fPrepared for:
Tronox LLC
Henderson, Nevada

Phase A
Source Area Investigation Work Plan
Tronox LLC Facility
Henderson, Nevada

ENSR Corporation
September 2006
Document No.: 04020-023-400

TRONOX

ENSR | AECOM

Prepared for:
Tronox LLC
Henderson, Nevada

Phase A
Source Area Investigation Work Plan
Tronox LLC Facility
Henderson, Nevada

ENSR Corporation
September 2006
Document No.: 04020-023-400

Phase A Source Area Investigation Work Plan
Tronox LLC-Henderson, Nevada

Responsible CEM for this project

I hereby certify that I am responsible for the services described in this document and for the preparation of this document. The services described in this document have been provided in a manner consistent with the current standards of the profession and, to the best of my knowledge, comply with all applicable federal, state and local statutes, regulations and ordinances.

Susan M. Crowley, CEM 1428 exp. date 3/8/07
Staff Environmental Specialist
Tronox LLC

Individuals who provided input to this document

Sally Bilodeau, CEM 1953 exp. date 9/30/07
Senior Program Manager
ENSR International

Brian Ho
Project Scientist
ENSR International

Contents

Executive Summary ES-1

1.0 Introduction 1-1

1.1 Site History 1-2

1.2 Environmental Conditions Summary 1-3

1.3 Source Area Investigation – Phase A Objectives 1-5

1.4 Work Plan Organization 1-5

2.0 Site Information – Physical Setting 2-1

2.1 Site Location 2-1

2.2 Topography 2-1

2.3 Climate 2-1

2.4 Geology 2-1

2.4.1 Regional Geology 2-1
2.4.2 Local Geology 2-2
2.4.3 Local Hydrogeology 2-3

3.0 Source Area Investigation Rationale 3-1

3.1 Project Approach 3-1

3.2 Rationale for Proposed Drilling Locations 3-2

3.3 Rationale for Proposed Sampling Parameters 3-2

4.0 FIELD SAMPLING PLAN 4-1

4.1 Pre-Field Activities 4-1

4.2 Field Activities 4-1

4.2.1 Soil Borings 4-1
4.2.2 Soil Sampling 4-2
4.2.3 Soil Sample Handling 4-3
4.2.4 Borehole Abandonment 4-3
4.2.5 Groundwater Sampling 4-3

4.3 Field Documentation 4-6

4.3.1 Field Logbooks 4-6
4.3.2 Boring Logs 4-7
4.3.3 Chain-of-Custody Records 4-7

4.4 Analytical Testing Program 4-7

4.4.1 Soil Analytical Testing Program 4-8
4.4.2 Groundwater Analytical Testing Program 4-8

4.4.3 Geotechnical Testing Program 4-8
4.5 Equipment Decontamination 4-9
4.6 Management of Investigation-Derived Wastes 4-9
4.7 Surveying 4-9
4.8 Quality Assurance/Quality Control Program 4-9
4.8.1 Field QA/QC Samples 4-9
4.8.2 Laboratory QA/QC Procedures 4-10
4.8.3 Data Quality Indicators (DQI) 4-11

5.0 Data Evaluation and Reporting 5-1
5.1 Data Review 5-1
5.2 Reporting of Results 5-1
5.3 Assessment of Adequate Characterization for SRC Parameters 5-1
5.4 Assessment of Inadequate Characterization for SRC Parameters 5-2
5.5 Additional Investigation 5-2

6.0 Project Management Plan 6-1

7.0 References 7-1

APPENDICES

A	Tronox and NDEP Correspondence
B	Health and Safety Plan
C	Examples of Field Forms
D	**Standard Operating Procedures**

Deleted:

1.0 Introduction . 1-1
1.1 . Site History . 1-2
1.2 . Environmental Conditions Summary . 1-3
1.3 . Source Area Investigation – Phase A Objectives . 1-4
1.4 . Work Plan Organization . 1-4
2.0 Site Information – Physical Setting . 2-1
2.1 . Site Location . 2-1
2.2 . Topography . 2-1
2.3 . Climate . 2-1
2.4 . Geology . 2-1
2.4.1 . Regional Geology . 2-1
2.4.2 . Local Geology . 2-2
2.4.3 . Local Hydrogeology . 2-3
3.0 Source Area Investigation Rationale . 3-1
3.1 . Project Approach . 3-1
3.2 . Rationale for Proposed Drilling Locations . 3-2
3.3 . Rationale for Proposed Sampling Parameters . 3-2
4.0 FIELD SAMPLING PLAN . 4-1
4.1 . Pre-Field Activities . 4-1
4.2 . Field Activities . 4-1
4.2.1 . Soil Borings . 4-1
4.2.2 . Soil Sampling . 4-1
4.2.3 . Soil Sample Handling . 4-2
4.2.4 . Borehole Abandonment . 4-2
4.2.5 . Groundwater Sampling . 4-3
4.3 . Field Documentation . 4-6
4.3.1 . Field Logbooks . 4-6
4.3.2 . Boring Logs . 4-7
4.3.3 . Chain-of-Custody Records . 4-7
4.4 . Analytical Testing Program . 4-7
4.4.1 . Soil Analytical Testing Program . 4-7
4.4.2 . Groundwater Analytical Testing Program . 4-7
4.4.3 . Geotechnical Testing Program . 4-8
4.5 . Equipment Decontamination . 4-8
4.6 . Management of Investigation-Derived Wastes . 4-8
4.7 . Surveying . 4-9
4.8 . Quality Assurance/Quality Control Program . 4-9
4.8.1 . Field QA/QC Samples . 4-9
4.8.2 . Laboratory QA/QC Procedures . 4-10
4.8.3 . Quality Assurance Program . 4-10
4.8.4 . Comparison of Data Sets . 4-11
5.0 Data Evaluation and Reporting . 5-1
5.1 . Data Review . 5-1
5.2 . Reporting of Results . 5-1
5.3 . Assessment of Adequate Characterization for SRC Parameters . 5-1
5.4 . Assessment of Inadequate Characterization for SRC Parameters . 5-2
5.5 . Additional Investigation . 5-2
6.0 Project Management Plan . 6-1
7.0 References . 7-1

List of Tables

Table 1 LOUs and Known and/or Postulated Chemicals of Interest

Table 2 General Investigation Parameters

Table 3 Rationale for Borings and Monitoring Wells to be Sampled

Table 4 Site-Related Chemicals Analyte List for Soil and Groundwater Samples

Table 5 Proposed Soil Sample Analytical Plan

Table 6 Proposed Groundwater Analytical Plan

Table 7 Alphabetical Listing of Site-Site-Related Chemicals

Table 8 Sample Containers, Analytical Methods, and Holding Times for Groundwater Samples

Table 9 Sample Containers, Analytical Methods, and Holding Times for Soil Samples

List of Figures and Plates

Figure 1 Site Location Map

Figure 2 Project Organization Chart

Plate 1 Potential Source Areas, Proposed Borings and Wells to be Sampled

ABBREVIATIONS AND ACRONYMS

AP&CC	American Potash and Chemical Company
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
bgs	below ground surface
CLP	Contract Laboratory Program
COC	Chain-of-Custody
COPC	constituents of potential concern
DO	dissolved oxygen
DOT	Department of Transportation
ECA	Environmental Conditions Assessment
EPA	United States Environmental Protection Agency
F	Fahrenheit
ft/ft	feet per foot
GC/MS	Gas Chromatography/Mass Spectrometry
GRO	gasoline range organics
HASP	Health and Safety Plan
ICP	inductively coupled plasma
IDW	investigation-derived wastes
LOU	Letter of Understanding
MCcg1	Muddy Creek Formation, first (upper) coarse-grained facies
MCfg1	Muddy Creek Formation first (upper) fine-grained facies
MCL	Maximum Contaminant Level
NAPL	Non-Aqueous Phase Liquid
NDEP	Nevada Division of Environmental Protection
OCPs	Organochlorine pesticides
OPPs	Organophosphorous pesticides
PAHs	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PID	photoionization detector
PRGs	Preliminary Remediation Goals as established by EPA Region 9 October 2004
QA/QC	quality assurance/quality control
SAW	Source Area Investigation Work Plan
SCRs	site-related chemicals
SVOCs	semivolatile organic compounds

Deleted: ¶

Formatted: Indent: Left: 0", First line: 0"

Deleted: DQL . . . data quality limit¶

Formatted: French (France)

Formatted: Indent: Left: 0", First line: 0"

Deleted: ¶

Formatted: French (France)

ABBREVIATIONS AND ACRONYMS

SWMU	solid waste management unit
TDS	total dissolved solids
TOC	total organic carbon
TPH	total petroleum hydrocarbons
Tronox	Tronox LLC
USA	Underground Services Alert
USCS	Unified Soils Classification System
VOA	volatile organic analysis
VOCs	volatile organic compounds
WECCO	Western Electrochemical Company

EXECUTIVE SUMMARY

This work plan describes activities intended to characterize soil and groundwater conditions at the approximately 450-acre Tronox LLC facility (the Site) located within the Black Mountain Industrial (BMI) Complex in Henderson, Nevada. The Site is owned and operated by Tronox LLC (formerly Kerr-McGee Chemical LLC), headquartered in Oklahoma City, Oklahoma (Tronox). The assessment is being conducted under the regulatory oversight of the Nevada Division of Environmental Protection (NDEP).

Deleted: supervision

A draft Source Area Investigation Work Plan (SAW) Phase A was submitted to the NDEP in February 2006. The February SAW included eight borings and associated groundwater samples, and proposed a 3-phase investigation program (Phases A, B and C). Comments were received from the NDEP dated March 11, 2006.

In response to the comments received, and in cooperation with the NDEP during monthly meetings in March through September 2006, Tronox revised and expanded the SAW to include 27 borings and an equal number of groundwater samples. Whereas the original SAW was based on three phases of site characterization, the revised SAW, described herein, combines the work elements included in the former Phase A and Phase B. The scope of work included in this revised SAW includes the assessment and initial characterization of site related chemicals (SRCs) and the development of geologic and chemical impact data along five, sub-parallel, east-west transects across the site. The copies of Tronox and NDEP correspondence are included in **Appendix A.** Future work beyond that proposed herein was renamed from the former Phase C in the February SAW to Phase B in this work plan.

This work plan sets forth the objectives and work scope for the collection and analyses of soil and groundwater for the Phase A-Source Area Investigation (Phase A-SAW). This investigation focuses on the soil and groundwater conditions associated with areas within the Site that are suspected to be impacted or comprise potential contaminant source areas. **Table 1** lists the potential study areas identified by the NDEP in their August 15, 1994 Letter of Understanding (LOU). Historically these areas have been called LOU study areas, or LOU areas, for short, and many of them are suspected contaminant source areas. Along with the LOU areas, the U.S. Vanadium site was added to the **Table 1**.

Table 1 also presents the known and/or postulated chemicals of interest associated with the potential source areas. **Table 2** presents the general investigative parameters. The information summarized in **Tables 1 and 2** were combined in **Table 3** which presents the rationale for the proposed boring and groundwater sample locations. **Plate 1** depicts the LOU areas, other potential source areas, the proposed soil borings, and the groundwater sample locations.

The initial suite of chemical data collected during Phase A includes the analysis of 230 chemicals, as listed in **Table 4**. These data will be used to identify and characterize the SRCs present in soil and groundwater at the 27 locations sampled across the site. Cross sections will be developed to refine the understanding of the subsurface geology and the presence and distribution of SRCs.

Each of the SRC parameters will be evaluated to assess the adequacy of its characterization. The adequacy of characterization will be determined by applying appropriate statistical tools to verify the comparability of the parameter with other data populations; comparing the SRC parameter detections with the available EPA Industrial PRG values (Industrial PRG x 0.10) or MCLs; evaluating the SRC parameter occurrence and frequency of detection; comparing the SRC parameter with upgradient data and background conditions; and reviewing the SRC parameter for evidence of historical uses and or occurrence. Once a SRC parameter is established to be adequately characterized it will be recommended for exclusion from future characterization activities.

Phase B of the Source Area Investigation will be focused on defining the nature and extent of impacts identified during Phase A which require additional characterization. Additional soil borings and wells will be drilled to define the nature and extent of SRC parameters requiring additional characterization. The data generated during both Phase A and Phase B will be used to support risk assessment studies, fate and transport modeling, as necessary, and the evaluation of remedial alternatives, if appropriate.

This document describes the approach and methodology for Phase A – Source Area Investigation (Phase A). The following Phase A scope of work elements have been identified:

- Soil borings will be drilled at 27 locations on the Site.
- Sonic drilling techniques will be employed and the continuous core produced will be observed to prepare the boring log. The samples from 0.5 feet below ground surface (bgs) and at approximate 10 foot intervals to just above the water table in each of the borings will be submitted for laboratory analysis.
- Soil samples will be analyzed for up to 230 SRCs identified on **Table 4**. Approximately 10 percent duplicate samples will be collected and analyzed.
- Groundwater samples will be collected using micropurge methods from approximately 23 wells with 10 percent duplicate samples and analyzed for up to 230 SRCs identified on **Table 4.** Groundwater grab samples will be collected from four boreholes where there are not existing, useable monitoring wells near by. If a well identified for sampling is dry, or otherwise unusable for sampling, a groundwater grab sample will be collected from the borehole.
- Samples of the manganese ore and tailings stockpiles will be collected and analyzed for metals and radionuclides. The tailings sampling was completed in September 2006.

The soil and groundwater analytical data will be used to characterize the impacts present at the selected sample locations, and to identify which of the SRC parameter(s) have been adequately characterized.

The data will be compared to upgradient and background data as well as subjected to appropriate statistical tests and comparisons. These data will be used to direct the focus of the Phase B sampling efforts, to identify which SRC parameters require further characterization, and support future risk assessments.

1.0 Introduction

This work plan describes activities intended to characterize soil and groundwater conditions at the approximately 450-acre Tronox LLC facility (the Site) located within the Black Mountain Industrial (BMI) Complex in Henderson, Nevada. The Site is owned and operated by Tronox LLC (formerly Kerr-McGee Chemical LLC), headquartered in Oklahoma City, Oklahoma (Tronox). The assessment is being conducted under the regulatory oversight of the Nevada Division of Environmental Protection (NDEP).

Deleted: supervision

A draft Source Area Investigation Work Plan (SAW) Phase A was submitted to the NDEP in February 2006. The February draft SAW included eight borings and associated groundwater samples, and proposed a 3-phase investigation program (Phases A, B and C). Comments were received from the NDEP dated March 11, 2006.

In response to the comments received, and in cooperation with the NDEP during monthly meetings in March through September 2006, Tronox revised and expanded the SAW to include 27 borings and an equal number of groundwater samples. Whereas the original SAW was based on three phases of site characterization, the revised SAW, described herein, combines the work elements included in the former Phase A and Phase B. The scope of work included in this revised SAW includes the assessment and initial characterization of site related chemicals (SRCs) and the development of geologic and chemical impact data along five, sub-parallel, east-west transects across the site. The copies of Tronox and NDEP correspondence are included in **Appendix A.** Future work beyond that proposed herein was renamed from the former Phase C in the February SAW to Phase B in this Workplan.

This work plan sets forth the objectives and work scope for the collection and analyses of soil and groundwater for the Phase A-Source Area Investigation (Phase A-SAW). This investigation focuses on the soil and groundwater conditions associated with areas within the Site that are suspected to be impacted or comprise potential contaminant source areas. **Table 1** lists the potential study areas identified by the NDEP in their August 15, 1994 Letter of Understanding (LOU). Historically these areas have been called LOU study areas, or LOU areas, for short, and many of them are suspected contaminant source areas. Along with the LOU areas, the U.S. Vanadium site was added to the **Table 1**.

Plate 1 depicts the LOU areas, the other potential source areas, the proposed borings, and the groundwater sample locations. The following U.S. Environmental Protection Agency (EPA) guidance documents were consulted during the preparation of this work plan:

- EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Office of Emergency and Remedial Response, October.

Formatted: Bullets and Numbering

- EPA 1989, Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A) interim final (EPA/540/1-89/002), December.

Formatted: Bullets and Numbering

- EPA. 1992. Guidance for Data Useability in Risk Assessment (Part A). 9285.7-09A.
- EPA, 1995, Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality Related Documents, EPA QA/G-6, Office of Research and Development, Washington, D.C., EPA/600/R-96/027, November.
- EPA 2002, Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, OSWER Technology Innovation Office, (EPA 542-S-02-001) May.

Table 1 also presents the known and/or postulated chemicals of interest associated with the potential source areas. **Table 2** presents the general investigative parameters. The information summarized in **Tables 1 and 2** were combined in **Table 3** which presents the rationale for the proposed boring and groundwater sample locations.

The initial suite of chemical data collected during Phase A includes the analysis of 230 chemicals, as listed in **Table 4**. These data will be used to identify and characterize the SRCs present in soil and groundwater at the 27 locations sampled across the site. Cross sections will be developed to refine the understanding of the subsurface geology and the presence and distribution of SRCs.

Each of the SRC parameters will be evaluated to assess the adequacy of its characterization. The adequacy of characterization will be determined by applying appropriate statistical tools to verify the comparability off the parameter with other data populations; by comparing the SRC parameter detections with the available EPA Industrial PRG values or MCLs; by evaluating the SRC parameter occurrence and frequency of detection; by comparing the SRC parameter with upgradient data and background conditions; and by reviewing the SRC parameter for evidence of historical uses and or occurrence. Once a SRC parameter is established to be adequately characterized it will be recommended for exclusion from future characterization activity(s).

Phase B of the Source Area Investigation will be focused on defining the nature and extent of impacts identified during Phase A. Additional soil borings and wells (if necessary) will be drilled to define the nature and extent of SRC parameters requiring additional characterization. The data generated during Phase A and Phase B will be used to support risk assessment studies, fate and transport modeling, as necessary, and the evaluation of remedial alternatives, if appropriate.

This document describes the approach and methodology for Phase A – Source Area Investigation (Phase A). Once Phase A has been completed and approved by the NDEP, a work plan for subsequent phases will be prepared for NDEP review and approval.

1.1 Site History

The BMI complex has been the site of industrial operations since 1942 and was originally sited and operated by the U.S. government as a magnesium production plant in support of the World War II effort. Following the war, a portion of the complex was leased by Western Electrochemical Company (WECCO). By August 1952, WECCO had purchased several portions of the complex, including six of the large unit buildings, and produced manganese dioxide, sodium chlorate, and various perchlorates. In addition, in the early 1950s, pursuant to a contract with the U.S. Navy, WECCO constructed and operated a plant to produce ammonium perchlorate on land purchased by the Navy. In 1956, WECCO merged with American Potash and Chemical Company (AP&CC) and continued to operate the processes, with the Navy's continued involvement in the ammonium perchlorate process.

In 1962, AP&CC purchased the ammonium perchlorate plant from the Navy but continued to supply the Navy, and its contractors, material from the operating process. AP&CC merged with Kerr-McGee Corporation (Kerr-McGee) in 1967. This merger included boron production processes in California, which were moved to Henderson and began operation in the early 1970s. These included elemental boron, boron trichloride, and boron tribromide. In 1994, the boron tribromide process was shut down and dismantled. In 1997, the sodium chlorate process was shut down, and in 1998, production of commercial ammonium perchlorate ended as well. The ammonium perchlorate production equipment was used to reclaim perchlorate from on-site materials until early 2002, when the equipment was permanently shut down.

In 2005, Kerr-McGee Chemical LLC's name was changed to Tronox LLC. Processes currently operated by Tronox at the Henderson facility are for production of manganese dioxide, boron trichloride, and elemental boron. Additional companies operate within the BMI complex; details regarding ownership and leases within the BMI complex are described in the 1993 Phase I Environmental Conditions Assessment (ECA) report (Kleinfelder 1993).

During the 1970s, the EPA, the State of Nevada, and Clark County investigated potential environmental impacts from the BMI companies' operations, including atmospheric emissions, groundwater and surface water discharges, and soil impacts (E&E 1982). From 1971 to 1976, Tronox, then Kerr-McGee, modified their manufacturing process and constructed lined surface impoundments to recycle and evaporate industrial wastewater. In 1976, the facility achieved zero discharge status regarding industrial wastewater management. In 1980, the EPA requested specific information from the BMI companies regarding their manufacturing processes and their waste management practices by issuing section 308 letters. In 1994, the NDEP issued a Letter of Understanding (LOU) that identified 69 specific areas or items of interest and indicated the level of environmental investigation they wanted Tronox to conduct.

Tronox has undertaken environmental investigations to assess specific impacts in the area. A detailed discussion of the specific areas or items of interest identified in the LOU and a list of the products made, years of production, and approximate waste volumes for WECCO, AP&CC and Tronox are found in the Conceptual Site Model document (ENSR 2005).

1.2 Environmental Conditions Summary

Numerous investigations have been conducted to evaluate the nature, extent, and movement of contaminants on the Site and in downgradient and cross-gradient areas. A summary of the Site history, soil, and groundwater investigations is presented below.

In April 1991, Tronox, then Kerr-McGee, was one of six companies that entered into a Consent Agreement with the NDEP (NDEP 1991) to conduct environmental studies to assess site-specific environmental conditions that are the result of past and present industrial operations and waste disposal practices. The six companies that entered into the Consent Agreement included those past or present entities that conducted business within the BMI complex. The Consent Agreement specified that the companies accomplish the following:

- Identify past industrial practices and waste products generated;
- Identify known or suspected waste management units or areas active on or after November 19, 1980;
- Identify known or suspected spills of any pollutant or contaminant;
- Identify all current and prior owners and operators of any part of the Site;
- Collect and summarize records or investigations that identify, document, or address soil, surface water, groundwater, or air impacts; and
- Provide documentation of all measures that have been taken to monitor, characterize, mitigate, or clean up Site environmental impacts.

In April 1993, in compliance with the 1991 Consent Agreement, Tronox submitted the Phase 1 Environmental Conditions ECA (Kleinfelder 1993) to the NDEP. The purpose of the report was to identify and document site-specific environmental impacts resulting from past or present industrial activities. The Phase 1 ECA included a thorough assessment of the geologic and hydrologic setting, as well as historical manufacturing activities. The assessment identified 31 solid waste management units (SWMUs), 20 areas of known or suspected releases or spills, and 14 miscellaneous areas where Site activities may have impacted the soil, air, or groundwater.

In response to the NDEP review of the Phase 1 ECA and discussions between the NDEP and Tronox, the NDEP prepared a LOU summarizing requirements for additional information and data collection (NDEP 1994). The LOU identified 69 items to be addressed further (see ENSR 2005). The LOUs are listed on **Table 1**. Each of the LOU items was addressed by one or more of the following actions, as requested in the LOU by the NDEP:

1. Tronox provided additional information to the NDEP in a written response (35 items);
2. Tronox conducted field sampling and data collection (12 items);
3. Field investigation by the Henderson Industrial Site Steering Committee (2 items); or
4. “No further action required at this time” (20 items).

On October 2, 1996, Tronox submitted complete responses to the 35 LOU items requiring additional information or explanation (Kerr-McGee 1996b).

In 1996 and 1997, Tronox conducted additional data collection as part of a Phase II ECA. The field investigations were conducted in compliance with an NDEP-approved work plan (Kerr-McGee 1996a). The Phase II ECA addressed the 12 LOU items that were identified as needing additional characterization. In August 1997, Tronox submitted the Phase II ECA (ENSR 1997) report to the NDEP.

On June 10, 1998, the NDEP issued comments to the Phase II ECA report (NDEP 1998), which conditionally approved the document subject to selected additional work and development of a conceptual site model.

On November 9, 1998, Tronox submitted a response to the NDEP comments to the Phase II ECA report and included with the responses a Supplemental Phase II ECA Work Plan (Kerr-McGee 1998) designed to provide the supplemental data required by the NDEP for the Phase II ECA.

On December 17, 1998, the NDEP replied to Tronox, then Kerr-McGee; NDEP conditionally approved Tronox’s Response to Comments and the Supplemental Work Plan. According to the NDEP, the Work Plan was approved subject to “the development of a CSM [conceptual site model] for the Site and comparing the soil sample results that were and will be obtained to the Nevada cleanup standards and actual background values.”

In March and April 1999, the NDEP-approved field work for the supplemental Phase II ECA was conducted. In April 2001, Tronox prepared a report of the findings of the field work and submitted them to the NDEP as the Supplemental Phase II ECA (ENSR 2001).

In February 2004, the NDEP provided a response to the Tronox, then Kerr-McGee, Supplemental Phase II ECA (NDEP 2004). NDEP indicated that additional work would be required including identification of all potential contaminants associated with the Site, background sampling, assessment of site-specific action levels, and identification of data gaps.

In March 2006, six boreholes were drilled and sampled as part of the Tronox upgradient investigation. These data will be used to supplement the data generated through the source area investigation.

In February 2006, the SAW was provided to the NDEP. NDEP provided comments on the SAW March 11, 2006. This SAW has been revised to respond to the NDEP comments. Copies of Tronox and NDEP correspondence are included in **Appendix A**.

1.3 Source Area Investigation – Phase A Objectives

The objective of the Phase A Source Area investigation is to characterize the SRCs at 27 suspected source areas. The goal of the investigation is to develop data that can be used to refine the conceptual site model, to characterize site conditions, and to support for future risk assessments. An additional objective is to determine the compare the upgradient and downgradient chemistry of the soil and groundwater. On the basis of the characterization Tronox will make recommendations to the NDEP regarding which of the SRC parameters have been adequately characterized, and can be excluded from additional characterization through the Phase B investigation.

1.4 Work Plan Organization

The SAW is organized as follows:

- **Section 1** is the introduction and presents a brief history of the Site and summarizes the environmental conditions and source area investigation objectives at the Site;
- **Section 2** discusses the physical setting of the Site;
- **Section 3** contains a discussion of the project investigation rationale;
- **Section 4** describes the field methods that will be used to perform the Phase A Source Area Investigation;
- **Section 5** describes the procedures by which the laboratory data will be evaluated and a description of the resulting report;
- **Section 6** contains a brief description of the project personnel and their roles and responsibilities for the Source Area Investigation; and
- **Section 7** provides a bibliographic list for each of the references cited in this work plan.

Several appendices are included in this document including the following:

- **Appendix A** contains correspondence between the NDEP and Tronox;
- **Appendix B** contains the Site-specific Health and Safety Plan (HASP) that has been prepared for the Source Area Investigation; and
- **Appendix C** contains examples of field documentation forms that will be used during the performance of the Source Area Investigation.

2.0 Site Information – Physical Setting

2.1 Site Location

The Site is approximately 450 acres in size and is located 13 miles southeast of Las Vegas in an unincorporated section of Clark County, Nevada (**Figure 1**). It is completely surrounded by the incorporated area comprising the City of Henderson. The Site is in Township 22S, Range 62E, and covers portions of Sections 1, 12, and 13. The approximate center of the Site is longitude 36°02'45" W and latitude 115°00'20" N. Phase A of the Source Area Investigation is focused on gathering information from selected locations across the entire Site as depicted on **Plate 1**.

2.2 Topography

Elevations across the Site range from 1,677 to 1,873 feet above mean sea level. The land surface across the Site slopes toward the north at a gradient of approximately 0.023 feet per foot (ft/ft). The developed portions of the Site have been modified by grading to accommodate building foundations, surface impoundments, and access roads.

2.3 Climate

The climate of the Las Vegas Valley is arid, consisting of mild winters and dry hot summers. Average annual precipitation as measured in Las Vegas from 1971 to 2000 was 4.49 inches. Precipitation generally occurs during two periods, December through March and July through September. The winter storms generally produce low intensity rainfall over a large area. The summer storms generally produce a high intensity rainfall over a smaller area for a short duration. These violent summer thunderstorms account for most of the documented floods in the Las Vegas area. Temperatures can rise to 120^{O} Fahrenheit (F) in the summer, and average relative humidity is 20 percent. The mean annual evaporation from lake and reservoir surfaces ranges from 60 to 82 inches per year.

Winds frequently blow from the southwest or northwest and are influenced by nearby mountains. Strong winds in excess of 50 miles per hour are experienced occasionally.

2.4 Geology

2.4.1 Regional Geology

The Las Vegas Valley occupies a topographic and structural basin trending northwest-southeast and extending approximately 55 miles from near Indian Springs on the north to Railroad Pass on the south. The valley is bounded by the Las Vegas Range, Sheep Range, and Desert Range to the north; by Frenchman and Sunrise Mountains to the east; by the McCullough Range and River Mountains to the south and southeast; and the Spring Mountains to the west. The mountain ranges bounding the east, north, and west sides of the valley consist primarily of Paleozoic and Mesozoic sedimentary rocks (limestones, sandstones, siltstones, and fanglomerates), whereas the mountains on the south and southeast consist primarily of Tertiary volcanic rocks (basalts, rhyolites, andesites, and related rocks) that lie directly on Precambrian metamorphic and granitic rocks (Bell 1981).

In the Las Vegas Valley, basin-fill consists of Tertiary and Quaternary sedimentary and volcanic rocks and unconsolidated deposits, which can be up to 13,000 feet thick (Langenheim et al. 1998). The valley floor consists of fluvial, paludal (swamp), and playa deposits surrounded by more steeply sloping alluvial fan aprons derived from erosion of the surrounding mountains. Generally, the deposits grade finer with increasing distance from the source area and with decreasing elevation. The structure within the Quaternary and

Tertiary-age basin-fill is characterized by a series of generally north-south trending fault scarps. The origin of the faults is somewhat controversial; they may be tectonic in origin or may be the response to compaction and subsidence within the basin due to groundwater withdrawal.

A detailed discussion of the geology of the Site and surrounding area is found in the Conceptual Site Model document (ENSR 2005).

2.4.2 Local Geology

The local geology and hydrology are defined by data collected from the numerous borings and wells that have been installed in the area.

Alluvium. The Site is located on Quaternary age alluvial deposits that slope north toward Las Vegas Wash. The alluvium consists of a reddish brown heterogeneous mixture of well-graded sand and gravel with lesser amounts of silt, clay, and caliche. Clasts within the alluvium are primarily composed of volcanic material. Boulders and cobbles are common. Due to their mode of deposition, no distinct beds or units are continuous over the area.

A major feature of the alluvial deposits is the stream-deposited sands and gravels that were laid down within paleochannels that were eroded into the surface of the Muddy Creek Formation during infrequent flood runoff periods. These deposits are thickest within the paleochannel boundaries, which are narrow and linear. These sand and gravel deposits exhibit higher permeability than the adjacent, well-graded deposits. In general, these paleochannels trend northeastward.

The thickness of the alluvial deposits ranges from less than a foot to more than 50 feet beneath the Site. Soil types identified in boreholes on-site include poorly sorted gravel, silty gravel, poorly sorted sand, well sorted sand, and silty sand. The thickness of the alluvium, as well as the surface of the underlying Muddy Creek formation, was mapped to locate these paleochannels.

Muddy Creek Formation. The Muddy Creek Formation of Miocene and Pliocene (?) age occurs in Las Vegas Valley as valley-fill deposits that are coarse-grained near mountain fronts and become progressively finer-grained toward the center of the valley (Plume, 1989). Where encountered beneath the Site, the Muddy Creek Formation is composed of at least two thicker units of fine-grained sediments of clay and silt (the first and second fine-grained facies, respectively) interbedded with at least two thinner units of coarse-grained sediments of sand, silt, and gravel (the first and second coarse-grained facies, respectively). Everywhere beneath the Site, except for the southernmost 1,000 feet adjacent to Lake Mead Parkway, the first fine-grained facies (MCfg1) separates the first coarse-grained facies (MCcg1) from the overlying Quaternary alluvium. Within the southern 1,000 feet of the Site, the Muddy Creek Formation's first fine-grained facies (MCfg1) pinches out along a generally west-northwesterly trending line. South of this line, the first coarse-grained facies (MCcg1) directly underlies the Quaternary alluvium.

The Muddy Creek Formation represents deposition in an alluvial apron environment from the Spring Mountains to the west grading into fluvial, paludal (swamp), playa and lacustrine environments further out into the valley center. On the Site, the Muddy Creek does not crop out but instead subcrops beneath a veneer of Quaternary alluvium.

In on-Site borings, the contact between the Quaternary alluvium and the Muddy Creek Formation (MCfg1) is typically marked by the appearance of well-compacted, moderate brown silt-to-sandy silts or a stiff clay-to-sandy clays, whereas near the Las Vegas Wash, the contact is marked by gray-green to yellow-green gypsiferous clays and silts.

2.4.3 Local Hydrogeology

Alluvial Aquifer. Beneath the northern portion of the Site, the first groundwater encountered occurs within the Quaternary-age alluvium at depths of more than 30 feet below ground surface (bgs) and shallows northward, occurring near the ground surface at Las Vegas Wash. In the alluvial aquifer, groundwater flows towards the north-northeast with minor variations, generally mimicking the slope of the ground surface.

Muddy Creek Aquifer. Beneath the central portion of the Site, the first groundwater encountered occurs within the first fine-grained facies of the Muddy Creek Formation (MCfg1) and can be more than 50 feet bgs as documented in historical water-level measurements from well M-10. South of the MCfg1 pinch-out, beneath the southern portion of the Site, the first groundwater encountered occurs within the first coarse-grained facies of the Muddy Creek Formation (MCcg1) and can be more than 70 feet bgs as documented in historical water-level measurements from well M-103 and further confirmed from water-level measurements from the new wells (M-120 and M-121) installed as part of the upgradient investigation. The gradient and flow direction of the potentiometric surface in both the shallow first fine-grained and first coarse-grained facies of the Muddy Creek also mimics the ground surface and is to the north-northeast with minor variations.

Deep beneath the Site and extending into the Las Vegas Valley, confined groundwater occurs within the deeper coarse-grained facies of the Muddy Creek Formation. The flow direction of this deeper groundwater is more northeasterly than the shallow unconfined groundwater aquifer. Deep wells drilled into the Muddy Creek Formation all exhibit artesian conditions with some wells flowing at the surface. Most shallow wells drilled into the shallow Muddy Creek also demonstrate an upward hydraulic gradient.

The NDEP has advised Tronox that to the west of monitoring wells TR-3 and TR-4 non-aqueous phase liquids (NAPLs) have been reported in groundwater. The composition of the NAPL has not been reported at this time.

3.0 Source Area Investigation Rationale

3.1 Project Approach

The scope comprising this phase of investigative work consists of an initial assessment of soils and groundwater for the presence or absence of chemicals included on the SRC list. The assessment consists of an evaluation of soil conditions at 27 locations (SA-1 through SA-27) across the Site, each of which are suspected of contaminant impacts. In addition, groundwater samples will be collected at or near each borehole location. The manganese tailings and the manganese dioxide ore will also be analyzed.

One soil boring will be drilled using sonic drilling methods at each of the selected 27 locations as depicted on **Plate 1**. Soil samples destined for laboratory analyses will be collected at approximate depths of 0.5 bgs and, thereafter, at 10 foot depth intervals to just above the water table. Ground water levels will be estimated from extrapolated measurements in nearby wells. Each soil sample will be analyzed for the presence of up to 230 potential SRCs (listed in **Table 4**). The results will also be used to evaluate the need for additional site characterization activities at each of the 27 locations.

Twenty-three of the 27 soil borings will be drilled near existing monitoring wells. Groundwater samples will be collected from these existing monitoring wells and analyzed to assess the presence of potential SRCs. Where monitoring wells are not close to boring locations, a groundwater grab sample will be collected from four soil borings deepened into the water table. If a well proposed for sampling is dry, or otherwise unusable for sampling, a groundwater grab sample will be collected from the borehole.

The selected soil samples and groundwater samples will be analyzed for the SRCs identified on **Table 4**, which include the following chemicals.

- metals;
- volatile organic compounds (VOCs) including fuel oxygenates;
- semi-volatile organic compounds (SVOCs);
- polychlorinated biphenyl (PCB) compounds;
- total petroleum hydrocarbon [TPH as gasoline, diesel and oil range organics(GRO, DRO, and ORO) in soil only];
- radionuclides;
- perchlorate;
- organochlorinated pesticides (OCPs) and organophosphorous (OPP) pesticides;
- general chemistry (anions, physical, and aggregate properties);
- fuel alcohols;
- dioxins/dibenzofurans; and
- asbestos

Please see **Table 4** for the Site-Related Chemical Analytical List for Soil and Groundwater Samples, in which the proposed analytical plan for soil and groundwater samples is presented. Once the data analyses are completed and compiled, a report summarizing the results of the fieldwork and the analytical findings will be prepared and submitted to the NDEP.

3.2 Rationale for Proposed Drilling Locations

Since beginning operations in 1942, manufacturing activities and product and/or waste storage have been conducted at various locations on the Site. Areas that may constitute potential contaminant sources include former or existing production and/or storage areas. Many of these areas had been previously identified by the NDEP and Tronox through the 1994 LOU (described in more detail in Section 1.1).

Since 1994, the potential study areas identified in the LOU have been designated LOU areas (e.g., LOU 1, LOU 2, etc.). The locations of the LOU areas and the former U. S. Vanadium site are depicted on **Plate 1**, and a summary of the LOUs suspected chemicals of interest is presented in **Table 1**. At the request of the NDEP, U.S. Vanadium has been added to **Table 1**.

At this phase of the investigation, each of the individual suspected source areas will be evaluated for the chemicals most likely associated with the historic uses of that area. In addition, the NDEP has requested that each of the investigative areas undergo a much more inclusive screening for other constituents. A broad list of general investigative parameters will be applied to the investigation. **Table 2** lists the general investigative parameters and their proposed frequency of analysis. The specific SRC analytes for soil and groundwater sampling are listed on **Table 4**.

The rationale for selecting each of the boring locations and wells to be sampled is summarized on **Table 3**. In addition, each of the boring locations is twinned with a nearby groundwater sampling location. The groundwater monitoring well proposed for sampling is selected based on its proximity to the soil boring and its construction details (i.e., the screened interval must be suitable to measure potential impacts from the overlying vadose zone). The superposition of nearly co-located soil and groundwater data will allow the assessment of whether or not underlying groundwater is being impacted from chemicals detected in the overlying soils. **Table 3** lists each of the boring locations and its proposed associated groundwater monitoring location.

Of the 27 proposed boring locations, 23 have nearby monitoring wells that may be suitable to sample. For the remaining 4 boring locations without nearby monitoring wells, a grab sample of groundwater will be collected directly from the borehole. If a well identified for sampling is dry, or otherwise unusable, a groundwater grab sample will be collected from the borehole. **Tables 5 and 6** summarize the analytical plans for soil and groundwater sample locations, respectively.

3.3 Rationale for Proposed Sampling Parameters

Soil samples and groundwater samples will be analyzed for the SRCs as shown on **Tables 3 and 4**. Sample containers for each analytical parameter along with the respective holding times are shown on **Table 5** (for soil) and **Table 6** (for groundwater). A complete, alphabetically organized list of SRCs is presented in **Table 7**.

The extensive list of SRCs was developed at the request of the NDEP as specified in the February 11, 2004, letter. NDEP requested that all chemicals present at the Site or associated with historical operations be identified and included on the SRC list **(Table 7).**

The following text was excerpted from the February 11, 2004, NDEP letter (Attachment A pages 6 and 7):

> *SRCs include all raw materials, products processed, byproducts, waste products and any other chemical used at the facility. All degradation products associated with any chemical that may have been used at the facility are also SRCs. If it is unknown whether or not chemicals are present at the site or if all chemicals associated with historical operations have not been adequately documented, then a broad suite analysis is warranted for those chemical classes that may be present. Site-related chemicals associated with the KM facility need to be identified and justified for each chemical class including but not limited*

to: metals, radionuclides, volatile organic compounds, dioxins, furans, pesticides, and polycyclic aromatic hydrocarbons (PAHs).

The development of the SRC list was accomplished by reviewing available historical documents and data sets, along with information available on adjacent properties whose operations may have impacted the Site. These data along with anecdotal information provided by company personnel allowed the assembly of iterative lists, which were progressively refined in cooperation with the NDEP. After repeated reviews, the NDEP approved the SRC list for the Tronox Site in March 2005. The list was expanded to include additional constituents in 2005 and 2006; the current SRC list, arranged alphabetically, is presented in **Table 7.**

The detailed sample analytical plans are listed in **Table 5** (soil) and **Table 6** (groundwater), and a summary of the rationale for the proposed sampling parameters is summarized below and described in **Table 2.**

- Metals – all soil and groundwater samples will be analyzed for aluminum, antimony, arsenic, barium, beryllium, boron, calcium, cadmium, chromium (total and Cr^6), cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, platinum, selenium, silver, sodium, thallium, tin, titanium, tungsten, vanadium, and zinc. Silicon has been eliminated from the metals list because the background levels in the sandy soil at the Site are very high and the results could not be used in any meaningful way to assess site-related contamination. Methylmercury will be analyzed only if total mercury concentrations exceed 5 parts per million (ppm) in soil or 0.2 micrograms per liter (µg/L) in water or if other indicators such as low dissolved oxygen concentrations are present. In general, anaerobic conditions, which are unlikely at the Site, are necessary for the formation of methylmercury.

- VOCs – all soil and groundwater samples will be analyzed for the VOCs listed on **Table 4** to determine where VOCs are present.

- SVOCs – all soil and groundwater samples will be analyzed for the SVOCs listed on **Table 4** to determine where SVOCs are present. The frequency of selected ion monitoring (SIM) analysis for PAHs and hexachlorobenzene will be 10 percent of the total samples analyzed for SVOCs. The dichlorobenzenes are not included in the SVOC list because they are duplicated in the VOC analyte list.

- PCBs – all soil and groundwater samples will be analyzed for PCBs to determine if and where PCBs are present.

- TPH – analysis will be limited to areas historically used for automobile and auto parts storage and maintenance.

- Radionuclides –Radionuclides will be analyzed by gamma spectroscopy reporting Radium-226 and Radium-228 on 100 percent of the soil samples. Water samples will be analyzed by gamma spectroscopy for Radium-228 and by radon emanation for Radium-226. Isotopic thorium and uranium will be analyzed by alpha spectroscopy on 10 percent of the soil and groundwater samples (using alpha spectroscopy leach method). This radiochemical dataset should provide enough information to confirm secular equilibrium and allow inference of the other radionuclide activities in the respective uranium and thorium isotope decay chains.

- Perchlorate – all soil and groundwater samples will be analyzed for perchlorate to determine where and at what concentration perchlorate is present.

- OCPs and OPPs – will be analyzed in the 0.5-foot soil sample only. The 10-foot samples from SA-2, SA-4, SA-16, SA-17, SA-18, SA-21, SA-22, and SA-23 will be collected. If OCPs or OPPs are detected in the 0.5 foot sample, the 10 foot sample will be analyzed. The herbicide Silvex will be added for the analysis of surficial soils in the vicinity of LOU 1 (SA-21, SA-22, and SA-23). Samples

Deleted: Pesticides were not manufactured at the Site.

will be collected from 0.5 and 10 feet bgs. Samples from 10 feet will not be analyzed unless it is detected in the 0.5 foot sample. Groundwater will also be analyzed fro OPPs and OCPs as shown on **Table 6.**

- General Chemistry includes analysis of alkalinity, ammonia, bromide, chloride, chlorate, electrical conductivity (EC) (water only), nitrate, nitrite, orthophosphate, sulfate, surfactants (methylene blue active substances [MBAS]), pH, total dissolved solids (TDS), and total organic carbon (TOC). Data quality checks such as anion-cation balance, gravimetric vs. calculated TDS, and TDS to EC ratio will also be determined. Sulfide, sulfite, residual chlorine, and flashpoint have been eliminated because they are or are related to highly reactive chemical species which are unlikely to persist at the Site.

- Fuel alcohols including ethylene glycol will only be sampled in areas historically used for automobile and auto parts storage and maintenance.

- Dioxins/dibenzofurans analyses will be confined to the 0.5-foot soil samples only, due to the very low water solubility of these analytes and the fact that subsurface contamination is unlikely unless the 0.5-foot sample is significantly contaminated. Of the soil samples analyzed for polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDFs), 100 percent will be screened using modified EPA Method 8290 screen and 10 percent will be analyzed using EPA Method 8290 to confirm the screen results.

Deleted: the EPA Method 4025 immunoassay screen

Deleted: and calibrate

- The asbestos analytical method for soil will be changed to the modified elutriator procedure per NDEP's request. Only surficial soils will be analyzed for asbestos.

- In response to the NDEP's request that 1,4 dioxane be added to the SRC, all soil and groundwater samples will be analyzed for this constituent.

Soil samples and groundwater samples collected during this phase of the source area investigation will be analyzed for the SRCs listed on **Table 4.** The proposed sample analytical plans for soil and groundwater are presented in **Tables 5 and 6**, respectively. Sample containers for each analytical parameter along with the respective holding times are shown on **Table 8** (for soil) and **Table 9** (for groundwater).

4.0 FIELD SAMPLING PLAN

The following sections describe the sampling strategy, investigative methods and procedures, sample analysis program, sample handling, decontamination procedures, and management of investigation-derived wastes (IDW).

4.1 Pre-Field Activities

The following activities will be performed prior to the start of field activities.

The proposed drilling locations will be marked, and at least 3 days before the start of drilling activities, Underground Services Alert (USA) (1-800-642-2444) will be notified of the intent to drill. USA will contact the utility owners of record within the Site vicinity and notify them of our intention to conduct a subsurface assessment in proximity to buried utilities. All utility owners of record, or their designated agents, will be expected to clearly mark the position of their utilities on the ground surface throughout the area designated for this assessment.

If necessary (and only after consultation with on-site Tronox staff and after reviewing as-built plans of underground utilities), an underground utility locating service will be contracted to mark underground utilities that may be near the proposed boring locations.

4.2 Field Activities

Twenty-seven soil borings will be drilled and soil samples will be collected at regular intervals. Soil samples from each boring will be submitted for laboratory analyses. Groundwater samples for laboratory analyses will be collected from approximately 23 existing on-site monitoring wells. Groundwater grab samples will be collected from the remaining four soil borings where there are not adequate groundwater monitoring wells nearby. If a well identified for sampling is dry, or otherwise unusable, a groundwater grab sample will be collected from the borehole. A description of the field activities is presented below.

4.2.1 Soil Borings

Soil borings (SA-1 through SA-27) will be drilled on the Tronox property at the locations shown on **Plate 1**. The soil borings will be drilled using a sonic drill rig. Each boring will be drilled to just above the water table, a depth of approximately 25 to 50 feet bgs. The depth to water will be determined from nearby monitoring wells. The boreholes will be backfilled upon completion and the surface restored to match the surrounding grade.

During drilling operations, organic vapors will be monitored with a Photovac™ microtip-photoionization detector (PID) with a 11.7 eV lamp and a flame ionization detector (FID). The boring logs will record the following sampling information: boring number and location; sample identification numbers; date and time; sample depth; lithologic description in accordance with the Unified Soils Classification System (USCS) and American Society of Testing Materials (ASTM) standards; description of any visible evidence of soil contamination (i.e., odor, staining); and organic vapor monitor readings. An example of a boring log form is included in **Appendix C.**

Deleted: 10.2

Deleted: v

Deleted: or

The following references will be used in identifying and classifying soils:

a. ASTM International, 2000, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System), Designation: D 2487-00. (Primarily for laboratory procudures)

Formatted: Bullets and Numbering

Deleted: o

b. ASTM International, 2000, Standard Practice for Classification of Soils (Visual-Manual Procedure), Designation: D 2488-00.

The following section describes the soil sampling methodology that will be used at the Site.

4.2.2 Soil Sampling

For each soil boring, the sonic core will be observed to prepare the lithologic description. In addition, discrete soil samples will be collected from the following depths for laboratory analyses. Soil samples will be collected at the following depths: 0.5 and, thereafter, at approximately 10 foot depth intervals to just above the water table. If observations during drilling suggest the presence of impacts at other depths, additional, non-scheduled soil samples will be collected from the area of suspected soil impacts.

Deleted: te

Deleted: If staining or odors indicative of contamination are observed at other depths, additional samples will be collected from the odiferous or stained soil.

Deleted:

Deleted: hollow-stem auger flights

When the target sample depth is reached, a modified split-spoon sampler mounted to a steel pipe will be inserted through the center of the sonic core barrel, and the split-spoon sampler will be driven 18-inches into the soil below the drill bit in order to obtain samples of undisturbed soil for laboratory analyses. The sampler will be driven into the soil by the repeated percussive action of a 130-pound hammer falling approximately 30 inches onto the steel rod/split-spoon assembly. The split-spoon sampler will be fitted with three 6-inch-long brass or stainless steel liners (sleeves). As the split-spoon is advanced downward, soil is driven into the sleeves.

As soon as the split-spoon sampler is removed from the borehole and disassembled, the sleeve corresponding to the target sample depth will be chosen for analysis by an off-site laboratory. Teflon™ sheets will be placed on both ends of the sleeve; the sleeve will then be capped, labeled, and placed on ice inside an ice chest for delivery to the laboratory (under chain-of-custody protocol). As an alternative, soil samples designated for analyses for non-volatile constituents may be placed in a laboratory-supplied glass jar and sent to the laboratory. An example of a chain-of-custody (COC) form is included in **Appendix C**.

Soil samples designated for VOC and Gasoline Range Organics (GRO) analysis will be collected from the chosen sleeve and preserved in the field using both DI water and methanol preservatives, as prescribed under EPA Method 5035. A new, disposable syringe (T-handle) will be used to collect a roughly 5-gram aliquot directly from the sample sleeve. The sample will be placed into 40-milliliter glass vials containing pre-weighed amounts of liquid DI water or methanol. Three vials of DI-preserved soil for low level analysis, and one vial of methanol-preserved soil, for medium to high level analysis, will be collected at each sample depth for GRO or VOC analyses.

Deleted: sodium bisulfate

Deleted: sodium bisulfate

Deleted: wo

Deleted: sodium bisulfate

If a soil sample is designated for both GRO and VOC analyses, then one set of vials (two vials with DI water, one vial with methanol) will be collected for GRO analyses and a second set of vials will be filled for VOC analyses. DI water ,rather than sodium bisulfate, will be used for the low-level VOC analyses vials because strong effervescence is expected if the acid preservative is used due to the calcareous nature of the site soils. The label on the filled vials will be filled out, and the vials will be placed in Ziploc™ plastic bags and placed on ice in a cooler along with the rest of the samples pending delivery to the analytical laboratory. The pre-filled volatile organic analysis (VOA) vials containing the DI water and methanol will be provided by the analytical laboratory. A new T-handle syringe will be used to obtain 5-gram aliquots of soil at each sample depth and then discarded to the trash.

Deleted: sodium bisulfate

Deleted: If the sample reacts with the sodium bisulfate, unpreserved samples will be collected

Deleted: sodium bisulfate

Deleted: preservatives

The remaining unused portion of the soil core will be used for lithologic description and screening for VOCs with a PID. For headspace analysis by the PID, approximately 200 grams of soil will be removed from the sampling tube and placed in a Ziploc™ plastic bag. Care will be taken to select soil from the middle portion of the sampling tube. Once sealed in the bag, the soil will be broken apart and allowed to equilibrate to ambient temperatures for about 20 minutes. The probe tip of the PID will be inserted into the plastic bag and a reading obtained. These organic vapor readings will be recorded on boring logs prepared by the field geologist during drilling activities. The PID will be calibrated to 100 ppm isobutylene each day prior to its use.

4.2.3 Soil Sample Handling

Soil samples for laboratory analyses will be placed on ice in an ice chest for shipping to the laboratory. The soil samples will be logged on a COC form, and the samples will be shipped to the laboratory at the end of each day of sampling. Analytical methods, types of containers, and holding times are discussed in Section 4.4.1 – Soil Testing Analytical Program.

4.2.4 Borehole Abandonment

Each borehole will be abandoned once the target depth has been reached and the necessary soil (and, if necessary, groundwater) samples are obtained. The boreholes will be abandoned by backfilling each borehole with a bentonite/neat cement grout that will be placed into the borehole with a tremie pipe. The bentonite/neat cement grout will be placed from the bottom of the borehole to within 5 feet of the ground surface. A surface plug consisting of neat cement, cement grout, or concrete grout will be placed from a depth of 5 feet to the ground surface.

4.2.5 Groundwater Sampling

Groundwater samples will be collected from 23 existing monitoring wells and grab samples from four borings as listed on **Table 3**. Groundwater will be tested to assess for the presence of potential SRCs. The wells will be purged using micropurge methodology. Groundwater samples will be collected using the bladder pumps set at low-flow rates (less than 1 liter per minute).

Groundwater grab samples will be collected from boreholes where suitable wells are not present nearby. The borehole will be advanced at least two feet into the water table. Once the water enters the hole and stabilizes, a stainless steel bailer or hydropunch sampler will be used to withdraw the water.

The groundwater samples will be analyzed for SRCs including: perchlorate, chlorate, metals, cyanide, VOCs, pH, electrical conductivity, alkalinity, general water chemistry ions, radionuclides, SVOCs, organochlorinated pesticides, organophosphorus pesticides, and 1,4 dioxane.

The groundwater sampling procedures are described below.

4.2.5.1 Groundwater Elevation Measurement

Water levels will be measured with an electric sounder prior to sampling the well. The well sounder will be equipped with an indicator light, audible buzzer, or other mechanism to indicate when the water table has been contacted. The electric sounder will be decontaminated by washing with Simple Green^{TM} or equivalent and rinsing with deionized (DI) water after each use. The typical procedure for obtaining depth to water is to check the sounder for audible or light activation by pressing the test button. The sounder is then carefully lowered into the well until it contacts the surface of the water and the buzzer sounds. The sampler then raises the sounder and lowers it again to verify the depth to water as measured at the marked measuring point on the well casing. When two consecutive readings are the same, the sampler records the depth to water on the sampling and purging form.

Depth to water is measured from the top of the casing reference point to the nearest 0.01 foot and recorded on the well sampling field form. The casing reference point is marked by a small notch in the top of the casing. The groundwater elevation at each monitoring well is calculated by subtracting the measured depth to water from the surveyed elevation of the top of the well casing. Total well depths for those wells scheduled for sampling are measured by lowering the sensor to the bottom of the well. Total well depth, used to calculate purge volumes and to determine whether the well screen is partially obstructed by sediment, is recorded to the nearest 0.5 foot on the sampling and purging form.

4.2.5.2 Monitoring Well Purging

Monitoring wells: These wells will be purged by micropurge methods (low-flow purging using bladder pump). The bladder pump will be placed approximately mid way along the screened interval. The water intake will be at least 2 feet from the top and 1 foot from the bottom of the screen. The pump will be lowered slowly into the well to minimize disturbance of the formation, and the water level will be allowed to equilibrate prior to purging and sampling. Typically the water will be evacuated at 100 to 500 milliliters per minute, although lower pump rates can be used. The water level will be monitored either on a continuous or periodic basis and should not vary more than 0.3 feet (3.6 inches). The water quality parameters will be monitored using a periodic or continuous meter. The flow-through cell is preferred, although a standard meter is also acceptable. Stabilization of water quality parameters is indicated when the following criteria are met in the final three consecutive readings: the pH is within 0.1 unit, temperature is within 1 degree Celsius, electrical conductivity is within 3 percent, and the dissolved oxygen is within 5 percent and turbidity is within 10 percent. If field parameters do not stabilize within 30 minutes, the deviation will be noted on the field sampling field sheet and a sample will be collected. An example of a low-flow groundwater sample collection record field form is included in **Appendix C**.

Deleted: are

Deleted: 5

Field Measurements. Groundwater parameter field measurements obtained during sampling will be recorded on a Groundwater Sample Collection Record field log form, an example of which is included in **Appendix C**. Field data sheets will be reviewed for accuracy and completeness by the sampling coordinator after the sampling event is completed. Copies of the field sheets will be included in the monitoring report.

The pH, electric conductivity, turbidity, dissolved oxygen (DO), and temperature meters or flow through cells will be calibrated each day before beginning field activities. The calibration will be checked once each day to verify meter performance. The field meter calibrations will be recorded on an Instrument Calibration sheet. Copies of the calibration sheets will be included in the monitoring report.

4.2.5.3 Collection of Groundwater Samples from Monitoring Wells

Upon completion of well purging, a representative groundwater sample will be withdrawn from the well. Samples will be placed in containers in the order of decreasing volatilization sensitivity. Thus, the individual containers for analyses will be filled in the following order:

1. VOCs;
2. Metals (including platinum and hexavalent chromium; one filtered sample will be collected for comparison with unfiltered analysis);
3. Perchlorate;
4. General Water Chemistry/Anions/Ions (including cyanide and chlorate);
5. pH; and
6. Radionuclides (one filtered sample will be collected for comparison with unfiltered analysis).

A low flow bladder pump (micropurge pump) will be used to dispense the water samples into the appropriate sample container as long as static water level is maintained for the duration of bottle-filling activities. If the water level falls more than 0.33 feet (0.1 meter) the pump rate will be decreased. If the water level continues to fall, the sample will be collected and the water level change noted on the sample sheet. Low flow sampling procedures are described in the Low Flow Standard Operating Procedure 7130-04020 (Appendix D).

When taking samples for VOC or GRO analyses, containers will be filled to produce a positive meniscus over the lip of the container. Upon capping, the VOC sample bottles will be inverted and tapped to check for bubbles. If bubbles are observed, a new sample will be obtained.

4.2.5.4 Collection of Groundwater Grab Samples

Groundwater grab samples will be collected from boreholes where there are not suitable monitoring wells nearby. The borehole will be advanced at least two feet into the water table. The groundwater sample will be obtained from a bailer or a hydropunch tool. The procedure for collecting the water sample from the bailer is to carefully lower a stainless steel bailer into the water table and retrieve the sample. If the hydropunch method is used, the hydropunch tool is lowered through the casing and driven forward through the borehole bottom into the formation and then pulled back approximately 18 inches to expose a stainless steel screen. Once the groundwater flows through the hydropunch screen, past a check valve and into the sample chamber by hydrostatic pressure, the sample is retrieved.

4.2.5.5 Groundwater Sample Containers and Preservatives

Sample containers required for the specified analyses will generally be provided by the laboratory immediately prior to the sampling event. The containers will be pre-cleaned and will not be rinsed prior to sample collection. Preservatives, if required, will have been added to the containers by the laboratory prior to shipment of the sample containers to the sample collector.

Analytical methods, number of samples, types of containers, preservative, and holding times are summarized in Section 4.4.2 - Groundwater Analytical Testing Program.

4.2.5.6 Sample Packaging and Shipment

To identify and manage samples obtained in the field, a sample label will be affixed to each sample container. The sample labels will include the following information:

- Project number
- Site name
- Boring number
- Sample identification number
- Sampler’s initials
- Date and time of collection
- Preservative

Following collection and labeling, samples will be immediately placed in a sample cooler for temporary storage. The following protocol will be followed for sample packaging:

- Sample containers will be placed in leak-resistant clear plastic bags prior to placement in the ice chest. Screw caps will be checked for tightness prior to placing the sample in the bag.

- Samples to be shipped will be placed in the cooler and packed with packaging materials to minimize the potential for disturbance and/or breakage of the sample containers.

- Ice will be placed in leak-resistant plastic bags and included in the coolers to keep samples at a chilled temperature during storage and transport to the analytical laboratory. When ice is used, the drain plug of the cooler will be secured with fiberglass tape to prevent melting ice from leaking out of the cooler.

- The COC form will be placed in a water-resistant plastic bag and taped on the inside of the lid of the cooler.

- Samples designated for fuel alcohol analyses will not be placed in the same cooler as VOC vials containing methanol as a preservative.

A temperature blank consisting of a 40-milliliter glass vial of distilled water will be included in each cooler sent to the analytical laboratory. The purpose of the temperature blank is to allow the analytical laboratory to obtain a representative measurement of the temperature of samples enclosed in a cooler without disturbing the actual samples. The field team will package and label the temperature blank like a regular water sample; however, the analytical laboratory will only measure the temperature of the blank.

Every effort will be made to transport the samples to the analytical laboratory at the end of each sampling day. However, if sampling runs late and the laboratory is closed, samples will be stored overnight in a secured location under appropriate COC procedures, and the samples will be shipped to the laboratory the next day. Prior to overnight storage, the cooler(s) will be restocked with new ice to maintain the samples in a chilled state. The temperature blank inside each cooler will be checked by the sample collector at the beginning of the evening and in the morning, and the temperature readings will be recorded in the field logbook.

4.3 Field Documentation

4.3.1 Field Logbooks

Field logbooks will document where, when, how, and from whom any vital project information was obtained. Logbook entries will be complete and accurate enough to permit reconstruction of field activities. Logbooks will be bound with consecutively numbered pages. Each page will be dated and the time of entry noted in military time. All entries will be legible, written in black ink, and signed by the individual making the entries. Language will be factual, objective, and free of personal opinions or other terminology that might prove inappropriate. If an error is made, corrections will be made by crossing a line through the error and entering the correct information. Corrections will be dated and initialed. No entries will be obliterated or rendered unreadable.

Entries in the field logbook will include at a minimum the following for each sample date:

- Site name and address
- Recorder's name
- Team members and their responsibilities
- Time of site arrival/entry on-site and time of site departure
- Other personnel on-site
- A summary of any on-site meetings
- Deviations from sampling plans and site safety plans
- Changes in personnel and responsibilities, as well as reasons for the changes
- Levels of safety protection
- Calibration readings for any equipment used and equipment model and serial number

At a minimum, the following information will be recorded during the collection of each sample:

- Sample identification number

- Sample location and description
- Site sketch showing sample location and measured distances
- Sampler name(s)
- Date and time of sample collection
- Designation of sample as composite or grab
- Type of sample (i.e., matrix)
- Type of preservation
- Type of sampling equipment used
- Field observations and details important to analysis or integrity of samples (e.g., heavy rains, odors, colors, etc.)
- Instrument readings (e.g., PID, etc.)
- COC form numbers and COC seal numbers
- Transport arrangements (courier delivery, lab pickup, etc.)
- Recipient laboratory(ies)

4.3.2 Boring Logs

A lithologic description of the materials encountered and collected will be maintained on boring logs compiled by the field geologist. Soils will be classified in accordance with the USCS, and descriptions will include soil type, particle size and distribution, color, moisture content, and evidence of contamination (discoloration, unusual odors, etc.). The soil samples will be screened in the field for the presence of elevated organic vapor concentrations using a PID, and the measurements will be recorded on the boring log.

4.3.3 Chain-of-Custody Records

COC records are used to document collection and shipment of samples to the laboratory for analyses. All sample shipments for analyses will be accompanied by a COC record. Form(s) will be completed and sent with the samples for each laboratory and each shipment. If multiple coolers are sent to a single laboratory on a single day, COC form(s) will be completed and sent with the samples for each cooler. The COC record will identify the contents of each shipment and maintain the custodial integrity of the samples. Generally, a sample is considered to be in someone’s custody if it is either in someone’s physical possession, in someone’s view, locked up, or kept in a secured area that is restricted to authorized personnel. Until receipt by the laboratory, the custody of the samples will be the responsibility of the sample collector. An example of a COC form is provided in **Appendix C**.

The shipping containers in which samples are stored (usually sturdy picnic cooler or ice chest) will also be sealed with self-adhesive custody seals any time they are not in someone’s possession or view before shipping. All custody seals will be signed and dated.

4.4 Analytical Testing Program

The analytical testing program is designed to evaluate the environmental condition of soils and groundwater at various locations on the Site. A description of the analytical program is discussed below.

4.4.1 Soil Analytical Testing Program

The proposed soil analytical plan is shown in **Table 5**. Sample containers, analytical methods, and holding times for the various analytes that the soil samples will be tested for are shown on **Table 8.** **Table 4** presents the Site-Related Chemicals Analyte List for both soil and groundwater samples. This table also contains the EPA Region 9 industrial-based Preliminary Remediation Goals (PRGs) for soil, and tapwater PRGs for water (EPA 2004). The laboratories have been instructed to achieve reporting limits lower than one tenth of the relevant PRG where possible using the standard laboratory procedures. It should be noted that achieving these limits is dependant on the sample matrix and the concentrations of other constituents that may be present. Some laboratory methods may not achieve the reporting limit goals for some analytes even in the absence of matrix interferences. The laboratories selected are Nevada Certified laboratories for most of the methods identified. Some methods may not have been certified by Nevada. Correspondence will be continued with the state throughout the source characterization process regarding the certification process and status of certification regarding the methods proposed for use.

Deleted: data quality limits (DQLs). The DQLs are

Deleted: 0.1 of the DQLs

4.4.2 Groundwater Analytical Testing Program

For the Source Area Investigation – Phase A, groundwater samples will be collected from 23 on-site monitoring wells listed on **Table 3**. Groundwater grab samples will be collected from four boreholes where there are not suitable monitoring wells nearby. If a well identified for sampling is dry, or otherwise unusable, a groundwater grab sample will be collected from the borehole. The groundwater analytical plan is summarized on **Table 6**. Sample containers, analytical methods, and holding times for the various analytes that the groundwater samples will be tested for are shown on **Table 8.** A full list of the analytes that groundwater will be tested for is presented on **Table 4**. The groundwater PRG listed in **Table 4** are EPA Region 9 tap water PRGs (EPA 2004).

Deleted: DQLs

Deleted: drinking water maximum contaminant levels (MCLs) or

4.4.3 Geotechnical Testing Program

Up to four soil samples will be collected and sent to a geotechnical engineering laboratory in order to measure physical parameters of the soil encountered during the course of this investigation. Data from the geotechnical tests will be used to support risk assessment studies, modeling of the vadose zone for potential contaminant migration pathways, and (if necessary) to support evaluation of remedial alternatives.

Fine-grained and coarse-grained soil samples will be collected and analyzed for the following parameters:

- Moisture content (dry weight basis) using American Society for Testing and Materials (ASTM) Method D-2216;
- TOC using the Walkley-Black Method (Nelson and Sommers, 1992);
- Intrinsic permeability using ASTM Method D-4525;
- Particle size analysis using ASTM Method D-422 and ASTM Method C 117-04;
- Soil Bulk Density using ASTM D854;
- Total Porosity (calculated from soil bulk density and grain density);
- Soil Volumetric Air Content (calculated from the moisture content);
-

Deleted: Lloyd Kahn or

Deleted: , or equivalent

Deleted: <#>Effective permeability, permeability to air, volumetric water content (wet weight basis), grain, and bulk density (dry and natural) using the Dean Stark methods described in the American Petroleum Institute (API) RP-40 technique;¶

Formatted: Highlight

Formatted: Bullets and Numbering

Deleted: <#>Specific gravity using ASTM Method D-854 or API RP-40 technique; and¶
Hydraulic conductivity using ASTM Method D-2434 of two fine-grained and two coarse-grained samples

Formatted: Highlight

4.5 Equipment Decontamination

Drilling equipment will be decontaminated prior to the beginning of each boring by steam cleaning in a designated area on-site. All non-disposable soil sampling equipment (e.g., split-spoon samplers, etc.) will be disassembled and decontaminated prior to the collection of each sample. This equipment may be decontaminated by either steam cleaning or by washing with a non-phosphate detergent solution (Simple Green™ or similar) followed by rinsing with distilled/deionized water. Decontamination fluids will be temporarily stored on-site in Department of Transportation (DOT)-approved 55-gallon steel drums pending results of the soil analyses. Tronox is not planning on using Alconox^{TM} for decontamination of sampling equipment on site because some samples of Alconox^{TM} have been reported to contain perchlorate.

Formatted: Superscript

Deleted: found

If non-dedicated groundwater sampling equipment is used to collect groundwater samples, the equipment will be decontaminated by circulating a solution of water and detergent (e.g., Simple Green™) through the equipment followed by rinsing with distilled water.

4.6 Management of Investigation-Derived Wastes

Soil cuttings (including unused cores), and other solid or liquid wastes (decontamination fluids, development water, and purged groundwater) will be temporarily stored in DOT-approved 55-gallon drums or roll-off boxes, as appropriate. Each container will be marked with water-proof labels and water-proof markers. Each container will receive a unique identification number and will be cataloged for waste containment documentation purposes. The IDW will be disposed of in an appropriate manner based on the results of the chemical analyses. It is anticipated that groundwater and decontamination liquids will be placed in GW-11 and treated on-site.

4.7 Surveying

The boring locations will be surveyed to an accuracy of 0.01-foot vertical and 0.1-foot horizontal relative to U.S. Geological Survey elevation and Nevada Coordinate System datum (NAD83 - Nevada East Plane) by a licensed-land surveyor.

Deleted: s

4.8 Quality Assurance/Quality Control Program

An integral part of the Source Area Investigation sampling and analysis plan is the quality assurance/quality control (QA/QC) program to ensure the reliability and compatibility of all data generated during this assessment. The following subsections describe the QA/QC program that will be implemented as part of the Source Area Investigation at the Site.

4.8.1 Field QA/QC Samples

Field QA/QC procedures will be followed to ensure viability and integrity of sample analytical data. The field investigative team will be responsible for submitting QA/QC samples to the laboratory. QA/QC samples include field duplicates, trip blanks, equipment decontamination blanks, and field blanks.

4.8.1.1 Field Duplicate Samples

One field duplicate will be collected for every 10 samples submitted for analysis. The duplicate sample will be tested for the same suite of analytical parameters as the corresponding original sample. For duplicate groundwater samples, two sets of sample containers will be filled and both submitted for analysis.

4.8.1.2 Trip Blanks

Trip blanks are provided by the laboratory. One pair of VOA trip blanks will be included in each cooler. One trip blank per day will be analyzed for the VOCs and GRO scheduled for analysis. The trip blanks for water samples will consist of laboratory reagent water shipped to and from the sample Site in the same type of sample containers and with the same preservative as the collected samples. Trip blanks will not be opened or exposed to the atmosphere in the field.

4.8.1.3 Equipment Decontamination Blanks

Equipment decontamination blanks will consist of reagent water rinsed through sampling devices. This will include the soil sampling equipment and groundwater sampling equipment used in the investigation. A minimum of one equipment blank per day of sampling will be collected and analyzed for the same set of parameters as the samples collected that day (except for cations, pH, and electrical conductivity, for which an equipment blank will not be collected). If a non-dedicated groundwater pump is used, a pump decontamination blank will be obtained for each pump used before and after use for the groundwater sampling event.

4.8.1.4 Field Blanks

Field blanks consist of the source water used for the equipment decontamination blanks. At a minimum, one field blank from each event or work period will be collected and analyzed for the same set of parameters as samples collected during the event.

All of the above-mentioned QA samples will be sent to the laboratory as blind samples with sample numbers sequenced in with actual Site samples.

4.8.2 Laboratory QA/QC Procedures

Laboratory QC measures will be taken to confirm the integrity of the laboratory data generated during the source area investigation program. The procedures used to assess laboratory data quality are described in this section and the associated Quality Assurance Project Plan (QAPP; ENSR 2006).

Method blanks will be analyzed daily to assess the effect of the laboratory environment on the analytical results. Method blanks will be performed for each parameter analyzed.

Each sample to be analyzed for organic parameters will contain surrogate spike compounds. The surrogate recoveries will be used to determine if the analytical instruments are operating within limits. Surrogate recoveries will be compared to control limits established and updated by the laboratory based on its historical operation.

Matrix spike and matrix spike duplicate (MS/MSD) samples will be analyzed at a frequency of approximately 5 percent of the project samples submitted. MS/MSD results will be evaluated to determine whether the sample matrix is interfering with the laboratory analysis and provide a measure of the accuracy and precision for the associated analytical data. MS/MSD recoveries and precision will be compared to control limits established and updated by the laboratory based on its historical operation.

A full Contract Laboratory Program (CLP)-like laboratory QC data package will be included with the analytical results. This QC data will include method blanks, surrogate spike recoveries (for organic parameters only), matrix spike recoveries, sample duplicate or matrix spike duplicates results, all initial and continuing calibration data, all gas chromatography/mass spectrometry (GC/MS) tuning data, all instrument raw data including chromatograms and mass spectra, all inductively coupled plasma (ICP) serial dilutions and interference check sample results, all standards and sample preparation worksheets, and a case narrative describing all QA/QC non-conformances and corrective action. Radiochemical analyses reports will include calibration control charts and background results for all detectors associated with all radiochemical results. All results will be reported including estimated values between the detection and reporting limits.

Prior to submitting analytical results to Tronox/ENSR, the supervising chemist will check the entire data package so that the data are acceptable. These checks include:

- Project requirements for precision, accuracy, and detection limits;
- Analytical procedure blanks, duplicates, matrix spike recoveries, and other method required QC results; as well as internal quality checks such as anion-cation balance, measured vs. calculated TDS, and the TDS to EC ratio and
- Instrument standardization and response factors.

If the data are acceptable, a written report is generated and reviewed by the senior chemist before submission to Tronox/ENSR.

4.8.3 Data Quality Indicators (DQI)

Accuracy is the degree of agreement of a measured value with the true or expected value of the quantity of concern. Accuracy measures the bias in a measurement system. Accuracy will be evaluated using percent recovery data from spiked samples and laboratory control samples. Percent recovery is defined as:

$$\%\ \text{Recovery} = (R / S)\ \text{X}\ 100$$

where:

S = spiked concentration.

R = reported concentration.

Percent recovery acceptance criteria used to evaluate the results will be analyte and laboratory specific and based on laboratory statistical control limits.

Precision is the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions. It is concerned with the "closeness of results," that is, the reproducibility of measurements under a given set of conditions. Precision will be evaluated using duplicate samples and expressed as relative percent difference (%RPD) or percent relative standard deviation (%RSD). These quantities are defined as follows:

$$\%RPD = (A1 - A2)/(A1 + A2)/2\ \text{X}100$$

where A1 and A2 are the reported concentrations for each duplicate sample.

The objectives for field duplicate precision RPDs are 30% RPD for aqueous samples and 50% RPD for solid samples. The objectives for laboratory duplicate precision will be based on requirements within the appropriate EPA methods or laboratory SOPs.

Completeness is the percentage of measurements made that are judged to be valid measurements. Completeness can be quantitatively assessed simply by calculation of the percentage of valid data obtained. Field completeness is a measure of the amount of valid samples obtained during all sampling for the project. The field completeness objective is greater than 90 percent. Laboratory completeness is a measure of the amount of valid measurements obtained from all the measurements taken in the project. The laboratory completeness objective is greater than 95 percent.

Deleted: EPA

Deleted: Quality Assurance Program

Deleted: Specific quality assurance objectives for measurement are defined by precision, accuracy, representativeness, comparability, completeness, and sensitivity. ¶
Specific requirements for data accuracy, precision, representativeness, comparability and completeness will be based on standard laboratory methods, QAPP requirements, and data validation guidelines. Definitions of accuracy, precision, and completeness as they pertain to analytical data and standard methods used to assess accuracy, precision, and completeness are briefly described below and more thoroughly described in the associated QAPP. If data do not meet data quality objectives, action will be taken to address the issues and resolve them as appropriate. ¶
<#>Definitions¶
Accuracy = the degree of agreement of a measured value with the true or expected value of the quantity of concern. Accuracy measures the bias in a measurement system.¶
Precision = the degree of mutual agreement characteristic of independent measurements as the result of repeated application of the process under specified conditions. It is concerned with the "closeness of results," that is, the reproducibility of measurements under a given set of conditions.¶

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Formatted: Font: Not Bold

Deleted: Completeness = the percentage of measurements made that are judged to be valid measurements. The completeness goal is the same for all data uses that a sufficient amount of valid data be generated to accomplish the objectives of the study.¶
Standard methods of evaluation will be used to assess accuracy and precision data. Completeness can be quantitatively assessed simply by calculation of the percentage of valid data obtained. Specific methods of assessing accuracy and precision will be as follows:¶
Accuracy will be evaluated using percent recovery data. Percent recovery is defined as:¶
% Recovery = (R / S) X 100¶
where:¶
S = spiked concentration.¶ ... [1]

Representativeness is the degree to which sample data accurately and precisely represent a characteristic of a population parameter, variations at a sampling point, or an environmental condition. Representativeness is a qualitative parameter that is mostly concerned with the proper design of the sampling program (i.e., that the number and locations of samples are sufficient for the purposes of the investigation). Measures can be taken to achieve a high degree of representativeness. Such measures will include but are not necessarily limited to the following:

Deleted: <#>Comparison of Data Sets¶

Formatted: Font: Bold

Deleted: defined by the EPA as

- Obtaining samples over a range of environmental conditions. In the case of groundwater sampling, this would include (a) the systematic collection of samples over time to account for temporal variations and (b) an adequate number of, and appropriately located, sampling locations to account for spatial variations.

- Use of previously collected site-specific data to guide the selection of appropriate sampling locations and chemical parameters.

- Use of appropriate sample collection procedures.

Details of the sampling program design and sample collection procedures are presented in Section 4.3.

Comparability is a qualitative expression of the measure of confidence that two or more data sets may contribute to a common analysis. Comparability of data within the investigation will be controlled by using standard EPA methods for sampling and analysis, reporting data, and data validation,

5.0 Data Evaluation and Reporting

5.1 Data Review

Data will be evaluated to verify that soil, groundwater, and QA/QC samples were collected in compliance with the specifications contained in the work plan. The laboratory-certified analytical reports will be reviewed to determine if samples were analyzed within holding times and that laboratory QA/QC samples, such as MS/MSD were within the laboratory-specific acceptable ranges. Deviations, if any, will be identified. One hundred percent of the laboratory data will be reviewed and 10 percent of the laboratory packages will be undergo comprehensive data validation as described by NDEP guidance (NDEP 2006). For this reason, the laboratories have been requested to provide CLP-like data packages. If some of the validation packages indicate problems, a larger percentage may be validated. As appropriate, the following statistical tests may be applied to the data: T-test, Gehan Modification of the Wilcox Rank Sum, Analysis of Variance (ANOVA), Krusall-Wallis, Quantile Test, Slipage Test, and box and whisker plots.

5.2 Reporting of Results

A report will be prepared that presents the results of the source area investigation – Phase A for soil and groundwater sampling. The report will include a description of the field methods employed, analytical methods, analytical results, data evaluation methods, data validation results, and a scale map containing the locations of the soil borings and monitoring wells installed. Typed boring logs and well completion diagrams will be included in the report. The results of laboratory analysis will be presented in tabulated form. The laboratory-certified analytical reports will be provided in Adobe Acrobat (.pdf) electronic form on a CD in an appendix. A Nevada-Certified Environmental Manager will sign the report.

The soil data will be used to characterize the on-site soil chemistry within the alluvium and underlying Muddy Creek formation from 0.5 feet to a maximum depth of just above the water table (roughly 50 feet bgs). The groundwater data will be used to assess on-site conditions and identify SRCs that are present in the water table beneath the Site. These soil and groundwater data will be compared to available on-site and off-site data.

5.3 Assessment of Adequate Characterization for SRC Parameters

Consistent with the EPA Risk Assessment Guidance for Superfund. Volume 1 (USEPA 1989) and EPA Guidance for Data Useability in Risk Assessment (Part A) (USEPA 1992), each of the SRC parameters investigated during Phase A will be evaluated to assess the adequacy of its characterization. A particular SRC parameter may be determined to be adequately characterized by applying a combination of the following evaluation steps:

Deleted: E

- Apply appropriate statistical tools verify the comparability of the parameter with other data populations;
- Determine if parameter detections are less than one tenth (0.10) the available EPA Industrial PRG values or MCLs;
- Determine whether the data indicate that the parameter is either absent or is rare in frequency;
- Compare the parameter detections with the upgradient data, and assess whether background or upgradient conditions are exceeded; and,
- Determine whether the probability of a parameter occurring at a specific location or depth is remote due to the lack of evidence of historical uses and or occurrence.

These review steps, and others as needed, will be applied to the SRC data to assess whether characterization is adequate. Once a SRC parameter is established to be adequately characterized it will be recommended for exclusion from future characterization activities.

Deleted: These review tools,

Deleted:

5.4 Assessment of Inadequate Characterization for SRC Parameters

Consistent with the EPA Risk Assessment Guidance for Superfund. Volume 1 (USEPA 1989) and EPA Guidance for Data Useability in Risk Assessment (Part A) (USEPA 1992), a particular SRC parameter may be determined to be inadequately characterized when applying a combination of the following evaluation steps:

Deleted: A

- Apply the application of appropriate statistical tools to verify the comparability off the parameter with other data populations;
- Determine if the parameter detections exceed one tenth (010) of the available EPA Industrial PRG values or MCLs;
- Determine if the parameter is present and occurs with significant frequency;
- Determine if the parameter detections are comparable to, and significantly exceed the background or upgradient data;
- Determine whether the probability of a parameter occurring at a specific location or depth is likely due to the evidence(s) of historical uses and or occurrence.

Once a SRC parameter is established to be inadequately characterized it will be recommended for inclusion in future characterization activity(s).

5.5 Additional Investigation

For those parameters found to be inadequately characterized, additional investigative work will be needed. The subsequent Phase B investigation is proposed to collect the data necessary to characterize the nature and extent of those SRC parameters that are inadequately characterized.

The scope of the Phase B investigation will be dependent upon the results of the Phase A Source Area Investigation, and the identified data gaps.   Once the Phase A Source Area Investigation is completed and the data are compiled and interpreted, a Workplan outlining additional recommended characterization work will be developed for NDEP review and approval.

6.0 Project Management Plan

The overall organization of the project includes the following individuals and agencies, and is illustrated in **Figure 2**.

This work is being conducted as part of the ECA under agreements with the NDEP. The NDEP project manager is Mr. Brian Rakvica.

The Tronox project manager is Susan Crowley. Ms. Crowley is a Nevada-Certified Environmental Manager (CEM # 1428, expiring March 8, 2007) and is the person who serves as the point of contact for regulatory and environmental issues pertinent to the Site. She is located at the Tronox Henderson Facility. Her telephone number is (702) 651-2234. Ms. Crowley manages the subcontractors that will be performing the tasks described in this work plan. Ms. Crowley will be supported by Tronox technical specialists Mr. Keith Bailey (engineer) and Mr. Tom Reed (hydrogeologist).

ENSR Corporation is Tronox's environmental consultant. Mr. David Gerry, Senior Program Manager, Sally Bilodeau, Senior Geologist, Edward Krish, Field Manager, Brian Ho and Robert Kennedy, Quality Assurance Officers, and ENSR Staff Geologists will be assisting with this project as needed. Ms. Margaret Sharpe will be responsible for QA/QC of documents.

At present, the laboratory contractor has not been selected for this project, however, the selected laboratory will be certified with the State of Nevada as an environmental testing laboratory. The laboratory may subcontract some of the soil and groundwater analysis to other specialty laboratories and those subcontract laboratories will also be certified with the State of Nevada as environmental testing laboratories. Laboratory data will be provided to Tronox in hard copy format as well as Tronox-specific EQuIS electronic data deliverable (EDD) format. The laboratory will provide sample receipt notification upon receipt of samples at the laboratory. Specific information regarding the laboratories will be provided via letter following contract award.

The implementation of the work plan is the shared responsibility of the ENSR Senior Program Manager, the Field Manager, the Quality Assurance Officer, the field and office personnel, and the contractor personnel. The Senior Program Manager's responsibilities include:

- Providing the field personnel with a copy of the work plan;
- Notifying the laboratory regarding site-specific data quality requirements;
- Checking chain-of-custody and field logs to verify sample collection; and
- Taking corrective action if necessary.

The responsibilities of the Quality Assurance Officer and Senior Geologist include:

- Reviewing the field and laboratory data to determine if the data quality objectives were met;
- Preparing a summary of QA/QC data; and
- Conducting audits and implementing corrective action as necessary.

The responsibilities of the Field Manager include:

- Noting work plan progress and corrective actions taken on daily field logs;

- Collecting and compiling the daily field logs from field personnel and providing them to the Senior Program Manager within 2 days; and
- Keeping the Tronox Project Manager advised of project status daily.

The responsibilities of the office and field personnel include:

- Reviewing and implementing the work plan and QAPP;
- Field calibration of measurement and test equipment, as needed;
- Maintaining required documentation of activities;
- Collection, labeling, handling, storage, shipping, and filling out COC forms for environmental samples collected;
- Maintaining control of samples until they are appropriately released; and
- Notifying the Project Manager if there are deviations from or problems implementing the work plan or quality assurance procedures.

The responsibilities of the QA/QC of Documents team include:

- Review of reports for formatting, spelling, grammar, and references.

The responsibilities of the laboratory subcontractor include:

- Provide appropriate sample containers, preservatives, and coolers to the Site;
- Advise the Project Manager of delays experienced in analyzing the samples;
- Advise the Project Manager upon receipt of samples if there are questions regarding the analysis requested or if there are quality or sample integrity issues that need to be addressed;
- Perform the requested analyses under SW-846 and/or state-approved protocol; and
- Conduct the required instrument calibration and QA/QC protocols specified in the laboratory’s internal quality assurance plans.

The responsibilities of the drilling subcontractor include:

- Provide appropriate drilling equipment and trained personnel as specified in the subcontract agreements.

7.0 References

ASTM International, 2000, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System): D 2487-00.

Deleted: o

ASTM International 2000. Standard Practice for Description and Identification of Soils: D2488-00

Deleted: .

Deleted: 199

Deleted: 84

Bell, J.W., 1981, Subsidence in Las Vegas Valley: Nevada Bureau of Mines and Geology, Bulletin 95, 84p.

Ecology & Environment (E&E), 1982, Summary and Interpretation of Environmental Quality Data, BMI Industrial Complex, Henderson Nevada, November 1982.

ENSR, 1997, Phase II Environmental Conditions Assessment located at Kerr-McGee Chemical Corporation, Henderson Nevada, August 7, 1997.

ENSR, 2001, Supplemental Phase II Environmental Conditions Assessment, April 2001.

ENSR, 2005, Conceptual Site Model, Kerr-McGee Facility, Henderson, Nevada, February 28, 2005.

ENSR, 2006 Quality Assurance Project Plan

Environmental Protection Agency (EPA), 1982, Test Methods for Evaluating Solid Waste – Physical/Chemical Methods, SW-846, 2nd Edition.

EPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA. Office of Emergency and Remedial Response, October.

EPA, 1989, Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual (Part A) interim final (EPA/540/1-89/002) December.

EPA. 1992. Guidance for Data Useability in Risk Assessment (Part A). 9285.7-09A.

EPA, 1995, Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality Related Documents, EPA QA/G-6, Office of Research and Development, Washington, D.C., EPA/600/R-96/027, November.

EPA 2004. Preliminary Remediation Goals Tables October 2004 (http://www.epa.gov/region9/files/04prgtable.pdf) 16 pages.

Nelson, D.W. and L.E. Sommers, 1992. Total Carbon, Organic Carbon, and Organic Matter. In: A.L. Page et al. (editors), Methods of Soil Analysis: Part 2 Chemical and Microbiological Properties. ASA (American Society of Agronomy, Inc.) Monograph Number 9, p. 539-579.

Formatted: Indent: Left: 0", Hanging: 0.5"

Kerr-McGee, 1996a, Phase II Work Plan, May 1996.

Kerr-McGee, 1996b, Response to Letter of Understanding Henderson Nevada, October 1996.

Kerr-McGee, 1998, Response to Phase II Report Comments and Supplemental Phase II Work Plan, November 9, 1998.

Kleinfelder, 1993, Environmental Conditions Assessment, Kerr-McGee Chemical Corporation, Henderson, Nevada Facility, April 15, 1993 (Final).

Langenheim, V.E., Grow, J., Miller, J., Davidson, J.D., and Robinson, E. 1998, Thickness of Cenozoic Deposits and Location and Geometry of the Las Vegas Valley Shear Zone, Nevada, Based on Gravity, Seismic-Reflection and Aeromagnetic Data: U.S. Geological Survey Open-File Report 98-576, 32p.

NDEP, 1991, Consent Agreement. Phase I Environmental Conditions Assessment, April 25, 1991

NDEP, 1994, Phase II Letter of Understanding between NDEP and Kerr-McGee, August 15, 1994.

NDEP, 1998, Review of Phase II Environmental Conditions Assessment, June 10, 1998.

NDEP, 2004, Response to Supplemental Phase II Report-Environmental Conditions Assessment, February 11, 2004.

NDEP, 2006, NDEP Guidance on Data Validation, BMI Plant Sites and Common Areas Projects, Henderson, Nevada

Plume, R.W., 1989, Ground-Water Conditions in Las Vegas Valley, Clark County, Nevada: Part 1. Hydrologic Framework: U.S. Geological Survey Water-Supply Paper 2320-A, 14p.

TABLES

FIGURES

Plates

APPENDIX A
Tronox and Regulatory Correspondence

APPENDIX B
Health and Safety Plan

APPENDIX C
Examples of Field Forms

Page 4-11: [1] Deleted **sbilodeau** **10/26/2006 12:09:00 PM**

Completeness = the percentage of measurements made that are judged to be valid measurements. The completeness goal is the same for all data uses that a sufficient amount of valid data be generated to accomplish the objectives of the study.

Standard methods of evaluation will be used to assess accuracy and precision data. Completeness can be quantitatively assessed simply by calculation of the percentage of valid data obtained. Specific methods of assessing accuracy and precision will be as follows:

Accuracy will be evaluated using percent recovery data. Percent recovery is defined as:

$$\% \text{ Recovery} = (R / S) \text{ X } 100$$

where:

S = spiked concentration.

R = reported concentration.

Percent recovery limits are analyte-specific.

Precision will be evaluated using duplicate samples and expressed as relative percent difference (%RPD) or percent relative standard deviation (%RSD). These quantities are defined as follows:

$$\%RPD = (A1 – A2)/(A1 + A2)/2 \text{ X}100$$

where A1 and A2 are the reported concentrations for each duplicate sample.