron (radon-220) flux from the final disposal cell.

3.1.3 Radium

The raffinate pit samples will be analyzed for radium-226 and radium-228. The results will be reported as activity per unit volume. The analytical method used will follow EPA 600/4-80-032 "Prescribed Procedures for Measurement of Radiation in Drinking Water" August 1986.

The results of these analyses will be used to estimate the radium-226 and radium-228 source terms independently. The source terms will then be used in various pathway analysis calculations for radium, in the final-disposal-cell design, and in estimating radon (radon-222) flux from the final disposal cell.

3.2 CHEMICAL

3.2.1 HSL Compounds

Analyses for those volatile organics, semi-volatile organics, PCBs/pesticides and metals contained within the Hazardous Substance List (see Table 3-1) will be performed following the CLP methodologies. A detailed list of these analyses are presented in Appendix B of the WSSRAP Quality Assurance Program Plan.

3.2.2 Nitroaromatics

Analyses for nitroaromatics including 2,4 DNT, nitrobenzene and isophorone will be performed through EPA Method 609. 2,4,6 TNT will be quantified through performance of the United State Army Toxic and Hazardous Materials Agency (USATHAMA) methodology for that compound by a USATHAMA registered laboratory.

3.3 PHYSICAL

The number of physical tests required to adequately characterize the sludge waste is currently estimated as shown on Table 3-6. These numbers represent the minimum number of tests to be performed. Specific parameter testing may be expanded based on data variability. Samples representative of the top and bottom of each bulk sampling location in Pits 1, 2 and 4 and samples representative of the top, middle and bottom of bulk sampling locations in Pit 3 will be tested for moisture content, specific gravity, phase separation, viscosity and Atterberg limits. Particle size distributions will be performed on samples from multiple locations within each pit as shown on Table 3-6. The remaining physical testing parameters will be determined using a single composite sample.

Physical sample analysis will be required to evaluate the feasibility of the selected stabilization technologies. The indicative parameters for chemical stabilization and dewatering

methods other than mechanical are presented in Table 3-7. These parameters will be used in the feasibility evaluations. Vitrification tests will be accomplished by providing a composite sample to Pacific Northwest Laboratories where they will vitrify the material and analyze the off-gasses. This analysis will provide input for the evaluation of the feasibility and, if necessary, the design of the off-gas treatment system. These special studies are discussed in detail in the special study on sludge stabilization.

3.4 LABORATORY FUNCTIONS AND RESPONSIBILITIES

The analytical laboratory will be required to furnish standard operating procedures, equipment calibration and maintenance procedures, and personnel qualifications required to perform all analytical procedures. The laboratory will also report, for each method, the detection limit, sensitivity, interferences or bias, and analysis time. The laboratory must follow prescribed QA/QC protocol as mandated by the CLP/USATHAMA methodologies or internal QA plans. Written documentation of the results of that QA/QC testing prescribed in the laboratory QA/QC plan and described in the QAPP must be furnished. Any variance from those procedures will be reported and noted for data qualification.

TABLE 3-7

Indicative Parameters for Treatability Studies

Parameter	Stabilization Method
Sludge Moisture Content	Chemical stabilization; in-situ stabilization techniques
Sludge Specific Gravity	Chemical stabilization
Sludge Capillary Moisture	Dewatering
Sludge Particle Size Analysis	Confirm % passing #200 sieve
Sludge Viscosity	Handling techniques (pumpability and mixing)
Sludge Solids Specific Gravity	Chemical stabilization
Sludge Phase Separation	Chemical stabilization
Sludge Solids Surface Charge	Dewatering
Centrifuge Moisture Yield	Dewatering - decant water will be analyzed as worst case for liner compatibility study
Consolidation	Dewatering
Atterberg Limits	Handleability

4.0 QUALITY ASSURANCE MEASURES

All aspects of the site characterization, field investigations and data collection will conform to and adopt the required practices of the WSSRAP Quality Assurance Project Plan (QAPP). The QAPP presents the policies, organizations, objectives, functional activities and specific quality assurance (QA) and quality control (QC) activities designed to achieve the data quality goals of WSSRAP. Detailed below are the specific practices to be employed as quality assurance measures during characterization of the wastes in the raffinate pits.

The general QA objectives for analytical data are that data of known and acceptable quality be provided. To provide a check of the quality of the laboratory analytical data, a number of blank, duplicate, and spiked samples will be submitted to the analytical laboratory as per standard protocol for the CLP. Blank samples will be analyzed to check for container contamination and the adequacy of the field decontamination procedures. Duplicate samples provide a check for sampling and analytical error. Spiked samples will be analyzed for recovery determination. The frequency of submittal is detailed in the following sections.

4.1 FIELD BLANKS

One sample per each twenty samples collected will be acquired as field blanks by filling a sample container with distilled, deionized water, exposed to the sampling environment to detect accidental or incidental contamination.

4.2 DECONTAMINATION (RINSATE) BLANKS

One rinsate blank sample will be prepared per every twenty sludge samples collected. Following decontamination, the sample will be prepared by rinsing the sampling apparatus with distilled water and collecting the rinsate to check for residual contamination on the sampling tools.

4.3 BLIND FIELD DUPLICATES

One sample per every twenty samples collected for chemical/radiological analysis will be split and both samples analyzed by the same laboratory to determine data reproducibility. These samples will be labelled with different sample numbers to disguise their relationship.

5.0 DATA DOCUMENTATION

5.1 SAMPLE TRANSFER/CHAIN-OF-CUSTODY RECORDS

All raffinate pit samples leaving the Weldon Spring Site shall be in Department of Transportation regulated and approved containers. All sludge samples shall be handled and shipped according to Standard Operating Procedure (SOP) ENP-11.

5.2 FIELD REPORTS

The construction engineer responsible for monitoring field activities will, as outlined in Standard Operating Procedure numbers ENP-12 and ENP-18 (see Attachment A), fill out a field activity report and make appropriate entries into the field daily diary. Appropriate entries include date, time, sample number, location sketch, physical description, analyses requested, recovery and any problems encountered in obtaining the sample. Logs of stratification breaks, color, texture, etc. will also be recorded for the undisturbed samples.

5.3 PHOTOGRAPHS

Following extrusion from the sampling tool, all sludge samples shall be photographed. A legible sample identification card will be in each frame to identify the sample in the picture.

6.0 REPORTING REQUIREMENTS

Appropriate data obtained from this sampling plan will be reported in the Remedial Investigation Report. Original data forms and reports will be placed in the site document control files.

7.0 REFERENCES

1. Bechtel National, Inc., 1984, Engineering Evaluation of Alternatives for the Disposition of the Weldon Spring Raffinate Pits Site, Appendix A, US DOE Oak Ridge Operations Office, Contract No. DE-AC05-81OR20722, Bechtel Job No. 14501, US DOE

   Characteristics of waste in the WSRP-1983 sampling and analysis by Eberline Instrument Corporation. Chemical and radiological data by pit. No description of sampling method. No validation information.

2. Bechtel National, Inc., 1986, Results of Additional Testing of the Raffinate Pits at WSS, FUSRAP Project DOE Contract No. DE-AC05-81OR20722, Bechtel Job No. 14501, US DOE

   Radiological testing and initial RCRA screening. 26 sample locations, top, middle, and bottom samples at each location. Sample method not described. No validation information.

3. Environmental Science and Engineering, Inc., et. al., Oct. 1983, Material Test Report, Sludge Sampling and Testing Services, Weldon Spring Storage Site, Missouri, Subcontract No. 14501-AA-SC-46.

   Physical characterization of raffinate pit sludge. Eight sample locations, top, middle, and bottom samples for each location. No validation information.

4. Holtz, Robert D., and Kovacs, William D., 1981. An Introduction to Geotechnical Engineering. Prentice-Hall, Inc., Englewood Cliffs, NJ

   Industry standard civil engineering reference text.

5. Mason, Benjamin J., Mar. 1983, Preparation of Soil Sampling Protocol: Techniques and Strategies. EPA-600/4-83-020 Environment Research Center, University of Nevada, Las Vegas, Cooperative Agreement No. CR 808529-01-2.

   Provided back-up documentation and rationale for implementing specific statistical considerations to the raffinate pit sampling strategy.

6. Meier, Jim, and Ferguson, Rick, Report of Telephone Conversation, Jan. 4, 1988, Telephone conversation between Jim Meier of PMC and Rick Ferguson of the Corps of Engineers concerning sludge sampling.

7. Michels, D. E., 1977, "Sample size effect on geometric average concentrations for log-normally distributed contaminants", Environmental Science and Technology, v. 11, no. 3, p. 300-302.

Indicates how increasing sample size leads to diminishing gains in accuracy with regard to characterization of a contaminated area in the environment.

8. Nyhan, J. W.; Schofield, T. G.; White, G. C.; and Trujillo, G.; 1981, Sampling soils for 137Cs using various field sampling volumes, Los Alamos National Laboratory, LA-8951-MS, 12 p.

Indicates how increasing sample size leads to diminishing gains in accuracy with regard to characterization of a contaminated area in the environment.

9. Project Management Contractor, MK-Ferguson Company, 1987, WSSRAP Water Quality Phase I Assessment Report, Section 5.3 Surface Water-WSRP, DOE/OR/21548-003

Chemical characterization of surface water ponded on raffinate pits. QA and QC information available.

10. U.S. Department of Energy, 1987, Draft Environmental Impact Statement Remedial Action at the Weldon Spring Site. DOE/EIS-0117D. Washington, D.C.. February 1987.

11. U.S. Environmental Protection Agency, July 1985, Contract Laboratory Program, Statement of Work, Inorganic Analysis, EPA SOW No. 785.

12. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. Nov. 1986, Test Methods for Evaluating Solid Wastes Vol. II - Field Manual Physical/Chemical Methods. EPA Doc. No. SW-846 Third Edition.

Comprehensive explanation of sampling strategy design.

ATTACHMENT A

MK-FERGUSON COMPANY Weldon Spring Site Remedial Action Project Prime Contract No. DE-AC05-86OR21548	ENP-11	Rev. No. 0
	Issue Date	
	Page 1 of 1	

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

SET I.D. _____

APPROVAL SHEET FOR

PROCEDURES FOR HANDLING AND
SHIPPING OF GEOTECHNICAL SAMPLES

	Signature	Date
PROJECT MANAGER	[illegible]	2/8/88
ENGINEERING MANAGER	D R Lewis	2/8/88
CONSTRUCTION/OPERATION MANAGER	[illegible]	2/9/88
E. S. & H. MANAGER	[illegible]	2/8/88
QUALITY ASSURANCE MANAGER	J. J. Hairston	2/8/88

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

1.0 OBJECTIVE

1.1 To provide instruction to the Field Technical Representative (FTR) for packaging, marking, and shipping soil and rock samples collected in the field.

2.0 APPLICABILITY

2.1 This procedure outlines the minimum requirements for handling and shipping soil and rock samples collected in the process of site characterization. Figures 1 through 3 show completed examples of the required forms.

- Soil Sample Inventory
- Soil Sample Inventory Summary
- Diffusion Coefficient/Radon Emanation Sample Inventory

Figures 4 through 7 show the proper labeling procedures for the appropriate samples collected.

2.2 Soil samples from field sampling programs consist of large and small bulk samples, Standard Penetration Test (SPT) samples, Shelby Tube samples and large diameter (2 or 3 inch) ring or tube samples.

2.3 In conjunction with this Engineering Procedure and when shipping any soil or rock sample thought to possess low levels of radioactivity, ES&H Procedure 2.03.10 "Packaging and Shipping Radioactive Materials" is applicable and must be strictly followed.

3.0 EQUIPMENT

- 5-gallon plastic buckets with lids
- Large plastic bags - 3 mil thick
- Small plastic bags - 2 mil thick
- Shelby tube shipping boxes
- Twist ties

4.0 PROCEDURE

4.1 Sample ID

A sample identification number will be assigned to each discrete sample to ensure that data collected retains uniqueness from other data collected when ambiguity is possible. The final number assignment for all samples will be made in accordance with the Environmental Numbering System, ES&H Procedure number 4.01.01, where practical.

4.2 Large Bulk Samples

Large bulk samples shall be placed into a 5-gallon bucket which has been lined with a large plastic bag. A twist tie shall be used to securely fasten the top of the plastic bag. The top of the plastic bag shall have a complete sticky-back sample tag placed on it. The lid shall be securely fastened onto the top of the bucket. Complete sticky-back sample tags shall be placed on the top and on the side of the plastic bucket and covered with clear tape.

4.3 Small Bulk and Standard Penetration (SPT) Samples

Small bulk and SPT samples shall be placed inside small sample bags and shall be double-bagged. A complete sticky-back sample tag shall be placed on the outside of the inner bag prior to insertion into second bag. A twist tie shall be used to securely fasten the top of each plastic bag.

If several small bulk samples or SPT samples are collected from one or more test pit or borehole locations, they should be placed into a 5-gallon bucket with Soil Sample Inventory forms placed inside the bucket showing what location ID and sample ID's are contained within this 5-gallon bucket. The outside of the bucket should then be labelled on the lid and side or on a blank sticky label, with an indelible pen. Requisite label information shall be the site name and sample ID of the samples contained therein. In any case, a complete sticky-back label should be placed on the side of the bucket and covered with clear tape.

4.4 Large Diameter Ring Samples

Ring samples shall have the top and bottom capped with a plastic cap. The drilling subcontractor shall provide the rings as well as plastic caps. Caps shall be sealed to the ring or tube with plastic tape.

Labeling ring samples shall consist of placing a completed stick-back sample label on the side of the ring. Once this has been done the ring shall be placed inside a single, small plastic bag and securely fastened with a twist tie.

If several ring samples are collected from one or more borehole locations, they shall be placed into a 5-gallon bucket with Soil Sample Inventory forms placed inside the bucket that shows what sample ID's are contained within this 5-gallon bucket. The outside of the bucket should then be labelled on the lid and side, with an indelible pen, as to the site name and ID's of the samples contained therein.

In no instance shall the ring samples be allowed to freeze during handling and shipping operations.

4.5 Shelby Tube Samples

Shelby tube samples, once recovered, shall have the top and bottom of the tube sealed with paraffin. If insufficient space remains at the bottom of the tube for sealing, trim away 3/4-inch of soil and seal the tube. Once the wax has hardened, a plastic cap shall be placed over both ends. Seal the caps to the Shelby tube with strapping tape. The drilling subcontractor shall provide the Shelby tubes, paraffin, plastic caps, and the means to melt the paraffin.

Labeling of Shelby tube samples shall include placing a completed stick-back sample label on the side and near the top of the Shelby tube, and one sticky-back sample label on the plastic cap covering the top of the tube. The Shelby tube shall then be placed inside an adequately constructed shipping crate in preparation for shipment.

In no instance shall Shelby tube samples be allowed to freeze or be placed in any position different from the orientation in the bore hole. Vibration and movement of Shelby tubes should be minimized.

4.6 Post-collection/Pre-shipping Instruction

Prior to shipping soil samples, and preferably as they are collected, the Soil Sample Inventory Summary form shall be complete with the appropriate sample ID, sample type (large or small disturbed bulk sample, SPT, ring, Shelby tube or drill cuttings), material type (Unified Soil Classification, ASTM D2487 and D2488), depth sample taken from, if sample was taken from a borehole or test pit, where the sample was shipped and any comments. It is the Field Technical Representative's responsibility to retain a copy of the Soil Sample Inventory Summary form.

Additionally, the Diffusion Coefficient/Radon Emanation Sample Inventory Log must also be complete and returned to the Radiation Protection Manager or his designee within approximately 5 days.

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 1

SOIL SAMPLE INVENTORY

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SOIL SAMPLE INVENTORY

DATE: 01-31-88 FIELD REP.: John Smith

SAMPLE I.D.	DEPTH INT.	SAMPLE I.D.	DEPTH INT.
SD 3001	0-2'		
SD 3001	2'-4'		
SD 3001	4'-6'		
SD 3001	6'-8'		
SD 3001	8'-10'		
SD 3001	10'-10.5'		
9SD 3999	0-5'		
SD 3999	5'-10'		
SC-107951-58320	2.0'-2.5'		
SC-3508	0-2'		

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 2

SOIL SAMPLE INVENTORY SUMMARY

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

SOIL SAMPLE INVENTORY SUMMARY

SITE WSSRAP DATE: 4-10-87

FIELD REP.: John Smith

	SAMPLE ID	SAMPLE TYPE	MATERIAL TYPE	SAMPLE DEPTH	BOREHOLE/ TEST PIT	SHIPPED TO	COMMENTS
	SD-3001	LD	Sludge	0-2'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	2'-4'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	4'-6'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	6'-8'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	8'-10'	TP	ORNL	1-Sgal, TypeA
	SD-3001	LD	Sludge	10'-11.5'	TP	ORNL	1-Sgal, TypeA
	SD-3999	T	ML	0-2'	BH	Chen	& Associates
	SD-3999	T	ML	2-4	BH	Chen	& Associates
	SD-3999	T	ML	4-6	BH	Chen	& Associates

SAMPLE TYPE: LD-LARGE DISTURBED, SD-SMALL DISTURBED, SPT-STANDARD PENETRATION TEST, R-RING, T-SHELBY TUBE, C-DRILL CUTTINGS

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 3

DIFFUSION COEFFICIENT/RADON EMANATION SAMPLE INVENTORY LOG

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A MORRISON KNUDSEN COMPANY

DIFFUSION COEFFICIENT/RADON EMANATION SAMPLE INVENTORY LOG

SITE: WSSRAP DATE SHIPPED: 4-10-87

FIELD REP: John Smith SHIPPED VIA: Trailways Bus Page 1 of 1

Sample (DIFFUSION COEFFICIENTS)

Sample ID.	DEPTH	MATERIAL TYPE	BORROW	COMMENTS:
1. SO-3001	2'-4'	Silty Clay	X	1-5gal
2. SO-3025	6'-8'	Sand-contaminated		1-5gal
3. SO-3840	5'-9'	Clay-contaminated		1-5gal
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				

SAMPLE (RADON EMANATION)

Sample ID.	DEPTH	MATERIAL TYPE
1. SD-3099	2'-4'	Sludge
2. SD-3699	N/A	Stab. Sludge
3. SO-3047	10'-12'	contaminated clay
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		
12.		
13.		
14.		
15.		

SHIP SAMPLES TO:
Rogers & Associates Engineering
515 E-4500 S. Suite E-100
Salt Lake City, Utah 84107
(801) 263-1600

ADDITIONAL COMMENTS:

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 4

LABELING LARGE BULK SAMPLES

ATTACH TO TOP OF PLASTIC LINER INSIDE 5 GALLON SHIPPING CONTAINER.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SD-3999
Depth Interval:
Beginning Depth: 0 Ending Depth: 2 ft.
Comments: Sludge Sample
Collected By: D. Smith
Date: Jan. 18, 1988

ATTACH TO TOP OF LID ATOP 5 GALLON SHIPPING CONTAINER.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SD-3999
Depth Interval:
Beginning Depth: 0 Ending Depth: 2 ft
Comments: Sludge Sample
Collected By: D. Smith
Date: JAN. 18, 1988

ATTACH TO SIDE OF 5 GALLON SHIPPING CONTAINER NEAR THE TOP.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SD-3999
Depth Interval:
Beginning Depth: 0 Ending Depth: 2 ft.
Comments: Sludge Sample
Collected By: D. Smith
Date: JAN. 18, 1988

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 5

LABELING SMALL BULK SAMPLES AND STANDARD PENETRATION TEST (SPT) SAMPLES

SAMPLE IS DOUBLE BAGGED. ATTACH ON THE OUTSIDE OF THE INNER BAG.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO-3001
Depth Interval:
Beginning Depth: 2.0' Ending Depth: 4.0'
Comments: Soil Sample
Collected By: J. Smith
Date: JAN. 31, 1988

IN SHIPPING NUMEROUS SPT OR SMALL BULK SAMPLES FROM THE SAME BOREHOLE OR TEST PIT, PLACE THEM IN A 5 GALLON SHIPPING CONTAINER AND LABEL AS SHOWN BELOW.

ATTACH TO TOP OF LID ATOP 5 GALLON SHIPPING CONTAINER.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO-3001
Depth Interval:
Beginning Depth: N/A Ending Depth: N/A
Comments: SPT Sample
Collected By: J. Smith
Date: JAN. 31, 1988

ATTACH TO SIDE OF 5 GALLON SHIPPING CONTAINER NEAR THE TOP.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: SO-3001
Depth Interval:
Beginning Depth: N/A Ending Depth: N/A
Comments: Small Bag Samples
SO-3001, 3005, 3007
Collected By: John Smith
Date: JAN. 31, 1988

IF SAMPLES ARE FROM NUMEROUS TEST PITS OR BOREHOLES, LIST SEPARATE LOCATION IDS IN COMMENTS COLUMN.

PLACE INSIDE SHIPPING CONTAINER A SOIL SAMPLE INVENTORY (BOREHOLE INFORMATION) OR SOIL SAMPLE INVENTORY SUMMARY (TEST PIT AND/OR BOREHOLE INFORMATION) FORMS LISTING ALL SAMPLES CONTAINED WITHIN.

FIGURE 6

LABELING LARGE DIAMETER RING SAMPLES

ATTACH ON THE SIDE OF THE BRASS RING.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: S0-3508
Depth Interval:
Beginning Depth: 0.0 Ending Depth: 2.0
Comments: Ring Sample
Collected By: D. Smith
Date: Jan. 25, 1988

PLACE SEVERAL RING SAMPLES IN 5 GALLON SHIPPING CONTAINER AND LABEL OUTSIDE OF CONTAINER AS DIRECTED IN FIGURE 5 "LABELING SMALL BULK SAMPLES AND STANDARD PENETRAION TEST (SPT) SAMPLES".

PLACE INSIDE SHIPPING CONTAINER A SOIL SAMPLE INVENTORY SUMMARY FORM LISTING ALL SAMPLES CONTAINED WITHIN.

PROCEDURE TITLE: PROCEDURES FOR HANDLING AND SHIPPING OF GEOTECHNICAL SAMPLES

FIGURE 7

LABELING SHELBY TUBE SAMPLES

ATTACH ON THE OUTSIDE OF THE SHELBY TUBE, NEAR THE TOP.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: 50-107351-58320
Depth Interval:
Beginning Depth: 2.0 Ending Depth: 2.5
Comments: Shelby Tube
Collected By: J. Smith
Date: Jan. 9, 1988

ATTACH ON THE TOP OF THE PLASTIC CAP WHICH COVERS THE TOP OF THE SHELBY TUBE.

Weldon Spring Site Remedial Action Project (WSSRAP)
MK-FERGUSON COMPANY (PMC)
Rt. 2, Hwy 94, St. Charles, MO 63303
Phone (314) 441-8086
Sample ID: 50-107351-58320
Depth Interval:
Beginning Depth: 2.0 Ending Depth: 2.5
Comments: Shelby Tube
Collected By: J. Smith
Date: Jan. 9, 1988

PLACE INSIDE SHIPPING CRATE A SOIL SAMPLE INVENTORY SUMMARY FORM LISTING ALL SAMPLES CONTAINED WITHIN.

MK-FERGUSON COMPANY Weldon Spring Site Remedial Action Project Prime Contract No. DE-AC05-86OR21548	ENP-12	Rev. No. 0
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PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

SET I.D. _____

APPROVAL SHEET FOR

COMPLETING THE DAILY FIELD

ACTIVITY REPORT

PROJECT MANAGER	J. Hammond	2/8/88
ENGINEERING MANAGER	D R Lewis	2/8/88
CONSTRUCTION/OPERATIONS MGR.	C. J. Stewart	2/8/88
E. S. & H. MANAGER	Roger A. Miles	2/8/88
QUALITY ASSURANCE MANAGER	J. J. Hairston Signature	2/8/88 Date

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

1.0 OBJECTIVE

1.1 This Standard Operating Procedure describes the procedures to be followed in completing the Daily Field Activity Report (DFAR). The need for completing a DFAR for a subcontract shall be determined by the Technical Representative (TR) and shall be requested either in the technical specifications or as instructions to the Field Technical Representative (FTR). The DFAR permits tracking of all billable items and serves as a basis of payment at the completion of the subcontract. Proper completion is vital to the successful execution of the contract. Adherence to the provisions of this procedure will ensure proper completion of the DFAR.

1.2 Figure 1 shows an example of a completed DFAR. Variations in the specification line items prevents using common line items on the form. A blank form is shown as Figure 2. As an alternative a specific DFAR may be developed for specific subcontracts. This DFAR form should be included in the Technical Specifications for the subcontract. Alternative DFAR forms should have line items with identifiable units and quantities and spaces for signatures or initials of Contractor's and Subcontractor's representatives.

1.3 Each DFAR shall be prepared with the item number description. The item and unit of payment shall be recorded as it appears in the Subcontract Pricing Schedule. A sample DFAR should be inserted in the Request For Proposal so that the bidder is fully aware of its existence. The items listed on the DFAR should be prepared by the FTR in cooperation with the Subcontract Administrator (SA). The FTR shall daily record the total material and/or labor quantities on the appropriate line. Then the FTR and the Subcontractor's Representative shall initial the indicated space for the day's activities.

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

2.0 PROCEDURE

2.1 Preparation of the Daily Field Activity Report.

2.1.1 In the blanks provided, enter the site name, Subcontract number, the full name of the FTR, and the week. The week should be shown as Monday's date to Sunday's date. Write in each date to correspond to the day of the week.

2.1.2 Enter the appropriate billable work items for which records must be kept. Lump sum items such as Mob/Demob are not necessary. If additional space is needed, use a second sheet clearly labeling these as sheets 1 of 2 and 2 of 2. A breakdown of items not in the pricing schedule should go into the FTR's Diary, not on the DFAR.

2.2 Daily entries for labor and/or material quantities.

2.2.1 Enter the totals of work done for each day in each category. The FTR shall total the items and ensure that units of measurement are in agreement with the pricing schedule. Some costs can be in "hours" or by "volume" or by "each". For example, casing installation may be in units of hours or by lineal feet. Tensiometer installations are by "each". The same type of work, under different conditions may be priced differently and thus require separate entries. For example, drilling an 8-inch borehole may or may not be at the same cost per foot, or per hour, as a 6-inch borehole. Be aware that certain single labor entries could be a group of tasks rather than a single task; for example, well installation and development includes labor for casing installation, gravel pack, bentonite seal, grouting, and well development.

2.2.2 Enter the unit quantity for materials used each day. Verify that units agree with the pricing schedule. Refer to the item number to ensure that materials are not lumped in with labor costs for these tasks.

2.2.3 Discuss the entries with the Subcontractor's representative and have that person initial the column for each day's entry. No other entries shall be made after the column is initialed. Show a dash in each unused item. Details are given on the example, Figure 1. The FTR shall indicate on the DFAR if the Subcontractor's representative refuses to initial the day's entry.

2.2.4 Changes made on the DFAR entries shall be initialed by both the FTR and the Subcontractor.

2.3 After completing each sheet, the FTR should total all items. This total provides the FTR with a weekly progress summary that can be reported to the SA.

2.4 The DFAR is the basis of payment for each subcontract line item. The Subcontractor shall receive a copy of this document to prepare the billing. This will reinforce the instructions of the Subcontract on structuring the invoice so that it is consistent with the subcontract, i.e., on a daily basis for each line item and not on a hole by hole basis.

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

FIGURE 1

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

DAILY FIELD ACTIVITY REPORT

SITE NAME WSSRAP CONTRACT NO. 3589-SC-LP999 WEEK OF: 1/1/88 to 1/10/88

FTR: John Smith SUBCONTRACTOR: ABC Drilling

BILLABLE WORK	ITEM NO.	DATE / UNITS	1-4 MON	1-5 TUES	1-6 WED	1-7 THUR	1-8 FRI	1-9 SAT	1-10 SUN	WEEKLY SUMMARY
Rock Coring	2.1	LF	0	120	0	0	0	0		120
Drilling	2.3	LF	0	0	0	9.5	20	150		265
Stand by	3.1	Hr	0	0	1.5	15	Disputed 0 ABC	1.5		4.5
Devel. & Instal. (Well)	3.2	Hr	0	0	3	2	5	0		10
PVC Screen	4.2	LF	0	0	20	0	10	0		30
Daily Per Diem	6.0	per day	1	1	1	1	1	1		6
									No work	
FTR INITIALS:			JS	JS	JS	JS	JS	JS	JS	
SUBCONTRACTOR INITIALS:			ABC	ABC	ABC	ABC	ABC	ABC	ABC	

PROCEDURE TITLE: COMPLETING THE DAILY FIELD ACTIVITY REPORT

FIGURE 2

MK-FERGUSON
A MORRISON KNUDSEN COMPANY

DAILY FIELD ACTIVITY REPORT

SITE NAME _____ CONTRACT NO. _____ WEEK OF: _____

FTR: _____ SUBCONTRACTOR: _____

BILLABLE WORK	ITEM NO.	DATE / UNITS	MON	TUES	WED	THUR	FRI	SAT	SUN	WEEKLY SUMMARY
FTR INITIALS:										
SUBCONTRACTOR INITIALS:										

MK-FERGUSON COMPANY Weldon Spring Site Remedial Action Project Prime Contract No. DE-AC05-86OR21548	ENP-18	Rev. No. 0
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PROCEDURE TITLE: FIELD DAILY DIARY

APPROVAL SHEET FOR

FIELD DAILY DIARY

PROJECT MANAGER		2/8/88
ENGINEERING MANAGER	DR Lewis	2/8/88
CONSTRUCTION/OPERATIONS MGR.		2/8/88
E. S. & H. MANAGER		2/8/88
QUALITY ASSURANCE MANAGER	J.J. Hairston Signature	2/8/88 Date

PROCEDURE TITLE: FIELD DAILY DIARY

1.0 OBJECTIVE

1.1 This procedure provides guidelines for the minimum entries made by the Field Technical Representative (FTR) in the Bound Daily Diary while at a work site.

1.2 This procedure assigns responsibility and accountability to the FTR to maintain a bound daily diary. The diary shall contain the minimum entries described below and any other entries that the FTR's professional judgement dictates to completely document the conditions and events that affect the assignment.

1.3 This diary is assumed to be the only record of activity which can protect the Project Management Contractor (PMC) in case of litigation or dispute by the Subcontractor. Incidents and conditions are readily forgotten and those personnel who could provide any facts about the activities may have left the project.

2.0 PROCEDURE

2.1 At the start-up of each field assignment, the FTR should record (as a minimum) the following information in the diary:

- The diary shall be a permanently bound waterproof notebook. All entries should be made in waterproof ink or a pencil of at least 3-H hardness.
- A description of all significant equipment on the work site;
- The names and position of each crew member;
- A full inventory of all materials brought to the work site and a comparison with contractual quantities required;
- Any reference literature or special equipment provided by the PMC.

2.2 The FTR shall record the following information on a daily basis:

- Copies of "Daily Field Activity Report" or FTR diary provided to the Subcontractor.
- Active and inactive crews and equipment;
- Start and stop times of activities including arrivals and departures of individuals from the job site;
- Weather or surface conditions which may effect the activities (wind, rain, mud, heavy brush, etc);
- All conversations with and instructions given to the Subcontractor;
- All agreements or disagreements recorded on "Daily Field Activity Reports" affecting pay items or procedures;
- The names and purpose of any visitor entering the work area;
- A periodic summary of work accomplished (number of holes, footage, casing used, samples collected, etc.);
- Any additional material ordered or purchased for the project;
- Any information about conditions or procedures which appear to be unsafe and corrective actions taken.

2.3 At completion of the project, the following data shall be recorded:

- A complete inventory of all unused materials remaining plus any waste to be disposed of;
- Any work left undone (e.g., site restoration);
- A description of cleanup procedures;

- The final cumulative totals of materials used and work accomplished.

ATTACHMENT B

ATTACHMENT B

(REF: US EPA CONTRACT LABORATORY PROGRAM STATEMENT OF WORK, 1984)

EXHIBIT C

Hazardous Substance List (HSL) and
Contract Required Detection Limits (CRDL)**

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Detection Limits* Low Soil/Sediment[b] ug/Kg
1. Chloromethane	74-87-3	10	10
2. Bromomethane	74-83-9	10	10
3. Vinyl Chloride	75-01-4	10	10
4. Chloroethane	75-00-3	10	10
5. Methylene Chloride	75-09-2	5	5
6. Acetone	67-64-1	10	10
7. Carbon Disulfide	75-15-0	5	5
8. 1,1-Dichloroethene	75-35-4	5	5
9. 1,1-Dichloroethane	75-35-3	5	5
10. trans-1,2-Dichloroethene	156-60-5	5	5
11. Chloroform	67-66-3	5	5
12. 1,2-Dichloroethane	107-06-2	5	5
13. 2-Butanone	78-93-3	10	10
14. 1,1,1-Trichloroethane	71-55-6	5	5
15. Carbon Tetrachloride	56-23-5	5	5
16. Vinyl Acetate	108-05-4	10	10
17. Bromodichloromethane	75-27-4	5	5
18. 1,1,2,2-Tetrachloroethane	79-34-5	5	5
19. 1,2-Dichloropropane	78-87-5	5	5
20. trans-1,3-Dichloropropene	10061-02-6	5	5
21. Trichloroethene	79-01-6	5	5
22. Dibromochloromethane	124-48-1	5	5
23. 1,1,2-Trichloroethane	79-00-5	5	5
24. Benzene	71-43-2	5	5
25. cis-1,3-Dichloropropene	10061-01-5	5	5

(continued)

Volatiles	CAS Number	Detection Limits* Low Water[a] ug/L	Low Soil/Sediment[b] ug/Kg
26. 2-Chloroethyl Vinyl Ether	110-75-8	10	10
27. Bromoform	75-25-2	5	5
28. 2-Hexanone	591-78-6	10	10
29. 4-Methyl-2-pentanone	108-10-1	10	10
30. Tetrachloroethene	127-18-4	5	5
31. Toluene	108-88-3	5	5
32. Chlorobenzene	108-90-7	5	5
33. Ethyl Benzene	100-41-4	5	5
34. Styrene	100-42-5	5	5
35. Total Xylenes		5	5

[a]Medium Water Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[b]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Volatile HSL Compounds are 100 times the individual Low Soil/Sediment CRDL.

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
36. Phenol	108-95-2	10	330
37. bis(2-Chloroethyl) ether	111-44-4	10	330
38. 2-Chlorophenol	95-57-8	10	330
39. 1,3-Dichlorobenzene	541-73-1	10	330
40. 1,4-Dichlorobenzene	106-46-7	10	330
41. Benzyl Alcohol	100-51-6	10	330
42. 1,2-Dichlorobenzene	95-50-1	10	330
43. 2-Methylphenol	95-48-7	10	330
44. bis(2-Chloroisopropyl) ether	39638-32-9	10	330
45. 4-Methylphenol	106-44-5	10	330
46. N-Nitroso-Dipropylamine	621-64-7	10	330
47. Hexachloroethane	67-72-1	10	330
48. Nitrobenzene	98-95-3	10	330
49. Isophorone	78-59-1	10	330
50. 2-Nitrophenol	88-75-5	10	330
51. 2,4-Dimethylphenol	105-67-9	10	330
52. Benzoic Acid	65-85-0	50	1600
53. bis(2-Chloroethoxy) methane	111-91-1	10	330
54 2,4-Dichlorophenol	120-83-2	10	330
55. 1,2,4-Trichlorobenzene	120-82-1	10	330
56. Naphthalene	91-20-3	10	330
57. 4-Chloroaniline	106-47-8	10	330
58. Hexachlorobutadiene	87-68-3	10	330
59. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	10	330
60. 2-Methylnaphthalene	91-57-6	10	330
61. Hexachlorocyclopentadiene	77-47-4	10	330
62. 2,4,6-Trichlorophenol	88-06-2	10	330
63. 2,4,5-Trichlorophenol	95-95-4	50	1600

(continued)

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
64. 2-Chloronaphthalene	91-58-7	10	330
65. 2-Nitroaniline	88-74-4	50	1600
66. Dimethyl Phthalate	131-11-3	10	330
67. Acenaphthylene	208-96-8	10	330
68. 3-Nitroaniline	99-09-2	50	1600
69. Acenaphthene	83-32-9	10	330
70. 2,4-Dinitrophenol	51-28-5	50	1600
71. 4-Nitrophenol	100-02-7	50	1600
72. Dibenzofuran	132-64-9	10	330
73. 2,4-Dinitrotoluene	121-14-2	10	330
74. 2,6-Dinitrotoluene	606-20-2	10	330
75. Diethylphthalate	84-66-2	10	330
76. 4-Chlorophenyl Phenyl ether	7005-72-3	10	330
77. Fluorene	86-73-7	10	330
78. 4-Nitroaniline	100-01-6	50	1600
79. 4,6-Dinitro-2-methylphenol	534-52-1	50	1600
80. N-nitrosodiphenylamine	86-30-6	10	330
81. 4-Bromophenyl Phenyl ether	101-55-3	10	330
82. Hexachlorobenzene	118-74-1	10	330
83. Pentachlorophenol	87-86-5	50	1600
84. Phenanthrene	85-01-8	10	330
85. Anthracene	120-12-7	10	330
86. Di-n-butylphthalate	84-74-2	10	330
87. Fluoranthene	206-44-0	10	330
88. Pyrene	129-00-0	10	330
89. Butyl Benzyl Phthalate	85-68-7	10	330
90. 3,3'-Dichlorobenzidine	91-94-1	20	660
91. Benzo(a)anthracene	56-55-3	10	330
92. bis(2-ethylhexyl)phthalate	117-81-7	10	330
93. Chrysene	218-01-9	10	330
94. Di-n-octyl Phthalate	117-84-0	10	330
95. Benzo(b)fluoranthene	205-99-2	10	330
96. Benzo(k)fluoranthene	207-08-9	10	330
97. Benzo(a)pyrene	50-32-8	10	330

(continued)

Semi-Volatiles	CAS Number	Detection Limits* Low Water[c] ug/L	Low Soil/Sediment[d] ug/Kg
98. Indeno(1,2,3-cd)pyrene	193-39-5	10	330
99. Dibenz(a,h)anthracene	53-70-3	10	330
100. Benzo(g,h,i)perylene	191-24-2	10	330

[c]Medium Water Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 100 times the individual Low Water CRDL.

[d]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Semi-Volatile HSL Compounds are 60 times the individual Low Soil/Sediment CRDL.

Pesticides	CAS Number	Detection Limits* Low Water[e] ug/L	Low Soil/Sediment[f] ug/Kg
101. alpha-BHC	319-84-6	0.05	8.0
102. beta-BHC	319-85-7	0.05	8.0
103. delta-BHC	319-86-8	0.05	8.0
104. gamma-BHC (Lindane)	58-89-9	0.05	8.0
105. Heptachlor	76-44-8	0.05	8.0
106. Aldrin	309-00-2	0.05	8.0
107. Heptachlor Epoxide	1024-57-3	0.05	8.0
108. Endosulfan I	959-98-8	0.05	8.0
109. Dieldrin	60-57-1	0.10	16.0
110. 4,4'-DDE	72-55-9	0.10	16.0
111. Endrin	72-20-8	0.10	16.0
112. Endosulfan II	33213-65-9	0.10	16.0
113. 4,4'-DDD	72-54-8	0.10	16.0
114. Endosulfan Sulfate	1031-07-8	0.10	16.0
115. 4,4'-DDT	50-29-3	0.10	16.0
116. Endrin Ketone	53494-70-5	0.10	16.0
117. Methoxychlor	72-43-5	0.5	80.0
118. Chlordane	57-74-9	0.5	80.0
119. Toxaphene	8001-35-2	1.0	160.0
120. AROCLOR-1016	12674-11-2	0.5	80.0
121. AROCLOR-1221	11104-28-2	0.5	80.0
122. AROCLOR-1232	11141-16-5	0.5	80.0
123. AROCLOR-1242	53469-21-9	0.5	80.0
124. AROCLOR-1248	12672-29-6	0.5	80.0
125. AROCLOR-1254	11097-69-1	1.0	160.0
126. AROCLOR-1260	11096-82-5	1.0	160.0

[e]Medium Water Contract Required Detection Limits (CRDL) for Pesticide HSL Compounds are 100 times the individual Low Water CRDL.

[f]Medium Soil/Sediment Contract Required Detection Limits (CRDL) for Pesticide HSL compounds are 15 times the individual Low Soil/Sediment CRDL.

*Detection limits listed for soil/sediment are based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on dry weight basis, as required by the contract, will be higher.

** Specific detection limits are highly matrix dependent. The detection limits listed herein are provided for guidance and may not always be achievable.

Table 1. Elements Determined by Inductively Coupled Plasma Emission or Atomic Absorption Spectroscopy

Element	Contract Required Detection Level[1,2] (ug/L)
Aluminum	200
Antimony	60
Arsenic	10
Barium	200
Beryllium	5
Cadmium	5
Calcium	5000
Chromium	10
Cobalt	50
Copper	25
Iron	100
Lead	5
Magnesium	5000
Manganese	15
Mercury	0.2
Nickel	40
Potassium	5000
Selenium	5
Silver	10
Sodium	5000
Thallium	10
Vanadium	50
Zinc	20

Table 2. Cyanide Determination

Element	Contract Required Detection Level[1, 2] (ug/L)
Cyanide	10

1: Any analytical method specified in SOW Exhibit D may be utilized as long as the documented instrument or method detection limits meet the Contract Required Detection Level (CRDL) requirements. Higher detection levels may only be used in the following circumstance:

If the sample concentration exceeds two times the detection limit of the instrument or method in use, the value may be reported even though the instrument or method detection limit may not equal the contract required detection level. This is illustrated in the example below:

For lead:
Method in use = ICP
Instrument Detection Limit (IDL) = 40
Sample concentration = 85
Contract Required Detection Level (CRDL) = 5

The value of 85 may be reported even though instrument detection limit is greater than required detection level. The instrument or method detection limit must be documented as described in Exhibit E.

2: These CRDL are the instrument detection limits obtained in pure water that must be met using the procedure in Exhibit E. The detection limits for samples may be considerably higher depending on the sample matrix.

ATTACHMENT C

SET I.D. _____

APPROVED: ES&H MGR. _____ QUALITY MGR. _____

OBJECTIVE:

To provide guidance for packaging, marking, labeling, and shipping radioactive materials so as to ensure compliance with U.S. Department of Transportation (DOT) regulations.

APPLICABILITY:

During the course of remedial action at the WSS, radioactive materials will be shipped off-site for laboratory analysis. This procedure applies to the shipment off-site of any material of which the combined activity of all radionuclides in the material exceeds 2000 picocuries per gram (pCi/g). Failure to comply with this procedure could result in liabilities and fines levied against the shipper.

REFERENCE:

Code of Federal Regulations, Title 49, Parts 100-178 (Revision June, 1986)

EQUIPMENT AND MATERIALS:

1. Type A sample container(s) (5-gallon steel bucket, lid, and gasket, enclosure ring, locking nut and bolt).

2. Plastic liners with closures.

3. "Radioactive material" markings and labels:

   - Appropriate Radioactive White-1 or Radioactive Yellow-11 label as determined by this procedure.

   - Stencil(s) of "USA DOT 7-A Type A Radioactive Material LSA n.o.s. UN2912"; for liquid samples "This end up".

- Calibrated G-M Probe (located with ES&H radiological equipment)
- Exposure rate meter

PROCEDURE:

A. Method for estimating the total activity of all radionuclides in a 5-gallon steel container.

1. This section of the procedure describes a quick and conservative means of determining whether the material of concern must be classified as radioactive material. If the material is suspected to contain Th-230 then part A.1, A.2. and B.1 of this procedure does not apply.

   a. After the material has been placed in the container and before the lid has been fastened on, place the G-M Probe very near the surface of the material and obtain a one-minute count. (Note: Here, "container" refers to the primary vessel holding the material.)

   b. Fill out Part 1 of Form 2.03.10.01

   c. If the count rate of the G-M probe reads less than 700 counts per minute the material is assumed to contain less than 2000 pCi/g total activity. (The basis of this assumption is a calculation on file with the Radiation Protection Manager (RPM).) Continue with Part B of this procedure. 1

2. If the activity of the material is known from previous characterization studies or sample analysis this information may be used instead of method A.1 above with the RPM's approval. (49 CFR 172.402) 1

   a. Fill out Part 1 of Form 2.03.10.01, "Comments" section only, explaining where this data may be found.

B. Materials (excluding instruments, equipment, and articles) shipped off-site will conform to one of the two following classifications (see also Section A of this procedure):

1. Should the total activity of all radionuclides be less than 2000 picocuries per gram (pCi/g)(based on either A.1 or A.2 above), the material is then classified as non-radioactive and is therefore exempt from any shipping requirements concerning radioactivity. (49 CFR 173.403) 1

   NOTE: Frequently WSSRAP samples will contain more than one radionuclide. The 2000 pCi/g limit applies to the sum of the activities of all of the radionuclides present in the material being shipped.

   Radioactive materials or materials that could potentially contain radioactivity cannot be shipped off-site without signed approval (Form 2.03.10.01) from the RPM or his designee. 1

2. Should the total activity of all radionuclides be greater than 2000 pCi/g (based on A.1 or A.2 above), the material may be shipped either as limited quantity or as low specific activity (LSA). Materials from the WSS determined to be radioactive material will be shipped as "Radioactive material LSA n.o.s." for reasons of conservatism and ease of repetitive application of this shipping procedure. 1

   a. Place a plastic liner in a Type A container (5-gallon steel bucket) and fill the container with material as appropriate.

   b. Pull the ends of the liner together and seal it closed.

   c. Place lid and gasket on container. Install the lock-ring around the edge of the lid. Secure the lock-ring with a bolt and nut such that the accidental removal of the lid and content spillage is prevented. (Approximately 40 foot pounds).

d. Wipe any loose material from the outside of the container. Ensure that any removable contamination is less than 22 dpm/cm^2 (see WSSRAP Procedure No. 2.03.08). Include Form 2.03.03.01 with Form 2.03.10.01. Fill out only the smear survey section of Form 2.03.03.01. (49 CFR 173.443)

e. Measure the gamma levels at four locations on the surface of the 5-gallon steel bucket. Record these values on Form 2.03.10.01.

f. Determine the maximum radiation level in millirem per hour at one meter (3.3 feet) from the external surface of the container. Round up to the first decimal place. This is the transportation index to be applied to this container. Record this value on Form 2.03.10.01. (49 CFR 173.403)

g. Items e) and f) above and Table 1 will be used to determine the appropriate category of label to be applied to the container. The label to be applied shall be the highest category required for any of the two determining conditions for the package. (49 CFR 172.403)

Table 1: Category of label to be applied to radioactive materials containers.

TRANSPORT INDEX (TI)	RADIATION LEVEL AT PACKAGE SURFACE (RL)	LABEL CATEGORY
N/A	RL $\leq$0.5 mrem/hr	White-1
TI <1.0	0.5mrem/hr <RL <50 mrem/hr	Yellow-11
1.0 <TI	50 mrem/hr <R	Yellow-111

The following applicable items of information must be entered in the blank spaces on the "radioactive" label by legible printing using a durable weather resistant means of marking:

i. "Contents". The name of the radionuclides. For mixtures of radionuclides, the most restrictive radionuclides on the basis of radiotoxicity must be listed as space on the label allows.

ii. "Activity". Units shall be expressed in appropriate curie units.

iii. "Transportation index" as applicable.

A label must be placed on two opposite sides of the container.

h. The outside of each container must be marked as follows (in letters of at least one-half inch): (49 CFR 172.301, 172.310, 178.350)

USA DOT - 7A Type A
Radioactive material, LSA, n.o.s. UN2912

Liquid samples must be labeled "This end up".

The ES&H RPM has a stencil for this purpose.

Any internal packages or containers must be packed with closures upwards. (49 CFR 172.312)

i. Attach a label listing the shipper's name, address, and telephone number to each container. (49 CFR 172.306)

1

j. Another shipping consideration for material shipped as "Radioactive material LSA n.o.s." is the average concentration of the contents. Table 2 lists the average concentration limits for the radionuclides of concern at the WSS.

Table 2 Average concentration limits for Type A containers shipping material as radioactive LSA.

NUCLIDE	CONCENTRATION LIMIT (uCi/g)
U-238	unlimited
U-nat	unlimited
Th-nat	unlimited
Th-232	unlimited
Th-230	0.1
Ra-224	5
Ra-226	0.1
Ra-228	0.1
Pb-210	5
Ac-228	0.1

This will ensure that the material meets the definition of low-specific activity and meets the requirements of activity limits for Type A packages. (49 CFR 173.403, 173.431)

Record the average concentration of each radionuclide in the comments section of Part 2 of Form 2.03.10.01 or on an attached sheet (note attached page in comments section). This implies that the sample must be radiologically characterized by the WSSRAP radiological laboratory or WSSRAP RPM before shipment. (See Section A.2) 1

3. The RPM or his designee will authorize a container to be shipped only after a completed Part 1 of Form 2.03.10.01 has been filled out by the originator. If the RPM or designee determines that the container can be shipped as non-radioactive material, no further effort is required by the originator and the container may be shipped. 1

If the RPM or designee determines that the container must be shipped as radioactive material then the originator must complete Part 2 of Form 2.03.10.01 and comply with Section B.2 of this procedure. Additionally, the originator must complete the carrier's shipping papers as follows: 1

a. All description(s) must be printed in English and shall not contain any code or abbreviation except to specify the type of package and weight or volume. (49 CFR 172.201)

b. The container(s) must be described on the shipping papers exactly as follows (descriptions in parentheses require determination by shipper) (49 CFR 172.203):

"Radioactive Material, LSA, n.o.s. UN2912, (weight or volume) (limiting radionuclide(s) present), (form e.g. soil, liquid, gas, solid...) (total activity), (label category) (Transportation index)".

c. Included on the shipping paper must be the shippers' certification worded exactly as follows in either (i) or (ii) (49 CFR 172.204):

i. "This is to certify that the above-named materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation".

NOTE: The words "herein-named" may be substituted for the words "above-named".

ii. "I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respect in proper condition for transport by (*) according to applicable international and national governmental regulations."

d. No radioactive material from the WSS shall be transported by passenger aircraft. (49 CFR 172.204)

e. When a hazardous material and a material not subject to the requirements of 49 CFR Parts 170-178 are described on the same shipping paper the hazardous material shipping entries: 1

i Must be entered first, or
ii Must be entered or highlighted in a color that clearly contrasts with any description on the shipping paper of a non-hazardous material,
iii Must be identified by the entry of an "X" placed before the proper shipping name in a column captioned "HM".

4. Complete WSSRAP Chain of Custody requirements per ES&H SOP 4.01.02

* Additional language indicating the modes of transportation to be used may be inserted at this point. All modes of transportation may be indicated provided that any mode not applicable to a specific shipment is deleted.

FORM 2.03.10.01

PACKAGING & SHIPPING RADIOACTIVE MATERIALS

PACKAGING & SHIPPING RADIOACTIVE MATERIALS

FORM 2.03.10.01

SHIPPING DATE: 09-02-87 ORIGIN: WSSRAP DESTINATION: Columbia, Mo

CARRIER: Riedel

ORIGINATOR: S. Smith / WSSRAP

RPM APPROVAL: John Doe

PART 1

CONTAINER I.D.	INSTRUMENT READING (cpm)	RADIOACTIVE MAT'L[a] (YES/NO)	INSTRUMENT MODEL/SN

COMMENTS: Radionuclide concentration known from previous analysis.

PART 2

CONTAINER I.D.	SURFACE GAMMA LEVELS (mrem/hr)	HIGHEST 1-METER GAMMA LEVEL (mrem/hr)	TRANSPORTATION LABEL INDEX CATEGORY	WT (lbs)
(1)	<0.5, all four sides	0.02 (bkg)	T.I (N/A) White 1	5.5
(2)	<0.5, all four sides	0.02 (bkg)	T.I. (N/A) White 1	5.5

COMMENTS: See radionuclide concentrations on back

a) If the count rate is greater than 700 cpm the material is to be considered radioactive material. Further on site analysis is required.