GWOU ADMINISTRATIVE RECORD
SECTION TITLE:
GW-300-301-1.12

91429

FEB 0 6 2002

Mr. Dan Wall
Project Manager
Superfund Division
U.S. EPA
Region VII
901 N. 5th Street
Kansas City, Kansas 66101

Dear Mr. Wall:

GROUNDWATER SAMPLING PLAN FOR IN SITU CHEMICAL OXIDATION PILOT SCALE TESTING, REV. 0, JANUARY 2002

Enclosed find a copy of the above referenced document. This sampling event follows from the sampling notification number 02-001. This sampling plan is intended to assess the overall impacts of the in situ chemical oxidation (ICO) pilot scale treatment. The subcontractor will also prepare a sampling and analysis plan, which is intended to assess the effectiveness of the ICO in destroying TCE in the vicinity of the injection points. The subcontractor's plan will be made available to you in the near future. Overlap from these two sampling plans will provide for numerous duplicate samples. If you have any questions regarding the subject sampling plan, contact me at (636)926-7051.

Sincerely,

Thomas C. Pauling
Environmental Engineer

Enclosures:
As stated

cc w/enclosure:
Larry Erickson, MDNR
Ben Moore, MDNR Field Office
Mary Picel, ANL

cc w/o enclosure:
Barb Duletsky, PMC
Terri Uhlmeyer, PMC

EM-95:TPauling:x7051:emh:2/5/02 (m:ICO-TCEGWSamp)

CONCURRENCES/ REVIEWED BY:	
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DOE/OR/21548-912
CONTRACT NO. DE-AC05-86OR21548

GROUNDWATER SAMPLING PLAN FOR IN SITU CHEMICAL OXIDATION PILOT-SCALE TESTING

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

JANUARY 2002 **REV. 0**

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

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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	Rev. No. 0
PLAN TITLE: Groundwater Sampling Plan For In Situ Chemical Oxidation Pilot-Scale Testing	

APPROVALS

Environmental Safety and Health Manager	Date 1/31/02
Data Administration Coordinator	Date 1/30/02
Groundwater Operable Unit Coordinator	Date 1/30/02
Project Quality Manager	Date 1/31/02
Engineering Manager	Date 1-31-02
Project Director	Date 1/31/02

DOE/OR/21548-912

Weldon Spring Site Remedial Action Project

Groundwater Sampling Plan For In Situ Chemical Oxidation Pilot-Scale Testing

Revision 0

January 2002

Prepared by

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Prepared for

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations office
Under Contract DE-AC05-86OR21548

ABSTRACT

In situ chemical oxidation (ICO) pilot-scale testing will be conducted at the WSSRAP in early 2002 to determine the effectiveness of ICO in reducing trichloroethene (TCE) concentrations in groundwater under actual field conditions and to obtain data necessary for the design of a full-scale treatment system. A specialty subcontractor is responsible for the design, installation, and operation of the ICO pilot-scale system, as well as for monitoring groundwater in the immediate vicinity of each injection point. To complement the subcontractor's monitoring program, the PMC will monitor the impacts of the ICO pilot-scale test on groundwater at locations within the TCE-impact area and at off-site springs that have a potential hydraulic connection to the injection locations.

The purpose of the sampling described in this plan is to determine whether the pilot-scale ICO test affects groundwater contamination at locations beyond the subcontractor's immediate test area and to assess the potential long term impacts of ICO on physical and chemical characteristics of the aquifer.

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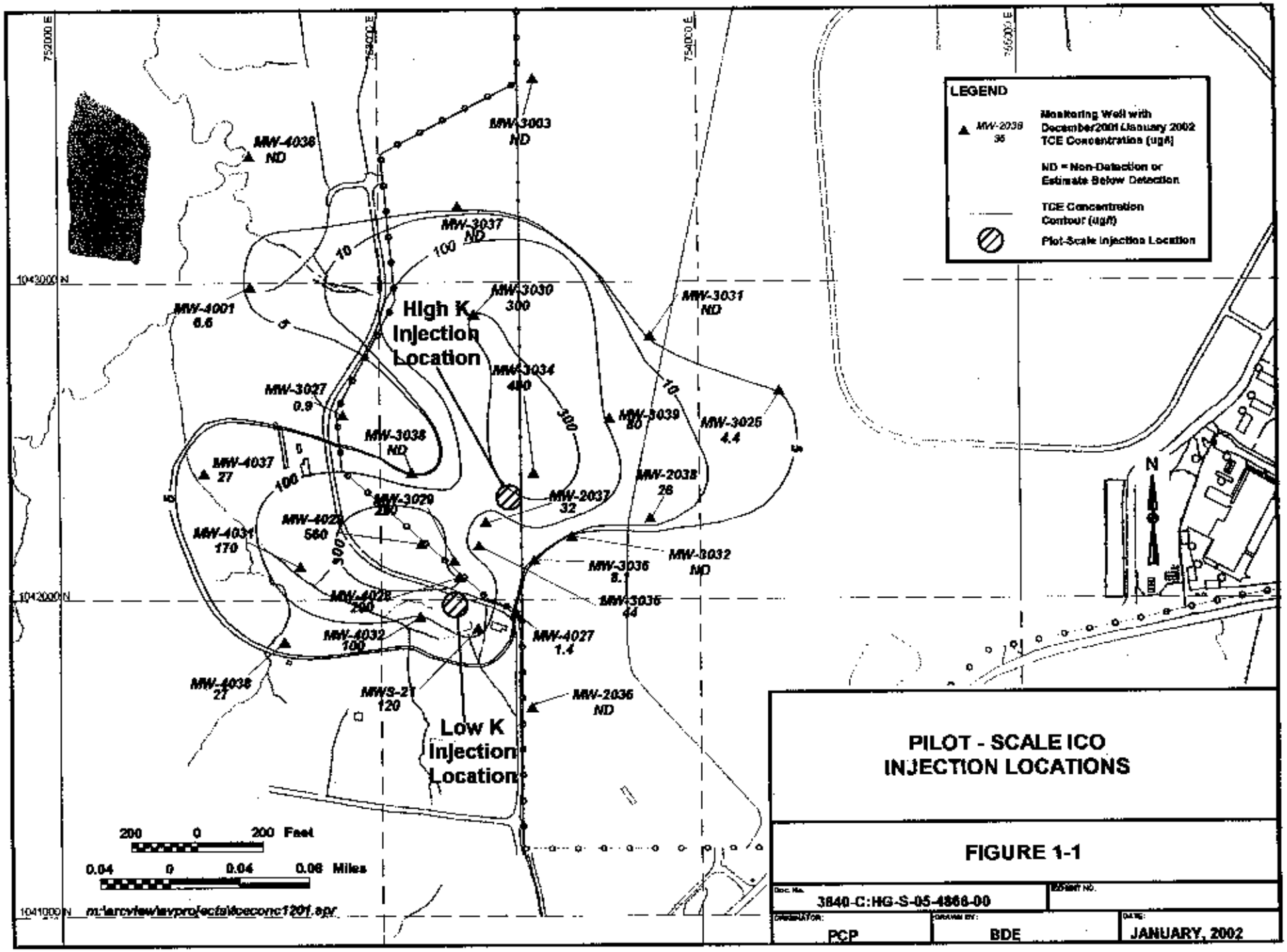
1. INTRODUCTION

The *Interim Record of Decision (IROD) for Remedial Action for the Groundwater Operable Unit (GWOU) at the Chemical Plant Area of the Weldon Spring Site* (Ref. 1) specifies the use of in situ chemical oxidation (ICO) to treat groundwater contaminated with trichloroethene (TCE) in the vicinity of the former raffinate pits at the Weldon Spring Site Remedial Action Project (WSSRAP). Bench-scale testing conducted in the spring of 2001 demonstrated that, under laboratory conditions, oxidation chemistry could effectively destroy TCE in groundwater samples collected from this area of the site (Ref. 2). Pilot-scale testing is scheduled to be performed in March 2002 to determine the effectiveness of ICO under actual field conditions and to assess the feasibility of implementing ICO on a full-scale basis.

The pilot-scale testing will be performed at two specified locations within the area of TCE impact: one location estimated to be in an area of relatively high hydraulic conductivity (i.e., $K \approx 10^{-2}$ to 10^{-4} cm/sec) and one location estimated to be in an area of relatively low hydraulic conductivity (i.e., $K \approx 10^{-5}$ to 10^{-6} cm/sec). These locations are shown on Figure 1-1, along with the locations and most recent TCE concentrations of existing monitoring wells in the TCE-impact area.

Design, installation, and operation of the ICO pilot-scale testing system will be conducted by a specialty subcontractor team consisting of ATC Associates and GeoCleanse International. The ATC team plans to inject approximately 8,400 gallons of 0.1% sodium permanganate solution at the "High K" location and 2,000 gallons at the "Low K" location (Ref. 3). Ten days after the injection is completed, ATC will collect groundwater samples from wells within a 200-foot radius of the injection point. If analytical data from these samples show that the injection failed to reduce TCE concentrations to less than 5 µg/l, as specified in the IROD, a second injection will be performed approximately 30 days after the first injection.

The ATC design requires installation of three new monitoring wells near each injection point, as shown in Figure 1-2. The locations of the new wells will be 50 feet upgradient, and 50 and 150 feet downgradient, from each injection point. These wells will be closely monitored by ATC to allow for optimization of the ICO system operating parameters, as well as to determine the reaction rate and radius of influence for each injection. ATC will also monitor the six closest existing wells (MW-2037, MW-3032, MW-3034, MW-4028, MW-4032, and MW-S021) prior to, during, and up to 30 days after the injections are complete, as described in their *Sampling and Analysis Plan: WP-568 – In-Situ Chemical Oxidation of TCE in Groundwater* (Ref. 4).



PILOT - SCALE ICO INJECTION LOCATIONS

FIGURE 1-1

Doc. No.	Sheet No.	
3840-C:HG-S-05-4866-00		
Designator: PCP	Drawn By: BDE	Date: JANUARY, 2002

FIGURE 1-2

ATC MONITORING WELL LOCATIONS

Base Map Source: MK-Ferguson, 2001

Geo-Cleanse® International, Inc.

N

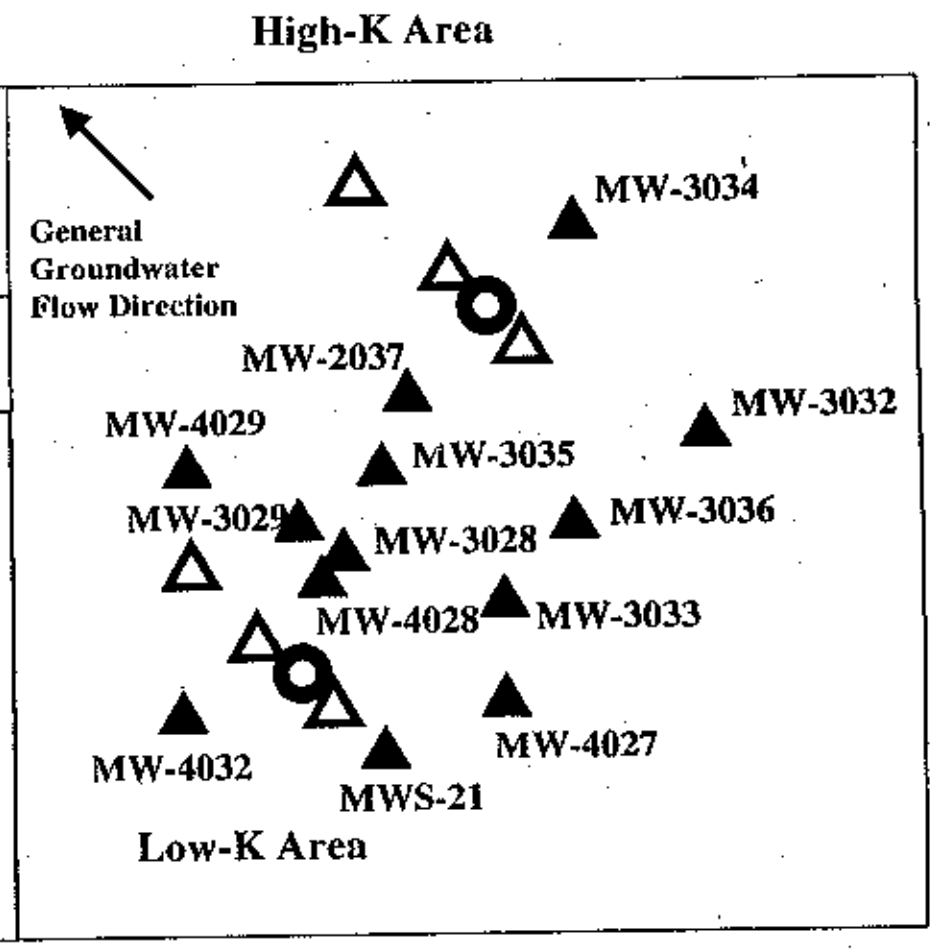
Scale (ft)

0 100 200 400

▲ Existing Monitoring Well

△ Proposed Monitoring Well

○ Proposed Injection Well



1.1 Purpose

This sampling plan is intended to complement the subcontractor's sampling plan by monitoring the same analytical parameters at the same frequency but over a larger geographic area. The results from the sampling described in this plan will be used in conjunction with the results of the subcontractor's sampling plan to evaluate the effectiveness of the ICO pilot-scale test in reducing TCE concentrations, identify potential impacts of ICO on other physical and chemical characteristics of the aquifer, and assess the feasibility of implementing ICO on a full-scale basis.

1.2 Objectives

The objectives of the sampling described in this plan are the following:

- Establish baseline conditions of the aquifer by measuring the following physical parameters prior to the ICO pilot-scale injection(s): static water level, temperature, pH, conductivity, dissolved oxygen, turbidity, and oxidation reduction potential.

- Establish baseline contaminant concentrations in the aquifer by measuring the following analytical parameters prior to the ICO pilot-scale injection(s): volatile organic analytes (VOAs, which include TCE, 1,2-DCE, PCE, and VC), uranium, nitrate, dissolved TOX metals (As, Ba, Cd, Cr, Pb, Hg, Ag, Se) and Mn, and nitroaromatic compounds (1,3,5-TNB, 1,3-DNB, 2,4,6-TNT, 2,4-DNT, 2,6-DNT, and NB).

- Monitor changes and identify trends in the above physical and analytical parameters at predetermined intervals after the injection(s) are complete.

- Collect, review, and summarize data to support an evaluation of the effectiveness of the ICO pilot-scale test, identification of potential impacts of ICO on other physical and chemical characteristics of the aquifer, and assessment of the feasibility of implementing ICO on a full-scale basis.

1.3 Scope

This plan describes five sampling events, the timing of which will be closely coordinated with the chemical injection event(s). Sampling will be conducted approximately 3 days prior to the first injection to define baseline conditions. Sampling will then be conducted approximately 10 days after the first injection is completed; and approximately 10 days, 30 days, and 60 days after the second injection is completed. If the results from the first 10-day sampling indicate that the desired TCE reductions have been achieved and that a second injection is unnecessary, sampling will then be conducted approximately 30 days and 60 days after the first injection is completed.

The geographic scope of this plan includes twenty-five locations: 22 existing monitoring wells within the TCE-impact area of the site and 3 springs that have demonstrated a potential hydraulic connection with the injection locations.

2. GROUNDWATER MONITORING

The groundwater monitoring plan outlined below is based on information obtained from industry experts regarding the potential effects of implementing ICO in a limestone bedrock aquifer. Experience among ICO subcontractors has shown that, while ICO can be an effective tool for treating chlorinated contaminants in groundwater, the variety of chemical reactions occurring underground require close monitoring to ensure that undesirable effects are minimized.

Reports of recent experience in field applications of ICO have identified the following potential detrimental effects associated with permanganate injection:

- *Metals mobilization* - Sodium permanganate, in both raw crystalline form and prepared as a solution, contains a wide range of metals impurities that are introduced to the aquifer upon injection (Ref. 3). In addition, increasing the oxidation potential of the groundwater may result in increased metals concentrations due to naturally-occurring metals leaching from the aquifer material or dissolution of existing metals contamination (Ref. 5 and Ref. 6). Mobilization is of particular concern for metals such as chromium and uranium, which are both present in the aquifer to some extent and pose greater health risks in their oxidized states.

- *Manganese oxide solids generation* - The chemical reactions by which permanganate dechlorinates TCE generate manganese oxides as colloidal precipitates (Ref. 7). This can result in aquifer plugging and substantial decreases in hydraulic conductivity. At sites where this has occurred, subsequent groundwater treatment efforts have been significantly hampered (Ref. 8).

- *Groundwater discoloration* - Permanganate is delivered to the aquifer as a purple solution, which fades as the chemical reacts with the contaminants and/or the natural oxidant demand (NOD) of the aquifer. Depending on the concentration and amount of permanganate injected, the presence of horizontal fractures and other highly conductive zones in the bedrock being treated, and the NOD of the aquifer, the purple color may persist over time and distance, potentially resurfacing at nearby springs.

- *Rebound of contaminant concentrations* - The heterogeneity of a fractured karst aquifer presents the most difficult hydrogeologic environment in which to perform an effective ICO treatment. If the delivery system does not provide for complete contact with the contaminated groundwater, both vertically and horizontally, contaminant concentrations will rebound over time and require further treatment.

The WP-568 contract documents require the subcontractor to consider the above possible detrimental effects in the design of the ICO pilot-scale test, and ensure that these effects are minimized. The ATC design addresses these concerns by means of a conservative approach that utilizes packer testing and borehole geophysics to quantify the fractures intersected by each injection well, a low (0.1%) concentration of sodium permanganate solution, and frequent monitoring of groundwater response to enable the optimization of injection parameters (e.g., flow rate and pressure).

The ATC groundwater sampling plan addresses how the subcontractor will assess the effects of the ICO pilot-scale test on groundwater within a 200-foot radius of each injection well. The sampling described in this plan is intended to complement the ATC sampling plan by monitoring groundwater at locations further than 200 feet from the injection wells.

2.1 Sampling Locations

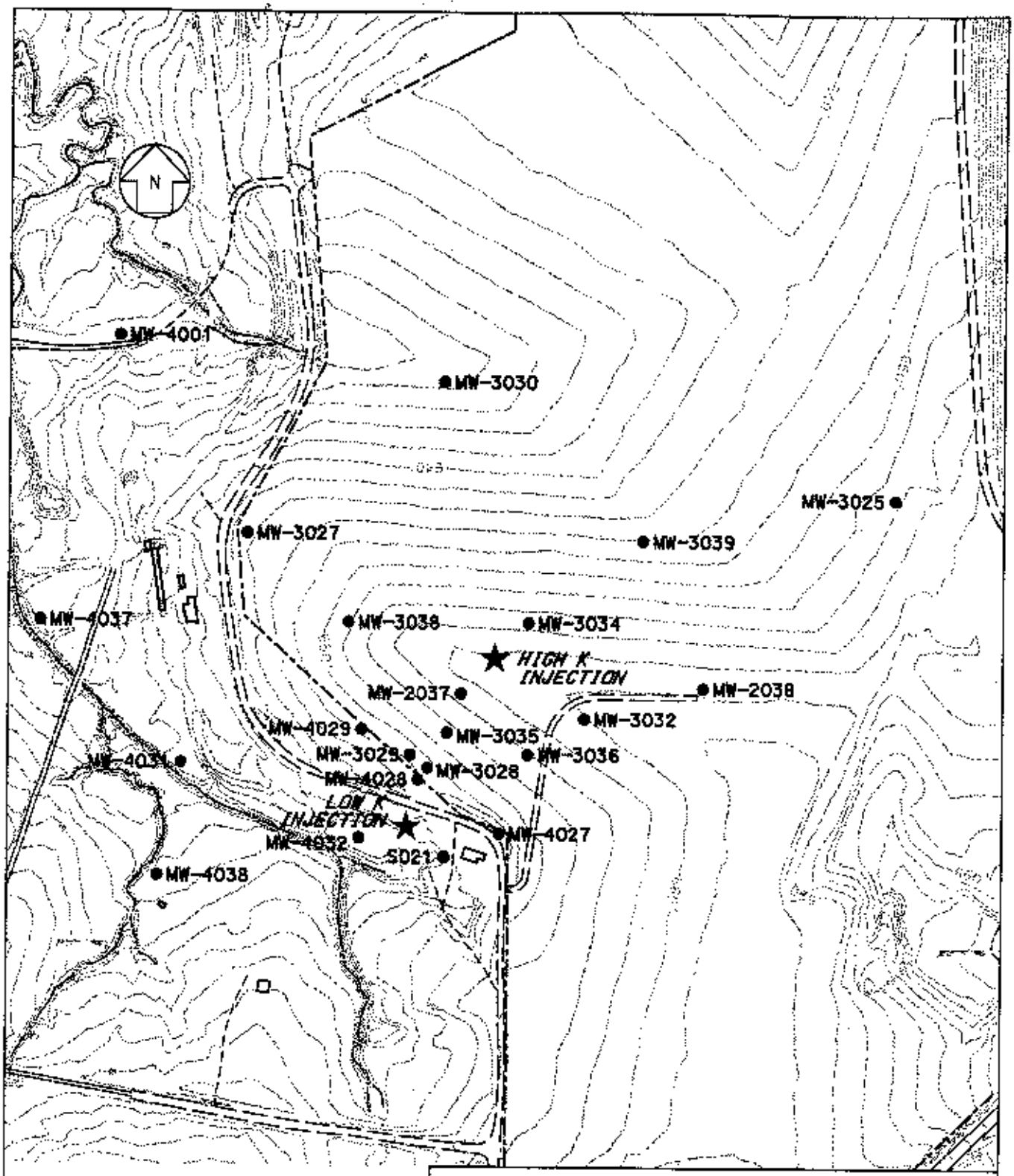
Groundwater samples will be collected from 22 existing monitoring wells located within the TCE-impact area of the site, as shown on Figure 2-1. These wells are screened in the weathered Burlington-Keokuk limestone portion of the aquifer. Each well currently either contains detectable levels of TCE or is located in the immediate vicinity of one of the injection wells.

Surface water samples will be collected from 3 off-site springs that have demonstrated a potential hydraulic connection with the TCE-impact area. The locations of these springs are shown on Figure 2-2. None of these springs currently contain detectable levels of TCE.

2.2 Monitoring Parameters

The samples collected under this plan will be analyzed for volatile organic analytes (TCE, 1,2-dichloroethene [DCE], tetrachloroethene [PCE], and vinyl chloride [VC]), uranium, nitrate, dissolved TOX metals (i.e., As, Ba, Cr, Cd, Pb, Hg, Ag, Se) and manganese, and nitroaromatic compounds. The lowest detection limits specified in the laboratory subcontracts will be used so that even small changes in the concentrations of these analytical parameters can be monitored.

The following physical parameters will be measured and recorded during each sampling event: static water level, temperature, pH, conductivity, dissolved oxygen, turbidity, and oxidation reduction potential. Any purple discoloration, which would indicate the presence of unreacted permanganate, will be noted on the field sampling sheet. The visible presence of any suspended solids in the form of a colloidal precipitate will also be noted on the field sheet, and the sampling personnel will collect an extra sample to have analyzed for total suspended solids (TSS).



LEGEND

● – MONITORING WELL

★ – INJECTION WELL

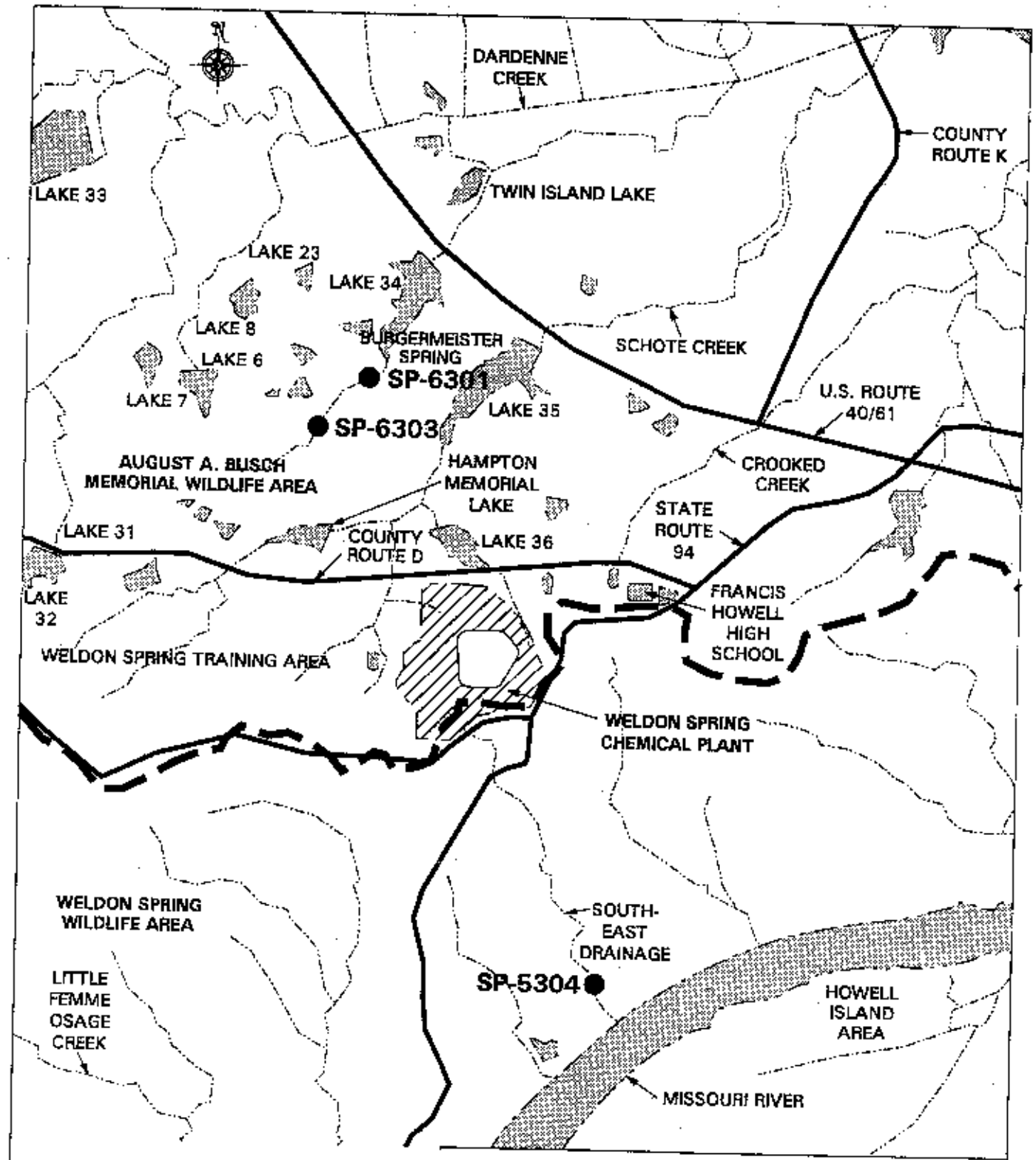
0 300 600

SCALE FEET

GROUNDWATER WELLS TO BE MONITORED DURING ICO PILOT-SCALE TESTING

FIGURE 2-1

REPORT NO.: DOE/OR/21548-912		EXHIBIT NO.: A/CP/001/0102	
ORIGINATOR: BD	DRAWN BY: GLN	DATE: 1/30/02	



LEGEND

- SPRING
- GROUNDWATER DIVIDE
- SURFACE WATER CHANNEL

0 1 MI
0 1.6 KM
SCALE

SPRINGS TO BE MONITORED DURING ICO PILOT-SCALE TESTING

FIGURE 2-2

REPORT NO.: DOE/OR/21548-912		EXHIBIT NO.: A/VP/001/0102	
ORIGINATOR: BD	DRAWN BY: GLN	DATE: 1/2/02	

2.3 Sampling Schedule

Table 2-1 lists the locations and corresponding frequencies of samples to be collected in conjunction with the ICO pilot-scale testing. The table is based on the assumption that two injections will be performed. Sampling will be conducted approximately 3 days prior to the first injection to define baseline conditions. Sampling will then be conducted approximately 10 days after the first injection is completed and approximately 10 days, 30 days, and 60 days after the second injection is completed for a total of 5 sampling events. If the results from the first 10-day sampling indicate that the desired TCE reductions have been achieved and that a second injection is unnecessary, sampling will then be conducted approximately 30 days and 60 days after the first injection is completed, for a total of 4 sampling events.

In cases where the scope of this plan is redundant with a sampling event previously specified in the *Environmental Monitoring Plan (EMP)* (Ref. 9), only one sample will be collected and analyzed. In cases where the scope of this plan is redundant with the subcontractor's Sampling and Analysis Plan (Ref. 4), split samples will be collected and sent to different laboratories to ensure independent analyses. Samples to be split with ATC are denoted by an "(S)" on Table 2-1. A seven-day turn around will be requested on all samples collected under this plan.

2.4 Sample Identification

All containers will be labeled in accordance with Procedure ES&H 4.1.1, *Numbering System for Weldon Spring Site Environmental Sampling*. Labels will include the following information:

- Sample ID number (e.g., MW-XXXX-MMDDYY, where XXXX is the 4-digit well ID and MMDDYY is the 6-digit date code)
- Date of collection
- Analyses to be performed
- Preservation method
- Name(s) of sampler(s)

2.5 Sample Collection

Samples will be collected in accordance with established site procedures and instructions. Samples from monitoring well locations will be collected in accordance with Procedure ES&H 4.4.1, *Groundwater Monitoring*. Samples from spring locations will be collected in accordance with Procedure ES&H 4.3.1, *Surface Water Sampling*. Field parameters will be measured prior to sampling and recorded on the respective sampling forms for each location. Static water levels will be measured prior to sampling in accordance with Procedure ES&H 4.4.2, *Groundwater Level Monitoring and Well Integrity Inspections*.

Table 2-1 Sampling Schedule for ICO of TCE in Groundwater (Based on Two Injections)

Location	Sampling Event				
	Baseline (3 days prior to 1st injection)	10 days after 1st injection	10 days after 2nd injection	30 days after 2nd injection	60 days after 2nd injection
MW-2037 (S)	✓	✓	✓	✓	✓
MW-2038	✓			✓	✓
MW-3025	✓			✓	✓
MW-3027	✓			✓	✓
MW-3028	✓	✓	✓	✓	✓
MW-3029	✓	✓	✓	✓	✓
MW-3030	✓			✓	✓
MW-3032 (S)	✓	✓	✓	✓	✓
MW-3034 (S)	✓	✓	✓	✓	✓
MW-3035	✓	✓	✓	✓	✓
MW-3036	✓	✓	✓	✓	✓
MW-3038	✓	✓	✓	✓	✓
MW-3039	✓			✓	✓
MW-4001	✓			✓	✓
MW-4027	✓	✓	✓	✓	✓
MW-4028 (S)	✓	✓	✓	✓	✓
MW-4029	✓	✓	✓	✓	✓
MW-4031	✓	✓	✓	✓	✓
MW-4032 (S)	✓	✓	✓	✓	✓
MW-4037	✓			✓	✓
MW-4038	✓			✓	✓
MW-5021 (S)	✓	✓	✓	✓	✓
SP-5304	✓		✓	✓	✓
SP-6301	✓		✓	✓	✓
SP-6303	✓		✓	✓	✓

Notes:

1. (S) indicates that samples collected from these locations will be split with ATC for all sampling events except the 60-day event.
2. Each sample will be analyzed for VOAs (TCE/1,2-DCE/PCE/VC), uranium, nitrate, dissolved TOX metals (As, Ba, Cd, Cr, Pb, Hg, Ag, Se) + Mn, and nitroaromatic compounds.
3. If visible colloidal precipitate is present, an extra sample will be collected and analyzed for TSS.
4. If a second injection is not necessary, the third sampling event (i.e., "10 days after 2nd injection) will be omitted, and the 4th and 5th events will be performed 30 days and 60 days after the 1st injection.

2.6 Sample Containers and Preservation Methods

Sample containers and preservation methods are summarized in Table 2-2.

Table 2-2 Sample Containers and Preservation

Parameter	Container Type	Preservation Method
VOAs (TCE, 1,2-DCE, PCE, VC)	2 @ 40-ml glass vial, no headspace	Cool (4°C) and 2 drops HCl
Uranium, total	250-ml plastic bottle	Nitric acid (pH<2)
Nitrate, as N	250-ml plastic bottle	Cool (4°C)
TOX metals (As, Ba, Cr, Cd, Pb, Hg, Ag, Se) + Mn	1-liter plastic bottle	Nitric acid (pH<2)
Nitroaromatic compounds	1-liter amber glass bottle	Cool (4°C)
Total suspended solids	500-ml plastic bottle	Cool (4°C)

2.7 Analytical Methods and Detection Limits

Analytical methods and detection limits are summarized in Table 2-3.

Table 2-3 Analytical Methods and Detection Limits

Parameter	Analytical Method	Required Detection Limit
VOAs (TCE, 1,2-DCE, PCE, VC)	EPA 8260	1.0 µg/l
Uranium, total	ASTM 5174-91	0.677 pCi/l
Nitrate, as N	EPA 300	1.0 mg/l
TOX metals (As, Ba, Cr, Cd, Pb, Hg, Ag, Se) + Mn	EPA CLP	2.0 µg/l
Nitroaromatic compounds	EPA 8330	0.03 µg/l
Total suspended solids	EPA 160.2	5 mg/l

3. QUALITY CONTROL

The Project Management Contractor (PMC) at the Weldon Spring Site Remedial Action Project (WSSRAP), has developed the *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 10) to guide all environmental activities conducted at the WSSRAP in accordance with the U.S. Environmental Protection Agency guidelines. The *Sample Management Guide* (Ref. 11) has been developed following the guidelines listed in the EQAPjP to establish the approach to sample planning, collection, and data analysis.

3.1 Chain-of-Custody

All samples collected under this sampling plan will comply with chain-of-custody (COC) procedures outlined in the *Sample Management Guide* and Procedure ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain-of-Custody*. COC forms will be completed and placed in the sample coolers to ensure that samples are properly relinquished.

3.2 Analytical Procedures

The off-site analytical laboratories conducting radiological and chemical analysis have provided the PMC controlled copies of their site-specific quality assurance project plans (QAPjPs) and standard operating procedures (SOPs). These plans and procedures have been reviewed by the PMC and determined to be in compliance with accepted standards and methodologies for performing analytical processes, operations, and activities. The laboratory QAPjPs and SOPs specify quality control requirements to demonstrate the precision, representativeness, and accuracy of the analytical data.

3.3 Quality Control Samples

Field quality control samples will be collected to ensure the precision and accuracy of sample collection and laboratory analysis. Table 3-1 provides a summary list of the quality control samples that will be collected to support this effort.

Table 3-1 Field Quality Control Sample Summary

QC SAMPLE TYPE	FREQUENCY	PURPOSE
Field Replicate	1 per 20 samples	Assess matrix, intralaboratory, and field operations variability
Matrix Spike/Matrix Spike Duplicate or Matrix Duplicate	1 per 20 samples	Assess matrix and possible intralaboratory variability
Trip Blanks (VOA analysis only)	1 per shipment	Assess possible introduction of VOAs during handling, transportation, and receipt at the laboratory

3.4 Data Verification

Data packages received from off-site contract laboratories will be reviewed and verified in accordance with Procedure ES&H 4.9.1, *Environmental Monitoring Data Verification*. The following elements will be evaluated to verify that samples have been handled according to WSSRAP protocol:

- Chain-of-custody
- Holding times
- Sample preservation requirements
- Sample analysis request form
- Quality control samples
- Laboratory receipt forms

3.5 Data Review

The data packages will be distributed to the data user(s) for review and comparison to historical and/or predicted values. The data will be reviewed to identify discrepancies in the field quality control samples, inconsistencies with characterization data, and apparent outliers. The data user(s) will report any identified deficiencies to the VVG and may request validation of questionable data to ensure its quality. The data review process will be conducted in accordance with Procedure ES&H 1.1.7, *Data Review and Above-Normal Data Reporting*.

3.6 Data Validation

Randomly selected laboratory data and questionable data identified by verification personnel and/or the data user(s) will undergo thorough evaluation of the analytical process in accordance with Procedure ES&H 4.9.2, *Environmental Monitoring Data Validation*. The VVG will conduct these evaluations.

The data validation process will provide a consistent means of reviewing and evaluating data resulting from laboratory analyses, as well as for documenting the evaluation and assessing the usefulness of the data. This will be accomplished by a thorough review of the analytical data using laboratory records to assess conformance to quality control criteria, data quality requirements, and procedural requirements.

4. DATA ANALYSIS AND REPORTING

Data obtained from this sampling plan will be evaluated to determine the success of the ICO pilot-scale test with respect to percent TCE reduction at each monitoring location and the potential effects on other characteristics of the aquifer. Specifically, the data will be used to evaluate the extent to which the ICO pilot-scale test affects the following characteristics of the aquifer underlying the TCE-impact area:

- Changes in TCE concentrations
- Changes in concentrations of other contaminants of concern (nitrate, uranium, nitroaromatic compounds)
- Possible introduction and/or mobilization of TOX metals and manganese
- Creation of unwanted byproducts of the oxidation reaction (e.g., manganese oxide solids, persistent purple color)

At the conclusion of the pilot-scale test, these results will be summarized in a completion report. The report will also contain the laboratory analytical and quality control data, field sampling sheets, changes or additions to the plan, and conclusions regarding the overall success of the pilot-scale test. The report will be used in conjunction with the subcontractor's completion report to assess the feasibility of proceeding with full-scale implementation of ICO at the WSSRAP.

5. REFERENCES

1. U. S. Department of Energy. *Interim Record of Decision for Remedial Action for the Groundwater Operable Unit at the Chemical Plant Area of the Weldon Spring Site.* DOE/OR/21548-798. Prepared by Oak Ridge Operations Office, Weldon Spring Site Remedial Action Project. Weldon Spring, MO. September 2000.

2. Geo-Cleanse International, Inc. *Bench Scale Test Report: Geo-Cleanse Treatment Program, Weldon Springs Site, Missouri.* Prepared for MK-Ferguson, St. Charles, MO. May 2001.

3. ATC Associates, Inc. *Technical Proposal: RFP No. 3589-SC-WP568 for MK-Ferguson, WSSRAP - In Situ Chemical Oxidation of TCE in Groundwater.* St. Louis, MO. 2001.

4. ATC Associates, Inc. *Sampling and Analysis Plan: WP-568 - In Situ Chemical Oxidation of TCE in Groundwater.* Subcontract No. 3589-SC-WP568. January 2002.

5. Crimi, M. and Siegrist, R. *In Situ Permanganate Oxidation Effects on Subsurface Metal Mobility.* Presented at the First International Conference on Oxidation and Reduction Technologies for In-Situ Treatment of Soil and Groundwater. Niagara Falls, Ontario. June, 2001.

6. Bryant, D., et. al., *Permanganate In-Situ Chemical Oxidation of TCE in a Fractured Bedrock Aquifer, Edwards Air Force Base, California.* Presented at the First International Conference on Oxidation and Reduction Technologies for In-Situ Treatment of Soil and Groundwater. Niagara Falls, Ontario. June, 2001.

7. Siegrist, R. and Watts, R. *Chemical Processes for the In Situ Oxidation of contaminants in Soil and Groundwater.* Presented at the First International Conference on Oxidation and Reduction Technologies for In-Situ Treatment of Soil and Groundwater. Niagara Falls, Ontario. June, 2001.

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9. MK-Ferguson Company and Jacobs Engineering Group. *Environmental Monitoring Plan,* Rev. 9. DOE/OR/21548-424. Prepared for the U. S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. December 2001.

10. MK-Ferguson Company and Jacobs Engineering Group. *Environmental Quality Assurance Project Plan,* Rev. 5. DOE/OR/21548-352. Prepared for the U. S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. November 2000.

11. MK-Ferguson Company and Jacobs Engineering Group. *Sample Management Guide*, Rev. 2. DOE/OR/21548-499. Prepared for the U. S. Department of Energy, Oak Ridge Operations Office. St. Charles, MO. June 2000.

PROCEDURES

ES&H 1.1.7, *Data Review and Above-Normal Data Reporting*
ES&H 4.1.1, *Numbering System for Weldon Spring Site Environmental Sampling*
ES&H 4.1.2, *Initiation, Generation, and Transfer of Environmental Chain-of-Custody*
ES&H 4.3.1, *Surface Water Sampling*
ES&H 4.4.1, *Groundwater Monitoring*
ES&H 4.4.2, *Groundwater Level Monitoring and Well Integrity Inspections*
ES&H 4.9.1, *Environmental Monitoring Data Verification*
ES&H 4.9.2, *Environmental Monitoring Data Validation*

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MK-Ferguson Company
Weldon Spring Site Remedial Action Project

TRANSMITTAL OF CONTRACT DELIVERABLE

Date: **February 1, 2002** Transmittal No.: **CD –281-00**

Title of Document: **Groundwater Sampling Plan For In Situ Chemical Oxidation Pilot-Scale Testing**

Doc. Num.: **912** , Rev. No.: **0** Date of Document: **January 2002**

Purpose of Transmittal: Request for Department of Energy acceptance of contract deliverable.

In compliance with the Project Management Contract, MK-Ferguson Company hereby delivers the attached document to the U.S. Department of Energy, Weldon Spring Site Office. The document has been reviewed and approved by Project Management Contractor management.

The document will be considered accepted unless we receive written notification to the contrary within 30 days of the date of this transmittal.

Number of copies transmitted: **Eight**

Steven D. Warren
Project Director

TMP: Form Contract Deliverable