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PHASE I SPRING AND SEEP REPORT

For The :
Weldon Spring Site Remedial Action Project
Weldon Spring, Missouri

Prepared By MK-Ferguson Company And Jacobs Engineering Group

AUGUST 1989 REV. 0

U.S. Department Of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

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and
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Prepared For:

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office
Under contract DE-AC05-86OR21548

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ABSTRACT

Pursuant to the overall objective of the WSSRAP to characterize the potential environmental and health impacts posed by the Weldon Spring Site, the Phase I Spring and Seep sampling effort was undertaken to evaluate the migration of site-related contaminants through conduit type groundwater flow. Samples were collected from springs during both high and low flow stages. Samples were analyzed for uranium, nitroaromatic compounds, CLP metals, and inorganic anions. Eight of the 27 springs which were sampled in a 2 mile radius of the site were found to contain levels of contaminants above calculated background levels. This report details the rationale, sampling and analytical methodologies, the analytical results, and the interpretation of transport mechanisms for each of the positive results.

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1 INTRODUCTION

The Phase I Spring and Seep sampling was conducted as a part of the Weldon Spring Site Remedial Action Project (WSSRAP) objective to characterize the contaminants at the Weldon Spring Site (WSS) and to identify the processes by which they migrate from the site. During the Phase I water quality assessment (DOE, 1987), sampling was undertaken to determine the extent of contamination in surface water and groundwater near the WSS. Groundwater, surface water, and vadose zone waters were sampled on and near the site. However, at the time of the Phase I assessment, the inventory of springs in the area had not yet been compiled.

The absence of data on the groundwater which emanates from springs and seeps has, to date, prevented the formulation of a complete picture of the groundwater flow and contaminant migration from the WSS. Sampling the spring waters was necessary to determine the extent of contaminant migration through groundwater via conduit flow. Springs and seeps, in concert with a strategic monitoring well network, are a valuable source of information on the concentrations and migration of contaminants from the WSS.

Samples were taken from 27 springs and seeps. Many of these locations are wet-weather features which could be sampled only during very short times following periods of moderate to heavy precipitation. Therefore, two samples were taken from each location. The first was to explore the total picture of subsurface conduit flow and migration of contaminants. The second was to identify normal flow from perennial springs when the discharge is not diluted by precipitation recharging the groundwater system.

1.1 SITE DESCRIPTION

The Weldon Spring Chemical Plant/Weldon Spring Raffinate Pits (WSCP/WSRP) site is located in St. Charles County, Missouri, approximately 30 miles west of St. Louis and 14 miles southwest of St. Charles as shown in Figure 1-1. The site is situated on Missouri State Highway 94 about 2 miles southwest of the junction of Highway 94 and U.S. Routes 40 and 61. The site is surrounded by State and Federal lands. It is adjoined on the west by the Weldon Spring U.S. Army Reserve and National Guard Training Area (WSTA) and on the east, north, and south by Missouri Department of Conservation (DOC) lands.

The communities of Weldon Spring and Weldon Spring Heights, with a combined population of 200, are located approximately 2 miles from the site. The metropolitan area of St. Louis, a significantly larger population exceeding 2.5 million, is within 30 miles of the site.

1.2 SITE HISTORY

The site history from 1941 to 1987, including previous decontamination efforts, is summarized below. A more detailed history of WSS operations is included in the WSSRAP Remedial Investigation/Feasibility Study (RI/FS) work plan (Peterson et al., 1988).

The land encompassing the WSS was privately held until April 1941 when the Department of the Army (DA) acquired 17,232 acres. From November 1941 through January 1944, Atlas Powder Company operated a trinitrotoluene (TNT) and dinitrotoluene (DNT) explosives production facility known as the Weldon Spring Ordnance Works (WSOW) on this land. The WSOW was closed and declared surplus to Army needs in April 1946. By 1949, all but approximately 2,000 acres had been transferred to the State of

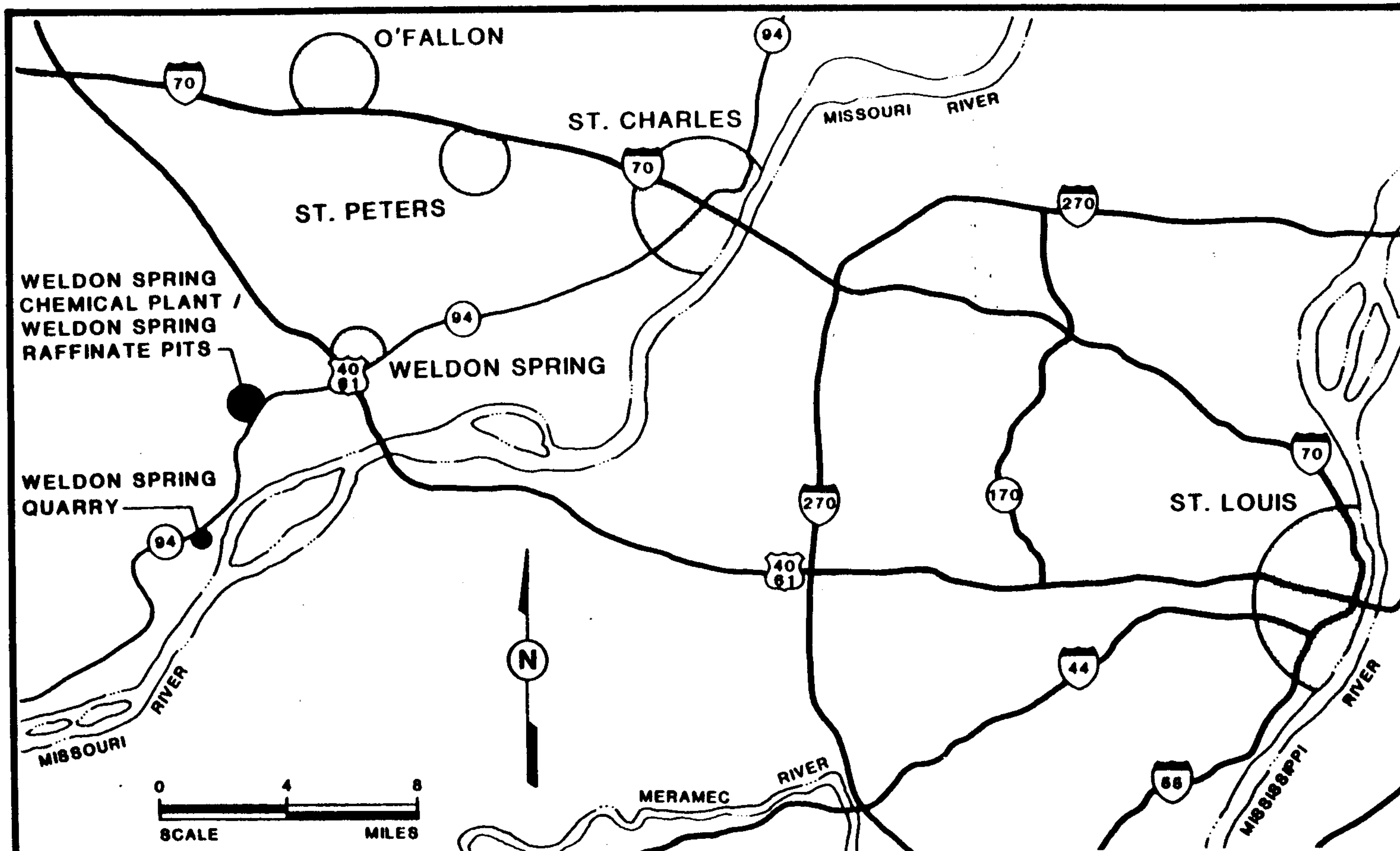


FIGURE 1-1

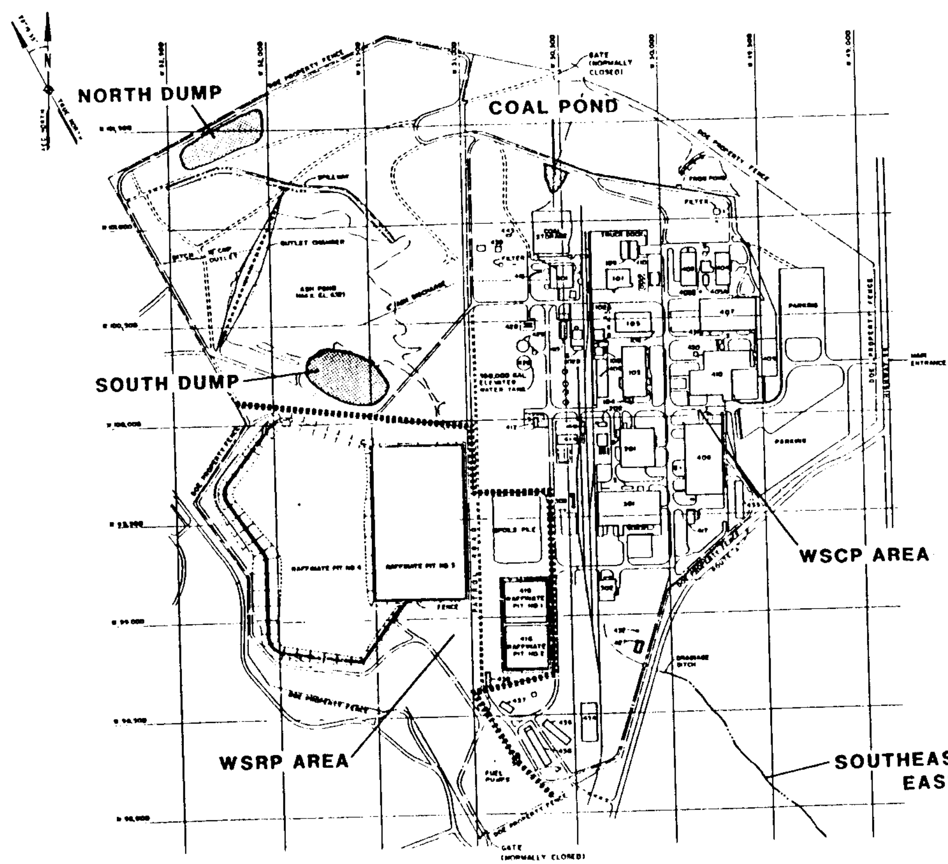
AREA AND VICINITY MAP, WELDON SPRING SITE, WELDON SPRING, MISSOURI

Missouri and the University of Missouri. The State developed the August A. Busch Memorial Wildlife Area on its parcel, and the university uses its share as experimental agricultural land. Except for several small parcels of land transferred to St. Charles County, the remaining property became the Weldon Spring Training Area.

Through a Memorandum of Understanding between the Secretary of the Army and the Atomic Energy Commission (AEC) in May 1955, 205 acres of the former WSOW were transferred to the AEC for the construction and operation of the Weldon Spring Uranium Feed Materials Plant (WSUFMP) to process uranium and thorium ore concentrates. Atlas Powder and the DA decontaminated a considerable portion of the explosives manufacturing facilities prior to construction of the WSUFMP (U.S. Department of the Army, 1976).

Uranium and thorium ore concentrates were processed at the WSUFMP from 1957 to 1966 with the Uranium Division of Mallinckrodt Chemical Works acting as the AEC Operating Contractor. This facility consisted of 13 major process buildings and approximately 30 support structures. The AEC closed the WSUFMP in December 1966.

On August 7, 1967, approximately 166 acres of the AEC facility were selected as the site for a herbicide production facility, later known as the Weldon Spring Chemical Plant. Figure 1-2 is a site plan of the WSCP. The remaining 51-acre area encompassed four process waste lagoons called the Weldon Spring Raffinate Pits and remained under AEC control. The Army was granted a license from the AEC for the contaminated source material present throughout the site. On December 31, 1967, 166 acres of property and improvements were transferred to the Kansas City District - U.S. Corps of Engineers, which was



BUILDING OR AREA	DESIGNATION
101	FEED PREPARATION AND SAMPLING PLANT
102A	REFINERY TANK FARM
102B	REFINERY TANK FARM
103	DIGESTION AND DENITRATION
104	LIME STORAGE
105	TBP AND ETHER EXTRACTION
106	PROOF SAMPLER
108	NITRIC ACID RECOVERY
109	DRUM STORAGE
110	DRUM STORAGE
201	GREEN SALT PLANT
207	GREEN SALT TANK FARM
301	METALS PLANT
302	MAGNESIUM STORAGE BUILDING
303	CHIP STORAGE
401	STEAM PLANT
403	CHEMICAL PILOT PLANT
404	METALLURGICAL PILOT PLANT
405A	PILOT PLANTS AUXILIARY
405B	PILOT PLANT AUXILIARY
406	WAREHOUSE
407	LABORATORY
408	MAINTENANCE AND STORES
409	ADMINISTRATION
410	SERVICES
412	ELECTRICAL SUBSTATION
413	COOLING TOWER AND PUMP HOUSE
414	SCRAP CLASSIFICATION AND EQUIPMENT STORAGE
415	CLAY BRICK INCINERATOR
416	RAFFINATE PITS 1 & 2
417	PAINT SHOP
426	ELEVATED WATER TANK
427	PRIMARY SEWAGE TREATMENT PLANT
428	PROPANE AND BUTANE GAS PLANT
429	RESERVE WATER FACILITIES
430	AMBULANCE GARAGE
431	PROOF SAMPLER
432	PROOF SAMPLER
433	STORAGE
434	STORAGE
435	STORAGE
436	STORAGE
437	STORAGE
438	STORAGE
439	FIRE TRAINING
441	CYLINDER STORAGE
443	FIRE TRAINING STORAGE

LEGEND:

- PAVED ROAD (ASPHALT OR CONCRETE)
- GRAVELED ROAD
- OLD ROADBED
- FENCE
- S ELECTRICAL SUBSTATION

SCALE 200 0 200 400 FEET

MKE DOCUMENT NO 5121-C 09-D-01-0279-A

U. S. DEPARTMENT OF ENERGY
OAK RIDGE, TENNESSEE

FIGURE 1-2
SITE MAP OF WSCP/WSRP

MORRISON-KNUDSEN ENGINEERS, INC.
WSSRA PROJECT

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responsible for the design and construction of the herbicide facility.

Decontamination and dismantling operations were initiated in January 1968. Some progress was made in the decontamination of areas required for herbicide production equipment before the project was cancelled. This cancellation was due in part to unexpected high costs in meeting the radiological contamination limits imposed on the facility and in part to the reduction of the military's requirements for herbicide.

The herbicide project was cancelled before any production equipment was installed. The DA retained the responsibility for the land and facilities at the WSCP.

The AEC contracted with National Lead Company of Ohio (NLO) to visit the WSRP periodically for environmental monitoring, maintenance of the pit embankments, and the performance of other maintenance and surveillance tasks as necessary. Bechtel National, Incorporated (BNI) assumed management responsibility for the WSRP from NLO in October 1981 under contract to the U.S. Department of Energy (DOE) which succeeded the AEC.

In November 1984, the DOE was directed by the Office of Management and Budget to assume custody and accountability for the WSCP from the DA. This transfer occurred on October 1, 1985.

In February 1985, the DOE proposed designating control and decontamination of the WSS a major project. Designation was effected by DOE Order 4240.1E, dated May 14, 1985. A Project Management Contractor (PMC) for the WSSRAP was selected in February 1986. In July 1986, a DOE Project Office was established on the site. The PMC, MK-Ferguson Company, assumed control of the WSS on October 1, 1986.

2 GEOLOGIC SETTING

2.1 REGIONAL PHYSIOGRAPHY AND GEOLOGY

The Weldon Spring Site (WSS) lies within two distinct physiographic regions. It is situated at the southern edge of the dissected till plains on the surface drainage divide between the Missouri and Mississippi Rivers. This area has a gently rolling topography. South of the chemical plant and raffinate pits (WSCP/WSRP), the topography changes dramatically as the dissected till plains give way to the rugged Salem Plateau characterized by rough topography, narrow ridges and valleys, and short, steep streams.

Various unconsolidated sediments overlie bedrock at the WSS. Exposed bedrock formations at or near the WSS range in age from middle Mississippian (Burlington-Keokuk) to late Ordovician (Kimmswick). A generalized bedrock stratigraphic column is presented in Figure 2-1. A more detailed description of regional bedrock geology may be found in "Hydrogeological Characterization Report for Weldon Spring Chemical Plant, Weldon Spring, Missouri" (BNI, 1987).

2.2 WELDON SPRING CHEMICAL PLANT AND RAFFINATE PITS GEOLOGY

2.2.1 <u>Overburden</u>

Four separate units make up the unconsolidated materials overlying competent bedrock at the WSCP/WSRP. The deposits encountered in descending order are loess, Ferrelview clay, glacial till, and weathered bedrock.

Loess deposits consist of wind-deposited silts and clays. These were deposited during Wisconsin glaciation. This unit is

	SYSTEM	UNIT	TYPICAL THICKNESS	DESCRIPTION
	MISSISSIPPIAN	BURLINGTON-KEOKUK	160'-200'	LIMESTONE, CHERTY, WHITE TO LT. GRAY, THICKLY BEDDED, MEDIUM TO COARSELY CRYSTALLINE
	MISSISSIPPIAN	FERN GLEN	50'-70'	LIMESTONE, CHERTY, YELLOW-BROWN FINE GRAINED MEDIUM TO THICKLY BEDDED
	MISSISSIPPIAN	CHOUTEAU	50'-70'	DOLOMITIC LIMESTONE, GRAY TO YELLOW BROWN, FINE GRAINED THIN TO MEDIUM BEDDED
BUSHBERG	DEVONIAN		5'-15'	QUARTZ SANDSTONE, RED-BROWN
SULFUR SPRINGS	DEVONIAN		35'-40'	CALCAREOUS SILTSTONE AND SANDSTONE WITH OOLITIC LIMESTONE AND SHALE
MAQUOKETA	ORDOVICIAN		30'-50'	CALCAREOUS OR DOLOMITIC SHALE, SILTY WITH SHALY LIMESTONE LENSES
	ORDOVICIAN	KIMMSWICK	90'-100'	LIMESTONE, WHITE TO LT. GRAY, COARSELY CRYSTALLINE, MEDIUM TO THICKLY BEDDED, CHERTY AT BASE
DECORAH	ORDOVICIAN		30'	INTER-BEDDED GREEN SHALES AND LIMESTONE
	ORDOVICIAN	PLATTIN	100'-125'	LIMESTONE, LT. TO DARK GRAY, FINELY CRYSTALLINE, THINNLY BEDDED

FIGURE 2-1
GENERALIZED STRATIGRAPHIC COLUMN

SOURCE : MK-FERGUSON, 1987

discontinuous over the WSCP/WSRP and varies in thickness from 0 to 10 feet.

The Ferrelview Formation is a clayey silt ranging from 0 to 17 feet in thickness. The Ferrelview Formation has developed from the underlying glacial till. Its extent is controlled by the extent of the glacial till.

The glacial till was deposited during the Kansan glaciation. Two units of this material have been identified by earlier investigators. The upper unit is composed of clay with minor amounts of silt, sand, and fine gravel. The basal unit consists of a cherty gravel in a clayey silt matrix. Glaciation and erosion controlled the horizontal extent of the glacial till unit. Thicknesses ranging from 0 to 45 feet were encountered during well installation (BNI, 1987).

Weathered bedrock ranging from less than 1 foot to 20 feet is present beneath the WSCP/WSRP. This material is a reddish-brown gravelly clay. Chert and limestone fragments comprise the gravel fraction. The amount of gravel depends on the composition of the weathered rock and varies both laterally and vertically.

2.2.2 Bedrock Geology

The Burlington-Keokuk cherty limestone is the first bedrock unit and contains the first aquifer underlying the WSCP/WSRP. The highest bedrock elevations, at approximately 635 feet mean sea level (MSL), are under the southeast portion of the WSCP. Surface topography and bedrock elevation do not necessarily correspond due to the presence of glacial till deposits.

The Burlington-Keokuk limestone is vertically fractured with two primary joint sets trending between N30°E and N72°E, and between N30°W and N65°W (BNI, 1987). The Burlington-Keokuk is susceptible to natural solution processes. Burlington-Keokuk solution features normally develop along fractures and bedding planes (Thornbury, 1969). Most solution features are small, up to several inches wide, and may be clay filled. No collapse sinks are known to exist on the WSCP/WSRP in the Burlington-Keokuk. Two small collapse features are known to exist within one mile of the site boundary: one at Lake 35 and one at Lake 12 on the Busch Wildlife area.

2.3 GENERAL DESCRIPTION OF SPRINGS

The types of springs in the vicinity vary from small seeps at the bedrock/clay interface to solution enlarged bedrock conduits and fractures that flow at rates of 200 and more gallons per minute during precipitation events.

Many of the spring-type features, known as wet-weather springs, flow only after moderate to heavy rainfall. They generally flow for short periods and the flow is sometimes quite heavy.

3 SPRING SAMPLING

3.1 SAMPLING RATIONALE

The objectives of sampling the springs near the Weldon Spring Site (WSS) were:

1. To determine if the contaminants present at the site are migrating via groundwater and conduit flow to nearby springs.

2. To identify the areas around the site which may be affected by contamination migrating via conduit flow.

3. To ascertain the concentrations of contaminants in the waters emanating from these springs in order to address concerns for public health and environmental impact.

4. To determine if the results of water quality and chemistry analyses can be used to correlate interconnections among various springs.

The springs were sampled in two phases. The entire inventory of springs was first sampled during a high flow period following a rain storm. Later, a smaller group of springs was sampled during a period of lesser flow resulting from dryer weather conditions.

The samples from the first phase were analyzed for the Type I parameters shown in Table 3-1. Samples from the second phase were analyzed for the same parameters, except the Contract Laboratory Program (CLP) organics and polychlorinated biphenyls

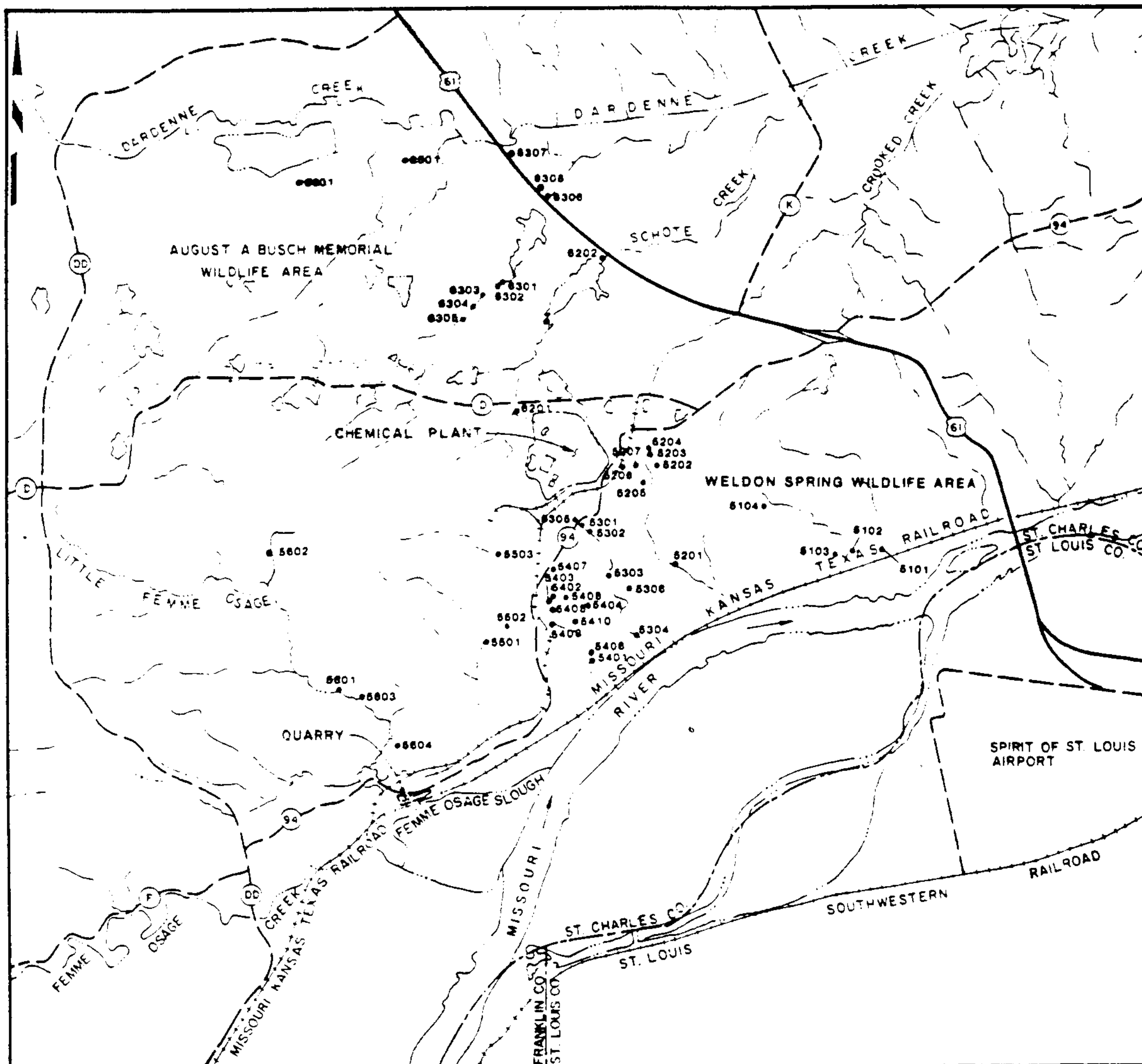

FIGURE 3-1

SPRINGS AND SEEPS IN THE VICINITY OF THE WELDON SPRING SITE

TABLE 3-1 Type I Analytical Parameters (Dissolved Fraction)

Type I Parameters	
Uranium (natural)	Chloride
Radium 226	Fluoride
Radium 228	Hardness
Thorium 230	Total Dissolved Solids
Thorium 232	Total Organic Carbon
Gross Alpha	CLP Metals; Lithium;
Gross Beta	Molybdenum
Nitrate	* CLP Organics
Sulfate	USATHAMA Nitroaromatics
	* PCBs/Pesticides

* Substances not analyzed in the second phase of sampling

(PCBs)/pesticides parameters. Quality assurance samples were collected during both phases.

3.2 SAMPLING LOCATIONS

A field survey of springs was performed within a 2 mile radius of the WSS. Drainages were walked by geologists, and the field location of each spring was logged on a map. A surface drainage numbering system was devised to aid in identifying and indexing the spring locations.

Other major springs outside the 2 mile radius were also logged and sampled on the basis of their relationship with the WSS and on information from historical accounts of events at the Weldon Spring Ordnance Works (WSOW). The surface drainages were numbered in a manner to permit indexing of these more distant springs. (See Figure 3-1.)

In addition to the field surveys performed by Weldon Spring Site Remedial Action Project (WSSRAP) personnel, the Missouri Department of Natural Resources (MDNR), Division of Geology and Land Survey, performed field surveys and logged local springs. Information transfers ensured that both organizations had complete inventories of spring and seep locations on file.

3.3 SAMPLING PROCEDURES

The samples were collected according to specific procedures developed for the WSSRAP (DOE, 1988). The spring samples for both phases were collected by dipping a laboratory-prepared clean glass beaker into each spring outfall in such a way that the mouth of the container pointed upstream. No special sampling equipment was necessary to collect the samples. Sample filtering, preservation, and analyses were performed by metaTRACE Laboratories in St. Louis, Missouri.

Several sampling locations were distant from roadways and accessible only by foot. Consequently, the samples were hauled by backpack to a vehicle where they were refrigerated. The entire process of collection, preservation, refrigeration, and shipment of each sample to the laboratory was performed within 24 hours. Field sheets, shipping forms, and chain-of-custody forms were completed for each sample.

3.4 OTHER STUDIES

Dye and water trace studies have been performed to investigate various aspects of the subsurface or conduit interconnection with the site and the contaminants found on the site.

3.4.1 Dye Studies

From 1983 to 1985 the MDNR conducted several dye trace studies. The results are summarized in Table 3-2.

3.4.2 Water Trace Study

In 1987, the MDNR conducted a water trace study in drainage 5300 by opening a fire hydrant at the upper end and allowing water to flow down the drainage way at a constant rate of 100 gpm for eight days. Water was seen to alternately lose into and resurge from the stream bed at four different points along the drainage. The study concluded that drainage 5300 is a losing stream, but also recognized that the stream contains its water within its drainage and does not recharge to a regional bedrock aquifer. The four springs in drainage 5300 each receive some of their flow from the losing stream condition. However, SP-5303 receives additional water from another source (Tischbein and Moylan, 1985). This conclusion is based on the fact that SP-5303 is consistently found to contain nitroaromatic

TABLE 3-2 Dye Trace Studies

DATE	RESULTS
02/83	The injection of dye into three drill holes yielded no connection to monitored locations. *
02/84	The introduction of dye into the surface drainage west of Raffinate Pit No. 4 and the detection of this dye at several springs including Burgermeister Spring (SP-6301) in the Busch Wildlife Area proved subsurface connection.
06/84	The introduction of dye at the process sewer outfall and detection of this dye in two springs along the drainage easement to the Missouri River established subsurface connection and a flow direction southward from the groundwater divide.
03/85	The introduction of dye into a losing stretch of the Ash Pond outflow stream west of the WSS and the detection of this dye at several springs including Burgermeister (SP-6301) demonstrated a surface water/groundwater connection for Ash Pond outflow.

* This summary was excerpted from a PMC memorandum written in 1986. Since then, further Missouri Department of Natural Resources dye detection efforts performed in 1987 began to detect dye within springs along drainage 5300--dye which had been injected into the borehole of well MW-2020 at the head of drainage 5300 in 1983. One possible explanation for the delayed detection is that the dye was injected into a zone of relatively impermeable bedrock and required several years to migrate to a conduit-influenced discharge zone.

Source: Meyer, 1986.

contamination which subsequently flows to SP-5304. None of the other springs within the drainage exhibit levels of nitroaromatic compounds that are detectable or noticeably higher than those in SP-5303.

4 ANALYTICAL RESULTS

4.1 BACKGROUND DETERMINATIONS

Many of the sampled springs are as much as 2 miles from the site boundary, but were nonetheless sampled to verify the absence of contaminants which might be attributable to the Weldon Spring Site (WSS). It was determined that these springs do not contain WSS-associated substances. For this reason, it was concluded that the values of the analytical results for these springs are representative of naturally occurring concentrations of substances, specifically inorganic anions and heavy metals. Weldon Spring Site Remedial Action Project (WSSRAP) personnel and the U.S. Geological Survey (USGS) representative agreed that the data acquired from these springs are probably the most accurate representation of background concentrations for groundwater in this area.

In some instances, such as where the data sets for a certain parameter displayed apparent outliers but where the data as a whole was well grouped, background concentrations were ascertained by calculating the mean of the grouped data and adding two standard deviations of the set. This approach was applied to several of the parameters to determine whether there was a statistically significant difference between the high values displayed and the data group. Wherever outliers occurred, attempts were made to explain the causes of the elevated concentrations. Table 4-1 displays some background values that were calculated using this method for parameters yielding full data sets.

4.2 RADIOLOGICAL PARAMETERS

All 27 springs were analyzed for uranium, radium, and thorium isotopes as well as gross alpha and beta emission rates.

TABLE 4-1: Derived Background Concentrations of Various Chemicals in Spring Waters Near the WSSRAP Site *

	SPECIE	BACKGROUND CONC.
INORGANIC ANIONS **	Cl	15.2
	F	0.5
	NO3	14.4
	SO4	60.9
METALS ***	Ca	71,712
	Cr	27.5 - 30.5
	Fe	380 - 490
	Mg	21,477
	Mn	32.6
	Na	14,773 - 16,193
	Zn	55.9 - 60.6

* CONCENTRATIONS DERIVED USING THE MEAN VALUE OF THE DATA PLUS TWICE THE STANDARD DEVIATION OF THE SET. NO DETERMINATIONS WERE MADE ON DATA SETS WHERE TOO FEW DATA WERE AVAILABLE. BACKGROUND RANGES WERE DERIVED BY CALCULATING "NOT DETECTED" VALUES INTO THE CALCULATIONS BOTH AS ZERO AND THE ANALYTICAL DETECTION LIMIT.

** UNITS IN MG/L.

*** UNITS IN UG/L.

Seven springs had indications of elevated uranium levels. These are SP-6301 (Burgermeister Spring), SP-6302 (Overflow Spring), SP-5301, SP-5302, SP-5303, SP-5304 (all within the contaminated Southeast Drainage), and SP-5203. The only spring among these that was not expected to show elevated uranium levels was SP-5203. Subsequent sampling of SP-5203 revealed no elevated radionuclides above background concentrations. The initial positive result for uranium may have been erroneous. Sampling of that spring will continue in order to verify continued background levels.

The concentrations of uranium detected in Burgermeister, Overflow, and the springs along the southeast drainage were consistent with the concentrations previously detected at those locations. All samples yielded results for radium and thorium isotopes (Ra-226, Ra-228, Th-230, Th-232) which were at or below the detection limits for each compound. At these levels, the concentrations remained within the ranges of background concentrations and well below Federal drinking water standards. In addition, the gross alpha and gross beta measurements for all samples, other than those with elevated uranium concentrations, remained at or below the maximum permissible activities after allowance was made for statistical margins of error (Tischbein and Moylan, 1985). Table 4-2 presents the results of analysis for radiological parameters in samples from the 27 springs near the WSSRAP site.

4.3 VOLATILE ORGANICS

Samples from five springs collected during previous sampling programs demonstrated possible influences by, or connections to, the site (DOE, 1987). These five springs, SP-5201, SP-5301, SP-5303, SP-5304, and SP-6301, were analyzed for Contract Laboratory Program (CLP) volatile organic compounds. The results showed no levels of these analytes above

Table 4-2: Radiologic Activity Levels in Springs Near WSSRAP.

ACTIVITY (pCi/L)

LOCATION	SAMPLE DATE	FLOW REGIME	Gross Alpha	Gross Beta	Radium 226	Radium 228	Thorium 230	Thorium 232	Total Uranium
		DETECTION LIMIT	3	6	1	1.0	1	1	1
SP-5101	05/18/88		ND	ND	ND	NA	ND	ND	ND
SP-5201	12/09/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5201	02/29/88	L	ND	ND	ND	NA	ND	ND	ND
SP-5201	03/28/88	L	3.6 +/- 2.2	ND	ND	NA	ND	ND	ND
SP-5201 DUP	03/28/88	L	ND	ND	ND	NA	ND	ND	1.3 +/- 0.7
SP-5202	12/08/87	H	NA	NA	ND	ND	ND	ND	1.1 +/- 0.8
SP-5203	12/08/87	H	NA	NA	ND	ND	ND	ND	11 +/- 2
SP-5203	02/26/88	L	ND	ND	ND	NA	ND	ND	ND
SP-5204	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5205	02/26/88	L	ND	ND	ND	NA	ND	ND	1.9 +/- 0.7
SP-5206	04/22/88	L	NA	NA	NA	NA	NA	NA	2.9 +/- 0.8
SP-5207	04/22/88	L	NA	NA	NA	NA	NA	NA	3.3 +/- 0.9
SP-5301	11/03/87		NA	NA	NA	NA	NA	NA	80 +/- 8
SP-5301	12/09/87	H	NA	NA	ND	ND	ND	ND	380 +/- 40
SP-5301	03/01/88	L	170 +/- 20	61 +/- 7	ND	NA	ND	ND	220 +/- 30
SP-5302	03/11/87	L	NA	NA	NA	NA	NA	NA	96 +/- 10
SP-5302	12/09/87	H	NA	NA	ND	ND	ND	ND	280 +/- 30
SP-5303	11/03/87		NA	NA	NA	NA	NA	NA	95 +/- 10
SP-5303	12/09/87	H	NA	NA	ND	ND	ND	ND	220 +/- 30
SP-5303	02/29/88	L	120 +/- 20	39 +/- 6	ND	NA	ND	ND	260 +/- 30
SP-5304	03/11/87	L	NA	NA	NA	NA	NA	NA	86 +/- 9
SP-5304	12/09/87	H	NA	NA	ND	ND	ND	ND	130 +/- 20
SP-5304	02/29/88	L	60 +/- 8	23 +/- 5	ND	NA	ND	ND	90 +/- 9
SP-5306	12/09/87	H	NA	NA	ND	1.2 +/- 0.7	ND	ND	ND
SP-5401	12/10/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5401 DUP	12/10/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5402	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5403	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5405	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5501	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5501	02/26/88	L	ND	ND	ND	NA	ND	ND	ND

Table 4-2: Radiologic Activity Levels in Springs Near WSSRAP (Continued)

ACTIVITY (pCi/L)

LOCATION	SAMPLE DATE	FLOW REGIME	Gross Alpha	Gross Beta	Radium 226	Radium 228	Thorium 230	Thorium 232	Total Uranium
		PARAMETER DETECTION LIMIT	3	6	1	1.0	1	1	1
SP-5502	08/12/87		NA	NA	ND	ND	ND	ND	ND
SP-5503	08/12/87		NA	NA	ND	ND	ND	ND	1.7 +/- 0.7
SP-5601	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5601	02/26/88	L	ND	ND	ND	NA	ND	ND	ND
SP-5602	12/10/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5603	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-5603	02/26/88	L	ND	ND	ND	NA	ND	ND	ND
SP-5604	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-6301	11/25/87		14 +/- 3	12 +/- 2	ND	NA	ND	ND	21 +/- 2
SP-6301	12/10/87	H	NA	NA	ND	ND	ND	ND	30 +/- 3
SP-6301	03/29/88	H	41 +/- 6	NA	NA	NA	NA	NA	100 +/- 10
SP-6302	11/25/87		14 +/- 3	14 +/- 3	ND	NA	ND	ND	24 +/- 3
SP-6302	12/10/87	H	NA	NA	ND	ND	ND	ND	10 +/- 2
SP-6303	12/08/87	H	NA	NA	ND	ND	ND	ND	1.1 +/- 0.8
SP-6303	02/26/88	L	ND	ND	ND	NA	ND	ND	ND
SP-6304	02/26/88	L	ND	ND	ND	NA	ND	ND	1.4 +/- 0.6
SP-6306	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-6306	02/29/88	L	3.2 +/- 2.5	6.3 +/- 4.0	ND	NA	ND	ND	4.1 +/- 1.1
SP-6501	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-6501	03/01/88	L	ND	ND	ND	NA	ND	ND	ND
SP-6601	12/08/87	H	NA	NA	ND	ND	ND	ND	ND
SP-6601	03/01/88	L	ND	ND	ND	NA	ND	ND	1.1 +/- 0.7

NA - Parameter not analyzed from this sample.
ND - Concentration not above the minimum detection limit, as listed above for each species.
H - High flow
L - Low flow

the detection limits, except two, acetone and methylene chloride. These compounds are common laboratory contaminants and contaminants and, on the basis of past results for field and trip blanks, they were dismissed as not representative of groundwater contamination (DOE, 1987).

4.4 NITROAROMATICS

Spring waters were tested for nitroaromatic compounds in an attempt to provide some indication of whether groundwater discharging from those springs was influenced by the nitroaromatic contamination contained within the boundaries of the WSS.

Eight of the 27 sampled springs indicated contamination by nitroaromatic compounds during either one or both rounds of sampling. These springs are SP-5201, SP-5303, SP-5304, SP-5503, SP-5602, SP-6301, SP-6302, and SP-6303. At least one of the following nitroaromatic compounds was detected in each of these springs: 2,4,6-TNT, 1,3,5-trinitrobenzene, 1,3- dinitrobenzene, 2,4-DNT, 2,6-DNT, and 1,3,5-trinitrobenzene. All other analyses yielded results below the accepted U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) required minimum limits. See Table 4-3 for the complete list of nitroaromatic data.

For at least two of the springs, the source of the nitroaromatic contamination can be inferred. SP-5201 is located downgradient and within the same surface drainage feature as a dump in drainage 5200 that is known to be contaminated with nitroaromatics. The nitroaromatic contaminants are presumably contributing to the groundwater/surface water system within that drainage as a result of gaining or losing stream conditions similar to those existing in drainage 5300 (Tischbein and Moylan, 1985).

Table 4-3: Nitroaromatics Concentrations in Springs Near WSSRAP

CONCENTRATIONS (UG/L)

LOCATION	DATE SAMPLED	FLOW REGIME	1,3,5-Tri-Nitrobenzene	1,3-Di-Nitrobenzene	2,4 DNT	2,4,6-TNT	2,6 DNT	Nitrobenzene
	COMPOUND		1,3,5-Tri-Nitrobenzene	1,3-Di-Nitrobenzene	2,4 DNT	2,4,6-TNT	2,6 DNT	Nitrobenzene
	DETECTION LIMIT		0.03	0.4	0.2	0.5	0.6	0.6
SP-5201	12/09/87	H	2.4	0.7	ND	77.1	ND	ND
SP-5201	02/29/88	L	0.78	ND	ND	19.76	ND	ND
SP-5201 DUP	03/28/88	L	0.51	ND	ND	12.04	0.90	ND
SP-5201	03/28/88	L	1.13	ND	ND	20.80	1.11	ND
SP-5202	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5203	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5204	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5301	12/09/87	H	ND	ND	ND	ND	ND	ND
SP-5301	03/01/88	L	ND	ND	ND	ND	ND	ND
SP-5302	12/09/87	H	ND	ND	ND	ND	ND	ND
SP-5303	12/09/87	H	ND	ND	ND	22.0	ND	ND
SP-5303	02/29/88	L	ND	ND	ND	19.74	ND	ND
SP-5304	12/09/87	H	ND	ND	ND	4.8	ND	ND
SP-5304	02/29/88	L	ND	ND	ND	1.28	ND	ND
SP-5306	12/09/87	H	ND	ND	ND	ND	ND	ND
SP-5401	12/10/87	H	ND	ND	ND	ND	ND	ND
SP-5401 DUP	12/10/87	H	ND	ND	ND	ND	ND	ND
SP-5402	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5403	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5405	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5501	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5502	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5503	12/08/87	H	ND	ND	ND	0.61	ND	ND
SP-5601	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5602	12/10/87	H	ND	ND	0.5	1.8	3.5	ND
SP-5603	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-5604	12/08/87	H	ND	ND	ND	ND	ND	ND
SP-6301	11/25/87		ND	ND	0.7	ND	ND	ND
SP-6301	12/10/87	H	ND	ND	ND	ND	ND	ND
SP-6301	03/29/88		ND	ND	0.5	ND	ND	ND

Table 4-3: Nitroaromatics Concentrations in Springs Near WSSRAP (Continued)

CONCENTRATIONS (UG/L)

LOCATION	COMPOUND / DATE SAMPLED FLOW REGIME	1,3,5-Tri-Nitrobenzene	1,3-Di-Nitrobenzene	2,4 DNT	2,4,6-TNT	2,6 DNT	Nitrobenzene
	DETECTION LIMIT	0.03	0.4	0.2	0.5	0.6	0.6
SP-6302	11/25/88	ND	ND	0.6	ND	ND	ND
SP-6302	12/10/87 H	ND	ND	ND	ND	ND	ND
SP-6303	12/08/87 H	ND	ND	ND	ND	ND	ND
SP-6306	12/08/87 H	ND	ND	ND	ND	ND	ND
SP-6306	02/29/88 L	ND	ND	ND	ND	ND	ND
SP-6501	12/08/87 H	ND	ND	ND	ND	ND	ND
SP-6501	03/01/88 L	ND	ND	ND	ND	ND	ND
SP-6601	12/08/87 H	ND	ND	ND	ND	ND	ND
SP-6601	03/01/88 L	ND	ND	ND	ND	ND	ND *

H = HIGH FLOW,
L = LOW FLOW

SP-5304 exhibits nitroaromatic contamination similar to that of SP-5303. A study of drainage 5300 for the Missouri Department of Natural Resources (MDNR) indicates that at least part of the water discharged at SP-5304 is contributed by the losing stream conditions within drainage 5300 (Tischbein and Moylan, 1985). However, the source of contamination in SP-5303 is not certain.

SP-5602 resurges within 100 yards of, and approximately 30 feet lower than, a former waste water lagoon which was used to store "red water" during the TNT manufacturing period of the Weldon Spring Ordnance Works (WSOW) (Meier, 1988). It is likely that this lagoon serves as the source of nitroaromatic contamination in the waters of this spring.

The nitroaromatic contamination in springs SP-5503, SP-6301, SP-6302, and SP-6303 has not been attributed to specific point sources but may result from widespread nitroaromatic contamination in both groundwater and soil across the area. This contamination is possibly associated with the neighboring Weldon Spring Training Area (WSTA).

4.5 INORGANIC ANIONS

Samples taken in both sampling phases were analysed for four naturally occurring inorganic anions. The results indicated that none of the sampled springs contain concentrations of nitrate, sulfate, chloride, or fluoride above primary drinking water standards. Table 4-4 displays the concentrations of anions detected in these springs.

A small number of the analytical results indicate what appear to be unnaturally high concentrations of chloride and sulfate anions. The highest readings for both chloride and sulfate appear in springs which discharge within drainage 5200

Table 4-4: Ionic and Water Quality Parameter Measurements from Springs Near WSSRAP.

LOCATION	PARAMETER / DETECTION LIMIT / UNITS / DATE_SAMPLED FLOW REGIME*	Cl	F	NO3(as N)	SO4	Conductivity	Hardness	TDS	TOC	pH
	DETECTION LIMIT	0.25	0.25	0.1	1.0	10	1.0	1.0	0.1	-
	UNITS	MG/L	MG/L	MG/L	MG/L	UMHOSCM	MG/L	MG/L	MG/L	UNITS
						MEASURED VALUES				
SP-5101	05/18/88	6.7	0.6	1.5	36.7					
SP-5201	12/09/87 H	8.4	0.2	2.2	48.0	369	204	236	1.6	7.49
SP-5201 DUP	12/09/87 H	5.9	ND	0.2	35.0	355	211	279	62.2	6.45
SP-5201	02/29/88 L	14.6	0.5	0.8	41.4	453		269	4.78	7.69
SP-5201 DUP	03/28/88 L	17.6	ND	0.4	41.2					
SP-5201	03/28/88 L	16.6	ND	0.4	40.0	376.8			28.6	7.54
SP-5202	12/08/87 H	13.7	0.5	4	24.6	675	394	381	1.76	7.67
SP-5203	12/08/87 H	77.6	0.41	1.1	59.1	550	152	343	7.72	7.81
SP-5203	02/26/88 L	147	ND	1	77.4					
SP-5204	12/08/87 H	75.0	0.4	1.3	58.2	458	140	211	6.65	7.26
SP-5205	02/26/88 L	6.4	0.3	ND	29.2					
SP-5206	04/22/88 L	16.9	0.4	2.5	99.3					
SP-5207	04/22/88 L	7.1	0.4	2.5	28.2					
SP-5301	12/09/87 H	5.1	0.38	11.4	52.5	397	186	221	4.4	7.70
SP-5301	03/01/88 L	8.5	0.6	18.4	56.9	451		304	3.61	7.85
SP-5302	12/09/87 H	4.8	0.4	21	31.6	349	180	ND	4.2	7.10
SP-5303	12/09/87 H	4.5	0.35	8.1	47.7	373	176	207	ND	7.68
SP-5303	02/26/88 L	5.0	0.5	8.5	38.8	443		106	3.68	7.78
SP-5304	12/09/87 H	3.8	0.32	7.2	42.2	365	182	233	2.3	7.60
SP-5304	02/29/88 L	3.4	0.5	5.2	26.2	457		266	2.25	7.62
SP-5306	12/09/87 H	2.6	ND	0.7	38.0	457	260	358	ND	7.67
SP-5401	12/10/87 H	6.0	0.2	0.1	30.0	374	198	212	32.2	7.68
SP-5402	12/08/87 H	4.3	ND	0.2	19	169	96	132	11.2	7.3
SP-5403	12/08/87 H	7.6	ND	1.7	19.6	178	78	168	13.1	6.94
SP-5405	12/08/87 H	6.9	0.3	0.7	9.2	298	152	202	6.77	7.65
SP-5501	12/08/87 H	3.2	0.3	2.5	29.9	241	140	185	7.01	7.24
SP-5501	02/26/88 L	3.3	0.4	2.6	42.1					
SP-5502	12/08/87 H	5.9	0.4	0.3	31.4	507	296	300	2.70	7.67
SP-5503	12/08/87 H	7.2	0.3	2.7	41.8	279	148	195	3.41	7.47
SP-5601	12/08/87 H	3.0	0.3	0.9	64.5	342	180	141	4.66	7.32
SP-5601	02/26/88 L	2.8	0.4	0.9	28.5					
SP-5602	12/10/87 H	1.8	ND	1.8	41.0	298	168	166	49.2	7.16

Table 4-4: Ionic and Water Quality Parameter Measurements from Springs Near WSSRAP (Continued)

LOCATION	PARAMETER DETECTION LIMIT UNITS DATE_SAMPLED FLOW REGIME*	Cl 0.25 MG/L	F 0.25 MG/L	NO3(as N) 0.1 MG/L	SO4 1.0 MG/L	Conductivity 10 UMHOSCM	Hardness 1.0 MG/L	TDS 1.0 MG/L	TOC 0.1 MG/L	pH - UNITS
		MEASURED VALUES								
SP-5603	12/08/87 H	3.0	0.3	0.84	29.5	329	200	ND	3.57	7.67
SP-5603	02/26/88 L	2.5	0.4	0.4	27.6					
SP-5604	12/08/87 H	2.6	0.5	5.4	28.0	541	300	141	1.84	7.63
SP-6301	12/10/87 H	4.6	0.2	14.9	55.0	268	114	68	52.1	7.09
SP-6301	02/22/88	6.8	0.3	15.5	24.6					
SP-6302	12/10/87 H	4.9	0.25	15	37.0	282	116	151	9.04	7.30
SP-6302	02/22/88	6.9	0.3	15	24.9					
SP-6303	12/08/87 H	4.4	0.6	35.7	33.3	386	184	ND	3.67	7.03
SP-6303	02/26/88 L	3.2	0.3	11.9	32					
SP-6304	02/26/88 L	5.4	0.4	6	40.0					
SP-6306	12/08/87 H	15.3	0.4	4.5	14.9	304	154	203	7.16	7.58
SP-6306	02/29/88 L	11.9	0.4	2	13.2	257		93	4.15	7.47
SP-6501	12/08/87 H	3.2	ND	3	16.3	175	92	98	5.08	7.08
SP-6501	03/01/88 L	3.5	0.3	3.7	21.6	255		151	16.9	7.29
SP-6601	12/08/87 H	2.2	ND	3.8	19.4	291	154	379	3.83	7.62
SP-6601	03/01/88 L	3.3	0.4	5.5	18.8	333		159	4.63	7.24*

H = HIGH,
L = LOW
ND = NO DATA

immediately downgradient of the Missouri State Highway Department Maintenance Facility. The highest chloride value was measured from SP-5203 at 147 mg/l. The average concentration of all the chloride values from the two sampling phases is 12.5 mg/l. It is probable that the elevated chloride level in SP-5203 is the result of the runoff of precipitation which comes into contact with the stockpile and residues of rock salt on the maintenance facility property. This leachate may then infiltrate into the groundwater system. SP-5203 discharges approximately 1,200 feet from the maintenance property. The fact that only the springs in the vicinity of that property, with its readily available source of chloride, revealed chloride levels of such magnitude is further evidence that the maintenance facility may be the source of these increased concentrations.

The chloride levels from all springs sampled, except the values from drainage 5200, were grouped with a mean of 5.0 mg/l and a standard deviation of 2.65. The range of background chloride concentration was therefore calculated to be 0 mg/l to 10.2 mg/l. This reinforces the conclusion that the drainage 5200 levels are outliers from natural background values.

The elevated sulfate concentrations of 77 mg/l and 99 mg/l in SP-5203 and SP-5206, respectively, may be the result of the infiltration of sulfate-contaminated water into the aquifer beneath the site, or it may be attributable to the stock pile and the use of asphaltic products at the highway department facility. The elevations of sulfate concentrations correspond well with the elevated chloride and sodium concentrations in SP-5203.

In five springs located in drainageways near the WSS, nitrate levels are higher than the background range derived as described in Section 4.1. These springs are SP-5301 and SP-5302 in the Southeast Drainage and SP-6301, SP-6302, and SP-6303.

It is likely that the source of high nitrates in the 5300 series springs is the surface water discharged from the site which loses into the stream bed at various known locations along that drainage. This conclusion is based on the known elevated nitrate levels which are regularly measured at National Pollutant Discharge Elimination System (NPDES) sampling location 003 at the head of drainage 5300, just outside the WSS boundary. In 1987, these levels averaged 147 mg/l.

The source of the elevated nitrate in the surface water discharge is not known specifically but can be attributed to some source within the boundaries of the WSS, whether residual contamination from WSOW operations or from operation of the chemical plant (WSCP).

The elevated nitrate levels in the 6300 series springs are believed to be associated with at least two separate sources. The data from SP-6301 and SP-6302 are similar for many parameters including aluminum, iron, manganese, chloride, fluoride, the radiological group, and the nitrate concentrations. Both also lack contamination by nitroaromatic compounds. However, through dye traces, these springs have been shown to be hydrologically connected to the surface discharges from the WSS (see Section 3.4). It is believed that the Ash Pond surface water discharge, which contains elevated nitrate concentrations (an average of 28 mg/l in 1987) contribute, at least in part, to the elevated concentrations at SP-6301 and SP-6302. It is also possible that the groundwater containing elevated nitrate concentrations beneath the WSCP and the raffinate pits (WSRP) may discharge some shall amount to conduit migration, which may in turn be linked to the SP-6301 and SP-6302 system.

SP-6303, on the other hand, is believed to be connected to a source of nitrate that is different from that of SP-6301 and SP-6302. In addition to differences in the data on metals, the radiological group, and inorganc anions, SP-6303 shows the presence of nitroaromatic contamination and a higher level of nitrates than springs SP-6301 and SP-6302. It appears that the water from SP-6303 is influenced by headwaters emanating either as surface or groundwater from the WSTA, where widespread sources of nitroaromatic compounds and nitrates are found. These sources are attributable to the production process involving nitric acid. The various relationships among the different chemical species that are evident in the data lead to the conclusion that, although these springs discharge in close proximity to one another and in a straight-line pattern, the fracture and conduit systems which feed them may be discrete and separate.

4.6 METALS

Spring samples were analyzed during both sampling phases for the 23 different metals prescribed by the U.S. Environmental Protection Agency Contract Laboratory Program (CLP) list of metals (see Table 4-5), plus lithium and molybdenum. Overall, most of the results indicate that the levels of metals in the spring waters are within the expected background ranges. However, the levels of sodium, manganese, lead, and aluminum in a few of the springs are relatively high.

Sodium

The average sodium concentration from all 27 springs was 10,663 µg/l. SP-5203 and SP-5204 samples yielded sodium levels ranging from 50,000 µg/l to 107,000 µg/l. These two springs are in close proximity to the Missouri State Highway Department Maintenance Facility where stockpiles of rock salt (NaCl) are

TABLE 4-5: Metals Concentrations in Springs Near WSSRAP

CONCENTRATIONS (UG/L)

Location	Date Sampled	Species * / Detection Limit / Flow ** Regime	Al 200	Sb 60	Ba 200	Cd 5	Ca 5000	Cr 10	Co 50	Cu 25	Fe 100	Pb 5	Mg 5000	Mn 15	Mo 13	K 5000	Ag 10	Na 5000	V 50	Zn 20
SP-5201	12/09/87	H	ND	ND	ND	ND	57400	16	ND	ND	ND	ND	12900	ND	15	ND	ND	11300	ND	ND
SP-5201	02/29/88	L	161	55	165	ND	65300	24	16	11	140	ND	14800	9	31	2660	ND	12100	23	27
SP-5201	03/28/88	L	ND	ND	85	ND	64000	ND	ND	9	67	ND	13380	6	ND	887	ND	12800	9	12
SP-5201 DUP	03/28/88	L	ND	ND	86	ND	63500	ND	ND	10	197	ND	13400	6	ND	875	12	12200	10	9
SP-5202	12/08/87	H	ND	ND	240	ND	76600	21	ND	ND	132	ND	36800	ND	22	ND	ND	10500	ND	28
SP-5203	12/08/87	H	ND	ND	ND	ND	40000	13	ND	ND	109	ND	10700	15	ND	ND	ND	50200	ND	ND
SP-5203	02/26/88	L	99	69	270	5	67000	25	18	14	75	ND	18000	9	31	4830	5	107000	23	11
SP-5204	12/08/87	H	251	ND	ND	ND	36000	12	ND	ND	301	ND	9650	ND	ND	ND	ND	50800	ND	43
SP-5205	02/26/88	L	93	73	72	5	35800	921	17	7	15	5.85	12400	5	35	3140	5	6550	18	27
SP-5301	12/09/87	H	ND	ND	ND	ND	49300	14	ND	ND	ND	ND	11500	18	15	ND	ND	14500	ND	ND
SP-5301	03/01/88	L	205	76	160	ND	61000	26	16	10	214	15.[illegible]	16100	57	42	3180	6	22100	22	30
SP-5302	12/09/87	H	ND	ND	ND	ND	47000	14	ND	ND	127	ND	10900	ND	20	ND	ND	13900	ND	ND
SP-5303	12/09/87	H	ND	ND	ND	ND	46900	19	ND	ND	ND	ND	10700	ND	23	ND	ND	12500	ND	ND
SP-5303	02/29/88	L	236	70	156	ND	64100	26	12	10	305	ND	13700	29	38	2610	ND	11900	23	27
SP-5304	12/09/87	H	ND	ND	ND	ND	52700	15	ND	ND	ND	ND	9300	ND	34	ND	ND	11100	ND	ND
SP-5304	02/29/88	L	175	73	155	ND	74100	26	15	10	154	ND	12300	11	39	2720	4	8260	24	31
SP-5306	12/09/87	H	ND	ND	ND	ND	76300	15	ND	ND	ND	ND	10500	ND	ND	ND	ND	ND	ND	ND
SP-5401	12/10/87	H	ND	ND	ND	ND	58800	13	ND	ND	117	ND	10200	ND	ND	ND	ND	5540	ND	61
SP-5401 DUP	12/10/87	H	ND	ND	ND	ND	59900	15	ND	ND	ND	ND	10400	ND	ND	ND	ND	5200	ND	40
SP-5402	12/08/87	H	502	ND	ND	ND	25300	ND	ND	ND	594	35	3570	ND	ND	ND	ND	ND	ND	57
SP-5403	12/08/87	H	900	ND	ND	ND	21400	10	ND	ND	1030	ND	3250	ND	ND	ND	ND	5280	ND	40
SP-5405	12/08/87	H	252	ND	ND	ND	40000	11	ND	ND	359	ND	6230	ND	ND	ND	ND	ND	ND	39
SP-5501	12/08/87	H	221	ND	ND	ND	39200	12	ND	ND	247	ND	7470	ND	ND	ND	ND	6080	ND	32
SP-5501	02/26/88	L	95	81	84	ND	57600	23	16	10	150	ND	10700	6	31	2240	4	7710	19	7
SP-5502	12/08/87	H	ND	ND	ND	ND	80000	21	ND	ND	312	7	16000	30	ND	ND	ND	6350	ND	58
SP-5503	12/08/87	H	ND	ND	ND	ND	40200	15	ND	ND	307	ND	8970	ND	ND	ND	ND	10700	ND	30
SP-5601	12/08/87	H	ND	ND	ND	ND	49400	14	ND	ND	ND	ND	10040	ND	ND	ND	ND	ND	ND	ND
SP-5601	02/26/88	L	106	95	131	ND	54500	24	18	10	63	ND	10800	6	31	2540	4	3820	20	26
SP-5602	12/10/87	H	ND	ND	ND	ND	55400	14	ND	ND	259	ND	6810	24	ND	ND	ND	5360	ND	50
SP-5603	12/08/87	H	ND	ND	ND	ND	56700	15	ND	ND	139	ND	11500	ND	ND	ND	ND	ND	ND	37
SP-5603	02/26/88	L	104	85	66	ND	56100	27	16	10	16.1	ND	11200	37	29	2310	4	3450	20	12
SP-5604	12/08/87	H	ND	ND	ND	ND	81600	23	ND	ND	ND	ND	18300	28	ND	ND	ND	12100	ND	42
SP-6301	12/10/87	H	606	ND	ND	ND	35600	ND	ND	ND	666	ND	7390	20	ND	ND	ND	9050	ND	31
SP-6302	12/10/87	H	810	ND	ND	ND	33300	13	ND	ND	900	ND	7070	29	ND	ND	ND	8400	ND	ND

TABLE 4-5: Metals Concentrations in Springs Near WSSRAP (Continued)

CONCENTRATIONS (UG/L)

Location	Date Sampled	Species * / Detection Limit / Flow ** Regime	Al 200	Sb 60	Ba 200	Cd 5	Ca 5000	Cr 10	Co 50	Cu 25	Fe 100	Pb 5	Mg 5000	Mn 15	Mo 13	K 5000	Ag 10	Na 5000	V 50	Zn 20
SP-6303	12/08/87	H	ND	ND	ND	ND	44300	14	ND	ND	193	ND	11700	1240	ND	ND	ND	11100	ND	ND
SP-6303	02/26/88	L	87	72	67	ND	30600	16	14	6	105	ND	7750	14	30	2510	ND	6830	13	11
SP-6304	02/26/88	L	96	64	72	ND	45000	20	16	27	66	ND	6750	13	24	3100	ND	6110	15	11
SP-6306	12/08/87	H	ND	ND	ND	6	34600	13	ND	ND	458	ND	8440	6100	ND	ND	ND	12200	ND	42
SP-6306	02/29/88	L	111	81	355	ND	33300	20	20	7	360	ND	7950	7050	34	2930	4	10800	14	31
SP-6501	12/08/87	H	1500	ND	ND	ND	26600	ND	ND	ND	1500	ND	ND	20	ND	ND	ND	ND	ND	43
SP-6501	03/01/88	L	163	86	167	ND	41000	19	16	6	119	ND	7470	6	24	2760	ND	5350	15	32
SP-6601	12/08/87	H	1420	ND	ND	ND	43600	12	ND	ND	1440	5	8090	33	ND	ND	ND	5230	ND	32
SP-6601	03/01/88	L	345	88	96	ND	52700	23	16	7	368	ND	8580	57	31	2530	3	5550	19	7

* Analyses were also performed for arsenic, beryllium, lithium, mercury, nickel, selenium, and thallium. All results for these elements were below the laboratory detection limits.

** H = High Flow, L = Low Flow

stored. Also, these are the same springs which yield higher than average chloride and sulfate concentrations, which is further evidence of a possible connection with the maintenance facility.

Manganese

SP-6306 contains apparently elevated manganese concentrations of 6,100 μg/l and 7,050 μg/l compared to a mean value of 417 μg/l. The source of these elevated concentrations is unknown. However, SP-6306 is believed to discharge waters from the bed of one of the Busch Wildlife Area lakes. The deeper portions of the lake may constitute a chemically reducing environment which may contribute to the increased dissolution of manganese.

One sample from SP-6303 also indicated an elevated manganese level of 1,240 μg/l. However, a subsequent sample showed the concentration to be well within the background range. The source of this sporadic elevated manganese concentration is unknown.

Manganese is a naturally occurring element in the glacial till material in this area and has been observed in soil samples on and around the WSS in the mineralized form, pyrolucite (MnO_2). In addition, manganese was detected in the raffinate sludges in Raffinate Pit 3. However, the level of solid manganese detected in the sludge is less than half the dissolved concentration in SP-6306. The source of the elevated manganese in SP-6306 is unknown. Possibly, it is dissolved from the natural soil material in the reducing environment of the lake bottom which feeds the spring.

Lead

The highest level of lead in any spring was 35 µg/1 in SP-5402, a wet-weather spring downgradient of the WSTA. The direct source of the elevated lead values is not known. However, it is known that lead was used as a non-sparking material in the production line buildings of the Army's ordnance operations in the 1940s.

Aluminum

Two springs, SP-6501 and SP-6601, showed somewhat elevated aluminum values of 1,500 µg/1 and 1,420 µg/1. The mean value of the 36 aluminum measurements from the 27 springs was 329.4 µ/1 and the calculated 2-sigma background concentration was approximately 970 µg/1.

Although the raffinate sludge at the WSS does contain aluminum in the solid form at that range of concentration, it is unreasonable to believe that only dissolved aluminum could travel the 2.5 miles to these springs and not be accompanied by any other substances associated with the sludge or other materials at the WSS. The source of the elevated aluminum concentration is unknown. However, aluminum is a naturally occurring metal in the glacial till clays and the residual clays in the area. Analysis for other metals, including arsenic, beryllium, cadmium, cobalt, lithium, mercury, nickel, selenium, silver, and vanadium, yielded results which were at or below the detection limits for these species. Table 4-4 displays the analytical results for parameters at concentrations above the detection limits.

4.7 POLYCHLORINATED BIPHENYLS/PESTICIDES

All of the 27 springs which were sampled in the first sampling effort were analyzed for 27 compounds in the polychlorinated biphenyl (PCB)/pesticide category.

None of the compounds were detected above the minimum detection limits, which ranged from 0.05 µg/l to 0.10 µg/l, in any of the sampled springs.

5 CONCLUSIONS

The data show no contamination by any of the potential WSS contaminants in 16 of the 27 springs.

Uranium was the only radioactive constituent found in any of the seeps and springs. It was found in seven locations; two in the 6300 drainage, four in the 5300 drainage, and one in the 5200 drainage.

No volatile organics were detected in any of the locations.

Nitroaromatics were detected in at least one location in each of the 5200, 5300, 5500, and 6300 drainages.

Chloride and sulfate levels were found to be elevated above the background levels in only the 5200 drainage. These waters are probably contaminated from runoff originating from the Missouri Highway Department facility.

Inorganic anions concentrations above background levels were located only in the 5200 drainage and at SP-6306. These are probably due to runoff originating from the Missouri Highway Department salt storage area and also from road surfaces treated with rock salt for snow and ice removal.

Concentrations of four species of metals were found to be elevated above background levels. Elevated concentrations of sodium were detected in the 5200 drainage, probably from runoff from the highway department facility. Other metals, including aluminum, manganese, and lead were detected at elevated concentrations in several other springs around the area. Aluminum and manganese are naturally occuring elements in the soils in this area. The source of the elevated lead concentrations is unknown.

No pesticides or polychlorinated biphenyls (PCBs) were detected at any locations.

6 RECOMMENDATIONS

The chemical and radiological survey of the 27 springs sampled revealed 11 springs which contained contamination by substances directly or believed to be possibly attributable to the Weldon Spring Site (WSS). These springs are:

SP-5201	SP-5304
SP-5203	SP-5503 (wet weather)
SP-5301	SP-6301
SP-5302	SP-6302
SP-5303	SP-6303
	SP-6306

It is recommended that these springs be incorporated into the Weldon Spring Site Remedial Action Project (WSSRAP) Environmental Monitoring Program Plan for routine and periodic monitoring.

The spring waters should be analyzed for radiologic parameters (uranium, thorium, and radon), inorganic anions, water quality, and nitroaromatics. In addition, each sample should be analyzed annually for Contract Laboratory Program (CLP) metals to track and update the status of the heavy metals concentrations. These data can be compared and possibly correlated with other groundwater and surface water metals concentrations.

Because the evidence indicates that they are not influenced by contaminants associated with the WSS, the remaining springs should not be included in the routine monitoring program. However, two springs do show some level of nitroaromatic contamination believed to be associated with the known nitroaromatic sources in the Weldon Spring Training Area (WSTA).

Valuable information can be obtained from the continued physical monitoring of the flow schemes of selected local wet-weather springs associated with precipitation events. Continued and increased emphasis should be placed on monitoring the flows of these springs including SP-5402, SP-5503, SP-6302, and any others which may later be discovered to show some unusual flow characteristics in response to precipitation. The monitoring should include, but not be limited to, visual flow monitoring and record keeping during and after several rainfall events to determine the response times of these springs to precipitation and increased infiltration.

7 REFERENCES

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BNI, see Bechtel National, Inc.

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency

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8 ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
BNI	Bechtel National, Inc.
CLP	U.S. Environmental Protection Agency Contract Laboratory Program
DA	Department of the Army
DNT	dinitrotoluene
DOC	U.S. Department of Commerce
DOE	U.S. Department of Energy
MDNR	Missouri Department of Natural Resources
MSL	Mean Sea Level
NLO	National Lead Company of Ohio
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyl
PMC	Project Management Contractor
RI/FS	Remedial Investigation/Feasibility Study
TNT	trinitrotoluene
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USGS	U.S. Geologic Survey
WSCP	Weldon Spring Chemical Plant
WSOW	Weldon Spring Ordnance Works
WSRP	Weldon Spring Raffinate Pits
WSS	Weldon Spring Site
WSSRAP	Weldon Spring Site Remedial Action Project
WSTA	Weldon Spring Training Area
WSUFMP	Weldon Spring Uranium Feed Material Plant

APPENDIX
DATA QUALITY

PHASEISS/TXTJOANN

DATA QUALITY

Throughout the sampling efforts, analytical data quality was assessed through the use of duplicate method blanks and blank spikes, matrix spikes, and matrix spike duplicates.

Analyses were performed on two blind field duplicate samples for metals, nitroaromatics, radiologic parameters, and inorganic anions. The results are presented in the tables within the text. In addition, laboratory duplicate analyses were conducted on two other samples for radiologic parameters alone. Duplicate analyses were conducted for nitroaromatic, compounds total organic carbon, and metals. These results are presented in this appendix.

Four sets of blank spiked samples were analyzed to determine the effectiveness of the method to recover the analyte. No shipping blanks were utilized. Results of the blank spikes are included in this appendix. Also, four matrix spike samples were analyzed for metals and total organic carbon to evaluate whether the sample matrix acted to mask or inhibit the yield of the extraction method. Results of the matrix spikes and spike duplicates are presented in this appendix.

Overall, no holding times were exceeded and the quality control data are acceptable. Therefore, the analytical data presented in this report conform to applicable standards of accuracy and precision and are representative of actual sample conditions at the time of collection.

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CLIENT: MK Ferguson
PROJECT #'s: 160-02, 100-03
SAMPLE #'s: AA06105 - AA08020 (water)

RADIOCHEMICAL ANALYSIS CONFORMANCE SUMMARY

1) GAS PROPORTIONAL COUNTER

- a) BACKGROUND ACCEPTABLE ALPHA ☒
- b) BACKGROUND ACCEPTABLE BETA ☒
- c) PERFORMANCE CHECK ACCEPTABLE ALPHA ☒
- d) PERFORMANCE CHECK ACCEPTABLE BETA ☒

2) ALPHA SPECTROMETER

- a) BACKGROUND ACCEPTABLE ☒
- b) CALIBRATION (KeV/CHANNEL) VERIFICATION ☒

3) ALPHA SCINTILLATION COUNTER

- a) BACKGROUND ACCEPTABLE ☐
- b) PERFORMANCE CHECK ACCEPTABLE ☐

4) METHOD SPECIFIC PARAMETERS

- a) BLANK IN CONTROL ☒
- b) SPIKED BLANK IN CONTROL ☒
- c) RPD FOR DUPLICATES IN CONTROL ☒

ADDITIONAL COMMENTS: ______

Richard H. Manny
PROJECT MANAGER

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

CLIENT: MK Ferguson
PROJECT #'s: 100-02, 100-03
SAMPLE #'s: AA06105 - AA08020 (water)

METALS/INORGANIC ANALYSIS CONFORMANCE SUMMARY

1) INITIAL CALIBRATION CURVE OR CALIBRATION CHECK STANDARD RUN PER METHOD EPA CLP ☒

2) BLANK CONTAMINATION - COMPOUNDS LISTED

   a) METALS no contaminates

   b) INORGANIC no contaminates

3) SPIKED BLANK (LABORATORY CONTROL SAMPLE) WITHIN CONTROL LIMITS ☒

4) SAMPLE HOLDING TIMES MET All holding times met ☒

5) MINIMUM DETECTION LIMITS ON METALS/INORGANICS AT OR BELOW METHOD SPECIFICATIONS ☒

6) ALL SAMPLES CONFORM TO EPA CLP QA/QC CRITERIA UNLESS OTHERWISE DENOTED BELOW ☒

ADDITIONAL COMMENTS:

Richard H. Manny
PROJECT MANAGER

metaTRACE, Inc. ■ 13715 Rider Trail North ■ Earth City, MO 63045 ■ (314) 298-8566

CLIENT: M K Ferguson
PROJECT #'s: 100-02 100-03
SAMPLE #'s: AA0 6105 - AA0 8020 (water)

GC/HPLC ANALYSIS CONFORMANCE SUMMARY

1) GC/HPLC CALIBRATION - INITIAL CALIBRATION CURVE OR CALIBRATION CHECK STANDARD RUN PER METHOD GC - EPA CLP HPLC - USATHAMA ☒

2) BLANK CONTAMINATION - COMPOUNDS LISTED

a) GC no contaminates

b) HPLC no contaminates

3) SPIKED BLANK WITHIN CONTROL LIMITS ☒

4) SAMPLE HOLDING TIMES MET All holding times met ☐

5) MINIMUM DETECTION LIMITS ON GC/HPLC METHODS AT OR BELOW METHOD SPECIFICATIONS ☒

6) ALL SAMPLES CONFORM TO EPA QA/QC CRITERIA UNLESS OTHERWISE DENOTED BELOW ☒

ADDITIONAL COMMENTS:

Richard H. Manny
PROJECT MANAGER

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CONDUCTIVITY - SPRINGWATER
DUPLICATE RESULTS (UMHOSCM)
CONDUCTIVITY STANDARD PERCENT RECOVERY

SAMPLE # AA06528
SITE ID: SP-5603-120887

ANALYTE	RESULT #1	RESULT #2
CONDUCTIVITY STANDARD	329	359

CONDUCTIVITY 91.9 PERCENT RECOVERY

SAMPLE # AA06538
SITE ID: SP-5503-120887

ANALYTE	RESULT #1	RESULT #2
CONDUCTIVITY STANDARD	279	296

CONDUCTIVITY 92.1 PERCENT RECOVERY

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TOTAL DISSOLVED SOLIDS - SPRINGWATER
DUPLICATE RESULTS (MG/L)
TDS STANDARD PERCENT RECOVERY

MPLE # AA06526
TE ID: SP-6306-120887

ALYTE	RESULT #1	RESULT #2
TAL DISSOLVED SOLIDS	203	172

TAL DISSOLVED SOLIDS STANDARD 112% RECOVERY

MPLE # AA06766
TE ID: SP-6301-121087

ALYTE	RESULT #1	RESULT #2
TAL DISSOLVED SOLIDS	161	208

TAL DISSOLVED SOLIDS STANDARD 112% RECOVERY

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WSSRAP PROJECT NO: 100-03
WATER DUPLICATES
MATRIX: WATER
UNITS: UG/L

SAMPLE NO: AA07055
SITE ID: GW-3007-0487

	NITRATE	FLUORIDE	CHLORIDE	SULFATE
RESULT #1	2657	0.7	4.9	255
RESULT #2	2020	0.7	4.9	157

SAMPLE NO: AA06531
SITE ID: SP-6601-120887

	NITRATE	FLUORIDE	CHLORIDE	SULFATE
RESULT #1	3.8	ND	2.2	19.4
RESULT #2	5.3	ND	1.8	18.4

SAMPLE NO: AA06764
SITE ID: SP-6301-121087

	NITRATE	FLUORIDE	CHLORIDE	SULFATE
RESULT #1	14.9	0.2	4.6	55
RESULT #2	15.4	<0.25	4.7	37

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RADIOLOGICAL - SPRINGWATER
DUPLICATE RESULTS AND BLANK SPIKE RECOVERY

SAMPLE # AA06761
SITE ID: SP-5401-120987

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
RADIUM 228	<1	<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
RADIUM 228	103

SAMPLE # AA06769
SITE ID: SP-6601-121087

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
RADIUM 228	<2	<2

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
RADIUM 228	91

SAMPLE # AA06517
SITE ID: GW-3013-0487

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
THORIUM 230/232	<1/<1	<1/<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
THORIUM 230/232	105/96

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RADIOLOGICAL - SPRINGWATER
DUPLICATE RESULTS AND BLANK SPIKE RECOVERY

SAMPLE # AA06526
SITE ID: SP-6306-120887

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
RADIUM 226	<1	<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
RADIUM 226	110

AMPLE # AA06761
SITE ID: SP-5401-120987

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
RADIUM 226	<1	<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
RADIUM 226	91

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RADIOLOGICAL - GROUND WATER
DUPLICATE RESULTS AND BLANK SPIKE RECOVERY

SAMPLE # AA06393
SITE ID: GW-2015-0487

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
THORIUM 230/232	<1/<1	<1/<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
THORIUM 230/232	90/92

SAMPLE # AA06517
SITE ID: GW-3013-0487

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
THORIUM 230/232	<1/<1	<1/<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
THORIUM 230/232	87/128

SAMPLE # AA06770
SITE ID: SP-6601-121087

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
THORIUM 230/232	<1/<1	<1/<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
THORIUM 230/232	105/96

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RADIOLOGICAL - GROUND WATER
DUPLICATE RESULTS AND BLANK SPIKE RECOVERY

SAMPLE # AA06324
SITE ID: GW-2001-0487

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
TOTAL URANIUM	1.3 +/- 0.7	1.8 +/- 0.8

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
TOTAL URANIUM	110

SAMPLE # AA06333
ITE ID: GW-2010-0487

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
TOTAL URANIUM	<1.2	<1.2

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
TOTAL URANIUM	105

SAMPLE # AA06613
SITE ID: SP-5201-120987

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
TOTAL URANIUM	<1	<1

ANK SPIKE

ANALYTE	PERCENT RECOVERY
TOTAL URANIUM	99

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NITROAROMATICS - WATER
BLANK SPIKE RESULTS
PERCENT RECOVERY

BLANK SPIKE #73

ANALYTE	PERCENT RECOVERY
1,3,5-TNB	28
1,3-DNB	50
NITROBENZENE	45
2,4,6-TNT	87
2,6-DNT	109
2,4-DNT	94

BLANK SPIKE #75

ANALYTE	PERCENT RECOVERY
1,3,5-TNB	95
1,3-DNB	97
NITROBENZENE	97
2,4,6-TNT	86
2,6-DNT	89
2,4-DNT	96

BLANK SPIKE #76

LYTE	PERCENT RECOVERY
1,3,5-TNB	65
1,3-DNB	75
NITROBENZENE	65
2,4,6-TNT	90
2,6-DNT	76
2,4-DNT	79

BLANK SPIKE #77

ANALYTE	PERCENT RECOVERY
1,3,5-TNB	24
1,3-DNB	46
NITROBENZENE	43
2,4,6-TNT	91
2,6-DNT	86
2,4-DNT	90

BLANK SPIKE #78

ANALYTE	PERCENT RECOVERY
1,3,5-TNB	29
1,3-DNB	46
NITROBENZENE	42
2,4,6-TNT	88
2,6-DNT	100
2,4-DNT	85

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SAMPLE # AA06761
SITE ID: SP-5401-120987

ANALYTE	RESULT #1	RESULT #2
1,3,5-TNB	<0.03	<0.03
1,3-DNB	<0.40	<0.40
NITROBENZENE	<0.60	<0.60
2,4,6-TNT	<0.50	<0.50
2,6-DNT	<0.60	<0.60
2,4-DNT	<0.20	<0.20

SAMPLE # AA06834
SITE ID: GW-1002-0487

ANALYTE	RESULT #1	RESULT #2
3,5-TNB	<0.03	<0.03
.,3-DNB	<0.40	<0.40
NITROBENZENE	<0.60	<0.60
2,4,6-TNT	<0.50	<0.50
2,6-DNT	<0.60	<0.60
2,4-DNT	<0.20	<0.20

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WSSRAP
WATER SPIKES
MATRIX: WATER
UNITS: UG/L

SAMPLE NO: AA06769
SITE ID: SP-6601-121087 (MS)

	SAMPLE CONC	SPIKE CONC	SAMPLE+SPIKE	PERCENT RECOVERY
ALUMINUM	240	2000	2270	102
ANTIMONY	<60	500	445	89
ARSENIC	<10	20	22	110
BARIUM	140	2000	2130	100
BERYLLIUM	<5	50	49	98
CADMIUM	<5	50	48	96
CALCIUM	----	NA	----	----
CHROMIUM	12	200	205	97
COBALT	<50	500	475	95
COPPER	<25	250	247	99
IRON	262	1000	1340	108
LEAD	<36	500	522	104
MAGNESIUM	----	NA	----	----
MANGANESE	10	200	210	100
MERCURY	<0.2	1	1.02	102
NICKEL	<40	400	404	101
POTASSIUM	----	NA	----	----
SELENIUM	<5	10	<5	0
SILVER	<10	50	23	46
SODIUM	----	NA	----	----
THALLIUM	<5	50	42	84
VANADIUM	<50	500	491	98
ZINC	26	200	218	96
LITHIUM	----	NA	----	----

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WSSRAP
WATER DUPLICATES
MATRIX: SPRING WATER
UNITS: UG/L

SAMPLE NO: AA06531
SITE ID: SP-6601-120887

	RESULT #1	RESULT #2
ALUMINUM	1420	225
ANTIMONY	ND	ND
ARSENIC	ND	ND
BARIUM	ND	110
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	43600	49800
CHROMIUM	12	35
COBALT	ND	ND
COPPER	ND	ND
IRON	1440	310
LEAD	5	ND
LITHIUM	ND	ND
MAGNESIUM	8090	8650
MANGANESE	33	ND
MERCURY	ND	ND
NICKEL	ND	ND
POTASSIUM	ND	ND
SELENIUM	ND	ND
SILVER	ND	ND
SODIUM	5230	5850
THALLIUM	ND	ND
VANADIUM	ND	ND
ZINC	32	185

SAMPLE NO: AA06614
SITE ID: SP-5306-120987

	RESULT #1	RESULT #2
ALUMINUM	ND	ND
ANTIMONY	ND	ND
ARSENIC	ND	ND
BARIUM	ND	95
BERYLLIUM	ND	ND
CADMIUM	ND	ND
CALCIUM	76300	76400
CHROMIUM	15	15
COBALT	ND	ND
COPPER	ND	ND
IRON	ND	310
LEAD	ND	ND
LITHIUM	ND	ND
MAGNESIUM	10500	10600
MANGANESE	ND	ND
MERCURY	ND	ND
NICKEL	ND	ND
POTASSIUM	ND	ND
SELENIUM	ND	ND
SILVER	ND	ND
SODIUM	ND	ND
THALLIUM	ND	ND
VANADIUM	ND	ND
ZINC	ND	ND

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TOC - SPRINGWATER
MATRIX SPIKE
PERCENT RECOVERY

SAMPLE # AA06535
SITE ID: SP-5202-120887

ANALYTE	PERCENT RECOVERY
TOTAL ORGANIC CARBON	82

SAMPLE # AA06765
SITE ID: SP-6301-121087

ANALYTE	PERCENT RECOVERY
TOTAL ORGANIC CARBON	96

TOC - SPRINGWATER
DUPLICATE RESULTS
(MG/L)

SAMPLE # AA06535
SITE ID: SP-5202-120887

ANALYTE	RESULT #1	RESULT #2
TOTAL ORGANIC CARBON	1.76	1.00

SAMPLE # AA06764
SITE ID: SP-6301-121087

ANALYTE	RESULT #1	RESULT #2
.OTAL ORGANIC CARBON	52.1	55.1

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RADIOLOGICAL - SPRINGWATER
DUPLICATE RESULTS AND BLANK SPIKE RECOVERY

SAMPLE # AA06767
SITE ID: SP-6302-121087

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
THORIUM 230/232	<1	<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
THORIUM 230/232	87/128

IPLE # AA06613
SITE ID: SP-5201-120987

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
TOTAL URANIUM	<1	<1

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
TOTAL URANIUM	99

SAMPLE # AA06769
SITE ID: SP-6601-121087

ANALYTE	RESULT #1 (pCi/L)	RESULT #2 (pCi/L)
TOTAL URANIUM	<1	<1

ANK SPIKE

ANALYTE	PERCENT RECOVERY
TOTAL URANIUM	102

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NITROAROMATICS - WATER
DUPLICATE RESULTS
(UG/L)

SAMPLE # AA06335
SITE ID: GW-2012-0487

ANALYTE	RESULT #1	RESULT #2
1,3,5-TNB	1.40	1.40
1,3-DNB	4.60	4.60
NITROBENZENE	<0.60	<0.60
2,4,6-TNT	1.00	1.00
2,6-DNT	<0.60	<0.60
2,4-DNT	7.60	7.90

SAMPLE # AA06527
SITE ID: SP-5604-120887

ANALYTE	RESULT #1	RESULT #2
1,3,5-TNB	<0.03	<0.03
1,3-DNB	<0.40	<0.40
NITROBENZENE	<0.60	<0.60
2,4,6-TNT	<0.50	<0.50
2,6-DNT	<0.60	<0.60
2,4-DNT	<0.20	<0.20

SAMPLE # AA06617
SITE ID: SP-5301-120987

ANALYTE	RESULT #1	RESULT #2
1,3,5-TNB	<0.03	<0.03
1,3-DNB	<0.40	<0.40
NITROBENZENE	<0.60	<0.60
2,4,6-TNT	<0.50	<0.50
2,6-DNT	<0.60	<0.60
2,4-DNT	<0.20	<0.20

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WSSRAF
WATER SPIKE
MATRIX: SPRING WATER
UNITS: UG/L

SAMPLE NO: AA06527
SITE ID: SP-5604-120887

	SAMPLE CONC	SPIKE CONC	SAMPLE+SPIKE	PERCENT RECOVERY
ALUMINUM	65	2000	1990	96
ANTIMONY	<60	500	508	102
ARSENIC	<10	20	24	120
BARIUM	76	2000	2060	99
BERYLLIUM	<5	50	52	104
CADMIUM	<5	50	55	110
CALCIUM	----	NA	----	----
CHROMIUM	23	200	216	97
COBALT	<50	500	466	93
COPPER	<25	250	249	100
[illegible]	490	1000	1490	100
[illegible]	<36	500	500	100
MAGNESIUM	----	NA	----	----
MANGANESE	28	200	214	93
MERCURY	<0.2	1	1.02	102
NICKEL	<40	400	405	101
POTASSIUM	----	NA	----	----
SELENIUM	<5	10	<5	0
SILVER	<5	50	43	86
SODIUM	----	NA	----	----
THALLIUM	<5	50	50	100
VANADIUM	21	500	497	95
ZINC	42	200	260	109
LITHIUM	----	NA	----	----

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WSSRAP PROJECT NO: 100-03
WATER SPIKES
MATRIX: WATER
UNITS: MG/L

SAMPLE NO: AA07056 1:200 DILUTION
SITE ID: GW-3007-0487 (MS)

	SAMPLE CONC	ADDED AMOUNT	SPIKE	PERCENT RECOVERY
NITRATE	2657	1	17.9	125
CHLORIDE	4.9	1	1.2	120
FLUORIDE	0.7	1	1.1	110
SULFATE	255	1	2.8	122

SAMPLE NO: AA06765 1:10 DILUTION
SITE ID: SP-6301-121087 (MS)

	SAMPLE CONC	ADDED AMOUNT	SPIKE	PERCENT RECOVERY
NITRATE	14.9	2	3.9	115
CHLORIDE	4.6	2	2.8	108
FLUORIDE	0.2	2	2.6	77
SULFATE	55	2	5.3	106

SAMPLE NO: AA06769
SITE ID: SP-6601-121087 (MS)

	SAMPLE CONC	ADDED AMOUNT	SPIKE	PERCENT RECOVERY
NITRATE	5.3	2	7.6	104
CHLORIDE	1.8	2	3.1	82
FLUORIDE	<0.25	2	1.7	85
SULFATE	18.4	2	20.5	100

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HARDNESS - SPRINGWATER
DUPLICATE RESULTS (MG/L)
BLANK SPIKE PERCENT RECOVERIES

SAMPLE # AA06528
SITE ID: SP-5603-120887

ANALYTE	RESULT #1	RESULT #2
HARDNESS	200	196

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
HARDNESS	100

SAMPLE # AA06767
SITE ID: SP-6302-121087

ANALYTE	RESULT #1	RESULT #2
HARDNESS	116	120

BLANK SPIKE

ANALYTE	PERCENT RECOVERY
HARDNESS	99

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pH - SPRINGWATER
DUPLICATE RESULTS (pH UNITS)
METER EFFICIENCY

SAMPLE # AA06526
SITE ID: SP-6306-120887

ANALYTE	RESULT #1	RESULT #2
pH	7.58	7.56

METER EFFICIENCY 0.9924

SAMPLE # AA06613
SITE ID: SP-5201-120987

ANALYTE	RESULT #1	RESULT #2
pH	7.49	7.46

METER EFFICIENCY 1.0036