FEASIBILITY STUDY WORK PLAN
KLONDYKE TAILINGS PROJECT
WQARF REGISTRY SITE
KLONDYKE, ARIZONA

December 2014

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TABLE OF CONTENTS

FIGURES

LIST OF ABBREVIATIONS & ACRONYMS

A.A.C.	Arizona Administrative Code
ADEQ	Arizona Department of Environmental Quality
A.R.S.	Arizona Revised Statutes
AWQS	Aquifer Water Quality Standard
COC	Contaminants of Concern
CSM	Conceptual Site Model
EDXRF	Energy dispersive X-ray fluorescence
FS	Feasibility Study
GPL	Groundwater Protection Level
RO	Remedial Objectives
RI	Remedial Investigation
R-SRL	Residential Soil Remediation Level
WP	Work Plan
WQARF	Water Quality Assurance Revolving Fund

1.0 INTRODUCTION

1.1 Purpose

This Work Plan (WP) presents the methodology that will be followed for completion of the feasibility study (FS) for the Klondyke Tailings Project Water Quality Assurance Revolving Fund (WQARF) site (the site) in Klondyke, Arizona. This work plan is required as part of the FS process, pursuant to Arizona Administrative Code (A.A.C.) R18-16-407(B).

The purpose of the FS is to develop and evaluate a reference remedy and alternative remedies that are capable of achieving the site's Remedial Objectives (ROs). An FS report will be developed that relies on data and information from the Remedial Investigation (RI), and further work that may be conducted during the FS, and will evaluate the remedy to ensure that the remedy meets the following in accordance with A.A.C. R18-16-407(H):

- Achieves the ROs;
- is consistent with water management plans and general land use plans; and
- is evaluated with comparison criteria including practicability, risk, cost, and benefit.

1.2 Site Description

The site is located on the north bank of Aravaipa Creek, approximately 4.5 miles upstream of the Aravaipa Canyon Wilderness Area in Arizona. The site is located approximately two miles north of the town of Klondyke in Section 6, Township 7 South, Range 20 East. The boundaries of this site are irregular and the boundaries are defined by the extent of the soil contamination above the residential soil remediation level for lead of 400 milligrams per kilogram (mg/kg). The site is comprised of two piles of mine tailings. The soil is between and adjacent to these piles and several surrounding properties as shown in Figure 1.

Previous soil investigations identified the heavy metals: arsenic, antimony, cadmium, copper, manganese and lead as the contaminants of concern in the tailings piles and surrounding soil. Those metals are present at concentrations exceeding the Residential Soil Remediation Levels (R-SRLs) and minimum Groundwater Protection Levels (GPLs). The Upper and Lower Tailings Piles were identified as the primary contaminant sources. However, two secondary sources of heavy metal contaminants was identified during these site characterization activities, the mineralized rock in Laurel Canyon upstream from the site, including mine tailings and waste rock located near the abandoned Grand Reef Mine and tailings material located on the hillside of parcel 110-47-006, believed to have been a historical attempt at processing ore from the Dogwater Mine.

A Conceptual Site Model (CSM) was developed to evaluate the migration pathways and exposure potential for the contaminants of concern from the source to human and ecological receptors. Physical migration pathways included surface water migration during storm water runoff from the tailings piles and surrounding impacted soil, and airborne migration during wind erosion and dust-generating activities, which would mobilize and transport contaminants. The potential for chemical migration of contaminants was verified by testing of tailings and soil for metal leaching from tailings material. The results indicated there is potential for metal contaminants to mobilize in the tailings piles. Once mobilized, metal ions can be transported by chemical processes such as ion-exchange or sorption between migrating fluids and soil or migrating/infiltrating fluids and soil pore water. The most likely mode of chemical migration is during a strong storm event where storm water runoff could pick up metal ions from tailings piles, transport the contaminants offsite, and release the metal ions during an exchange with soil or other fluid. Groundwater was not identified as a migration pathway. Human receptors include residents that live on adjacent properties where soil contamination is present. Ecological receptors include aquatic animal species such as fish and amphibians; and various terrestrial, mammal, bird, and reptile species that come in contact with contaminated surface water or stream sediments. Bioavailability testing for lead and arsenic indicated that these compounds are readily bioavailable in both the tailings and in soil samples collected from the former production area.

Aravaipa Creek's 17 mile long perennial flow stretch is considered by the Arizona Game and Fish Department to have the best remaining assemblage of desert fishes in Arizona. The stretch is home to seven native species including two federally-listed endangered species; the Spikedace, and the Loach Minnow. In addition, Aravaipa Creek is a unique water under A.A.C. R18-11-112.

Extensive soil, tailings and sediment sampling was conducted at and in the vicinity of the site in 2006 and 2007. Soil samples were collected at the surface (0 to 3 inches), 6 inches, 12 inches, and 24 inches below ground surface. Over 2,400 soil and tailings samples were collected and analyzed by energy dispersive X-ray fluorescence (EDXRF) to screen for lead and nine other metals. A total of 75 stream sediment samples were collected from Aravaipa and Laurel Creeks and analyzed for lead and nine other metals by EDXRF. To investigate the subsurface soil conditions at the site, nine soil borings were advanced and 30 subsurface soil samples were collected at 1, 5, and 10 feet below ground surface. Those subsurface samples were analyzed for 10 total metals by EPA Methods 6010B and 7471A, and cyanide by EPA Method SM4500-CN C, E.

Field screening (i.e., EDXRF) results for metals in soil samples were evaluated by comparing observed concentrations with R-SRLs. Exceedances of the R-SRL were reported for antimony, arsenic, cadmium, copper, lead, manganese, mercury, and zinc at the surface and depths of 6 inches at sampling locations at and in the vicinity of the site. At depths of 12 inches those same metals, except for copper, were reported exceeding the R-SRL. At depths of 24 inches only antimony, arsenic, lead and mercury were reported exceeding the R-SRL. Lead is the most prevalent contaminant in the samples analyzed.

Stream sediment samples collected from Aravaipa Creek and Laurel Creek were field screened for metals. None of the nine metals analyzed was detected at concentrations exceeding the corresponding R-SRL. Fixed-base analyses of four stream sediment samples reported arsenic exceeding the R-SRL in three samples and lead exceeding the R-SRL in two samples.

A statistical analysis was performed on soil data to compare cadmium, lead, and manganese results by the EDXRF screening method to their respective results by the fixed-base EPA

Method 6010B. The analysis confirmed that EDXRF results for cadmium, lead, and manganese are statistically correlated to their respective 6010B results and EDXRF results are generally conservatively greater than 6010B results. This means that, with the exception of arsenic results, EDXRF results can be used to guide remedial action at the site, with confirmation sampling used to verify that the excavation remediation is effective, and verification sampling used to confirm the correlation remains statistically significant. A statistical analysis comparing the EDXRF and fixed-base 6010B results for arsenic was not preformed due to the lead interference issues associated with the EDXRF Spectrometer used at the time of inspection. However, direct comparison of EDXRF and 6010B results for arsenic indicates that in all instances where EDXRF registered <10 mg/kg, the corresponding 6010B results were also below detection limits.

The EDXRF soil analytical results for lead were plotted on maps to show the lateral extent of contamination at and in the vicinity of the site. In addition, the vertical extent of contamination was shown on maps for three sampling depths: 6 inches, 12 inches and 24 inches. The maps show elevated concentrations of lead at and adjacent to the site, including high concentrations of heavy metals at a small historical mill site on the property, parcel 110-47-006, east of the main tailings piles. In addition, lead contamination is present on the Laurel Creek alluvial fan that extends southwestward out of Laurel Canyon.

The limited EDXRF and Method 6010 soil analytical results for arsenic were also plotted on maps, which showed the lateral and vertical extent of contamination at and in the vicinity of the site was similar to that of lead. These results are important to consider when planning and implementing remedial action at the site and on adjacent properties under the WQARF program.

In July 2001, fifteen private domestic wells in the Klondyke area were sampled. No drinking water standards were exceeded in any of the wells tested. Results indicated very good water quality with respect to metals. Private wells in the immediately in the area of the site have been sampled since 2006 and indicate only one exceedance of lead over an Aquifer Water Quality Standard (AWQS). That well has been resampled twice and the detection of lead over the AWQS could not be confirmed.

Aquifer conditions were also evaluated at the site by collecting quarterly groundwater samples at depths of approximately 75 feet below ground surface from four monitor wells on the site. No metals were detected at concentrations exceeding the corresponding the AWQS. The aquifer is the primary source for domestic water in Aravaipa Valley. These results suggest that, under normal conditions, groundwater is not a pathway for contaminant migration and exposure.

The lateral extent of lead contamination found in surface soils during this investigation was greater than originally expected. The sample results indicated the potential for a larger area of contamination from historic milling activities, windblown or surface water movement of metals contamination as well as other sources of metal contamination may exist in the vicinity of the site such as the Grand Reef Mine, Dogwater Mine, and tailings on parcel 110-47-006. A possible explanation of the extensiveness of the lead contamination could be the presence of the Grand Reef Mine and Dogwater Mine upstream in Laurel Canyon. Lead and arsenic contamination is present on the Laurel Creek alluvial fan that extends southwestward out of Laurel Canyon.

The results of the RI indicate that there are three sources of contamination: the Upper and Lower Tailings Piles; mineralized rock in Laurel Canyon up gradient from the site, including waste rock/tailings at and near the abandoned Grand Reef Mine and Dogwater Mine; and tailing material located on the hillside of parcel 110-47-006, believed to have been a historical attempt at processing ore from the Dogwater Mine.

2.0 FEASIBILITY STUDY TASKS

This section discusses the tasks associated with the development of the FS report. The FS tasks will be performed in order to meet the requirements of A.A.C. R18-16-407. The FS process considers the data gathered during the RI and further work that may be conducted during the FS and;

- considers the ROs;
- includes the identification of potential treatment and containment technologies that satisfy the ROs;
- includes remedial technology screening;
- includes the development and analysis of remediation alternatives and technologies, and;
- includes a comparison of the remedies and proposes a remedy.

2.1 Remedial Objectives

The ROs developed as part of the RI process, pursuant to A.A.C. R18-16-406 (I), were based on field investigation results, the land and water use surveys, the screening level risk evaluation, ADEQ input and input from the community during the draft RO Report public comment period. ROs are used during remedial alternatives development to identify appropriate remedial technologies.

2.2 Development and Screening of Remedial Measures

Remedial measures are remediation technologies or methodologies, and are screened based on anticipated removal or reduction of contaminants at a site and the ability to achieve the ROs. The FS evaluation will look at future risk under reasonably foreseeable uses of the source facility and surrounding properties. Typically, appropriate remediation alternatives and technologies are screened using the following criteria:

- compatibility with current and reasonably foreseeable land use,
- COC treatment effectiveness,
- regulatory requirements,
- constructability,

- operation and maintenance requirements,
- health and safety considerations,
- generation and management of waste products,
- flexibility/expandability, and
- cost.

2.3 Proposed Remedy

A.A.C. R18-16-407 (C) indicates that for remedies addressing only soils, an analysis of alternative remedies is not required. A feasibility report shall be prepared that demonstrates:

- That the proposed remedy addresses the contaminated soil in a manner that achieve compliance with Arizona Revised Statutes (A.R.S.) §49-152 and 18 A.A.C. 7, Article 2 and will achieve the remedial objectives for the use of the property;

- That the proposed remedy was selected based upon the best engineering, geological , or hydrogeological judgment following engineering, geological or hydrogeological standards of practice considering the following information:

  a. The remedial investigation;

  b. Best available scientific information considering available remedial methods and technologies;

  c. A written analysis explaining how the remedy is consistent A.R.S. §49-282.06 including a brief explanation of the comparison criterial as applied to the remedy.

3.0 COMMUNITY INVOLVEMENT

ADEQ will issue a Notice to the Public announcing availability of the work plan to implement the Feasibility Study on ADEQ's website at www.azdeq.gov.. The notice may be mailed to the Public Mailing List for the site; water providers, the Community Advisory Board, and any other interested parties.

4.0 FEASIBILITY STUDY REPORT FORMAT

An FS report will be prepared documenting the FS process. The FS report will be organized into the following sections:

- **Section 1.0 INTRODUCTION**
  This section will summarize the purpose of the FS report.

- **Section 2.0 SITE BACKGROUND**
  This section will present a summary of the site description, physiographic setting, nature and extent of contamination and a risk evaluation.

- **Section 3.0 FEASIBILITY STUDY SCOPING**
  This section will present the regulatory requirements presented in statue and rule, delineate the remediation areas and present the ROs identified in the RI.

- **Section 4.0 IDENTIFICATION AND SCREENING OF REMEDIAL MEASURES AND REMEDIAL STRATIGES**
  This section will present the evaluation and screening of various remedial measures and strategies related to contamination in soil and lists the technologies that have been retained for evaluation as part of the remedy pursuant to A.A.C. R18-16-407 (C).

- **Section 5.0 PROPOSED REMEDY**
  This section will present the proposed remedy as required in A.A.C. R18-16-407(C), and discusses how it will achieve the ROs, how the comparison criteria were considered, and how the proposed remedy will meet the requirements of A.R.S. §49-282.06, A.R.S. §49-152 and 18 A.A.C. 7, Article 2 and will achieve the remedial objectives for the use of the property.

- **Section 6.0 COMMUNITY INVOLVEMENT**
  This section will document the community involvement activities conducted in association with the FS.

5.0 REFERENCES

URS Corporation, 2014. Final Remedial Investigation Report Klondyke Tailings WQARF Site, Klondyke, Arizona.

FIGURES

Figure 1

Klondyke Tailings WQARF Site - Graham County, Arizona

Publication #: M 12 - 23