Expert Report

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Gregory A. Christian, et al., v. BP Amoco Corporation, et al., Atlantic Richfield Company, et al., Cause No. DV-08-173

Qualifications

I, John R. Kane, have worked in the Environmental Consulting field for 26 years. I am currently the CEO/President of Kane Environmental, Inc. based in Seattle, Washington. I have been working in this position for 13 years. My CV is attached.

During my 26 years of professional experience my main focus has been on contaminant investigation and remediation of soil and groundwater. My experience includes a wide variety of contaminants including metals, solvents, pesticides, PCBs, wood treating chemicals and petroleum.

I have supervised, designed, installed, and monitored various types of remedial technologies including soil vapor extraction, groundwater sparging, bioremediation, bioventing, monitored natural attenuation, passive barrier wall treatment, and excavation and off-site disposal.

Scope of Inquiry

On behalf of the plaintiffs, the owner's of private property located in Opportunity and Crackerville, Montana, I have been asked to investigate metals contamination in soil and groundwater on their property to determine whether restoration for their property is technologically and economically feasible and if so, to determine the cost and scope of work for restoration. I have completed similar work for private property locations

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associated with the former smelter located in North Everett, Washington, and residential properties in the vicinity of the former Asarco smelter in Tacoma, Washington. I worked as a field geologist on the Old Works and Smelter Hill sites from approximately 1987 to 1989 timeframe for a previous employer.

Opinions and information contained in this disclosure are based on review of available site information provided in ARCO and governmental documents, site investigation data results, and sampling data from Kane Environmental's soil, indoor dust, and groundwater sampling/testing work. ARCO's reports contain data collected by other consultants and contractors and the data were reviewed and compared with data collected by Kane Environmental and used for the basis of the opinions expressed in this disclosure. The attachments to this report may be used as exhibits at trial. Due to the volume of reference documents and data, and on-going investigations by ARCO's consultant and Kane Environmental, it is my intention to review and collect additional data before trial. I reserve the right to modify and/or supplement my opinions and attachments based on the review or collection of additional data and/or reports.

Facts and Opinions

Based on my review of existing data, I expect to testify to the following opinions:

1) Operations at the former Anaconda Smelter (Smelter Hill) resulted in significant and substantial contamination of arsenic and heavy metals detected above background concentrations from smelter emissions in soil and groundwater on private property in Opportunity and Crackerville.

2) Metals in soil and groundwater have known health effects and some are known carcinogens.

3) ARCO's testing and analysis provided inadequate characterization of the extent of metals soil and groundwater contamination above background in the residential areas in Opportunity and Crackerville.

4) Contrary to ARCO's representations, restoration of contaminated private property residential soils and shallow groundwater is feasible using accepted methods of cleanup.

5) The estimated cost to restore soil and groundwater on the plaintiffs private property is attached in Table 1.

6) Concentrations of arsenic and heavy metals were found in dust sampling conducted inside plaintiff's residences.

SUMMARY OF GROUNDS FOR OPINIONS

1) Operations at the former Anaconda Smelter (Smelter Hill) resulted in significant and substantial contamination of arsenic and heavy metals detected above background concentrations from smelter emissions in soil and groundwater on private property in Opportunity and Crackerville.

I have been asked to determine whether historical smelting operations at Smelter Hill resulted in concentrations of metals in soil and groundwater above background on private property owned by citizens of Opportunity and Crackerville that have brought this lawsuit. I determined the concentrations of arsenic and cadmium, copper, lead, and zinc in the soil and groundwater on the private properties. To determine whether the properties are contaminated, background concentrations of arsenic, cadmium, copper, lead and zinc were calculated from soil collected at the private properties, and from drinking water well data from the Opportunity and Crackerville areas obtained from the Montana Bureau of Mines and Geology. Based on my education, experience and review of historical data related to operations at Smelter Hill, I concluded that the most likely cause of the elevated arsenic and heavy metals in the soil and groundwater in Opportunity and Crackerville is from the operations at Smelter Hill.

1a. Background Concentrations of Arsenic and Other Heavy Metals

Background soil and groundwater concentrations were calculated for Opportunity and Crackerville based on soil samples collected during Kane Environmental's investigation

and using drinking water well data collected from drinking water wells in Opportunity and Crackerville areas from the Montana Bureau of Mines and Geology database.

Soil samples collected with a starting depth of 2 feet or more and beneath the surface from each sampling location in the unsaturated zone, was used to calculate background concentrations of arsenic, cadmium, copper, lead and zinc. Soil analytical data from the June and October 2012 soil sampling investigations were used. Laboratory duplicate analyses were used in the calculations. One-half the laboratory test detection limit was considered non-detectable concentrations of metals. A total of 168 samples were used to calculate background concentrations. The following mean (average) for each metal in parts per million (ppm) is:

Arsenic	12.98
Cadmium	0.232
Copper	17.94
Lead	9.577
Zinc	38.76

The median concentrations in ppm of the five metals is:

Arsenic	6.445
Cadmium	0.111
Copper	11.75
Lead	7.315
Zinc	32.70

Groundwater background concentrations were calculated using total metals from the Montana Bureau of Mines and Geology, using wells greater than or equal to 20 feet below ground surface. Only one duplicate laboratory result was reported in the database and it was not used in the background calculations. Test method detection limits were used because method detection limits were not provided in the Montana Bureau of Mines and Geology drinking water database. A total of 107 samples were used from a depth greater than or equal to 20 feet.

The following mean (average) for each metal in parts per billion (ppb) is:

Arsenic	1.134
Cadmium	0.432
Copper	6.856
Lead	1.106
Zinc	37.67

The median concentrations of the five metals is:

Arsenic	0.515
Cadmium	0.50
Copper	4.64
Lead	0.50
Zinc	5.34

Based on these sampling results, a reasonable range of background levels of arsenic and other heavy metals in soil and shallow groundwater is between the median and mean background concentrations.

1b. Levels of Arsenic and Other Heavy Metals Present in Soil and Groundwater.

ARCO's consultant collected groundwater samples from wells in the Crackerville area and south of Opportunity in 2003. Figure 1 (South Opportunity Area of Concern Investigation Sample Locations) and Figure 2 (Dutchman Creek Area of Concern Investigation Sample Locations) are provided in the appendices for reference. Concentrations of arsenic, cadmium, copper, lead, and zinc were found above background in some of the groundwater samples collected by ARCO's consultant.

On the plaintiffs properties, Kane Environmental conducted soil sampling and groundwater investigation in June and October 2012, and indoor dust sampling and additional soil and groundwater sampling in March 2013. Soil sampling conducted by Kane Environmental is consistent with and similar to the sampling conducted by ARCO's consultant during the summer of 2012.

Our findings reveal concentrations above the calculated background concentrations of arsenic, cadmium, copper, lead and zinc in soil and groundwater in Opportunity and Crackerville. Concentration contour maps showing distribution of contamination are provided in the attachments of this report. Figure 4-16 (Extent of Arsenic Contamination in Groundwater in the ARWW&S OU Final Site Characterization Report) prepared on behalf of ARCO shows an approximate north to northeastern extent of arsenic contaminated groundwater at or near Highway 1. Our findings are contrary to the findings shown in Figure 4-16 and discussed in Section 7.4 of the ARWW&S OU Final Site Characterization Report prepared on behalf of ARCO.

Sampling data has been reviewed, evaluated, and validated using guidance and quality control criteria documented by recognized analytical methods. See attached EcoChem, Inc. reports October 12, 2012 and April 1, 5, 8, and 10, 2013, incorporated herein.

1c. The Cause of the Contamination of Soil and Groundwater in Opportunity and Crackerville, MT.

The most likely reason for the elevated levels of arsenic and heavy metals in the soil and groundwater on the private property of the citizens of Opportunity and Crackerville is the operation of the smelter in Anaconda, MT by the Defendants or their predecessor corporations. Opportunity, Montana, is located at the south end of the Deer Lodge Valley, east of Anaconda, and Crackerville is also located east of Anaconda and south of Opportunity. Both communities are downwind of the giant Washoe smelter that operated near Anaconda from 1902 to 1980. The Anaconda Company and its predecessors operated the smelter. The Anaconda Company (known over time as the Anaconda Gold and Silver Company, the Anaconda Mining Company, the Anaconda Copper Mining Company, and The Anaconda Company) operated metallurgical reduction works (called smelters) at Anaconda from 1884 until 1980. Throughout that period, the smelters discharged smoke containing hazardous materials, including sulfur dioxide, arsenic, copper, and other heavy metals.

I have reviewed the expert report of Dr. Quivik. According to Dr. Quivik:

> *When the smelter opened in 1902, it was discharging an estimated 25 tons of arsenic trioxide per day, and in 1903 that figure rose to about 39 tons per day, before the ACM closed the smelter and installed the flue system and the 300-foot stack. After the smelter re-opened, it was discharging about 23-30 tons of arsenic trioxide per day, until copper production began to increase in the 1910s. The stack discharged about 40 tons of arsenic trioxide per day in 1911 and peaked at about 62 tons per day in both 1916 and 1918. After the construction of the Cottrell electrostatic treaters and the 585-foot stack, discharges of arsenic trioxide dropped to about six tons per day throughout the 1920s.*
>
> *****
>
> *Copper discharges peaked in 1916 and 1918 at about eight tons per day. With the Cottrell treaters, copper discharges dropped to below 0.2 tons per day. Lead discharges peaked at more than ten tons per day in 1916 and 1918, and then dropped to about 1.5 tons per day in the 1920s with the use of the Cottrell treaters.*

The smelter operated until 1980, and continued to deposit arsenic and other heavy metals onto the soil in Opportunity and Crackerville.

The Final Remedial Investigation Report for the Anaconda Regional Water, Waste & Soils Operable Unit (ARWW&S OU) prepared for ARCO and dated February1996 states in the conclusions section that:

> *Based on all available data, two potential sources responsible for low-level contamination of dissolved arsenic in groundwater of the alluvial aquifer have been identified in the vicinity of Willow Creek near MW225. The first source is an area of tailings located in the floodplain between Willow Creek and Silver Bow Creek. The second source is contaminated soil due to widespread deposition of smelter emissions.*

Both the United States Environmental Protection Agency (U.S. EPA) and Montana Department of Environmental Quality (DEQ) likewise concluded that the contamination

in Opportunity and Crackerville was due to the smelter operation. U.S. EPA and DEQ issued the ARWW&S OU Record of Decision (ROD R08-98/096 1998) including the rural communities of Opportunity and Crackerville in the South Opportunity Subarea. A ROD Amendment for the ARWW&S OU was issued by both agencies in September 2011.

The ROD and ROD Amendment state that "*widespread areas of contaminated soil are characterized in the South Opportunity Subarea as a result of deposition of smelter stack emissions*". These documents further report that groundwater contamination in the South Opportunity Subarea is characterized in portions of the alluvial aquifer underlying areas of contaminated soils which are flood irrigated on a year round basis in the vicinity of the Yellow Ditch, and in portions of the aquifer underlying wastes and contaminated soils at the Blue Lagoon. The depth of ground water contamination in this portion of the aquifer is reportedly estimated to range from less than 10 feet to approximately 30 feet. Potential loading sources for metals to the aquifer in this area include leaching of metals from wastes in railroad grade material, from contaminated soils, and from contaminated sediment of the Blue Lagoon. The depth of ground water contamination at the Blue Lagoon is thought to be limited to the upper 10 feet of the aquifer.

The ROD documents both report that the results of these studies indicate that arsenic is present in the ground water at the top of the aquifer over a large area of South Opportunity at concentrations up to 150 ppb. This plume is limited to the upper few feet of the aquifer and has not been detected in any domestic wells, which tend to penetrate past the top of the aquifer. This plume occupies two general areas: along Willow Creek and between Willow Glen Ranch and the Town of Opportunity. Based on historic mapping, this widespread plume coincides with areas that have been flood irrigated. One monitoring well, MW-232, has contained significantly higher arsenic than the ground water elsewhere in South Opportunity. This monitoring well is downgradient of Yellow Ditch and in an area that was irrigated before 1996. Possible sources of elevated arsenic in the MW-232 area include contaminated sediments in Yellow Ditch, contaminated water flowing into Yellow Ditch, or a combination of the two. A ground water investigation conducted in 2002 identified elevated arsenic in shallow ground water in one monitoring well in the Crackerville area. (Well SOSPZ26 contained 46 to 79 ppb arsenic in the area between Yellow Ditch and Silver Bow Creek just south of

Crackerville).

The ARWW&S OU Final Site Characterization Report South Opportunity Area of Concern dated September 2011 provides soil, surface water and groundwater data analysis, and conclusions. Section 7.1 Widespread Arsenic Plume states *"Arsenic is present in ground water over a large area of South Opportunity at concentrations up to 150 ug/L (micrograms per liter or ppb). This plume is limited to the upper few feet of the aquifer and has not been detected in any domestic wells which tend to penetrate past the top of the aquifer".*

2) Metals in soil and groundwater have known health effects and some are known carcinogens.

Ingestion of inorganic arsenic increases the risk of skin cancer and cancer in the liver, bladder, and lungs. Inhalation of inorganic arsenic increases the risk of lung cancer. The Department of Health and Human Services (DHHS) and the U.S. EPA have determined that inorganic arsenic is a known human carcinogen. The International Agency for Research on Cancer (IARC) has determined that inorganic arsenic is carcinogenic to humans.

Most cadmium used in the United States is extracted during the production of other metals such as copper, lead, and zinc. Long-term exposure to cadmium in air or water leads to a buildup of cadmium in the kidneys, and other long-term effects are lung damage and fragile bones. DHHS and IARC have determined that cadmium is a human carcinogen.

Copper is released to the environmental by mining and waste water releases into creeks and rivers. Breathing high levels of copper can cause irritation of the nose and throat, and ingestion of high levels of copper can cause damage to the liver and kidneys.

Lead is found in the environment from mining operations and other sources. Lead can affect almost every organ and system in the body, and the main target is the nervous system in adults and children. Exposure to lead can damage the brain and kidneys. DHHS has determined that lead may be a human carcinogen.

3) ARCO's testing and analysis provided inadequate characterization of the extent of metals soil and groundwater contamination above background in the residential areas in Opportunity and Crackerville.

My review of ARCO sampling in Opportunity and Crackerville found limited sampling of soil and groundwater in both communities. For example, a shallow groundwater investigation reported in the Final South Opportunity Ground Water Area of Concern Investigation and Dutchman Creek Ground Water Area of Concern Investigation Data Summary Report (DSR) did not include groundwater sampling north of Highway 1. Figure 1 showing sampling locations in this report is provided in the appendices. There has been insufficient characterization of soil and groundwater contamination compared to my analysis summarized in Opinion 1.

Background soil and groundwater concentrations were calculated for Opportunity and Crackerville based on soil samples collected during Kane Environmental's investigation and using drinking water well data results collected by the Montana Bureau of Mines and Geology from drinking water wells in Opportunity and Crackerville.

4) Contrary to ARCO's representations, restoration of contaminated private property residential soils and shallow groundwater is feasible using accepted methods of cleanup.

4a. Restoring Surface Soil to Background Levels of Arsenic and Other Heavy Metals is Feasible and Practicable. Removal of near-surface residential soils has occurred in some Opportunity and Crackerville private properties. Clean import fill material will be immediately placed in the excavated areas up to 22-inches in depth with a 2-inch thick layer of topsoil and leveled for sod placement for the final cover. The estimated amount of soil to be removed is approximately 430,000 cubic yards (approximately 650,000 tons). Clean import fill can be provided by local sources, used to provide clean fill for the Silver Bow Creek restoration. Removal of the upper 2-feet on private property is appropriate based on calculated site-specific background concentrations for Opportunity and Crackerville.

4b. Restoring Shallow Groundwater to Background Levels of Arsenic and Other Heavy Metals is Feasible and Practicable.

The restoration of groundwater to background levels of arsenic and other heavy metals can be accomplished by installing an underground Passive Reactive Barrier (PRB) wall which contains zero valent iron (ZVI) mixed with clean imported sand. The trench is estimated to be 8,000-foot long, 15-foot deep and 3-foot wide up-gradient of Opportunity. Shorter PRB walls would be placed up-gradient of Crackerville properties. The trenching can be completed either by biopolymer trenching or continuous trenching techniques. For the biopolymer approach, as the trench is excavated, biopolymer slurry is added to the trench to provide stability to the excavated trench walls. Recirculation wells are spaced along the length of the trench. After placement of the ZVI and sand, an enzyme is circulated through the wells to start the biopolymer breakdown process and allow the groundwater to flow through the ZVI PRB. The continuous trenching machines allow simultaneous excavation and backfilling with an open trench. Excavation is performed by a cutting chain immediately in front of a trench box that extends the width and depth of the finished trench. As the trencher moves forward, the ZVI/sand mixture is added to the trench. A PRB pilot test would be required to determine the best installation approach and to determine the amount of ZVI for the PRB walls. These underground PRB walls will be designed to remediate shallow groundwater in Opportunity and Crackerville.

5) The estimated cost to restore soil and groundwater on the plaintiffs private property is attached in Table 1.

Reasonable and necessary costs associated with remediation of plaintiffs' private property are summarized in Table 1, attached. Costs include the removal and restoration of the private properties and transport of the soil to a licensed landfill in Spokane, Washington. An estimated 8,000-foot long, 15-foot deep and 3-foot wide PRB wall would be constructed upgradient of Opportunity, and shorter PRB walls would be placed upgradient of individual Crackerville properties. Soil removal is estimated to take 20 months and installation of the PRB walls 4 to 6 months.

6) **Concentrations of arsenic and heavy metals was found in dust sampling conducted in plaintiff's residences.**

Kane Environmental conducted an indoor dust survey in 51 residences owned by the private property owners. A portion of the dust analytical results have been data validated, and remaining samples are currently under data validation. Concentrations of arsenic and heavy metals can be removed by HEPA vacuum and monitored with periodic sampling.

John R. Kane

4-15-13

Date

COSTS

TABLE 1

IRON FILINGS WALL GROUNDWATER RESTORATION
SURFACE SOIL EXCAVATION AND RESTORATION

Task 1 - Soil Excavation and Restoration

Excavator/Operator	400	days	$4,000	$1,600,000	2 excavators 812.5 tons per day; 5 days/ week; 20 months
Soil Disposal Cost	650000	tons	$26	$16,965,000	Disposal at Spokane WA Waste Management Landfill
Soil Disposal Cost - Transportation	650000	tons	$48	$31,200,000	Disposal at Spokane WA Waste Management Landfill
Clean Fill Import	650000	tons	$1	$650,000	
Topsoil	37,000	yards	$1	$37,000	
Sod	6,022,000	sq ft	$0.20	$1,204,400	
SubTotal				**$51,656,400**	

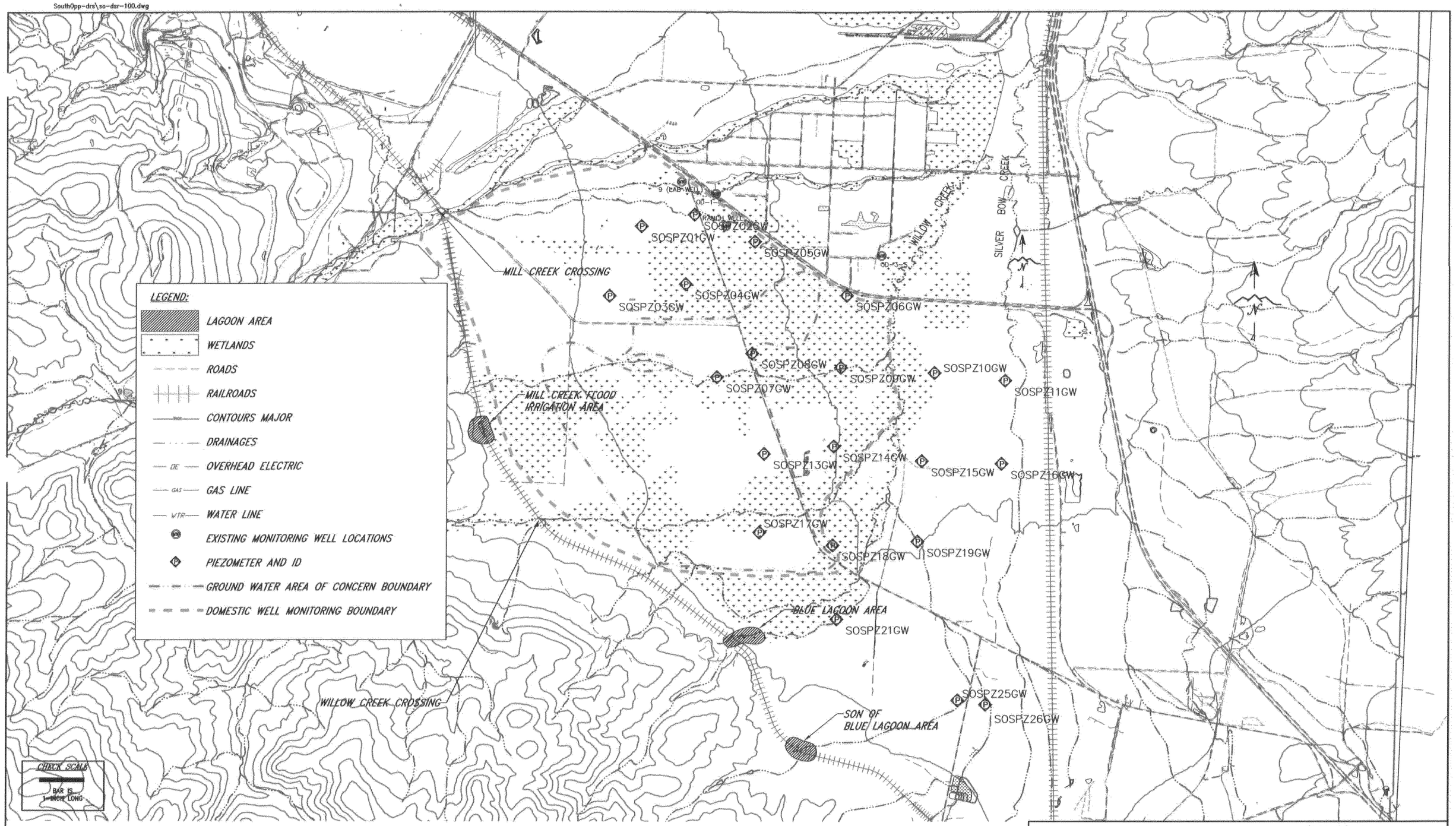
Task 2 - Iron Filings Wall Installation

Excavator/Operator - Opportunity	80	days	$4,000	$320,000	2 excavators; 5 days/ week; 4 months
Excavator/Operator - Crackerville	40	days	$4,000	$160,000	2 excavators; 5 days/ week; 2 months
Soil Removal for Opportunity Wall	20000	tons	$26	$261,000	Disposal at Spokane WA Waste Management Landfill
Soil Removal for Crackerville Wall	10000	tons	$26	$783,000	Disposal at Spokane WA Waste Management Landfill
Soil Disposal Cost - Transportation	30000	tons	$48	$1,440,000	Disposal at Spokane WA Waste Management Landfill
Iron Filing Wall Installation - Opportunity	120000	vsf	$50	$6,000,000	vertical square feet (vsf) = 15 ft depth x 8000 ft length
Iron Filing Wall Installation - Crackerville	60000	vsf	$50	$3,000,000	vertical square feet (vsf) = 15 ft depth x 4000 ft length
Iron Filing Cost	180,000	vsf	$20	$3,600,000	
Subtotal				**$15,564,000**	
Pilot Test		lump sum	$500,000	$500,000	
Contingency			20%	**$13,444,080**	
Legal Council Cost				$334,000	
SubTotal Task 1, Task 2 and Contingency				**$81,498,480**	
Engineering/Design/Management					
Project Management			5%	$4,074,924	
Remedial Design			5%	$4,074,924	
Construction Management			6%	$4,889,909	
O&M Technical Support			8%	$6,519,878	
SubTotal				**$19,559,635**	

Estimated Total Project Cost = $101,058,115

FIGURES

SouthOpp-drs\so-dsr-100.dwg

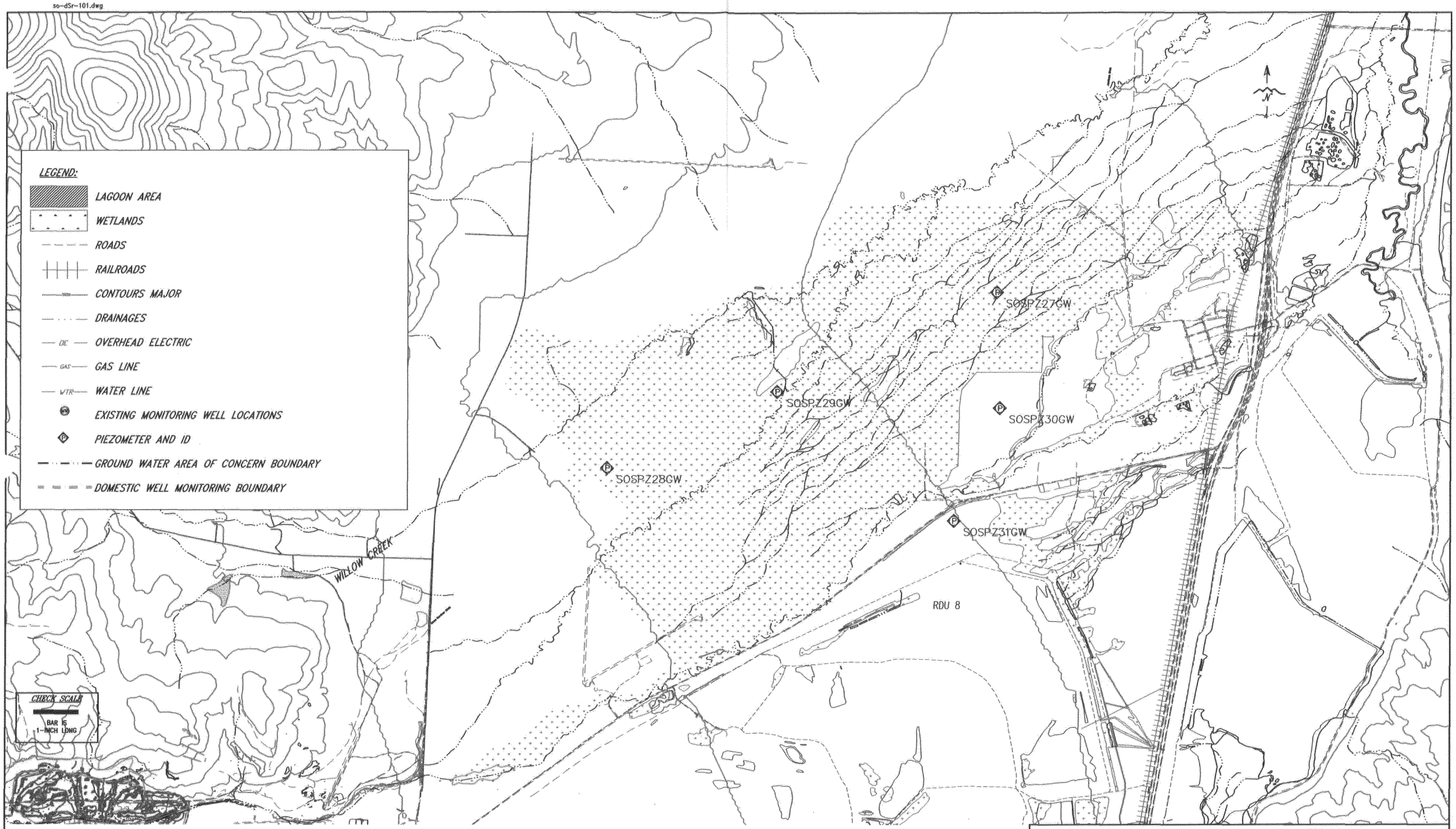


PIEZOMETER LOCATIONS SURVEYED BY PIONEER TECHNICAL SERVICES, INC. 7/2002.

PIONEER TECHNICAL SERVICES, INC.

FIGURE 1
SOUTH OPPORTUNITY
AREA OF CONCERN INVESTIGATION
SAMPLE LOCATIONS
SCALE: 1"=1500'
DATE: 1/13/03

so-dSr-101.dwg



PIEZOMETER LOCATIONS SURVEYED BY PIONEER TECHNICAL SERVICES, INC. 7/2002

PIONEER TECHNICAL SERVICES, INC.

FIGURE 2
DUTCHMAN CREEK
AREA OF CONCERN INVESTIGATION
SAMPLE LOCATIONS
SCALE: 1"=1500'
DATE: 1/13/03

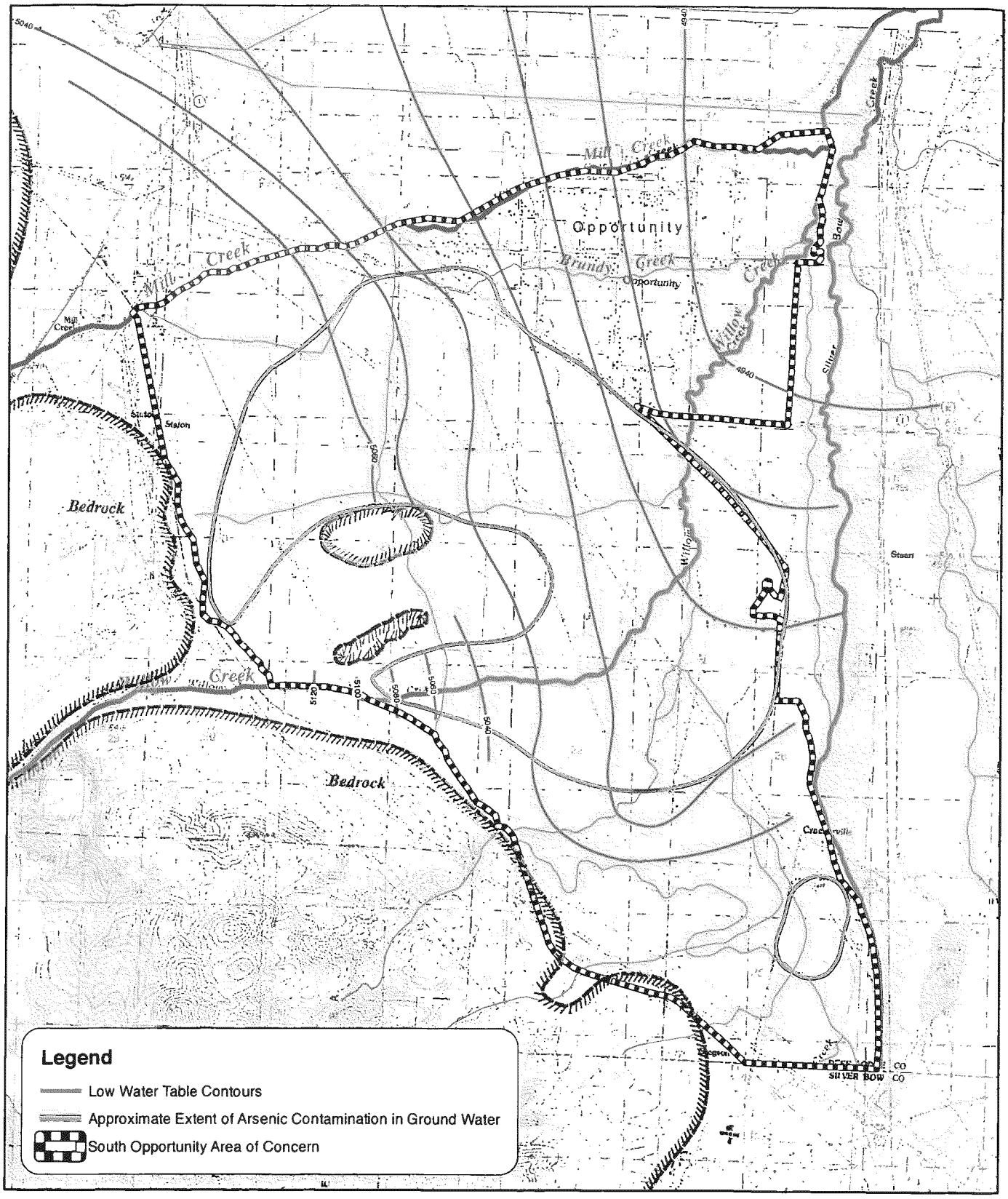


Figure 4-16
Extent of Arsenic Contamination in Ground Water
South Opportunity Characterization Report
Anaconda Regional Water, Waste and Soils OU
Anaconda Smelter NPL Site, Montana