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10/06/94

ARIZONA DEPARTMENT OF MINES AND MINERAL RESOURCES FILE DATA

PRIMARY NAME: CLARKDALE TAILINGS POND

ALTERNATE NAMES:
TAILING PONDS

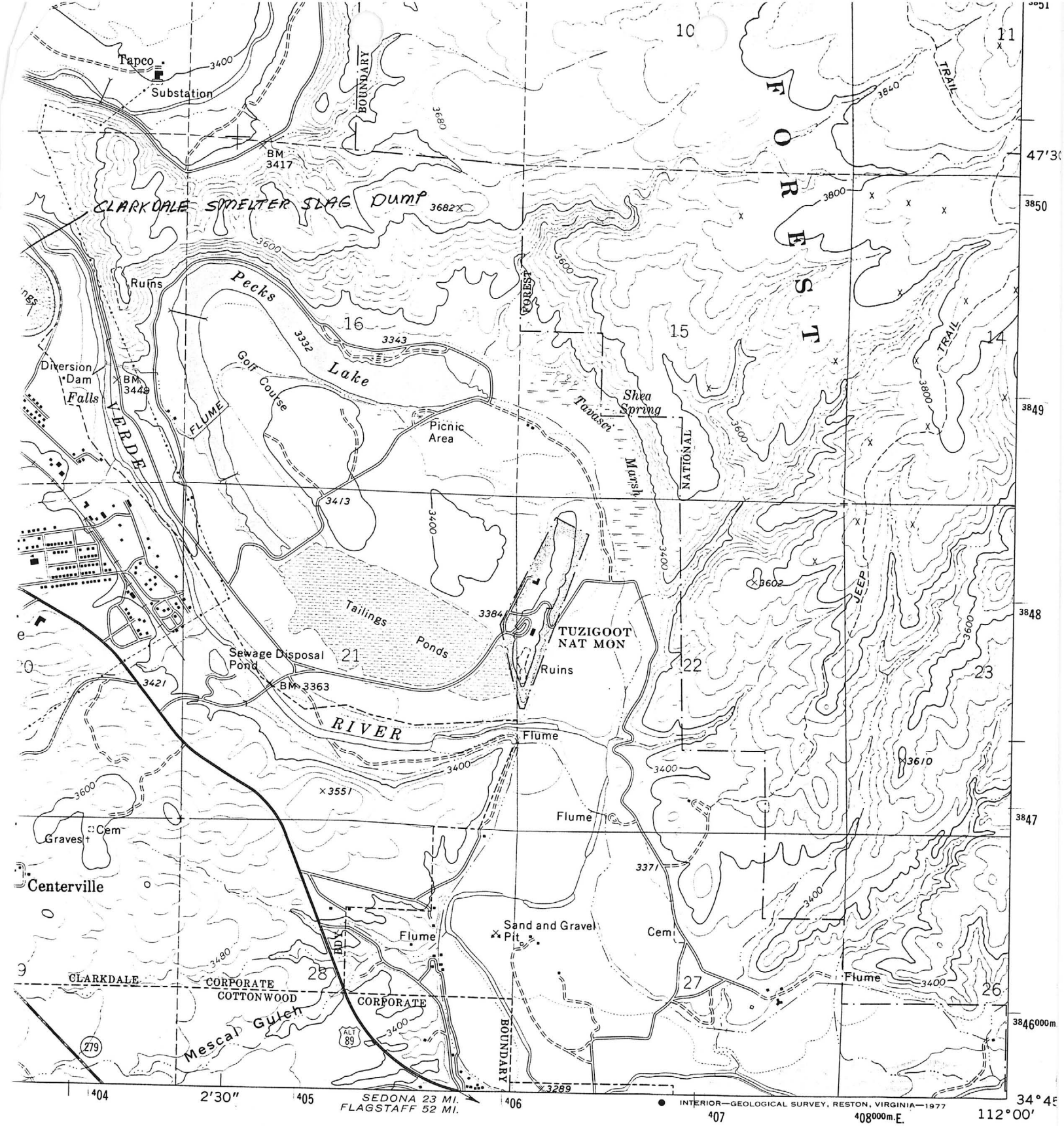
YAVAPAI COUNTY MILS NUMBER: 539

LOCATION: TOWNSHIP 16 N RANGE 3 E SECTION 21 QUARTER N2
LATITUDE: N 34DEG 46MIN 13SEC LONGITUDE: W 112DEG 01MIN 59SEC
TOPO MAP NAME: CLARKDALE - 7.5 MIN

CURRENT STATUS: PAST PRODUCER

COMMODITY:
MILL TAILING

BIBLIOGRAPHY:
USGS CLARKDALE QUAD
ADMMR CLARKALE TAILINGS POND FILE



RDS
TON, VIRGINIA 22092
ON REQUEST

CLARKDALE, ARIZ.

SE/4 CLARKDALE 15' QUADRANGLE

N3445—W11200/7.5

YES

CLARKDALE TAILINGS POND (f)

THIS NOTICE COVERS YAVAPAI MILL #539 TAILINGS POND

ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

Fife Symington, Governor Edward Z. Fox, Director

NOTICE OF THE PRELIMINARY DECISION TO ISSUE AN INDIVIDUAL AQUIFER PROTECTION PERMIT

Pursuant to Arizona Administrative Code, Title 18, Chapter 9, Article 1, the Director of the Arizona Department of Environmental Quality intends to issue an individual Aquifer Protection Permit to the following applicant(s):

Public Notice No. 29-94AZAP On or about July 8, 1994
Phelps Dodge Corporation - Clarkdale Tailings
Impoundment Closure (P-101076) and
The Town of Clarkdale - Wastewater Treatment Facility
(P-100715)
Phelps Dodge Corp.
2600 N. Central Avenue
Phoenix, AZ 85004-3015 and
The Town of Clarkdale
P.O. box 308
Clarkdale, AZ 86324

Aquifer Protection Permit Nos. P-101076 and P-100715

The Phelps Dodge Corp. - Clarkdale Tailings Impoundment site and the Town of Clarkdale Wastewater Treatment Facility (WWTF) are located in the Town of Clarkdale in Yavapai County, Arizona, over groundwater of the Verde river Groundwater Basin in Township 16 N, Range 03 E, Section 21 - Gila and Salt River Base Line and Meridian. Latitude 34° 46' 00.0" North and Longitude 112° 02' 00.0" West.

The Phelps Dodge - Clarkdale Tailings Impoundment is a former copper tailings impoundment that was operated from 1923-1953. The tailings from the United Verde Mine concentrator in Clarkdale were placed in an abandoned oxbow meander of the Verde River north of the river and the town of Clarkdale. In 1980, the town of Clarkdale began disposing of the effluent from the existing Clarkdale WWTF to the tailings pile. In 19912 the Town of Clarkdale and Phelps Dodge submitted applications to cease the discharge of effluent to the tailings pile, close the tailings pile, and construct a new wastewater treatment plant as part of the Verde Valley Ranch (VVR) development.

The closure plan for the tailings pile includes capping of the pile with a high-density polyethylene liner, drainage system and three-foot soil cover. The capped tailings will be

overlain, in part by the VVR golf course. The plan also includes the installation of a soil-bentonite slurry wall between the tailings and Pecks Lake, to prevent the migration of groundwater from Pecks Lake beneath and through the tailings, and eventually to the Verde River, where contaminated groundwater from the shallow alluvial aquifer underlying the tailings pile. Groundwater pumped form the shallow aquifer will be stored in a lined storage pond to be located at the VVR. This pond will also store the treated effluent form the new Clarkdale WWTF.

The new Clarkdale WWTF is an aerobic digestion wastewater treatment plant that utilizes the Biolac process and includes aerobic sludge digestion, sludge dewatering, tertiary filtration and ultraviolet disinfection. The effluent form the plant will be reused for landscaped irrigation on the VVR golf course in accordance with reuse permit R-101076 issued by ADEQ. the treatment ponds and the off-site effluent storage pond will be lined with 36-mil Hypalon liners. The existing aeration lagoon will be converted into an on-site effluent storage pond. All concrete basins and ponds at the treatment plant shall be constructed of a minimum of six inches of reinforced concrete with water-tight construction joints. All components of the existing treatment plant that will not be used in the new plant shall be closed and abandoned according to the permit. the materials authorized to be treated and disposed of through the plant are typical sewage and shall not include solvents, hazardous wastes, fertilizers or other materials not generally associated with toilet flushing, food preparation, laundry facilities, and personal hygiene.

The Phelps Dodge Clarkdale Tailings closure Aquifer Protection Permit includes a compliance schedule that provides for the timing of the construction activities, and submittal of groundwater monitoring data, an emergency response plan and as-built construction drawings. The permit requires monitoring of groundwater quality, surface water quality, groundwater table elevations, and of the quality of groundwater placed in the VVR effluent storage pond. Water quality monitoring parameters include bacteria, physical parameters, inorganic pollutants, heavy metals and radionuclides.

The Town of Clarkdale WWTF Aquifer Protection Permit requires monitoring of the treated wastewater, and of groundwater below the site in the uppermost aquifer. Both permit require that the facilities be designed, constructed, and operated according to the plans approved by the Arizona Department of Environmental Quality, Aquifer Protection Program Section.

A public hearing will be held on Wednesday, August 24, 1994, at 7:00 PM, at the Clark Memorial Clubhouse at 35 North 9th Street (9th and Main), Clarkdale, AZ 86324, phone number (602) 634-9591. The Town of Clarkdale contact is Pat Spence, Town Manager.

The permit and related materials are available for public review Monday through Friday 8:00 a.m. to 5:00 p.m. at the Arizona Department of Environmental Quality, Aqufer Protection Program Section, 3033 N. Central Avenue, 4th Floor, Phoenix, AZ 85012.

Persons may submit comments or request a public hearing on the proposed action, in writing, to Ed Pond, ADEQ, at 3033 N. Central Avenue, Phoenix, AZ 85012 within thirty (30) days

from the date of this notice. Public hearing request must include the reason for such request.

Clarkdale Tailings Pond
mine file

~~Privileged and Confidential~~
Prepared at the Direction
of Legal Counsel

Water Resources Associates, Inc.
A Subsidiary of Yellowstone Environmental Services, Inc.

January 4, 1993

Mr. Dalva L. Moellenberg, Esquire
Kimball & Curry, P.C.
2600 N. Central Avenue, Suite 1600
Phoenix, AZ 85004

SUBJECT: PROPOSED REMEDIATION PLAN, CLARKDALE TAILINGS IMPOUNDMENT, CLARKDALE, ARIZONA

Dear Mr. Moellenberg:

Water Resources Associates, Inc. (WRA) with technical support from Morrison-Knudsen Corporation (MK) has prepared the subject proposed remediation plan. This plan consists of the following basic components.

1. Synthetic cap on the tailings.
2. Bentonite slurry cut-off wall.
3. Pump-back system.

The synthetic cap design and specifications have been prepared by Coe & Van Loo Consultants, Inc. and submitted to Phelps Dodge Corporation under separate cover. Therefore, discussion regarding the synthetic liner will not be presented in this letter.

BACKGROUND

The purpose of the proposed remediation plan is to eliminate the underflow of ground water from the oxbow alluvial aquifer into the Verde River. In order to accomplish this task, water flowing into the oxbow aquifer must be minimized. To that extent, the water coming in contact with the tailings from precipitation or irrigation will be eliminated (synthetic liner on top of tailings), underflow from Peck's Lake will be minimized (Bentonite slurry cut-off wall), and ground water draining from the tailings and currently in that portion of the oxbow aquifer comprising the underflow will be extracted (pump-back system).

Phoenix, Arizona
Prescott, Arizona
4041 N. Central Avenue, Suite 1050
Phoenix, Arizona 85012-3393
(602) 248-8808 Telefax: (602) 248-7722
Lake Forest, California

BENTONITE SLURRY CUT-OFF WALL

A subsurface barrier to cut off ground-water flow originating from the Peck's Lake area is proposed as a key component of the overall remediation plan. The subsurface barrier will be placed across the alluvial channel between the mine tailings and Peck's Lake with the intent of minimizing underflow from the Peck's Lake area (Attachment I). The location and extent of the barrier is based upon the site hydrogeologic and geologic characteristics. Following barrier construction, the water surface elevation of Peck's Lake will be artificially maintained at a consistent level. The dimensions of the alluvial channel in the vicinity of the proposed barrier range in width from 1,000 to 1,200 feet and in depth up to 50 feet.

Alternative Barriers

MK engineers evaluated five barrier alternatives for implementation of the cutoff wall at the Clarkdale site. These include:

- Slurry Wall
- Composite Slurry Wall
- Deep Soil Mixing
- Injection Grouting
- Sheet Piling

Each of these five barrier types represent proven technologies and have been applied at numerous sites. Other more "exotic" barrier technologies that are in the pilot testing stage of development or have a limited application were not considered for this site. Of the five types of barriers discussed, the soil/bentonite slurry wall appears to be the barrier most suited for implementation at the Clarkdale site. The deep soil mixing, injection grouting, and sheet piling methods were eliminated from further consideration because their use would be less reliable in meeting the objective of constructing an effective barrier which reduces the flow of ground water. Given the highly permeable nature of the alluvial material, any gaps in these barriers will quickly negate the effectiveness of the remainder of that barrier. The effective placement of a soil mixed, grout, or sheet pile barrier over the entire cross-sectional area of saturated alluvium would be questionable due to the presence of large diameter cobbles and/or the limitations of the techniques, and would be difficult to verify the barriers' continuity in all cases. A secondary, though not decisive, disadvantage of these three barriers lies in their generally higher cost relative to other feasible barrier types.

A cement/bentonite slurry wall was eliminated from consideration because it too would be less reliable as an efficient cutoff. The higher in-place permeability of a cement/bentonite slurry wall makes this technique less effective. The advantage of not having to account for the quality or availability of soil backfill (as with a soil bentonite/slurry wall) is not relevant at this site, since an adequate source of soil is nearby. The generally higher cost relative to other suitable alternatives was also considered in the elimination process.

A composite slurry wall can be constructed to provide an effective barrier. However, the lower permeability and greater resistance to chemical degradation relative to soil/bentonite are not considered advantages, because the soil/bentonite mixture alone is considered satisfactory in this regard. Therefore, the additional time and cost associated with implementing this type of barrier is not warranted.

A soil/bentonite slurry wall is recommended as the preferred barrier type. With the combination of low permeability, flexibility in backfill design, reliability in verifying continuity, and economic appeal, the soil/bentonite slurry wall appears to best satisfy the barrier's objectives. Due to the nature of ground-water contamination determined from site characterization, the resistance of soil/bentonite to degradation by contaminants is not considered to be an issue for this site.

Concerning the requirement for a soil and bentonite mixing area, there is ample space for mixing available in the vicinity of the borrow area. The potential for trench collapse is addressed by considering locally obtained clay soil or clay soil plus a flexible membrane liner as a substitute for an excessively wide soil/bentonite slurry wall. The probability of trench collapse is still an unresolved issue; however, and will require further evaluation based on the results from the proposed site investigations performed in support of final detailed design.

Design Consideration

Soil/bentonite slurry walls are typically the most economical barriers to construct where the excavated material is suitable as backfill. This type of barrier can have a lower permeability and generally has greater resistance to degradation by exposure to pollutants than barriers containing cement. Other advantages generally include increased reliability in verifying the continuity of the barrier during construction, significant flexibility in design of the backfill, and lower relative cost compared to other types of barriers. The potential disadvantages include the possibility that the trench may collapse during construction where poorly-consolidated material is encountered, and the additional space required for a soil and bentonite mixing area.

Proposed Installation

The location and orientation of the soil/bentonite slurry wall is shown on Attachment I. Transverse and longitudinal profiles of the barrier are shown on Attachments II and III, respectively. The location and orientation were determined based upon information collected during a site visit by MK and from reviewing previously prepared site data.

The general location of the slurry wall between the tailings and Peck's Lake was selected based on both the favorable geometry of the alluvial channel in that area and the requirement that the barrier be upgradient of the tailings and downgradient of a significant source of water that recharges the oxbow aquifer as underflow. The orientation parallel to a wide zone of unvegetated ground between Peck's Lake and the tailings dam will allow sufficient room for maneuvering heavy equipment and the temporary storing of excavated material, and will not interfere with access using existing roads. The existing ground surface is a sufficient distance above the water table so that equipment will have stable ground to operate.

The slurry wall will extend approximately 1,100 feet across the full cross-sectional area of saturated alluvium, up to a maximum trench depth below existing grade of approximately 45 feet. The base of the wall will be keyed into bedrock, extending through the 0.5 to 1 foot thick weathered bedrock to contact competent rock (Verde Formation). The top of the slurry wall is set approximately 5 feet above the existing water table at an elevation sufficient to allow for changes in the water level of Peck's Lake.

The 1,100 feet length of the slurry wall is estimated based upon the assumption that the 3,330 and 3,340 feet structural contours of the top of the Verde Formation closely parallel the 3,310 and 3,320 contours mapped in the vicinity of the left and right ends of the wall. The depth of the wall is estimated based upon lithologic logs developed for three wells near the centerline of the proposed wall. The dimensions of the slurry wall may be modified following analysis of results from proposed site investigations performed in support of final detailed design.

The elements of a site investigation necessary as input into the final detailed design include:

1. Site surveying to provide accurate land surface topography where none is currently available;

2. Ground-water sampling to confirm water quality;

3. Borehole drilling to provide information on penetration resistance, lithology, and water table elevation at consistent intervals along the slurry wall alignment;

4. Water level measuring to provide an accurate interpretation of the water table in the vicinity; and,

5. Excavation of a test pit to observe the stability of the native material.

In the initial phase of construction, the site will be prepared by removing the thin layer of tailings covering the area between the toe of the tailings dam and the safety dam and filling in clean backfill soil to the same grade as the tailings. The tailings cleared from the area will be placed either inside the tailings impoundment or against the base of the tailings dam. In addition, the relatively steep slopes near both ends of the proposed slurry wall will be excavated to shallower slopes, as necessary, to prepare a suitable working bench for slurry wall construction.

The slurry wall will be constructed using a backhoe to excavate the trench. Excavated material will be discarded against the base of the tailings dam. A water and bentonite slurry mixing plant located near the trench will operate to maintain the slurry level inside the trench throughout the excavation and backfilling process. The backfill mix to be placed in the trench will be prepared adjacent to the borrow area (to be designated by Phelps Dodge and evaluated at a later date). The most suitable backfill will consist of proportioned amounts of gravel, sand, silt, and clay soil borrowed from the on-site source and bentonite imported from off-site as necessary to obtain the required permeability to place an effective

cutoff barrier. It is assumed that a suitable borrow area for silt and clay can be located within 0.5-mile of the construction area.

Following construction of the slurry wall, site regrading and revegetation will be performed. A minimum 3-foot thickness of fine-grained fill will be placed over the top of the slurry wall, and excavated areas near the ends of the completed wall will be recontoured. Using guidelines established by the client, all areas disturbed during slurry wall construction will be revegetated or stabilized by other means to minimize erosion.

PUMP-BACK SYSTEM

The final component of the proposed remediation plan is to extract water draining the tailings as well as that portion of ground water in the oxbow aquifer that may be further defined as underflow. The proposed pump-back system consists of pumping two to four existing monitor wells at rates of 5 to 20 gallons per minute (gpm). The pumped ground water would be collected in the irrigation sump system (Coe & Van Loo tailings cap design) and discharged into the on-site effluent storage pond. This water would then mix with effluent and Peck's Lake water and be re-used for on-site irrigation.

Ground-water extraction using the pump-back system will decrease with time following installation of the synthetic cap and cut-off wall. We anticipate that the extraction rate would decrease with time roughly paralleling the projected decrease in the drainage of the tailings as predicted in the HELP model (WRA, May 11, 1992). The anticipated duration of the pump-back system would be 3 to 5 years.

Following the elimination of underflow into the Verde River system, ground-water elevations will be measured from existing on-site monitor wells on a quarterly basis in order to confirm the integrity of the remedial system.

Details and specifications of the cut-off wall and pump-back system will be presented under separate cover at a later date. If you have any questions, please call.

Sincerely,

WATER RESOURCES ASSOCIATES, INC.

Stephen D. Noel

Stephen D. Noel, P.G.
President

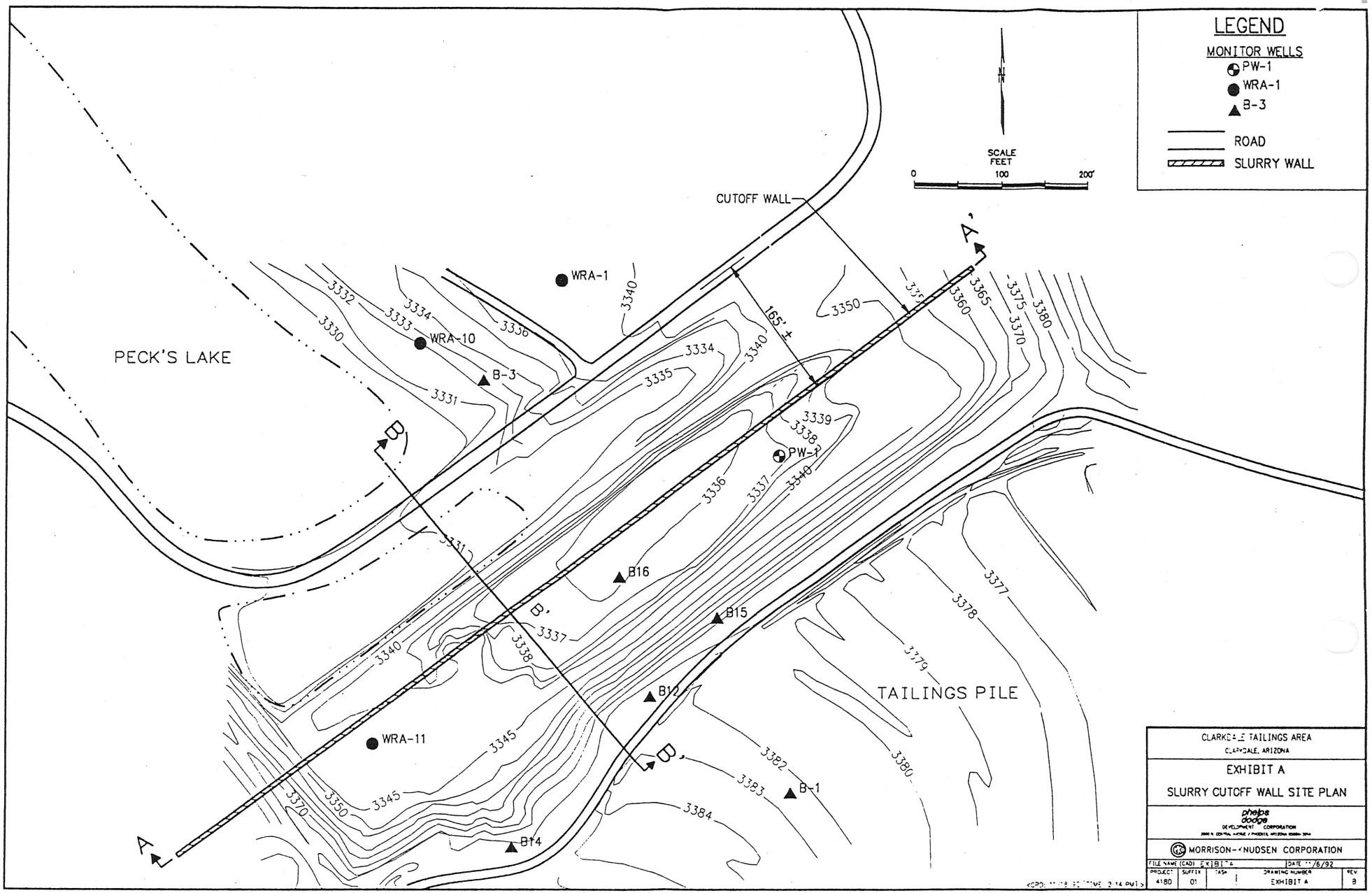
Attachments I through III

cc: Ms. Robin A. Kettlewell, Environmental Coordinator, Phelps Dodge Corp.
WRA File No. AEP-10930

ATTACHMENTS

ATTACHMENT I

Slurry Cutoff Wall Site Plan
(Exhibit A)



CLARKDALE TAILINGS AREA
CLARKDALE, ARIZONA

EXHIBIT A

SLURRY CUTOFF WALL SITE PLAN

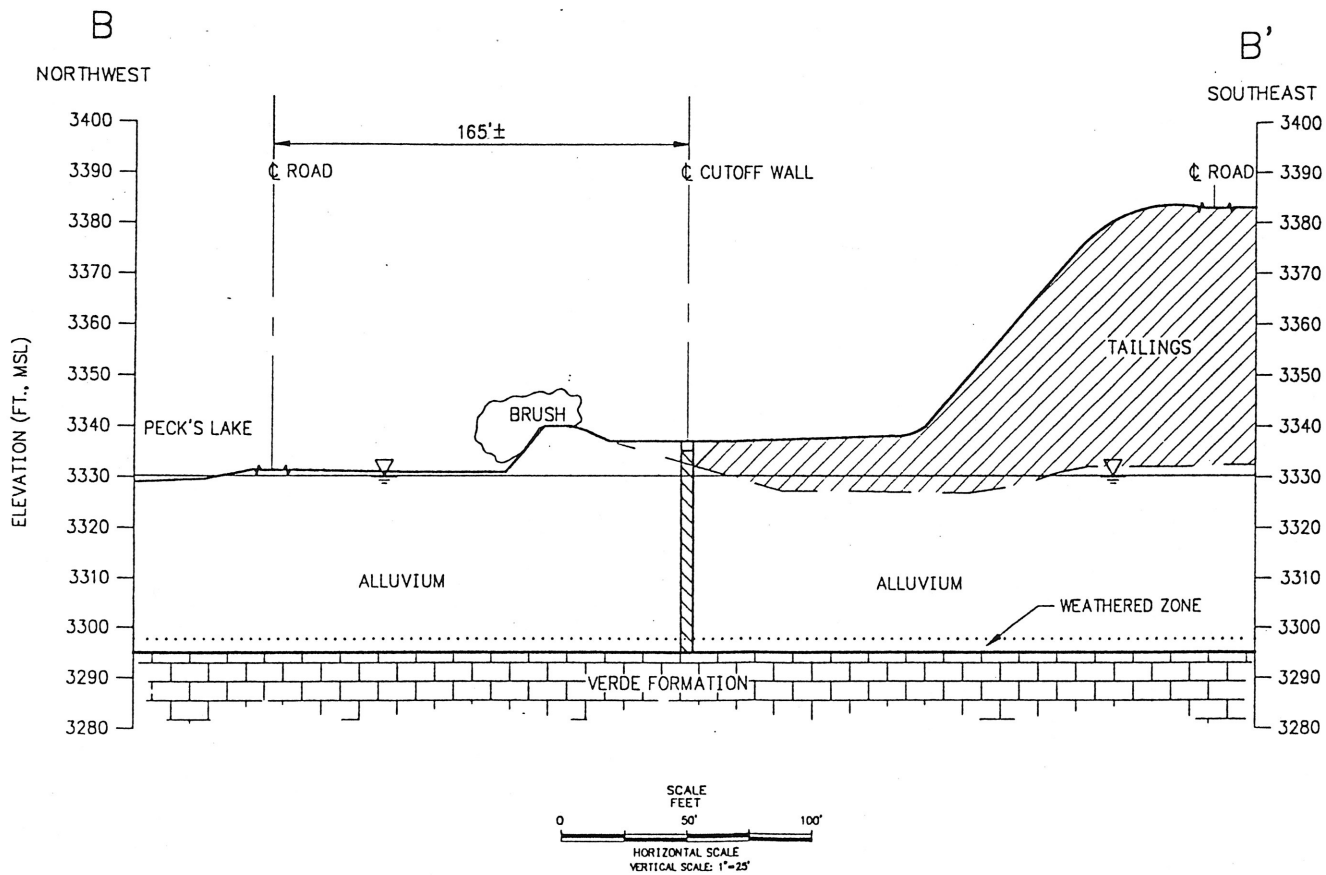
phelps dodge DEVELOPMENT CORPORATION

MORRISON-KNUDSEN CORPORATION

FILE NAME (CAD) EXHIBIT A			DATE 7/6/92	
PROJECT 4180	SUFFIX 01	TASK	DRAWING NUMBER EXHIBIT A	REV B

ATTACHMENT II

Slurry Cutoff Wall Section
(Exhibit B)



LEGEND

- GROUND WATER LEVEL
- APPROXIMATE CONTACT VERDE FORMATION
- TAILINGS
- ALLUVIUM
- VERDE FORMATION

SCALE FEET
0 50' 100'
HORIZONTAL SCALE
VERTICAL SCALE: 1"=25'

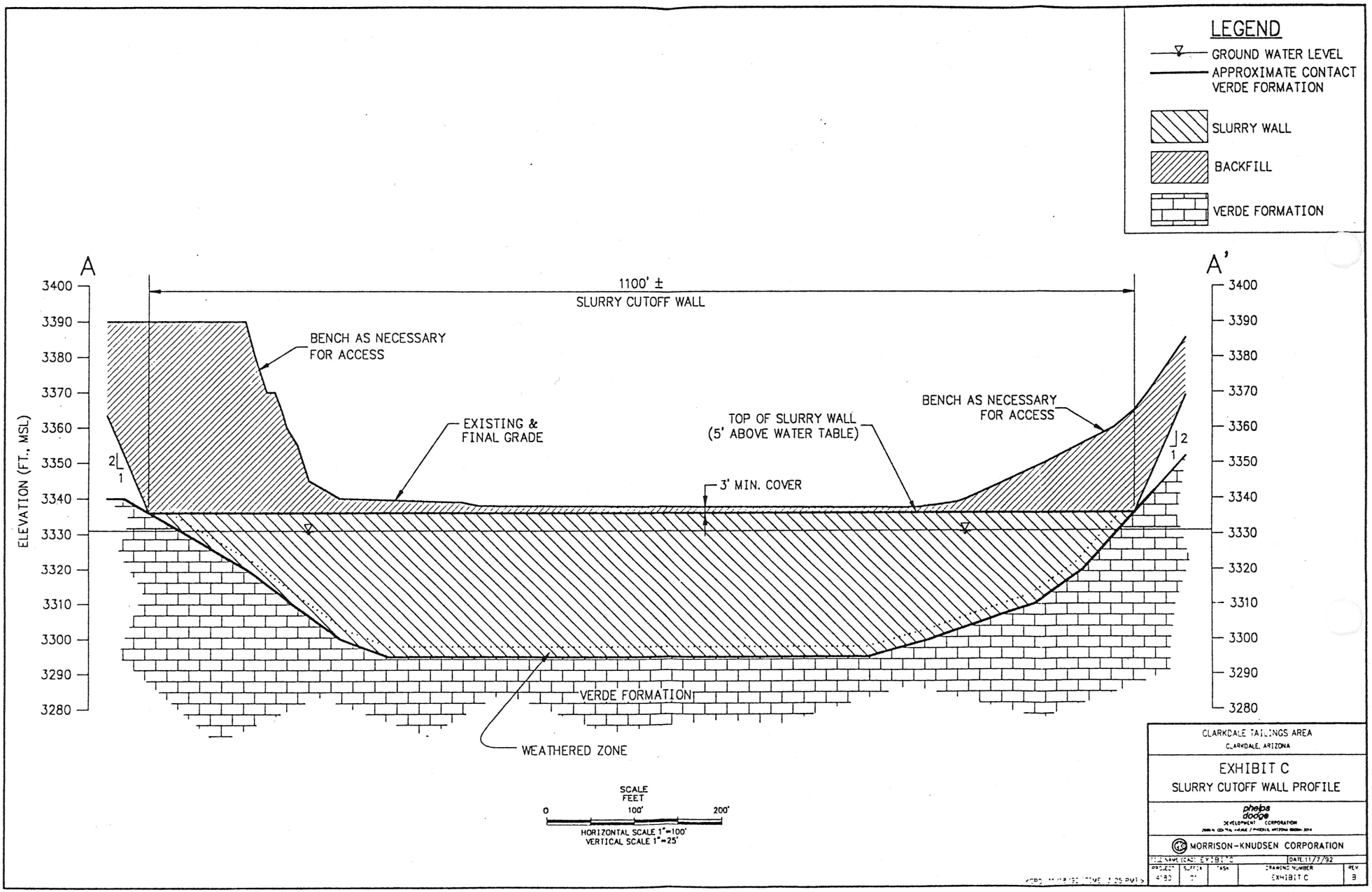
CLARKDALE TAILINGS AREA
CLARKDALE, ARIZONA

EXHIBIT B
SLURRY CUTOFF WALL SECTION

phelps dodge DEVELOPMENT CORPORATION

MORRISON-KNUDSEN CORPORATION

FILE NAME (CAD) EXHIBIT B			DATE 11/7/92	
PROJECT 4180	SUFFIX 01	TASK	DRAWING NUMBER EXHIBIT B	REV B


LEGEND
GROUND WATER LEVEL
APPROXIMATE CONTACT VERDE FORMATION
SLURRY WALL
BACKFILL
VERDE FORMATION
A
A'
1100' ±
SLURRY CUTOFF WALL
BENCH AS NECESSARY FOR ACCESS
EXISTING & FINAL GRADE
TOP OF SLURRY WALL (5' ABOVE WATER TABLE)
BENCH AS NECESSARY FOR ACCESS
3' MIN. COVER
2
1
ELEVATION (FT., MSL)
3400
3390
3380
3370
3360
3350
3340
3330
3320
3310
3300
3290
3280
VERDE FORMATION
WEATHERED ZONE
SCALE FEET
0
100'
200'
HORIZONTAL SCALE 1"=100'
VERTICAL SCALE 1"=25'
CLARKDALE TAILINGS AREA
CLARKDALE, ARIZONA
EXHIBIT C
SLURRY CUTOFF WALL PROFILE
phelps dodge DEVELOPMENT CORPORATION
MORRISON-KNUDSEN CORPORATION
DATE 11/7/92
DRAWING NUMBER
EXHIBIT C
REV
B

ATTACHMENT D

Proposed Slurry Wall QA/QC Plan
Clarkdale Tailings Impoundment
Clarkdale, Arizona

SPECIFICATION 02363

SOIL-BENTONITE SLURRY CUTOFF TRENCH

CLOSURE OF EFFLUENT DISCHARGE

CLARKDALE TAILING EMPOUNDMENT

TOWN OF CLARKDALE

PHELPS DODGE CORPORATION

CONTENTS

SPECIFICATION 02363

SOIL-BENTONITE SLURRY CUTOFF TRENCH

CLOSURE OF EFFLUENT DISCHARGE
CLARKDALE TAILING EMPOUNDMENT

1. SCOPE

A. The work consists of furnishing plant, labor, equipment, and materials, and performing operations as required to construct the slurry cut-off trench as specified on drawings and in the following paragraphs.

2. REFERENCE STANDARDS

A. Organizations whose standards are referenced herein include the following:

1) ASTM - American Society for Testing and Materials
2) API - American Petroleum Institute
3) COE - Corps of Engineers
4) USBR - U.S. Bureau of Reclamation

3. QUALIFICATION OF CONTRACTOR

A. Experience: The Contractor shall submit evidence to the Engineer that he is competent to construct a soil-bentonite slurry trench. This evidence should insure that the Contractor will have sufficient experienced personnel to carry out the operations specified. The Contractor qualifications should include extensive slurry trenching experience including some deep slurry trench construction.

B. Supervision: The contractor shall designate a Slurry Trench Specialist to supervise the construction, slurry preparation and quality control. The Slurry Trench Specialist shall have knowledge and be experienced in slurry trench construction. This experience should include, but not necessarily be limited to:

1) The use, testing and control of bentonite as a slurry.
2) The mixing methods required to properly mix the bentonite and backfill slurries required.
3) Trench excavating and backfill procedures.
4) Knowledge of construction equipment and materials testing as required

for slurry trench construction.

The credentials of the Slurry Trench Specialist shall be submitted to the Engineer for approval three weeks prior to starting trench construction.

4. GEOTECHNICAL SITE CONDITIONS

Prior to initiating construction work, a geotechnical investigation will be performed to determine the character of the materials to be excavated, determine the profile of the Verde Formation, assess the stability of subsurface materials, and evaluate water quality. A final detailed design package will be prepared on the basis of this information.

5. SUBMITTALS

A. General: The Contractor shall submit data for approval by the Engineer for items required by this section.

B. Schedule and Sequence of Operations: The Contractor shall submit a schedule and sequence of operations. This shall include but not necessarily be limited to:

1) Mobilization and site preparation
2) Trench excavation
3) Waste management
4) Slurry preparation
5) Slurry placement
6) Backfill preparation
7) Trench backfill
8) Clay cap placement
9) Demobilization

C. Layout of Operations: The Contractor shall submit a layout of operations. The layout of operations shall include, but is not necessarily limited to drawings depicting:

1) Bentonite storage area(s)
2) Slurry preparation area(s)
3) Backfill mixing area(s)
4) Backfill storage area(s)
5) Location and sizes of stationary equipment
7) Water storage tanks, pumps, valves, lines, hoses and materials
8) Waste area(s)

D. Slurry Trench Construction Method and Equipment: A description of the proposed method of construction of the soil-bentonite slurry cutoff trench, including excavation site plan and a listing of the Contractor's available equipment, shall be submitted to the Engineer for approval prior to construction.

E. Material Certification: A certificate describing the chemical and physical properties of the bentonite proposed for use in trench construction shall be submitted to the Engineer for approval prior to construction.

F. Mix Design: Mix proportions for the bentonite slurry and backfill slurry, including moisture content, density, mix proportions, and gradation, shall be submitted to the Engineer for approval prior to construction.

G. Excavation and Backfill Soundings: A description of the method to be used by the Contractor to determine trench depths shall be submitted to the Engineer for approval prior to construction.

H. Quality Control Testing Equipment and Procedure: Methodology proposed to perform required quality control tests shall be submitted to the Engineer for approval prior to construction (see Table 1). The Contractor shall furnish the Engineer with copies of all Quality Control testing during conduct of the work.

6. MATERIALS

A. Bentonite Slurry: The bentonite slurry is required to support the excavated trench prior to installation of the backfill, and to create a filter cake along the trench walls to minimize slurry loss from the trench. The bentonite slurry shall consist of a stable colloidal suspension of bentonite in water. Slurry properties shall be determined in accordance with API Specification 13B. The properties of the bentonite slurry may be altered to suit construction conditions through the use of additives, subject to the prior approval of the Engineer. No peptizing or bulking agents shall be used as additives to the bentonite slurry. The bentonite slurry shall have sufficient density and viscosity to support the trench walls without excessive slurry infiltration into the alluvium. The slurry shall be mobile enough to be displaced by the backfill slurry when necessary and to fill voids in the trench walls. The bentonite slurry shall be stable and not flocculate out of solution. The pH of the bentonite slurry shall be 7 ± 1. The quantity of bentonite used in preparing the bentonite slurry will be dependent upon the grade of bentonite the Contractor proposes to use. Approval of the Engineer is required regarding both the grade of bentonite proposed for use and the proposed bentonite-to-water mixture. No bentonite slurry shall be mixed by hand or in

the trench.

1) Density: The density of the bentonite slurry shall be monitored and controlled by the Contractor so that trench stability is maintained; slurry infiltration minimized; and slurry displacement by the backfill assured. The range of bentonite slurry densities will be determined during final detailed design.

2) Viscosity: The degree of hydration shall be determined through evaluating the apparent viscosity of the slurry. A Marsh funnel shall be used for evaluating viscosity. The range of slurry viscosities will be determined during final detailed design.

3) Filtrate: Filtrate loss shall be evaluated to determine the degree of slurry hydration. A filter press shall be used to evaluate filtrate loss. Slurry samples shall be subjected to a constant pressure of $100\#/in^2$ for 30 minutes and the amount of resulting filtrate monitored. Values of 15-30 cm^3 of filtrate shall be considered acceptable.

4) Hydration: Slurry hydration shall be completed prior to placement of the bentonite slurry into the trench. Degree of hydration shall be determined through evaluating the density and viscosity of the slurry.

B. Backfill Slurry: The backfill slurry shall be a mixture of bentonite, soil and water. This slurry solidifies to form the cutoff wall. The backfill slurry shall be composed of bentonite slurry mixed with selected materials transported from approved borrow areas. The soil used in the mixture shall contain at least 20% by weight of material passing U.S. Standard #200 sieve, and 100% passing a 1½-inch sieve. The backfill slurry shall be well mixed and shall not contain organic matter, roots or other deleterious matter. The backfill slurry shall be thoroughly mixed into a homogeneous mass, free of lumps of clay and silt and pockets of sand and gravel.

1) General: Backfill materials shall be thoroughly mixed with bentonite to form a homogeneous mass prior to placement into the trench. The backfill slurry shall be mixed by windrowing, disc harrowing, bulldozing or blading. Mixing with additional dry bentonite powder is allowable, subject to approval of the Engineer.

2) Slump Testing: Slump testing of the mixed backfill slurry shall be conducted as the backfill is added to the trench. A slump of 3 to 6 inches shall be considered acceptable.

3) Hydraulic Conductivity: Hydraulic conductivity tests shall be made on samples of the backfill taken just prior to placement in the trench.

C. Bentonite: The bentonite shall be sodium cation base montmorillonite powder (Premium Grade Wyoming-type bentonite) that conforms to the standards set forth in API Specification 13A. No chemically treated bentonite will be allowed. The Contractor shall furnish to the Engineer a certificate of compliance and a copy of the test reports from the bentonite for each lot or bentonite shipped to the site stating that the bentonite complies with all applicable standards. No bentonite from the supplier shall be used prior to acceptance by the Engineer. Bentonite may be subject to inspection, sampling, and verification of quality of testing by or under the supervision of the Engineer. Bentonite not meeting specifications shall be promptly removed from the site and replaced with bentonite conforming to specification requirements of the Engineer. Bentonite shall be protected from moisture during transit and storage.

D. Water: The water used in preparing the slurry and backfill trenches shall approximate fresh and potable water. The water shall be free from oil and excessive amounts of acid, alkali, organic matter and other deleterious substances. Potential water sources, identified by the Engineer, shall be tested as outlined in Table 1 prior to beginning trench excavation to assure water will be of suitable characteristics for slurry preparation and will not adversely affect the swelling of bentonite. Water used in preparing the bentonite slurry and soil-bentonite/ slurry shall have a pH of between 7 ±1. The water shall contain no more than 750 mg/l total dissolved solids. A water's total dissolved solid content is generally between 0.55 and 0.75 x of its specific conductivity. Total hardness shall not exceed 150 mg/l.

7. EQUIPMENT

A. Trench Excavation: Excavation of the slurry trench cutoff wall shall be accomplished by use of approved earth-moving equipment or combination thereof such as backhoe and/or clamshell so that the required trench width can be carried to its final depth of cut continuously along the trench line. Special chopping, chiseling, or other suitable equipment may be used as necessary to satisfactorily accomplish the required excavation. The width of the excavating tool shall be equal to or greater than the specified width of the cutoff wall. The trench bottom shall be cleaned and prepared prior to introduction of the backfill slurry.

B. Slurry Batching Plant: The bentonite slurry batching plant shall include the necessary equipment including a mixer capable of producing a stable suspension of soil in a bentonite and water slurry, pumps, valves, hoses, supply lines and other equipment as required to adequately supply slurry to the trench. Slurry for use in the trench shall be prepared using a suitable mixer. No slurry shall be prepared in the trench. Bentonite slurry shall be prepared

by mixing water and bentonite until the bentonite particles are fully hydrated and the resulting slurry appears homogeneous.

8. EXECUTION OF THE WORK

A. Description: The slurry trench cutoff wall shall be constructed to the lines, grades, and cross sections as indicated on the final detailed design drawings. The trench shall have essentially vertical walls, a nominal width of 36 inches, and shall extend through the unconsolidated alluvium so as to attain full contact (refusal) with the underlying Verde Formation. Should upper portions of the Verde Formation be composed of soft, easily excavated sand or sandstone, excavation will continue as directed by the Engineer into the Verde Formation until consolidated strata are encountered. Construction shall proceed such that undue interruptions of trench excavation and backfilling do not occur.

B. Trench Specifications: The trench shall be excavated to total depth at the point where excavation is started. The Contractor shall maintain the stability of the excavated trench at all times for its full depth. The sides of the trench shall be maintained from collapsing by keeping the trench filled with a bentonite slurry during excavation and prior to backfilling. The bentonite slurry will be displaced by a backfill slurry consisting of bentonite, fines and soil. The finished cutoff wall shall have a hydraulic conductivity approximating 1×10^{-7} cm/sec or less. The top of the cutoff wall shall extend a minimum of 5 feet above the maximum operating water surface elevation of Pecks Lake. The top of the cutoff wall shall be capped with a 3-foot thick clay layer.

C. Slurry Trenching: Excavation shall be carried to final depth along the line of the trench in a continuous operation. Slurry shall be introduced into the trench at the same time trenching is begun and shall be maintained in the trench during excavation. The Contractor shall maintain the stability of the excavated trench at all time for its full depth. The level of the slurry shall not be permitted to drop more than two feet below the proposed top of the completed cutoff wall except as approved by the Engineer. The level of the slurry shall be maintained a minimum of 3 ft above the water table. The Contractor shall have personnel, equipment, and materials ready to raise the slurry level at any time. To this end, the Contractor shall have personnel on call to raise the slurry level, weekends and/or holidays included.

1) Excavated Material: Excavated material shall be stockpiled on one side of the slurry cutoff trench as shown on the final detailed design drawings. Personnel working on this side of the trench will follow the Engineers directions in accordance with the project Health and Safety

Plan.

2) Water Table: Excavation shall cease and the trench backfilled if the water table should rise to within 3 ft of the proposed top of slurry wall and a continued rise appears evident. Excavation may again proceed when the water table recedes to an acceptable elevation as determined by the Engineer. The Contractor shall reexcavate the backfill where it does not meet standards due to the rising water table. The Contractor shall reexcavate a segment of the placed backfill of design specifications prior to reinitiating trench excavations to allow interconnection with new backfill.

3) Cleaning: If necessary, the bentonite slurry in the trench shall be cleaned prior to placement of the backfill slurry to remove soil particles which may have collected in the slurry. The slurry cleaning shall be accomplished by airlifting the slurry to the surface and subsequent circulation through desanding units or other suitable method approved by the Engineer. The slurry cleanup shall result in a bentonite slurry having a viscosity which will allow displacement by the backfill slurry.

B. Backfill Placement

1) Backfill Characteristics: The backfill slurry shall be mixed by windrowing, disc harrowing, bulldozing or blading to meet the required gradation. Mixing shall be conducted adjacent to the designated borrow area and transported to the site of the slurry wall.

2) Equipment: Equipment used in mixing the backfill can consist of earth moving or grading equipment such as bulldozers, barrows, and blade graders. A vibratory shaker screen shall be used to remove excess sand and sediment from the backfill if necessary.

3) Bottom Cleaning: The trench bottom shall be cleaned of gravel, sand and other sediment which may settle out of bentonite and backfill slurries. A jetting pipe, air lift pump or other suitable method approved by the Engineer may be used.

4) Backfill Placement: The backfill slurry shall be placed continuously from the beginning of the trench in the direction of excavation to the end of the excavation. Placement shall proceed in such a manner that the top of the backfill below the surface of the trench follows a reasonably smooth grade without hollows which may trap pockets of slurry during subsequent backfilling. Free dropping of backfill through the bentonite slurry will not be permitted. Initial placement of the

backfill shall by lowering it to the trench bottom using a crane and clamshell bucket as necessary until the surface of the backfill slurry rises to the trench surface at the excavation terminus. Additional backfill slurry shall then be placed by bulldozer in such a manner that the backfill enters the trench by sliding down the forward face of the previously placed backfill slurry. The slope produced by the backfill shall range between 1 to 5 and 1 to 10 vertical to horizontal.

Precautions shall be taken during the initial placement of the backfill slurry to insure that the backfill reaches the trench bottom and assumes a suitable slope. The toe of the backfill slope shall be within 50 to 100 ft of the leading edge of trench excavation to minimize the open length of the trench supported by the bentonite slurry. The physical properties of the bentonite and backfill slurries shall be controlled such that minimal amounts of bentonite slurry are trapped within the backfill. Equipment shall be operated in such a manner that sloughing of alluvium at the trench top does not occur. Backfill operations shall be suspended when the ambient temperature falls below 25°F.

C. Key: The bottom of the slurry trench will be keyed the minimum specified penetration into the Verde Formation as directed by the Engineer. The final depth and penetration of the trench shall be measured and checked by the Contractor and approved by the Engineer immediately following excavation.

D. Continuity Between Trench Segments: At such times that a trench segment is extended where the slurry in the previously excavated trench has settled, the excavation tools will be arranged to re-excavate a minimum three-foot overlap into the end of the previously placed backfill.

E. Slurry in Trench: If at any time the slurry in the trench begins to become unworkable before excavation is completed to the full depth at the point of excavation, or otherwise becomes unworkable, then sufficient freshly made slurry shall be added to correct the situation. Addition of water to the slurry in the trench shall not be permitted.

F. Treatment for Top of Cutoff Trench: After initial settlement of the slurry, the top of the completed cutoff trench shall be checked for decantation. Any free water in the trench shall be removed and the trench shall be filled to within 0.5 feet of the working platform with fresh slurry. After the trench has been topped off and the backfill has settled, but before drying can occur, the cutoff trench shall be capped in accordance with the details shown on the drawings. Open cracks in the top of the slurry due to shrinkage in the setting process shall be filled with fresh slurry.

G. Cleanup: After completion of trenching, any remaining excavated material and slurry shall be removed and placed in thin lifts in the construction area as shown on the final detailed design drawings. The surface shall be cleaned and leveled as directed by the Engineer. Excess slurry shall be disposed of by spreading in thin layers as designated by the Engineer.

H. Trench Cover/Clay Cap: The top of the completed slurry trench shall be covered by a geotextile fabric extending a minimum of 2' on either side of the trench and a 2-foot thick layer of fine-grained clayey soil compacted in 8" lifts as a protective layer to prevent drying. The trench shall be covered within 72 hours after the backfill reaches the top of the trench. Additional compacted fill shall not be applied for 14 days as backfill material in the trench shall be allowed to settle before being covered with permanent compacted alluvial material. The clay shall be compacted to 90% of maximum dry density at $\pm$2% of optimum moisture content as determined by Standard Proctor testing.

I. Revegitation: Following site grading, the construction area shall be revegitated as directed by the Engineer.

9. QUALITY CONTROL

A. General: The Contractor shall maintain his own Quality Control for the cutoff wall construction under the direction of his designated Slurry Trench Specialist. Testing requirements are summarized in Table 1. The Contractor shall provide the necessary personnel, laboratory facilities and testing equipment to perform the specified tests.

B. Documentation: Results of all tests performed in accordance with the specification will be recorded on forms acceptable to the Engineer and signed by the Contractor's Project Engineer. These forms will be available to the Engineer at all times for his inspection. Copies of all forms will be submitted daily to the Engineer for his reference.

10. QUALITY ASSURANCE

A. Testing: The Engineer may perform quality assurance testing on the slurry and backfill materials using the laboratory and equipment furnished by the Contractor. The testing will in no way relieve the Contractor of the responsibility of performing tests necessary to meet the construction requirements. The Contractor shall provide the equipment and laboratory space to the Engineer on demand and these services shall be considered a subsidiary obligation of the slurry trench construction. Routine testing procedures being conducted by the Contractor shall be available for

inspection by the Engineer.

B. Testing Equipment: The Contractor shall furnish and maintain test equipment necessary to adequately perform the required testing. Procedures shall conform to applicable API and ASTM specifications or other suitable methods as approved by the Engineer. The Contractor shall allow the Engineer access to testing equipment and test results without charge. The testing equipment shall include but not necessarily be limited to:

1) Marsh Funnel Viscometer and Measuring Cup (Baroid No. 201 and 202 or approved equal)
2) Sand Content Set (Baroid No. 400-01 or approval equal)
3) CO Cartridge Pressurized Filter Press System (Bariod No. 302-01 or approved equal)
4) Electric Laboratory Mixer
5) Stop Watch
6) pH Dispenser with Paper (Baroid No. 625 or approved equal)
7) Mud Balance (Baroid No. 140 or approved equal)
8) Slump Test Mold
10) Approved equipment for determining hydraulic conductivity

Test results will be reported to the Engineer within 24 hours of conducting a test.

TABLE 1 - QUALITY CONTROL TESTS REQUIRED

ITEM	CHARACTERISTIC	FREQUENCY	METHOD
Sounding	Trench Depth	10 ft	--
Water	Specific Conductivity	Each Morning	Chemistry
	pH, hardness	Each Morning	Chemistry
Bentonite Slurry	Density	Twice Daily	API 13A
	Viscosity	Once Daily	Marsh Funnel
	Filtration loss	Twice Daily	Filter Press
	Sand Content	Twice Daily	API 13A
Backfill Slurry	Slump	Twice Daily	ASTM C-143
	Gradation	300 yd^3	--
	Hydraulic Conductivity	200 ft	ASTM D-1587
	Water Content	200 ft	Grab Sample
Slurry Trench Cap		200 lf	Proctor Density

Note: These tests are considered to be the minimum needed and the contractor is still responsible for determining the number and frequency of the testing needed for successful completion of the trench.